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The Case for Context-Driven Testing

an interview with testing authority Cem Kaner

- by Sam Guckenheimer

Editor's Notes:

Testing Theory

Over the past decade or so, the business world has made much use, and sometime abuse, of Thomas Kuhn's notion of "paradigm shift," which he describes in his 1963 landmark contribution to the history of science, *The Structure of Scientific Revolutions*. It's hard to explain Kuhn's concept in a nutshell, but here goes: Each historical era of scientific thought understands the world according to accepted laws and ignores phenomena that those laws cannot explain. Over time, the evidence for the unexplainable becomes so great that new scientific laws accounting for those phenomena replace the old ones. In a sense, "reality" changes, paving the way for innovations within a new, revolutionary context. The shift to believing that theEarth orbits the sun instead of vice-versa is a classic example; in fact, it's where our more general sense of the word "revolution" comes from.

Kuhn's notion has been particularly appealing to the high-tech industry, where a few true visionaries and most corporate leaders tout their latest technologies as riding the wave of the latest "paradigm shift." By which they mean, for example, the move to client/server computing, then n-tier computing, then Internet and Web-based computing, e-commerce, and now, presumably, Web Services and grid computing. The problem is, these evolutions in computing architecture aren't really analogous to Kuhn's theory of scientific revolutions. Reality hasn't changed so much as simply sped up, and become increasingly distributed.

That's why we're delighted this month to publish Part I of a two-part interview with one of the world's leading authorities in testing, Cem Kaner, who has made good use of Kuhnian thought in his exploration of software test design. As a consultant, he noticed strict limits to what one testing organization would accept as valid, then similarly rigid but very different limits (laws) in another organization. In Part I of this interview by Rational's own testing guru, Sam Guckenheimer, Kaner describes his view that a given context, like a paradigm, is an important shaper of test design for different organizational realities. The second half of this interview will appear in our August issue.

This month we also offer three articles that treat different aspects of

requirements management: Dean Leffingwell returns with a look at requirements management in the context of agile development; Ben Lieberman takes a close look at risk management and how corporate culture and maturity can influence risk assessment; and two of Rational's own requirements management authorities, Catherine Connor and Leonard Callejo, provide lots of reasons *not* to leave RM strictly in the hands of requirements analysts in "Requirements Management Practices for Developers."

We also have an update from the experts at Forrester Research on the latest trends in software for the consumer electronics market. Claire Cates of SAS discusses how SAS implemented Rational Quantify and Purify to improve its internal development environment. And there's a big excerpt from the new book -- *Use-Case Modeling* -- by Rational use-case experts and frequent *Edge* contributers Kurt Bittner and Ian Spence.

Be sure to consider the plusses and minuses of Joe Marasco's energizing proposal in this month's "Franklin's Kite" column. The topic is especially appropriate, given that this summer marks the 250th anniversary of Benjamin Franklin's famous kite-in-the-thunderstorm experiment.

Happy iterations,

Mike Perrow
Editor-in-Chief

An Interview with Cem Kaner, Software Testing Authority

by **Sam Guckenheimer**
Senior Director of Technology for
Automated Test
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***Cem Kaner**, Ph.D. J.D., is Professor of Computer Sciences at Florida Institute of Technology. He is perhaps the world's most prolific and widely read author, consultant, educator, and attorney in the field of software testing.*

Last year, Dr. Kaner coauthored, with James Bach and Bret Pettichord, Lessons Learned in Software Testing: A Context-Driven Approach. One of his previous books, Testing Computer Software (coauthored with Jack Falk and Hung Nguyen), is a standard text for training software testers. Many of his articles on software testing are available at www.kaner.com. In addition, as an attorney, Dr. Kaner has been active in developing the law of software quality, and he was elected to the American Law Institute in recognition of his work.

Rational University recently engaged Dr. Kaner to develop content for a new course, Principles of Software Testing for Testers. Dr. Kaner will teach this course on August 17-18, immediately before the Rational User Conference (RUC) in Orlando. (The course will be available from Rational University instructors shortly afterwards.) At RUC, Dr. Kaner and his coauthor James Bach will also deliver a talk on context-driven software testing.

I recently had the pleasure of speaking with Dr. Kaner regarding the new Rational course, his work on context-driven testing, his new book, his curriculum development activities, and some of his foundational ideas in

software testing. I will share the highlights of that conversation with you below.

Sam Guckenheimer: Let's start with your book *Lessons Learned,* which you published about half a year ago. We liked the book so much we featured part of it on Rational Developer Network. It's generated a lot of interest, a lot of praise, and a little controversy. What drove you with James Bach and Bret Pettichord to do *Lessons Learned*?

Cem Kaner: The three of us were pretty enthusiastic about some aspects of the patterns movement. As I see it, the patterns movement involves a structured writing style for taking well-understood learning and trying to communicate it to other people. Although the structured style of writing in patterns looks very easy -- you have a bunch of subheadings and you fill in stuff for each one -- the method is time-consuming. And the essence of what you have to say gets lost inside all of the other components in which you don't have much special to say. I've done a lot of writing within structured constraints. In the first edition of *Testing Computer Software*, I tried to do something like that in the Appendix for bug descriptions, and discovered that I could make a much better product -- and not hurt the reader at all -- by focusing on the nugget of what I had to say and leaving out the other details. So rather than writing a book called *Patterns of Software Testing*, which came out of our first discussion, we said, Why don't we just write a book called *Lessons Learned*? We would consider a bunch of the things we had learned very well, extract the essence of those, and instead of putting them into a structured form, put them down one at a time and see what developed. *Lessons Learned* was the result.

SG: When you were creating *Lessons Learned*, did you set out to define context-driven software testing based on context and forces in patterns, or did it just emerge?

CK: The idea of context-driven testing had emerged in our group years before. In fact, Brian Marick, James Bach, and I started writing a book in 1997 to define the context-driven school. We opened the software test mailing list (http://groups.yahoo.com/group/software-testing/) specifically as a home list for the context-driven school. We were talking about context-driven testing a lot, but we were talking about it within an inner circle and polishing our ideas before exposing them under that name to the rest of the community. At some point during *Lessons Learned*, we realized that Brian would be happy to have the three of us kind of announce the school without his participation as a co-author. We were hesitant about doing that, since he had done so much work in this area. In any case, by the time we began work on the book, many of the context-driven ideas were quite mature.

SG: How has the reception been to context-driven software testing?

CK: I think a lot of folks have responded that it's what they do anyway, so while they're glad somebody is putting it into words, it's not really a big deal. Other folks have found it liberating, and some have found it intriguing; it's gotten them thinking. And some people are deeply offended

by it.

We're not surprised by the negative reactions. Many people in the testing community feel there is "*one* right way" to do certain things. They know the "right" lifecycle, the "right" test documentation method and test techniques. And then we come along, saying, "You know, no technique is good everywhere, and every technique is good somewhere, and the task is to figure out when something will work and when it won't, rather than whether it's good or bad." Some folks think that we're engaging in sloppy thinking and are personally offended by it. Some consultants don't know how to adapt their practices to include it, and simply attack it as something different from what they've been teaching for many years.

SG: I'm curious about the earlier work you've done on paradigms of testing which, of course, explores the notion that people have different ways to do software testing and that all of these different schools claim their method is the right one. Was that a driver behind context-driven testing?

CK: The paradigm notion was, for me, a very important driver. That early research was the first time that I had worked with anyone else to crystallize some of the notions of context. The history of the paradigms is kind of fun. When I was first breaking into consulting in the 1980s, I was working full time but would do consulting at night and on weekends for anybody desperate enough to hire me. You can imagine what sort of test manager or development manager would be willing to give up a late Saturday night to talk with a testing consultant. Those people were in deep trouble.

I would, in those days, tell them about domain testing, using boundary conditions, and about what I now call scenario testing, based on real-life examples of how people use the product or how we would like to imagine different users working with the product. And they would follow those principles, things would get much better, and they would think I was a genius -- and, of course, I thought I was pretty knowledgeable back then, too. Then I became a full-time consultant and started selling my services to people who weren't so desperate that they were willing to meet with me at midnight. They expected me there at normal business hours, they weren't in terrible trouble, and I would see them using methods that were "wrong." I don't know how else to put it. Fortunately, before telling them that everything they were doing was crazy, I had enough sense to ask for access to their customer support database, and I would take a look at what bugs they had in their bug tracking system and what complaints they were getting from customers. This revealed what bugs they had found and missed, and I realized that they had found things with their techniques that would have been very hard for me to find. There were a few things I had the ability to find that they had missed, but often, we simply had different visions of what good testing was, and these visions were yielding different, though quite effective, styles of testing.

Now, while these folks needed consulting -- they were certainly not as effective as they wanted to be -- it was nevertheless remarkable how much progress they could make following relatively few of the design principles that I thought were basic. So I would take that company's ideas

and put them in my toolkit and go on to the next company, only to find out they were doing something *else* that was different.

I had identified nine basic styles by the time I met James Bach at an American Society for Quality meeting in Dallas. We had e-mailed for years, and our first face-to-face meeting was extremely productive. We spent six hours in the Dallas airport talking about test design. He pulled out a list of nine basic testing styles, and lo and behold: They were the same as mine. The names were slightly different, but they were the same. For each style, we could name a company that relied almost exclusively on that style; if you talked to them about some other style, they'd say, "that's not testing," or "that's not interesting," or "that reveals bugs that nobody cares about."

As we further discussed these nine styles of testing, we agreed that the phenomenon looked very much like what Thomas Kuhn described in *The Structure of Scientific Revolutions* as pre-scientific paradigms. A paradigm really defines your scientific worldview. You have a set of data, you have a theory associated with those data, and you have measurement techniques or experimental techniques that are considered useful for finding new research results. Plus, you have a bunch of unanswerable questions that are out of scope relative to what you're currently working on and what you expect to continue working on within your field. All fields of science, over time, undergo revolutions in the ways problems are identified and resolved. Problems that used to be considered out of scope eventually offer an entirely new way of looking at the field. Practitioners start viewing those previously uninteresting and out-of-scope issues as central to the field of study. Bach and I both had had the experience of persuading people to adopt one or two new testing styles in their company and watching a transformation in their attitude about certain kinds of problems and test methods. So we started working on ways to communicate our style list to others.

Now, as soon as you come up with the notion that there are styles that overlap but are far from completely overlapping, you end up asking the question: If I were aware of all or most of these styles, how would I know when to use one or the other? What's the cost-benefit associated with one versus another? And you get into absolute contextual reasoning at that point. You have to ask questions like: What are the skill sets of the people who are doing this? What are the quality standards of people who have influence over development?

Quality standards are a funny thing, by the way. I was at Electronic Arts when we built Chuck Yeager's Flight Simulator. When I talk about context sometimes, I contrast EA's simulator with the kind that the Air Force would use. I point out that good testing for the Boeing flight simulator would be very different from good testing for the Chuck Yeager simulator. The response I often get back is, of course, that it would have been fine for the game flight simulator to be of lower quality, so we can use less rigorous approaches. But they miss the point. It's not that the entertainment Flight Simulator is of a lower quality -- it's of a *different* quality.

In a flight simulator game, it doesn't matter if the cockpit is shown

perfectly accurately. What matters is that somebody who has never flown an airplane can have fun dealing with a very complex virtual instrument. And if they can experience some of the thrill of flying without having to go through pilot training, then you have a game that might be not only commercially successful, but also entertaining in the best sense of the word. Boeing doesn't have to worry about making their simulator fun. Instead, they have to make their simulator absolutely realistic and structure it so that it will operate properly under all sorts of circumstances that test pilots are going to face. A kid crashing the game flight simulator has a very different emotional experience from a pilot crashing a training flight simulator. We don't have to worry as much about game players crashing; in fact, for some folks that's fun. We *do* have to worry about the screen being absolutely predictable and grouping the game controls in ways that novices will find appropriate. So the quality standards we used to create the game simulator at Electronic Arts were not necessarily higher or lower than the quality standards at Boeing, but the quality criteria -- playability, entertainment value, educational value -- are very different from the criteria for an Air Force flight simulator -- which are based on getting someone ready to fly a plane accurately and skillfully.

So the test techniques that you're going to use for the two flight simulators will really be very different, and at the end you will have two incredibly different products. The testers of one product might not be in any way competent to test the other product, but both products might still be absolutely successful and well respected. That's one of the best illustrations of context-driven testing that I can think of.

SG: You talk about this kind of spread in the Principles of Software Testing for Testers course as well. If an organization is like those you mentioned earlier - married to one kind of testing style but really should be using others too -- what does it take to get them to see the benefit?

CK: Generally, they have to notice that they are missing problems or spending too much finding the problems that they do find. Often it takes a crisis, like costly recalls that are visible to senior management. Sometimes the frustration comes from slow response time. If your product is really taking off and getting used under an increasingly wide range of circumstances out in the field, customers will encounter problems under the new usage conditions. If your testing style requires a long time to develop and document tests, you won't be able to keep up with all the problems and their fixes. Some test groups notice that their programmers and tech support staff catch the problems before they become disasters. But when you see problems caught by programmers or customer support that should have been caught by testers, you know it's only a matter of time before some problems will be missed by two or three levels of folks, and you're at great risk of serious failures or recalls. That's when people start thinking, Hmmm, maybe we need to do our testing a little differently than we've been doing it.

SG: The course that you helped Rational with, of course, covers all of the approaches. Would you say that the most important take-away from the course is the ability to appreciate new approaches to testing and take home ideas for new ones you can try?

CK: Actually, I think the Rational course offers several valuable things. Certainly laying out several different test techniques should be of value to anyone who takes the course. We also spend a lot of time on communication, on problem reporting.

I think that problem reporting is among the most fundamental skills that testers can have, yet it's among the least well-practiced. Rational publishes an excellent problem tracking tool, but if someone doesn't know what to write, then a well-structured database only helps them put stuff in that no one will read. Imagine that, when you discover a bug, someone other than you has to make an informed business decision about whether to fix it or even do follow-up research on it. Your goal, as a tester, is to give that person the best information they can have to make that decision; in some cases, that means pushing them pretty hard with data to get them to understand how serious the problem is, so they'll make a decision to go for higher quality even on a tough schedule or at a high cost. Under these circumstances, you need techniques to make the severity of the problem more clear, to make the circumstances under which the problem appears simpler to explain and imagine, and to make the presentation itself easier to read. In the Rational course, we drill these techniques, and I think that's a very important thing for testers.

I did a study at one company across six of their products, looking partly at the question of why certain bugs had escaped into the field and caused recalls. As I wandered through their bug tracking results, what struck me most was that they had many testers who were not writing really good problem reports. This came as a surprise to the company. They had such confidence that their engineers would fix problems if they understood them, that many testers felt that all they ad to do was to get a problem to the point where it was reproducible and write a description that was accurate. But too often, the descriptions were rambling, over-detailed, and not necessarily focused on the problem's effect on a customer or another stakeholder. By looking at the readability and focus of the report, I was able to predict whether a reported problem was likely to be fixed or not. I think many companies overlook very serious problems just because their tracking reports are weak. Programmers reading those reports would probably tend to turn their attention to fixing much less serious problems simply because their descriptions were easier to understand. So I think effective reporting is a fundamental skill for testers -- to be able to take what they learn through testing and communicate it very well in writing.

Coming next month: Part II of this series, with a focus on education and training for software testers.

Want to learn more from Cem Kaner himself about the testing issues, styles, and techniques discussed in this interview? Sign up now for the RUC Pre-Conference Training session *Principles of Software Testing*!

For more information on the products or services discussed in this

article, please click here and follow the instructions provided. Thank you!

Agile Requirements Methods

by **Dean Leffingwell**
Software Entrepreneur and
Former Rational Executive

To ensure that their software teams build the right software the right way, many companies turn to standard processes such as Rational Software's Rational Unified Process® (RUP®), a comprehensive set of industry best practices that provide proven methods and guidelines for developing software applications. Through the application of use cases and other requirements techniques, the RUP helps development teams build the right software by helping them understand what user needs their products must fulfill. Moreover, the RUP and many other contemporary software processes prescribe a software lifecycle method that is iterative and incremental, as this method helps teams address the risk inherent in a new development effort more effectively than did earlier, more rigid "waterfall" process approaches. Risk can originate from a variety of sources: technology and scale, deficient people skills, unachievable scope or timeline issues, potential health or safety hazards defects, and so on. Experience has proved repeatedly that addressing these risks early in the lifecycle is a key factor in producing successful project outcomes, and requirements management is one very effective way to accomplish this.

Mitigating Requirements Risk with Effective Requirements Practices

In our book *Managing Software Requirements: A Unified Approach*,[1] Don Widrig and I described a comprehensive set of practices intended to help teams more effectively manage software requirements imposed on a system under development. As the systems teams are building today can be exceedingly complex, often comprising hundreds of thousands or even millions of lines of code, and tens to hundreds of person-years in development time, it makes sense that requirements themselves are also

likely to be exceedingly complex. Therefore, a significant variety of techniques and processes -- collectively a complete *requirements discipline* -- are required to manage requirements effectively.

But lest we lose sight of the purpose of software development, which is to deliver working code that solves customer problems, we must constantly remind ourselves that the entire requirements discipline within the software lifecycle exists for only one reason: *to mitigate the risk that requirements-related issues will prevent a successful project outcome*. If there were no such risks, then it would be far more efficient to go straight to code and eliminate the overhead of requirements- related activities. Therefore, when your team chooses a requirements method, *it must reflect the types of risks inherent in your environment*. Each of the requirements techniques we describe in our book, as well as those recommended in the RUP, was developed solely to address one or more specific types of requirements-related risks. Table 1 summarizes these techniques, along with the nature and type of risks that each is intended to mitigate.

Table 1: Requirements Techniques Address Specific Project Risks

Technique	Risk Addressed
Interviewing	- The development team might not understand who the real stakeholders are. - The team might not understand the basic needs of one or more stakeholders.
Requirements Workshops	- The system might not appropriately address classes of specific user needs. - Lack of consensus among key stakeholders might prevent convergence on a set of requirements.
Brainstorming and Idea Reduction	- The team might not discover key needs or prospective innovative features. - Priorities are not well established, and a plethora of features obscures the fundamental "must haves."
Storyboards	- The prospective implementation misses the mark. - The approach is too hard to use or understand, or the operation's business purpose is lost in the planned implementation.
Use Cases	- Users might not feel they have a stake in the implementation process. - Implementation fails to fulfill basic user needs in some way because some features are missing or because of poor usability or error and exception handling, etc.
Vision Document	- The development team does not really understand what system they are trying to build, or what user needs or industry problem it addresses. - Lack of longer term vision causes poor planning and poor architecture and design decisions.
Whole Product Plan	- The solution might lack commercial elements necessary for successful adoption.
Scoping Activities	- The project scope exceeds the time and resources available.
Supplementary Specification	- The development team might not understand non-functional requirements: platforms, reliability, standards, and so on.

Trace Use Cases to Implementation	- Use cases might be described but not fully implemented in the system.
Trace Use Cases to Test Cases	- Some use cases might not be tested, or alternative and exception conditions might not be understood, implemented, and tested.
Requirements Traceability	- Critical requirements might be overlooked in the implementation. - The implementation might introduce requirements or features not called for in the original requirements. - A change in requirements might impact other parts of the system in unforeseen ways.
Change Management	- New system requirements might be introduced in an uncontrolled fashion. - The team might underestimate the negative impact of a change.

Methodology Design Goals

As we have said, the purpose of requirements methodology is to address requirements-related project risks. The purpose of the overall development methodology is to address collective project risks. In his book on agile development, Alistair Cockburn identifies four major principles to apply when designing and evaluating methodologies:

1. Interactive, face-to-face communication is the cheapest and fastest channel for exchanging information.
2. Excess methodology weight is costly.
3. Larger teams need heavier methodologies.
4. Greater ceremony is appropriate for projects with greater criticality.[2]

Let's examine these principles briefly to see what insight we can gain into selecting the correct requirements management methodology for a particular project context.

Principle #1: Interactive, Face-to-Face Communication Is the Cheapest and Fastest Channel for Exchanging Information

Whether eliciting requirements information from a customer or user, or communicating that information to a team, face-to-face is the best and most efficient way to communicate. If the customer is close to the team and directly accessible, if the customer can explain requirements directly to the team, and if the *analyst* can communicate directly with the customer and the team, then less documentation is needed[3] -- although critical requirements must still be documented. Otherwise, there is a danger that the tacit assumption "We all know what we are developing here" may become a primary risk factor for the project team. But certainly the team can get by with fewer, highly necessary documents -- Vision documents, use cases, supplementary specs, and the like -- and these can be shorter and less detailed.

Principle #2: Excess Methodology Weight Is Costly

This principle translates to: "Do only what you have to do to be successful." Every unnecessary process or artifact slows the team down, adds weight to the project, and diverts time and energy from essential coding and testing activities. The team must balance the cost and weight of each requirement activity with the risks listed in Table 1. If a particular risk is not present or likely, then consider deleting the corresponding artifact or activity from your process. Alternatively, think of a way to "lighten" the artifact until it's a better fit for the risk in your particular project. Write abbreviated use cases, apply more implicit traceability, and hold fewer reviews of requirements artifacts.

Principle #3: Larger Teams Need Heavier Methodologies

Clearly an appropriate requirements methodology for a team of three developers who are subject matter experts and who have ready access to a customer may be entirely different than the right methodology for a team of 800 people at five different locations who are developing an integrated product line. What works for one will not work for the other. The requirements method must be scaled to the size of the team and the size of the project. However, you must not overshoot the mark either, as an over-weighted method will result in lower efficiency for a team of any size.

Principle #4: Greater Ceremony Is Appropriate for Projects with Greater Criticality

The criticality of the project may be the greatest factor in determining methodology weight. For example, it may be quite feasible to develop software for a human pacemaker's external programming device with a two- or three-person coding team. Moreover, the work would likely be done by a development team with some subject matter expertise as well as ready access to clinical experts who can describe exactly what algorithms must be implemented. However, on such a project, the cost of even a small error might be quite unacceptable, and even entail loss of human life. Therefore, all the intermediate artifacts that specify the use cases, algorithms, and reliability requirements must be documented in exceptional detail, and they must be reviewed and vetted as necessary to ensure that only the "right" understanding appears in the final implementation. In such cases, therefore, a small team would need a heavyweight method. And conversely, a non-critical application with sufficient scope to require a larger team might very well be able to use a lighter method.

Documentation Is a Means to an End

Most requirements process artifacts, Vision documents, use cases, and so forth -- and indeed most software development artifacts in general, require non-code documentation of some kind. Given that these documents divert time and attention from essential coding and testing activities, a reasonable question to ask with respect to each one is: "Do we really need to write this document at all?"

You should answer "Yes" *only* if one or more of these four criteria apply:

1. The document communicates an important understanding or agreement for instances in which simpler, verbal communication is either impractical (larger or more distributed team) or would create too great a project risk (pacemaker programmer device).
2. The documentation allows new team members to come up to speed more quickly and therefore renders both current and new team members more efficient.[4]
3. Investment in the document has an obvious long-term payoff because it will evolve, be maintained, and persist as an ongoing part of the development, testing, or maintenance activity. Examples include use case and test case artifacts, which can be used again and again for regression testing of future releases.
4. A requirement for the document is imposed by some company, customer, or regulatory standard.

Before including a specific artifact in your requirements method, your team should ask and answer the following two questions (and no, you needn't document the answers!).

- Does this document meet one or more of the four criteria above? If not, then skip it.
- What is the minimum level of specificity that can be used to satisfy the need? If you do not need the level the project calls for, then either do not use it, or use an abbreviated version.

With this perspective in hand, let's move on to defining a few requirements approaches that can be effective in particular project contexts. We know, or course, that projects are not all the same style and that even individual projects are not homogenous throughout. A single project might have a set of extremely critical requirements or critical subsystems interspersed with a larger number of non-critical requirements or subsystems. Each element would require a different set of methods to manage the incumbent risk. So a bit of mixing and matching will be required in almost any case, but we can still provide guidelines for choosing among a few key approaches.

An Extreme Requirements Method

In the last few years, the notion of extreme programming as originally espoused by Beck[5] has achieved some popularity (along with a significant amount of notoriety and controversy). One can guess at what has motivated this trend. Perhaps it's a reaction to the inevitable and increasing time pressures of an increasingly efficient marketplace, or a reaction to the overzealous application of otherwise effective methodologies. Or perhaps it's a reaction to the wishes of software teams to be left alone to do what they think they do best: write code. In any case, there can be no doubt of the "buzz" that extreme methods have

created in software circles, and that the "agile methods" movement is now creating, as it attempts to add balance and practicality to the extreme approach. Let's look at some of the key characteristics of XP and then examine how we might define an Extreme Requirements Method that would be compatible with this approach.

Three Points to Remember About Method

- The purpose of the software development method is to mitigate risks inherent in the project.
- The purpose of the requirements management method is to mitigate requirements-related risks on the project.
- No one method fits all projects; therefore the requirements method must be tailored to the particular project.

1. The scope of the application or component permits coding by a team of three to ten programmers working at one location.
2. One or more customers are on site to provide constant requirements input.
3. Development occurs in frequent builds, or iterations, each of which is releasable and delivers incremental user functionality.
4. The unit of requirements gathering is the "User Story," a chunk of functionality that provides value to the user. User stories are written by customers on site.
5. Programmers work in pairs and follow strict coding standards. They do their own unit testing and are supposed to provide constant refactoring of the code to keep the design simple.
6. Since little attempt is made to understand or document future requirements, the code is constantly re-factored (redesigned) to address changing user needs.

Let's assume you have a project scope that can be achieved by a small team working at one location. Further, let's assume that it's practical to have a customer on site during the majority of the development (an arrangement that is admittedy *not* very practical in most project contexts we've witnessed). Now, let's look at XP from the standpoint of requirements methods.

A key tenet of any effective requirements method is early and continuous user feedback. When looked at from this perspective, perhaps XP doesn't seem so extreme after all. Table 2 illustrates how some key tenets of XP can be used to mitigate requirements risks we've identified so far.

Table 2: Applying XP Principles to Requirements Risk Mitigation

XP Principle	Mitigated Requirements Risk
Application or component scope is such that the coding can be done by three to ten programmers at one location.	Constant informal communication can minimize or eliminate much requirements documentation.
One or more customers are on site to provide constant requirements input.	Constant customer input and feedback dramatically reduces requirements-related risk.
Development occurs in frequent builds, or iterations, each of which is releasable and delivers incremental user functionality.	Customer value feedback is almost immediate; this ship can't go too far off course.
The unit of requirements gathering is the "User Story," a chunk of functionality that provides value to the user. User stories are written by customers on site.	A use case is "a sequence of events that delivers value to a user." Can user stories and use cases be all that different? If users contribute to both of them, then how far apart can they be?

With this background, let's see if we can derive a simple, explicit requirements model that would reflect or support an XP process. Perhaps it would look like Figure 1 and have the following characteristics.

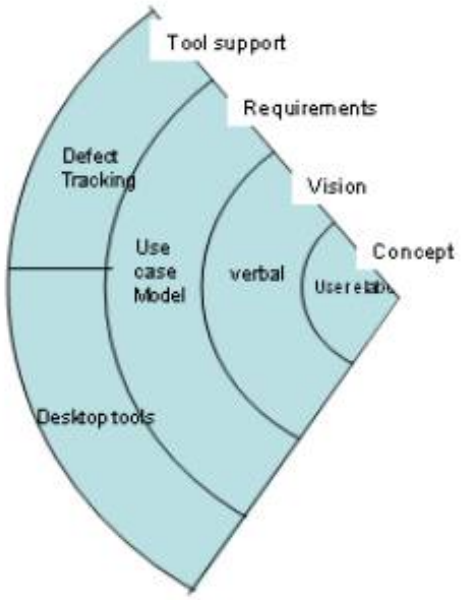

Figure 1: Extreme Programming Requirements Model

Concept. At the heart of any requirements process lives the product *concept*. In this case, the concept is communicated directly from the customer to the project team -- verbally, frequently, and repeatedly as personnel change.

Vision. As explained in *Managing Software Requirements*[6] and in the RUP, the *Vision* carries the product concept, both short term and long term. A "Delta Vision document" typically describes the new features and use cases to be implemented in a specific release. In XP, this document may not exist. We are dependent on the customer's ability to tell us what the product needs to do *now*, and what it needs to do *later*, and we are

dependent on the development team to make the right architectural decisions *now* -- for both *now* and *later*. Whether or not this can be made to work in practice depends on a number of project factors and the relative risks the team is willing to take; you can't say for certain that it couldn't work, at least for some project scenarios.[7] So we'll leave this artifact out of our extreme requirements method.

Requirements. Another principal tenet of our text and the RUP is that the use-case model carries the majority of functional requirements. It describes who uses the system and how they use it to accomplish their objectives. XP recommends the use of simple "stories" that are not unlike use cases, but perhaps shorter and at a higher level of abstraction. However, we recommend that there *always* be a use-case model, even if it's a simple, non-graphical summary of the key user stories that are implemented and what class of user implements them. We'd insist on this use-case model, even for our extreme method.

Supplementary Spec/Non-Functional Requirements. XP has no obvious placeholder for these items, perhaps because there are not very many, or the thinking is that they can be assumed or understood without mention. Or perhaps customers communicate these requirements directly to programmers whose work is affected by them. Seems a bit risky, but if that's not where the risk lies on your project, so be it; we'll leave this artifact out of our extreme method.

Tooling. The tools of XP are whiteboards and desktop tools, such as spreadsheets with itemized user stories and priorities, and so forth. However, defects will naturally occur, and although XP is quiet on the tooling subject, let's assume we can add a tracking database of some kind to keep track of all these stories: perhaps their status, as well as defects that will occur and must be traded off with future enhancements.

With these simple documents, practices, and tools, we've defined an *extreme requirements method* that can work in appropriate, albeit somewhat extreme, circumstances.

An Agile Requirements Method

But what if your customer can't be located on site? What if you are developing a new class of products for which no current customers exist? What if the concepts are so innovative that customers can't envision what stories they would fulfill? What if your system has to be integrated with either new systems or other existing systems? What if more than ten to twenty people are required? What if your system is so complex that it must be considered as a "system of systems" -- with each system imposing requirements on others? What if some of your team members work from remote sites? What if a few potential failure modes are economically unacceptable? What then?

Then you will need a more robust method. One that can address the additional risks in your project context. Then you will need a method that looks more like the agile method depicted in Figure 2.

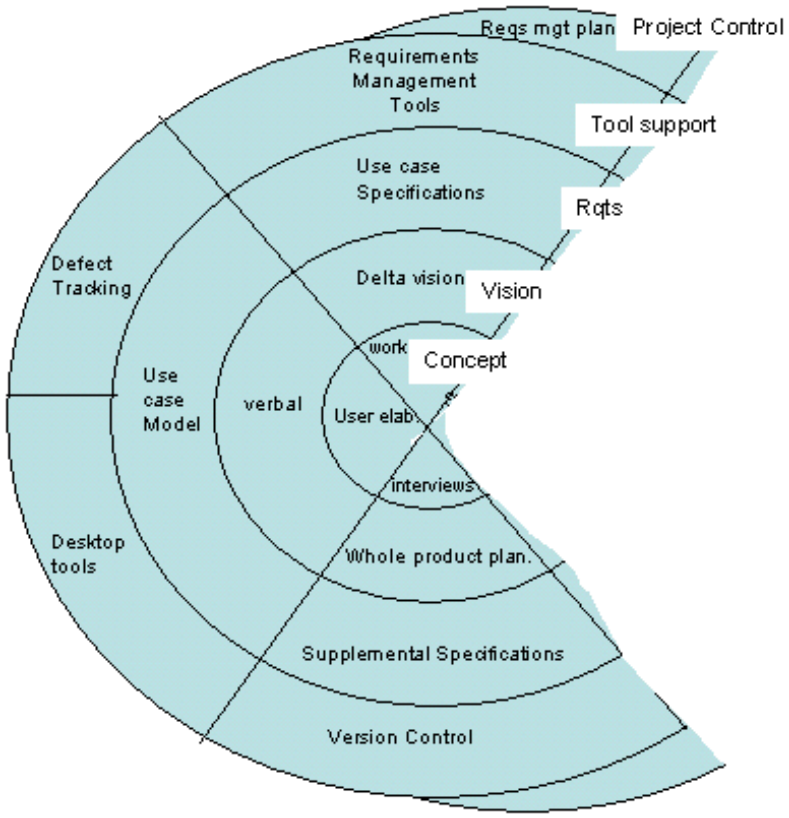

Figure 2: An Agile Requirements Approach

Concept. In the agile method, the root of the project is still the concept, but that concept is tested and elaborated by a number of means, including requirements workshops or interviews with prospective customers.

Vision. The Vision is no longer only verbal; it is defined incrementally in the Delta Vision document which describes the new features and use cases to be implemented in a specific release. The whole product plan describes the other elements of your successful solution: the commercial and support factors, licensing requirements, and other factors that are keys to success.

Requirements. The use-case model diagram defines the use cases at the highest level of abstraction. In addition, in this more robust method, each use case has a specification that elaborates the sequence of events, the pre- and post-conditions, and the exceptions and alternative flows. The use-case specifications will likely be written at differing levels of detail. Some areas are more critical than others; other areas are more innovative and require further definition before coding begins. Still other areas are straightforward extensions to known or existing features and need little additional specification.

Supplementary Spec/Non-Functional Requirements. Your application may run on multiple operating systems, support multiple databases, integrate with a customer application, or have specific requirements for security or user access. Perhaps external standards are imposed upon it, or a host of performance requirements that must be individually identified, discussed, agreed to, and tested. If so, then the supplementary specification contains this information, and it is an integral artifact to an

agile software requirements management method.

Tooling. As the project complexity grows, so do the tooling requirements, and the team may find it beneficial to add a requirements tool for capturing and prioritizing the information or automatically creating a use-case summary from the developed use cases. And the more people that work on the project, and the more locations they work from, the more important version control becomes, both for the code itself and for the use cases and other requirements artifacts that define the system being built.

Well now, with some practical and modest extensions to our extreme method, we've now defined a practical and *agile requirements method*, one that is already well proven in a number of real world projects.

A Robust Requirements Method

But what if you *are* developing the pacemaker programmer we described above? What if your teams are developing six integrated products for a product family that is synchronized and released twice a year? You employ 800 developers in six locations worldwide, and yet your products must work together. Or what if you are a telecommunications company, and the success of your company will be determined by the success of a third-generation digital switching system that will be based on the efforts of thousands of programmers spanning a time measured in years? What then? ***Then you will need a truly robust requirements method***. One that scales to the challenge at hand. One that can be tailored to deliver extremely reliable products in critical areas. One that allows developers in other countries to understand the requirements that are imposed on the subsystem they are building. One that can help assure you that your system satisfies the hundreds of use cases and thousands of functional and nonfunctional requirements necessary for your application to work with other systems and applications -- seamlessly, reliably, and flawlessly.

So now, we come full circle to the robust requirements management method expressed in Figure 3.

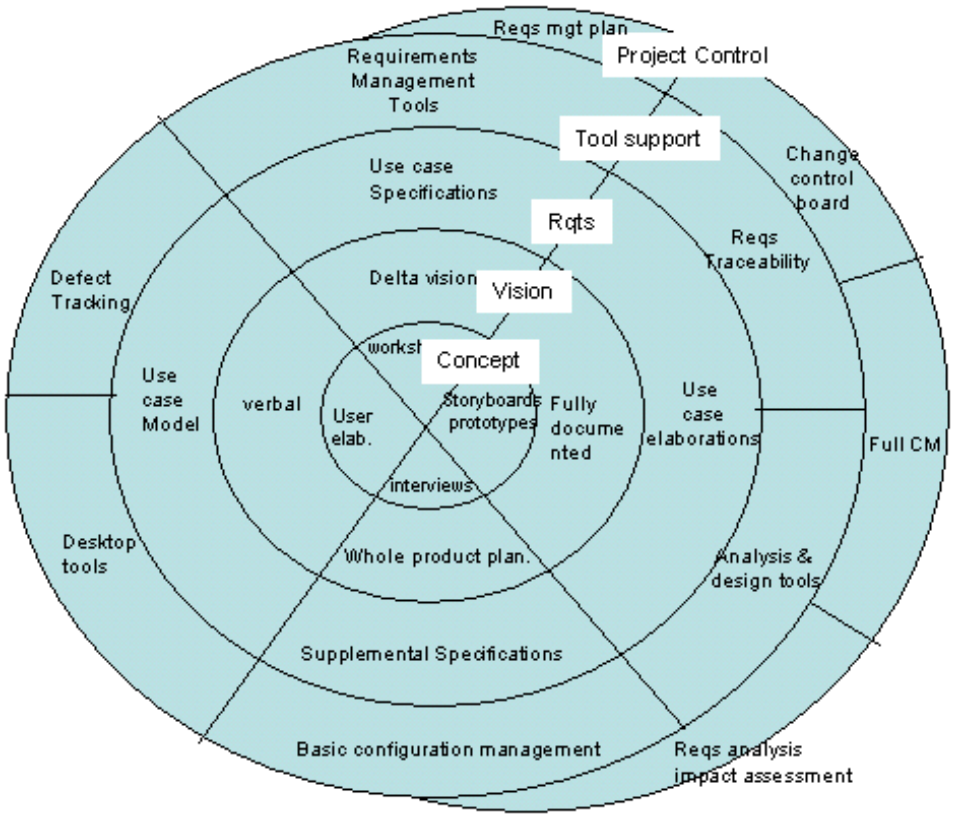

Figure 3: A Robust Requirements Management Method

Concept. Given the complexity of the application itself, and the likelihood that few, if any, features can actually be implemented and released before a significant amount of architectural underpinnings are developed and implemented, we want to add a range of concept validation techniques. Each will bring us closer to our goal of understanding the intended behavior of the system we are about to build.

Vision. In order to assure understanding amongst a large number of stakeholders, developers, and testers, the Vision, both near term and longer term, must be documented. It must be sufficiently long-range for the architects and designers to design and implement the right architecture to support current and future features and use cases. The whole product plan should be extended to describe potential variations in purchase configurations and likely customer deployment options. The plan should also define supported revision levels of compatible applications.

Requirements. The use cases are elaborated as necessary so that prospective users can validate the implementation concepts. This ensures that all critical requirements will be implemented in a way that helps assure their utility and fitness. Because the application is critical, all alternative sequences of events are discussed and described. Pre-and post-conditions are specified, and are as clear and unambiguous as possible. Additional, more formal techniques -- analysis models, activity diagrams, message sequence diagrams -- are used to describe more clearly how the system does what it does, and when it does it.

Supplementary Spec/Non-Functional Requirements. The supplementary specification is as complete as possible. All platforms,

application compatibility issues, applicable standards, branding and copyright requirements, and performance, usability, reliability, and supporting requirements are defined.

Tooling. Larger, more distributed teams require industrial strength software tooling. Analysis and design tools further specific system behavior, both internal and external. Multi-site configuration management systems are employed. Requirements tools support requirements traceability from features through use cases and into test cases. The defect tracking system extends to support users from any location.

Project Control. Larger projects require higher levels of project support and control. Requirements dashboards are built so that teams can monitor and synchronize interdependent use-case implementations. A Change Control Board is constituted to weigh and take decisions upon possible requirements additions and defect fixes. Requirements analysis and impact assessment activities are performed to help understand the impact of proposed changes and additions.

Taken together, these techniques and activities in our robust requirements management method help assure that this new system -- in which many tens or hundreds of man years have been invested and -- which will touch the lives of thousands of users across the globe -- is accurate, reliable, safe, and well suited for its intended purpose.

Summary

In this article, we've reinforced the concept that the project methodology is designed solely to assure that we mitigate the risks present in our project environment. Too much methodology and we add overhead and burden the team with unnecessary activities. If we aren't careful, we'll become slow, expensive, and eventually uncompetitive. Some other team will get the next project, or some other company will get our next customer. Too little methodology, and we assume too much risk on the part of our company or our customers, with perhaps even more severe consequences.

To manage this risk, we've looked at three prototypical requirements methods: an *extreme requirements method*, an *agile requirements method*, and a *robust requirements method*, each of which is suitable for a particular project context. And yet we recognize that every project is unique, and every customer and every application is different; therefore, your optimal requirements method will likely be none of the above. Perhaps itwill be some obvious hybrid, or perhaps a variant we did not explore. But if you are properly prepared, then you can select the right requirements method for your next project.

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Notes

[1] Dean Leffingwell and Don Widrig, *Managing Software Requirements: A Unified Approach*. Addison-Wesley, 1999.

[2] Alistair Cockburn, *Agile Software Development*. Addison Wesley, 2002, pp. 149-153.

[3] It is important to take this notion with a grain of salt. As Philippe Kruchten points out, "I write to better understand what we said."

[4] In our experience, this issue is often overrated, and the team may be better off focusing new members on the "live" documentation inside the requirements, analysis and design tools, and so forth.

[5] Kent Beck, *Extreme Programming Explained: Embrace Change*. Addison-Wesley, 2000.

[6] Leffingwell and Widrig, *Op.Cit*.

[7] As we said, the method is not without its critics. One reviewer noted the big drawback of the "one user story at a time," is the total lack of architectural work. If your initial assumption is wrong, you have to re-factor architecture one user story at a time. You build a whole system, and the n-1th story is, "OK, this is fine for one user. Now, let us make it work for 3,000."

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Software Development for Consumer Electronics: Bigger, Better, Faster, More -- Or Bust

An Interview with Josh Bernoff, Forrester Research; and Jed Kolko, Forrester Research

Success in the consumer electronics (CE) industry has always revolved around hardware innovations. But as products become more complex and feature rich, it is the design and function of software-driven interfaces that increasingly differentiate the players and determine the winners.

Software developers still face all the challenges you'd expect in a market where nearly every application is embedded and must be as fast, cheap, proven, and modular as possible. Development cost is also a major factor in profitability, especially in commodity categories such as VCRs and televisions, where margins are slim.

But perhaps the most significant trend in consumer electronics today, particularly from the standpoint of software engineering, is the accelerating need to integrate devices -- from cell phones to cameras -- with PCs, the Internet, and other technologies. Indeed, ease of connectivity can be the deciding factor in a product's acceptance. Bringing a well-designed, well-connected product to market at warp speed requires a shared vision and a well-coordinated process encompassing all the players on the team: hardware engineers, software developers, product designers, and market researchers.

To learn more about how changes in the consumer electronics business are impacting software development, reporter ***Scott Cronenweth***

*interviewed two industry experts at Forrester Research: **Josh Bernoff**, Principal Analyst, and **Jed Kolko**, Senior Analyst. Bernoff currently specializes in the television marketplace and has broad expertise on the supply side of consumer electronics; Kolko focuses on the demand side, through his research on consumer devices, access, and services.*

SC: What are the key factors that determine success in the consumer electronics marketplace? Getting an innovative product to market first? Pricing? Gee-whiz features? Usability? Interoperability with the PC?

JB: There are really only two strategies for success in consumer electronics. One is to get a new product out before anyone else and then defend your market leadership position. You can command a comparatively high price for your product by going after early adopters. The trouble is, however, that in this extremely competitive environment, any worthwhile advance generally gets copied pretty quickly.

So the second strategy is to be a fast follower. In the long run, most of the money ends up being made by the Toshibas and Sonys of the world coming in on the heels of the early leaders and producing products that have either some special design feature or a lower price tag. Those companies' success rests on having the cheapest manufacturing and prodigious distribution strength. To achieve economies of scale you need global reach and global manufacturing capability, and you have to get into the right stores. Unless you're in Circuit City and Best Buy you're unlikely to succeed in consumer electronics.

> *"Software design and development practices need to be as good as they can be, because the competitive playing field in consumer electronics is so even and so fiercely contested that something like your embedded software interfaces can easily make or break you."*

The upshot is that, by and large, products in the same category are very similar to each other. When this happens, buyers become very sensitive to price, and they pay less attention to what company label is on the product. Cost is especially important at the lower end of a given market. Design and look-and-feel -- the way the remote control looks; the way it feels in your hand if it's a portable device -- are important differentiators at all price points.

SC: Let's go back to what's required to succeed with that first strategy. How do you capture those early adopters if you have an innovative product?

JK: What we consistently find in our research is that the most successful product launches happen when consumers are presented with reasonable

expectations and basic applications.

If a consumer is not comfortable using the keypad on her cell phone to send a quick message, then she will not have the experiential background to comfortably embrace SMS (short message services) or wireless instant messaging, or to get excited by an ad campaign around mobile commerce or video conferencing. This critical need to focus on what consumers really want makes it imperative that organizations establish clear, ongoing communication and a shared, clearly understood vision across their marketing and development functions in the design, development, and introduction of a new product. Otherwise, consumers may fail to adopt even well-designed offerings.

In introducing wireless technology for cars, for example, the telematics industry has wisely focused first on emergency assistance and other very basic safety and security features. As opposed to trying to hype real-time traffic reports and automatic trip calculations, which don't even really exist yet. What's currently going on in the home networking arena will be an interesting test case. The hype there now is "Get broadband, get a home network, and soon your PC will be talking to your washing machine." The right message is "If you get a home network, then multiple PCs in your house can share a broadband connection." This is a very straightforward application of the technology, but one that resonates with a need consumers have -- and are aware of -- now. Few people really care about the sexy-but-impossible applications.

SC: The logic of what you're saying seems almost beyond debate. So why are straightforward value propositions so hard to come by in the marketplace?

JK: I think it's simply that marketing and market research teams on one hand, and design and core product development teams on the other hand, represent two very different cultures and viewpoints. Engineers focus on creating a device that incorporates cutting edge technology and provides the best solution to a problem. Whereas the marketing team is focused on the more mundane factors that drive a consumer toward a new technology -- or keep them away from it. Because most product developers and designers are accustomed to pushing the limits of technology, it's naturally rather easy for them to lose sight of the pragmatic reasons why consumers either adopt or don't adopt the technology.

For instance, many consumers hesitate going to broadband because they don't want to give up the e-mail address that they have with their dial-up service provider. All the technological improvements in the world won't get consumers to make the shift if their main concern is the hassle of telling all their friends they have a new e-mail address. Now that's way below the development radar screen! But factors like these are often on the minds of the marketers whose job it is to put themselves in consumers' shoes. The key is to communicate and maintain a common goal and a coherent business model for the product as it goes to market. That's a step that product teams sometimes gloss over, and that can spell disaster.

Figuring out the requirements for a product should begin with figuring out what's important to your potential customers. The issue isn't a lack of features; it's a lack of usability. A lot of developers rightly focus on the most extreme possibilities for a new technology. But marketing has to counterbalance that bias; its focus should on the less glamorous capabilities that will actually get consumers to buy the product.

Take a look at the Palm Pilot. It succeeded in a category where all the previous products, like the Newton, had flopped completely. Why? First, the original concept of what would appear on the screen, and where the buttons would be, was extremely well thought out. Second, it was tested and refined for ideal usability, so people liked it immediately. If you follow a new product vision completely in your own head, then you're probably not going to understand everything that users want. But if you have a brilliant idea and you combine it with the testing that's required to really refine it, then you'll succeed.

JB: At Forrester we see examples all the time of new products that do things nobody's ever seen before, that were engineered very creatively, and that fall flat on their faces. And in many cases it's because they do something that people don't want. Like the WebTV viewer,[1] which doesn't particularly appeal to that many people. But it's more frequently the case that a product flops because its design is so clunky that it's a major challenge for people to figure out how to use it. The ZapStation[2] comes to mind in that category.

One of the insights that we found really instructive came from a report I co-authored at the end of last year called The Secret to Device Success. We looked at MP3 players, digital cameras and PDAs (personal digital assistants), comparing their interfaces and their overall usability. What became abundantly clear was that the ability of these kinds of devices to connect in a rational way to the PC was hugely important in their success. And you can readily see that all three of those product types succeed or fail in many ways based on how easy it is to connect them to the PC and copy or move information back and forth.

In that comparative context, one can also cite examples of products that seemed to have been introduced too early, before the company really understood the usability issues they needed to address. And a product that's inferior from a usability standpoint in any of those spaces is simply not competitive. I think the lesson here is that the design and features have to add up to making usability effortless -- which is what it really takes to be successful. And as hardware designers hand things off to the software designers, you have to ensure that the focus on usability is not lost.

SC: So how does this need for effortless usability, along with all the market pressures you mentioned --- for rapid introduction, rapid innovation, low cost -- impact the people who develop software for consumer electronic devices?

JB: Consumer electronics today is a challenging environment for developers, obviously. The software that runs in these products is almost always embedded, and the bottom-line goal is to make it as small and cheap as possible. Modularity is also increasingly important: If you can't drop in and reuse components, then you won't make it to market quickly, and your costs will go up. A component-based architecture also makes it easier for you to refine the design or the interface of a device in response to usability testing or other market research.

Then add new levels of complexity to the equation. Software in CE devices used to consist of little more than the enabling layer that drives things like the display that appears when you hit the Volume Up key on your television remote. But that's changing rapidly as we see more and more sophisticated products like a TiVo or a cable set-top box. There's some relatively advanced stuff going on in there. Inside the TiVo, for example, is Linux.

By far the most important driver for increased software complexity, however, is the value consumers perceive in being able to connect a device to your PC or to something on the Internet. ReplayTV, for example, has a system whereby you can go to a Web site and tell that site what programs you want the device to record. Then, when it does its daily call to download information, the device will recognize and act on your commands; there's actually a Web component to its command interface. Likewise, products like PDAs and cell phones are designed to communicate with PCs and in some cases with the Internet, in order to update the information they're presenting. Now you even have PDAs beaming software at each other.

Integration across CE devices hasn't traditionally been much of an issue, but now that's changing, too. By and large people have simply bought components. They bought speakers or a television or a DVD player, and these products were relatively easy to hook up together. Now that television setups in particular are getting more and more complicated, the ability of these products to communicate with each other is becoming a whole lot more important.

What all that means for developers and manufacturers is that you can't just shove the software into the device any more. A more connected kind of world is opening up, a world in which these new devices need to work well across a much broader spectrum of interfaces and inputs. There's more to test, more code to control, more people involved, and so forth. There's also much more emphasis on interfaces. Cell phones, MP3 players, the TiVo, and even some DVD players have interfaces. These are not the hardware products of the past, when the interface essentially consisted of pushing the Play button on the remote control. As more devices get screens, more products require the capability to connect to one another, and more and more of them demand interaction, this sort of interface competence becomes increasingly important.

Software design and development practices therefore need to be as good as they can be, because the competitive playing field in consumer electronics is so even and so fiercely contested that something like your embedded software interfaces can easily make or break you.

SC: A couple of your previous remarks imply that many consumer electronics products are designed and built using what software developers term a "waterfall" approach, which can make it difficult to make changes as requirements are refined. Is that a valid assumption?

JB: Yes, I think you're right on target. In many instances we've seen of substandard usability, the manufacturer could easily have done exactly the tests that we did to detect flaws. But often by the time that level of testing takes place, those sorts of problems are already "baked in." What's interesting to me is that computer companies are increasingly beating traditional consumer electronics companies at their own game -- like HP with digital cameras and Apple with MP3 players, for instance. And I think a big reason is that the PC vendors have a better software development methodology. They're accustomed to the idea that your first take on how things might work doesn't necessarily give you the best result. You have to test prototypes with users and redesign the system iteratively until you get it there. That means validating components at each step in the development cycle. The more complex the software, the more crucial that approach becomes, both to reliability and to usability. It also means implementing automated testing and other controls to ensure quality. A lot of high-tech companies have adopted a process that provides these best practices and guides the activities you need to accomplish all of this. Traditional consumer electronics manufacturers could profit from adopting this approach.

Another issue is that sometimes there's a real disconnect between process demands for different products. Say you're manufacturing a personal stereo. You want to have the best possible design, you want to design the features well, and then you want to be able to make 100 million of them so they're cheap. But, suppose you decide to branch out into making digital cameras. For those, you need to ensure that the device works well in conjunction with a PC and has a seamlessly usable interface. That requires a different process and a different set of competencies than you need for stamping out personal stereos, and companies that don't recognize this aren't going to make it when they venture into new markets.

SC: So are companies that mass produce cheap goods like personal stereos outsourcing to get the skills and process they need to make more sophisticated consumer electronics?

JB: What we see is a growing trend among the big consumer electronics companies toward marketing and distributing products designed by startups, and in many cases the products are actually assembled and manufactured by yet another company. Again, the TiVo is a good example: It's designed by TiVo, Inc. but manufactured and distributed by Philips, Sony, and others. So you do, increasingly, see a sort of division of labor in this business.

And even within those startups, you may see development teams turning to third-party software to speed things up and control costs. If you're making a VCR, there's not a whole lot of value in writing the embedded operating environment yourself. The problems have already been solved. So you might start with a commercial application and perhaps customize it somewhat. But if you're making a cell phone, the interface capabilities of that phone in many ways represent your differentiation in the marketplace. So you are more likely to expend some serious effort in either writing the operating system yourself, or customizing an existing platform extensively. If you're making a personal video recorder, then once again the software is really your point of differentiation. It is everything.

In short, the decision about whether or not to develop software in-house really looks very different, depending on whether you're creating a commodity product, or one that you plan to differentiate based on software-driven features. Today, commodity products account for perhaps 90 percent of the consumer electronics industry. But if you go into Circuit City and look closely at what they're selling, for many of the higher margin products, it's the software that distinguishes that product from everything else in the category. You could even say that those new, software-driven interfaces and capabilities are a primary driver for growth and innovation across the whole CE industry.

Notes

1 A Microsoft offering that simulates the television browser on a personal computer, to help verify that the Web content displayed is appropriate for the form factor and resolution of the receiving device.

2 A digital media product from ZapMedia, designed to enable consumers to access digital content stored on a PC via a television or stereo.

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Gambling with Success: Software Risk Management

by **Benjamin A. Lieberman, Ph.D.**
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"Nothing ventured, nothing gained," goes the saying. And as many a visitor to Las Vegas knows, the ideas of Gain and Risk are highly intertwined. In software development, the costs associated with ill-defined project risks can be enormous. Without properly considering these risks, we are doing little more than throwing the dice and hoping for a favorable outcome.

A more mature organization realizes that risk is the price of opportunity,[1] and that risks can be well understood and mitigated. A true "risk" involves some possibility for loss, and "risk acceptance" is a decision to live with the resulting consequences for a given risk. It is the primary purpose of risk analysis to determine which risks have acceptable outcomes -- i.e., outcomes one can live with. For example, the loss of $1,000 dollars poses less risk to a billionaire than to an impoverished family.

One additional component must be present for some occurrence to qualify as a "risk": the element of choice. If there is no choice about whether to mitigate or avoid the risk, then the possible occurrence is out of one's control and better understood as a "chance," or a so-called "Act of God." The ability to choose which risks are worthwhile (i.e., risks for which the gain justifies the possibility of loss) and which are foolhardy is core to the concept of risk management. The concept of choice indicates there is more than one possible approach available; further, the more choices that are available, the better the likelihood one of those choices will lead to a beneficial outcome.

The key to risk management is the identification and mitigation of all true risks or, failing all else, the development of a contingency plan in case the potential risk becomes a concrete reality. In this article I will explore the identification and consideration of risks common to software development, paying particular attention to the effect of a company's level of maturity and existing culture on perception of risk.

Management Maturity and Risk

Because all software development involves human beings, the *perception* of risk plays a great role in the approach for lessening the probability of risk occurrence[2]. Often the "politics and perception" of risk involve ego and pride on the part of individuals -- some of whom are willing to take on a greater risk of loss than may be reasonable based on the level of anticipated gain. Thus, mitigation strategies will differ, based on the level of "corporate maturity."[3] For a young, entrepreneurial company, survival is based on taking chances, and risk mitigation is mostly about preventing disastrous losses. For more established firms, what often appears to be most critical for survival includes maintaining the status quo, so that risk mitigation centers around eliminating "disruptive" elements or competition -- i.e., the classic "If it isn't broken, don't fix it" mentality. Finally, for firms that are highly inflexible to change (what Azides refers to as Late-Aristocratic or Bureaucratic[4]), risk management is based on returning to the status quo, which means eliminating or reducing the need for the project in the first place.

Thus, a risk that is considered too extreme for an established firm may be one that a young firm is willing to accept, because it has less to lose and more to gain. In terms of software development, this may include a greater acceptance by the executive management of "bleeding-edge" technologies that have not been firmly established, or a willingness to experiment with development methodologies or development tools. Often it is the development group that proposes these approaches, acting on the mistaken belief that they can meet an unreasonable timeline if only they apply the "right" process. Risk management in this case should focus on risk reduction and early elimination of technical risks; these are usually the least known and most likely to disrupt or derail the project.

In contrast, a well-established firm is primarily interested in maintaining existing customers and gradually adding new ones, and so will focus more on risk transfer strategies (such as outsourcing). This is because transfer approaches allow a company to reduce its overall risk exposure but still retain control over the risk.

Finally, for the hide-bound, bureaucratic firm, it may be a wonder that a project is ever started in the first place. Perhaps a new CEO, recognizing the need for change in order to avoid company failure down the road, initiates a project. If the company is typically hostile to any sort of change, then the primary risk management activity is to continually assess the attitude of executive management. The highest risk is that the change project will be canceled before there is a chance to show value.

Aside from the company's maturity level, there are many other pitfalls

that can affect risk management in any organization. Consider the traps in Table 1.

Table 1: Pitfalls for Risk Management

Pitfall	Description
Out of Sight, Out of Mind	Teams often don't pay sufficient attention to risks that are obvious but not necessarily very visible. They assume the risk is so obvious that it will be dealt with, when in fact the risk may be forgotten until it is too late.
Selective Bias	If the project carries a large number of risks and the development team has limited skills, the team might focus on a small subset of the risks rather than deal with all the risks equally.
Expertise Bias	Some development teams are overly confident; their attitude is, "We are so good, we can handle any risk, so why worry?"
Data Presentation Bias	As Mark Twain was fond of saying,[5] "There are three kinds of lies: lies, damned lies, and statistics." He derided conclusions based on statistical analysis because it is possible to alter the analysis to fit the proposition; in other words, you can find support for any position if you work the numbers hard enough. If a team uses a statistical approach to analyze risk, then a rigorous and objective analysis of the underlying assumptions is required to avoid biasing the perception of the risk.
Conservatism Bias (dogma)	Comparing current risks to those previously encountered can be an effective strategy because it takes prior experience into account; but it can lead to assumptions that mitigation should be done a certain way because it has *always* been done that way.
Law of Small Numbers (variability)	This refers to the false assumption that small sampling numbers have a large associated error (also see **Data Presentation Bias**).
Self-Fulfilling Prophesy	The risk is a true one; the team acts in a way that ensures it will materialize into a problem. For example, if the team is convinced that the new configuration management tool will lead to project failure, then they will not expend the effort to learn the proper way to apply the tool.
Gambler's Fallacy (probability)	Some people mistakenly think that future probability is altered by past events -- i.e., the chance that a seven will be rolled next is smaller because it has been rolled three times previously. The probability of a risk becoming an actual problem on a current project is not lessened because the same didn't materialize on the previous project.
Incorrect Associations	This refers to assuming a cause-and-effect relationship between two unrelated situations -- for example, assuming that a project quality problem is the fault of the programmers rather than of the poorly conceived and rapidly changing system requirements.
Sin of Omission	Leaving out critical data is almost as bad as including incorrect information.

The common theme of all the pitfalls in Table 1 as well as the different

business approaches we discussed earlier is that the people who are investigating and evaluating risks can alter the perception of risk. The single most effective strategy for avoiding these pitfalls is to be aware of their existence, so you can consciously identify and counter them. After all, success is based on understanding the situation as it truly is, rather than how we would wish it to be. As the late physicist Richard Feynman very eloquently pointed out,[6] "For a successful technology, reality must take precedence over public relations, for nature cannot be fooled."

Corporate Culture and Risk

Experts in company behavior have demonstrated that, contrary to what we might assume, organizational culture is often independent of maturity; that is, culture is more closely aligned to the style of leadership encouraged by company executives. According to Geofee and Jones[7] there are four basic cultural types, each with a positive and negative form: Fragmented, Networked, Mercenary, and Communal.

A Fragmented culture is typified by independent action, such as scientific research. A well-connected, in-group mentality typifies Networked cultures, with a focus on personal relationships. Mercenary cultures are strongly goal-oriented, even at the expense of team morale or well-being. Finally, Communal cultures are typified by a closely connected group with well-focused goals (i.e., a "we are family" approach).

As it is for different levels of organizational maturity, the perception of risk is dramatically different for each culture. A Fragmented culture might view risk through each individual's eyes, biasing the risk analysis toward personal gain. Networked cultures are typically more concerned with risks such as political issues that might affect the health of the team (even over the health of the company), potentially ignoring other risks to project success. Mercenary cultures focus on all risks that affect project success, but are often less concerned with risk to people, such as the risk of burnout or strained team relationships. Communal cultures, which are fairly rare, have well-developed interpersonal relationships and are least likely to bias the risk analysis. However, they are also the most likely to exhibit arrogance regarding their own success and therefore to assume risks without enough potential gain to sufficiently counter the potential loss.

Culture and Maturity Risk Profiles

Within each of the four cultures, it is important, during risk analysis, to understand the effect that the corporate culture will have on the interpretation and ranking of risk. The assignment of importance based on perception should always be considered, or at least reviewed, in this light. Although corporate culture is relatively independent of corporate maturity, there are several typical combinations.

The Entrepreneurial Profile. Entrepreneurial companies are often Mercenary or Communal in nature, and are most influenced by the company founder. If the founder has a relentless focus on business success, then the culture will tend to be more Mercenary. If a family

founds the company, then the culture is more likely to be Communal. In either case, the concern is that risks will be judged to be less consequential than they really are, given the high degree of arrogance that is typical of both cultures and fostered by the company style. To avoid marginalizing critical risks, teams should use objective measures (e.g., financial cost, lost business opportunity) to rate risk exposure rather than a more subjective approach (e.g., past experience, "instinct").

The Mature Profile. Mature companies (five or more years old with greater than $20 million annual revenue[8]) are frequently Networked. This is due to the relatively long period of time that the company employees have had to work together and form relationships. This combination provides for stability and good interpersonal relations to judge and mitigate against risks. The major caveat is to be on the watch for cliques that seek to protect their own interests (i.e., the well-being of the group) in opposition to the entire company. One strategy to prevent this form of "empire building" is to include a senior executive in the project planning and risk discovery phase of the project, and to encourage cross-team interactions. The mere presence of a senior executive will discourage blatant inter-team rivalry, but other team conflicts can be addressed only by open communication between teams.

The Bureaucratic Profile. Finally, Late Aristocracy/Bureaucratic organizations have either a strongly Networked or Fragmented culture, depending on whether the people involved are co-located or distant from one another. The principal difficulty with this type of organization is its reluctance to accept the kind of change a new project represents. Conducting risk discovery and assessment requires obtaining continuous commitment from senior management and a very aggressive/persistent project leader who can overcome organizational roadblocks.

Risk Identification and Mitigation

Having considered some of the complex contexts in which risk assessment will occur, we can turn our attention to the mechanics of risk identification and ranking. Risks come in many forms, but software companies share a fairly large set of common risks, as shown in Table 2.[9]

Table 2: Common Forms of Risk

• Requirements volatility • Poorly defined requirements • Unrealistic schedule pressure • Low quality (error-prone modules) • Cost overruns • Corporate politics • Excessive paperwork • False productivity claims	• Lack of a defined, repeatable process • Inadequate organizational structures • Overemphasis on short-range planning • Malpractice (incompetent management) • Staff deficiencies • Unrealistic budgeting

• High maintenance costs • Inaccurate cost estimating • Poor configuration controls (change management) • Inadequate understanding of risk • Poor customer relations (expectation management)	• Over-engineering • Subcontractor deficiency • Shortfall in the execution of external tasks • Use of bleeding-edge technology • Inadequate system performance • Inadequate deployment planning

The list in Table 2 is in no way exhaustive, and it is critical to identify, analyze, and contain *any* situation that can significantly affect or impede the project.

Risk Description

There are four basic steps in describing risks, which can help lead to success in any software development project:

1. **Identification:** Discovery of potential loss.
2. **Assessment:** Determining the level of exposure to loss.
3. **Mitigation:** Creation of a risk containment or avoidance plan.
4. **Closure:** Successful avoidance or compensation.

These steps will lead to a complete description of all risks, which should be captured in a formal "Risk List."[10]. Each risk on the list should have the following details:

- Definition: Concise statement of the risk.
- Consequence: Expected impact if the risk is realized.
- Likelihood: Probability that the risk will occur.
- Exposure: Expected loss weighted by the probability of occurrence (Exposure = Likelihood * Consequences).
- Risk Ranking: Relative ranking-based consideration of Exposure.
- Indicators: Signs and symptoms to monitor the risk.
- Mitigation Strategy: Description of approach to avoid realization of the risk.
- Contingency Plan: Secondary plans to deal with consequences of risk realization.

Now that we have a framework for capturing risks, we can identify and

assess each risk in turn.

1. Identification of Risk

The first step in any risk management scheme is to identify all the factors that can lead to delay or cancellation of the project. Many of the risks in Table 2 are associated with the development *process*, the *product* under construction, or the management of the *project* itself. The project team should therefore consider these three areas while asking the following questions to determine the types of risk, the likelihood of occurrence, and the impact the risk would have on the project:

- What can go wrong?
- How likely is this to occur?
- What would be the cost or damage if this happened?
- How can we avoid this?

2. Assessment of Risk

The second step is to assess the level of exposure for each risk. If the actual dollar values can be determined, it is of benefit to provide this information as part of the risk description. This permits a non-biased ordering and ranking of the risk impact. Alternatively, you can use a simple scale to qualitatively rank the risks,[11] as shown in Figure 1:

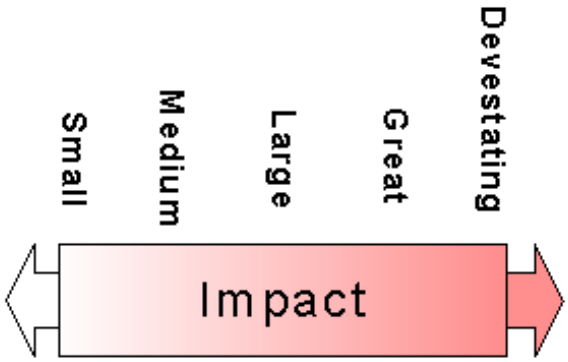

Figure 1: Qualitative Ranking Scale for Risks

A low-impact risk is one that incurs only negligible costs. Alternatively, a devastating impact risk is one that will lead to project cancellation, legal issues, and/or termination of the project team. When determining risk impact, it is helpful to take a backward-looking approach -- that is, to pretend as if the risk has already materialized and judge the resulting situation. As you do this, you should consider the effects on project personnel, customer satisfaction, and senior executive confidence, as well as the actual economic costs borne by the business.

Likelihood is a simple probability assessment from 1% (very unlikely) to 99% (all but unavoidable). Indicators are signs and symptoms that suggest the risk has either been mitigated or is occurring; for example, if

the risk is customer satisfaction, then a poor customer response to a release is an indicator that the risk is occurring or has already occurred.

Mitigation of Risk

Risk mitigation is an attempt to avoid or prevent the consequences associated with the risk. There are three primary mechanisms for mitigation:

1. **Risk reduction**: Reduce the probability of risk occurrence by forward planning.
2. **Risk avoidance**: Reorganize the project so that it cannot be affected by that risk.
3. **Risk transfer**: Reorganize the project so that someone or something else bears the risk (customer, outsource vendor, another company, another department, or the like).

Mitigation plans should be written and placed into effect as soon as possible. Since a key element of iterative software development is to take a risk-based approach to development and attempt the highest risk items early in the project, teams should address and retire the highest impact risks as early as possible in the development lifecycle. Addressing high-risk items early in the project is beneficial for several reasons:

- It leaves you plenty of time to deal with risk-generated problems.
- It reduces the impact of potential risks on the quality and timeliness of system delivery.
- The costs associated with a risk often increase over time.[12]

Contingency Plans contain steps that should be taken once a risk becomes a reality. For example, if the risk is to project schedule, than the contingency will be to maintain a time "buffer" to be used if the mitigation strategy of iterative development fails. For technological risks, the contingency may be to have a fallback plan to continue using the current solution while the new solution is made to work. Finally, for political risks, the contingency may be to petition the most senior executive in the company if a lower level executive becomes an impediment (typical of Bureaucratic firms).

As noted earlier, options must be associated with any endeavor that has enough potential for loss to qualify as a risk. In the event that a risk is realized, it is best to have a plan in place to deal with the costs and minimize impact to the project. Just as with a city disaster plan, the hope is that this plan will never have to be used, but it is best to define and practice it beforehand, just in case. A contingency plan might include additional schedule time "held in reserve," additional budget for emergency consultants, or other pre-disaster planning.

Conclusion

Risk management is critical for a project's success. An understanding of 1) how personal biases affect risk perception, and 2) the effect of corporate culture and maturity on risk planning and acceptance can better prepare the project team to manage major project risks. These influences must be carefully and objectively considered when creating a risk management plan. Risk management starts with the identification and documentation of situations or conditions that can lead to undesired consequences, including project cancellation. Risk mitigation consists of reducing the threat, avoiding undesired consequences, and/or transferring costs for identified project risks.

By assuming a risk-based approach to scheduling, including addressing the highest-risk items early in a project, the project team can increase the overall probability of success. It is important to avoid gambling with a project's success, which means accepting risks that are not justified by potential gains. By adopting a more rational approach to risk, the project development team will be able to prepare for all foreseeable circumstances and plan to meet them. Running successful projects, therefore, involves spending time to determine potential threats, understanding relative costs and benefits associated with those threats, devising mitigation plans to avoid realization of associated costs, and creating contingency plans to deal with possible undesirable outcomes.

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Notes

[1] E. Hall, *Managing Risk: Methods for Software Systems Development*. Addison-Wesley, 1998.

[2] R.N. Charette, *Applications Strategies for Risk Analysis*. McGraw-Hill, 1990.

[3] In this context, "maturity" relates to the natural growth of a company, and refers to the corporate business approach (e.g., entrepreneurial, balanced, change adverse, etc.). This should not be confused with the SEI's Capability Maturity Model (CMM), which measures the level of competence with respect to the software development process.

[4] I.Azides, *Corporate Lifecycles: How and Why a Corporation Grows and Dies and What to Do About It*. Prentice-Hall, 1988.

[5] Mark Twain (Charles Neider, Editor), *Mark Twain's Autobiography*. Harper Perennial, 2000.

[6] R.P. Feynmen, *What Do You Care What Other People Think?* Bantam Books, 1988.

[7] R.Goffee, and G. Jones, *The Character of a Corporation*. HarperCollins, 1998.

[8] E. Flamholtz, *Growing Pains: How to Make the Transition from an Entrepreneurship to a Professionally Managed Firm*. Jossey-Bass Publications, 1990, p.407.

[9] See B.W. Boehm, *Software Risk Management*. IEEE Press, 1989, and C. Jones, *Assessment and Control of Software Risk*. Prentice-Hall, 1994.

[10] I. Jacobson, G. Booch, and J. Rumbaugh, *The Unified Software Development Process*. Addision-Wesley, 1999.

[11] E. Hall, *Op.Cit*.

[12] See Jacobson, Booch, and Rumbaugh, *Op.Cit.*, and W. Royce, *Software Project Management*. Addison-Wesley, 1998.

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Requirements Management Practices for Developers

by Catherine Connor
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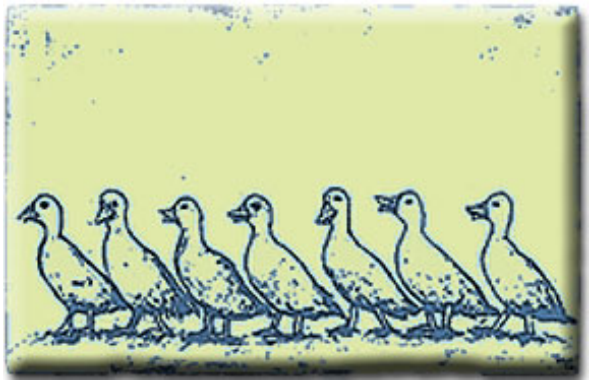


As a developer, do you get requests from every corner to incorporate "minor" changes into your code that will supposedly improve the existing system? Are you often working from incomplete or inaccurate specifications that leave you wondering what the requirements are actually trying to convey? Do you sense that the requirements are not truly known, and that you are therefore aiming at a constantly moving target? Do you feel as if you're at the tail end of a whip, constantly reacting to the lashes of fickle customers?

If you answered "yes" to any of the above questions, then keep reading: There is hope. Although many software development organizations still assign RM responsibility exclusively to the analysts on a project team, many others have realized that when developers contribute to RM practices, the project team has a much greater chance of successfully delivering the right solution to the customer. The goal of this article is to illustrate what this critical role entails and to provide RM implementation tips that developers can apply to help their teams succeed.

Why Should Developers Care About Requirements Management?

To understand how important it is for developers to get involved in RM, reflect for a moment on the purpose of RM: to establish a common understanding between the customer and the software team. That common understanding is the basis for planning and managing the project. Without effective RM, a team has limited ability to construct an accurate project plan, control project scope, deliver on key milestones, or prevent development and testing resources from being wasted on the

wrong tasks.

Developers can play a crucial role in ensuring that the team is working from a complete set of clearly expressed requirements. Developers should get involved early on with the requirements specification and continue to help clarify and refine requirements as these evolve through the iterative development lifecycle. Developers are responsible for turning concepts into reality, so the sooner they take an active role in the requirements process, the greater the likelihood that the requirements can be accurately translated into a workable system -- within the shortest amount of time.

Studies such as the Standish Group reports (see **References** below) have shown that requirements errors are the most expensive and aggravating errors to fix -- and the longer they go uncorrected, the more costly they become. Starting with a requirement that takes you in the wrong direction, or changing direction in the middle of the development lifecycle, can invalidate your design and result in expensive architectural rework, inaccurate validation tests and user documentation, and so on. You'll spend more and more time fixing problems that you might easily have avoided in the first place.

Proper RM can also simplify a developer's life. When Quality assurance (QA), quality engineering (QE), and documentation teams work from quality requirements that are clear, then they don't have to interrupt developers with questions about what to test. In addition, those in charge of maintenance can focus on actual implementation defects in the system rather than problems stemming from fuzzy requirements. Better requirements management ultimately leads to better quality software, and that enables developers to focus on forward-thinking enhancements.

How Formal Does RM Have to Be?

In general, the more informal your RM process, the greater the risk that your solution will not satisfy the customer. Common arguments for adopting a loose RM process include:

- It will allow us to develop faster.
- It will give us more flexibility to adapt to changing market demands.
- We don't need formal requirements documents to know what we are supposed to create.

Unfortunately, these are precisely the arguments that come back to haunt many project teams. Before adopting a position, the team needs to analyze carefully the degree of RM formalism required for project success. Fundamentally, your RM practices should yield:

- Requirements that are clearly understood by all team members.
- Control over changing requirements to keep the team on track for delivering the right solution.
- Effective communication to keep the entire project team on the

same page.

Of course, in certain cases, adhering to a very formal RM practice might be overkill. For instance, if your team is tasked with building a video game, then you can expect enhancement and change requests to pour in at a rapid rate. Following a traditional change control process that includes obtaining approvals from a Change Control Board (CCB) might inhibit developers' creativity, act as a bottleneck to software delivery, and ultimately compromise the project's chances for success. Even in this instance, however, the team would benefit from using selective RM techniques, such as storyboards or prototypes, to validate game ideas before committing to develop and deliver them.

At the other extreme are cases that demand strict adherence to formal RM practices. For example, if your project team is tasked with developing software to run a medical device that automatically administers an exact amount of medication to a human patient under certain variable conditions, then your team should adopt a highly structured RM process to ensure total accuracy. Making a mistake with a requirement in this situation could lead to loss of human lives.

Solutions for Requirements Management Problems that Affect Developers

Let's get down to specifics. In this section, we will look at some requirements-related problems that affect developers and propose RM approaches to remedy them.

Problem 1: Incomplete Requirements Specifications

Among the top RM challenges your team faces are the inevitable ambiguities in the first version of a requirements document. When was the last time you read a first-version RM document and felt confident that you had a solid understanding of what you were expected to build? The first version of requirements documents are almost always incomplete and ambiguous to some extent. Unfortunately, most requirements documents do not undergo revisions beyond the first draft; this means they lack sufficient information for developers to design their part of the system, leaving them to "interpret" what users want.

Despite analysts' best efforts to gather and document requirements through RM workshops, joint application development (JAD) sessions, interviews, or focus groups, developers often have many questions after their initial review of the requirements. This is true no matter how much subject matter expertise the analysts have. Often, developers simply provide a different perspective that the analyst might have overlooked. For example, they might raise exception situations that users may encounter but which the analyst failed to anticipate. Therefore, it is imperative that developers and analysts work closely together to refine the original requirements specifications before starting design.

Remedy: Detailed and Unambiguous Requirements

Specifications

Good RM practices recognize that requirements specification reviews should be the norm rather than the exception on any project. The entire project team should review the first version of the specification, and developers should have sufficient time to raise questions. In turn, the requirements analyst should have sufficient time to answer these questions and document clarifications. In particular, the analyst needs time to investigate questions directly with the customer to gather more details. It is essential that all developer issues be addressed before design begins. Otherwise, the developers might make their own assumptions and introduce unwanted elements into the system.

In addition to reviews, teams can employ use cases to express functional requirements. Use cases describe how a system behaves when interacting with the outside world by documenting system functionality as a dialog bewteen the user and the system. This provides software teams and their customers with a common understanding of the system's expected behavior, from a user's perspective. It is critical that developers play an active role in detailing these use cases in order to improve the clarity of requirements and thereby minimize misunderstandings. Analysts often gloss over major use cases (usage scenarios) and conclude that there are no major issues. However, once the developer begins to flesh out the details by identifying alternative use-case flows (usage scenarios based on something going wrong), then the real issues begin to surface. If a developer does not do this elaboration work *before* design, then the design will need to be reworked many times to incorporate all user scenarios. Consequently, the ability of the developer and analyst to establish a strong, collaborative relationship at this stage often determines the success of the final product.

Note, however, that not all requirements can be expressed in use cases. For instance, reliability and performance requirements are better expressed in declarative form (e.g., "The system shall..."), but use cases *do* provide a mechanism to document the user experience with the system in a comprehensive way. By focusing on the user point of view, use cases also eliminate unwanted design elements in requirements specifications and thereby free designers from unwarranted design constraints.

Problem 2: Constant Change Requests

The Standish Group's 2001 Extreme Chaos report states that "Changing requirements are as certain as death and taxes." Gaining control over these changing requirements is critical to the success of a project, and it is a practice that directly impacts the lives of developers. Consider your own projects. How often do sales or marketing people ask you to incorporate a customer-requested change into your code? Do you graciously try to accommodate these requests by working extra hours? If so, then you are doing your team a disservice. These constant interruptions have a negative impact on your productivity; they make it harder to concentrate and stay focused. But even more important, they can be devastating to the project plan and overall software quality. Even the smallest change can have a ripple effect on other team members and project areas. For example, unless the testers are informed about the change, they won't

build the necessary validation scripts to test it, and the resulting impact on QA/QE or documentation might delay the entire project schedule. In general, these constant interruptions can cause project plans to expand ("scope creep"), sidetrack the team from its initial objective, and result in software that does not meet the customer's expectations.

Remedy: Control Requirements by Assessing Potential Impact

The remedy is a set of RM practices that prevent developers from making casual changes before the team evaluates their possible impact. Requirement specifications should change only after they pass the criteria set by a Change Control Board (CCB) representing, at a minimum, the customer, the development team, and the testing team. This Board's responsibility is to evaluate every change request from three points of view: customer, development, and testing and documentation. (Depending on the type of application, training and support staff might need to be involved as well.)

- The *development representative* should assess all design areas that the change request impacts, as well as the level of effort required to implement the change. He or she might call on developers for help in analyzing the proposed change's potential impact.
- The *QA representative* should assess the feasibility and level of testing effort associated with the proposed change. A change that might be easy to incorporate in code might be very difficult, or even impossible, to test.
- The *customer representative* provides the business perspective and ensures that the change does not distract the project from pursuing its original business objectives. This person should also provide additional information about the change to help the CCB understand customer needs.
- It is wise to include representatives from training, support, and documentation on the CCB, because change requests often impact these areas as well.

Each Board member should be responsible for finding an adequate replacement in case of absence so that the assessments of change requests are unbiased. If all parties are not represented, then the Board should defer the evaluation process.

Using an iterative approach to development rather than a traditional waterfall approach is also a great help in managing changes to requirements. Traditional approaches freeze requirements specifications at the start of a project and theoretically don't allow changes until after the software is released. That approach encourages people to go directly to developers and ask them to change their code, which brings on all the negative consequences we discussed above. Iterative development, in contrast, allows software teams to split the work into iterations with internally stable requirements. At the start of the next iteration, the team gets a chance to update the requirements specification and incorporate

any changes that were submitted and accepted during the previous iteration. As specifications can change only at the start of an iteration, developers can concentrate on a firm set of requirements during the iteration itself.

Problem 3: Being in the Dark about Changes that Affect Your Work

As a developer, when requirements change, how are you informed? Often developers work on obsolete requirements because someone forgot to inform them of a change that impacts their work. Although the analyst on your team might discuss alternatives with a particular developer to gauge the impact of a change before voting to accept it, he or she may fail to realize the impact it might have on the work of other developers on the team. Also, even when you hear about a change in requirements, unless someone on your team is tracking the relationships between requirements and the design elements created to fulfill them, it is very hard to quickly and accurately assess the impact the change will have on your work.

Remedy: Requirement Change Notification

If your team assigns someone to track dependencies between requirements and design artifacts, then as soon as a requirement changes, that person can pinpoint which part of the design will be affected and inform all the developers working on it. Also, developers will know they can contact that designated person to make sure they are up to date on the latest requirements.

Because requirements are moving targets, this tracking person will need to use *traceability* -- the ability to track dependencies between requirements to ensure that requirements are actually implemented. There are various levels of traceability, but basically its purpose is to provide some assurance that the functionality you committed to your customers will indeed be implemented (coded by developers) and will work as specified (validated by testers). Tracing requirements to design elements is key to ensuring that those requirements will be implemented and helps in assessing the impact of a requirement change on design. To ensure that requirements are validated and that test validation is updated when a requirement changes, requirements should also be traced to test artifacts, typically test cases.

What about tracing requirements to source code? Although this idea seems appealing at first (e.g., if I change a requirement, then I will know which piece of code must be updated), it is actually impractical, because code is more dynamic than are requirements. If you start with a design and then optimize it, then the new design will likely result in code changes but still comply with requirements. Maintaining traceability links takes time, which is something software teams never have enough of, so you should use traceability judiciously. Skip using it for coding changes unless you work on systems that are audited by standards bodies, like the FDA, which mandate traceability from requirements to code, sometimes even lines of code. Even in such cases though, do not trace requirements to code while building the software. You only need to report that the *final*

product requirements trace to code and that no piece of code was built without fulfilling a requirement. If you try to get more detailed than that, then managing traceability links between requirements and source code will become a full-time job -- with few rewards.

Problem 4: Obsolete Requirements Specifications

The requirements specification document is the primary means an analyst uses to ensure that everyone on the team understands what system needs to be developed and what customer problems the system should address. It is critical that developers can easily locate this document, and that it be kept up to date. These seem like obvious, simple instructions, but the process can be complicated. Specifications often are reviewed on an ad hoc basis; so when decisions are made and assumptions are drawn, the requirements do not always get updated in a timely manner. Furthermore, when they are finally updated, the requirements do not always get redistributed to the team, or they might get lost amidst the clutter of e-mail in everyone's inbox.

Remedy: Up-to-Date Specifications Readily Available

Good RM practice dictates that the team clearly designate a central repository for the requirements specification document so that everyone always has access to the latest version. This ensures that developers will not waste time and effort coding against obsolete requirements. As an extra step, it is also a good idea to notify the team (via e-mail, phone, meeting, etc.) when the requirements specification document has been updated.

Six Tips for Improving Requirements Management in your Organization

In addition to the remedies we suggest above, here are a few simple and effective guidelines developers can use to help *prevent* the four problems we just discussed from occurring in the first place.

Tip 1: Participate in Establishing a Change Request Process

This may seem daunting, but it is actually quite easy to achieve. Simply put, any requests for change should be validated before they are accepted.

- The first step in establishing a

A Requirements Management Tool for Developers

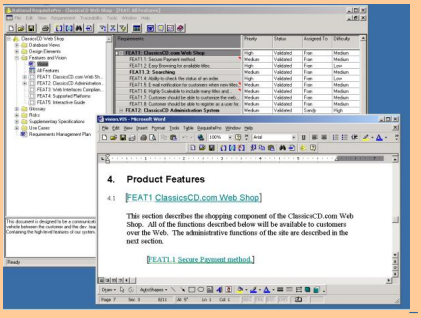
Rational RequisitePro, one of the most powerful requirements management solutions on the market, provides many benefits to developers[3]:

- Fast access to the most current requirements specifications.
- Control over requirements changes.
- Quick access to the Glossary when reviewing specifications.
- Complete audit trails of requirement creation and changes.
- Immediate identification of how requirements changes will impact design.
- Use-case specification templates.
- Ease of use through tight integration with Microsoft Word, the most widely used format for requirements specifications (see

change request process is to determine how your team will collect and manage change requests. The simplest method is to create a standard form that everyone can fill out and submit either via e-mail or fax, or in person. A more robust method would be to employ a tool like Rational® ClearQuest.®

- Next, determine how you will store these requests. Will you keep the paperwork in a three-ring binder or an electronic database? Using a commercial defect and change tracking tool (like Rational ClearQuest) greatly simplifies the management of change requests by allowing people to submit them over the Web; this requires no local software installation and allows the CCB to review the change requests and determine which ones to accept.
- Finally, decide how often the CCB should meet to review change requests and determine criteria for deciding which ones to implement.

Figure 1).



Click to enlarge

Figure 1: Rational RequisitePro Features Tight integration with Microsoft Word

Rational RequisitePro is also integrated with Rational's Rational XDE™[4] development environment, as well as with Rational Rose.®[5] With these integrations, you get seamless navigation from use-case diagrams -- documented in either Rational XDE or Rational Rose -- to the use-case specifications stored in Rational RequisitePro. RequisitePro maintains use-case specifications as true requirements documents, so you get all the benefits of managed requirements while documenting software use cases.[6]

Tip 2: Enforce the Change Request Process by Just Saying NO

As a developer, you can play a critical role in making the change request process work for your team. If you continue to accept and implement ad hoc change requests from salespeople, customers, senior management, and others without having the CCB assess them, then you and your team will continue to feel plagued by constant demands for change. Also, your behavior will only increase the number of ad hoc requests that come directly to *you*, because the requestors will know you are a "soft touch."

Instead, you must learn to say "no" to your requestors and direct them toward your established change control process. This can lead to high pressure from salespeople, for example, who are often the instigators of ad hoc requests that are accompanied by claims such as, "I can close the XYZ account if you add that feature," or "I have been losing deals lately to the competition because we don't have the ABC feature." No matter what arguments people use, you and your development team have to exhibit strong discipline and politely direct these people to the proper change request process. Although they may not change their behavior overnight, if they understand the benefits of the process and that you are firm and

dedicated to this process, then they will change their behavior over time.

Tip 3: Establish and Participate in Requirements Specification Reviews

As a developer, you know that whenever you receive a set of requirements you likely will have many questions, because some of the specifications are unclear or ambiguous. Make sure your team's project plan allocates time for periodic requirements specification reviews. The benefits of this are many: You do not have to make guesses about the changing spec; you better ensure that your team will deliver what the customer is asking for; and you avoid rework for yourself and for your team. These reviews do not need to be terribly formal; they should be an open forum in which the development team can discuss pieces of the requirements specification to ensure that everyone has the same solid understanding of the requirements.

You should be an active participant in these review sessions and come prepared with preliminary designs or concepts based on your interpretation of the requirements. This process is highly iterative in nature; typically, you need multiple sessions to establish a solid understanding of the requirements and prepare to move into design. Through these iterations, the analyst on your project team can ensure that all changes are properly captured and documented. Furthermore, these iterative reviews provide a self-checking mechanism for the team to ensure the quality of both the software requirements and preliminary designs. By keeping both of these artifacts in synch, the project team can move forward together and increase its chances of delivering a successful solution. Consequently, time should be allocated to continue the reviews through the design phase; that is when many developers discover more ambiguities in the requirements specifications that must be resolved so that they can proceed with their work without making assumptions they will later have to correct.

Tip 4: Maintain a Glossary

A glossary document that is owned, developed, and maintained by the analyst is a simple yet powerful way to remove ambiguity from requirements specifications and avoid misunderstandings. The glossary does not need to list every term used in the requirement specifications, but it should definitely include any that might be subject to multiple interpretations. If terms defined in the glossary have specific and important relationships to other terms (e.g., in building a financial application, a *customer* can only have a set number of *accounts*, and no more than two customers can share the same account), then you may want to supplement the glossary with a domain model that visually depicts those relationships (e.g., between *customer* and *account*), as the software will need to respect them.

Any member of the project team can suggest terms for the analyst to add to the glossary, but the entire team must agree upon the terms' definitions. As a developer, you must take responsibility for understanding the key terms related to the system area for which you are responsible.

Tip 5: Insist on a Project Vision to Guide Your Solution

To help developers understand the application of the software you will be building, your project leader or analyst should be documenting the specific business problems your team will be tasked to solve with this project. Without an understanding of these problems, developers run a great risk of creating something that will not be useful to customers.

Think about a competitive athlete, a runner, for a moment. Before the season begins, the runner establishes a primary goal to accomplish. Then he analyzes his strengths and weaknesses and develops a training plan with periodic minor goals that will allow him to accomplish his primary goal. As he trains, unexpected things are bound to happen -- such as injuries, illness, and bad weather -- that force him to alter his training program. However, by keeping his goal in focus, the runner is able to adapt to the changes and adjust his training so that he is still able to achieve his primary goal. Without keeping such a focus on his primary goal and maintaining discipline in striving for his minor goals, the runner would be highly susceptible to making incorrect adjustments to his training program that would prevent him from ever achieving his primary goal.

Similarly, on software projects, teams need to have a clear understanding of the project vision and a corresponding project plan with intermediate milestones to help them achieve their primary goal. Inevitably, during a project certain factors come into play (e.g., technical limitations, unforeseen performance problems, etc.) that alter the original course of action. Also, it is common for team members to lose sight of the vision in the middle of a project and become very myopic in their work. These things can cause teams to stray from their intended path and prevent them from fully achieving their original goal. Just as the runner has to adapt to changes and stay disciplined by striving for minor goals while maintaining focus on his primary goal, so too must a project team be adaptive yet disciplined. The team must strive for its milestones, always focusing on its overall vision. Therefore, as a developer, before you dig into the requirements and start designing, review your project's Vision document. If one does not exist, then insist that your project leader or analyst develop one before you get started. You might avoid wasting a lot of time building useless software.

Tip 6: Adopt Use Cases to Illustrate System Functionality

Express functional requirements in the form of use cases to better understand how people will actually use the software. As you create usage "stories" for the software, you will flush out requirements details and save yourself from having to do a lot of guesswork. Use cases are unique in their ability to express requirements and describe what the software should do for users in a format accessible to both technical and non-technical folks. By enabling software teams to avoid traditional user and system representations of requirements that often lead to a disconnect between less technical analysts and developers, use cases provide a better chance that everyone will understand and agree on the expected system functionality.

In addition, with use cases you can create use-case storyboards, a great alternative method for building a user interface prototype to validate usability requirements. Use-case storyboards are logical, high-level descriptions of how the user interface will present to users the functionality described in the use case. As they are much faster to develop than the actual user interface, you can employ use-case storyboards to try out various user interface options before you prototype, design, and implement an actual interface.

Writing good use cases takes practice, and Rational provides resources to help, including Webinars and articles on *The Rational Edge*[1] and the Rational Developer Network.

Automating the Requirements Management Process

An automated tool can support all the requirements management practices we've discussed, but it's important to remember that an RM tool is only as good as the process it automates. Furthermore, the tool can automate only parts of the process; no tool can replace good communication among team members. To be successful, first be sure that your organization's RM practices are sound and work well. Then introduce an RM tool, and your team will be able to benefit from using it.[2]

In addition to an RM tool, consider automated process support. Although you can find plenty of guidelines for best practices in books (see References below), providing your team with just-in-time access to guidelines is one way to help ensure that people will follow them. That is why Rational publishes the Rational Unified Process as a navigable and searchable Web site.[2] The RUP defines best practices for RM, including team roles and responsibilities (see Figure 2).

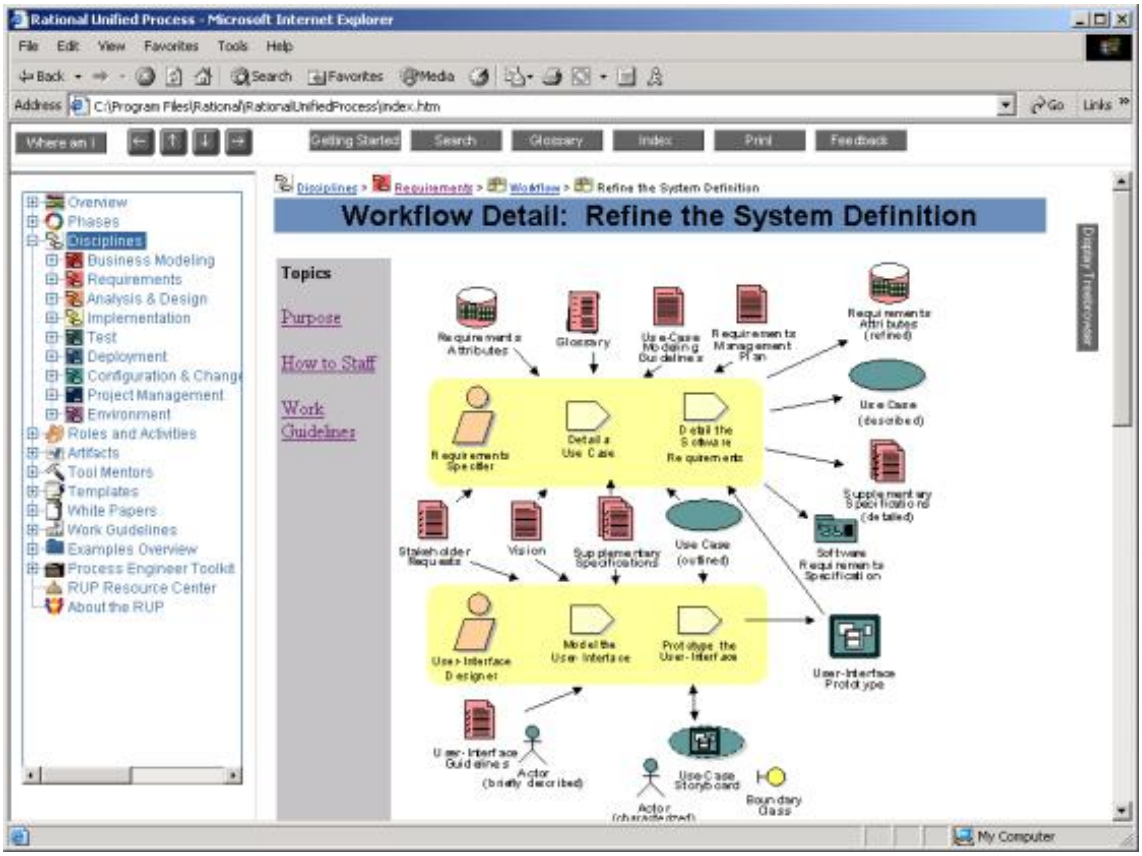


Figure 2: RM Best Practices in the Rational Unified Process

The RUP also includes tool mentors, which spell out exactly how to implement RM best practices while using Rational RequisitePro (see Figure 3).

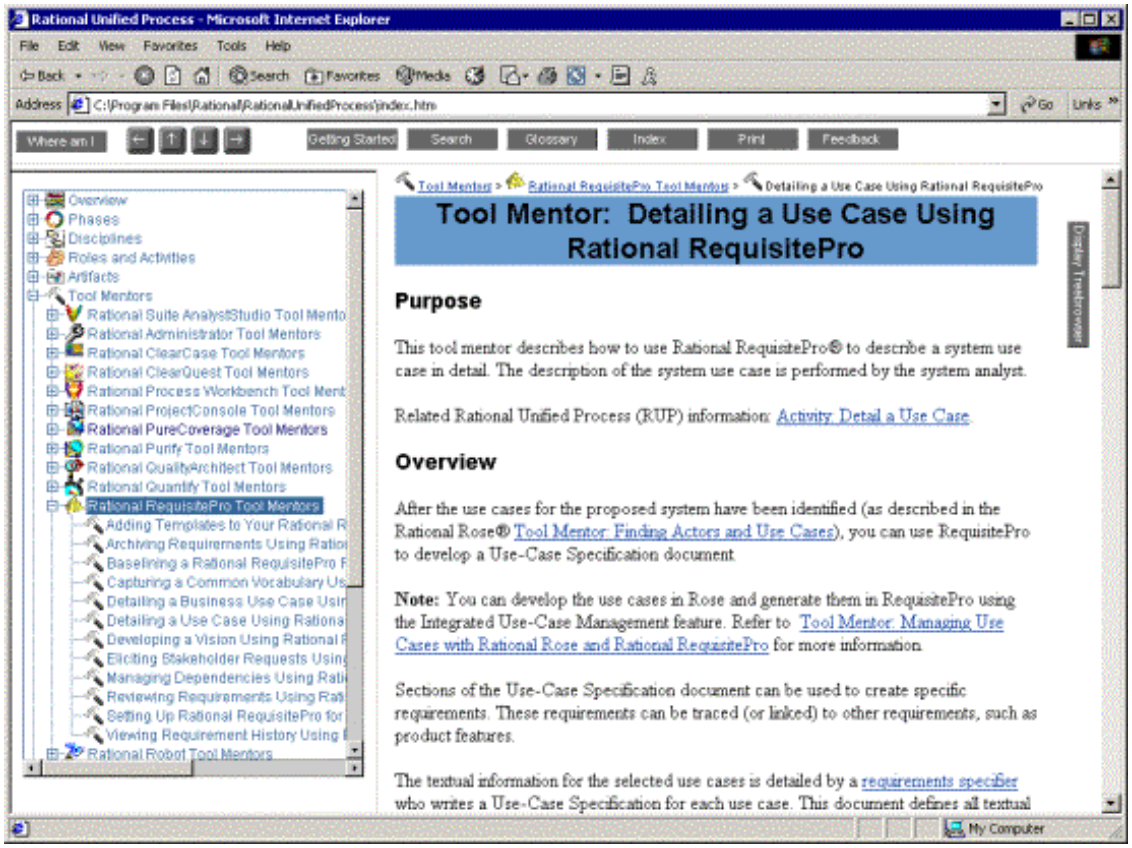


Figure 3: Rational RequisitePro Tool Mentors Provide Tool Guidance Inside the Rational Unified Process

The Key: Require Good Requirements

As we've discussed, effectively managing a project's evolving requirements can have a huge impact throughout the development lifecycle. Requirements define what to design, what to test, and what to put in the user manual -- and requirements errors are the most costly to fix. Yet once you know what to watch for, such errors are relatively easy to avoid. And developers can play a key role in helping the team avoid them.

Given today's pressures to deliver software, it's critical that developers take an active role in formulating unambiguous and complete requirements right from the start, before they begin design -- because they may not have time to fix defects caused by poor ones. Then, by refusing to incorporate changes that are not approved, developers can reduce daily rework and frustration and help their team deliver software that actually solves customers' problems. By taking an active role in requirements management, you, as a developer, can both minimize the chaos in your life and help your software projects succeed.

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These sources can help you and your team understand the value of adopting good RM practices.

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- Rational Developer Network, http://www.rational.net. Provides a wealth of information for software developers at Rational customer companies (registration required), including guidance on requirements management and Java and .NET development processes.

Notes

[1] See articles by Leslee Probasco, Ellen Gottesdiener, Anthony Crain.

[2] Rational provides a complete RM solution, including process guidance in the Rational Unified Process (RUP), tool automation with Rational RequisitePro, and public or on-site classes from Rational University (http://www.rational.com/university/index.jsp). Rational also offers various forms of onsite Professional Services through local customer teams.

Get a glimpse of the RUP at http://www.rational.com/products/rup/index.jsp

[3] View demos of Rational RequisitePro online at:

- http://www.rational.com/products/reqpro/index.jsp (overview)
- http://www.rational.com/tryit/reqpro/seeit.jsp (detailed demos)

[4] See www.rational.com/xde

[5] See www.rational.com/rose

[6] For more information on these integrations, see the use-case management white papers on the Rational Web site (www.rational.com/products/reqpro/whitepapers.jsp).

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Book Review

Primal Leadership: Realizing the Power of Emotional Intelligence
by Daniel Goleman, Richard E. Boyatzis, Annie McKee

Harvard Business School Press, 2002
ISBN: 1-57851-486-X
Cover Price: US$26.95
352 Pages

When I began reading this latest effort by Daniel Goleman et al., I was a bit skeptical. Seems like an increasing number of what I call "Kumbaya" books have come onto the market lately -- books promoting the touchy, feely side of leadership. Fortunately, I was pleasantly surprised: This work offers much more than that. I found myself relating to many of the real world situations that are used as context for Goleman's claims. This reality-based context made the information much more meaningful and allowed me to see the practical side as well as the theoretical.

The basic claim Goleman makes in *Primal Leadership* is that a leader's behaviors are just as important, or even more so, than other attributes leaders must possess, such as vision, intelligence, and so on.

In the first part of this book, Goleman and his co-authors help us assess who we are as leaders, what styles we use, and how people perceive us. They identify four behavioral domains important for leadership:

- **Self Awareness**. This includes the ability to read our own emotions and recognize their impact on others, know our own limits and strengths, and have a good sense of our capabilities.
- **Self Management**. This domain encompasses having emotional self control, being honest, adaptable, and driven to improve performance and meet standards of excellence, and possessing initiative and optimism.
- **Social Awareness**. Leadership requires empathy and sensitivity to others' emotions, taking interest in others, organizational and political awareness, and a willingness to serve the needs of both customers and employees.
- **Relationship Management**. Success in this domain rests on our ability to guide and motivate others, to influence people and help them develop, and to serve as a catalyst for change, manage

conflict, and forge the bonds required for effective teamwork and collaboration.

The authors claim that very few people are excellent in all four domains (How many can you think of?), but successful leaders are very competent in at least two or three.

The authors also theorize that different situations require different types of leadership. This seems like common sense, but in my experience, the dynamic range of most managers is rather limited. Therefore, I thought the chapters that discuss various leadership styles (Visionary, Coaching, Affiliative, Democratic, Pacesetting, Commanding) were quite accurate. The examples are good, too; The authors present the pros and cons of each style within the context of an actual business situation, explaining that the style should map to the situation. You wouldn't want a democratic leader in a battle situation (commanding style would be preferable here), for example, and you wouldn't want a pacesetting style in an academic environment (affiliative or coaching styles would be top choices in this situation).

Emotional Intelligence versus Strategic Thinking

Another important point the authors make in this book is that it is critical to put people before strategy. Here I thought they were a little off. Although I agree that you should never discount the importance of people, I believe that you should consider them in parallel with strategy. Why? Because I strongly feel that leaders need a balance between emotional intelligence (the personal, behavioral side of leadership) and what I call functional intelligence (the vision, knowing the market, decision making, judgment, etc.) in order to do their job effectively. If we spent all our time building teams and rallying the troops but ignoring business strategy, then how would we know in which direction we were going? And what type of people we needed to get there?

In fact, as I read farther into the book, I got the feeling that the perspective was getting progressively more academic and psychological and less pragmatic. I would also like to have seen more data to support several claims the authors make. For example, when they say that a new manager in a failing company turned the organization around and became successful (there are many examples like this in the book), it would have been helpful if they had elaborated on a few specific key actions that contributed to the person's success. Instead, the reader must be content with referring back to their theories about success and drawing whatever conclusions one can from the scanty description of the situation.

These frustrations notwithstanding, I highly recommend this book to everyone in any management role, especially in the technical field. All too often, we discount the importance of applying emotional intelligence in our interactions, which can certainly affect a team's willingness to get behind a leader. Like Goleman, I've always believed that without the motivation and commitment of the entire team, successes are short-lived and rarely sweet. But I also believe that, to succeed, leaders need more than the traits discussed in this book; they must also know and be able to apply the

business fundamentals and practical mechanics required to thrive in a real work environment.

-**Sid Fuchs**
Director of Professional Services
Rational Software

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Book Review

Leading Quietly: An Unorthodox Guide to Doing the Right Thing
by Joseph L. Badaracco, Jr.

Harvard Business School Press, 2002
ISBN: 1-57851-487-8
Cover Price: US$25.95
224 Pages

Ever since King Solomon offered to bisect that baby, it's been clear that effective executive decision-making requires the incumbent to possess both wisdom *and* moral authority. However, even with the current recession firmly in place, there simply aren't that many ex-monarchs of a similar caliber out there job-hunting just now. (And even if there were, then what with the price of thrones, red carpeting, and palace flunkies these days, they would be hard to sell as potential CEO candidates to any half-decent board of directors.) Nonetheless, Silicon Valley has done an excellent job of generating its own royal pretenders: Steve Jobs, Larry Ellison, and Scott McNealy, to name but three. Like modern-day royalty, these are personalities that get to live life in the full glare of the media spotlight. And over time, they've come to personify what a CEO surely has to be, right?

Wrong. The reality is -- and *must* be -- that the vast majority of businesses operate perfectly well, thank-you-very-much, without superstars. As the author of this new book puts it, "Quiet leadership is what moves and changes the world."

A perfectly reasonable premise, but, as it turns out, only one aspect of what this book sets out to achieve. *Leading Quietly* is just as concerned with the moral dimension of leadership as it is with celebrating the "unsung heroes" of management. Hardly surprising, really, given that Joseph Badaracco is presently the John Shad Professor of Business Ethics at Harvard Business School.

As he points out, history has often shown us that "just following the rules" can generate at least as great a moral vacuum as completely breaking them would do. In practice, of course, the truly capable manager usually operates somewhere in the *terra incognita* that lies between those two extremes, but nowhere is that unexplored land rockier and more dangerous than when it comes to addressing the ethical problems that litter that landscape. This is a subject all too rarely discussed, so it's in

that territory that this book potentially has something significant to offer.

As the author himself readily admits, this work is more like an extended essay than a proscriptive handbook, and it is best read as such. Use it as a means to catalyze your own thoughts and reflections on the topics it raises, and the book will serve a useful purpose. Come to it expecting a "Ten easy steps to being a better manager" approach, and you'll end up disappointed.

Realism is Paramount

One of the book's main thrusts is that taking a realistic -- in contrast to an idealistic -- world-view still can lead to decision-making that is both morally responsible and extremely effective. The chapter headings themselves -- such as "Don't Kid Yourself," "Buy a Little Time," and "Craft a Compromise" -- do a pretty adequate job of conveying this intent. Whether you are leading quietly or with a megaphone clamped to your lips, this is all sensible stuff.

In the "Don't Kid Yourself" chapter, for example, Badaracco offers four guiding principles to help managers ensure they maintain a realistic view of the world (and themselves), namely:

- You don't know everything.
- You will be surprised.
- Keep an eye on the insiders.
- Trust, but cut the cards.

Again, nothing especially new or innovative here, but this book does remind us that managers -- even CEO superstars like Jobs et al.-- are human beings with the frailties, insecurities, and capacity for making mistakes that we all possess. Moreover, whatever their own unique personal strengths, they still have to manage organizations that are themselves full of people exhibiting every vice and virtue known to man. As Kant succinctly put it, "From the crooked timber of humanity, no straight thing was ever made."

Which leads us to another chapter worth exploring here: "Trust Mixed Motives." At first glance, this seems a little contradictory: Often, we're inclined to *mistrust* people who operate in such a way. Convention has it that great leaders throughout history have always been purely altruistic and demonstrated nothing but total adherence to the noble cause in which they were engaged. This is, of course, nonsense. As Professor Badaracco points out, "At best, these stories provide inspiration and guidance. At worst, they offer greeting card sentimentality in place of realism about why people do what they do. They also tell people with mixed or complicated motives that they may be too selfish, divided or confused to be 'real' leaders." How true.

Nevertheless, let's not dismiss the fact that true leaders *are* different along at least one dimension: They have a strong bias for directed action.

The author makes three key points that, to my mind, provide a good perspective on the relationship between action and motivation.

- First, he says, leaders should have a bias for action, but then he rightly cautions, "... don't get bogged down in the morass of motives," the point being that trying to fully understand all of the psychological drivers involved can lead to substituting endless navel-gazing for making real progress.
- Second, he urges us to take heart: Mixed or complicated motives *don't* disqualify you from being leadership material.
- Third, he assures us that internal conflict is OK and might be telling us something important -- so pay attention!

Without doing a prýcis of the entire book, I find one other point Professor Badaracco makes worthy of mention in this review: "Buy a little time." Again, the popular image of a successful leader promotes the notion that constant, rapid, and emphatic decision-making is mandatory, and that it always results in optimal outcomes. Alas, the reality in modern business is that managers too often commit the cardinal sin of hastening to a quick answer in lieu of finding a way to "right-time" the decision-making process -- to create a breathing space within which further information gathering and investigation can take place in order, ultimately, to arrive at a better decision.

Strengths and Weaknesses

Succeeding chapters address issues such as the crucial role of political capital within a business context, the importance of compromise, how to escalate issues effectively and -- a tricky one, this -- how to bend the rules when, as the British say, "needs must."

All of these areas are explored via a number of well-written case studies that help to get the reader thinking about the complex, ethical issues raised and subsequently explored. The good professor writes eloquently but simply, drawing from a wide range of sources and personal experience. (Where else might you find references ranging from Aristotle to Dave Barry by way of Kierkegaard, all within a few pages of each other?)

In summary, on a scale of five, this book deserves a solid three. Weaknesses? The first half reads better than the second (though it's difficult to say precisely why), and more discussion on the differences between leaders and managers would have been welcome. One caution: There's a strong danger that having (mis)read this book, you'll find new and interesting ways to justify your own weaknesses -- so beware!

Strengths? The case studies are very well presented and drawn from a wide range of businesses, the writing is erudite without being turgid, and overall the book touched upon a number of important issues that all managers would do well to consider.

It's worth repeating that this isn't some punchy, hard-hitting recipe book

intended to help bake a better manager. View it as a launching point for your own self-analyses, and it should serve you well enough. It encourages leaders to be realists, pragmatists, and, above all human beings, our inherent foibles notwithstanding. It urges us to take heart: You don't have to be a clone of Solomon or one of Silicon Valley's crowned princes in order to be an effective leader. Often, just being human is quite enough.

-**John Lambert**
Vice President and General Manager of Developer Solutions
Rational Software

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Book Review

Use-Case Modeling
by Kurt Bittner and Ian Spence

Addison-Wesley, 2003 (available 8/23/02)
ISBN: 0-201-70913-9
Cover Price: US$34.99
384 Pages

In my office are a number of books that have "use case" in their title. All of these books provide a minimal introduction to use-case modeling, presumably based on the misguided assumption that "basic" use-case modeling is simple. Also, each of them tends to have a particular slant on use-case modeling; some introduce the author's own use-case modeling "extensions," whereas others focus on "advanced" use-case modeling techniques. None, however, provides really thorough, solid coverage of use-case modeling.

This book by Bittner and Spence plugs the gap: Not only does it provide an excellent introduction to use-case modeling (acknowledging that even "basic" use-case modeling can be difficult), but it also puts more advanced techniques in context. The authors devote only one chapter (entitled "Here There Be Dragons!") to these techniques, and at that it's the tenth of twelve chapters.

So what's in chapters 1 through 9? Put simply, this is where the authors provide a "basic," balanced perspective on use-case modeling, through chapters rich in their description of relevant artifacts, process, and, above all, experience. By sharing their varied experiences on a wide range of projects, my friends and colleagues, Bittner and Spence, really make this book shine. Their examples draw from a number of different problem domains to illustrate various aspects of use cases in different contexts, ranging from a real-time event monitoring system to the seemingly ubiquitous automated banking system. This variety allows the authors to explore a great deal of conceptual territory.

The first part of the book gets right to the point by introducing the basic concepts we encounter in use-case modeling, such as actors and use cases, together with the essence of the modeling process. Throughout these early chapters, the book deliberately avoids getting bogged down in detail. It also describes the means for placing use-case modeling in a business context, including key artifacts that drive the use-case modeling

effort -- in particular the project Vision, which identifies system stakeholders and defines system features.

We're then treated to a discussion of how to get started with use-case modeling by holding a workshop. The detailed practical guidance includes instructions on how to run such a workshop, packed with anecdotal evidence of what works and what doesn't. Especially helpful is the guidance given for ensuring that the right people participate in shaping the project vision and in the use-case modeling workshop itself. On a number of projects I've worked on, much time was wasted simply because the right people weren't in the meeting. For me, the discussion on workshops is one of the best areas of the book, and I'm really looking forward to running a workshop along the lines the book describes now that I have this knowledge in my armory!

The second part of the book explores some of the details involved in use-case modeling. It includes a discussion of writing and reviewing use-case descriptions and considers all elements of a use-case description in detail: the flows through a use case, preconditions, and post-conditions. Although this part of the book delves into more "in-depth" material, it continues to provide straightforward, pragmatic advice along the way. A major problem I've encountered in other books is that they lack examples of a fully-explored use case; they treat the content very lightly -- in some cases even suggesting that a "complete" use case consists of a dozen or so bullet points and little in the way of alternate and exceptional flows. Bittner and Spence have provided a number of fairly complete examples in the text itself, supplemented by a completely developed use-case description in an Appendix.

The very last part of the book covers more challenging techniques for use-case modeling, such as *include*, *extend* and *generalization* relationships. Again, it continues to provide very pragmatic advice, together with a number of lessons learned while applying these techniques in real situations. For example, I've seen many teams struggle with how to avoid functional decomposition while improving the readability and comprehensibility of use-case descriptions, and the book offers helpful practical advice on this issue. It concludes with a discussion of how to review use cases, with an emphasis on following an orderly process for the review.

I've been waiting for a book such as this for a long time (not only for me, but also for the customers I work with) -- a book that really gets to the essence of use-case modeling, with good, pragmatic advice about what to focus on, as well as what works and what doesn't. This experience-based advice makes the book valuable for advanced practitioners of use-case modeling as well as novices. I've been modeling with use cases for a number of years, and yet I learned something in every chapter.

In the book's Foreword, Ivar Jacobson concludes that "This is the very best book on use cases ever written." Enough said. Kurt and Ian -- thanks for a job well done and for moving this industry forward.

-**Peter Eeles**
Strategic Services Organization

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Integrating Rational Quantify and Rational Purify with the SAS® System

Part 1: Integrating Rational Quantify and Rational Purify into the SAS Development Environment on UNIX

by Claire Cates
Senior Manager
Advanced Performance Research
SAS

SAS is the world's largest privately held software company and the world leader in business-intelligence software and services. We market highly sophisticated software that enables businesses, government agencies, and educational institutions to turn raw data into usable knowledge. The SAS System contains millions of lines of code, most of which are written in C and run on a variety of platforms, from PCs to UNIX workstations to mainframe systems. The base portion is a PL1-like programming language with vertical products built on top. The system was initially developed in the early 1970s and has grown to incorporate new business concepts.

For us, the holy grail is to deliver the SAS System to our customers error-free, knowing that it will run efficiently in their particular environment. We've discovered that the Rational® Purify® and Quantify® products can help move us closer to this ideal by uncovering memory problems and pinpointing performance bottlenecks, and we've embraced the use of these products in our research and development division.

This first article in a two-part series on the SAS implementation of Rational Purify and Quantify describes all the activities involved in integrating the tools into the SAS UNIX development environment, including product

selection, challenges, and resolutions. Part II will focus on the process of migrating this implementation to our Windows NT development environment. Both parts will discuss how SAS made the tools easier for developers and testers to use by taking advantage of published APIs to integrate Purify and Quantify into our nightly build process, debuggers, and runtime environment.

Investigating Quantify

At the time SAS first investigated the use of Quantify, about seven years ago, we were dealing with a company called Pure Software, which offered both Quantify and Purify. (Subsequently, Pure Software merged with Atria to become Pure Atria, which was then acquired by Rational.) At that time we thought we could do without Purify, because the SAS System has an internal memory subsystem that detects many types of memory errors.

When the investigation of profilers began, the development operating system was HPUX, and all developers had HPUX platforms on their desktop, so we were seeking a profiler that would run in this environment. We knew that if the developers could access the product via their desktop, they would be more likely to learn the profiler and, more important, to use it.

In addition to Quantify, we considered various hardware profilers that are useful but often yield non-reproducible results. We wanted one that produced "somewhat" reproducible results. That is why we were interested in Quantify. Whereas most profilers we considered interrupted the system after a fixed amount of time, Quantify counts instruction cycles and measures the time required to execute system functions that cannot be instrumented. Because it counts instruction cycles, and because there's a feature to turn off system level function timings, Quantify results are almost 100 percent reproducible. The product's unique approach minimizes interference due to other processes or a busy network. Many of the areas in which SAS would like to optimize performance are algorithmic rather than I/O bottlenecks; therefore, we did not time system calls in most of our experiments, although we did profile them in some instances so that I/O time could be tracked.

A Quantify feature we discovered made the algorithm analysis much easier: Quantify computes timings not only on a routine as a whole but also on each individual source code statement. None of the other profilers in use at SAS had this feature. Much of the SAS System was written in the early 1970s in PLI and later converted to C. Many algorithms that were optimized for those earlier systems are inefficient on today's operating systems, so detailed analysis of the source code was a must, and Quantify's ability to analyze individual source statements was the product's premier selling point. While I was working with one of our developers at that time, Quantify pointed to a routine that was a bottleneck in the test case. We checked the source code, and the developer walked out of my office after a few minutes, shaking his head. "I thought the bottleneck was in a different routine, much less in that portion of the code," he said, obviously quite impressed with Quantify's

capabilities.

Another important feature in Quantify is its call tree information (which is different from Quantify's Call Graph). This refers to data Quantify produces on what functions call a routine, how often they call it, and what functions the routine calls. Our original profilers had identified areas within the SAS System that needed a performance emphasis, but we did not know why these routines were showing up as bottlenecks. Quantify's analysis of the same test gave us a wealth of additional information on the usage patterns of these routines. Many times we knew that routine *x* was indeed a major bottleneck, but Quantify showed us that routine *y* called routine *x* an excessive number of times. As a consequence, we changed our focus from making routine *x* faster to rewriting routine *y* to make it call *x* fewer times. Learning the usage patterns of routines allows us to resolve many problems throughout our code base that we never would have found with conventional profilers. When viewing the function detail window on routine *x*, we also discovered that some calls to *x* were more expensive than others. Often, routine *z* called routine *x* more often than routine *y* called routine *x*, yet the time spent in routine *x* that was contributed by routine *y* was greater. Next, we investigated individual calls under the debugger to determine the reasons for performance differences. Again, this information led to better algorithm design and therefore better performance. Quantify, unlike any other tool, gave us a wealth of information on how sections of the code were actually executing.

Investigating Purify

During negotiations for the purchase of Quantify, Pure Software told us that Purify would find more memory problems than our internal memory management subsystem. We decided to take up the challenge, thinking that we could prove them wrong. Little did we know that we would end up making Purify an integral part of our development environment.

The internal memory subsystem SAS uses does detect memory overwrites that occur within a few bytes of a memory allocation and also detects many of the Uninitialized Memory Reads (UMRs) in the system. Unfortunately, what the system detects is extremely hard to track down, because the detection occurs only when memory is freed. We decided we had little to lose by testing Purify. To do so, we simply ran the proof-of-concept system that we had used with Quantify, using Purify instead. This version of the system did not interface to the standard memory routines, so we knew the full memory analysis would not be available, but we still felt it was a fair and quick test. During initialization of the SAS System, Purify detected several memory-related problems. Further, Purify pointed us to the *exact* line of code at which the problem occurred and indicated where the memory in question was allocated. We were sold!

Integrating Purify and Quantify into Our Custom Development Environment

Even before we made our purchase decision, we knew that Purify and Quantify could not address some areas of our system; certain internal tasking, memory management, and shared library-loading subsystems were part of our custom solution and therefore unsupported by the products. After talking with the products' technical support people and developers, we felt that we would likely need workarounds. Yet we were reluctant to spend time creating complicated solutions when we were not positive of the results Purify and Quantify would produce for us. Therefore, we chose a temporary solution that would allow the SAS System to proceed through initialization and some minimal functionality. If we could prove the products' usefulness for that much of the system, then we could justify spending the time on workarounds.

Our first task was to build all the shared libraries we needed as one executable, so that the dynamic shared library mechanism would not engage. We ignored our internal memory management system, because it did execute `malloc` calls; it was just that `malloc` calls were made in large blocks, not on the individual allocations. Limiting the `malloc` calls did limit what Purify could report, but it allowed us to determine if Purify would detect any memory errors in the code that our memory subsystem did *not* detect. Finally, we chose to temporarily ignore the tasking issue. This wasn't really a problem for Purify, but it did cause Quantify to produce some strange call trees. Once the proof-of-concept version was built, we did a test run with both products. Quantify pinpointed several "hot spots" in the code, and Purify displayed several memory errors that were not found by our internal memory subsystem. The proof-of-concept version was easy to create and allowed us to determine that both products would be useful -- and that it was worthwhile to invest resources in achieving a more general solution.

Hurdle Number One: SAS Custom Dynamic Shared Library Loader

Once we finalized our purchase decision, we needed to work on a complete "non-kludged" system that worked well with both products. The first major hurdle was to get the products to work with our dynamic shared library loader. The SAS System is composed of hundreds of shared libraries; if the entire system were loaded at one time, it would be huge, so SAS chose to implement demand-loading technology. That means only required modules are loaded into memory on demand, when they are accessed for the first time. These modules can also be unloaded when they are no longer in use. The big problem was, our internal implementation for demand loading is in assembler code, which depends heavily on specific registers, and Purify and Quantify both use many of those same registers. As you can imagine, this did not work well with either product. We tried several ways to avoid instrumentation of the assembler linkage areas, from using `deadcode` and `registercode` directives to finally putting each of the assembler linkage routines into a separate subspace and then using the `-ignore-unknown-subspaces` option on the invocation of the products. As it turned out, the `-ignore-unknown-subspaces` option proved to be the easiest and cleanest way of avoiding the instrumentation.

The lessons we learned in dealing with the shared library issue, specifically

with keeping some of our assembler code from being instrumented, allowed us to work around other problems we confronted in integrating the two systems. We used the deadcode directive, along with putting code in new subspaces, to work around a variety of problems that were caused by Purify and Quantify instrumentation. Unfortunately, using these approaches meant that Purify and Quantify would not check for problems or collect profiling data in these sections of code, so now we use them as a last resort.

Another problem occurred during the dynamic loading of shared libraries. Certain library functions like `ceil` and `tan` were flagged as undefined. This is related to the fact that Purify and Quantify rename many of the standard library routines so that they can supply their own version for better error checking. Given that we have non-standard shared libraries, this renaming causes the routines to not be found when the image is loaded. The workaround for this problem is to export each of these routine names from the main executable when it is linked. Using this approach, when the shared library is loaded, the references resolve to the routines in the main executable, and the routines in the main executable are instrumented.

Hurdle Number Two: SAS Custom C Compiler

Our next hurdle was the use of our own C compiler. SAS is supported on a variety of platforms, but we keep our development environment very restrictive so that we can detect most errors before porting the source code to other platforms. Our compiler generates code for the HPUX development environment, yet it forces many of the common platform problems to be diagnosed up front. This compiler also taught our developers the idiosyncrasies of portable coding; unfortunately, the code generated by this compiler differs somewhat from the standard compilers that Purify and Quantify support, so we experienced problems. The Purify and Quantify developers worked along with our compiler developers to resolve each issue as it arose. Sometimes the solution was to change the instrumentation engine within Purify and Quantify. More often, we made the changes in our compiler and then added them via special compiler options. (See the section on Integrating Purify and Quantify into the Development Build Process.) For instance, the special option tells the compiler not to use registers that Purify and Quantify intend to use. It also triggers different code generation sequences similar to those the standard compilers produce. Specifically, the code generated for a `switch` statement and a `?:` construct had to be changed. Finally, the option also informs the compiler not to insert special epilog and prolog functionality that is normally added to the compiler-generated code.

Hurdle Number Three: SAS Custom Thread Implementation

Next we had to make Purify and Quantify understand our internal thread implementation. At that time we did not use operating system threads; instead, SAS implemented a custom-threading model. The products' tech support team pointed us to a thread interface they supplied on the UNIX System that was included in their documentation. In order to inform the products of our non-standard threading usage, we had to:

- Create and initialize three global variables in the main executable:
  - `unsigned int pure_use_locking = 0;`
  - `int pure_thread_init_protocol = PURE_THREAD_INIT_IMPLICIT;`
  - `int pure_thread_switch_protocol = PURE_THREAD_PROTOCOL_NOTICE_STACK_CHANGE;`

- Add several routines for the products to call:
  - `unsigned int pure_thread_id_size()`
    returns the size of the internal thread handle
  - `void pure_thread_id(id_p)`
    returns a pointer to the internal thread handle
  - `int pure_thread_id_equal(id1_p, id2_p)`
    compares 2 thread handles for equality

Using this information, we were able to easily integrate our thread model with Purify and Quantify. We also used the `-threads` Purify and Quantify option to tell the products that we would potentially need a large number of threads along with the `-thread-stack-change` option that allowed the products to detect our internal task switches. Internally, changes were needed in our thread switching code. The thread switch code was built using `set jump` and `long jump`, which caused some confusion with the products. We changed the code to assembler and simply saved and restored the registers. Given that all registers had to be saved, and Purify and Quantify use many of the registers in the instrumented code, we chose to add the task switch routine to a subspace unknown to the products, thereby preventing Quantify and Purify from instrumenting it.

Hurdle Number Four: SAS Custom Memory Management

Next we tackled the use of our own internal memory subsystem. The SAS memory subsystem is based on pools of memory, a concept that had to be maintained; otherwise a large amount of code would have had to change. The Purify documentation describes a series of routines within the Purify API that support memory pooling, so we added calls to the following routines in the memory management code, allowing Purify to track our memory pools.

```
Purify_set_pool_id(char*mem, int id)-- associate memory "mem" with
pool id "id"
Purify_get_pool_id((char *mem)-- return the pool id associated with
"mem"
Purify_set_user_data(char *mem, void* data)-- sets auxiliary user data
associated with "mem" to "data"
Purify_get_user_data(char *mem)-- returns the auxiliary user data
associated with "mem"
Purify_map_pool( int id, void(*fn)(char(*mem))-- apply function "fn"
to all memory areas in pool "id"
Purify_map_pool_id (( void(*fn)(char(*mem))-- apply function "fn" to
all memory areas in all pools
```

The `Purify_map_pool` routine is used to free all memory associated with a pool when the internal SAS delete pool routine is called.

We knew that we would get better information from Purify if calls to `malloc` and `free` were used instead of our internal memory management calls. It would have been impossible to change all the code in the system to use `malloc` calls because of their pool orientation, so instead we chose to change just the internal allocation and free routines, and we added `#ifdef PURIFY` and `#endif` directives to the memory management code. When the system is built to run with Purify, the symbol `PURIFY` is defined. The memory management routines use `malloc/free` for the allocation routines and add calls to the pool mapping routines so that Purify can track memory on a pool basis.

Hurdle Number Five: The Use of Code Generated by SAS Compiler

The last major hurdle was our use of generated code. As was stated earlier, SAS itself is a programming language. To improve performance, machine code is generated in many instances instead of using the runtime code interpreter. When generated code is created at runtime, the interpreted code jumps to the generated code in order to execute it. Unfortunately, Quantify and Purify expect all code that is executed to be instrumented. SAS generated code is not instrumented. When generated code was encountered, the system crashed. Our first solution was to set the SAS user option so that we would always use the interpreter. This worked well for Purify and was our final solution for that product. Using the interpreter also worked well with Quantify, except when the code being profiled normally executed a large amount of generated code. The interpreter is intended for use only if code generator errors are diagnosed in the field; therefore, it was not written very efficiently. This inefficiency caused the code interpreter to be the major bottleneck in our analysis. Unfortunately, Quantify does not have a mechanism to instrument a section of code that is in memory; therefore, we had to come up with an alternative solution. Simple cases using generated code were run to determine what results (including crashes) Quantify would produce. Our first change was to make the code generator avoid using the registers required by Quantify. After that change, we noticed that the problems *really* occurred when the generated code called routines located in instrumented C code. If the code generator was called and returned back to the interpreter without calling out of the generated code, then the system seemed to work fine. Then we decided to debug the code insertion added by Quantify to determine if there was a way to add the same code insertion into the generated code, and we noticed a series of calls being made by Quantify. One call in particular is always inserted into the code stream after a call to a routine. We changed the code generator to add this call after every call it generated, and the change now works for the majority of our tests and allows Quantify to produce correct results. The code generator added the `#ifdef QUANTIFY` directive around the insertion so that only the "Quantified" SAS System would add this extra call.

Making the System Easier to Use

Once the Purify and Quantify tracks were built and running correctly, our next goal was to make the system easier to use. The typical complaints we received from developers and testers included:

- There was constant instrumentation of the shared libraries.
- Quantify output on one HP hardware system did not match the next developer's output, which was produced on a slightly different HP system.
- Our internal SAS debugger would not work seamlessly with the systems. (Yes, we have our own debugger, too.)

Ensuring Consistent Results on Different Machines

We addressed each problem as it arose, and inconsistent results between different machines was the first problem we encountered. The differing results were caused by the fact that many different varieties of HP hardware were in use throughout the company. When tech support informed us about the `-use-machine` option, we chose one of the many varieties of HPUX machines installed in house and made that value the default. This option was added to the Quantify track variables that are used to build the master executable. All shared libraries and the main SAS executable are accessed from a global area on the network, so all developers now run with the same machine type; once the instrumentation of each shared library was the same for all users, we could set up a global cache for instrumented modules. We set the cache to be on the global network and added the `-cache-dir` option that pointed to this global area for both the Purify and Quantify builds. Finally, a post-processing step was also added to our nightly build process to instrument each shared library after it was built and to place the instrumented image in the cache. This change allows a user to start working in the morning with up-to-date, pre-instrumented images. The user no longer has to watch as each shared library is loaded and instrumented on the first run each day.

Stopping at Breakpoints When Running SAS with Purify

Another problem was that developers were unable to set breakpoints in our debugger when running a Purified or Quantified version of the SAS System. They could run with the debugger and set a breakpoint on `purify_stop_here`, but they could not set a breakpoint in a particular shared library. This problem was caused by the fact that Purify and Quantify munge the shared library name by appending a constant string to the image name that is given to the instrumented shared library. For example, if the shared library name is `sasxfs`, the instrumented shared library name looks something like `sasxfs_pure_q7152_420_B1020`. The images loaded by the system and therefore by our debugger are the instrumented shared libraries. Our debugger did not know about this name aliasing, so we worked with the debugger developers to add a global variable that is built with the SAS System that contains the appended value. When the debugger loads SAS, it now looks for this global variable;

if it finds the variable, then the debugger removes the appended text from all the shared library names that are loaded. The image names are now consistent with the non-instrumented image names, so user breakpoints can be set. This change is added for both Purify and Quantify, and the global variable is surrounded by either a `#ifdef PURIFY` or a `#ifdef QUANTIFY`. We do have to change this prefix value each time we upgrade to a new release of Purify or Quantify.

New SAS Language Statements for Calling Purify and Quantify APIs

Our next set of optimizations was intended for developers, but it is actually used more often by testers. We added new SAS statements to the SAS language that allow the user to call the Quantify and Purify API functions by executing an SAS runtime statement. The code that implements the statement interpretation is enclosed in `#ifdef QUANTIFY` or `#ifdef PURIFY`. The actual statement parsing is portable, so these statements can be added to the baseline tests and just ignored when the test is not run in the appropriate track. The statement syntax is:

```
Options Quantify = "statements"
```
and
```
Options Purify = "statements"
```

Developers are the primary users of the Quantify option statement. Most developers work on one section of code that is independent from other sections of code within the system. These sections of code are called SAS procedures. When a developer wants to look at performance, he does not want to see what the rest of the system is doing; he is only concerned with how his procedure is executing and how the code that his procedure calls is executing. Inserting a set of `Options Quantify` statements meant that Quantify would report only on the performance of the enclosed procedures.

For example, here is a simple set of SAS programming statements:

```
Data a;
   Do I=1 to 10;
      Output;
   End;
Run;

Proc print; run;
```

If the developer for the procedure `Print` wants to quantify his code but does not want the results of the data step included, then he can change his SAS test program to the following:

```
Options quantify = "clear";
Proc print; run;
Options quantify="stop all";
```

The first quantify statement calls the Quantify API routine to clear the current accumulated statistics for the run, and the last Quantify statement stops Quantify from accumulating any more statistics within the run.

Testers use the Purify option statements more often. They add comments to the code so they can better determine which procedure within the test stream is causing the problems, and they use the options to insert more frequent checks for memory leaks.

The Quantify API calls that can be made via the options quantify statement are:

- Quantify_stop_recording_data --called if option "STOP" specified
- Quantify_start_recording_data --called if option "START" specified
- Quantify_clear_data --called if option "CLEAR" specified
- Quantify_save_data --called if option "SAVE" specified
- Quantify_add_annotation --called if option "COMMENT" specified

The Purify API calls that can be made via the options purify statement are:

- Purify_printf -- called if option "COMMENT" specified
- Purify_new_inuse -- called if option "INUSE NEW" specified
- Purify_new_leaks -- called if option "LEAKS NEW" specified
- Purify_all_inuse -- called if option "INUSE ALL" specified
- Purify_all_leaks -- called if option "LEAKS ALL" specified
- Purify_stop_batch -- called if option "STOP" specified
- Purify_start_batch -- called second if option "START" specified
- Purify_clear_messages -- called first if option "START" specified
- Purify_name_thread -- called if option "NAME" specified. (This changed the name of the thread and allowed a user to be able to better identify a particular procedure that was being run.)

Finally, we added a call to purify_printf whenever a new thread is started so that the thread's internal name is printed. A call to purify_new_leaks was also added to the thread termination routine. Adding the calls to purify_printf at the start of every procedure allows testers to see in exactly which procedure memory problems are occurring. In many cases the tests contain hundreds of procedures, and determining exactly which procedure is causing the problem is difficult. Adding the memory leak check to the termination of each procedure also helps to pinpoint the procedures with memory leaks.

Miscellaneous Changes

When our testers began reporting problems found by Purify, the

developers dismissed them. "Oh, that is not a problem," they said. "Purify is detecting a false hit." They would promptly change the status on the defect to NOBUG and add the problem to the global suppression file. This made the problems disappear, not because they were fixed, but because they were suppressed. Previously, we had made a decision to keep the global suppression file, because some problems do reside either in third-party software or in code that cannot be changed, and we wanted these problems suppressed for all users. But when developers began sweeping Purify-detected problems into this suppression file, we decided that, instead of allowing everyone to have write access to it, we would create a master suppression file and gave exclusive write access to one person. Now, this person considers requests to suppress a problem and requires the requester to verify that the problem cannot be fixed. Often, this forces the keeper of that file to prove to the developer/tester that the Purify result is accurate and that there truly is a problem. Unfortunately, it turns out that some bugs *are* in fact false positives, but this is strictly because of the assembler code our compiler produces. We have found only about five false hits, and each one has been added to the master suppression file.

Finally, within the C source some code was added because the symbol `DEBUG` is defined in our baseline builds. The `DEBUG` symbol is not turned on for a released software build but is used internally on the development platform to help detect coding errors. We determined early on that we did not want this symbol defined in either the Purify or the Quantify tracks. Developers do not fix the memory problems Purify finds that are within the `#ifdef DEBUG` sections, but we did not want to add suppressions because they could not be localized to those sections, so problems in other areas within the routine would also be suppressed. In addition, we removed the `#ifdef DEBUG` sections from the Quantify builds because we did not want code that was not being shipped to be included in the performance analysis. We therefore turned off the definition of the `DEBUG` symbol for both the Purify and Quantify tracks.

Integrating Purify and Quantify into the Development Build Process

Purify and Quantify changes were put within the *C* source code via `#ifdef` directives. Also, special compile options are needed for each of the builds, and special runtime options are needed to run SAS with each of these products. Because these options are product specific and we did not want them in our regular builds and execution runs, we chose to place the Quantify and Purify builds into separate tracks. The SAS development environment defines a build track as an area for storing all compiler and linker output. Special compile and link options can be set for a track, along with special execution options. The Purify and Quantify tracks are therefore implemented as two separate build tracks that are distinct from the main debug and optimized tracks. SAS implements its own source management and process management tools, which allows us to make changes to the tools so that special option settings will be transparent to developers. All the developers need to do is to determine which track they want to use -- Purify or Quantify -- and then tell the system by setting an environment variable. Once this variable is set, the

user can build, run, and test the system, using the same instructions that would have been used in a normal track.

During the compile phase, the symbols `PURIFY` or `QUANTIFY` are defined, depending on the track being used. These symbols are added throughout the code to turn on the changes needed for supporting the shared library and tasking support. In the case of Purify, the `PURIFY` symbol also enables the alternate memory routines. When the symbol `QUANTIFY` is defined, code is added to disable the recording of data for certain areas of code. All of this code is controlled by enclosing it in either `#ifdef QUANTIFY` or `#ifdef PURIFY` directive blocks. The track also sets special compiler options that force the compiler to generate a different code sequence for the `switch` statement and the `?:` construct. These are areas in which the code generated by our internal compiler causes problems in the instrumentation engines for both products. Our compiler is forced to generate more traditional assembler code.

During the execution phase, all invocation options that are needed in Purify or Quantify as well as any internal SAS options are set. The user never sees these options, as they are added "under the covers" by the standard SAS toolset used to execute the code.

Finally, the SAS System is built nightly on the development platform. Once the tracks were in place for Purify and Quantify, the builds for the products were added to the nightly build process. This allows developers and testers to easily test the latest version of the code with Purify and Quantify.

A Worthwhile Investment

Integrating both Purify and Quantify with our SAS System was not an easy task, but SAS received help from the products' technical support team and developers along with developers from SAS. The implementation is now transparent to users but gives them the full functionality of Purify and Quantify. The benefits have been substantial.

- During development, Purify has saved untold time that we used to spend hunting down the source of problems. Our other tools could tell us that memory was being overwritten, but we couldn't pinpoint where. Debugging was a huge binary process that could take days; now it takes minutes or hours. Also, Purify finds problems we didn't know we had; it picks up errors that our internal memory system did not, such as Array Bound Reads (ABRs) and Array Bound Writes (ABWs). So we avoid debugging time later on, too. Ultimately, that means we can get our product to customers much faster.
- As they write code, developers use Quantify to test and comparison test various algorithms before making a permanent change. If they see big differences in performance, then they know to choose the more efficient option.
- Now that testers have ready access to Purify for checking new code, we can avoid passing on problems to our customers. Testers run

checks on builds almost nightly to ensure that any new code the developers pushed did not introduce new errors.

- Developers use Quantify to troubleshoot existing implementations; if a customer complains that their SAS application is too slow, then our developers run the job through Quantify to identify code that's consuming excessive resources. They also run it through Purify to check for and correct memory problems. The end result of this work is a faster, more efficient system for our customer, which saves them time and money.
- The integration has allowed us to automate a portion of our testing and our performance analysis. We've created back-end processes that use the text data files Quantify and Purify produce. These back-end tools will be discussed in a future article.

Stay tuned. In Part II of this series, I'll describe the ins and outs of how SAS migrated this UNIX integration to a PC environment.

For more information on the products or services discussed in this article, please click here and follow the instructions provided. Thank you!

Caring for Your Rational ClearCase VOBs

by **Mark Zukowsky**

This article is based on one of the presentations I gave at the Rational User Conference (RUC) in 2001, to help Rational ClearCase users. The material presented here is directed at more elementary Rational ClearCase users; it's intended to help you perform "autopsies" when something goes wrong with a VOB (versioned object base). After some introductory comments about VOBs, I'll look at what can go wrong with them, how to recognize when something's gone wrong, and how to minimize VOB problems through preventive maintenance.

Another presentation I gave during a session about advanced change management has been turned into the Rational Developer Network article, Avoiding Common Problems in Rational ClearCase. The second article is designed for more advanced users.

Introduction to VOBs

The VOB storage directory has numerous subdirectories in it. The four main areas of VOB storage are source pools, cleartext pools, derived object pools, and the database. Things can go wrong in any of these areas.

The VOB database (the `db` subdirectory) is one of the more important parts of the system (along with the source pools, which are in the `s` subdirectory). Taking a closer look at the database, we see that it uses the Raima proprietary format (where Raima is a company that's gone out of business twice since we started using them). There's one database per VOB; on a VOB server, no matter how many VOBs you have, there will be just one database in each VOB storage directory. The database consists of eight major files:

- three data files (`.d01` through `.d03`), which contain the actual data
- four key files (`.k01` through `.k04`), which contain indexes for random access into the data files

- a string file (`.str_file`), which contains configuration records, among other things

There's also a schema, which defines how the database is organized internally.

Possible Problems and Their Causes

Three main types of things can go wrong:

- Corruption in source containers
- VOB accesses not working
- Data loss or corruption in the VOB database

Source containers get corrupted for a variety of reasons, usually network-related. These reasons include: NFS problems that create zeroes in the middle of the files; network problems such as fragmentation or reassembly errors for large NFS packets; or faulty NICs (network interface cards).

VOB accesses can stop working because you ran out of disk space or hit an OS file size limitation (2 GB on some systems) or internal database limitation (particularly in ClearCase 3.0 or schema version 53; more on schema versions later). If you encounter one of these problems, you're in big trouble, because you won't be allowed to write anything else into the VOB.

The reasons for data loss or corruption in the VOB database include:

- Hardware-induced failures (such as disk failures or RAID failures, throwing zeroes in the middle of the files or swapping things around a bit). These are sometimes just single-bit errors. We've seen memory checksum problems where a single bit has been flipped in the middle of the data file.
- "Pilot error." For example, if someone attempts to clone a VOB by copying it into the same region, that can cause problems. We've also had people try to remove individual database files to save space. Having a remote database storage location can also be an issue, but it's less so now that we support filers (discussed later).
- Software-induced failures, from either the operating system or ClearCase (in Raima). The last Raima problem was reported four years ago; however, there was an issue last year with multiple derived object pools on HP systems, where we could actually go in and corrupt a database - not corrupt the contents, but mess up the records a bit so that certain information couldn't be referenced. We were able to provide a fix for that.

Detecting Problems

Now let's take a look at how you can recognize when one of the above types of problems has occurred. Table 1 lists the sections that follow and the possible problem areas that might be uncovered as described within them.

Table 1: Sections on detection mapped to problem areas

Section on detection	Possible problem area(s)
Detecting Data Loss or Corruption	VOB accesses not workingData loss/corruption in database
Detecting When a VOB Is Near a Limit	VOB accesses not working
Detecting Source Container Integrity Problems	Corruption in source containers Data loss/corruption in database
Detecting Problems with checkvob	Corruption in source containers

Detecting Data Loss or Corruption

Symptoms of having a corrupt VOB database include the following:

- You're unable to access the VOB or VOB objects. (`cleartool` commands fail, reporting an error like a database ID not found.)
- Either `scrubber` or `vob_scrubber` fails.
- You can't lock the VOB (which in general means you can't do any write transactions to the database).
- You can't replicate (or import replica packets). This indicates possible database corruption, but it might also just indicate divergence, depending on the error logs.
- Reformatting the VOB fails. In this case, the database is almost certainly corrupt.

The only two processes that talk to the VOB database are `db_server` and `vobrpc_server`. In their ClearCase log files, you'll see messages like these in the event of data loss or corruption:

- `Unable to open VOB database` - This isn't critical. It usually means you've tried to move or copy the VOB without maintaining the proper permissions on a subset of files in the VOB storage directory tree).
- `db_VISTA error` *nnn*- You'll see error numbers like `-922`, `-909`, and `-6`. Note that `db_VISTA` is essentially synonymous with Raima; anything that's a `db_VISTA` error is a Raima problem, although not necessarily a corruption. Raima could be having problems with the system, as in not being able to see it, read it, or write to it. This message can also mean that the API being used in ClearCase to

interact with Raima is returning an error code.

- `Internal error in VOB database`, `Unexpected error in VOB database`, or `Something not found in VOB database` (basically, "I don't know what you're looking for, but it's not there") - If you see one of these not-so-useful messages, please call Rational Technical Support right away; don't wait a few months or ignore it altogether.

Detecting When a VOB Is Near a Limit

A VOB can stop working if it's near a limit. (I talk about this in more detail in the article *Avoiding Common Problems in Rational ClearCase*. To help you detect how full a VOB database is, two utilities are available from Technical Support: `countdb` analyzes the data (`.d01-.d03`) files, and `string_report` analyzes the string file.

If you see messages in ClearCase log files indicating `db_VISTA` error `-909` or (during a `clearmake`) `2`, that means you're approaching one of the VOB file's limits.

Detecting Source Container Integrity Problems

Missing or unreferenced source containers will be detected by `checkvob`. If you use VOB snapshots to back up your VOB, you'll need to run `checkvob` after restoring the backup, to make sure the database and source pools are in sync.

The problem of corrupted source containers is usually detected from user-level errors; specifically, `cleartool checkin` or `checkout` will fail. If you find you have a bad container, you can copy the equivalent container from another replica in the VOB family (if you have one), and then run `checkvob` to make sure everything's healthy.

In addition, we ship a utility called `ck_all_tfd_for_nulls.pl` in the `etc/utils` subdirectory that enables you to examine text file delta containers in a cursory way. This script will look for a zero byte in the middle of every text file delta container, which would indicate the presence of binary data in the middle of the file (meaning the file is bad). This utility won't fix anything for you - we don't have any good way of fixing containers - but it will at least give you an idea of whether a container is healthy. If it's not, you'll have to fix it manually, by either finding the container and backing it up or copying it from another replica.

Detecting Problems with checkvob

I've already mentioned that `checkvob` will detect missing or unreferenced source containers. It will also detect VOB problems like inconsistencies between the VOB database and storage pools; if the VOB database says there has to be five versions of the file, the source container better have five versions as well.

Fortunately, checkvob will fix problems whenever possible. For example, it will fix hyperlinks pointing to nonexistent objects, so if you remove an admin VOB, it will fix that (assuming the VOB is unlocked). It will also detect and fix problems with global types stored in admin VOBs.

Since checkvob isn't run by default in ClearCase, you should run it if you're restoring a VOB from backup, and you must run it if you're using VOB snapshots to back up your VOB or if you copy the database separately from the source containers during your backup. You can also run checkvob regularly to look for inconsistencies; once a week seems to be a reasonable time frame.

Minimizing the Impact of VOB Problems

Now we'll explore how you can minimize the impact of any problems you're noticing (although not necessarily fix them) and how you can prevent them by running various utilities to help keep things working right. Table 2 shows how the sections that follow are organized and the related problem areas for each.

Table 2: Sections on minimizing impact mapped to problem areas

Section on minimizing impact	Related problem area(s)
Minimizing Exposure to Data Loss • Making Backups • Checking for Corruption • Scrubbing	By subsection: • Corruption in source containers; data loss/corruption in database • Data loss/corruption in database • VOB accesses not working
Minimizing Problems with VOBs Approaching a Limit • Upgrading to Large VOB Support" • Working Around a Full Database • Accelerating Reformatting • Testing Reformatting	VOB accesses not working

Minimizing Exposure to Data Loss

The two main ways to minimize your exposure to data loss are to make backups and to maintain VOBs by periodically running various checks,

such as the following:

- Checking for corruption, primarily by running `dbcheck` regularly. (This is the most important maintenance you can do.)
- Scrubbing, to free up disk space in the case of containers (and also to remove minor events for deleted objects that are no longer present in the VOB database).
- Monitoring the log files and any problems that users report.
- Running `countdb` and `string_report` to see if you're approaching a limit (in either the OS file size or the number of records in a file).
- Monitoring disk space usage.

These techniques won't necessarily prevent things from going bad, but they'll help you find problems as quickly as possible.

I'll first discuss backups and then elaborate on some of the more useful maintenance techniques.

Making Backups

The most important thing about backups is to actually do them. There are customers who don't think they need backups, but they do. Next in importance is to do the backups correctly. At an absolute minimum, you should back up the following: any files in the main directory (*vob-storage*)

- all of the source containers (*vob-storage*`/s`)
- the entire database subdirectory (*vob-storage*`/db`)

There are a lot of different methods for backing up VOBs. Here are some of them along with their advantages and disadvantages:

- **Rational ClearCase MultiSite** - This is the most cost-effective method (you knew I'd say that!). You can use MultiSite one-way from your main VOB to a backup replica, which has the advantage that you never have to lock the VOB. In addition, everything is handled appropriately by the syncing; your backups are as up to date as your last sync. On the other hand, restoring from backup involves recreating the replica, which has the disadvantage that views referencing the old VOB can't access those references in the new VOB. In a moment we'll look at a utility that will help with this, actually switching everything around for you. One other slight disadvantage to using MultiSite is that not everything gets replicated, so things like nonversioned derived objects and triggers wouldn't be backed up.
- **Mirroring** - The advantage of this method is that VOB lock time is minimized. However, during the time the mirror is broken and you're backing up from it, you've got reduced redundancy on the database. There's also the disadvantage of disk cost, but that's

minimal these days.

- **VOB snapshots** - On the plus side, the VOB is locked for a minimal amount of time if you use `vob_snapshot` for backup. During a snapshot, we lock the VOB, copy the database files from the `db` subdirectory, unlock the VOB, and copy the source pools from the `s` subdirectory; we can then back up the database files and source pools that were copied. Since the VOB is unlocked, the source pools can change on you, which is why you need to run `checkvob` if you do restore from that backup; `checkvob` will make sure the database and source pools are in sync.
- **Filers** - Support for this method is new this year. A filer is a network-attached storage device, and the VOB storage directory itself would be on it. I don't know much about the procedure, but apparently you can create snapshots of any file on the filer and back up from that; the database should be locked when that snapshot is made. The possibility of inconsistent backup is small but, on the down side, there's the cost of purchasing the filers.
- **Your choice of copy programs** - This can be, for example, `cpio` on UNIX or Backup Exec on Windows NT. Note that the VOB has to be locked when you're copying the database file. Also, the utility you use must be able to back up open file handles and preserve file permissions. The former is more of a problem on Windows NT; I believe that by default Backup Exec won't back up open file handles but rather will require you to go into Control Panel and set it to do that. Even though you're not writing to the VOB, the VOB files are still open.

As mentioned above, if you use ClearCase MultiSite and you then need to recreate the replica from your backup, any view that points to the old replica won't be able to access the new replica. In this case, `cleartool recoverview` won't help you. However, we started shipping a utility in ClearCase 4.0, called `view_sr` (where `sr` stands for "switch replica"), that will go through the entire view database and switch every reference from the old replica to point to the new replica. Any checkout that happens to make it to the backup replica before you restore from the backup will be preserved; it will still exist in the view. Any checkout that hasn't made it over (that is, you did a checkout but you never had a chance to sync) won't be known in the view after this utility is run, but it will become view-private and will eclipse checked-in versions. All other view-private files will be preserved. You won't lose anything, either; anything `view_sr` can't figure out what to do with will go into the lost-and-found areas.

Some additional notes on `view_sr`:

- Under no circumstances should you use the old replica after running `view_sr`. That's equivalent to cloning a VOB by copying it into the same region.
- You can use `view_sr` in two cases. Let's say replica A is your production VOB and replica B is your backup VOB. When replica A is

lost, you can use view_sr in one of two ways to get up and running again. The first method is to move replica B to the original server, run view_sr, and start using replica B as your production VOB; you can then use mkreplica to create a new backup replica C. The second, simpler way is to use mkreplica at replica B to create a new replica, A2, to replace the original replica; you would then run view_sr against replica A2 to use A2 as the production VOB.

- You need to use documented replica recover procedures, which would involve running restorereplica.
- The alternative to view_sr is to replace all the views on the system.

There's a new RPC that the view server needs to respond to that only exists in ClearCase 4.0 and later, so view_sr won't work if your view is stored on a pre-4.0 machine. If you have an earlier version of ClearCase running on the view server, view_sr can't do anything for you, so you'll need to replace the view.

Checking for Corruption

If you think something's wrong in the VOB database itself, not necessarily in the containers, you can use dbcheck, or perhaps reformatvob. Although it's the single most important maintenance you can do, running dbcheck will detect only about 80% of the corruptions that can occur. The reformatvob utility is much slower but will detect almost all of the remaining possible corruptions (an additional 17% of the total possible). During normal ClearCase use, complaints from users about various cleartool commands will detect any other corruptions in the database (that is, the remaining 3%).

We've shipped dbcheck in every version of ClearCase, in etc/utils. It does a structural integrity check on the VOB database files, but only on the three data files (.d01-.d03) and four key files (.k01-.k04); it doesn't do anything with the string file. dbcheck is concerned only with an individual record and a database. For example, if you have five versions of an element, there's one element record and five version records in the database; dbcheck is concerned only that each of the version records is findable, and not whether there are five of them or whether they all belong to the same element. On the other hand, reformatvob cares more about the interactions between the records (which accounts for the difference in what types of corruption these two tools will detect).

It can take several hours to run dbcheck on large databases, and the VOB must be locked while you're running it (otherwise you'll get false error conditions - pages and pages of output, probably none of it valid). If any true errors surface, please contact Technical Support; we treat these problems seriously, and we'll let you know if we can fix things for you.

To avoid downtime spent running dbcheck on a production database, you can run it on a backup copy of the VOB database. You can either run it on

a recent backup of the VOB or lock the VOB, copy the database files to a temporary area, unlock the VOB, and run dbcheck on the copy you made in the temporary area. You don't need the VOB to be registered or tagged; dbcheck is just running on the flat files in the database. You do, however, need read-write access to the database files. (This is a Raima quirk, where everything Raima does has to have write access, even though dbcheck won't actually modify the database.) You also need to be in the directory where the database files reside; if you've copied them to a temporary location, cd to that location and then run dbcheck. To enable the process to run faster, you should run dbcheck local to the machine where the database resides.

The syntax for running dbcheck is illustrated in this example:

```
dbcheck -a -k -p8192 vob_db
```

- The -a and -k options combine to tell dbcheck the maximum amount of error checking it can possibly do. It will check all the data files and key files as well as the internal delete chains, which store unused space in the data files. It will also make sure all the index files are sorted properly (and the like).
- The -p option tells dbcheck how many pages (4096 bytes) of memory to allocate to the process. Note that there's no space between the p and the number following it; dbcheck is picky about this. The maximum number is 32766, and specifying larger numbers will generally speed up the process considerably, assuming there's enough memory on the machine. For the maximum of 32766, you'd need about 134 MB of RAM to run the process. If you have a relatively small database - say, under 100 MB total - increasing the number of pages won't help you; in fact, it will slow things down slightly; on a medium-sized database, the slowdown will be about 16 to 19 minutes. We've found 8192 pages to be an optimal size for small to medium-sized databases (but we haven't played around much with testing this). On a large database, increasing the number of pages can speed up the process by about 35%-40%.

Finally, you should make sure that when you run dbcheck it's actually doing something. Occasionally the parameters get screwed up - for example, if you run with space between the p and the number following it - so you should examine the output of dbcheck to confirm that it's running correctly. The output should say Processing data file (or key file) for each of the seven files. A clean dbcheck that's gone through all the files successfully will end with the following line:

```
0 errors were encountered in 0 records/nodes
```

A problem will cause output like the following:

```
Problems at node 18:
    * key field CONTAINER_DBID(71) error:
```

```
    slot 15's record-dba=[0:1731] has invalid record-id and/or
inconsistent dba
```

If dbcheck does reveal problems with your database, you can restore it from backup or recreate the replica. Again, we encourage you to report the problem to Technical Support. We'll ask you to send the dbcheck output and possibly also a copy of the database, depending on how bad the problem is. If we request a copy of the database, we want only the db subdirectory and not any containers or source code; that will give us access to host names, user names, and comments, which is all we're interested in. If you see only one error in dbcheck and most things seem to be working OK, we suggest you lock the VOB and send us a copy; you can then continue working in the VOB in any place that doesn't appear to be problematic. Rational Engineering will examine the database and, if possible, we'll send you a tool specific to your database that will fix it. However, note that in general, unless it's a known defect that we've seen before or an easily fixed corruption such as a single-bit problem, recovering from a backup or recreating the replica will usually be faster than going through Engineering.

Scrubbing

Scrubbing on a regular basis will save on disk space and prevent encounters with internal database limitations. It removes unnecessary data from the database (old configuration records, events, and oplogs), from the derived object pools, and from the cleartext pools (cleaning things up that haven't been used for a while).

The two processes you can use to accomplish this are scrubber, which runs daily by default and cleans up the configuration records and the pools, and vob_scrubber, which runs weekly by default and scrubs the database events and oplogs.

Specifically, scrubber does the following:

- It removes cleartext containers that haven't been accessed for some time. You can modify the various parameters; for example, the age parameters enable you to save cleartext for a longer amount of time, if you have enough disk space. But in general, we'll generate cleartext containers as we need them.
- It removes from the database files any configuration records that aren't being referenced by derived objects. Internally that space will be marked as available for use. Note, however, that no matter what you remove, the database files will never shrink. The only way to shrink a database is to run reformatvob.

vob_scrubber cleans up the events in the database, removing minor events based on how old they are. (There's a list of all minor events in the events_ccase reference page.) It also removes old oplogs based on their age. Oplogs can take up a lot of database space, and the default is to keep them around forever. (This is discussed in more detail in *Avoiding*

Common Problems in Rational ClearCase.) If you sync successfully on a regular basis, consider reducing the number of stored oplogs to only those six months old or less. You don't need oplogs in order to create new replicas with `mkreplica`; `mkreplica` will essentially take a snapshot of the current database.

Minimizing Problems with VOBs Approaching a Limit

As mentioned earlier, it's a good idea to run `countdb` and `string_report` to see if you're running into a limit (in either the OS file size or the number of records in a file). Here we'll look at how to reduce the likelihood of that happening by installing the support necessary for large VOBs. I'll also discuss how to work around the problem if you do end up having a full database, and how to speed up VOB reformatting, which can take a prohibitively long time with large databases.

Upgrading to Large VOB Support

Support for large VOBs is currently an installation option in ClearCase version 4.0 and later on Solaris, HP, and Windows NT systems. (It's under investigation for other platforms.) This option allows database files to grow past 2 GB, which is a limitation of the operating system calls used in earlier versions. It also allows more records to be stored in each database file: 2^{56} instead of just 2^{24} (about 16 million) records.

A VOB database uses schema 54 for large VOB support and schema 53 otherwise. During installation, you can (in response to a prompt) specify that you want to install schema 54 for large VOB support. The command

`cleartool describe vob:`*`vob-tag`*

will tell you which schema you're using.

On any one VOB server machine, every VOB has to be at the same schema level in order for you to use it. So if you upgrade to schema 54, you have to reformat each of the VOBs individually.

In addition, all replicas in a family should make the transition to schema 54 at the same time. If one replica goes over a limit - either the 2 GB file size or the 16 million record limit - then every other replica that needs to import that packet must also be able to exceed these limits. Things like derived objects take up a lot of room in the string file, and many people need to upgrade to schema 54 because of all the configuration records. Since derived objects don't replicate, the string file at one site may be 2 GB while the string file at another site that doesn't do any builds may be only 100K. If you want to upgrade the 2 GB one to schema 54, you can leave the other one at schema 53, and syncing will continue to work.

Note that schema level does not equal feature level; you can mix and match. You can have either schema 53 or schema 54 at feature level 1 or 2.

When deciding whether to upgrade to large VOB support, keep in mind

that it will result in quite a bit of downtime. As already mentioned, you'll need to reformat all the VOBs on the server. Each one is accessible to your clients as soon as you reformat it, but if you have, say, 50 VOBs, it could take a lot of time before they're all accessible. Some people create a secondary server that uses schema 54 and then move the VOBs over to it one at a time and do the reformatting there; this enables all VOBs except one to be accessed at any given time.

The same database will be about 35% larger under schema 54 than schema 53, and it will take more time to seek across the disk. Even though schema 54 allows the files to grow as large as you want, enabling you to work past the usual limits, you should still be monitoring the string file (using `string_report`) and the `countdb` output to make sure things are being cleaned up properly.

Note that the 35% size increase is an estimate for the average VOB. If you haven't reformatted yet for schema 54 and you'd like a closer estimate of what the size increase will be for one of your VOBs, contact Technical Support. We have a tool called `vob_size` that will run on a schema 53 database and estimate how big it will be when reformatted it to schema 54.

Working Around a Full Database

If you have a full database file and haven't upgraded to schema 54, doing that upgrade for large VOB support (if it's available on the platform you're using) is clearly one way to work around the problem. Another way is to split the VOB using `cleartool relocate`, although this won't work if you're using UCM. The reason for this restriction is immutable baselines: if an element has ever been in a baseline, it can never be moved to another place; the baseline needs to know where to look for it. So a UCM element really can't be relocated.

If you have a full database file with a lot of oplogs in it, you can run `vob_scrubber` with more aggressive oplog parameters. If the full database has a lot of labels in it, you need to remove some of them; if it has a lot of other stuff in it, you can contact Technical Support for recommendations.

In the case of a full string file, you should remove derived objects and run `scrubber` to clean up unreferenced configuration records. This is covered in more depth in *Avoiding Common Problems in Rational ClearCase*.

Accelerating Reformatting

As mentioned earlier, `dbcheck` catches the majority of corruptions but won't detect all of them; `reformatvob` will catch more, but it's slow. For large databases, `reformatvob` can take nine or more hours, and the VOB is inaccessible while you're doing it. Under those conditions it wouldn't be practical for you run `reformatvob` as a periodic check to determine if the database healthy. There is, however, an environment variable (named `CCASE_LOADER_NEW_CACHE_SIZE`) that you can set to speed up part of the `reformatvob` operation. Its default value is `4096`, and (similar to `dbcheck`)

you can increase it to 32766. This will speed up only the load (not the dump phase) by a factor of about 2, which will cut down the reformat phase from about nine hours to roughly five and a half.

Note that on UNIX, this environment variable has to be set in the atria_start script (the script that kicks off the actual load and dump processes), so that any child processes the ALBD server initiates will have it set. On Windows NT, you need to set this variable in the system environment variable area and then restart ClearCase.

Testing Reformatting

To close, I'll describe a procedure that will allow you to carry out the steps reformatvob would perform, but without actually running reformatvob. You can do this as a test to make sure the database is healthy before doing a real upgrade. This will also enable you to determine approximately how much time reformatvob is going to take.

You'll need to run this procedure as root. Also, you'll need enough disk space to dump and load the database - about three times the current size of the VOB database (for the copy of the current database, the dump files, and the copy of the new database).

1. Get a copy of the VOB database in either of these ways:
   - Lock the VOB, copy the contents of the db subdirectory to a temporary location (let's assume /tmp) and unlock the VOB.
   - Alternatively, if you have a backup copy of the VOB, simply copy that backup into the temporary location.

   Note that you only need a copy of the database files; the VOB doesn't need to be tagged or registered.
2. Using cd, change directory to /tmp.
3. Within /tmp, create a directory - named dumpdir, for example - in which to perform the database dump.
4. Change directory to /tmp/dumpdir and run the command

   ```
   /usr/atria/etc/dumpers/db_dumper.53 ..
   ```

   where:
   - .53 denotes the schema version and so should be replaced with the schema version of the existing database if it's not 53. If you've installed support for large VOBs, you'll use db_dumper.54. If you happen to be running V2, my condolences, but you can use db_dumper.38 as well.
   - On Windows NT, these utilities will instead be in *atria-home*/bin/dumpers. ***

   This command will print information as it dumps the reformatted

database. The output you're concerned with is the phrase `Dumper done`, reported at the end of the process to indicate that the dump phase was successful. If you don't see the `Dumper done` output, please contact Technical Support, letting them know of any database errors that were reported during the dump. In general, if the dump phase fails, you'll need a copy of the database and you'll run the dumper in the debugger to determine what problems exist.

Assuming the dump phase worked, it will create three ASCII files in `/tmp/dumpdir`. Next comes the load phase.

5. Optionally, set the `CCASE_LOADER_NEW_CACHE_SIZE` environment variable, as described in the previous section. You can do this from the command line now, because you're going to start the load phase directly rather than use the ALBD server to kick off the process. If you'd like to see how much time setting the environment variable will save you, you can run the loader once without the variable set and then again after setting it.
6. To run the loader, create a new directory - say, `newdb` - within `/tmp/dumpdir` as the location for the new VOB database.
7. From within the `/tmp/dumpdir` directory, run the command

   ```
   /usr/atria/etc/db_loader newdb
   ```

   This will take those three ASCII files, read from them, run the loader, and create a new set of VOB database files. The output of interest is `Loader done`; if it doesn't appear (or if you encounter any other problems during this procedure), please contact Technical Support.

If this procedure succeeds, `reformatvob` will work on the live VOB; if something fails here, `reformatvob` will fail in the same manner.

Once you're done, you can delete the copy of the database you started with, the temporary ASCII files, and the new copy of the database that was created.

Summary

Things can and will go wrong with Rational ClearCase VOBs. For a variety of reasons, you could have corruption in source containers, VOB accesses not working, or data loss or corruption in a VOB database. I've discussed how to recognize when one of these types of problems has occurred and how to minimize the impact. Please keep in mind that Rational Technical Support will try to help you as much as possible.

References and Other Resources

- Avoiding Common Problems in Rational ClearCase by Mark Zukowsky

- ClearCase VOB Database Troubleshooting by Carem Bennett

***NOTE:** This article was originally published on Rational Developer Network, the learning and support channel for the Rational customer community. If you are a Rational customer and have not already registered for your free membership, please go to www.rational.net.

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Avoiding Common Problems in Rational ClearCase

by **Mark Zukowsky**

As a member of Rational's Customer Advocacy Group (CAG), which deals with the calls that Rational Technical Support can't handle, I've heard about certain problems with Rational ClearCase over and over again from a number of different users. In this article, based on a presentation I gave at the Rational User Conference (RUC) in 2001, I'll describe some of the most common problems I hear about. I'll analyze each problem, describe the sort of data we collect in order to fix the problem, and explain how you can avoid the problem in the first place.

[Editor's Note: We've published another presentation made by Mark at RUC 2001 as an article on Rational Developer Network. Caring for Your Rational ClearCase VOBs is intended for beginning Rational ClearCase users.]

Problems Unlocking a Client VOB

You can use metadata in multiple client VOBs (versioned object bases) at the same time via hyperlinks to and from the admin VOB. Time and again, customers run into the following problem related to the admin VOB: When they try to unlock a client VOB, they get the error messages "Trouble opening VOB database," "Unable to search for process guards," and "Unable to unlock versioned object base."

To collect data about the problem, we can run `cleartool describe` on the client VOB. Listing 1 shows the results of one such query. As you'll see at the bottom, there are two errors, both returning the pathname of an admin VOB.

```
[msz_cag] zukowsky@grouse> cleartool describe vob:/var/tmp/msz_client
versioned object base "/var/tmp/msz_client" (locked)
 created 18-Apr-01.16:00:28 by Mark Zukowsky (zukowsky.user@grouse)
 VOB family feature level: 2
 VOB storage host:pathname "grouse:/var/tmp/msz_client.vbs"
 VOB storage global pathname "/net/grouse/var/tmp/msz_client.vbs"
 database schema version: 54
 VOB ownership:
  owner atria.com/zukowsky
  group atria.com/user
```

```
 Attributes:
  FeatureLevel=2
cleartool: Error: Error from VOB database: "/var/tmp/msz_admin"
cleartool: Error: Trouble opening VOB database: "/var/tmp/msz_admin"
```

Listing 1: Results of running cleartool describe on the client VOB

In this case, we ran `cleartool lsvob` on the missing admin VOB and found no matching entries.

This told us that what happened is that the client VOB was locked and then the admin VOB was removed, resulting in a situation where the client VOB couldn't be unlocked due to a hyperlink pointing to the nonexistent admin VOB. Running `checkvob` won't work in a situation like this because the client VOB is locked. This situation can also occur if you have to restore an entire set of VOBs from backup, and you decide you no longer want the admin VOB and just don't restore it.

At first we wrote a tool to solve this problem, a tool that would unlock a VOB for you forcibly. With the introduction of UCM came two environment variables that you can set to prevent client VOBs from going to the hyperlink to the admin VOB. Here they are, along with the values they should be set to:

- `CLEARCASE_PROCFLAGS = no_abort_op`
- `CG_PROCFLAGS = no_process`

If you set these environment variables, you'll be able to unlock a VOB without errors, and then you can run `checkvob` to clean up the dangling hyperlink to the admin VOB that's no longer there.

To avoid this problem in the first place, make sure when you're moving an admin VOB that the client VOBs are unlocked. If you're restoring completely from backup, be sure the admin VOB is restored as well.

Problems Relocating a Version

When running `cleartool relocate`, customers sometimes see the error messages illustrated in Listing 2.

```
#cleartool relocate-force-update ./src/server ./src/common ../callcopy
. . .
  updated version "/main/Bcallistox/0"
cleartool: Error. INTERNAL ERROR detected and logged in
"/var/adm/atria/log/error_log".
cleartool: Error: Unable to duplicate version dbid:78438.
cleartool: Error: Unable to duplicate version dbid:78438.
cleartool: Error: Unable to duplicate versions for branch dbid:41406.
cleartool: Error: Unable to duplicate versions for branch dbid:32769.
cleartool: Error: Unable to duplicate object "server/ebrt/readme.txt"
```

Listing 2: Symptoms of a problem with cleartool relocate

To troubleshoot this problem the first time a customer brought it to us, we

asked for `cleartool dump` and `cleartool describe` output for each database ID listed in the `cleartool relocate` output. This didn't tell us anything, so we requested a copy of the VOB database from the source VOB so that we could try to reproduce the problem in house. But *that* didn't work because we had problems with hyperlinks, so we requested a copy of the customer's VOB database from the admin VOB to alleviate those issues.

Once we had the copy of the VOB database and the admin VOB in house, we did reproduce the problem with the equivalent `cleartool relocate` command. We ran everything in the debugger to find the root cause of the problem. We then reproduced the test case external to the customer environment and figured out exactly what was causing the problem.

It turned out that the version that couldn't be relocated was on a branch off of a version that had been removed. Removing data for the latter version also removed essential data for the former. And the internal error was due to referencing a container incorrectly.

So we raised a defect against `cleartool relocate`, and it got fixed in ClearCase 4.2. For the customer, we created a utility to fix the container references internally, and that allowed the relocate operation to work. There's nothing you can do ahead of time to avoid this problem, but if you do see it, you can contact Technical Support. Once the patch is out, you can use that as well.

Problems with Full Database Files

ClearCase users quite often run into problems with full database files. This happens in schema 53 databases when you hit the limits on the size of individual database files and on the number of records you can have in each individual database file. There are two database files that tend to fill up - `vob_db.d01` and `vob_db.str_file`. We'll look at examples of each here and discuss how to deal with the problem. (It's very rare for files other than these two and `vista.tjf`, which I'll briefly mention at the end of this section, to fill up.)

Listing 3 shows an excerpt from a customer's database server log illustrating the kinds of error messages you might encounter if your `vob_db.d01` file fills up. "File record limit exceeded" means we've put the maximum number of records we can into that file, which happens to be 224 (about 16 million).

```
3/15/01 09:51:57 AM db_server(3577): Ok: *** db_VISTA
   database error -909 - file record limit exceeded
03/15/01 09:51:57 AM db_server(3577): Error: DBMS error
   in "../db_oplog.c" line 118
03/15/01 09:51:57 AM db_server(3577): Error: DBMS error
   in /vobstore/equinox1/equinox_ne_loadbuild.vbs.db.
3/15/01 09:51:57 AM db_server(3577): Error: db_VISTA
   error -909 (errno == "Resource temporarily
   unavailable")
```

Listing 3: Error messages in the database server log caused by a full vob_db.d01 file

To find out what's going on here, we can use a tool called `countdb` that's

included in the etc/utils subdirectory in ClearCase 4.1 and later. (If you have an earlier version of ClearCase, contact Technical Support for help.) It tells us how many there are of each individual record type in the database list. It also gives the sum and tells us how close we are to filling up the database with the 16 million records.

Listing 4 is an excerpt from countdb output showing the information it provided on the data file vob_db.d01. The total number of records in use is 16 million plus, the maximum number of records possible. Of this total, approximately 6 million are labels attached to various versions in the database and 6 million are oplogs in the database.

```
*********************************************************
Data file name : vob_db.d01
*********************************************************
Total records in use     :     16777212
Maximum records possible :     16777215
% of maximum records used:       100.00%

VERSION_LABEL_LINK               :  6289673
HLINK_TYPE                       :       10
HARROW                           :    19465

EPOCH_TABLE_ENTRY                :        3
EXPORT_TABLE_ENTRY               :     6088
OPLOG_ENTRY                      :  6688217
```

Listing 4: Excerpt from countdb output

The .d01 file usually fills up due to high numbers of VERSION_LABEL_LINK and OPLOG_ENTRY records, as well as DOT_DOT/NAMESPACE_DIR_VERSION_ENTRY records. If you encounter the problem of full database files and get large numbers for any of these three types of records when you run countdb, we recommend that you take action to reduce the number of records.

- Each one of the VERSION_LABEL_LINK records is an instance of a label attached to a version of an element. The only way to clean these up is to actually remove the label type or the individual labels attached to the versions.
- DOT_DOT/NAMESPACE_DIR_VERSION_ENTRY records are created when you check out a directory, make an element in the directory, and then check in the directory. Every entry in each version of the directory causes one of these records, so if you have five versions of the directory with five files in that directory, that's 25 of these records. The way to add multiple files to a directory version without causing these records to proliferate like that is to check out the directory, make elements for all of the files you want to add, and then check the directory back in. To reduce the number of records of this kind, you can remove older versions of the directories that you don't need anymore.
- Each oplog causes an OPLOG_ENTRY record to be placed in the database. Unfortunately, the default is never to scrub oplogs, so if you've been syncing using MultiSite on a database for three years, you have three years' worth of oplogs in there, way more than you generally need. To

clean this up, you can modify the vob_scrubber_params file and then run the VOB scrubber, and it will delete oplogs that are older than the number of days you specify. Don't scrub the oplogs too aggressively, though. If you're syncing once a week you need at least 7 days' worth of oplogs; to be on the safe side, you should make it even more than that - maybe 60 days' worth.

To avoid the problem of full .d01 files, you can upgrade to schema 54, which alleviates the limit of 16 million records per database file. (But note that that's not an excuse to let your database grow to mammoth proportions: you should still be monitoring the database for performance, disk space, and the like.) You can run countdb to monitor the file, and if you see a lot of VERSION_LABEL_LINK, OPLOG_ENTRY, or DOT_DOT/NAMESPACE_DIR_VERSION_ENTRY records, you can clean them up as detailed above.

The other file in the database subdirectory that tends to fill up is the vob_db.str_file file, which was implemented in ClearCase 3 to store "blob" information strings, configuration records, and so on. Schema 53 combined with operating system considerations limits the size of this file to 2 GB. Listing 5 shows an excerpt from a customer's database server log during a clearmake operation illustrating the kinds of error messages you might encounter if this database file fills up.

```
07/20/99 13:24:26 db_server(15545): Error: DBMS error in
  /spm_cc_storage/SPM/db.
07/20/99 13:24:26 db_server(15545): Error: db_VISTA error 2
  (errno=="Resource temporarily unavailable")
07/20/99 13:27:03 db_server(9723): Error: DBMS error in
  "../db_str.c" line 153
```

Listing 5: Error messages in the database server log caused by a full vob_db.str_file

The utility called string_report, shipped in ClearCase 4.1 and later versions in the etc/utils subdirectory, will tell you what's filling up the string file. In general, it's usually configuration records. If you have a 2 GB string file, it's a pretty good guess that at least 1.8 GB will be filled with configuration records.

We can use the scrubber to remove unused configuration records from the string file. Well, actually, it's a little more complicated than that. As shown in Figure 1, the scrubber physically removes only those configuration records with a reference count of 0, which doesn't include all the configuration records in a library.

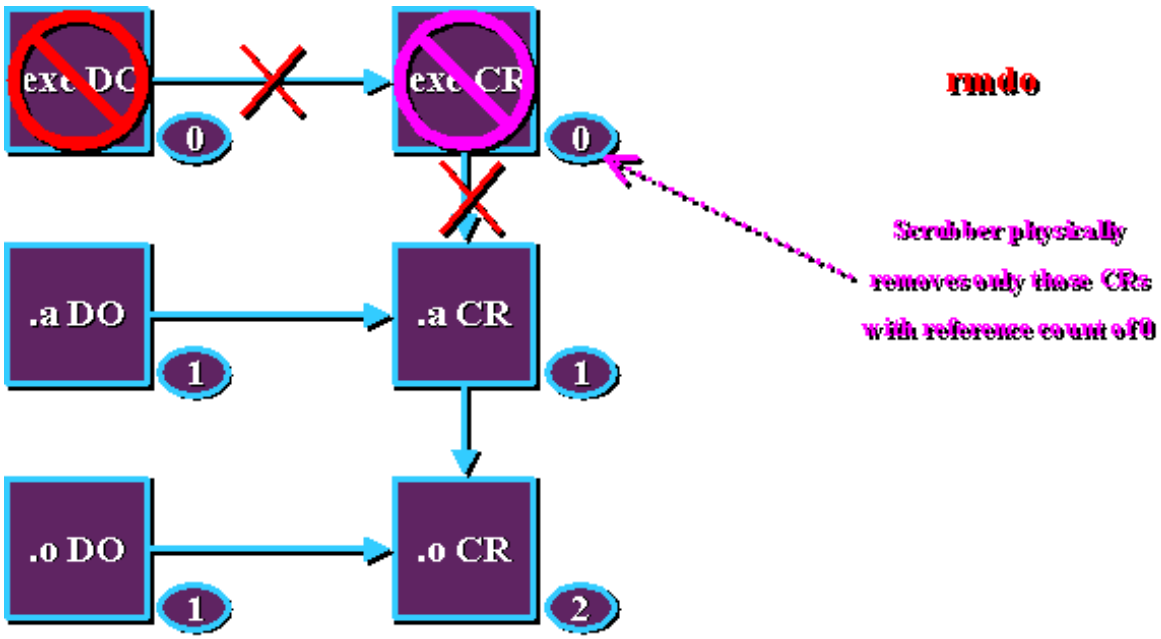

Figure 1: Versioned DOs and CRs in a library

To start out, we have a derived object (DO) with a reference count of 1, referencing a configuration record (CR) that also has a reference count of 1. We then build a library that has that DO in it, and we get a .a DO with a reference count of 1, which points to a CR for the .a DO with a reference count of 1. That .a CR also references the .o CR as a subconfiguration record, which means the reference count on that .o CR is now up to 2. At this point, if we decide our string file is full and do an `rmdo` on the .exe DO, that DO will be gone from the system and its reference count will drop to 0. That DO no longer references the CR, and the CR reference count drops to 0. The CR no longer references the .a CR; its reference count drops to 1 because it's still referenced by the .a DO.

When we run the scrubber, it removes from the string file only those configuration records with a reference count of 0. So in our example, even though we've removed the .exe DO, we still have .a CR and .o CR taking up space in the string file. To get rid of these, we need to get their reference counts to 0.

It gets even worse in MultiSite, as shown in Figure 2. When we check in a DO in MultiSite, we create an oplog for that check-in, and that oplog references the CR as well, so its reference count goes up to 3. And when we check in the .a DO and the .exe DO, we also have oplogs that reference the CRs, and their reference counts go up as well.

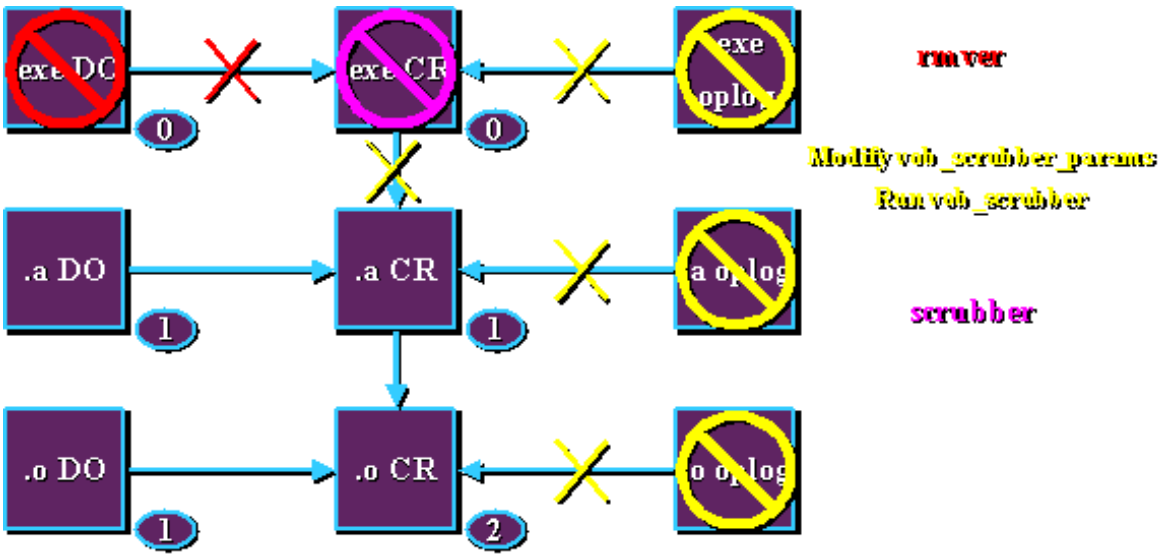

Figure 2: Versioned DOs and CRs in a MultiSite environment

In this case, when we do an rmver on the .exe DO, its reference count drops to 0. It no longer references the CR, whose reference count drops to 1. But the scrubber won't remove this CR because its reference count isn't 0. In fact, we can remove all the versions of all the DOs we have and the string file still isn't going to shrink when we run the scrubber, because we have all those oplogs still pointing at the CRs.

So what we need to do before running the scrubber is to modify the VOB's scrubber parameters, as discussed earlier for the `countdb` output. With the appropriate parameters, the scrubber will then remove each of the oplogs and its references to the CRs. The reference counts on the CRs will be decremented by 1. But the scrubber will only get rid of CRs with reference counts of 0, so we'll still have CRs left in the string file taking up space.

The thing to realize is that the string file will never actually shrink even if we've removed all our CRs religiously, but in reality there may still be plenty of space available to use. The `string_report` utility will give us that information.

In summary, then, to resolve the problem of a full string file, you must monitor DO usage and remove older ones that you don't need anymore. In addition, you need to scrub your oplogs a little more aggressively.

To avoid the problem, you can do the following:

- Monitor `string_report` output, which will tell you the total size of the file, how many gaps it has, and how much space is available.
- Monitor old view usage, which usually has references to DOs. If a reference to a DO is there, a reference to a CR is there also, taking up space.
- Find unused CRs and force their reference count to 0. The catch is that there's no way to get the reference count of a CR and there's no way to figure out what references a CR. There's a utility available from Technical Support called `cc_do_strlen_list` that will list all of the DOs

still in the VOB by database ID and tell you how much space each DO is taking up and, by implication, how much CR information that DO actually references in the string file. Removing that DO won't necessarily recover all of that space in the string file, though, because DOs are shared: a `.o` DO can be used in multiple `.a` DOs.

There's one more file that can fill up in the database subdirectory - the `vista.tjf` file, which contains transactions that were playing to the database. This file has a 2 GB limit even if you do go to schema 54. It's normally flushed every five minutes, but if you run things like the scrubber or MultiSite sync operations, it can still fill up. There are a couple of ways to avoid filling up the `vista.tjf` file:

- One of the more recent patches will prevent it from filling up in all but one case.
- A journal file limit option (found on the `config_ccase` manual page) that you can put into the `db.conf` file will, in almost every case, prevent the `vista.tjf` file from filling up, even if you're doing a lot of transactions in a five-minute period.

Problems with Imports Failing in ClearCase MultiSite

ClearCase MultiSite allows for development across multiple sites by replicating changes at one site to other sites via oplogs. An oplog is a single operation that gets replayed at each replica. Oplogs that have occurred are tracked via epoch numbers.

The main problem customers seem to have with MultiSite is that `multitool` imports fail. Depending on the version of ClearCase you're running, you may or may not see something that resembles Listing 6. Older versions will fail with some meaningless error.

```
texarkana:scm::19:multitool syncreplica -import
/usr/atria/shipping/ms_ship/incoming/sync_01-04-11.04-00-01_29413
multitool: Error: CORRUPTION DETECTED!!! Sync. packet
/usr/atria/shipping/ms_ship/incoming/sync_01-04-11.04-00-01_29413
   targeted for non-replicated VOB/vobstorage/NMIP/COTS_ARCHIVE.vws
multitool: Error: Sync. packet
/usr/atria/shipping/ms_ship/incoming/sync_01-04-11.04-00-01_29413
   is not applicable to any local VOB replicas
```

Listing 6: Error messages caused by failure of a multitool import

To collect data about such problems, CAG has a script called `multisiteinfo.pl` that runs these commands:

- `cleartool lsvob` *`vob-tag`*
- `cleartool -VerAll`
- `multitool -VerAll`
- `cleartool Isreplica -long`

- `multitool lsepoch`

It also runs the following for each replica:

- `cleartool describe replica:`*`replica`*
- `cleartool dump replica:`*`replica`*

We can send you this script, but if you want to be proactive, you can just run these commands when you have a MultiSite issue and send the output to Technical Support.

What we usually find has happened when `multitool` imports fail is that the customer has restored a replica from backup without running the `restorereplica` command as described in the admin manual. The chain of events is pictured in Figure 3. The table on the right in the figure shows how many operations replica A thinks have been replayed at replica A and at replica B, and how many operations replica B thinks have occurred at replica A and at replica B.

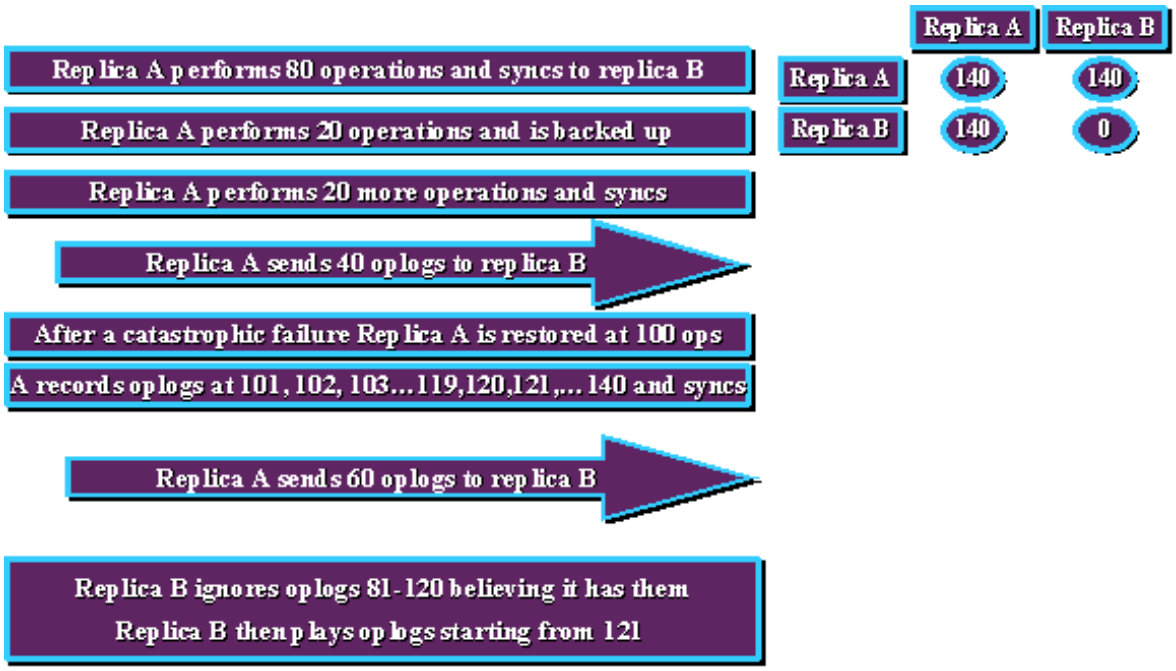

Figure 3: Restoring a replica from backup without running restorereplica

Replica A first performs 80 operations (oplogs) and syncs to replica B. At this point, replica A knows that replica A has done 80 operations and that replica B has 80 operations that it played at its site; and replica B knows about 80 operations that have been played at replica A.

Replica A then performs 20 more operations and is backed up. At this point, replica A knows it has performed 100 operations, but because it hasn't synchronized to B, it thinks B only knows about 80 of them. Replica A does 20 more operations and then syncs. It sends 40 oplogs to replica B to catch replica B up with the 120 operations it's done.

Replica A then suffers a catastrophic failure, is restored from backup without running `restorereplica`, and records oplogs up to 140. At this point, it thinks it needs to send 60 oplogs to replica B because it only knows from the backup that B had 80 of these oplogs. But replica B has already gotten 120 oplogs from replica A, so it's going to start replaying them at 121. At this point the replicas diverge and replica A is locked. The error that says "corruption detected" is based on replica B's thinking that oplog 81 is a duplicate. In reality, this error may not show up immediately; it may take a couple of months for imports to start failing, but when they do, it's usually because there was a restoration without running `restorereplica`.

To resolve the problem, we need to go back to the backup version and run `restorereplica`. When `restorereplica` is run, replica A sends a message to replica B that amounts to saying, "I don't know what's going on! I don't know how many operations I should have, or how many you have. Let me know what you've got." Replica B will respond with 20 oplogs - the 20 that A doesn't know about but B does. Replica A replays those 20 oplogs and is then unlocked and open for business after all the tables have been updated.

To avoid this problem, be sure to follow the admin manual procedures and run `restorereplica` when restoring MultiSite VOBs from backup.

Problems with UCM

UCM provides out-of-the-box processes and methodology for code development VOBs. It's implemented by way of a lot of hyperlinks between component and process VOBs. In general, the problems customers have with it are similar to admin VOB issues in that they're the result of interactions among activities, baselines, projects, and components not being cleaned up properly. For example, running `cleartool rmvob` *`component-VOB`* can cause problems when you attempt to remove a component with `rmcomp` if activities in the process VOB still reference activities in the component VOB. Defects have been raised and will be fixed, but meanwhile, such problems are part of UCM's growing pains.

To avoid these problems, be sure to back up process VOBs and component VOBs simultaneously and restore them as a unit, if it comes to that. If you want to remove components, do it via the `rmcomp` command while your component VOBs are still in existence. And if you can't deliver or rebase, contact Technical Support for help. We have numerous utilities available to help you out if you find yourself in one these situations.

Problems with the Lock Manager

The Lock Manager coordinates access to VOB databases by multiple clients. Problems occur due to various resource limitations. Listing 7 shows examples of two different types of error messages you might see as a result of a problem with the Lock Manager. In general, a `***db_VISTA database error -922` is always going to be related to the Lock Manager.

```
05/03/00 04:46:40 db_server(469): Error: db_server.exe(469): Error: Cannot
```

```
   open database in "d:\ClearCase_Storage\VOBs\gus_safeview.vbs\db"
05/03/00 04:46:40 db_server(469): Error: db_server.exe(469): Error: Too
   many open databases on host (try increasing -f argument on lockmgr
   command line)

db_server(14571): Ok: ***db_VISTA database error -922 - the lock manager
   is busy
db_server(14571): Error: DBMS error in /vobs/smi/pbn/db.
db_server(14571): Error: db_VISTA error -922(errno == "No such file or
   directory")
db_server(14571): Error: Cannot open database in "/vobs/smi/pbn/db"
```

Listing 7: Error messages caused by problems with the Lock Manager

When we collect data about a problem with the Lock Manager, we want to know how busy the server is - how many VOBs are on there and how they're being used, whether to run `clearmix` or just to sync a lot. We want to know what the current Lock Manager parameter settings are. We also want to gather some statistics that tell us how many processes are talking to the Lock Manager at any one time.

We can get these on UNIX by sending `SIGQUIT` to the `lockmgr` process. We can get them on Windows NT by first killing the Lock Manager as a service (`net stop lockmgr`) and then restarting the Lock Manager in a command window as `clearcase_albd run` -

<ATRIAHOME>\bin\lockmgr -a almd -q 1024 -u 1016 -f 1016 -nosvc

- and periodically pressing CTRL-C to get the `lockmgr` process to dump some statistics.

The Lock Manager manages lock requests from any process that needs to access a VOB database. Actually, there are only two of those - `db_server` and `vobrpc_server`. There's only one `lockmgr` process per VOB server, no matter how many VOBs you have on the server. And the Lock Manager has various limits that are defined when it's started, via the command line or via a registry value for file tables (the `-f` parameter), user tables (the `-u` parameter), or queue tables (the `-q` parameter). Let's look at each of those parameters along with their limits and what they should be set to for optimal performance (at least in theory).

- The `-f` parameter indirectly determines how many VOBs can be accessed on a system at any one time. VOB databases have 7 files each - 3 data files and 4 key files - in the VOB storage area `db` subdirectory. The default `-f` value of 256 files means that there can be 36 VOBs (256 divided by 7) on a server without modification. If you have more than 36 VOBs on a server and you haven't modified this, you might encounter problems such as poor end-user response while waiting for locks, and various error messages in the log file. Try increasing the `-f` parameter to increase the size of the `lockmgr` process. There's no practical limit to the size of the file table, but we recommend that you set the value to 7 times the number of VOBs you're going to have on

the system.

- The -u parameter determines the maximum number of db_server and vobrpc_server processes that can request locks from the Lock Manager. Again, the default value is 256. Typically, there's only going to be one active db_server process for each active client ClearCase command. This parameter essentially limits the amount of concurrent ClearCase activity, no matter how many VOBs are on the system. Again, you'll see poor end-user response and "lock manager is busy" errors if the -u parameter is set too low. If you do run into these problems, you can increase the value of this parameter. With the old Lock Manager, the maximum value allowed is 1018, based on the limit for select system calls. With the shared memory Lock Manager that came out in ClearCase 4.1 for Solaris and in ClearCase 4.2 for HP, the limit is based on virtual memory, so you can make it as large as you want. To calculate the parameter value you should use, we recommend writing a script to collect data periodically (say every half hour) for a week that counts the total number of db_server and vobrpc_server processes on the system. Take the maximum number of processes seen in any one sample and set the -u parameter value to two times that maximum number. The -u value is the most difficult to formulize; it's best to determine what your system requires by running the monitoring steps.
- The -q parameter determines how many lock requests can be queued by the Lock Manager at any one time. The default is 1024. Again, you'll see poor end-user response and "database timed out" messages in the log file if this parameter is set too low. To resolve the problem, we recommend you increase the -q parameter to up to five times the value of the -u parameter (although in actuality there's no upper bound), because the db_server process usually requests a lock for five database files in one request.

To change the value of these parameters on a UNIX machine, go to the $ATRIAHOME/etc/atria_start script and change the values in the line that looks something like this:

```
${ATRIA}/etc/lockmgr${LOCKMGR_ALIAS_OPT} -q 1024 -u 256 -f 256
   >> $ADM_DIR/log/lockmgr_log 2>$1
```

Then restart ClearCase on the machine. (Note that if you install a patch later on, these values may get overwritten unless you modify them again in the release area so that they get propagated to all the clients that may need them.)

To change the parameters on a Windows machine, use the Registry Editor to look for the LockMgrCmdLine value in the path Hkey_Local_Machine\Software\Atria\ClearCase\CurrentVersion. If the value isn't there (it won't be unless you've previously modified it), you can create it. Set the parameters in the string -a almd -u 256 -f 256 -q 1024 and make sure the type is REG_SZ. Once you've modified the parameters, restart ClearCase on the machine.

Don't Worry, Be Happy

This article has given you a place to start in addressing a number of the most common problems that Rational ClearCase users run into. If you find yourself facing one of these problems, try following the suggestions for resolving it given here. But if that doesn't work, don't hesitate to call on Rational Technical Support. They'll either help you out or spin your problem off to us in CAG. One way or the other, we'll get it handled and you can get on with your tasks.

***NOTE:** This article was originally published on Rational Developer Network, the learning and support channel for the Rational customer community. If you are a Rational customer and have not already registered for your free membership, please go to www.rational.net.

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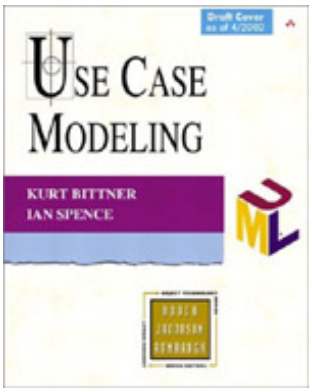
"Establishing the Vision" (Chapter 3) and "The Life Cycle of a Use Case (Chapter 6)*

from *Use-Case Modeling* by **Kurt Bittner** and **Ian Spence** (forthcoming; available from Addison-Wesley August 23, 2002).



Intended to be a ready reference for the practitioner -- the person who is actually grappling with the unique challenges of working with use cases -- this new book from Rational authors Bittner and Spence focuses on basic techniques, methods, and tools for using use cases effectively. The topics and discussions draw heavily upon lessons learned over the many years these two professionals have devoted to helping countless project teams work their way through use-case development issues.

Chapter 3, "Establishing the Vision," is a pivotal chapter in Part I, which introduces basic concepts and methods. It concentrates on ensuring that you will define the right solution when you develop a use-case model by presenting proven techniques for identifying the business problem you are solving, identifying stakeholders for the solution, and deciding what the system should do for those stakeholders to solve the business problem. Chapter 6, "The Life Cycle of a Use Case," is from Part II, which delves into finer details of working with use cases. It describes the transformations a use case undergoes as it evolves from concept to complete description. This chapter establishes context for the remaining chapters and also places the content from the first part of the book into a larger context.

* Both chapters posted in their entirety by permission from Addison-Wesley.

For a review of *Use-Case Modeling*, visit our Rational Reader section in this month's issue.

Chapter 3 pdf file (637 K) and Intro to Part II / Chapter 6 pdf file (328 K)

For more information on the products or services discussed in this article, please click here and follow the instructions provided.

Thank you!

Chapter 3

Establishing the Vision

Too many project teams dive into the details of the use-case model before they have established a stakeholder community, a shared vision, the real need for the product, or the constraints under which it is to be built. Proceeding with use-case modeling without this kind of foundation often causes immense problems. Some projects are completed before the team realizes that the system produced doesn't meet any of the stakeholders' real needs. Other project teams find it impossible to produce a stable use-case model or even to agree on one at all.

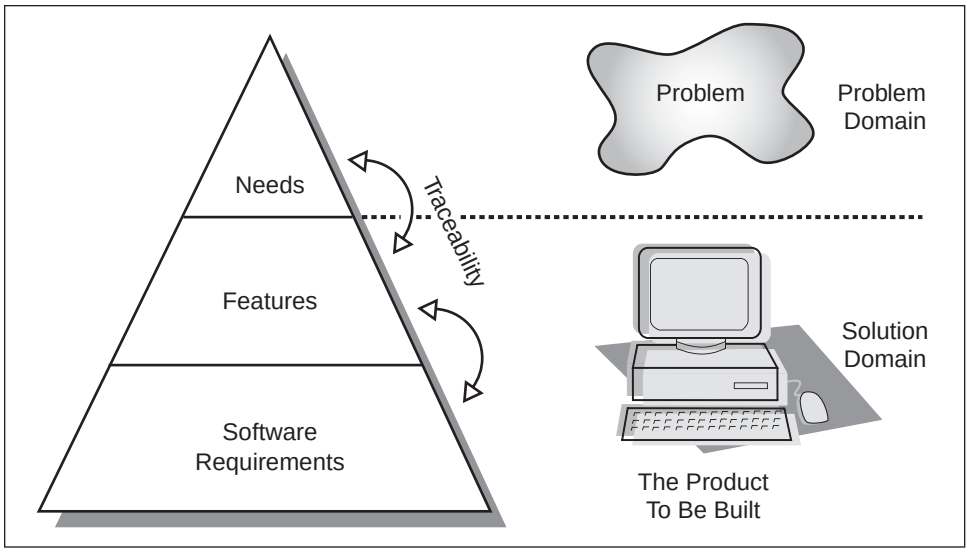
To avoid these kinds of problems, it is essential that the team:

- Establish a good understanding of the stakeholder community
- Demonstrate an understanding of the problem to be solved
- Capture the real needs of the stakeholders and the system features required to fulfill them
- Ensure that the views of the stakeholder community are actively and appropriately represented throughout the project

In this chapter we look at strategies that will help you in these activities and the positive effect that this will have on the quality of the use-case model you produce.

In Chapter 1, we briefly introduced the concept of the requirements pyramid, as shown in Figure 3-1, to clarify the role, purpose, and context of use cases. In this chapter we look more closely at the other elements of the requirements pyramid, discuss how they can be captured, and describe how they affect the construction and detailing of use-case models.

Figure 3-1 The requirements pyramid: Our map of the territory



INTRODUCING STAKEHOLDERS AND USERS

Before you start any use-case modeling or other requirements-management activity, you must understand the project's stakeholder community and how it will be involved in the project. You must understand the stakeholder community in order to tackle the following tasks:

- Establishing an understanding of the problems the project should be addressing. This is very hard to do without first identifying who is affected.
- Preparing for a requirements workshop. If a workshop is to be run to identify the system's actors and use cases, then the coordinator needs to know who to invite and which aspects of the business the invitees represent.
- Identifying the sources of the system's requirements. Requirements come from many sources, including, but not limited to, customers, partners, users, and domain experts. Understanding these sources of requirements will allow the project team to decide how best to elicit information from them.

To deliver an effective solution, one that will be wholeheartedly accepted by the stakeholder community, you must have a clear understanding of the stakeholders and their particular needs. It is also important that the people

asked to become involved in the project understand the role that they are expected to play and the responsibilities that they are expected to fulfill.

In this section we will look at:

- The definition of a stakeholder
- Why stakeholders are important
- The role of stakeholders in the project
- Why it is necessary to explicitly identify users, stakeholders, and actors.
- How to identify and involve the stakeholders in the project
- The relationships among stakeholders, users, actors, and use cases

What Are Stakeholders?

A stakeholder is

> An individual who is materially affected by the outcome of the system or the project(s) producing the system.[1]

Using this definition, some obvious stakeholders spring to mind:

- The users of the system. If the users are not materially affected by the outcome of the system, they won't use it and the system itself will be a failure.
- The development team. If these people are not materially affected by the outcome of their project and the system that it produces, there is probably something amiss with the commissioning organization's reward structure.

The full set of stakeholders will actually be larger than this. For example, the people who suffer from the problem being addressed are also stakeholders, regardless of the kind of solution chosen.

The decision to develop a system will often affect a great many other people. For example, the decision to invest in a new system involves the investors themselves in the success of the system; the decision by the development team to use third-party software in their solution will involve the suppliers as additional stakeholders. Although these people may not be directly affected

[1] This definition is a combination of the definitions of stakeholder from the RUP (the stakeholder role is defined as anyone who is materially affected by the outcome of the project) and Leffingwell and Widrig, 1999 (a stakeholder is an individual who is materially affected by the outcome of the system). This new definition reflects the fact that the stakeholder community comprises both the individuals directly affected by the system and those that are indirectly affected by the system by their involvement in the project.

by the original problem, they are affected by the outcome of the project. Figure 3-2 sums up the relationship between the stakeholders and the problem and its solution.

There can be millions of stakeholders for even the smallest project. Consider for a moment the simple telephone system discussed in the first two chapters. Everyone who uses, or potentially could use, the system is a stakeholder. If you take into account all those who could be materially affected by the outcome of the system, the stakeholder community must also include

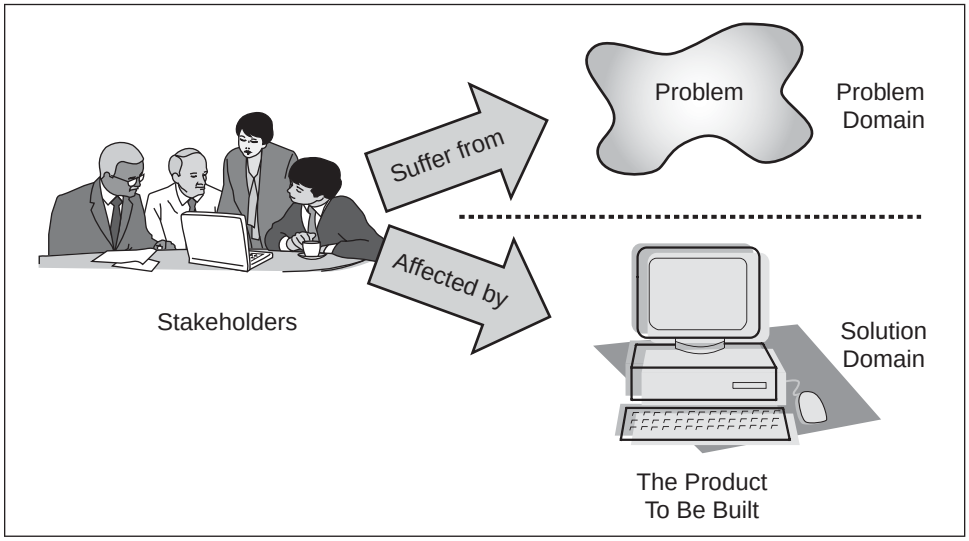
- The company's customers: the people who will be paying the bills
- Other telephone companies: the suppliers of the other telephone systems involved in making long-distance calls
- The other companies' customers and users

And so on…. It is obviously impossible to identify all of these people as individuals and involve them all in a project. However, it is entirely possible (not to mention good practice) to put in place a mechanism to allow us to understand the views of all the different types of stakeholder and to ensure that they are all represented in the project's requirements and decision-making process.

Identifying Stakeholder Types

The first step to understanding the stakeholder community is to identify the types of stakeholder affected by the system.

Figure 3-2 The stakeholder community is made up of those people that suffer from the problem and/or are materially affected by the outcome of the solution.



Stakeholder Type: The classification of a set of stakeholders sharing the same characteristics and relationships with the system and/or the project that produces the system.

In the phone system example, users, customers, customer support representatives, technical support staff, developers, marketers, other telephone companies, and the customers of other companies are all candidate stakeholder types for the project producing the simple telephone system.

Stakeholders typically fall into the following categories:

- **Users:** The most obvious types of stakeholder are the actual users of the system. These are the people who will be taking on the roles defined by the actors in the use-case model.
- **Sponsors:** The business managers, financiers, shareholders, champions, department heads, sellers, marketers, steering committee members, and other people who are investing in the production of the system. These stakeholders are only indirect users of the system or are affected only by the business outcomes that the system influences. Many are economic buyers for or internal champions of the system.
- **Developers:** Project managers, system maintainers, testers, support staff, designers, coders, technical writers, production staff, and any other types of developer involved in the production and support of the system.
- **Authorities:** Experts in a particular aspect of the problem or solution domain. These include legislative authorities, standards organizations, organizational governance departments, external and internal regulatory bodies, domain experts, and technology experts.
- **Customers:** The people and/or organizations who will actually be purchasing the final system. These can include the buyers, evaluators, accountants, and agents acting on behalf of the purchasing organizations.

The actual list of stakeholder types for a project will be more concrete than this; it will identify specific user types, agencies, and organizational units. The key thing is to ensure that all those affected by the outcome of the system are considered. When identifying the stakeholder types, focus on understanding how they are affected by the project and the system it will produce.

Identifying Stakeholder Representatives and Stakeholder Roles

The next step is to define a set of stakeholder roles within the project that enable the views of all the stakeholder types to be represented. Appropriate people can then be recruited to fulfill these roles. The objective is to recruit a set of *stakeholder representatives* to be directly involved in the project.

> **Stakeholder Representative:** A member of the stakeholder community directly involved in the steering, shaping, and scoping of the project. A stakeholder representative represents one or more stakeholder types.

Before you can recruit an appropriate set of stakeholder representatives, you must define how these representatives will participate in your project.

> **Stakeholder Role:** The classification of a set of stakeholder representatives who share the same roles and responsibilities with respect to the project.

The definition of the stakeholder roles allows the stakeholder representatives to understand the commitment they are making to the project, the responsibilities that they are taking on, the level of involvement they will be required to provide, and who they are representing. When identifying the stakeholder roles, you are interested in understanding how they will interact with the project as well as which subset of the stakeholder types they represent. It is important to ensure that each type of stakeholder is represented and that their representation is at a level that reflects both the importance of the stakeholders to the project and the capabilities, and availability, of the representatives.

Some methodologies go so far as to explicitly define a set of stakeholder roles to complement the more commonly defined developer roles. For example, the Dynamic System Development Method (DSDM)[2] explicitly defines the following stakeholder roles as essential to any user interface-intensive project:

- **Ambassador User:** Responsible for bringing knowledge of the user community into the project team and disseminating information from the team back to the rest of the users. The ambassador users act as the major source of requirements to the project.
- **Advisor User:** Responsible for representing users not covered by the ambassador users. Typically part of a panel of staff that attends workshop-style demonstrations of prototypes. Outside prearranged events, the Advisor Users channel their information and feedback through the Ambassador Users.
- **Visionary:** Responsible for ensuring that the right decisions are made with respect to system scope and that the original business objectives of the project are met.
- **Executive Sponsor:** Responsible for project funding. Executive sponsors are the ultimate decision maker in the business area.

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[2] The Dynamic Systems Development Method is a rapid application development method for constructing use interface-intensive systems popular in the United Kingdom.

That stakeholders play four critical roles further underscores the importance of achieving the correct level of stakeholder involvement in modern software development practices. (By way of contrast, only two developer roles have been defined: Senior Developer and Developer.[3])

It is impossible to define a useful, universally applicable set of stakeholder roles. These generic roles will inevitably be too abstract to be useful as anything more than a checklist (that is, how many user types does each ambassador user represent and how exactly do you involve them in the project?). We recommend that you instead perform a formal analysis of the stakeholder types and define a specific set of concrete stakeholder roles. This significantly increases the chances that you will secure a sufficient and appropriate level of stakeholder representation and involvement in the project. (Remember that for a large-scale project there could be many millions of stakeholders, far too many to directly involve in the development project.)

In most projects, the term *stakeholder* is used to indicate the set of stakeholder representatives directly involved in the project. Little thought is given to the broader stakeholder community and to the fair representation of their views. Because stakeholder representatives can play a much more significant role than they are sometimes given credit for, it is well worth your effort to ensure that they understand both their responsibilities to the project and to the people they represent.

The practicalities of defining stakeholder types and stakeholder roles are covered in the section Involving Stakeholders and Users in Your Project later in this chapter. This section also explains how to recruit stakeholder representatives and suggests ways to involve them throughout the project.

The Role of Stakeholders and Stakeholder Representatives

Stakeholders and stakeholder representatives own the problem and are affected by the proposed solution. They are also the primary source of requirements. Figure 3-3 illustrates this relationship. The problem itself being fairly intangible, it is the stakeholder representatives that bridge the gap between the problem and the specification of the proposed solution. The requirements documentation itself is a formal articulation of the stakeholders' goals and acts as their surrogate on the project when the stakeholder representatives themselves are not available. Figure 3-4 sums up the relationships between the stakeholders, the system, and the requirements documentation.

[3] These roles are presented for illustrative purposes only and are not intended to reflect the full set of roles defined by the DSDM.

Figure 3-3 The stakeholders are the primary source of requirements.

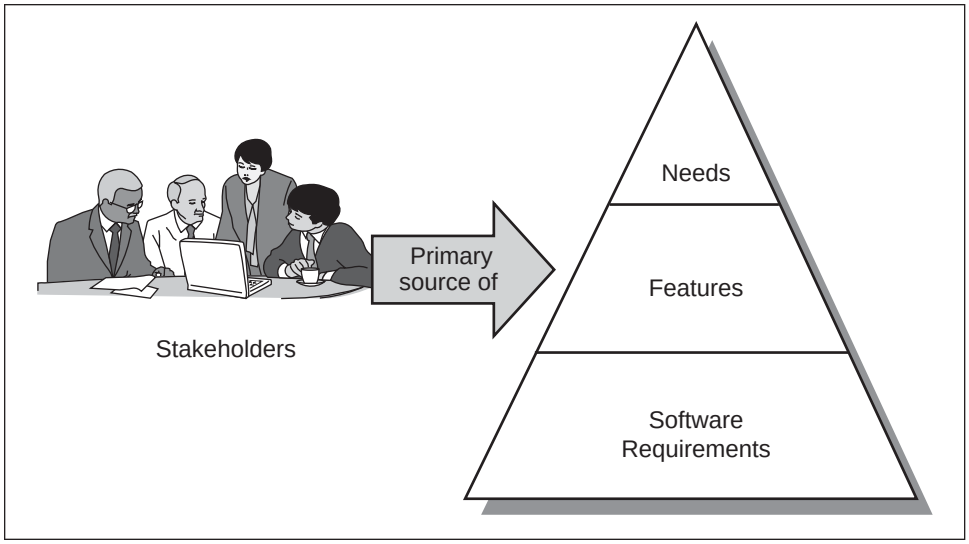
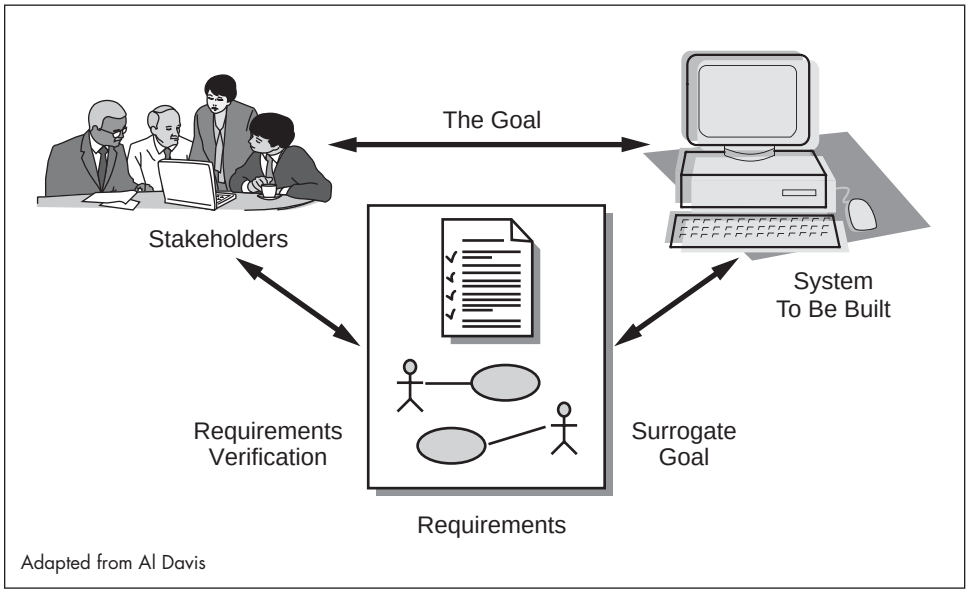


Figure 3-4 The requirements act as the representation of the stakeholders' goals.



Consider which stakeholder types will be the sources of the requirements when defining stakeholder roles and appointing stakeholder representatives. All stakeholder types must be represented, but it is important to focus attention where it will receive the best return. For example,

shareholders are a type of stakeholder, but they will not provide many, or any, requirements to the project. Although their interests should certainly be considered and represented, the project team should focus on addressing the requirements of the more direct stakeholders, such as users and developers. The makeup of the set of stakeholder representatives should reflect the relative importance of the stakeholder types as requirements sources.

The stakeholder representatives who will act as the primary source of requirements information must be directly involved in the project and have a clear understanding of the role that they are expected to play. Many projects run into trouble because the stakeholder representatives are not actively engaged in the project and do not provide feedback when it is needed. Stakeholder representatives' indifference may manifest itself by their unavailability when eliciting project requirements, not making time to review and sign off on project deliverables, not committing themselves for the full lifetime of the project, or just plain forgetting why they are involved in the first place. The quality of the final result is often directly derived from the quality of the participation of the stakeholders.

To combat this, clearly define the stakeholder roles and ensure that stakeholder representatives understand their roles and their responsibilities in representing different stakeholder communities. The role of stakeholder representative includes but is not limited to the following:

- Faithfully representing the views and needs of the section of the broader stakeholder community they represent
- Taking an active role in the project
- Participating in requirements and other project reviews
- Participating in the assessment and verification of the product produced
- Attending workshops and meetings
- Doing independent research
- Championing the project to the stakeholders they represent

There are many ways of involving the stakeholder representatives in the project. If you are developing an information system to be used internally within your company, you may include people with user experience and business domain expertise in your development team. Very often you will start the discussions with the business needs and corresponding processes rather than with the system requirements. Alternatively, if you are developing a product to be sold to a marketplace, you may make extensive use of your marketing people and tools such as questionnaires and surveys to better understand the needs of customers in that market.

Each and every project requires focused stakeholder involvement. For all projects:

- Active stakeholder involvement is imperative.
- A collaborative and cooperative approach involving all the stakeholders is essential.[4]

Remember: The stakeholders own the problem and are the source of the project's requirements. If the system is not a success with the stakeholders, then it is not a success, period.

Users: A Very Important Class of Stakeholder

We now focus on one important type of stakeholder: system users. Users will play most of the roles defined by the system's actors, and their requirements help to shape the use-case model. Every user is a stakeholder, because he or she will be *materially affected by the outcome of the system*, but not all the stakeholders are necessarily users.

In Chapter 2 we discussed the difference between users and actors. Even in our simple telephone system the difference between the users and the actors is quite clear. The actors define roles, whereas the same user could play many roles. In some cases the caller (the person making the phone call) will be the customer (the payer of the bills). In some cases (if reversing of charges is supported) the person being called could be the customer.

To fully understand the user environment and provide context for the actor definitions, you must undertake a detailed analysis of the various types of users.

> **User Type:** The classification of a set of users with similar skill sets and other characteristics who share the same roles and responsibilities within the system's environment.[5]

A User Type is a fine-grained definition of a particular stakeholder type. Having a full profile of each user type is essential so that you can understand their skill set, attitude, language, and other characteristics. When dealing with the more abstract concept of actors, it is very easy to forget that actual users may have varying skill levels and capabilities.

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[4] These are variations of two of the nine principles that drive the Dynamic Systems Development Methodology.

[5] If RUP-style business modeling is being undertaken, then the user types are the subset of the business workers and business actors that directly interact with the system.

Some user types[6] for the simple telephone system example are

- **Technology Adopters**—Many of the potential users are technology adopters interested in exploiting the full set of facilities provided by the system, especially text and e-mail capabilities.
  - *Characteristics:* High-volume users of the system. Technology adopters currently make up 40 percent of the company's customer base. They are typically young and highly influenced by trends, fashion, and marketing.
  - *Competencies:* Technically literate, happy to learn complex operating procedures to set up and use their systems. Have e-mail accounts and other on-line facilities.
  - *Success Criteria:* Reliability, range of functionality, and low cost of additional facilities.
  - *Actors:* Caller, Callee, and Customer.
- **Standard Users**—A large subset of the existing user community having no interest in exploiting the technical capabilities of the telephone network and requiring a simple system that functions in the same way as traditional telephone systems.
  - *Characteristics:* Low-volume users of the system. Standard users currently make up 60 percent of the company's customer base. They are typically older and resistant to trends, fashion, and marketing.
  - *Competencies:* Would like to use the more technical features of the system but are frustrated by having to learn complex operating procedures to set up and use their systems.
  - *Success Criteria:* Reliability, ease of use for traditional features, no increase in cost for, or imposition of, additional facilities.
  - *Actors:* Caller, Callee, and Customer.
- **Messaging Devices**—Fax machines, voice-mail systems, answering machines, and other devices capable of sending and receiving telephone communications.
  - *Characteristics:* Over 50 percent of the current customer base connect secondary devices to their systems to send and receive messages.
  - *Competencies:* Limited capabilities to respond to messages from the system. Negotiate messaging protocols etc. with each other.
  - *Success Criteria:* High speed, high bandwidth, low noise connections.
  - *Actors:* Caller, Callee.

[6] This is not intended to be the full user list but an illustrative sample. Other user types include those related to the support and maintenance of the system. These are not required for the purpose of this illustration.

All of these user types play the roles defined by the Caller and Callee actors but they have different characteristics and capabilities. They also have different success criteria and requirements for the system being built. This will impact on the contents and structure of the use-case model and the other requirements documentation. If these variations in emphasis are not considered during the use-case modeling, then the system produced may end up satisfying only a very small segment of the target customers.

As one of the most important types of stakeholder, active users are essential to most projects. The amount of user involvement required is variable; one user may be a full-time *user ambassador* permanently assigned to the project, another may be a member of a user panel, and yet another may simply submit ideas and feedback by questionnaire. When defining the stakeholder roles, you should take into consideration the amount of user involvement necessary to support the project, the style of user involvement most suited to the project and the users, the availability of the users to the project, and the level of commitment the users have to the project.

In most cases, it will be impossible to involve all of the users. What is essential is that the set of stakeholder representatives includes user representatives and that for each type of user there is clearly defined representation. Users must understand how they are represented in the project, and user representatives must understand their responsibilities toward the users they represent.

For the project developing the simple telephone system, the stakeholder roles have the following responsibilities for representing the users:

- **Marketer**—The marketing team representative to the project; also represents the interests of the marketing and sales departments as well as the users. The marketer is available to attend workshops and reviews related to the system's requirements.
  - *Users Represented:* Technology Adopters, Standard Users.
- **Ambassador User**—A member of the customer support team has been seconded to the project to provide full-time user representation; responsible for representing all the users of the system, including the organization's support and operational teams. The ambassador user is key member of the project's requirements team, creating requirements documentation as well as attending workshops and reviews.
  - *Users Represented:* Technology Adopters, Standard Users, Messaging Devices, plus the company's internal users (as yet undefined).
- **Support Working Group Member**—A working group has also been set up to represent the support and operational staff affected by the

new system. This is chaired by the Ambassador User and meets once a month to discuss the requirements and progress of the new system.
  – *Users Represented:* The company's internal users (as yet undefined).

- **Focus Group Member**—Various focus groups are set up and run by the Marketer to explore requirements issues with representative groups of target and existing customers. These are formed on an as-needed basis and facilitated by the Marketer and the Ambassador User.
  – *Users Represented:* Technology Adopters, Standard Users.

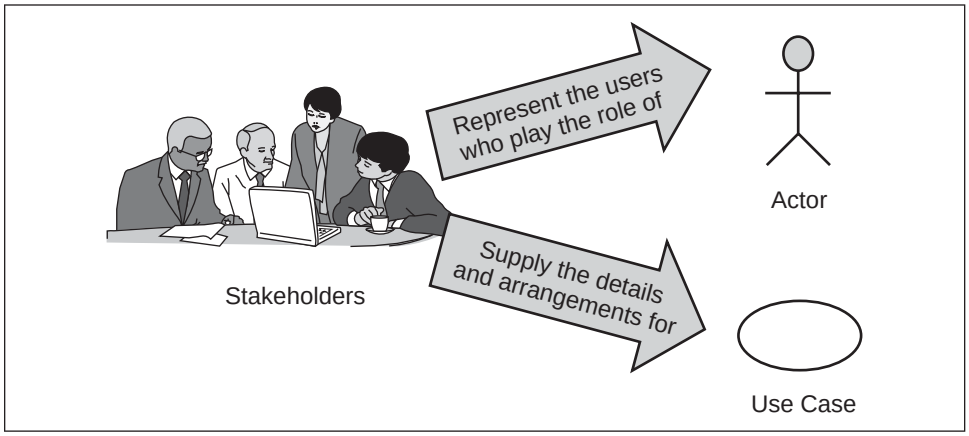
Stakeholders and Use-Case Modeling

An understanding of the stakeholders and their particular needs is essential to developing an effective use-case model. In many cases, the system has indirect (or secondary) goals that are not directly related to satisfying the needs of the actors (and by implication, the users). Other stakeholders may have a vested interest in the outcome of a particular use case. This is often the case when management reports must be generated or management information captured but none of the managers is directly involved in the use case. "What are the actor's goals? Where is the value to the actor?" ask the use-case modelers. In these cases, the user, playing the role of the actor, is often a more junior employee whose only real goal is to do a job, which is a valid goal for a use case to support and can certainly be considered of value to the actor.

The set of stakeholders who supply the requirements for the use case is not restricted to those who represent the users involved in the use case (that is, play the role specified by the actors). If you want to know the amount of management information that must be captured, you should talk to the managers who will be using the information and not the operators who will be producing the reports. Understanding these indirect relationships can be of great help when viewing the use-case model, because the goals of the broader stakeholder community can often be contrary to those of the actor involved. For example, the stakeholders may require additional security checks or impose limits and restrictions on what the actor is allowed to achieve.

The most effective way to work with stakeholders is to directly involve the stakeholder representatives in the development and review of the use cases themselves. Figure 3-5 illustrates the relationship between the stakeholder representatives and the actors and use cases. As we explain throughout the book, use-case modeling is a synthetic rather than analytic

Figure 3-5 The relationships between stakeholders and actors and stakeholders and use cases



technique. If you do not involve the correct stakeholder representatives in the creation and validation of the use-case model, then the model itself will be worthless. Identifying and involving the correct set of stakeholder representatives is the essential foundation of any successful use-case modeling activity.

We have often been subcontracted to facilitate workshops or provide training to software engineers who have been charged with producing a use-case model to express the requirements of the system they are about to build. One thing soon becomes clear: Given a challenge, these highly talented people will rise to the occasion and produce a solution. No matter how little experience they have of the problem to be addressed or the domain in which it occurs, they will produce a use-case model and by the end of its development believe that it is an accurate reflection of the actual requirements. In reality, the use-case model produced will be a fiction, reflecting the technical objectives of the developers rather than the business needs of the stakeholders. Unless the people involved in creating the use-case model have excellent domain experience and communicate thoroughly with the other stakeholders, the model produced will not capture the real requirements.

Knowledgeable stakeholder representatives must be involved in all of the use-case modeling activities throughout the life cycle of the project if the project is to be a success. To facilitate this involvement, it helps to trace the stakeholder roles to the areas of the use-case model where their input is most useful. Table 3-1 shows the relationship between the stakeholder roles and the use cases for the simple telephone system example.

Table 3-1 Relating Stakeholder Roles to Use Cases for the Simple Telephone System

Stakeholder Role	Use Case
Ambassador User	Place Local Call Place Long-Distance Call Get Call History Get Billing Information
Marketer	Place Local Call Place Long-Distance Call Get Call History
Support Working Group	Get Billing Information

INVOLVING STAKEHOLDERS AND USERS IN YOUR PROJECT

The following steps can be applied iteratively to establish an appropriate level of stakeholder involvement in your use-case modeling activities.

Step 1: Identify Stakeholder and User Types

Because the number of actual stakeholders can be very large, you should first identify the various types of stakeholder that must be involved in the project. Model the stakeholder community by defining discrete types of stakeholders: The set of types is determined by the problem domain, user environment, development organization, and so on. Depending on the domain expertise of the development team, identifying the stakeholder types may be easy or hard. A good start is to ask decision makers, potential users, and other interested parties the following questions:

- Who will be affected by the success or failure of the new solution?
- Who are the users of the system?
- Who is the economic buyer for the system?
- Who is the sponsor of the development?
- Who else will be affected by the outputs that the system produces?
- Who will evaluate and sign off on the system when it is delivered and deployed?
- Are there any other internal or external users of the system whose needs must be addressed?
- Are there any regulatory bodies or standards organizations to which the system must comply?
- Who will develop the system?
- Who will install and maintain the new system?

- Who will support and supply training for the new system?
- Who will test and certify the new system?
- Who will sell and market the new system?
- Is there anyone else?
- Okay, is there anyone else?

Stakeholder Type information

When defining the stakeholder types, be sure to capture the following information:

- **Name:** Name the stakeholder type.
- **Brief Description:** Briefly describe what the stakeholder type represents with respect to the system or the project. Typically, users take on the role of one or more system actors.
- **Stakeholder Representative:** Summarize how the stakeholders will be represented within the project. This is typically done by referencing the applicable stakeholder representative role or roles.

For stakeholder types that are also user types, the following information is also worth capturing:

- **Characteristics:** User types may be characterized in terms of their physical environment, social environment, numbers, and other general characteristics such as gender, age, and cultural background.
- **Competencies:** Describe the skills that users need to perform their job, as well as any other relevant information about the user type that is not mentioned elsewhere. This can include their level of domain knowledge, business qualifications, level of computer experience, and other applications that they use.

A more detailed definition of the stakeholder and user types may be required if the stakeholder or user community is particularly complex. In these cases, full stakeholder and user descriptions can be produced. Examples of such descriptions are provided in the Vision documents included in the case study and template appendices.

Step 2: Identify and Recruit the Stakeholder Representatives

After the stakeholders in the project have been identified, it is time to start recruiting the stakeholder representatives who will actively participate in the project. Of particular interest are those who will be directly involved in the use-case modeling activities. Before you approach any individuals to become stakeholder representatives, you should attempt to define exactly what their roles and responsibilities toward the project will be as well as which part of

the stakeholder community they will represent. You do this by defining a set of stakeholder roles and relating these to the stakeholder types that they explicitly represent.

Stakeholder Role information

When defining stakeholder roles, be sure to capture the following information:

- **Name:** Name the stakeholder role.
- **Brief Description:** Briefly describe the stakeholder role and what it represents with respect to the development project. Typically, the role is to represent one or more stakeholder or user types, some aspect of the development organization, or certain types of customer or some other affected area of the business.
- **Responsibilities:** Summarize the role's key responsibilities with regard to the project and the system being developed. Capture the value the role will be adding to the project team. For example, responsibilities could include ensuring that the system will be maintainable, ensuring that there will be a market demand for the product's features, monitoring the project's progress, approving funding, and so forth.
- **Involvement:** Briefly describe how they will be involved. For example, a permanent user ambassador will undertake use-case modeling and other requirements activities, attend requirements workshops during the inception phase, and serve as a member of the change control board.

Again, sometimes a more detailed definition of the stakeholder role is required if the stakeholder community is particularly complex or stakeholder involvement is particularly difficult to achieve. In such cases, a full stakeholder role description can be produced. Examples of such descriptions are provided in the Vision documents included in the case study and template appendices.

The set of stakeholder roles and their relative importance will evolve over time. Certain stakeholder roles may be more important during the production of the first release of the product than the later releases. For example, the initial version of a product may be aimed at only certain user types that have the characteristics of the early adopter, whereas later versions may be geared toward less technologically advanced types of users.[7]

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[7] See *Crossing the Chasm: Marketing and Selling Technology Products to Mainstream Customers* by Geoffrey A. Moore, 1991, HarperCollins, for the definitive text on early adopters and other forms of customers. This highlights the reasons why the analysts must understand their stakeholders if they want their product to be successful.

When setting up the initial set of stakeholder representatives, look for users, partners, customers, domain experts, and industry analysts who can represent your stakeholders. Determine which individuals you would work with to collect information, taking into consideration their knowledge, communication skills, availability, and "importance." These individuals will make good stakeholder representatives for the project—the set of stakeholder representatives form, in effect, an "extended project team." In general, the best approach is to have a small (2–5) group of people that can stay for the duration of the project. Also, the more people there are in your extended team, the more time it will take to manage them and make sure that you use their time effectively. Often these people will not work full-time on the project—they typically participate in one or more use-case modeling and requirements-gathering workshops in the early phases of the project, and later on they participate in review sessions.

Many companies have problems establishing effective communication between the business and IT communities. Very often it is difficult for software development projects to get any time from the appropriate business people; there is usually something more important to do than worry about a system that doesn't even exist yet. Recruiting the right stakeholder representatives to participate in the project is therefore extremely important. Potential stakeholder representatives should understand the commitment required of them to provide not only the initial requirements for the solution but also ongoing guidance and review of progress. Larger projects will require full-time user and business representatives. If you cannot find stakeholders willing to make such commitments, then you probably should question the commitment of the organization to the project. In companies where this happens, there are usually patterns of two sequential projects: one to develop the wrong system, followed by another to develop the right system.

Depending on the proximity and commitment of the stakeholder community to the project, identifying the stakeholder representatives may be easy or hard. Often, this simply involves formalizing the commitment the user and business representatives are making to the project.

The following questions can help you define the stakeholder roles:

- Is every stakeholder type represented?
- Is every affected business unit and department represented?
- Who will evaluate and sign off on the requirements specification?
- Who will attend the use-case modeling and other requirements workshops?
- Who will supply the domain knowledge required to develop a successful solution?

- Who will be involved in any market research undertaken to justify and validate the product?
- Which stakeholder types are the most important?
- Who is the target audience for the release of the product under development?

The stakeholder representatives that represent the users are only one subset of the stakeholder representatives. It is important to recognize that the set of stakeholder representatives must be broader than those drawn directly from the user community. A good way to ensure that all the stakeholders are covered by the set of stakeholder representatives is to check that every stakeholder type is represented by at least one stakeholder role and that there is at least one stakeholder representative fulfilling each stakeholder role.

Step 3: Involve the Stakeholder Representatives in the Project

Various techniques can be used to involve the stakeholder representatives in the project. They include (but are not limited to) the following:

- **Interviews:** Interviews are among the most useful techniques for involving stakeholders in a project. If you have a good understanding of the stakeholder's role, you can keep the interview focused on the issues at hand.
- **Questionnaires:** Questionnaires are a very useful technique, particularly when a large number of stakeholder representatives is involved. Questionnaires have to be designed, and the audience targeted, with great care.
- **Focus Groups:** A focus group allows you to sample sets of stakeholder representatives to get their perspective on what the system must do. Focus groups tend to be used to gather specific feedback on specific topics.
- **Advisory Boards:** An advisory board is a kind of standing focus group. It provides a way to gather stakeholder perspectives without the overhead of establishing a focus group. The disadvantage compared to a focus group is that the composition of the advisory board can't be varied according to topic.
- **Workshops:** Workshops can be a very useful way to capture requirements, build teams, and develop their understanding of the system. They should be well planned with a defined agenda that is sent to participants beforehand along with any background reading material.
- **Reviews:** Reviews are formal or informal meetings organized with the specific intent to review something, whether a document or a prototype.

- **Role Playing:** This is a facilitation technique that is typically used in conjunction with workshops to elicit specific information or feedback.

The choice of technique is very closely coupled to the definitions of the stakeholder roles and the availability of actual individuals to take on the responsibilities defined by the roles. There is no point in deciding that a project will have full-time ambassador users attending weekly requirements workshops if there are no experienced users in a position to take on this level of commitment. This is why the three steps should be applied iteratively and the level of stakeholder representative involvement constantly monitored. In our experience, paying attention to the stakeholder community and continuously involving them, in the project in appropriate ways significantly increases the chances of project success.

The technique most closely associated with the creation of use-case models is the workshop. These can, of course, be used to investigate many other aspects of a project, for example, to brainstorm the characteristics of the target customer, or to develop a vision statement. Chapter 5, Getting Started with a Use-Case Modeling Workshop, explicitly addresses how workshops can be used to kick-start the use-case modeling process.

To successfully build use-case models, you must have sufficient stakeholder representation in the creation and validation of the models, and stakeholder representatives must focus on satisfying the real needs of the broader stakeholder community.

CREATING A SHARED VISION

After the initial set of stakeholder representatives has been assembled to work on the project, the first thing to do is to create a vision of the system that they can all share. To be effective, this vision must provide a shared understanding of the problem to be solved and unify the various stakeholder perspectives. If there is no shared vision, then it will be very difficult to:

- Actively involve the stakeholder representatives in the project
- Assess whether real progress is being made
- Manage the project scope
- Validate the decisions made in the day-to-day running of the project
- Bring new developers or stakeholder representatives into the project
- Have effective communication among the stakeholders

To be able to achieve a truly collaborative and cooperative working environment, it is essential that everyone involved in the project share the same vision of the project and the system to be built.

In this section we will look at:

- Identifying the underlying problem to be solved
- Capturing the stakeholders' needs
- Providing a high-level requirements specification
- Providing a product overview
- How these elements complement the use-case model

Analyze the Problem

Before you dive into the specification and production of your solution, it is always a good idea to take a step back and consider the problems that you expect your solution to solve and the opportunities it will exploit. This will enable you to ensure that all of the functionality provided by the system is directly contributing to the alleviation of these problems and the success of the product. It will also help you to validate that you have the correct stakeholders involved in the project.

A problem can be defined as the difference between things as perceived and things as desired (Gause and Weinberg, 1989) or as a question or matter to be worked out (*Collins Modern English Dictionary*). Both of these definitions emphasize that there are many ways to solve a problem, not all of which require the production of a solution. In many cases, changing the customers' perception of what they have now or changing their perception of what they want is sufficient to resolve the problem. If a difference does not exist between what you perceive you have and what you want to have, then you don't have a problem.

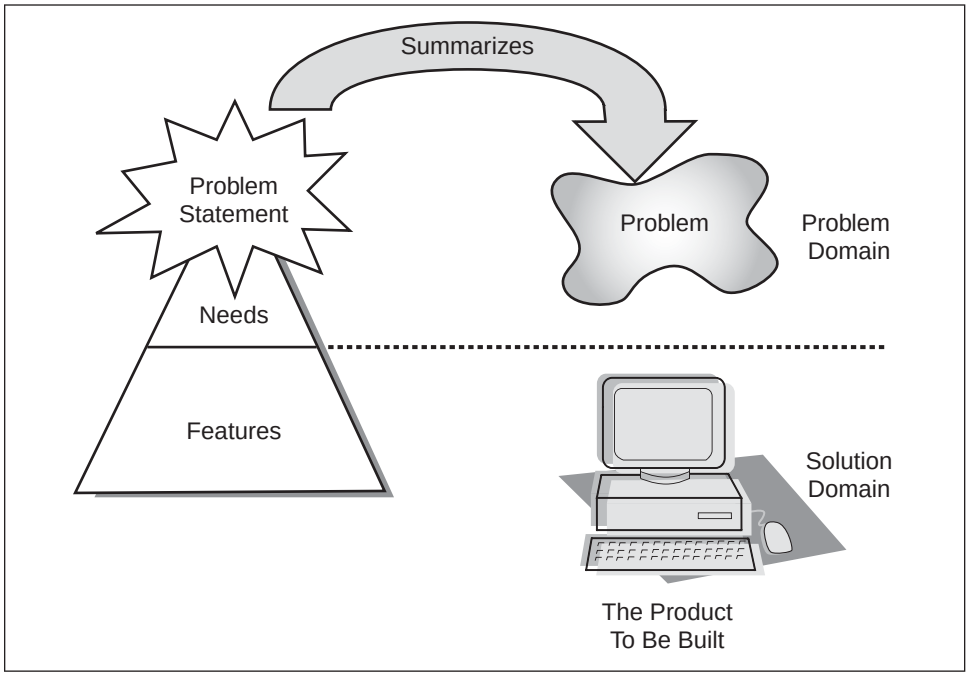
If you want to satisfy customers' real needs, you must understand what problem they are trying to solve. You want to avoid hearing a "Yes . . . but . . ." when you deliver the final product (for example, "Yes, it meets the requirements, but it does not solve my problem."). Also, if you want to avoid extra work, it pays to focus on the real problem and to focus on the part of the problem that you actually need to solve. Solving the wrong part of the problem means you may have to go back and redo much of your work.

The best way to capture the problem is to construct a problem statement. This is a solution-neutral summary of the stakeholders' shared understanding of the problem to be solved. It includes an assessment of the problem's impact and the benefits to be gained by its solution. It can be captured using the simple template shown in Table 3-2. The beauty of the problem statement is its ability, as illustrated by Figure 3-6, to represent the tip of the requirements pyramid while simply and succinctly summarizing the problem to be solved. Understanding the problem is the first step in understanding the requirements. The stakeholders often describe the problem in terms of their own

Table 3-2 Problem Statement Template

The problem of	[describe the problem]
Affects	[the stakeholders affected by the problem]
The impact of which is	[what is the impact of the problem?]
A successful solution would	[list some key benefits of a successful solution]

Figure 3-6 The problem statement represents the tip of the requirements pyramid.



needs, but each need should reflect an aspect of the same underlying problem. All projects embarking on use-case modeling should take time to produce at least a simple problem statement.

Often, the stakeholders have different perspectives on the problem (these are represented by the different stakeholder needs; see the next section), but it is very important that they reach agreement on a shared problem at some shared level of abstraction. If they cannot agree on a simple problem statement, then they are unlikely to agree on the scope or suitability of any proposed solution. Sometimes, achieving a shared definition of the problem can

be very difficult, yet it's essential to understand why stakeholders want to do something new. There are many ways to build up this understanding. Our favorite is to perform some root-cause analysis using fishbone diagrams and then apply the Pareto principle to help in leveling the root causes.[8]

Remember: After a team of people starts use-case modeling, it is very easy for them to forget the problems that the system is intended to address and to start inventing new use cases. It is very easy for their interest in applying a modeling technique, such as use cases, to totally override the original purpose that led to the adoption of the technique. You should always remember that use-case modeling is a means to an end and not an end in itself.

Table 3-3 shows an example problem statement for a customer support system. Note that in the problem statement, the subject is the stakeholder, "I need to . . . ," in the corresponding requirements, the subject is the system "The system provides . . . ." The goal of this problem analysis is to make sure that all parties involved agree on what the problem to be solved is. To this end, it is important to consider the business aspects of the problem as well as technical ones. Without checks and balances, many development teams will immediately dive into the technical details of their proposed solution without even considering the business aspects of the problem the solution is intended to solve. It is essential that the project team have a good understanding of the business opportunity being met by the product and the market forces that motivate the product decisions. This will require the development of additional business-focused documentation (for example, a business case and supporting business model) to complement the problem analysis summarized by the problem statement.

Table 3-3 The Problem Statement for a Customer Support System

The problem of	untimely and improper resolution of customer service issues
Affects	our customers, customer support representatives, and service technicians,
The impact of which is	customer dissatisfaction, perceived lack of quality, unhappy employees, and loss of revenue.
A successful solution would	provide real-time access to a troubleshooting database by support representatives and facilitate dispatch of service technicians, in a timely manner, only to those locations that genuinely need their assistance.

[8] Leffingwell and Widrig, 2000.

Understand the Key Stakeholder and User Needs

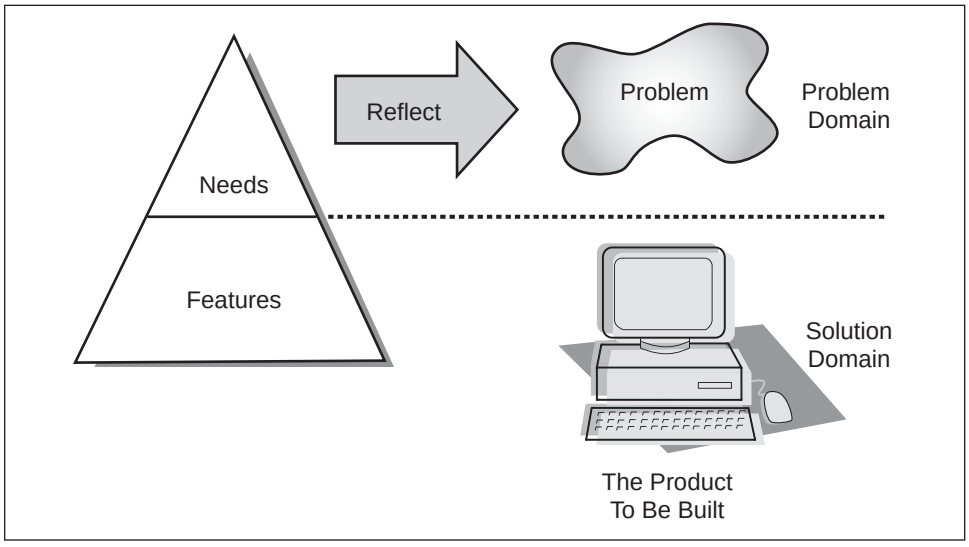
Effectively solving any complex problem involves satisfying the needs of a diverse group of stakeholders. Typically, stakeholders will have different perspectives on the problem and different needs that must be addressed by the solution. These can be acknowledged and tracked by explicitly capturing and documenting the needs of each stakeholder type.

We'll define a stakeholder need as

> A reflection of the business, personal or operational problem (or opportunity) that must be addressed to justify consideration, purchase or use of a new system.[9]

Figure 3-7 uses the requirements pyramid to illustrate the relationship between the needs and the problem statement. Capturing stakeholder needs allows us to understand how and to what extent the different aspects of the problem affect different types of stakeholders. This complements, and provides a deeper understanding of, the shared problem statement. You can think of stakeholder needs as an expression of the true "business requirements" of the system. They will provide an insight into the root causes of the overall shared problem and define a set of solution-independent requirement statements that, if met, will solve the underlying business problem.

Figure 3-7 Needs reflect the problem from an individual stakeholder perspective.



[9] Leffingwell and Widrig, 2000.

The description of each stakeholder need should include the reasons behind the need and clearly indicate why it is important to the affected stakeholders. The needs should be written in a solution-independent fashion and address the root causes of the problem only. Attempting to address more than the root causes will encourage the solution developers to produce solutions to problems that do not exist. For each stakeholder need it is also useful to understand

- The relative importance the stakeholders and users place on satisfying each need.
- Which stakeholders perceive the need
- How this aspect of the problem is currently addressed. State the current business situation. By specifying the current state you will better be able to understand the impact of the use cases you will write.
- What solutions the stakeholders would like to see. Specify the desired business situation.
- How success will be measured. All requirements should have some measurable success criteria. If you are unable to measure the success, you will never be able to determine whether you have reached your desired state. When changing something as large as a business, it may be that the success criteria cannot be measured for some time.

The documentation of the stakeholder needs does not describe

- The stakeholders' specific requests (which are captured in separate stakeholder request artifacts).
- The stakeholders' specific requirements. High-level requirements are captured as features, and the detailed requirements are captured in the use-case model and Supplementary Specifications.

The stakeholder needs to provide the background and justification for why the requirements are needed. A typical system will have only a handful of needs, usually somewhere between 10 and 15. For example, the set of needs for the simple telephone system includes

Easy to Use: The system shall be easy to use by both technology adopters and technophobes enabling all users to simply and effectively use both the standard and advanced features of the system.

Provide Up-to-Date Status Information: The system shall provide real-time information to all users related to the duration and costs of calls.

Extensible: The system shall be extensible, allowing the introduction of new services and facilities without disruption to the level of customer service supplied.

Elicitation activities may involve using techniques such as interviews, brainstorming, conceptual prototyping, questionnaires, and competitive analysis. The result of the elicitation is a list of requests and needs that are described textually and that have been given priority relative one another.

We recommend the use of the MoSCoW rules[10] when prioritizing stakeholder needs. MoSCoW is derived from the first letters of the following prioritizing criteria:

Must have (Mo)
Should have (S)
Could have (Co)
Want to have but will not have this time round (W)

For most practitioners, the "W" actually stands for "Won't have." Ranking and cumulative voting techniques are used to identify the needs that **must** be solved as opposed to those that the stakeholders would like addressed. The use cases defined for the system can then be explicitly traced back to the stakeholder needs that they address. This allows a more objective assessment of the benefit provided by each use case and ensures that each use case is actually helping to address actual stakeholder needs.

Describe the Features and Other High-Level Product Requirements

To complement the use-case model and provide a high-level view of the system, it is very useful to create a high-level requirements view of the product to be built. This view is provided by the product feature set and, where required, other high-level product requirement definitions.

More on Features

Features are the high-level capabilities (services or qualities) of the system that are necessary to deliver benefits to the users and that help to fulfill the stakeholder and user needs. The feature set provides a summary of the advertised benefits of the product to be built. Figure 3-8 illustrates the relationship among the needs, the features, and the system to be built.

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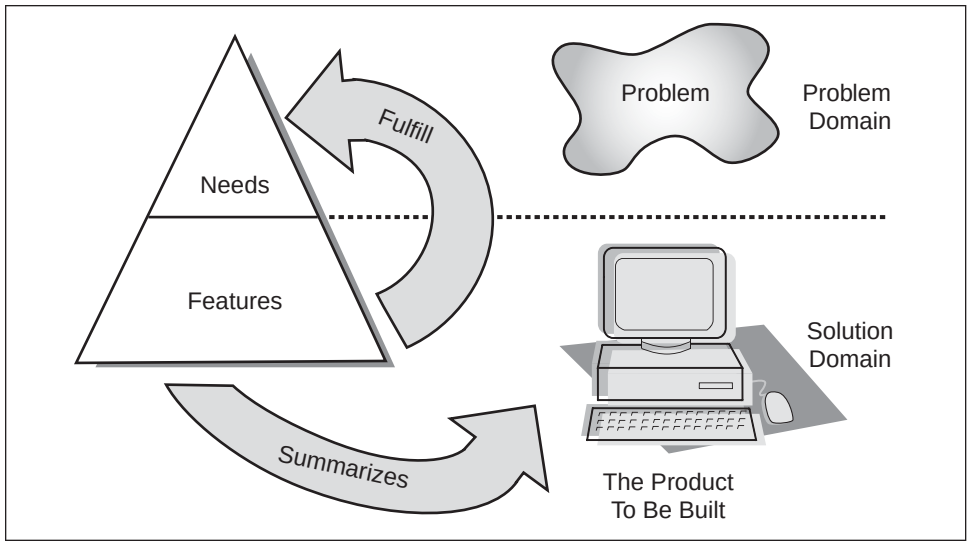
[10] The MoSCoW rules are a method for prioritizing requirements used quite widely in the United Kingdom especially by followers of the Dynamic System Development Method (DSDM). *In The Dynamic System Development Method,* Jennifer Stapleton introduces the MoSCoW rules thus:

> You will not find the MoSCoW rules in the DSDM Manual, but they have been adopted by many organizations using DSDM as an excellent way of managing the relative priorities of requirements in a RAD project. They are the brainchild of Dai Clegg of Oracle UK, who was one of the early participants in the DSDM Consortium.

Figure 3-8 The features fulfill the needs and summarize the product to be built.



Features can be functional or nonfunctional. Many features describe externally accessible services that typically require a series of inputs to achieve the desired result. For example, a feature of a problem-tracking system might be the ability to provide trending reports. Other features describe the externally visible qualities that the system will possess. For example, another feature of the problem-tracking system might be the quality of the data used to produce the trending reports. Because features are used to summarize the capabilities and qualities of the product to be built, they must be accessible to all the members of the project team and all the stakeholders. The level of detail must be general enough for everyone to understand. However, enough detail must be available to provide team members with the information they need to shape, validate, and manage the use-case model and Supplementary Specifications.

The problem with defining features is that they are often "all over the map"; they have no precise definition and cannot be used to really drive the development or testing of the system. Although generally high level in nature, there is no defined level of abstraction to which a feature must conform. They just represent some area of the functionality of the system that, ***at this time***, is important to the users of the system. Because they represent the things that are important ***at this time***, there will always be a list of features for every release and these feature lists will be different each time.

Another side effect to the immediacy of the features is that there is no need for them to provide a complete definition of the system. They represent the advertised benefits, the hot aspects, of the latest release of the system

rather than a summary of its entire functionality. In this way, they complement the use-case model, which, in terms of the set of use cases, presents an overview of the system's entire functionality and often shows no changes from release to release.

The immediate and informal nature of features makes them a very powerful tool when working with the stakeholders and customers in defining what they want from a system's releases. When asked, stakeholders will be able to quickly come up with a list of the top 10 features they would like to see added to the system; in contrast, they will often struggle to identify any new use cases that are required.

Features provide the fundamental basis for product definition and scope management. To effectively manage application complexity, the capabilities of the system should be sufficiently abstract so that no more than 25 to 99 features describe the system. Each feature will be manifested in greater detail in the use-case model or the Supplementary Specifications. The combination of features and use cases provides a very powerful mechanism for managing the scope of the system, keeping all of the stakeholders involved and informed about the progress of the system and ensuring that a complete requirements specification is produced in an easily accessible and manageable form. Individually, neither features not use cases provide such a manageable or complete solution.

DOCUMENTING FEATURES

When documenting features:

- Include a description of functionality and any relevant usability issues that must be addressed.
- Avoid design. Keep feature descriptions at a general level. Focus on required capabilities and why (not how) they should be implemented.
- Assign each feature a unique identifier for easy reference and tracking.

In addition to system functionality, also consider the nonfunctional qualities required of the system, such as performance, usability, robustness, fault tolerance, scalability, licensing, installation, and documentation (user manuals, online help, labeling, and packaging).

The features of the system may be categorized and presented in many ways. For elicitation and verification, it is best to present the features by functional area and type. For scope management and publication purposes, it is best to group the features by target release, sorted in order of priority so that it is easy to distinguish between those that are in-scope and those that have been deferred. Again, as with the needs, we recommend the use of the MoSCoW rules to prioritize the feature set. Table 3-4 shows the prioritization of some of the features of the simple telephone system.

Table 3-4 Example Features for the Simple Telephone System

Identifier	Description	Priority
FEAT1	The system shall allow the caller to place local calls.	Must
FEAT2	The system shall allow the caller to place long-distance calls.	Must
FEAT3	The system shall select the cheapest routing for all long-distance calls.	Should
FEAT4	The system shall provide a continuously up-to-date call history for all accounts.	Must
FEAT5	The system shall be continuously available 24 hours a day, seven days a week.	Should

Other Product Requirements

Other high-level requirements may not be as readily captured as features of the product. These include any constraints placed on the development of the product and any requirements the planned product will place on its operating environment. These other product requirements should be documented separately from the features and clearly identified as either constraints or operational requirements to prevent team members from confusing them with the actual requirements of the product.

CONSTRAINTS

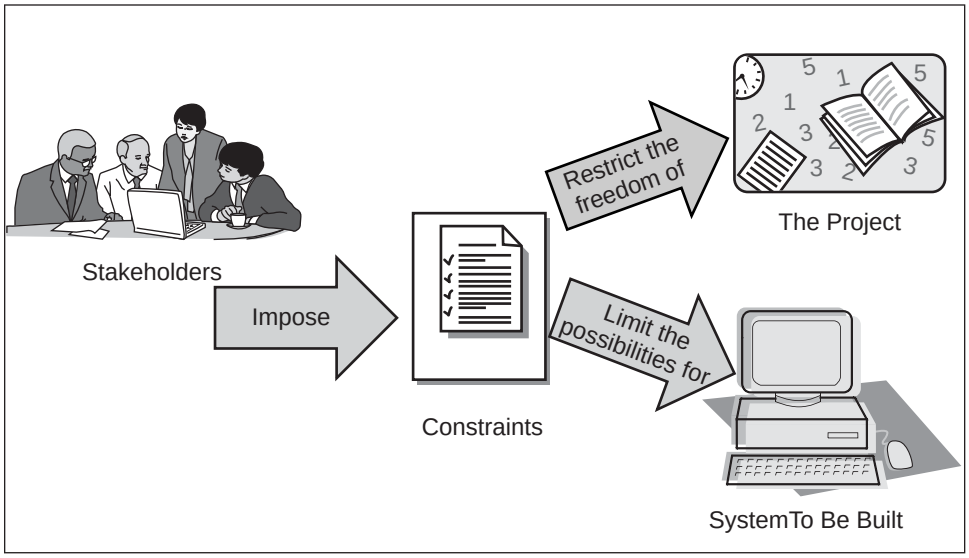
No matter how technology independent the requirements-gathering and the software development processes are, some constraints[11] are inevitably placed on the possible solution. Constraints are not related to fulfilling the stakeholders' needs; they are restrictions imposed on the project by external forces. Although constraints arise from the stakeholder community, they are not directly related to the problem to be solved. Figure 3-9 illustrates how the stakeholders impose constraints on the project and system to be built.

Many different kinds of constraint may be imposed on a project. These include

- Business and Economic: Cost and pricing, availability, marketing, and licensing issues

[11] A constraint is formally defined as "a restriction on the degree of freedom we have in providing a solution" (Leffingwell and Widrig, 2000).

Figure 3-9 The relationship between the constraints imposed by the stakeholders and the project and the system it is producing



- Environmental: External standards and regulations that are imposed on the development project
- Technical: The technologies that the project is forced to adopt or the processes that the project has to follow (such as a requirement that the system be developed using J2EE)
- System: Compatibility with existing systems and operating environments
- Schedule and Resources: Dates the project has been committed to or limitations on the resources that the project must use

Stakeholders may impose constraints for a variety of reasons:

- Politics: Constraints may be placed on the project by the relationships among the stakeholders rather than the technical or business forces shaping the project.
- Organizational Policies: Organizational policies may be in place that constrain the way that the product can be developed. A company may have made a policy decision to move toward specific techniques, methodologies, standards, or languages.
- Strategic Directions: Strategic directions may be in place that constrain the project to use specific technologies and suppliers (such as a corporate decision to outsource all coding or to host all applications on a specific application server).
- Organizational Culture: The culture of the organization may itself constrain the project by limiting the way that the project must address the

problem. (There is a limit to the amount of change that people can cope with at any one time, and this could prevent a project from adopting its preferred technologies and methods.)

The constraints must be kept in mind when you create and assess the use-case model. Constraints imposed on the system will limit the freedom of the solution and therefore must be reflected in the style, scope, and structure of the use-case model. Understanding the constraints imposed on the system can be particularly useful when selecting the appropriate set of actors and use cases required to describe the system. This is discussed in more detail in Chapter 4, Finding Actors and Use Cases.

Most constraints are low-level design constraints arising from designers' choice of technology and method. These are captured as part of the Supplementary Specification alongside the nonfunctional software requirements. Here we are talking about identifying the much smaller set of high-level constraints: those that will fundamentally impact on the scope and direction chosen for the project. These are documented in the Vision document alongside the stakeholder needs and the product features.

Constraints can limit your ability to successfully provide a solution. Sometimes an apparently simple constraint can introduce tremendous complexity when it is examined. As a result, constraints must be constantly evaluated to determine how and where they will apply. Constraints may also influence your selection of stakeholder representatives, the manner in which those representatives are involved, and your choice of elicitation techniques. For example, a system that has a number of budgetary and financial performance constraints requires greater involvement of project accountants and financial analysts than one without financial constraints.

When documenting a constraint, you should also capture the source of the constraint and the rationale behind it. Because the constraints are unrelated to the problem being solved, they should be documented and tracked separately from the requirements.

OPERATING REQUIREMENTS

In some cases the product to be produced results in requirements being placed on the operating environment in which it will be deployed. These are not requirements to be fulfilled by the solution, but requirements that must be met by the operating environment if the solution, is to be successfully deployed. These requirements may include:

- System Requirements: Any system requirements necessary to support the application. These can include the supported host operating systems and network platforms, configurations, memory, peripherals, companion software, and performance.

- Operating Environment Requirements: For hardware-based systems, operational issues can include temperature, shock, humidity, and radiation. For software applications, environmental factors can include usage conditions, user environment, resource availability, maintenance issues, and error handling and recovery.

These should be documented in the same way as the system's constraints, with attention paid to the source and rationale that led to their specification.

Provide an Overview of the Product

The features and other product requirements are not sufficient to provide a complete high-level view of the system. You also need to document the benefits, assumptions, dependencies (including interfaces to other applications and system configurations), and alternatives to the development of the product.

Product Position Statement

Every system is (or should be) built for at least one good reason. Like any good enterprise, the system requires a good "mission statement" or reason for being. You should be able to state in clear terms what the system does and why it does it. The description need not be long—in fact, the more succinct the better—but it should be put in writing.

Think of traveling in an elevator with the president of the company. Suppose the president asks what you are working on right now. You need a short answer that conveys the real value of the system being built. Most projects that find themselves in difficulties do so because, at least in part, no one really knows what is being built and why. The product position statement is a vehicle for communicating a brief definition of the system to all stakeholders.

The template shown in Table 3-5 can be used to express the product positioning statement, a key element of the vision.[12] This format reminds people about all of the things that must be considered when establishing a vision for the system. A description of the system is important because it gives everyone a common high-level understanding of what the system does. Anyone associated with the project should be able to briefly describe what the system does in simple terms. Being able to do so creates a foundation for common understanding that pays dividends as the project progresses.

Let's consider an automated teller system. What does it do? One might tend to give details in a description, such as how the user's identity is authenticated and how funds are allocated. These are important details, but they do

[12] This format is taken from Moore, 1991.

Table 3-5 Product Position Statement Template

For	(target customer)
Who	(statement of the need or opportunity)
For	(target customer)
Who	(statement of the need or opportunity)
The	**(product name)** is a (product category)
That	(statement of key benefit, that is, compelling reason to buy)
Unlike	(primary competitive alternative)
Our product	(statement of primary differentiation)

not belong in the basic description. Think like a venture capitalist: What is the system going to do for someone? What's the value? An example product position statement for the automated teller machine is presented in Table 3-6.

This description isn't fancy or complicated; it simply conveys the essence of what the system does. It should state what problem the system principally solves, who it principally serves, and what value it provides. When writing the description, try to describe the system as you would to someone who is unfamiliar with it and the problem it solves and try to convey the value it will deliver. If you cannot describe the system in very simple terms, you probably do not have a very clear idea of what the system will do.

Note that this description does not try to capture even a fraction of the requirements, and it should not. Is it important that the ATM prints a receipt?

Table 3-6 The Product Position Statement for an Automated Teller Machine (ATM)

For	Current account-holding customers
Who	Require instant access to their account details and the funds they contain
The	**Super ATM** is an automated teller machine
That	Provides the ability to perform simple bank transactions (such as withdrawing or depositing funds, or transferring funds between accounts)
Unlike	Accessing funds and details over the branch counter
Our product	Is available 24 hours a day and does not require the assistance of a bank teller

Not at this point. What about security? Not in the brief description. What about other kinds of transactions that might be handled? No need to describe them all here. We merely want to capture the essence of what the system does so that everyone will be clear about it.

Completing the Product Overview

To provide a complete overview of the product, you may also need to summarize other aspects of the product not directly captured by the high-level requirements. Typically, it is worth documenting:

- **Summary of Capabilities:** Summarize the capabilities that the system offers to its users. Presenting a brief overview of the use-case model will summarize the functionality offered by the system.
- **Customer Benefits:** Summarize the benefits that the product offers to its customers and which features provide the benefit. This may just be a matrix relating the stakeholder needs to the features.
- **Assumptions and Dependencies:** List any assumptions that have been made that if changed, will alter the vision established for the system. Also list any dependencies the product has on other products or the target environment.
- **Alternatives and Competition:** List any alternatives that the stakeholders perceive as available, including a description of their strengths and weaknesses, to allow comparison with the solution being proposed.

It is important to provide the stakeholders with these additional perspectives on the product, because they demonstrate that the product is not being considered in isolation from its target business and operational environments.

BRINGING IT ALL TOGETHER: THE VISION DOCUMENT

The Vision document is the Rational Unified Process artifact that captures all of the requirements information that we have been discussing in this chapter. As with all requirements documentation, its primary purpose is communication.

You write a Vision document to give the reader an overall understanding of the system to be developed by providing a self-contained overview of the system to be built and the motivations behind building it. To this end, it often contains extracts and summaries of other related artifacts, such as the business case and associated business models. It may also contain extracts from the system use-case model where this helps to provide a succinct and accessible overview of the system to be built.

The purpose of the Vision document is to capture the focus, stakeholder needs, goals and objectives, target markets, user environments, target platforms, and features of the product to be built. It communicates the fundamental "whys and whats" related to the project, and it is a gauge against which all future decisions should be validated.

The Vision document is the primary means of communication between the management, marketing, and project teams. It is read by all of the project stakeholders, including general managers, funding authorities, use-case modelers, and developers. It provides

- A high-level (sometimes contractual) basis for the more detailed technical requirements
- Input to the project-approval process (and therefore it is intimately related to the business case)
- A vehicle for eliciting initial customer feedback
- A means to establish the scope and priority of the product features

It is a document that gets "all parties working from the same book."

Because the Vision document is used and reviewed by a wide variety of involved personnel, the level of detail must be general enough for everyone to understand. However, enough detail must be available to provide the team with the information it needs to create a use-case model and supplementary specification.

The document contains the following sections:

- **Positioning:** This section summarizes the business case for the product and the problem or opportunity that the product is intended to address. Typically, the following areas should be addressed:
  - **The Business Opportunity:** A summary of business opportunity being met by the product
  - **The Problem Statement:** A solution-neutral summary of the problem being solved focusing on the impact of the problem and the benefits required of any successful solution
  - **Market Demographics:** A summary of the market forces that drive the product decisions.
  - **User Environment:** The user environment where the product could be applied.
- **Stakeholders and Users:** This section describes the stakeholders in, and users of, the product. The stakeholder roles and stakeholder types are defined in the project's Vision document—the actual stakeholder representatives are identified as part of the project plan just like any other resources involved in the project.

- **Key Stakeholder and User Needs:** This section describes the key needs that the stakeholders and users perceive the product should address. It does not describe their specific requests or their specific requirements, because these are captured in a separate stakeholder requests artifact. Instead, it provides the background and justification for why the requirements are needed.
- **Product Overview:** This section provides a high-level view of the capabilities, assumptions, dependencies (including interfaces to other applications and system configurations), and alternatives to the development of the product.
- **Features:** This section lists the features of the product. Features are the high-level capabilities (services or qualities) of the system that are necessary to deliver benefits to the users and satisfy the stakeholder and user needs. This is the most important, and consequently usually the longest, section of the Vision document.
- **Other Product Requirements:** This section lists any other high-level requirements that cannot readily be captured as product features. These include any constraints placed on the development of the product and any requirements the planned product places on its operating environment.

In many cases, a lot more work is put into uncovering the business opportunity and understanding the market demographics related to the proposed product than is reflected in the Vision document. This work is usually captured in-depth in business cases, business models, and market research documents. These documents are then summarized in the Vision document to ensure that they are reflected in the ongoing evolution of the products specification.

We recommend that the Vision document be treated primarily as a report and that the stakeholder types, user types, stakeholder roles, needs, features, and other product requirements be managed using a requirements management tool. If the list of features is to be generated, it is recommended that they be presented in two sections:

- In-Scope features
- Deferred features

Appendix B, Templates for Artifacts, contains a comprehensive Vision document template that contains a full definition of the structure and contents of a typical Rational Unified Process vision document. Appendix C, Case Study, contains a completed Vision document that complements the examples that appear within this chapter.

DO YOU REALLY NEED TO DO ALL OF THIS?

You are probably thinking that this all sounds like an awful lot of work, and you probably want to get started on the actual use-case modeling without producing reams and reams of additional documentation.

Well, projects are typically in one of four states when the use-case modeling activities are scheduled to commence:

1. A formal Vision document has been produced.
2. The information has already been captured but not consolidated into a single Vision document.
3. There is a shared vision, but it has not been documented.
4. There is no vision.

If your project is in one of the first two states, and the information is available to all the stakeholder representatives, then you are in a position to proceed at full speed with the construction and completion of the use-case model. If your project is in one of the last two states, then you should be very careful not to spend too much effort on the detailed use-case modeling activities. This does not mean that use-case modeling cannot be started—it simply means that any modeling you do must be undertaken in conjunction with other activities aimed at establishing a documented vision for the product. In fact, in many cases, undertaking some initial use-case modeling can act as a driver and facilitation device for the construction of the vision itself.

Our recommendation would be to always produce a Vision document for every project and to relate the information it contains to the use-case model to provide focus, context, and direction to the use-case modeling activities. Formally relating the two sets of information also provides excellent validation of their contents and quality. If there is sufficient domain knowledge and agreement between the stakeholder representatives, then producing and reviewing the Vision document can be done very quickly. If there isn't, then there is no point in undertaking detailed use-case modeling; the resulting specifications would be ultimately worthless as they would not be a reflection of the product's true requirements.

SUMMARY

Before embarking on any use-case modeling activities it is essential to establish a firm foundation upon which to build. The foundation has two dimensions, which must be evolved in parallel with one another:

1. An understanding of the stakeholder and user community
2. The establishment of a shared vision for the product

Understanding the stakeholder community is essential as the stakeholders are the primary source of requirements. The following are the key to understanding the stakeholder community:

- **Stakeholder Types:** Definitions of all of the different types of stakeholder affected by the project and the product it produces.
- **User Types:** Definitions of characteristics and capabilities of the users of the system. The users are the people and things that will take on the roles defined by the actors in the use-case model.

For the use-case modeling activities to be successful, the stakeholders and users will need to be actively involved in them. The stakeholders and users directly involved in the project are known as stakeholder representatives. To ensure that the stakeholder representatives understand their commitment to the project, it is worthwhile to clearly define the "stakeholder roles" that they will be adopting. The stakeholder roles serve as a contract between the stakeholder representatives and the project, reflecting the responsibilities and expectations of both sides.

To establish a shared vision for the project, the following are essential:

- **The Problem Statement:** A solution-neutral summary of the problem being solved, focusing on the impact of the problem and the benefits required of any successful solution.
- **Stakeholder Needs:** The true "business requirements" of the stakeholders presented in a solution-neutral manner. These are the aspects of the problem that affect the individual stakeholders.
- **Features, Constraints, and Other High-Level Product Requirements:** A high-level definition of the system to be developed. These complement and provide a context for the use-case model and enable effective scope management.
- **Product Overview:** A summary of the other aspects of the product not directly captured by the high-level requirements.

The Vision document can be used to capture all of this information in a form that is accessible to all the stakeholders of the project.

The vision does not have to be complete before use-case modeling activities start; in fact, undertaking some initial use-case modeling can act as a driver and facilitation device for the construction of the vision itself, but if the vision is not established alongside the use-case model, then there is a strong possibility that it will not be a true reflection of the real requirements.

PART II

WRITING AND REVIEWING USE-CASE DESCRIPTIONS

Part I, Getting Started with Use-Case Modeling, introduced the basic concepts of use-case modeling, including defining the basic concepts and understanding how to use these concepts to define the vision, find actors and use cases, and to define the basic concepts the system will use. If we go no further, we have an overview of what the system will do, an understanding of the stakeholders of the system, and an understanding of the ways the system provides value to those stakeholders. What we do not have, if we stop at this point, is an understanding of exactly what the system does. In short, we lack the details needed to actually develop and test the system.

Some people, having only come this far, wonder what use-case modeling is all about and question its value. If one only comes this far with use-case modeling, we are forced to agree; the real value of use-case modeling comes from the descriptions of the interactions of the actors and the system, and from the descriptions of what the system does in response to the actions of the actors. Surprisingly, and disappointingly, many teams stop after developing little more than simple outlines for their use cases and consider themselves done. These same teams encounter problems because their use cases are vague and lack detail, so they blame the use-case approach for having let them down. The failing in these cases is not with the approach, but with its application.

The following chapters describe how to write use-case descriptions, how to manage detail, and how to structure the model to make it easier to understand. We also discuss how to review use cases, including how to organize and staff the reviews. The intent of these chapters is to reveal how the use-case descriptions unfold from the basic modeling effort and how the structure of the use-case model emerges from the contents of the use-case descriptions.

The goal of Part II is to equip you with the knowledge needed to write good use-case descriptions, managing detail appropriately and avoiding the pitfalls of too much or too little structure. Part II also represents a transition from a "group" style of working to a more solitary style. While it is best to identify actors and use cases as a group, it is impractical to write use-case descriptions as a group; writing is almost always principally an activity performed by one person, with reviews of the material conducted as a group. Finally, we conclude Part II with a discussion of how and when to review use cases.

So let's continue on our journey into the world of use cases.

Chapter 6

The Life Cycle of a Use Case

So far, we have seen the basic concepts behind the use-case modeling approach to eliciting and capturing software requirements and looked at how to get started in applying them. Before we look at the mechanics of authoring full use-case descriptions, we need to have a better understanding of the life cycle of a use case and how well-formed, good quality use cases can drive and facilitate the other, downstream software development activities. We also need to put what we have learned into a broader perspective with regard to software development and team working.

Use cases have a complex life cycle—they undergo a series of transformations as they mature through a number of development stages, from discovery to implementation and eventually to user acceptance. One way that this life cycle manifests itself is in the style and form adopted for the use-case descriptions. To speak of a single way of representing a use case is to miss the point—there are different presentation approaches and styles that are useful at different points in the use case's evolution. There is no one single form that is "better" in the absolute sense; they all play a role. This is why you will often see use cases expressed in different formats by different authors in different use-case texts.

Use cases also play a broader role, outside of the requirements space, in driving the analysis, design, implementation, and testing of the system. This is why you will also read about use cases being realized in design and tested by testers. Sometimes the use cases are so embedded in the design process of the system that the impression is given that the use cases are a development artifact rather than a requirements one. This misconception often leads to

developers trying to manipulate the use-case model in a misguided attempt to design the system using use cases.

To fully understand the role and purpose of use cases, and consequently the most appropriate form to use, we need to look at the life cycle of a use case from a number of different but complementary perspectives:

- Software development—how the use case is reflected throughout the full software development life cycle
- Use-case authoring—how the use case and its description evolves through the authoring process
- Team working—the activities involved in creating a use case model and how these impact on team and individual working practices

THE SOFTWARE DEVELOPMENT LIFE CYCLE

As well as facilitating the elicitation, organization, and documentation of requirements, use cases can play a more central and significant role in the software development life cycle. This is especially true for many of the object-oriented and iterative development processes for which use cases are recommended.

From a traditional object-oriented system model, it's often difficult to tell how a system does what it's supposed to do. This difficulty stems from the lack of a "red thread" through the system when it performs certain tasks.[1] Use cases can provide that thread because they define the behavior performed by a system. Use cases are not part of traditional object orientation, but over time their importance to object-oriented methods has become ever more apparent. This is further emphasized by the fact that use cases are part of the Unified Modeling Language.

In fact, many software development processes, including the Rational Unified Process, describe themselves as "use-case driven."[2] When a process employs a "use-case driven approach" it means that the use cases defined for a system are the basis for the entire development process. In these cases the life cycle of the use case continues beyond its authoring to cover activities such as analysis, design, implementation, and testing. This life cycle is shown,

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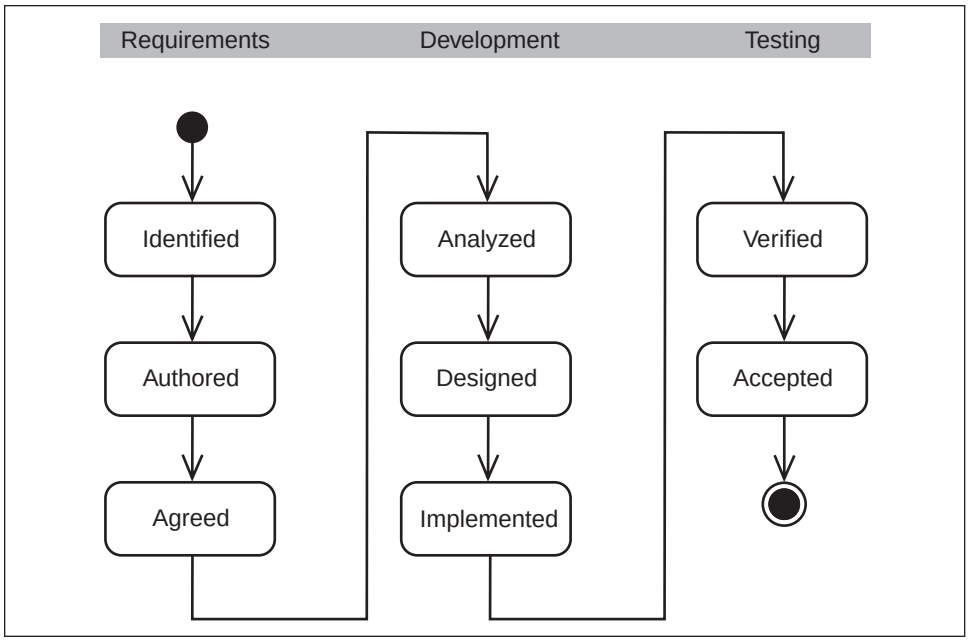
[1] Ivar Jacobson introduced the notion that use cases can tie together the activities in the software development life cycle; see *Object-Oriented Software Engineering, A Use-Case Driven Approach*, 1992, ACM Press.

[2] See, for example, Philippe *Kruchten's The Rational Unified Process: An Introduction* or Jacobson et al., *The Unified Software Development Process*.

Figure 6-1 The software development life cycle*



* This life cycle diagram is not intended to imply that analysis cannot be started until all the use cases have been agreed on or even until any use cases have been agreed on. The diagram is just saying that you cannot consider the analysis of a use case to be completed before the use case authoring has been completed and the use case itself agreed on.

in simplified form, in Figure 6-1. Figure 6-1 is arranged to emphasize the three main applications for the use cases:

- Requirements: the identification, authoring and agreement of the use cases and their descriptions for use as a requirement specification. This is the focus of this book.
- Development: the analysis, design, and implementation of a system based on the use cases. This topic is outside the scope of this book.[3]
- Testing: the use-case-based verification and acceptance of the system produced. Again, the details of how to undertake use-case-based testing is outside the scope of this book.

[3] For more information on using use cases to drive the analysis and design of software systems, we would recommend Doug Rosenberg and Kendall Scott's *Use Case Driven Object Modeling with UML: Practical Approach* and Craig Larman's *Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and the Unified Process*.

It is this ability of use cases to unify the development activities that makes them such a powerful tool for the planning and tracking of software development projects.[4]

To fully understand the power of use cases, it is worth considering this life cycle in a little more detail. Use cases can play a part in the majority of the disciplines directly associated with software development.

- **Requirements:** The use-case model is the result of the requirements discipline. Requirements work matures the use cases through the first three states, from Identified to Agreed. It also evolves the glossary, or domain model, that defines the terminology used by the use cases and the Supplementary Specification that contains the systemwide requirements not captured by the use-case model.
- **Analysis and Design:** In analysis and design, use cases are realized in analysis and design models. Use-case realizations are created that describe how the use cases are performed in terms of interacting objects in the model. This model describes, in terms of subsystems and objects, the different parts of the implemented system and how the parts need to interact to perform the use cases. Analysis and design of the use cases matures them through the states of Analyzed and Designed. These states do not change the description of the use cases, but indicate that the use cases have been realized in the analysis and design of the system.
- **Implementation** (also known as code and unit test or code and build): During implementation, the design model is the implementation specification. Because use cases are the basis for the design model, they are implemented in terms of design classes. Once the code has been written to enable a use case to be executed, it can be considered to be in the Implemented state.
- **Testing:** During testing, the use cases constitute the basis for identifying test cases and test procedures; that is, the system is verified by performing each use case. When the tests related to a use case have been successfully passed by the system, the use case can be considered to be in the Verified state. The Accepted state is reached when a version of the system that implements the use case passes independent user-acceptance testing. Note: If the system is being developed in an incremental fashion, the use cases need to be verified for each release that implements them.

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[4]If a project manager's perspective on use cases is desired, we recommend Walker Royce's *Software Project Management: A Unified Framework*.

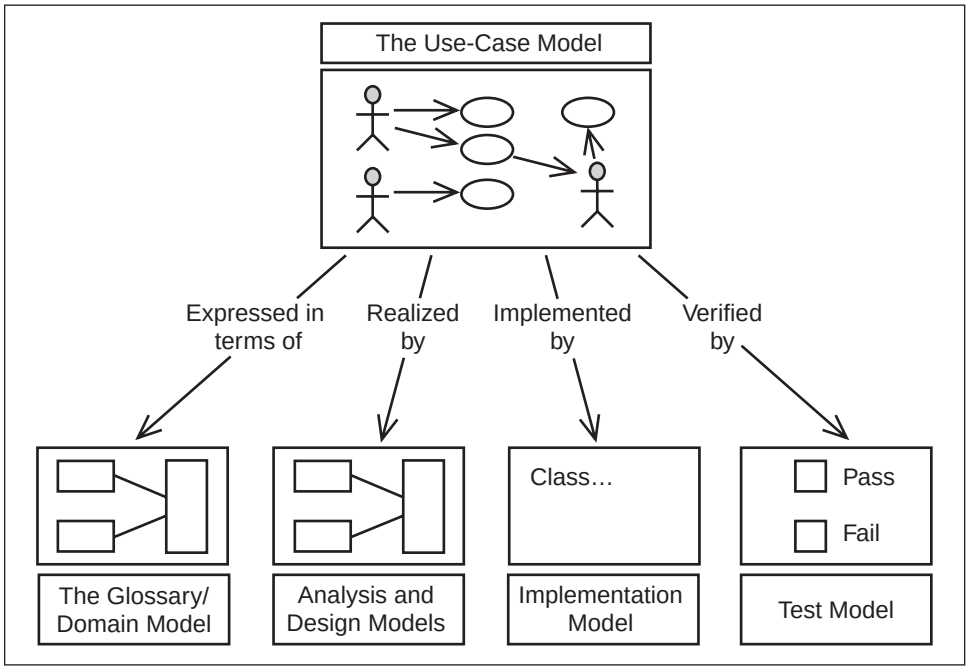
These relationships are directly reflected in the life cycle of the use case just described and are illustrated in Figure 6-2.

Use cases can also help with the supporting disciplines, although these do not impact upon the life cycle of the use cases themselves:

- **Project Management:** In the project management discipline, use cases are used as a basis for planning and tracking the progress of the development project. This is particularly true for iterative development where use cases are often the primary planning mechanism.
- **Deployment:** In the deployment discipline, use cases are the foundation for what is described in user's manuals. Use cases can also be used to define how to order units of the product. For example, a customer could order a system configured with a particular mix of use cases.

Although primarily a requirement-capture technique, use cases have a significant role to play in the ongoing planning, control, development, and testing of the system. It is this unification of the software development process that makes use cases such a powerful technique. To get the full benefit of

Figure 6-2 The use-case model and its relationship to the other software development models



using use cases, they should be placed at the heart of all the software development and project planning activities.[5]

THE AUTHORING LIFE CYCLE

Of more direct relevance to the people involved in the writing of use cases is having a clear understanding how the use case and its description evolves through the authoring process. We have seen the following use-case formats in use in various different projects and texts:

- Use cases that look like just brief descriptions—a short paragraph that describes something that the system does
- Use cases that look like outlines—a numbered or bulleted list of events and responses
- Use cases presented in the form of a table of actor actions and system responses
- Use cases that present a purely "black box" view of the system, focusing on the actions taken by the actor and the system's response
- Use cases presented as structured English, using sequential paragraphs of text and a more expansive, narrative form, like many of the examples presented in this book

There are also many different popular styles of use case, such as *essential use cases*[6] and *conversational style*[7] use cases.

What are all these use cases, and how do they relate to one another?

It is our contention that these are all just states in the evolution of a use case. Figure 6-3 provides a visual summary of the states of a use case during its evolution from its initial discovery to the production of its fully detailed and cross-referenced description. Each of these different forms is appropriate at different points in the evolution of a use-case model. Different use cases will evolve at different rates. It is not uncommon for an early version of the

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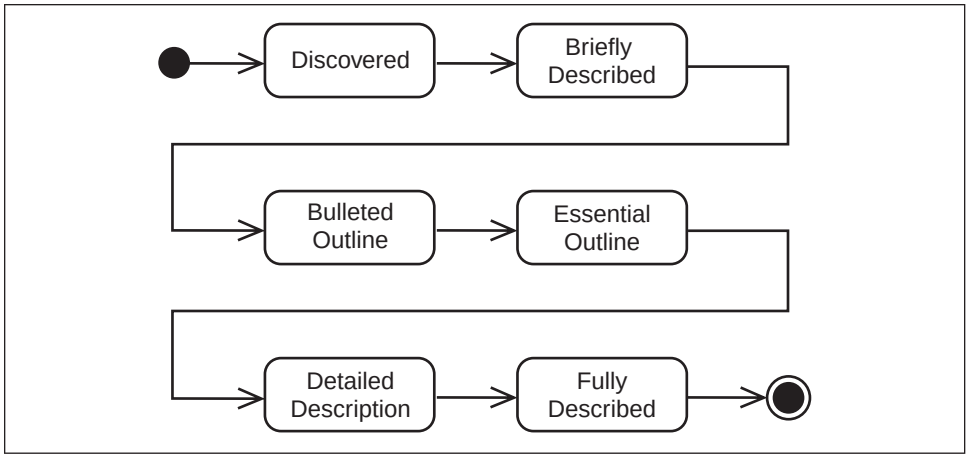
[5] For more information on how use cases can shape and drive the entire software development process, we would recommend the following texts:
- Philippe Kruchten, *The Rational Unified Process: An Introduction*
- Jacobson, Booch, and Rumbaugh, *The Unified Software Development Process*
- Jacobson, Christerson, Jonsson, and Overgaard, *Object Oriented Software Engineering: A Use Case Driven Approach*, the original books that popularized use cases.

[6] Larry Constantine is most often associated with this formulation of use cases; see L. Constantine, "The Case for Essential Use Cases," *Object Magazine,* May 1997. SIGS Publications.

[7] Rebecca Wirfs-Brock has notably promoted this technique; see R. Wirfs-Brock, "Designing Scenarios: Making the Case for a Use Case Framework," *Smalltalk Report,* Nov-Dec 1993.

Figure 6-3 The authoring life cycle*



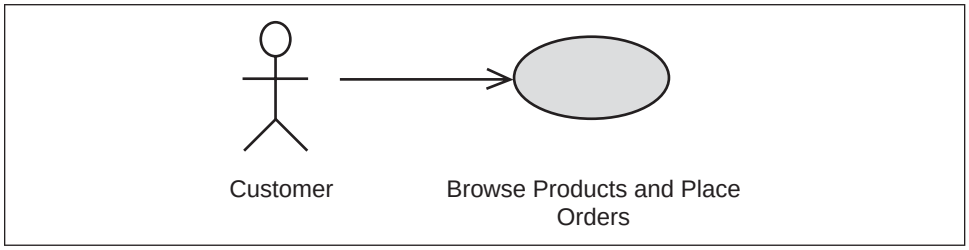
* The states shown in the authoring life cycle can be considered to be substates of Identified and Authored states in the software development life cycle shown in Figure 6-1. Discovered and Briefly Described are substates of Identified; the others are substates of Authored.

use-case model to contain a number of key use cases that are fully described and other, less important use cases that are still in the briefly described state or even awaiting discovery. It is worth taking a detailed look at each of these states, how they are manifested in the use-case description, and the role that they play in the evolution of the use case.

State 1: Discovered

A use case will begin as just a name (for example, *Browse Products and Place Orders*), perhaps on a diagram with an associate actor (for example, Customer), as in Figure 6-4. This name is a placeholder for what is to come, but if

Figure 6-4 A newly discovered use case.



this is as far as the description goes, it is not very useful. The use-case diagrams produced at this stage really act as no more than a visual index, providing a context for the use-case descriptions that are to come.

State 2: Briefly Described

Almost immediately, usually while the name is being discussed, people will start briefly describing the use case; typically, they can't help it. Even as a name is being proposed, people will start to elaborate on the name (for example: *This use case enables the customer to see the products we have to offer and, we hope, to buy them. While browsing, they may use a number of techniques to find products, including direct navigation and using a search facility.*) These discussions should be captured more formally as the brief description of the use case.

Example

Brief description for the use case *Browse Products and Place Orders* in an on-line ordering system

This use case describes how a Customer uses the system to view and purchase the products on sale. Products can be found by various methods, including browsing by product type, browsing by manufacturer, or keyword searches.

This brief description is important, and it may be as far as the use case evolves, especially if the required behavior is simple, easily understood, and can be expressed in the form of a prototype more easily than in words. But if the behavior is more complex, particularly if there is some defined sequence of steps that must be followed, more work is needed.

State 3: Bulleted Outline

The next stage in the evolution of the use case is to prepare an outline of its steps. The outline captures the simple steps of the use case in short sentences, organized sequentially. Initially, the focus is on the basic flow of the use case—generally this can be summarized in 5–10 simple statements. Then the most significant alternatives and exceptions are identified to indicate the scale and complexity of the use case. This process was discussed in detail in Chapter 4, Finding Actors and Use Cases, as it is an integral part of establishing the initial shape and scope of the use-case model.

Example

Outline for the use case *Browse Products and Place Orders*

Basic Flow

1. Browse Products
2. Select Products
3. Identify Payment Method
4. Identify Shipping Method
5. Confirm Purchase

Alternative Flows

A1 Keyword Search

A2 No Product Selected

A3 Product Out of Stock

A4 Payment Method Rejected

A5 Shipping Method Rejected

A6 Product Explicitly Identified

A7 Order Deferred

A8 Ship to Alternative Address

A9 Purchase Not Confirmed

A10 Confirmation Fails

etc….

Bulleted outlines of this form are good for getting an understanding of the size and complexity of the use case, assessing the use case's architectural significance, verifying the scope of the use case, and validating that the use-case model is well formed. They also provide a good basis for exploratory prototyping aimed at revealing requirement and technology-related risks.

If the use cases are to act as the specification of the system and provide a basis for more formal analysis, design, and testing, then more detail is required.

State 4: Essential Outline

So-called *essential* use cases are at another point in the use case's evolutionary timeline. Essential use cases focus on only the most important behavior of the system and leave much of the detail out (even omitting the mention of a PIN when describing the ATM's Withdraw Cash use case, for instance) in order to

focus on getting right what the system must do. This is important early in the use-case identification process, when it is easy to get mired in details that will become important later but are not essential to defining the system as a whole.

The defining characteristic of this format is that it presents a pure, external, "black-box" view of the system, intentionally focusing on its usability. The strength of this approach is that it places usability "front and center" and in so doing ensures that the needs of the user are placed first. This format helps describe user intent and actions, along with the observable response of the system, but it does not elicit details about what is happening inside the system. It also ignores the specifics of the user-interface (because this information is better and more easily presented in prototypes and user interface mock-ups). The description is often presented in a two-column format:

Example

The essential form of the use case *Browse Products and Place Orders*

User Action	*System Response*
1. Browse product offerings	Display product offerings
2. Select items for purchase	Record selected items and quantities
3. Provide payment instructions	Record payment instructions
4. Provide shipping instructions	Record shipping instructions
5. Complete transaction	Record transaction and provide receipt

The mistake made with essential use cases is forgetting that they will continue to evolve, adding detail and increasing in both scope and number, as the project progresses. Not every use case will pass through the Essential Outline state. Many use cases will progress straight from the bulleted outline to the more detailed formats, if they evolve beyond the bulleted outline form at all. Typically, the essential use-case form is used to provide an early embryonic description of the most important use cases in the system. The descriptions will then continue to evolve. You do not develop a set of essential use cases, then move on to a separate set of conversational use cases, and then move on to a another, different set of more detailed use cases. They are the same things at different points in their evolution.

Essential use cases are very effective for facilitating user-interface and user-experience analysis and design, especially where a system's visual metaphor needs to be established, typically early in the project's life cycle. Too much detail in the use cases often limits and constrains the creativity of the user-interface designers. The stripped-down essential outlines capture the essence of the required dialog without forcing the designers into any particular technology or mode of interaction. This allows them to start to explore the presentation

options for the system, which, once defined, may impact in turn on the style and level of detail adopted in the final-form, fully detailed use-case descriptions.

Some people recommend that use-case authoring stop at the essential outline state, but if the use cases are to be used to drive the other aspects of systems design, act as the basis for formal integration and system testing, or be used as the basis for contractual relationships, more detail is required.

State 5: Detailed Description

The next step in the authoring life cycle is to start adding to the outline the detail required to complete the specification of the system. In this state, the use case is evolving, as more and more detail is added to flesh out the outline. If the use case expresses a strong sense of a dialog between an actor and the system, then the description may be in the *conversational form*; otherwise, it will be in the *narrative form* and simply list the steps in order.

The Conversational Form

The conversational form of use-case description is most useful when the system and actor engage in a well-defined dialog in which the actor does something and the system does something in response.

Example

The conversational form of the use case *Browse Products and Place Orders*

User Action	*System Response*
1. Browse product offerings	Display product offerings, showing categories selected by the user
2. Select items for purchase	For each selected item in stock, record selected items and quantities, reserving them in inventory.
3. Provide payment instructions	Record payment instructions, capturing payment terms and credit card type, number, and expiration date using a secure protocol.
4. Provide shipping instructions	Record shipping instructions, capturing billing address, shipping address, shipper preferences, and delivery options.
5. Complete transaction	Record transaction and provide receipt containing a list of the products ordered, their quantity and prices, as well as the billing and shipping addresses and the payment terms. The credit card information should be partially omitted, displaying only the last 4 digits of the credit card number.

This *conversational* format is excellent for a number of situations: where there is only one actor and where the system and actor engage in an interactive dialog. It can be expanded to include a considerable amount of detail but will often become a liability. It is difficult to use when there is more than one actor (as often happens in real business systems) or when there is a simple actor action (like pressing on the brake pedal) with a complex response (such as controlling the antilock braking system).

The Narrative Form

The most common format for a detailed use-case description is the *narrative form*. In this form, the outline is again expanded by adding detail but the tabular format is replaced by a more narrative description.

Example

The narrative form of the use case *Browse Products and Place Orders*

1. The use case starts when the Customer selects to browse the catalogue of product offerings. The system displays the product offerings showing the categories selected by the Customer.

2. The Customer selects the items to be purchased. For each selected item that is in stock the system records the items and quantity required, reserving them in inventory.

3. The system prompts the Customer to enter payment instructions. Once entered, the system records payment instructions, capturing payment terms and credit card type, number, and expiration date using a secure protocol.

4. The system prompts the Customer to enter shipping instructions. Once entered, the system records the shipping instructions, capturing billing address, shipping address, shipper preferences, and delivery options.

5. The system prompts the Customer to confirm the transaction. Once confirmed, the system records the transaction details and provides a receipt containing a list of the products ordered, their quantity and prices, as well as the billing address, shipping address, and payment terms. Credit card information is partially omitted, displaying only the last 4 digits of the credit card number.

This format is more flexible, allowing the system to initiate actions and supporting the interaction with multiple actors if required. This is the format that we prefer, as it more readily supports the ongoing evolution of the use case into its final form and the use of subflows to further structure the text.

Using the Detailed Description

Regardless of the form chosen for the detailed description, it is a state that the majority of use cases will pass through as they evolve toward the fully detailed description. In fact, this is the state that most allegedly "completed" use cases are left in as the use-case modeling efforts run out of steam. Unfortunately, it is dangerous to evolve the use cases to this state only and not to complete their evolution. The detailed description loses the benefits of brevity and succinctness offered by the bulleted and essential outline formats and lacks the detail required of a fully featured requirements specification. We do not recommend to stopping work on the use cases when they have reached this state. If it is not necessary to evolve a use case to its full description, then stop at the outline format and don't waste time adding incomplete and ambiguous detail just for the sake of it.

State 6: Fully Described

The final state in the evolution of a use case is Fully Described. This is the state in which the use case has a complete flow of events, has all of its terminology fully defined in the supporting glossary, and unambiguously defines all of the inputs and outputs involved in the flow of events.

Fully described use cases are

- Testable—There is sufficient information in the use case to enable the system to be tested.
- Understandable—The use case can be understood by all of the stakeholders.
- Unambiguous—The use case and the requirements that it contains have only one interpretation.
- Correct—All of the information contained within the use case is actually requirements information.
- Complete—There is nothing missing from the use cases. All the terminology used is defined. The flow of events and all of the other use-case properties are defined.
- Attainable—The system described by the use case can actually be created.

Fully described use cases support many of the other software development activities, including analysis, design, and testing. One of the best checks of whether the use-case description is finished is to ask yourself if you could use the use case to derive system tests. The best way to tell if the use cases fit the purpose is to pass them along to the analysis and design team for analysis and the test team for test design. If these teams are satisfied that they can use the use cases to support their activities, then they contain sufficient levels of detail.

Example

An extract from the fully described use case *Browse Products and Place Orders*

Basic Flow

1. The use case starts when the actor Customer selects to browse the **catalogue of product offerings**.

{Display Product Catalogue}

2. The system displays the **product offerings** highlighting the **product categories** associated with the Customer's **profile**.

{Select Products}

3. The Customer selects a **product** to be purchased entering the number of items required.

4. For each selected item that is in stock the system records the **product identifier** and the number of items required, reserving them in inventory and adding them to the Customer's **shopping cart**.

{Out of Stock}

5. Steps 3 and 4 are repeated until the Customer selects to order the **products**.

{Process the Order}

6. The system prompts the Customer to enter **payment instructions**.

7. The Customer enters the **payment instructions**.

8. The system captures the **payment instructions** using a **secure protocol**.

9. Perform ***Subflow Validate Payment Instructions***

. . .

Note that this fully described use case uses the narrative format. If the use case has only one actor and the system and actor engage in an interactive dialog, then the conversational style could also be used.

As you can see, there is much more to be said about the formatting and authoring of fully described use-case descriptions. This is the subject of Chapter 7, The Structure and Contents of a Use Case; Chapter 8, Writing Use-Case Descriptions: An Overview; and Chapter 9, Writing Use-Case Descriptions: Revisited.

TEAM WORKING

Another interesting perspective on the life cycle of a use case is that related to team working and the activities that are undertaken to produce the use-case model. We have seen that use cases have an important role to play in the

software development life cycle and also have an authoring life cycle of their own. In Chapters 3, 4, and 5, we also looked at how the use-case model starts to emerge from the vision of the system via a series of workshops and other group-focused activities. In this section, we will look at the use-case modeling process and how this impacts on individual and team working.

You may wonder why we have saved this more formal look at the use-case modeling process for the second part of the book rather than presenting it earlier. Well, basically, we wanted you to have a good understanding of the concepts before we started to talk about all of the activities involved in creating a use-case model. So treat this section as part recap of what you have already learned and part teaser for what you will learn in Part II.

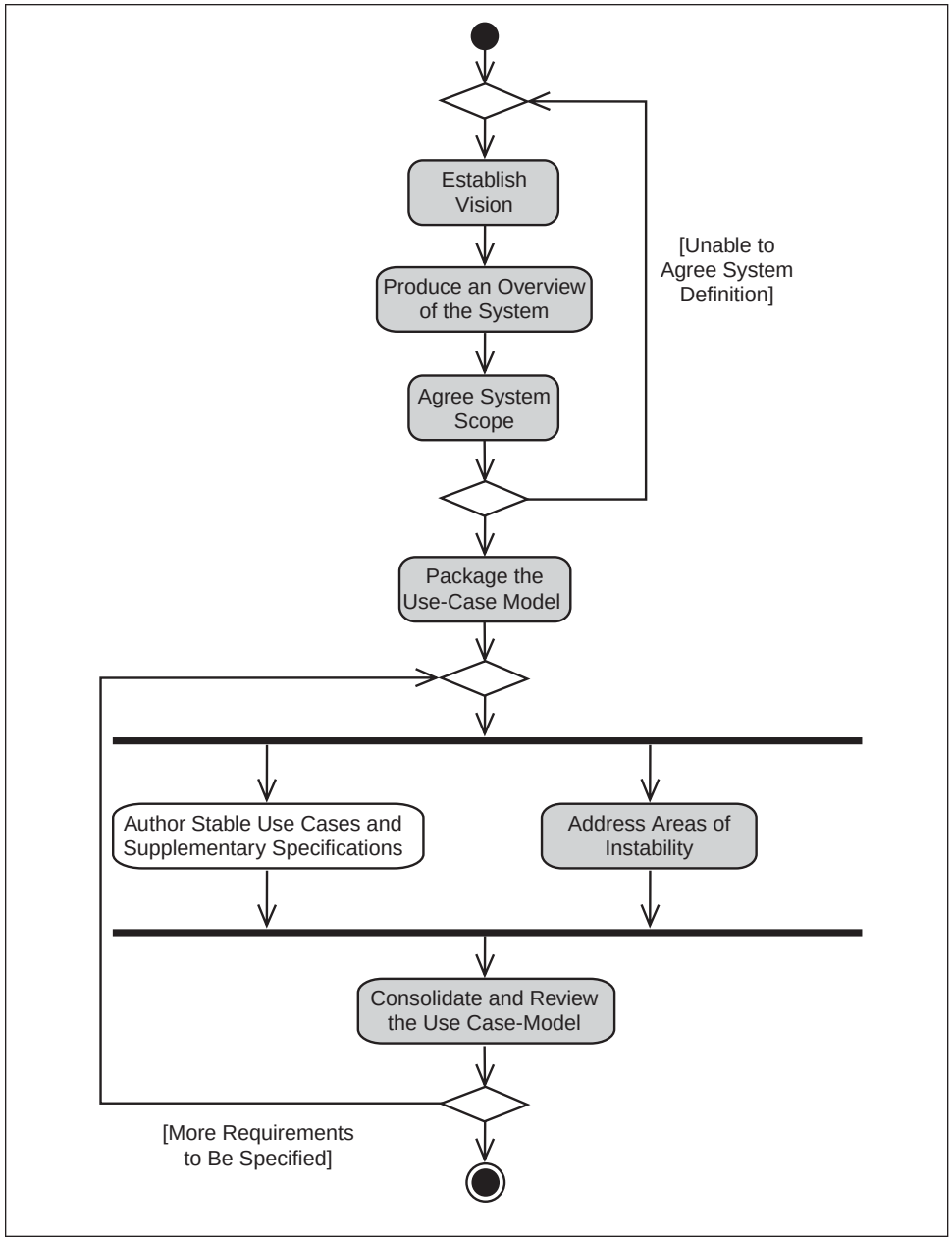
The Use-Case Modeling Process

Figure 6-5 illustrates the activities involved in the development of a use-case model. This is a simplified subset of a full requirements process[8] and emphasizes the major activities involved in the evolution of the use-case model, which is being used as the primary requirements artifact. It is interesting to look at this workflow from the perspective of group and individual activities. In Figure 6-5, the group activities are shown in gray and are focused on preparing the groundwork for the evolution of the use-case model and its supporting Supplementary Specification by establishing the vision, scoping the system, addressing areas of uncertainty and instability in the requirements definition, and consolidating and reviewing the use-case model as a whole. The diagram can give the wrong impression that the majority of the effort in use-case modeling is related to group activities and that the model can be accomplished by simply holding a series of workshops and brainstorming sessions with the user and stakeholder representatives.

In fact, more time is typically spent on the individual use case and Supplementary Specification authoring activities than is spent on all of the group activities put together. Figure 6-6 shows the relative amounts of effort expended on group and individual activities across the life of a project, which would typically iterate through the process many times. Note that the figure shows the relative amounts of effort and is not intended to be indicative of the total amount of effort required at any point in the project. The graph illustrates where healthy projects spend their time and should not be taken as a definitive statement. The amount of time the group activities will take is dependent on the ability of the group to focus and reach decisions. If all the

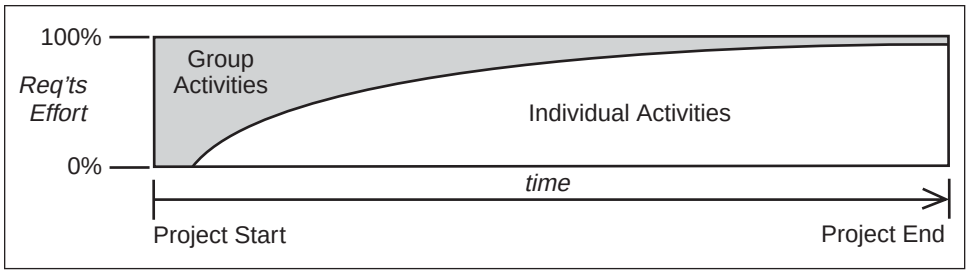
[8] For a fully documented Requirements Life Cycle that is seamlessly integrated with all of the other software development disciplines, see the Rational Unified Process.

Figure 6-5 The use-case modeling process*



* Note: The use-case modeling process is not as waterfall / linear as this figure may imply. If applying the process iteratively, then you only need agreement that a single use case is in scope and its purpose is stable before you start to author it; there is no need to have a full scope definition in place. This process can in fact be applied in every iteration, with just enough envisioning and scoping of the system to select the use cases to be worked on in the iteration.

Figure 6-6 Ratio of group and individual activities for a typical project



stakeholder representatives disagree with each other and spend all of their time fighting and arguing, the project may never achieve enough stability for it to be worth undertaking the authoring of the use cases. These issues were addressed in Part I: Getting Started with Use-Case Modeling. The amount of time that the individual authoring activities will take is dependent on the complexity of the solution and the capabilities of the individuals involved. These issues are addressed in more detail in Chapter 8, Writing Use-Case Descriptions: An Overview.

It is worth taking a detailed look at each of the activities shown in Figure 6-5 and the roles that use cases and the use-case model play in undertaking them.

Establish the Vision

Establishing the vision is a group activity aimed at getting all of the stakeholders to agree about the purpose and objectives for both the project and the system to be built. The best way to achieve this is to use traditional requirements-management techniques to produce a high-level system definition and to ensure that there is agreement on the problem to be solved. Typically, this is done via a series of workshops involving the project's major stakeholder representatives. This topic was covered in detail in Chapter 3, Establishing the Vision.

The use-case model can help in establishing the vision by defining the system boundary and providing a brief overview of the system's behavior, but it is really no substitute for a vision document. If this stage is skipped, then no real attempt is made to analyze the problem before starting on the definition of the solution. This is really only applicable for small-scale, informal, low-accountability projects with a very small set of stakeholders and where the developers and the users work very closely together. Without undertaking any problem analysis, it can be difficult to know when the use-case model itself describes a suitable solution.

Produce an Overview of the System

The initial use-case model, containing the key actors and use cases with brief descriptions and outlines, provides a very good overview of the functionality of a system. This should be complemented with an initial draft of the key Supplementary Specifications and an outline glossary or domain model. At this stage, there is no need to fully detail any of the use cases, although it is a good idea to have identified the majority of the significant alternative flows for each of them. We are just looking for enough information to allow the scoping of the system with regard to the current project. This activity is best done as a group activity in a series of use-case modeling workshops, as described in Chapter 5, Getting Started with a Use-Case Modeling Workshop, and using the techniques described in Chapter 4, Finding Actors and Use Cases.

Reach Agreement on System Scope

The next activity is to reach agreement on the scope of the system. To do this, the proposed use-case model needs to be examined in light of the vision and any other high-level requirements documentation produced as part of the project.

Use cases are a very powerful aid when attempting to manage the scope or the system. Use cases lend themselves to prioritization. This prioritization should be undertaken from three perspectives:

1. Customer Priority—What is the value placed on each of the use cases from a stakeholder perspective? This will identify any use cases that are not required by the stakeholders and allow the others to be ranked in order of customer priority.
2. Architectural Significance—Which of the use cases are going to stress and drive the definition of the architecture? The architect should examine the use cases and identify those use cases that are of architectural significance.
3. Initial Operational Capability—What set of use cases would provide enough functionality to enable the system to be used? Are all of the use cases needed to provide a useful system?

By considering these three perspectives it should be possible to arrive at a definition of system scope, and order of work, that satisfies all parties involved in the project.

If these three perspectives do not align (that is, the use cases the customer most wants are not those of architectural significance and do not form a significant part of a minimally functional system), then the project is probably out of balance and likely to hit political and budgetary problems. A lot of

expectation management would be required to bring these three perspectives into alignment and place the project on a healthy footing where the customer and the architectural goals are complementary rather than contradictory.

Beyond the use cases themselves, we can also use the flow-of-events structure for scope management. In most cases, the basic functionality of the majority of the use cases will be needed to provide a working system. The same cannot be said of all of the alternative flows. In the ATM system, is it really necessary to support the withdrawal of nonstandard amounts or the use of the secondary accounts associated with the card? In many use cases, the majority of the alternative flows will be "bells and whistles" that are neither desired by the customer nor necessary to produce a useable system. This will be discussed in more detail in Chapter 7, The Structure and Contents of a Use Case, when we discuss the additive nature of use-case flows.

Once the scope for the project has been agreed on, the use cases that have been selected for initial implementation can be driven through the rest of their life cycle to completion and implementation. If iterative and incremental development is being undertaken, then the use cases can be assigned to particular phases and iterations.

Package the Use-Case Model

As the scope of the system and the structure of the use-case model start to become apparent, it is often a good idea to package up the use cases and actors into a logical, more manageable structure to support team working and scope management. Using the UML, packages can be used to structure the use-case model.

The UML defines the package as

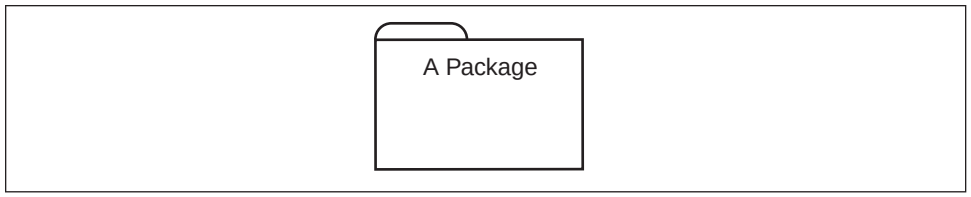
> A general-purpose mechanism for organizing elements into groups.

Graphically, the package is represented using a folder icon, as shown in Figure 6-7. In a use-case model a package will contain a number of actors, use cases, their relationships, use-case diagrams, and other packages; thus, you can have multiple levels of use-case packages (packages within packages), allowing the use of hierarchical structures where appropriate. Often, the use-case model itself will be represented as a package that contains all of the elements that make up the model.

There are many reasons for using use-case packages to partition the use-case model:

- To manage complexity. It is not unusual for a system to have many actors and use cases. This can become very confusing and inaccessible to the stakeholder representatives and developers working with the

Figure 6-7 The graphical representation of a package



model. A model structured into smaller units is easier to understand than a flat model structure (without packages) if the use-case model is relatively large. It is also easier to show relationships among the model's main parts if you can express them in terms of packages.

- To reflect functional areas. Often, there are families of use cases all related to the same concepts and areas of functionality (for example, customer service, operations, security, or reporting). Use-case packages can be used to explicitly group these use cases into named groups. This can make the model more accessible and easier to manage and discuss. It also helps to reduce the need for enormous "super" use cases that include massive sets of only loosely related requirements.
- To reflect user types. Many change requests originate from users. Packaging the use-case model in this way can ensure that changes from a particular user type will affect only the parts of the system that correspond to that user type.
- To support team working. Allocation of resources and the competence of different development teams may require that the project be divided among different groups at different sites. Use-case packages offer a good opportunity to distribute work and responsibilities among several teams or developers according to their area of competence. This is particularly important when you are building a large system. Each package must have distinct responsibilities if development is to be performed in parallel. Use-case packages should be units having high cohesion so that changing the contents of one package will not affect the others.
- To illustrate scope. Use-case packages can be used to reflect configuration or delivery units in the finished system.
- To ensure confidentiality. In some applications, certain information should be accessible to only a few people. Use-case packages let you preserve secrecy in areas where it is needed.

The introduction of use-case packages does have a downside. Maintaining the use-case packages means more work for the use-case modeling team, and the use of packaging means that there is yet another notational concept

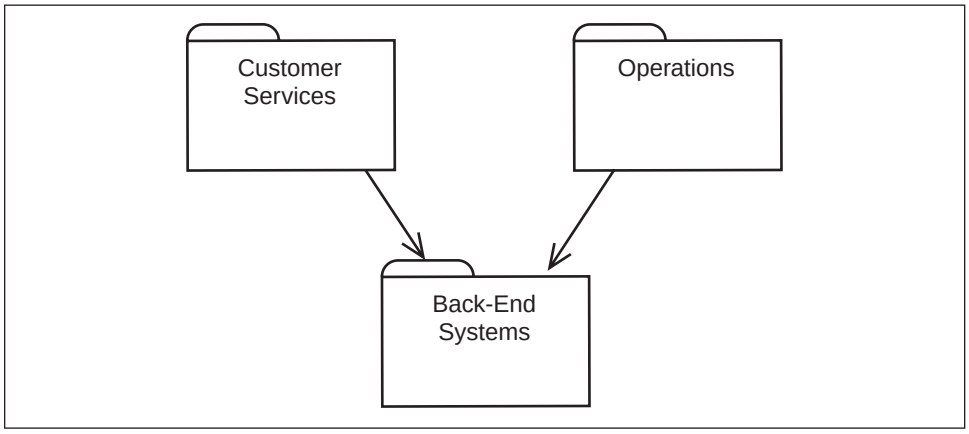
for the developers to learn. As the need for packaging is directly related to the size and complexity of the use-case model, this is an optional activity and may be skipped for smaller models.

If you use this technique, you have to decide how many levels of packages to use. A rule of thumb is that each use-case package should contain approximately 3 to 10 smaller units (use cases, actors, or other packages). The following list gives some suggestions as to how many packages you should use given the number of use cases and actors. The quantities overlap because it is impossible to give exact guidelines.

- 0–15: No use-case packages needed.
- 10–50: Use one level of use-case packages.
- > 25: Use two levels of use-case packages.

Packages are named in the passive, as opposed to the active names used for the use cases themselves, typically representing some area of the system's functionality or some organizational element of the business that is going to use or support the system. For example, the ATM functionality could be split into two packages, Customer Services and Operations, both of which are supported by the back-end banking systems, as shown in Figure 6-8. The dashed arrows are UML dependency relationships, which, in this case, indicate that model elements in the Customer Services and Operations packages access model elements in the Back End Systems package. This allows us to see how independent the packages are from one another, which is essential if the packaging is to support team working and model management. Packages are a

Figure 6-8 A possible package structure for the ATM use-case model



standard UML model element and are not any different for use-case models than they are for any other UML model.[9]

Once the packaging has been put in place, it is usually difficult to change without causing great disruption to the people working with the model. For this reason, it is not advisable to attempt the packaging too early in the evolution of the use-case model. Packaging the model is again primarily a group activity that is undertaken, with the help of the stakeholder representatives, as part of the final use-case modeling workshop or review.

Address Areas of Instability and Author Stable Use Cases and Supplementary Specifications

Once the scope of the system has been established and the use-case model structured to facilitate the further development of the use cases, we are faced with two parallel activities:

1. The detailed authoring of the requirements for those areas of the model where there is stability. This is an individual activity and is the subject of Chapter 8, Writing Use-Case Descriptions: An Overview, and Chapter 9, Writing Use-Case Descriptions: Revisited. It is in the authoring of the detail that most of the effort related to use cases is expended.
2. Continuing to run additional workshops to address those areas where there is still instability in the use-case model. This entails running use-case modeling workshops (as described in Chapter 5, Getting Started with a Use-Case Modeling Workshop) with more detailed objectives and a more specialized selection of stakeholder representatives.

Typically, when the use-case model is being constructed initially, there will be some areas of the model with which everybody agrees and others where consensus is harder to reach during the early project brainstorming and use-case modeling workshops. There is no need to wait for agreement on every area of the use-case model before proceeding to the authoring of detailed use-case descriptions. Once agreement has been reached that a use case is required, it can be driven through the authoring process to produce the fully detailed description and through the software development process to facilitate the design and implementation of the software. It is counterproductive to start doing detail work for use cases whose scope, purpose, and intention are still under debate. To evolve these beyond the essential outline stage

[9] For more information on packages and package relationships, we would recommend the *Unified Modeling Language User Guide* by Booch, Rumbaugh, and Jacobson.

is likely to cause large amounts of scrap and rework. The level of detail provided by the outlines should be sufficient to allow scoping and other decisions to be made.

The first use cases to stabilize and then proceed through the authoring process should be those of architectural significance, those that explicitly help to attack project risk, and those essential to the initial release. Once the authoring of any of these use cases is complete, they should be passed over to the designers so that they can progress through the rest of the software development life cycle. In the same way that there is no need for all the use cases to have been identified and outlined before detailed authoring starts, there is no need for all the use cases to have been authored before analysis, design, and the other downstream activities start. It is our recommendation that use cases be passed on to the other project teams as soon as they become available. This allows the downstream activities to start as soon as possible and will provide the use-case authors with the immediate feedback on their work that they can use to improve the quality of the use-case model as a whole.

Consolidate and Review the Use-Case Model

As the use cases, the Supplementary Specifications, and the use-case model evolve, it is worth taking some time to consolidate and review the team's work as a whole. This should be a group activity and should focus on achieving consistency and completeness across the whole of the requirements space. This is also the time when you may want to do some more detailed structuring of the use cases themselves. These topics are covered in more detail in Chapter 10, Here There Be Dragons, and Chapter 11, Reviewing Use Cases. It is also worthwhile to check the detailed requirements work against the vision for the system to make sure that they have not diverged as the use-case model has evolved.

These suggestions are not intended to imply that all of the use cases are to be reviewed in one go at the end of the process. Walkthroughs and reviews are an essential part of the authoring process, as we shall see in Chapter 11, Reviewing Use Cases. Here we are talking about looking at the model as a whole rather than at the individual use cases.

SUMMARY

There is a common misconception that use cases have one form or can be stated in only one way. Practitioners are therefore confused when they see use cases stated in different ways. Many of the differences between use cases stem

from the fact that a use case has a life cycle, and it will take different forms at different points in that life cycle.

The life cycle of a use case can be considered from many perspectives. It is important that people working with use cases understand the life cycle from the broader team working and software development perspectives as well as the use-case authoring perspective.

For the purposes of this book, the most important life cycle is use-case authoring. Initially, use cases begin as drawings that show the use cases and the actors who interact with the system during the use case. The use cases are little more than "ovals" and very terse names. This is sufficient for identification, but not much more. Very quickly, however, they evolve into brief descriptions, short paragraphs that summarize the things that the use case accomplishes. This brief description is sufficient for clarification, but more is still needed. The brief descriptions quickly give rise to outlines of the flows of events. Initially, these are just bulleted lists illustrating the basic flow and identifying the significant alternative flows. These bulleted outlines give an indication of the size and complexity of the use cases and are very useful for initial prototyping aimed at revealing requirements and technology-related risks.

For user-interface-intensive systems, the flows are often elaborated to cover the important things the user sees and does when interacting with the system. These "essential" use-case outlines are the primary drivers of the user interface's design. This level of description, while more than sufficient for users and interface designers, is greatly lacking for software developers and testers.

Additional evolution adds more information about the internal interactions, about testable conditions, and about what the system does, providing a more complete picture of the behavior of the system. These complete descriptions drive the development and testing of the system.

It's important to keep in mind that these are not "different" use cases, but the same use case from different perspectives and at different points in time. This "unified" view makes understanding and employing use cases easier.

The key to deciding how detailed to make your use cases is to consider two factors:

1. How unknown the area of functionality covered by the use case is. The more unknown, misunderstood, and risky the functionality described by the use case, the more detail is required.
2. What use is to be made of the description. It is very difficult to know when the use-case descriptions are complete if the downstream activities that the use cases are going to support are not also understood.

The following table summarizes the purpose, risks addressed, and downstream activities for each of the use-case authoring states:

Authoring State	Primary Purpose	Risks Addressed	Downstream Activities
Discovered	Identify the use case	• Not knowing the boundary of the system	• Scope management
Briefly Described	Summarize the purpose of the use case	• Ambiguity in the model definition	• Scope management
Bulleted Outline	Summarize the shape and extent of the use case	• Not knowing the extent, scale or complexity of the system • Not knowing which use cases are required	• Scope management • Low-fidelity estimation. • Prototyping aimed at addressing requirements and technological risks.
Essential Outline	Summarize the essence of the use case	• Ease of use	• User interface design • Prototyping aimed at addressing requirements and technological risks
Detailed Description	To allow the detail to be added incrementally	• None—it is not recommended that use cases in this state be used outside of the authoring team	• None—this is purely an intermediate step.
Fully Described	Provide a full requirements specification for the behavior encapsulated by the use case	• Not knowing exactly what the system is supposed to do • Not having a shared requirements specification	• Analysis and design • Implementation • Integration testing • System testing • User documentation • High-fidelity estimation

Top Ten Ways Project Teams Misuse Use Cases -- and How to Correct Them

Part II: Eliciting and Modeling Use Cases

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Use cases are a favorite way to describe the desired functionality of a software system under development. But creating use cases is by no means a foolproof process. In my many years of facilitating software development teams, I've encountered many cases of what I call (tongue firmly in cheek) "use case abuses" -- misuses and mistakes teams make when documenting and developing use cases. This article is the second in a two-part series that focuses on my own top ten list of "Misguided Guidelines" teams use for creating use cases.

Part I, published in the June issue of The Rational Edge, *examined ways to correct the first six of these erroneous "guidelines," which relate to use case form and content. In this issue, I explore the remaining four mistakes and misuses, which revolve around the process of eliciting and modeling use cases.*

Here's a quick recap of those "Ten Misguided Guidelines":

1. Don't bother with any other requirements representations. (Use cases are the only requirements model you'll need!)
2. Stump readers about the goal of your use case. (Name use cases obtusely using vague verbs such as *do* or *process*. If you can stump readers about the goal of a use case, then whatever you implement will be fine!)
3. Be ambiguous about the scope of your use cases. (There will be scope creep anyway; you can refactor your use cases later. Your users keep changing their minds, so why bother nailing things down?)

4. Include nonfunctional requirements and user interface details in your use-case text.
   (Not only will this give you a chance to sharpen your technical skills, but also it will make end users dependent on you to explain how things "really work.")
5. Use lots of extends and includes in your initial use-case diagrams.
   (This allows you to decompose use cases into itty-bitty units of work. After all, these are part of the UML use-case notation, so aren't you supposed to use them?)
6. Don't be concerned with defining business rules.
   (Even if they come up as you elicit and analyze use cases, you'll probably remember some of them when you design and code. If you must, throw a few into the use-case text. You can always make up the rest when you code and test.)
7. Don't involve subject matter experts in creating, reviewing, or verifying use cases.
   (They'll only raise questions!)
8. If you involve users at all in use-case definition, just "do it."
   (Why bother to prepare for any time with the users? It just creates a bunch of paperwork, and they keep changing their minds all the time, anyway.)
9. Write your first and only use-case draft in excruciating detail.
   (Why bother iterating with end users when they don't even know what they want, and they only want you to show them meaty stuff, anyway?)
10. Don't validate or verify your use cases.
    (That will only cause you to make revisions and do more rework, and it will give you change control problems during requirements gathering. So forget about it!)

If you recognize yourself in any of the last four "guidelines," you're not alone. Fortunately, there are some ways -- many of them surprisingly easy, all of them time-tested -- to avoid falling into these traps.

Correcting Misguided Use-Case Modeling Guidelines

Let's start with one mistake many teams make: trying to construct use cases without the help of the people who ultimately need and use the software.

7. Don't Involve Subject Matter Experts in Creating, Reviewing, or Verifying Use Cases.

One way to play Russian roulette with your requirements is to define them without user input. "Users" is a broad term that includes:

- *Direct end users* who will interact directly with the system (human actors).

- *Business subject matter experts* who have content knowledge but may not also be direct end users.
- *Customers* who sponsor the development project with resources. For commercial and business systems software, customers are the people or organizations who commission a software project. For shrink-wrap software, customers are end users of the software or perhaps buyers who might not interact directly with the software.

It can be hard to figure out how to implement a cost-effective system for involving users. Each category of users has insights into user requirements, yet it often seems that they are all too busy, uncommitted, or inaccessible to the project. If you're having trouble getting good feedback, it's time to rethink your user involvement strategies. First, consider what you've done in the past as an opportunity to learn what does *not* work in terms of getting user and customer involvement. After all, as Albert Einstein (or Benjamin Franklin, depending on which authority you consult) once quipped, "The definition of insanity is doing the same thing over and over and expecting different results." Don't assume various user classes are inaccessible. Instead, invent creative ways to involve them in your requirements process. Don't get stuck with elegant but inaccurate use cases. After all, user requirements should describe what users really need and not the project team's interpretation of possible needs.

To mitigate requirements risks on one project, I helped the development team conduct a chartering (start-up) workshop that included risk analysis. Participants generated a list of requirements risks, ranked them, and then identified risk mitigation strategies for the high-probability, high-impact risks. One such risk was lack of access to the "real" subject matter experts. It turned out that the best strategy was one we had already employed: inviting the project sponsor and stakeholders to the workshop. When these people saw the likely outcome if experts did not fully participate in the requirements work, they came up with several creative approaches. For example, they changed the timing of monthly reports to give the experts time to participate in requirements elicitation, offloaded some work to mid-level experts to expand their skills, and shifted the timing for requirements workshops to permit business experts to handle high-priority issues at the start and end of each workshop day.

How much user participation do you need? At a minimum, end users should verify requirements by doing use-case walkthroughs. Scenarios -- sequences of behaviors or example uses of a use case -- are the best way to conduct a walkthrough, especially if the end users have developed the scenarios. Even if they can't be involved in ongoing use-case specification, they can help you fix and evolve the use cases during that hour or two walkthrough.

Another approach is to engage subsets of customers: *sponsors* (who allocate resources to the development effort) and *champions* (who keep the project alive and people motivated) to help increase end-user involvement. To do that, take the pause that refreshes -- do a requirements debrief (also called a retrospective). Gather your team to assess your most recent requirements work. Seek to understand what

happened during requirements -- the good, the bad, and the ugly -- including how customers and users were (or weren't) involved. After learning about what worked, what didn't work, and what could be improved, name specific actions that you can take to do better next time. Then present this list to your managers and get their support. If managers and stakeholders don't participate in the debrief, then invite them to a brief presentation of your findings.

If you're developing commercial software, it is worth doing whatever it takes to gain access to your true end users. A big concern for requirements in these projects is a possible disconnect between what real end users need and want and what surrogate users *think* end users will need and want. In general, it's not a good idea to develop detailed use cases before doing some reality checks with real end users. Try to get them to commit to a session in which you can conduct reviews or walkthroughs with them, or show them early prototypes.

If you simply can't get the customer's time, then product managers can serve as stand-ins for end users. They can conduct focus groups to get feedback on draft user requirements -- or prototypes -- for some scenarios covered by your draft use cases. Or, you can ask knowledgeable business people in the marketing organization to role-play representative end users, inventing names and personal backgrounds for each person to make the role play experience more realistic. One commercial vendor conducted requirements workshops with its top three customers at each of the customers' respective locations, and promised those companies that they would be beta site customers. This was a win for both parties.

How can you use users' time most effectively? The users themselves can help you figure that out. As you attempt to involve them more fully, periodically solicit their feedback about how the process is working for them. Tell them what you need for the requirements development process to be successful, explaining the risks associated with insufficient user involvement. This will allow both of you to adjust your interactions and build sound and trusting relationships.

Now, on to the next common mistake.

8. If You Involve Users at All in Use-Case Definition, Just "Do It."

User requirements don't come from thin air. As you begin use-case modeling, there is always *something* to start with, even if it's a simple business goal statement or objective jotted on a napkin, a context diagram reverse-engineered from an existing system, or a list of customer complaints and change requests.

As a starting point, you need to draft some requirements models, even if they're wrong or incomplete, before gathering users together. These draft models should look rough and unfinished, inviting users to fix and elaborate on them. Low fidelity tools such as whiteboards, poster boards, and walls with sticky notes or cards pinned to them are good ways to do initial documentation for user requirements.

Draft models are a solid basis for asking focus *questions*, queries that direct people's attention to a specific topic. These questions give you the information you need to generate, evaluate, filter, elaborate, and verify the content of your models. For example, suppose you've drafted an actor table or map, and now you want to name use cases. Your focus question would be, "What goals does this actor have for interacting with the system?"

Use a variety of starting models, combining text and diagrams if possible. For example, you might start with a use-case list and an actor map, a context diagram and an event table, a list of stakeholder classes and a workflow (process map) diagram, or an analysis class model and some scenarios. Remember to pick models that fit the business problem domain (see the discussion of Misguided Guideline #1 in Part I of this series, published in the June issue of *The Rational Edge*).

Using multiple models (also discussed in Part I) helps you to quickly get details for your entire requirements set. For example, suppose you're using a high-level domain model or a statechart diagram. Focus questions for those models might be, "What do you do with <domain> to get your work done?" and "What system interactions are needed when the <domain> is <in statename> (e.g., "What do you need to do when claims are pending?").[1]

Be sure the right people are working with your user community. Requirements work is difficult and takes certain skills and proclivities, including the ability to listen, question, and abstract, as well as a genuine interest in people's work life, a sense of curiosity, and a tolerance for ambiguity. If team members working on requirements lack these skills, then seek training and mentoring for them or grow requirements expertise in others who have natural skills.

Let's examine another common error.

9. Write Your First and Only Draft in Excruciating Detail.

You can specify use cases using various forms and formats and with varying degrees of precision. To write highly detailed use cases, start with high-level descriptions and then provide greater detail iteratively, after you clarify each use case and ensure that it is important to the project. This strategy will save you unnecessary work, allow you to correct defects along the way, and speed your overall requirements effort.

Table 1 shows some sample use-case forms. Note that the level of complexity increases as you move down the table.

Table 1: Possible Use-Case Forms and Formats

Text Format	Visual Format
Use-case name only ("verb + [qualified] object")	Use-case diagram (ovals and Actors icons, à la the Unified Modeling Language, or UML)
Use-case name plus single sentence goal statement	Same as above
Use-case brief paragraph description (three to six sentences explaining what the use case does)	Use-case dependency diagram (UML ovals with dependency notation[2])
Sequence format (use-case header information plus a list of ordered steps)	Use-case flow or steps (activity diagram, flowchart, process map)
Conversational format (use-case header information plus two columns -- one for Actors and one for system responses -- written in a conversational style)	Use-case flow or steps (sequence diagram -- with an Actor class, activity diagram, flowchart, process map)

Here's an effective way to plan your iterations.

- First, decompose your various requirements models into their component parts. For example, a use-case paragraph is part of a complete use-case description, and data attributes are part of an analysis class model.
- Next, group these component parts at roughly the same level of detail. For example, business rules written using a business rule template would group with the sequential or conversation format use case and a fully attributed data model.
- Deliver these groups in chunks, or iterations, verifying each iteration with your development team or users in use-case reviews, walkthroughs, or prototype walkthroughs before beginning the next iteration.

This approach lets you correct requirements and adjust the process itself as you develop the requirements.

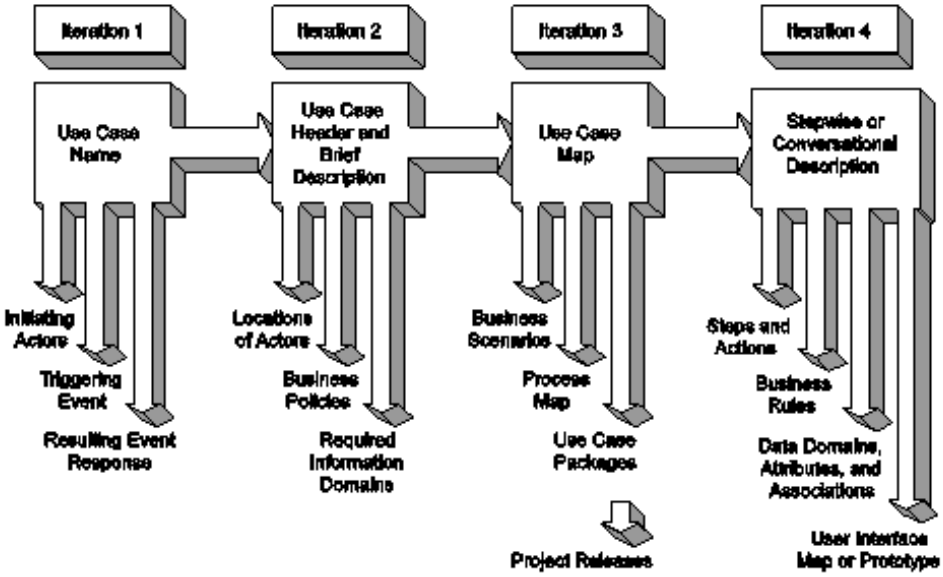

Figure 1: Iteratively Delivering Detailed Use-Case and Related Requirements Models

Figure 1 shows an example of a top-down path through your user requirements. I find that three or four iterations works best, so this one shows four iterations.

1. In Iteration 1, you discover use cases (and name them well!) and related scope-level requirements.
2. In Iteration 2, you define the use-case header and write a one-paragraph description of each use case. You also list the physical locations of the actors, associated business policies, and a high-level domain model (class model or data entities).
3. In Iteration 3, participants create a use-case map, which shows the sequence of use-case execution. At this point, you understand enough about the requirements to logically group the use cases into packages, forming cohesive use-case sets. These sets, in turn, should be prioritized and used to define releases or increments for delivery.
4. Finally, in Iteration 4, you rework the use cases by listing their steps, defining the business rules associated with each step, naming the data attributes needed by the steps and their rules, and sketching user interface prototypes for each use case.

For one use case, this set of iterations can take minutes to hours to define, depending on the use case's complexity and the knowledge of the people doing the work. To keep your momentum going, decide ahead of time how you will reach closure on the each iteration, and bite off the most important use cases first.

Creating a high-level, first-cut set of use cases can often give you enough

information to prioritize user requirements. You can then elaborate on only the most important use cases -- or those that are most unclear and therefore pose special risks. In the end, this can help you avoid requirements scope creep and optimize the time you devote to requirements development by spending it wisely on use cases that matter. It also enables you to avoid rework that might result from going down the wrong path.

Compiling a survey of use cases before you detail them is particularly helpful if you have a large project with multiple teams working concurrently on the system. The teams should work through the use case and related requirements at roughly the same level of precision, periodically regrouping to review each other's requirements to find shared requirements and avoid duplication of effort.

Calibrate the level of desired detail for use cases according to the project's needs. Alistair Cockburn[3] aptly points out that more correct and complete documentation is necessary on projects with a large number of team members producing mission-critical software with nondiscretionary funds. Factors to consider when deciding how detailed to go include:

- Project size (the number of people who have to be coordinated).
- Criticality of the software (human lives or simply human comfort at stake).
- Project priorities (Are the funds at stake essential or discretionary?).
- Project velocity (Are you driven by time as opposed to cost or functional scope?).
- Project team's familiarity with the problem domain.
- Project team's familiarity with use cases.

If the developers really know the domain and speed is of the essence, then a set of use-case names each with three to six sentences each will do. On the other hand, software governing such systems as airline cockpit controls, missile guidance, or human clinical trials must be precise and well documented. Decide how much detail you need and plan your iterations accordingly.

Finally, here's the last common mistake.

10. Don't Validate or Verify Your Use Cases.

Validation involves checking your use case for necessity, to ensure that your project is delivering the right functionality. Crosscheck each use case to be sure it satisfies one or more elements of your project vision or goals and objectives. *Verification* involves testing your use cases for correctness, completeness, clarity, and consistency, to ensure that you created the right thing. By "testing" I don't mean doing something on a computer after you write test scripts and build test data. Instead, you should challenge your use cases using other requirements models, such as scenarios, or by

using walkthroughs and reviews. Be sure to involve testers and quality analysts throughout requirements elicitation.

Scenarios are one of the most effective ways to test (and elicit) use cases. As you iterate through your use cases, try to test them with scenarios that business users have generated. Walk through each use case, beginning with the *happy case* (ideal) scenarios. Then move on to the *unhappy case* (error and exception) scenarios involving business rules violations.

In one project, we conducted several such one- to two-hour customer walkthroughs of use cases during requirements development. Because we didn't want to bog down this larger group with detailed use-case text, we walked through the scenarios using rough screen shots of the interaction flow. Participants had created the scenarios earlier, in short meetings with the primary subject matter expert, who was also a team member. Another team member adjusted the use-case text, business rules list, and domain model, as our lead designer walked through the scenario-driven prototype screens.

On another project, the project team generated test cases at the same time as use cases. The final use-case workshop then became a walkthrough session, in which participants led each test case through the use cases to see if the system functionality met expectations.

Another approach to validation is *peer reviews*: short meetings that focus on a work product, such as a set of use cases and related requirements models, to improve it and remove errors.[4] For these sessions to be successful, reviewers must prepare by individually checking the work product beforehand. Give them quality assurance (QA) checklists or questions that might help them find errors. For example:

- For each event in our event table and context diagram, is there at least one associated use case?
- Which use case handles each scenario?
- What states does this use case cover?
- For each use-case step, have all the business rules been defined?
- What data is needed to support those business rules?

The questions should suit the models you employ and their levels of detail.[5]

A complement to peer reviews is *perspective-based* reviews,[6] which invite various concerned parties -- perhaps specific actors, a tester, a designer, a help desk technician -- to examine the use cases from their unique perspective. Testers and quality analysts should also be active participants in your use-case modeling process. On one project, our test lead used our use-case templates as the basis for developing and documenting test cases. During our modeling sessions, he asked questions that helped us uncover missing data attributes and business rules. Involving testers and QA experts encourages a "test first" approach to requirements development, which yields higher quality requirements from the start.

Finally, do your best to get business experts to participate in your walkthroughs and reviews. In their absence, surrogate users, such as product development managers or business-savvy developers, can role-play being end-users and uncover important defects.

Using any or all of these verification techniques will help you find errors in your requirements that you might otherwise detect much later -- when they cost much more to correct.

The Case for Use Cases

Use cases are a wonderful way to define behavioral requirements for your software. In your zest to use them, however, don't fall into the trap of turning them into abuse cases. If you're guilty of following any of my ten "misguided guidelines," then it's time to reform your process and make your requirements effort more efficient and productive.

Here are some specific actions you can take:

- Use multiple models to represent requirements, and trace each to the other to maintain associations.
- Create strongly named use cases,[7] and don't rely solely on use-case diagramming elements to describe the use case (see Table 1).
- Proactively specify business rules as distinct requirements associated with your use cases, and keep nonfunctional requirements and GUI constructs out of your use-case text.
- Find ways to engage users in developing use cases and plan your time with them. Begin with draft requirements models and pose focus questions to see how well the models match users' actual requirements.
- Plan and follow an iterative use-case development process, beginning with rough-cut use cases. Prioritize the use cases as you go.
- Verify that each use case really belongs within your project scope. Continue to use checklists and conduct periodic reviews with users and project team members to verify that each use case is still necessary. Carefully control the scope of valid use cases.

The time you spent on developing and managing requirements and use cases is just a small part of your overall development effort, yet it can have a huge impact on the quality of your end product. By working to transform your habitual mistakes into positive actions, you can make your use cases a powerful means for delivering what your user community really needs.

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Notes

[1] For a comprehensive list of focus questions you can ask to elicit a requirements model by starting with an existing model, see the requirements workshop asset titled "Focus Questions for Modeling Tasks " on my Web site: http://www.ebgconsulting.com/reqtsbycollab.html.

[2] See: http://www.ebgconsulting.com/publications.html, section "Use Cases" for an example.

[3] See Alistair Cockburn, *Agile Software Development*. Addison-Wesley, 2002.

[4] See Karl Wiegers, *Peer Reviews in Software: A Practical Guide*. Addison-Wesley, 2002.

[5] For a more complete list of questions, see "QA Checklist for Checking the 'Doneness' of Requirements Models" on my Web site: http://www.ebgconsulting.com/ReqtsByCollab.html

[6] See Forrest Schull, Ioana Rus, and Victor Basili, "How Perspective-Based Reading Can Improve Requirements Inspections," *IEEE Computer*, 2000, vol.33, no. 7, pp. 73-79.

[7] See "Misguided Guideline #2" in the list above, the use-case naming guidelines in Part I of this series, published in the June 2002 issue of *The Rational Edge* (http://www.therationaledge.com/content/jun_02/t_misuseUseCases_eg.jsp) and also Leslee Probasco's advice in the March 2001 issue of *The Rational Edge* (http://www.therationaledge.com/content/mar_01/t_drusecase_lp.html).

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Software, Refreshingly Simple

by **Joe Marasco**
Senior Vice President and General Manager
Rational Software

In this issue, I address the pesky problem of upgrading software in a certain class of device: those that are handheld, mobile, wireless, and fairly lightweight. Amongst them we find cell phones, personal organizers, GPS receivers, digital cameras, and various combinations thereof. They all have embedded software, some programmable memory, and batteries. They may or may not communicate with other devices.

This class of device is increasingly important, and its members are proliferating, for at least two reasons. In the first place, every product that is designed for personal portability tends to get smaller over time; and as the benefits of their functions (for instance, the transferability of digital photographs) become widely understood in the marketplace, their decreasing size makes them more attractive as well. In the second place, we are constantly seeking ways to free ourselves from detestable "tethers." Wireless communications does that nicely, since there's no landline to fuss with; and batteries do away with the other tether, the power cord.

My notion is that upgrading software for these devices should be made as simple as possible. The proposed solution is speculative, but I believe it merits further discussion.

The Current Situation

When you buy one of these products today, you *think* you are buying a device. Actually, there is a basic shell of a device, but all the good stuff is in the software. Any software person knows when he turns on his cell phone, for example, that he has to wait for it to "boot up." And that numeric keypad you use to dial phone numbers is also the keyboard you

use to program the software.

Effectively, this device consists of three parts. There is the "hardware," there is the embedded "software," and there are the batteries, without which, I hasten to add, nothing will work. Today, this device is packaged as two parts: "the phone," which contains both the hardware and software, and "the batteries." That is just the way things have evolved.

Now this poses an interesting dilemma.

All the intelligence is in the software. So when you want to upgrade the phone, you have two options: 1) somehow upgrade the software, which, today, means either replacing or reprogramming the chip in the phone; or 2) depending on the economics, replace the whole phone with a new one, which, in turn, might be exactly the same shell with a newer version of the chip.

Other devices take a slightly different tack: You can hook them up to your PC, get on the vendor's Web site, and download a new version of the software. Sometimes called an "oil change," this operation allows you to replace the software with a more recent version. The oil change analogy is a little dangerous for some people because it implies that your software gets replaced for you automatically at regular intervals without revealing what internal changes the vendor made, and they find that notion scary. For others, the whole process of using the PC to accomplish the objective seems more akin to changing out an engine instead of just the oil in it. That is, they do not view it as a simple task.

The Software Upgrade Game

Software vendors are under continual pressure to make their products better. This means that they issue, at fairly regular intervals, upgrades to their software. New purchasers get the latest and greatest when they buy. And, to spread the development costs and keep existing customers happy, vendors would like to encourage current users to acquire the latest version too, albeit at a modest price point.

So, how do they get people to upgrade their software?

The industry is wrestling with this issue as we speak. People tend to get used to their software, and getting them to upgrade to the latest and greatest version is a bit of a problem. You have to convince them to pry open their wallets and spend some of their discretionary income to replace something that already works pretty well. Vendors have tried various mechanisms, most of them based on a subscription model; TIVO's "oil change" and AOL's online upgrades, for example, both depend on users paying for their software (and, implicitly, the upgrades) as part of a monthly service.

It has been noted in some parts that Microsoft has been tinkering with all sorts of pricing ideas, including subscriptions, to guarantee a steady revenue stream into the foreseeable future.

But once we get past the economic problem, we still have the quasi-technical problem. How do we make the upgrade as easy and user-friendly as possible?

A Modest Proposal

What we ought to do, for cell phones and, by extension, all devices with embedded software, is to *package the software with the battery*, not with the device. You would buy the basic device without batteries or software, although it wouldn't be worth much -- not even as a doorstop, since it's so lightweight. But at least it could be commoditized down to the lowest unit cost manufacturing efficiencies will allow.

Then, to power it up, you would buy batteries.[1] (Each device would have its own type of battery.) The software would come along, piggybacked onto the battery. We abstract the technical implementation details here; think of it as a "battery pack" if you like; I prefer, for marketing reasons, just to think of it as a "smarter" battery.

This would cause a vast diversification in the battery business, but we have seen industrial transformations of this type before. Today, we tend to think of batteries as a commodity. Actually, they already exist in many sizes and varieties, depending on electrical requirements and how much you want to spend; rechargeable costs more, for instance. You might think that turning such a commodity business into a more variegated "marketplace" is counterintuitive. But not really; as an analog, just think of the infinite variety of tires (car, truck, tractor, snow, racing, high-performance, etc., not to mention a dizzying array of sizes and form factors) that are currently stocked for mass consumption today. Yet most people think of tires as a commodity. And a hundred years ago, they were.

Needless to say, the battery distribution business would change; there would still be the "dumb batteries" we have today, along with the "smart batteries" that would have piggybacked software. Not all corner grocery stores, souvenir shops, and convenience stores would carry both kinds. We would expect though, that over time, more and more stores would stock and carry smart batteries as the demand for them increased.

This transformation would lend another layer of meaning to the phrase "power it up." When you turned on a device, you'd be feeding it *electrical* power by virtue of the battery; you'd also be giving it *intellectual* power by virtue of the software on the battery. Power to the hardware, in both senses!

Software Upgrades, Revisited

Under this new regime, when you purchased your software with your batteries, you would upgrade as you go. When your batteries ran out, you would replace them. And when you did, you would get the latest version of the software applicable to your device.

Notice that this has an interesting property: It couples the shelf life of the battery to the useful life of the software, so we wouldn't have to worry

about obsolete versions of software lying around.

What about the cost of the upgrade, or, more generically, the cost of the software? No one in his right mind thinks that the batteries for his cell phone should be free. So your batteries would cost a little more, of course, because you'd have to cover the software development expenses. But those expenses would be spread over the cost of all the batteries the software is piggybacked onto.

There is also this wonderful coincidence. Someone who used his device sparingly would replace batteries infrequently. However, whenever he did, he would automatically get upgraded to a recent version of his software. On the other hand, someone who used his device constantly would go through a lot of batteries and would therefore typically be replacing his software with identical copies of what he had been using. The intensive user would see little or no change over time, and the infrequent user would see "step" changes in his software when he swapped out his batteries, something he would do rarely. So there would be a really good match between upgrades and the respective usage patterns.

As the software that goes onto the battery would have to be completely self-contained, we would do away forever with the notion of patching old software. You would throw away your old software with your dead battery, and your fresh battery would start over again. Manufacturers would have to be clever to ensure that features wouldn't change abruptly. At the worst, there might have to be some "release notes" for your new batteries. I think marketing folks could put the appropriate spin on this and turn it into an attractive feature.

The big advantage of this model is that it saves users from having to download software upgrades from the Net. Which is easier -- doing a download and install of software from the Net, or just changing the batteries? Ask your mom.

Some Nice Things Come for Free

We already have this notion that devices with embedded software should be easy to use. As the old saying goes, "There is no Maytag User's Group, because there doesn't have to be." So people think we should adopt an "appliance" model for these devices.[2]

Unfortunately, software sometimes gets in the way of this.

But consider some of the benefits of packaging batteries and software together. Want to install your software? Plug in the "softerry."[3] This would bring new meaning to the term "plug and play." Want to move your software from one device to another (compatible) device? Just move your softerry from one device to the other. If the devices weren't compatible, then you would have the equivalent of trying to use the wrong battery. Most people would understand that.

Note that for this scheme to work, the softerry would have to contain some kind of writeable memory in order to store user-specific information

(settings, files, etc.). Otherwise it wouldn't be too useful to plug the softerry into another device. The memory could be PROM or NVRAM, but since it would be integrated with the battery, it could even be normal RAM. One reason you might want to upgrade the softerry would be to get more memory.

Our European friends have already started down this path. My friend and colleague Pascal Leroy writes from France: "The GSM phone system in Europe relies on a chip called the SIMS card, which contains (1) information about your rights, subscription, phone number, and so on, and (2) your settings. People have gotten used to plugging their SIMS card into just about any phone to place a call: I was on the train the other day next to two girls, one of whom had a cell phone with an dead battery; she just borrowed her friend's phone, plugged in her own SIMS card, and was able to chat on the phone for the entire trip. And they didn't exactly look like nerds, so this kind of technology is probably usable by just about anybody." This "ease of use" example demonstrates some of potential benefits of the softerry, which would take the idea one step further.

Do you have multiple devices, each of which needs the same software? Well, in the old days, software manufacturers might have worried about you. In many cases it was rather easy, although illegal, to purchase a licensed copy of the software and install it on multiple machines. With the softerry, the question would become moot for both you and the manufacturer. You could either buy multiple softerries to use simultaneously, or you could put a softerry into the device you wanted to use right away, and then transfer it to another device later if you wished. As with ordinary batteries, it would be your choice: cost versus convenience. Here we see the instantiation of the ideal model that maps one copy of the software to one physical device. By making these softerries simple and cheap enough, we would reduce the incentive to copy software illegally.

Why This Will Work

Economics.

People don't like subscriptions. They don't like to be locked into recurring charges. As the economy tightens, we see people cut back, and the first thing they cut back on, if they are smart, are those silent monthly charges. If software vendors decide to go in the direction of subscription pricing, my guess is that they will prosper in good times and get pinched in hard times. I think this is basic economics and psychology at work.

The fundamental dynamic here is that people will always fear that they will not get enough for their money with a subscription. That is, they will always be concerned that their usage will be below average, and hence that they are funding (subsidizing) other "free riders" who use the service more, at their implicit expense.

On the other hand, people are used to paying for batteries. Batteries are a consumable, and *you pay for them according to how much energy you use*. Use the device more, deplete your batteries more. No one complains

about that. To most people, that seems fair.

To illustrate my point, look at the consumption of ink-jet cartridges in low-cost color printers. These cartridges are relatively expensive, but the market tolerates this because they are viewed as a consumable. In fact, there are all sorts of after-market vendors whose existence attests to this basic usage model; their only function is to lower the unit cost.

So by putting the software into the batteries, you would transform it into a consumable that gets thrown away with the dead battery. You would factor the software cost into the price of the battery. Spread over many, many units, the added cost would be pretty low. Coupling software usage to battery usage might ultimately be the simplest algorithm we could ever devise for charging (no pun intended) for software based on a usage model.

Will people (electrically) recharge their software batteries? They could, assuming we have piggybacked our software onto rechargeable batteries. In this case, they would retain their old software, perhaps indefinitely. But it wouldn't invalidate the basic model. And someone could always upgrade their software, if they wanted to, by throwing away a perfectly "good" battery and replacing it with a newer one. Who knows, there might spring up a secondary market for "old" batteries that still hold a charge. Maybe there will be battery exchanges. We could ring up a lot of changes on the basic model. The important concept here is that the free market and its economics would drive things appropriately.

Refinement

There are a few additional details to consider, which might appeal to some of you techno-junkies. By coupling software and batteries, some new horizons open up.

One refinement, suggested by Philippe Kruchten, would be to take advantage of large memory capacities to store the software for multiple devices on a single softerry. This would ease the distribution problem somewhat, as one physical unit could then serve several different devices. So you might imagine a generic "cell phone" battery, and so on. What this would mean is that you could replace your Motorola cell phone with a Nokia cell phone, plug in the softerry you used with the Motorola, and everything would still work. Of course this would require that the various cell phone manufacturers agree on some standards, and that is always tricky.

Conversely, one could imagine a vertically integrated company putting the software for several different device types on one softerry. Then one could purchase, for example, an Ericsson softerry, which would power (both from an electrical and software point of view) devices of different types made by Ericsson.

Today you can, of course, introduce all sorts of power-saving algorithms in the software to economize as much as possible on battery usage. We already do this in laptops, whose software ships with the device. Under

our proposal, we would put these same power-saving algorithms where they more logically should reside: into the laptop battery.

Also, consider a generation "n" battery with generation "n" software. Let's say that in the next revision of the software, you improve your algorithms and so on, so that you can get the same amount of work done in the same amount of time with less electrical power. That means you can now ship generation "n+1" software on a battery that has less electrical output and still achieve the same result. So the price of the battery could come down, or your profit could go up, or some combination of both.

These possibilities are all definitely within the realm of current technology but not essential. They are refinements of the original idea, and I want to obey the KISS[4] principle as much as possible.

What About Software Piracy?

Fundamentally, we want to eliminate piracy by making the softerry the most persuasive economic choice for the majority of users. As with all other schemes, when we try to build a better technical mousetrap, we just incite smarter mice. Better to figure out a way to make them buy the cheese of their own accord. Perhaps the softerry's memory will be programmed at the factory, using a device that is relatively expensive and not generally available to the public. Then it would be cheaper just to buy a new softerry instead of copying the software from an existing one and trying to "reburn" it onto an older softerry. But, fundamentally, we are not trying to address software piracy with this proposal. It may have some fortuitous side effects, but that is incidental.

Until the Sun Takes Over

Today lots of money is spent making batteries better (smaller, more powerful, longer lasting, etc.) so that we can become mobile. Some day, there might be solar-recharged capacitors capable of replacing batteries entirely. This technology depends on getting the form factor small enough, the capacitance large enough, and the solar panel interface nearly perfect. We would use the capacitor as a "virtual battery." It would be just another way of storing energy for use at a later time. However, unlike batteries, the capacitor/solar panel combination would not have to be replaced periodically. Until that day comes, we will be replacing or recharging batteries. So why not marry them to our software?

It would be foolhardy of me to claim that I have stumbled upon the next great vertical integration of our time: batteries and software. On the other hand, the idea intrigues me. I doubt very strongly that Rational will be getting into the softerry business anytime soon; that is why we have a Franklin's Kite column, after all. It lets us explore the pluses and minuses of such schemes, without any terminal effects.

Softerries would solve the software upgrade problem for electronic devices by making the operation as simple as changing batteries. They would alter the pricing dynamics, by making software more of a consumable than a capital item. As the devices that the embedded software reside in are

themselves becoming commodities, this makes sense. There may ultimately be interesting distribution issues for softerries, but I'm confident that these could be addressed effectively.

I would be very interested in your response to this idea. Please get in touch with me at the usual coordinates: jnm@rational.com.

Notes

[1] Of course, these batteries may be packaged with the device at the time you buy it.

[2] We acknowledge that a Maytag washing machine is not a handheld device.

[3] Sounds better than "batware," which might be misconstrued as a Batmobile accessory.

[4] KISS stands for Keep It Simple, Stupid!

For more information on the products or services discussed in this article, please click here and follow the instructions provided. Thank you!

A Primer on ClearQuest Integrations

by Mike Exum

Editor's Note: *Each month, we will feature one or two articles from the Rational Developer Network, just to give you a sense of the content you can find there. If you have a current Rational Support contract, you should* ***join the Rational Developer Network now!***

Introduction

This paper is intended for those considering the construction of an integration between ClearQuest and some other tool or system. It discusses many of the issues to be aware of, and some examples of how other integrations have addressed them. The organization of this paper starts with requirements definition. Following this, the paper is organized into discussions of various topics that typically impact the design of the integration.

Because integration projects typically require advanced skills, this paper is aimed at users who already have a solid foundation of ClearQuest knowledge. Also, because every custom integration is unique, the focus here is on providing general guidance and and best practices material that will be useful in almost every project.

Requirements

If I had a nickel for every time someone asked for "an integration" with something...

"An integration" can mean radically different things to different people, so the important point is to make sure you understand what is needed. Needs can range from simply invoking some operation in one system from the other, to associating records between the two systems, keeping them synchronized, handling error conditions, and many other capabilities.

The Rational Unified Process (RUP), Rational's compilation of best practices, recommends you apply requirements analysis techniques to ensure the goals of a project are understood and agreed to by everyone. More importantly, it also provides guidance as to what those techniques are and how to apply them. I will not go into detail on those here, but I will outline some of the highest-level steps and how they may be applied to this specific domain.

An effective ClearQuest integration project begins with understanding who the stakeholders are. If the integration is between ClearQuest and a simple desktop product/tool, the stakeholders usually include the users of both sides of the integration (both those who invoke the operations as well as those who simply utilize the data), the integration's designers, developers, and maintainers, and, sometimes, management personnel. If the integration is between ClearQuest and another business system, such as a customer relationship management (CRM) system, the set of stakeholders expands dramatically by adding the organizations responsible for each system and higher levels of management who have a vested interest in integrating the two systems.

Once you have identified the stakeholders you can begin the requirements solicitation and analysis process. Use cases can be defined by identifying who the users of the integration are and what they need the integration to do. Other important requirements can be identified through other questions, such as: What operations are automated, which are manual? Are these use cases invoked on demand, triggered by some set of criteria, or performed periodically? Is there some set of data that users need access to from one tool/system or the other? Are there any reporting requirements that span the two integrated tools/systems? Beyond this, there are more universal requirement categories (i.e. supplementary requirements) such as for performance, platform compatibility, etc., that RUP can also help you with.

Communications

There are two general classifications of integrations with ClearQuest, inbound and outbound. Inbound integrations perform some ClearQuest operation(s) from an external context, such as the Submission of a Defect from a testing or CRM tool. Outbound integrations perform some external operation(s) from within the ClearQuest context, such as e-mail notification. Bi-directional integrations are viewed as a combination of individual inbound and outbound capabilities.

Outbound

The most significant factor in determining whether an integration can be built is whether the two applications can communicate and how they are going to communicate. For outbound integrations, it is natural to plan a ClearQuest hook to interact with the other application. However, there are many issues that may make this not so straightforward to implement.

Obviously, the other application must first offer some way to interact with it externally. The common mechanisms to look for are command line

interfaces (CLIs), APIs, or Web-based technologies, such as HTML and XML, SOAP, etc.

Also, you need to consider how a hook can be invoked in a fully deployed environment. For example, ClearQuest hooks execute on the Windows and UNIX client machines, and on the Web server, in the case of the ClearQuest Web client. Therefore, the interface that will be accessed by a ClearQuest hook must be available to all of these machines. If you are planning to use an API or CLI, this typically requires the other application (or at least its interface) to be installed on every ClearQuest client that might invoke the integration. Furthermore, it's possible that your ClearQuest hook may have to invoke some compiled executable to access the API or CLI (for example if the API was available only to compiled programs), which would also require installation.

You must also consider the ramifications on the other application's deployment architecture of invoking its interface from the ClearQuest clients and servers executing the hooks. For example, not all interfaces are designed to work across a WAN, across firewalls, etc., so if invoking an application's API from a ClearQuest client machine might violate some of the other application's deployment constraints, you must figure out a way to prevent it.

In the context of ClearQuest Web, where all users' hooks are running concurrently on the Web server, you must take into consideration that different users can access the interface concurrently, so the interface would have to support this or you would have to invent a mechanism to prevent it somehow.

Security

Security may also need to be considered if the other application requires authentication or if the data being transferred is sensitive in any way. If authentication is required, does it need to be interactive or can it be programmed? If interactive, only the ClearQuest native clients have the ability to pop up a dialog requesting information. If programmed, who will have access to the source code (if compiled) or hook (everyone has read permission on a schema)? Also, you need to consider the impact of authorization rules of the other application that can prevent access to common operations or require special procedures under certain circumstances. Static rules can be planned for in advance, but dynamic rules may be hard or impossible to plan for, and must be handled gracefully at runtime.

MultiSite

Finally, ClearQuest MultiSite presents additional challenges to the other application's deployment by stretching it even further. Since the same hooks are fired in each replica, there is the chance that the interface is exercised from a very remote location, unless prevented. CQMS also presents an issue of connectivity, since each replica can continue to operate independently in the event of a connection failure. In this case, the interface may not be accessible or may not be able to complete the

task, so proper error handling must be provided.

Inbound

Inbound integrations present the complementary set of issues to consider, with the roles reversed.

ClearQuest offers a number of interfaces to utilize externally. First, on Windows, a COM interface is available that can be accessed from any COM-based language, including VB, VB Script, Visual C++, and others, as well as from Perl (through appropriate COM packages). ClearQuest also offers a customized version of Perl (based on ActiveState Perl) which you can use directly, or just utilize its packages from any other Perl implementation. Cqperl (as it is called) is available on every native platform ClearQuest supports, including Windows, UNIX, and Linux. There is also a command line interface available on the supported UNIX and Linux clients, but documentation on it is only available via man pages and interactively. There is an HTML interface, but the public access to this interface is very limited (no record creation or modification), as it supports record lookup and running only predefined queries, reports, and charts. Another interface available is the ClearQuest E-mail Reader that parses incoming messages for operations and content to use for field assignment. Unfortunately, this interface does not support reporting the ID of any record created, so it has limited value for creating records, but is more commonly used for modifying existing records (if you know the ID already). If you are wondering how the other Rational tools display forms and association dialogs, etc., these operations are supported by another interface (CQIntSvr), which is as yet undocumented, and subject to change at any time.

So the question in this case is not "Does ClearQuest offer an interface" but rather, "Does the other application provide a means of interacting with one of them?" Some applications only provide a means to invoke an executable or method in a dll (typically through an add-in that might add some menu options for invoking them), such as many Microsoft Office tools or other IDEs. Other applications provide a rich scripting environment (such as with ClearQuest and CRM tools like Siebel, Vantive, or Remedy, and even with Microsoft Word or Excel). There can be unexpected limitations in these scripting environments, however. For example, one such environment was a derivative of VB and was thought to provide all necessary operations. It turned out however, that it did not support passing objects as parameters into the ClearQuest COM interface, which was required (at the time) by the session's EditEntity method. The ClearQuest API now offers an EditEntity method to the Entity object to work around this kind of situation. So beware when utilizing other scripting environments, you can run into unforeseen roadblocks.

If you plan to utilize the ClearQuest API or Unix CLI, it will only be accessible by installing ClearQuest on every machine that might invoke the integration. Keep in mind that even if you are not going to use the client (i.e., GUI) from those machines, the API and CLI still operate under the same rules as a client, and must have local (i.e., LAN) access to the ClearQuest database server. The only available interfaces for remote operation include the HTML interface and the E-mail Reader, both of them

supporting limited capabilities as described earlier.

Concurrent access to the ClearQuest API from a single machine is covered. The API requires a unique session object to be built, so there is never any conflict between concurrent users.

Security

Security is definitely an issue to address when interfacing with ClearQuest. ClearQuest AccessControl and Field Permission hooks can dynamically change the authorization rules for actions and fields, which if used, can require a strategy for dealing with this in the integration. A related issue is when there are mandatory fields that do not map to any data in the other system, leaving nothing to initialize them with. A strategy that has been used to resolve this issue is to have the integration provide some "default" value to placate the mandatory requirement. It would be nice to allow users to interact with the record form before commit, to satisfy this issue and related ones (i.e., validation), or to permit them to provide additional information, but until the CQIntSvr interface is exposed, this is not possible.

Another consideration to make regarding authentication (and record keeping) is whether the integration should use a single (static) userid, or if it should support a more dynamic model. Most integrations use a static userid and password for ClearQuest login, but it's possible to map the userids of the external application to those of ClearQuest, and use this mapping for the integration to log in with. This solution would track record changes (in the history records) more accurately (real user IDs instead on one generic one). In either case, the mechanism used may need to be made secure itself, as the mapping table or even the static userid and password can be seen by anyone if precautions are not taken (for example, all ClearQuest userids have read-only access to all schemas and hooks within them).

MultiSite

If ClearQuest MultiSite is deployed, integrations must address the possibility that an existing record may not be mastered locally, which prevents any modification to it. Solutions to this can be to change the mastership back to the local site (a difficult issue), or to connect to the mastered site directly (usually a remote location, and accessing ClearQuest via a WAN is not a supported nor recommended configuration). Another solution employing the data model may be possible (discussed at the end of the next section).

Integration Architecture

The integration architecture encompasses the data models of the information relevant to the integration (in both systems), and the actors that influence it. The design of the architecture is typically driven by the use cases and other requirements of the integration, as well as by the constraints of the existing systems. Dozens of integrations have been built, but many of them share common traits. Discussing these can be

very helpful in planning a new integration.

One characteristic of many integrations is a need to simply invoke an operation in the other system, without any feedback or memory of the interaction required. This trait is seen in the ClearQuest integration with Rational SoDA (which launches the generation of the selected report), the Test Log Viewer's (part of Rational TeamTest) integration with ClearQuest (which simply creates a new Defect in ClearQuest, with automated initialization), and the PurifyPlus integration (which does roughly the same thing). The integration architectures in these cases are minimal.

Another common characteristic is the need to create an association between objects in one system, and those in the other. If you are modeling the integration, two important characteristics of associations are visibility and cardinality, as they significantly shape the architecture. The visibility of the association defines whether it is one way or two way (i.e., do both systems know there is an association, or only one), while its cardinality defines if the association is 1:1, 1:n, n:1, or n:m.

The visibility of the association is typically chosen to correspond to which side operations are supported. For example, the ProjectTracker integration only stores the IDs of the associated Defects (or whatever record type you choose) in the Microsoft Project plan file, because all operations of the integration are performed from within Microsoft Project. If there are only requirements to perform operations from within ClearQuest (either invoked manually or as a side effect inside hooks), the association should be stored in ClearQuest records. An example of this is the contributed ClearQuest/Microsoft Project integration (not to be confused with the "ProjectTracker" integration). It stands to figure that integrations supporting operations from within both systems typically store the association on both sides. The RequisitePro integration with ClearQuest is an example of this.

If the cardinality of the association is 1:1, then designs typically store the ID of the associated object and any additional information as attributes (in fields) of the objects themselves. Additional information can include other necessary data (such as the pathname or other identifier of the other system/repository) to information for user convenience (such as a name or title to go along with the ID, etc.). As an example, the RequisitePro integration holds both the ID of the Enhancement Request as well as its Headline as attributes of the requirement type, and likewise holds the Requirement ID and Title in fields of the Enhancement Request record type. Of course, the association and related information can be stored in a separate record rather than directly within it, and included by reference.

If the association is other than 1:1, then storing the association in fields directly in the object is not usually done. Obviously, if there are multiple objects in the other system to associate with, and especially if there is a large or variable number, dedicating a field (or set of fields) to each one is not practical. This applies to inbound as well as outbound relationships. One of the most commonly requested integrations, which also serves as a good example here, is an integration with a Customer Relationship Management (CRM) system (such as Siebel, PeopleSoft/Vantive, Remedy, etc.) commonly used by Help Desk and Customer Support organizations.

In such integrations, there is a need to create multiple records in the ClearQuest database and associate them to the one record in the CRM system (such as when a customer reports a number of issues all at once). This represents a 1:m relationship (from CRM to CQ). If another customer calls in to report one of the same issues (providing the support engineer recognizes this), there is also the need to have multiple records in the CRM system associated with a single ClearQuest record, a n:1 relationship. Combined, this results in a n:m relationship. Due to the practicalities of storing multiple references and the need to view more data than just the record IDs in the other system, a solution involving shadow records is typically used, as shown in Figure 1.

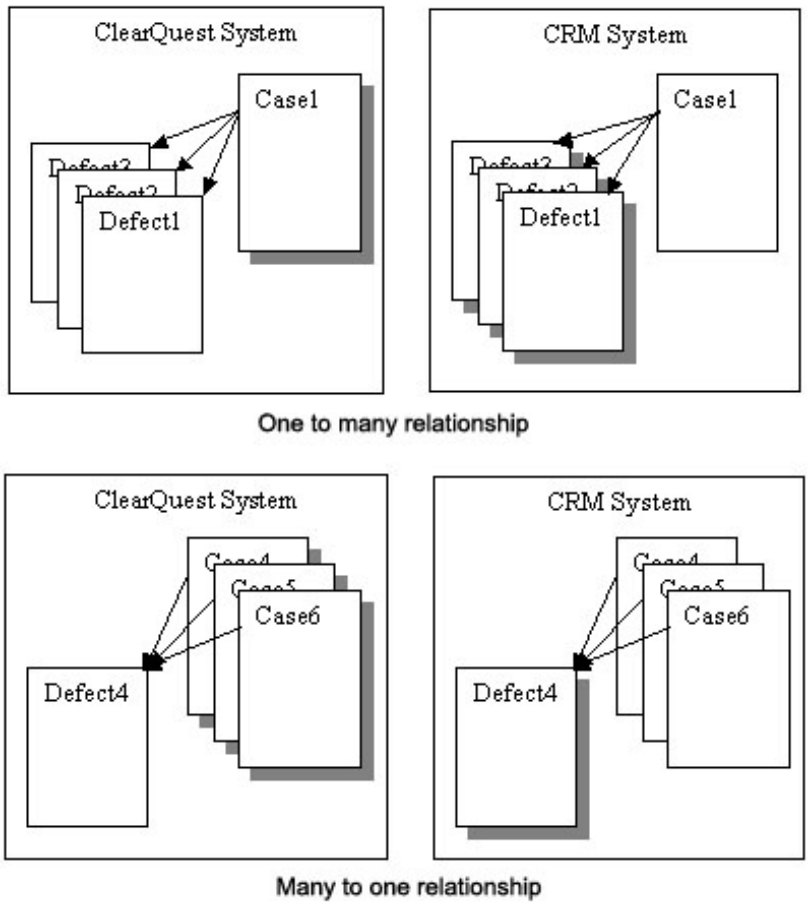

Figure 1: Shadow records

By creating shadow records in the other system, the integration can utilize many system features. For example, in ClearQuest, a Reference_List field can be used between the Defect and (stateless) Case shadow records. The Case shadow records can contain a subset of the actual Case in the CRM system, so a listview control on the Defect form can show many of these fields. The listview control also supports navigating to a selected record, which can contain even more fields (such as Multiline_String fields). Typical CRM tools support similar functionality, permitting the integration to display select fields of the Defect shadow record in a control on the Case form(s).

One of the additional advantages to this architecture is that it can be

implemented in a way so that it supports ClearQuest MultiSite. Since the mastership of the Defect must be allowed to move to different sites, updating the Reference_List field in the Defect with additional associations cannot be done. However, by making the stateless record the parent of the relationship (and implementing a back reference field from the Defect) this restriction can be lifted (because the association is added to the stateless record instead). This is depicted in the diagrams above by the direction of the arrow. So, as long as the mastership of the stateless records is not changed, and remain mastered at their original site, they can be updated from there as necessary, while allowing the Defects to float from site to site as needed.

Synchronization

If you choose to implement a solution that copies data from one system to the other (whether contained directly in the associated record, or contained in shadow records), you may need to include a mechanism to keep the data updated as changes are made at the source. Typical strategies include pulling data when needed, pushing data when changed, or independently synchronizing the data on a periodic basis. Of course ClearQuest offers facilities (API and hooks) to implement any of these strategies, but usage scenarios, constraints of the other system, and/or those discussed in the communications sections above, may lead you to implement the strategy entirely within one system or the other.

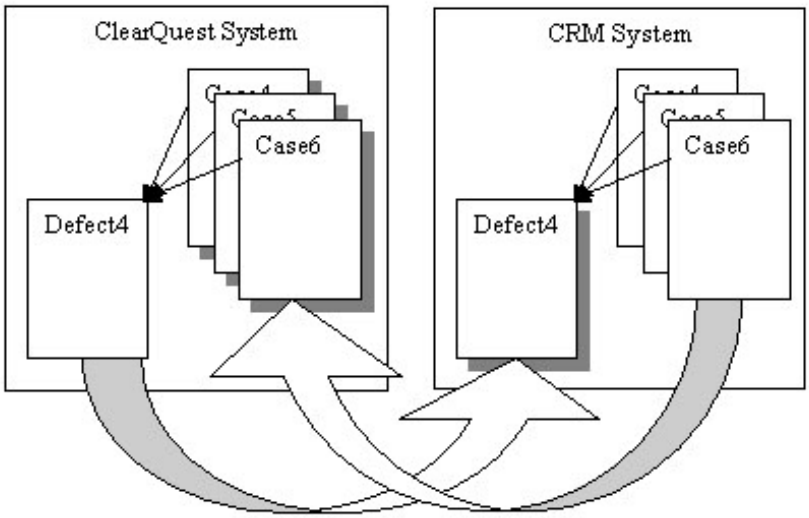

Figure 2: Shadow record synchronization

Translation

Initializing new records in one system from data in the other and synchronizing copied data usually involves a mapping and translation process, because whenever two previously independent systems are brought together, there are often many differences regarding process and terminology. For example, a Support organization may define priority to be how important a particular issue is to that customer, whereas the development organization may define priority to be the *business* priority, or priority to the business of addressing the issue. Even though they have the same name, their definitions are vastly different, and do not

necessarily map to each other at all. In fact, different terms may map to each other better than terms with a common name. Even after equivalent terms are identified, the values may not map to each other. A Support term may define levels of "High", "Medium", and "Low", whereas the corresponding engineering term may use numerical values. Unless both user communities are trained in the other's terminology and definition, these differences typically need to be addressed by the integration.

To accommodate this, the integration needs to be aware of the terms requiring translation, and the corresponding definitions for both communities. For the example above, the integration must know what field in one system maps to what field in the other, and what each of its values in one system translates to in the other. In some cases, it may even involve a combination of fields. Note that there is also a potential need for translating in the opposite direction also, especially if there is not a 1:1 mapping of field values. Figure 3 provides an example of this:

Support Case	Defect
High	1
Medium	3
Low	4

Translation of "Severity" from Support Case to Defect

Defect	Support Case
1	High
2	High
3	Medium
4	Low
5	Low

Translation of "Severity" from Defect to Support Case

Figure 3: Translations of "severity""

Presentation

Invoking the integration can be done in a variety of ways, including manual and automated approaches. A manual approach typically utilizes GUI features of the system to invoke operations in the other upon demand. Automated approaches can employ independent processes that periodically poll one system or both for certain criteria that triggers it into action. Since ClearQuest does not offer a way to extend its menus, invoking manual operations from within ClearQuest (i.e., outbound integrations) must either utilize buttons placed on record forms or actions on the Actions pull-down control (either as a side effect of an existing

action, or as a dedicated one potentially implemented as a Record Script Alias). The caveat on buttons is that they are only active when the record is editable. ClearQuest also does not provide a built-in mechanism for pop-up or interactive dialogs. This can be accomplished on native clients by calling custom, platform, or third-party utilities, but these are usually unique to each platform, and cannot be supported through the ClearQuest Web client. Keep in mind that the other tool may offer additional options through its API.

Similarly, inbound integrations are usually invoked via GUI facilities available through another system's environment, and utilize the ClearQuest API to perform their operations. The ClearQuest API does not provide the ability to display a record form, but the ClearQuest Web server can. The Web server supports form display, and stored query, report and chart execution, and can either be supplied a userid and password or will prompt the user to log in first (the format of the URL can be seen by creating a shortcut in the ClearQuest Web client). This can be used as a way to simulate displaying a form at the time it is being automatically created for users to supply additional information ý the difference being that the record is submitted via the API and then the integration displays the form via the Web server (so it's not actually being displayed during the initial creation process). Unfortunately, there isn't any solution through the ClearQuest API for resolving permission or validation issues interactively. A partial solution to this is to open an AdminSession, and determine the mandatory fields and prompt the user to supply this information (through facilities of the other system or custom, platform or third-party utilities) before the operation is invoked, but this only works for predefined/static behaviors (not dynamic, hook-based behaviors). Ideally, one would be able to display the form to the user for interactively resolving permission or validation issues (static or dynamic), but this functionality is not available at the current time.

Conclusion

There are typically a great deal of considerations to make when developing an integration with ClearQuest, and hopefully, this paper has raised your awareness of them and perhaps provided some ideas for how to address them. For more information regarding the customization of ClearQuest, please see the ClearQuest product documentation and ClearQuest Customization Best Practices.

For more information on the products or services discussed in this article, please click here and follow the instructions provided. Thank you!

Reader Mail

Got questions or comments about something you've read in* The Rational Edge? *Send them to mperrow@rational.com, and we will try to get you an answer ASAP! All questions and answers that could be useful to other readers will be printed in this section.

Dear *Rational Edge*:

Regarding the Rational Unified Process's (RUP's) focus on iterative development and architecture first, I am trying to figure out how to map RUP to a deployment model that is rigidly oriented toward "Development -> Staging -> Production."

The Production environment is seen as 1) sacrosanct, 2) on public view, and 3) the only environment allowed to communicate with the outside world (i.e., necessary for Web Services to work). The staging environment is schizophrenic: It is viewed by deployment support as a pre-production environment, and viewed by development as a test environment. These very different views are source of friction, and that's a problem in and of itself!

The point is, the iterative / architecture-first approach, especially for Web Services, seems to demand prototypes in Production, and multiple deployments to Production; whereas the "Dev -> Staging -> Production" concept implies it is "finished" before it hits staging.

Any pointers or references you could email me to reconcile the two concepts?

Thanks!

One of Rational's use-case experts Kurt Bittner (featured elsewhere in this issue) responds:

This is an interesting question, something that many people grapple with.

Many industries have a strong requirement to maintain the public trust: banking, financial services, health care are but a few. In these environments, the standard for quality, and the cost of failing to deliver quality, is extremely high. I assume that your business environment falls into this category.

The cost of deploying an application into the "production" environment is often very high as well. Typically, large amounts of customer data or financial records may need to be converted when a new version of an existing application is deployed, which costs a significant amount of the project time and financial budget.

A common strategy is to create a "staging" or "pre-production" environment in which new applications (or new versions of existing applications) can be tested. The staging environment provides a way to test applications in an environment that is as close to the production environment as possible.

An iterative software development approach like the RUP is completely consistent with this approach. In an iterative approach, we develop the system in a series of incremental steps, each one building on the prior steps. These "steps" (iterations) produce executable results, but typically they are not released to the customer to use in "production." Rather, the iteration results provide us with clear and unambiguous ways to evaluate risk and progress against plans. The executable results, especially in early iterations, may not even be usable by the customer; they may simply explore some critical aspect of the architecture.

The staging area provides us with an environment into which the results from later iterations, when the system is nearly complete, can be deployed to test the deployment worthiness of the application. This will typically occur late in the Construction Phase, and certainly no later than the beginning of the Transition Phase (when the "beta" software would be deployed for testing by a subset of users).

The Transition Phase is focused primarily on addressing feedback resulting from the beta, and with moving (transitioning) the application into the production environment. Activities that are performed here often deal with data conversion, software upgrade, user training, support staff training, and all manner of other things that are needed to successfully deploy an application.

I hope this helps.

-Kurt Bittner

Speaking of Kurt Bittner, articles by him and others in *The Rational Edge* archives are still quite timely. Check them out when you have a chance, as this reader did:

Folks,

Kurt Bittner's article on managing use case details [Archives: April 2001] is fantastic; it validates a tremendous amount of thought I have put into this subject. The concept of the domain model and its relationship to the use case is particularly compelling; I think there are few use cases that can't benefit from such a model.

The articles on your site are routinely excellent and Kurt Bittner and Ben Lieberman are two of my favorites. Please encourage more such work on the topics of business concept and process modeling.

Thanks!

-- *George Knoll*

Joe Marasco's June article on "Popular Science" drew (mostly positive) comments from several readers:

Another excellent article. It started me thinking about the converse notion -- that is, the things I've learned about science and mathematics that I've actually been able to put to use in my work. I was lucky when I was in school to have studied compiler theory, which I've used quite a bit in (duh) writing compilers. Aside from that, however, I can only think of a few things I learned in school that I've been able to put to use:

- The scientific method, which I've used in debugging.
- Algorithmic complexity, which has helped in understanding why some programs are slow and how to write fast ones.

-- *Peter Steinfeld*

As a mere chemist, I also enjoyed the article a lot and was in almost total agreement with its thesis. I would differ only in Joe's deprecation of the term "Heisenbug," which I find quite acceptable usage, at least if all concerned actually understand the real Uncertainty Principle. This term is rather well described in the Hacker's Dictionary:

http://www.jargon.net/jargonfile/h/heisenbug.html

I have found the most useful guides to debugging to be P.B. Medewar's book *Science: The Art of the Soluble*, and Sherlock Holmes.

Maybe, if Stephen Wolfram is right, the math taught in schools will eventually be more directly relevant to computer science and even programming.

-- *Mike Harrison*

For more information on the products or services discussed in this article, please click here and follow the instructions provided. Thank you!