

Ad Hoc Networks

Medium Access Control

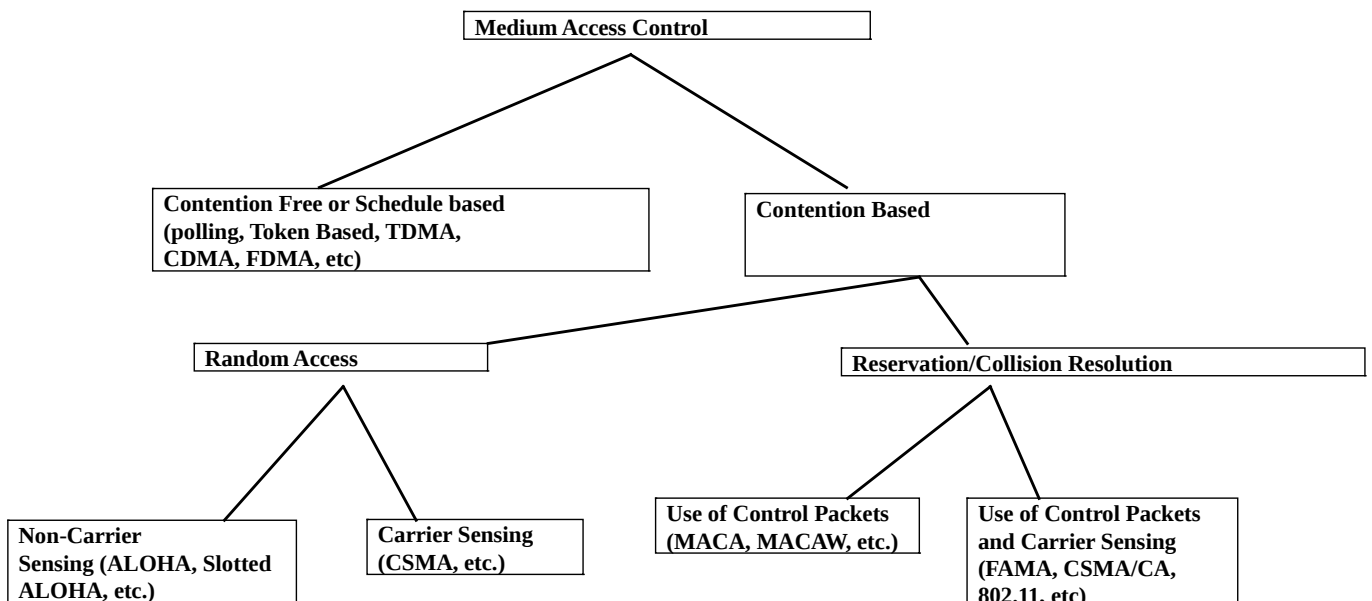
Responsibilities of MAC

- Facilitate single-hop communication
 - No routing here
 - Some broadcast!
- Sharing the medium
 - May perform carrier sense
 - No one else is sending
 - May exchange control packets
 - Tell other I am going to send
 - What if collision occurs?
 - Keep sending might not be a good idea!

Responsibilities of MAC

- Error detection and correction
 - Cyclic redundancy checks, Parity schemes
- Flow control
- Power management
 - Sleep management
 - Reduce idle listening
 - Idle listening state, a sensor node continuously listens to the medium
- Mobility issues

Classification of MAC schemes



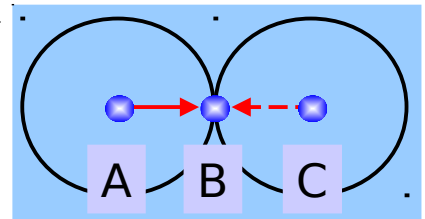
Carrier Sense Multiple Access With Collision Detection

- Carrier Sense Multiple Access (CSMA)
 - Sense the medium
 - If not free
 - wait for till it is free
 - Transmit
- Carrier Sense Multiple Access With Collision Detection (CSMA/CD)
 - Sense the medium
 - If not free
 - Backoff random amount of time
 - Check medium again,
 - if free then transmit.
 - Otherwise Backoff again

Problem for MAC protocol

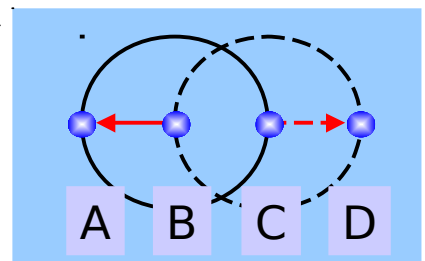
● Hidden Terminal

- Node A is sending data to B
- Node C perform carrier sense
 - Finds medium free.
- Node C start sending to B
- B had collision



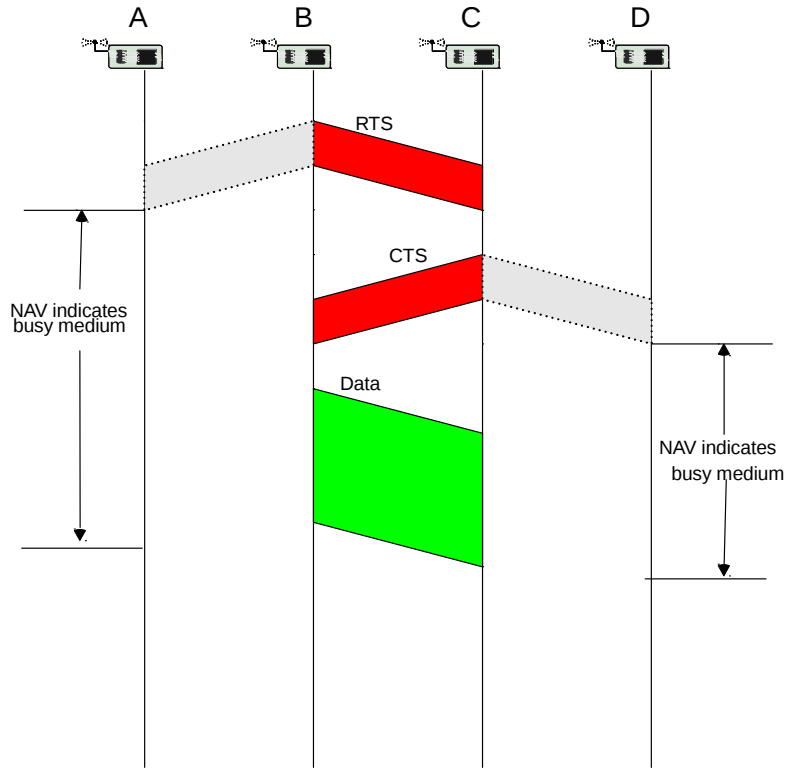
● Exposed terminal

- Node B is sending data to A
- Node C performs carrier sense
 - Finds medium occupied
 - Hence node C do not send data to D
- Sending data to D was safe



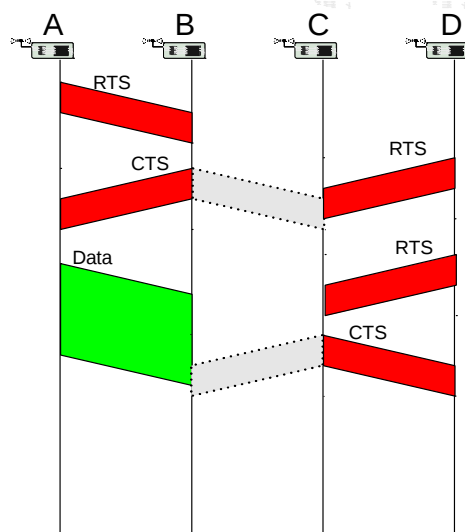
Multiple Access with Collision Avoidance (MACA)

- Sender B asks receiver C whether C will be able to receive a transmission
Request to Send (RTS)
- “A” overhears B’s RTS. It waits until Data should have been received.
- Receiver C if agrees to receive, sends out a **Clear to Send (CTS)**
- “D” overhears CTS. It waits until data should have been received. CTS has length of data specified inside it.



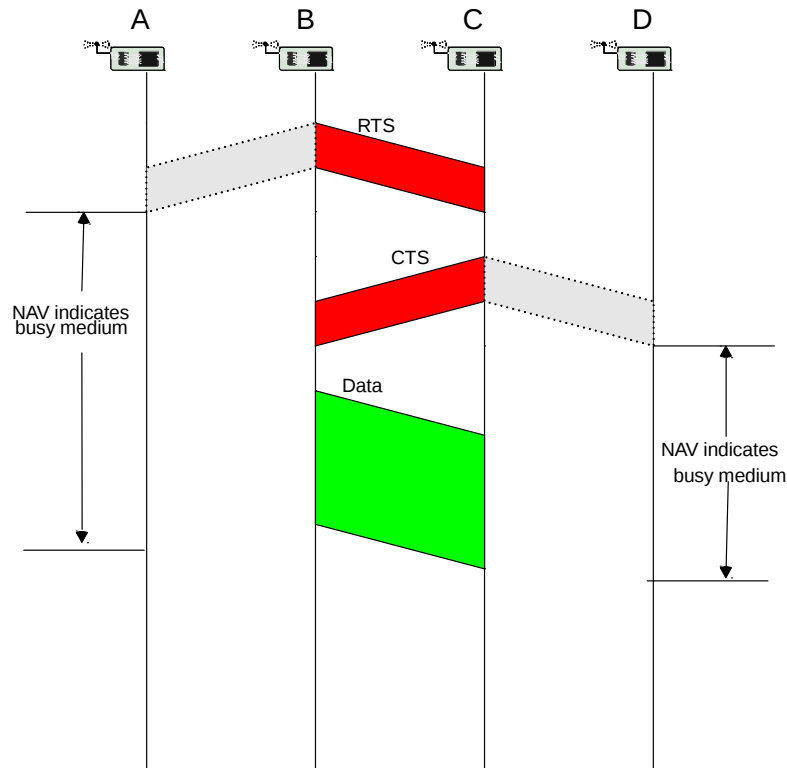
MACA and Hidden Terminal Problem

- MACA Solves Hidden terminal Problem?
 - Yes during data but not during RTC/CTS
 - In figure “C” has become hidden terminal and cannot hear first RTS due to CTS. It is because of this later CTS collides with data.



MACA and Exposed Terminal Problem

- A overhears RTS.
- Waits until CTS
- Medium busy because of the Data.
- Based on information in RTS.
 - A now know that it could send during data transmission.
- Exposed Terminal solved?
 - s. exercise



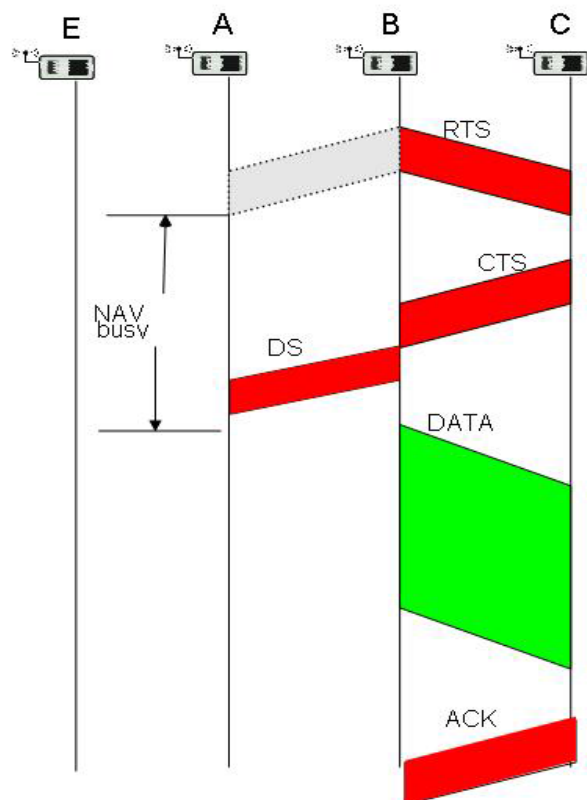
MACA Wireless (MACAW)

MACAW – Basic Message Exchange

- Uses RTS-CTS-DATA-ACK
- Acknowledgement (ACK)
 - If data is received
 - No ACK, data is Resend

MACAW-DS

- Uses RTS-CTS-DS-DATA-ACK
- DS (Data sending)
 - To tell that CTS is received.
 - Every station that hears DS defers its transmission
 - DS holds the transmission length information



Power-aware MAC Protocol

- MANET nodes are battery powered
 - Energy conservation
 - Efficient power utilization
- Principles of power conservation
 - Collisions avoidance: retransmission is expensive
 - Transceiver modes: Standby mode vs. Active mode
 - Lower power mode: based on distance to destination node
- Protocol implementation
 - Power management: alternating sleep and wake cycles
 - Power control: variation in transmission power

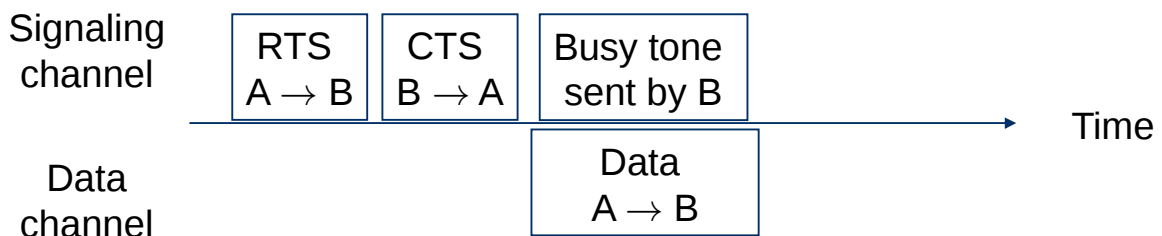
PAMAS

- Raghavendra & Singh (1998)
 - Power Aware Medium Access Control with Signaling
 - PAMAS = MACA + Separate Signaling Channel
- Signaling and data channel
 - Combine busy tone with RTS/CTS
 - Results in detailed overhearing avoidance, does not address idle listening
- Sleep and awake modes
 - Node powers off its data channel if busy tones is heard and it is neither the sender nor the receiver of the transmission

PAMAS

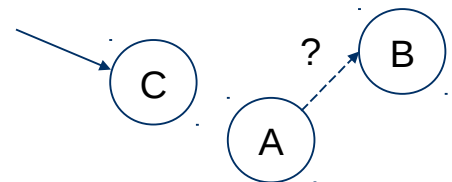
- Procedure

- Node A transmits RTS on signaling channel, does not sense channel
- Node B receives RTS, sends CTS on signaling channel if it can receive and does not know about ongoing transmissions
- B sends busy tone on signaling channel as it starts to receive data



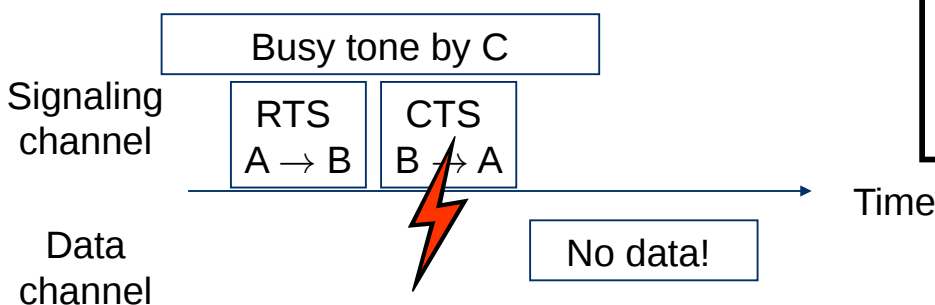
PAMAS: Already ongoing transmission

- Suppose a node C in vicinity of A is already receiving a packet when A initiates RTS



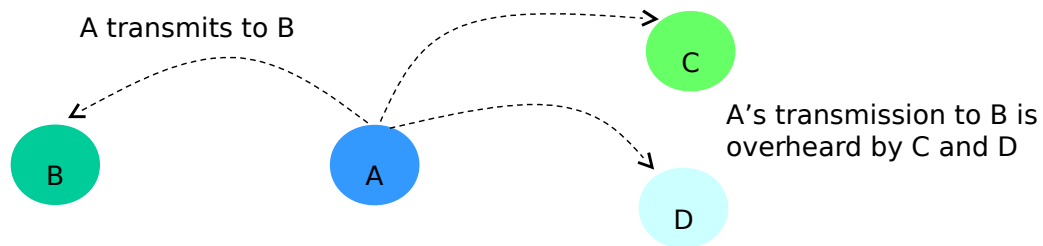
- Procedure

- A sends RTS to B
- C is sending busy tone (as it receives data)
- CTS and busy tone collide, A receives no CTS, does not send data



Similarly: Ongoing transmission near B destroys RTS by busy tone

PAMAS: Power Conservation

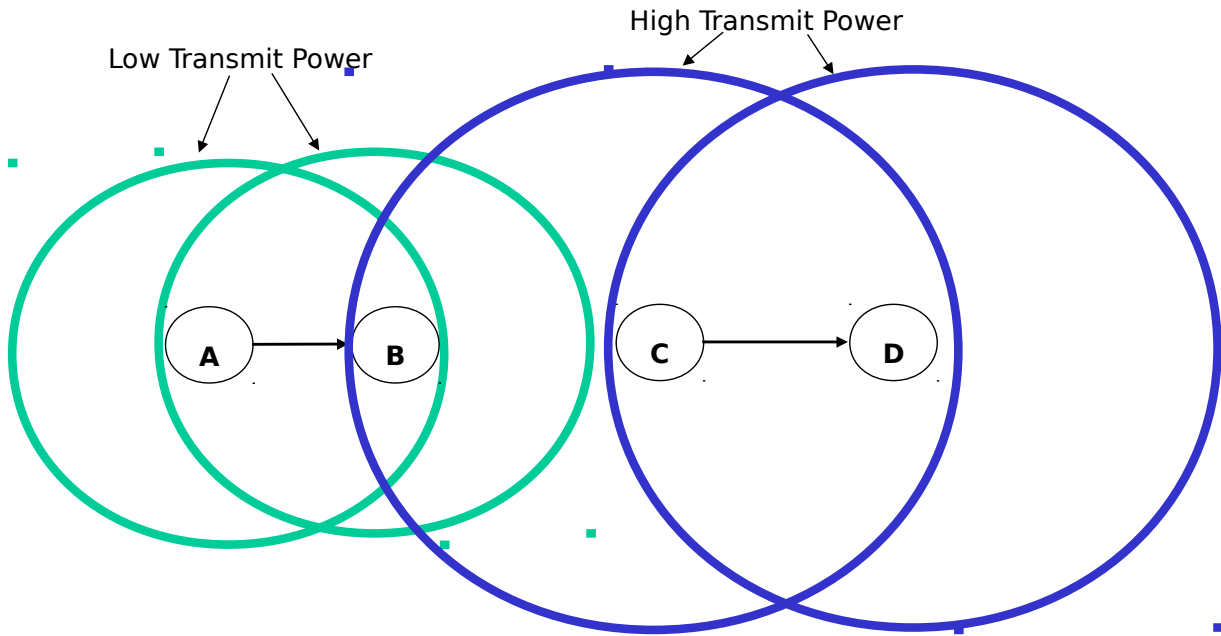


- When does a node enter the power-off state?
 - Condition 1: The node has no packets for transmission and if a neighbor begins transmitting.
 - Condition 2: A neighbor node is transmitting and another is receiving packets at the same time (data channel is busy, it cannot transmit or receive a packet)
- Duration of power-off state
 - Duration field in RTS frame
 - Probe message on signaling channel

PCM

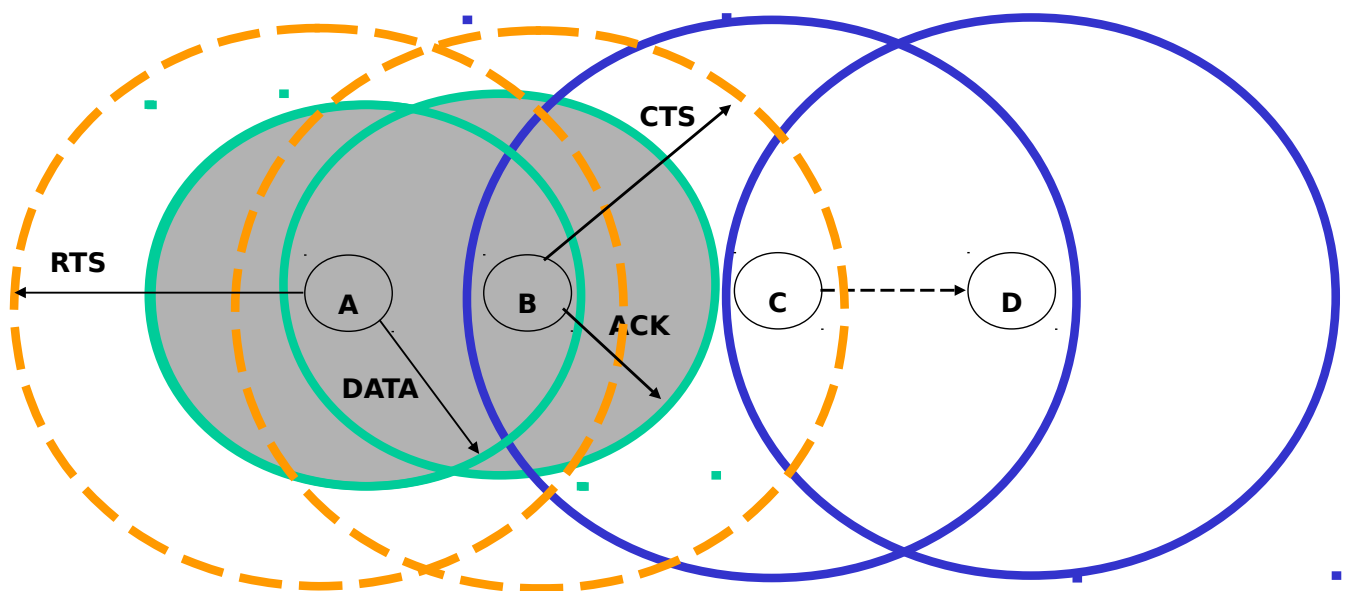
- Jung & Vaidya (2002)
 - Power Control MAC
- Based on BASIC power control protocol (Gomez et al., 2001)
 - Varied transmission power
 - Max. Power: RTS/CTS
 - Min. Power required: Data & ACK

Problem of Using Different Transmit Power



- Asymmetric situation causes collision
 - Node C starts transmitting to D as it does not sense transmission between A and B

Solution: BASIC Protocol



Transmit Power Level

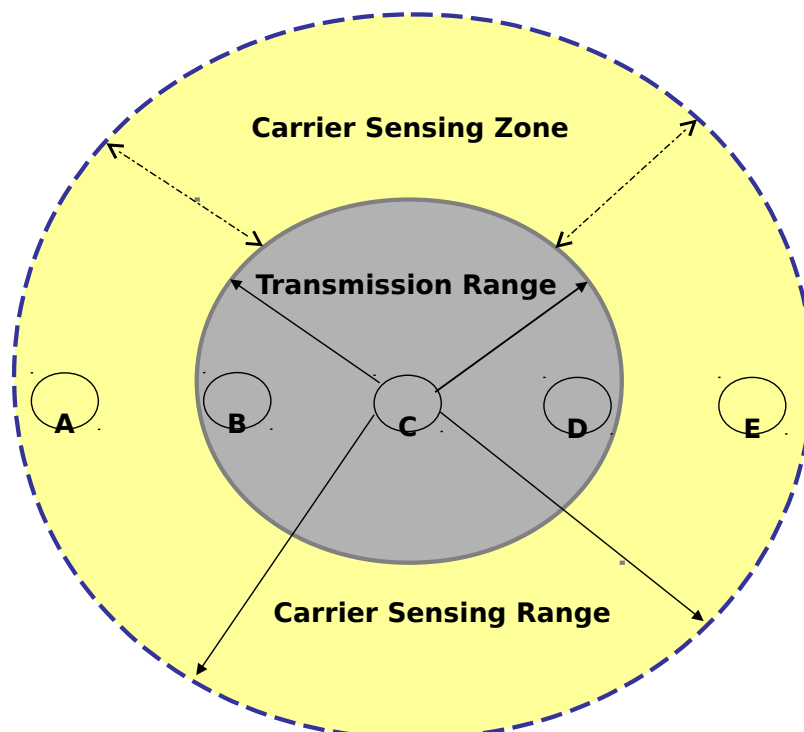
● Method 1:
$$P_{t_i,des} = \max\left\{\frac{RX_Des}{G_{ij}}, \frac{SIR_Des \cdot Pn_D_j}{G_{ij}}\right\},$$

- Transmit Power of RTS is indicated in RTS
- Gain can be computed based on both sender and receiver power of RTS
- Signal-to-noise level is considered to compute transmit power level for DATA

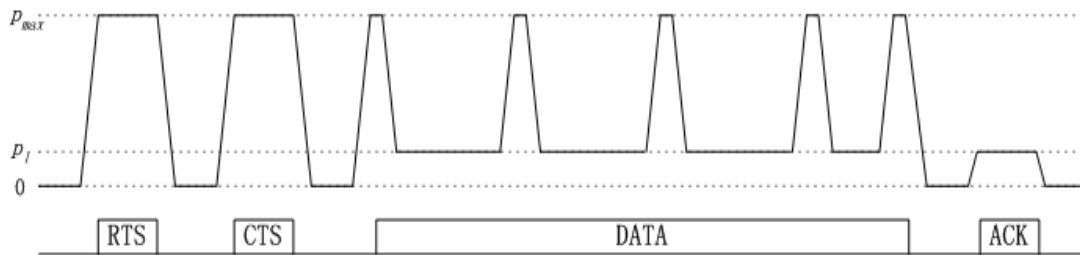
● Method 2:
$$p_{desired} = \frac{p_{max}}{p_r} \times Rx_{thresh} \times c$$

- CTS is sent at max. transmit power

Carrier Sensing vs. Transmission Range



PCM



- RTS-CTS are transmitted at maximum power level
- DATA are transmitted at minimum necessary power level BUT at the maximum level periodically
- ACK are transmitted with minimum necessary power

PCM

- Highlights:
 - Comparable performance to IEEE 802.11
 - Less energy consumed than IEEE 802.11
- Solve drawback of BASIC partly
 - Periodic use of Max Power for DATA
 - But does not completely prevent collision (collision with DATA)
- Drawbacks
 - Accurate estimation of received packet signal strength is difficult (e.g. fading, shadowing)
 - Difficult implementation of frequent change of transmit power level

Literature

- H. Karl and A. Willig: Protocols and Architectures for Wireless Sensor Networks. Wiley, ISBN: 978-0-470-09510-2, 2005.
- Suresh Singh, C. S. Raghavendra: PAMAS - power aware multi-access protocol with signalling for ad hoc networks. Computer Communication Review 28(3): 5-26 (1998)
- Eun-Sun Jung, Nitin H. Vaidya: A power control MAC protocol for ad hoc networks. ACM MOBICOM 2002: 36-47.
- Vaduvur Bharghavan, Alan J. Demers, Scott Shenker, Lixia Zhang: MACAW: A Media Access Protocol for Wireless LAN's. ACM SIGCOMM 1994: 212-225.