



Chapter 6 Relay-Based Multi-Rate MAC Protocol

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- Background
- Related Work
- Motivation
- “rDCF: A Relay-enabled Medium Access Control Protocol for Wireless Ad Hoc Networks”, IEEE Trans. on Mobile Computing, Sept. 06
- “A Relay-Aided Media Access (RAMA) Protocol in Multirate Wireless Networks”, IEEE Trans. On Vehicular Technology, Sept. 06
- Conclusion



-
- Scrambled One's
- 1 Mbit/s DBPSK
- SYNC 128 bits
- SFD 16 bits
- SIGNAL 8 bits
- SERVICE 8 bits
- LENGTH 16 bits
- CRC 16 bits
- PLCP Preamble 144 bits
- PLCP Header 48 bits
- PSDU
- 192 μ s
- PPDU
- 1 DBPSK
2 DQPSK
5.5 or 11 Mbit/s
- a) X'0A' (msb to lsb) for 1 Mbit/s;
b) X'14' (msb to lsb) for 2 Mbit/s;
c) X'37' (msb to lsb) for 5.5 Mbit/s;
d) X'6E' (msb to lsb) for 11 Mbit/s.



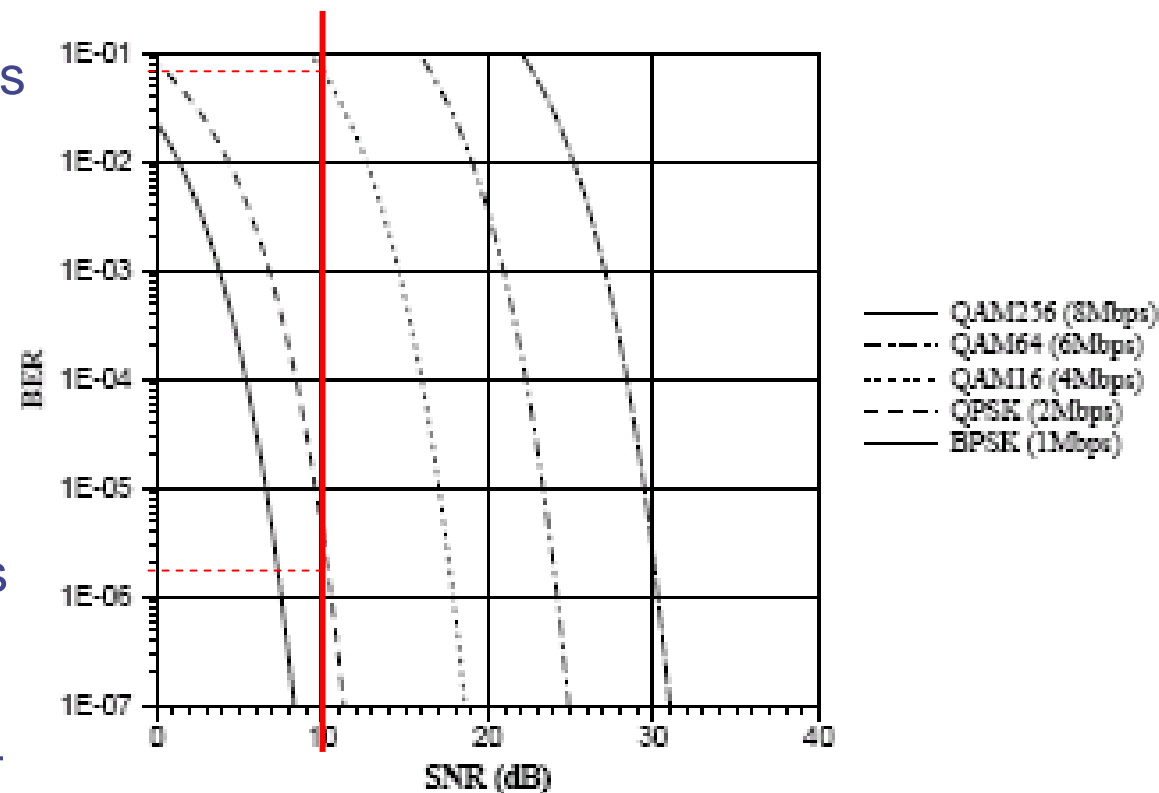
Modulation Scheme V.S. SNR and BER



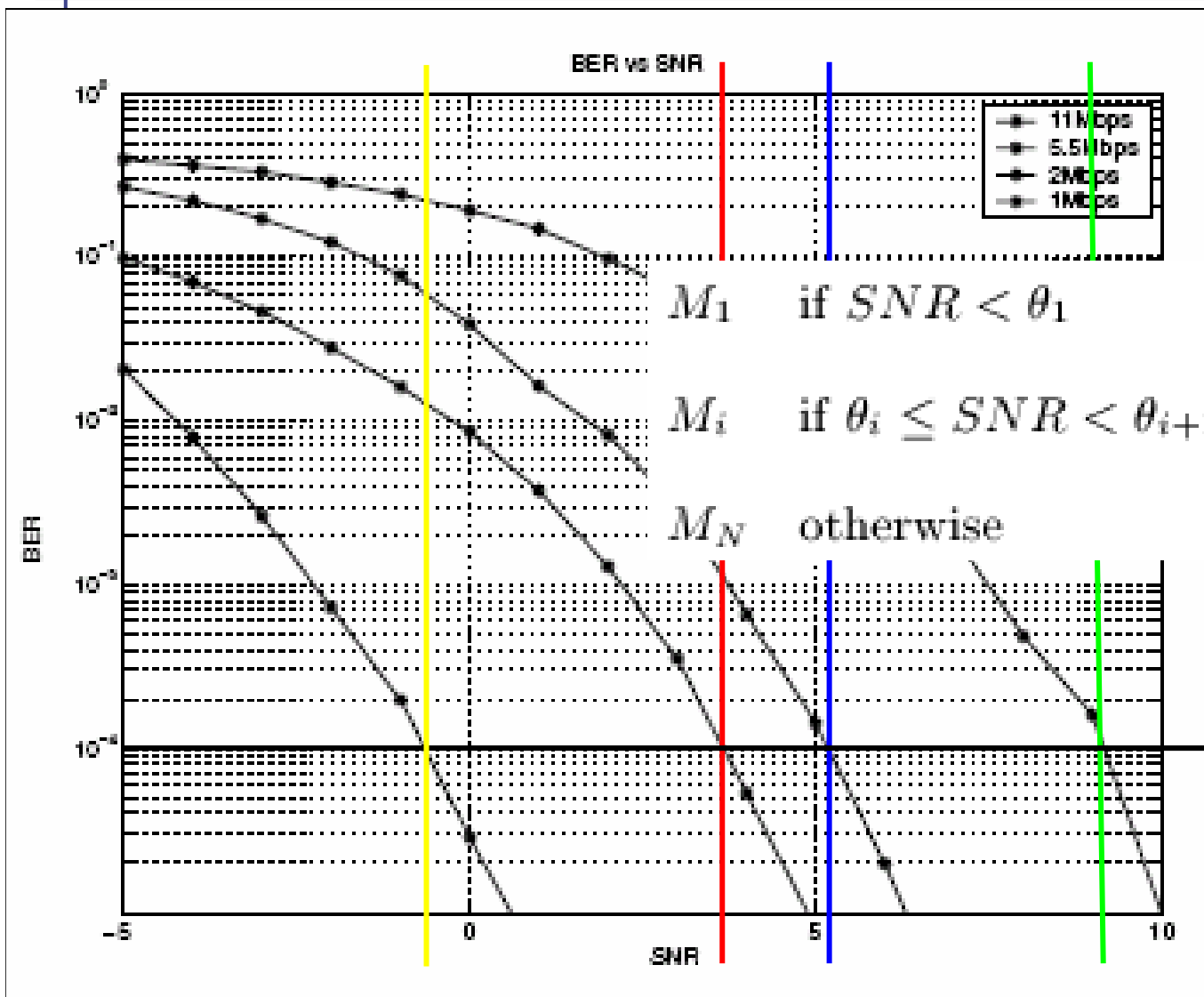
- Path loss, fading, and interference cause variations in the received signal-to-noise (SNR) ratio
- Fixed SNR
 - The higher bit rate modulation, the higher BER

QAM16 4Mbps

QPSK 2Mbps



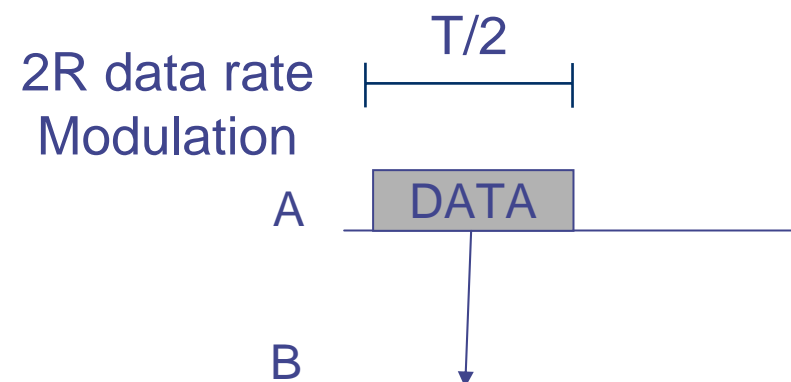
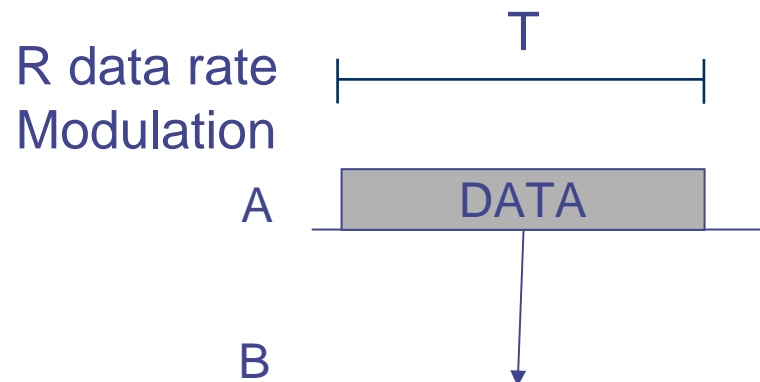
How to Choose the Bit Rate



Background



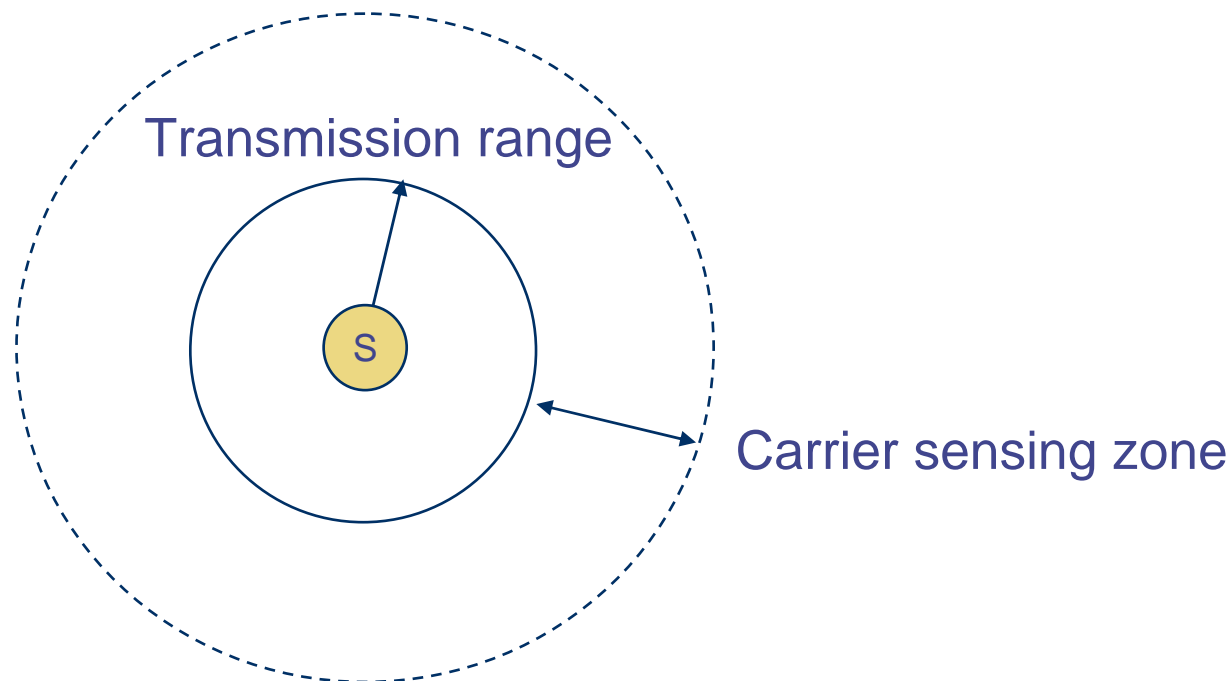
- A higher data rate modulation scheme requires higher signal-to-noise ratio (SNR)
- The relationship between transmission time and data rate modulation
 - Transmission time requires T if exploiting R data rate modulation
 - Transmission time requires $T/2$ if exploiting $2R$ data rate modulation



Background



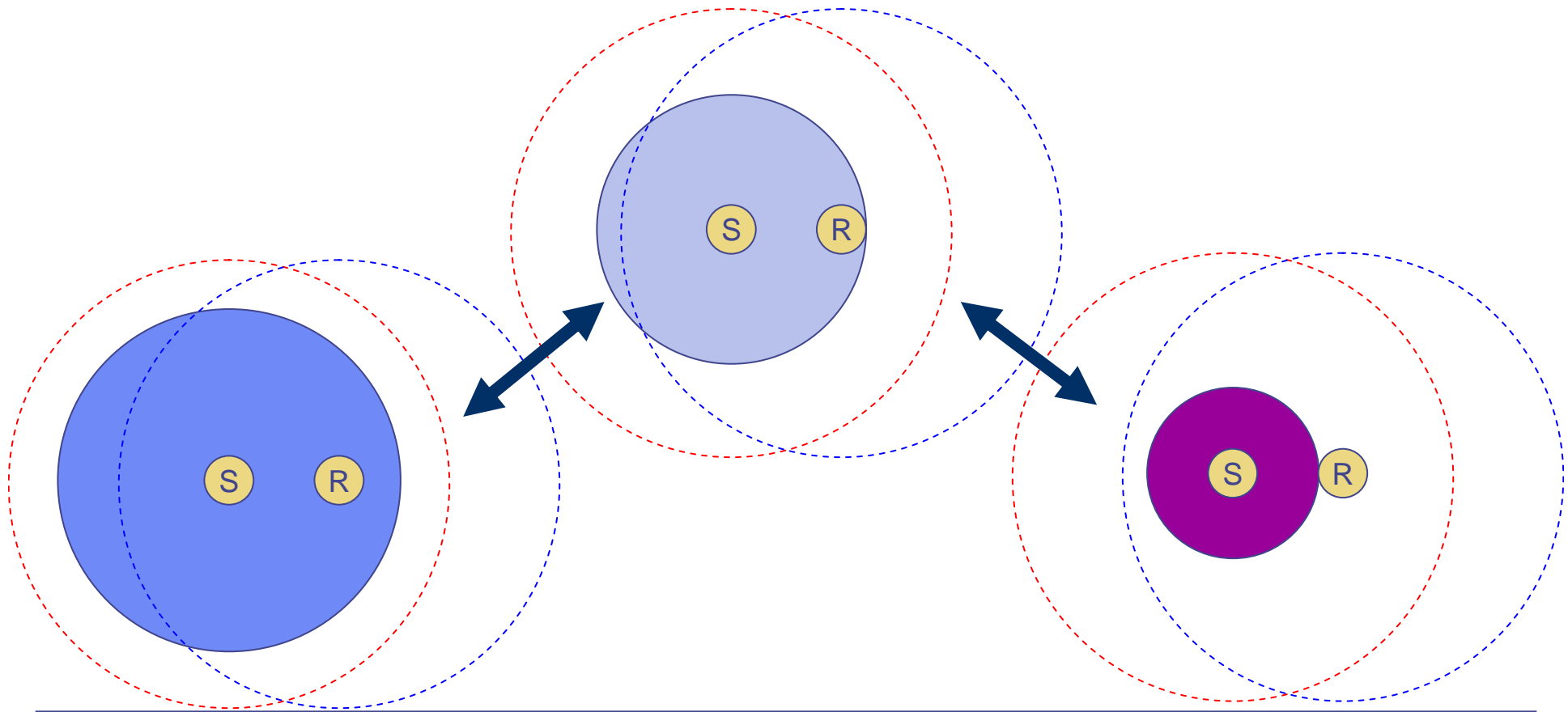
- Transmission range
 - A node can receive and correctly decode packets.
 - Transmission range is in inverse proportion to data rate modulation.
- Carrier sensing zone
 - A node can sense the signal but cannot decode it correctly.



Related Work: ARF



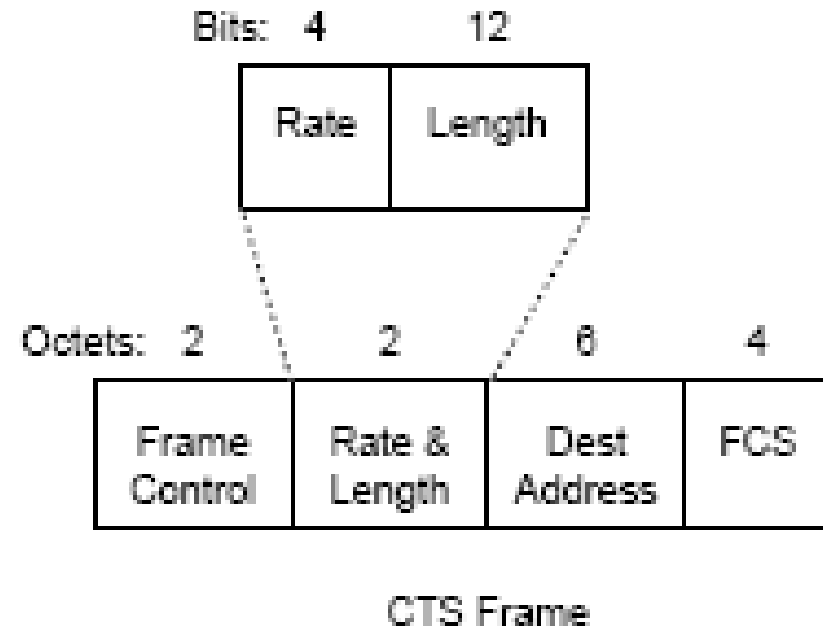
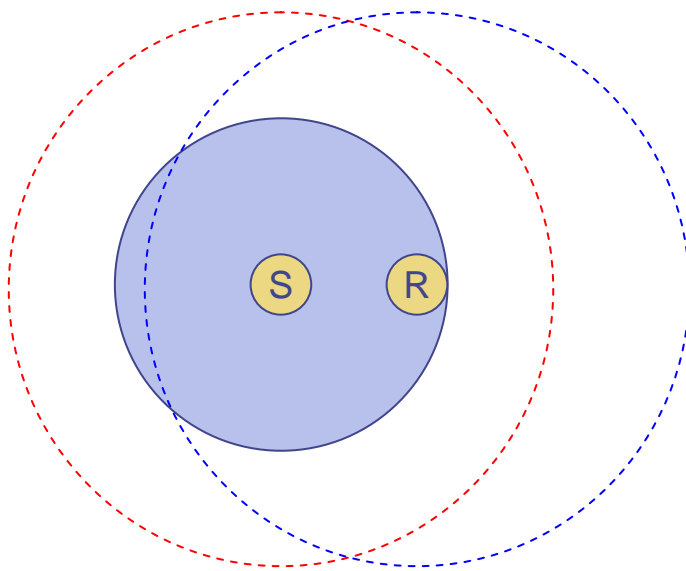
- *A. Kamerman, L. Monteban. “WaveLAN-II: A high-performance wireless LAN for the unlicensed band”, Bell Labs Tech. Journal, 97 Summer*



Related Work: RBAR



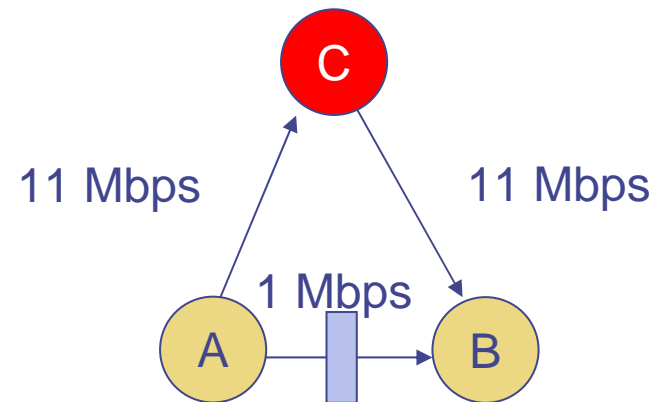
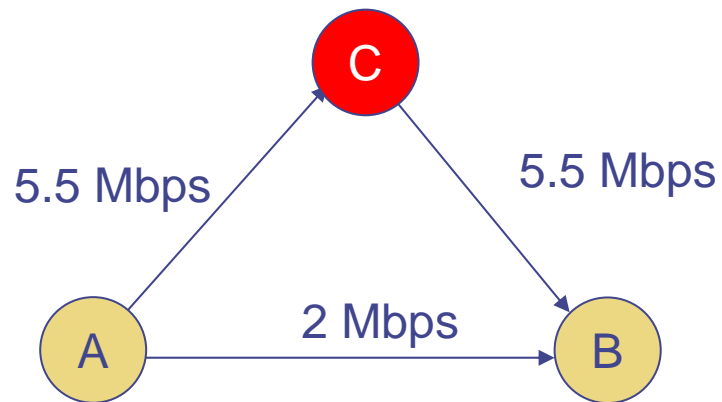
- *G. Holland, N. Vaidya, P. Bahl*, “**A Rate-Adaptive MAC Protocol for Multi-Hop Wireless Networks**”, Mobicom 01



Motivation



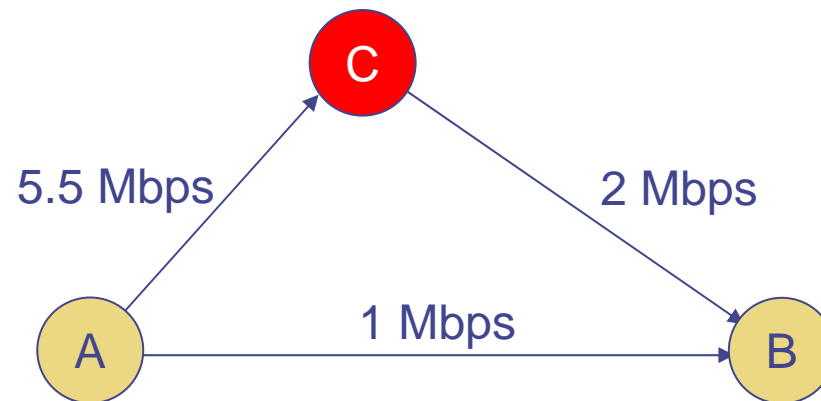
- A lower rate link can be replaced by two higher rate links.
 - $T_{AC} + T_{CB} < T_{AB}$



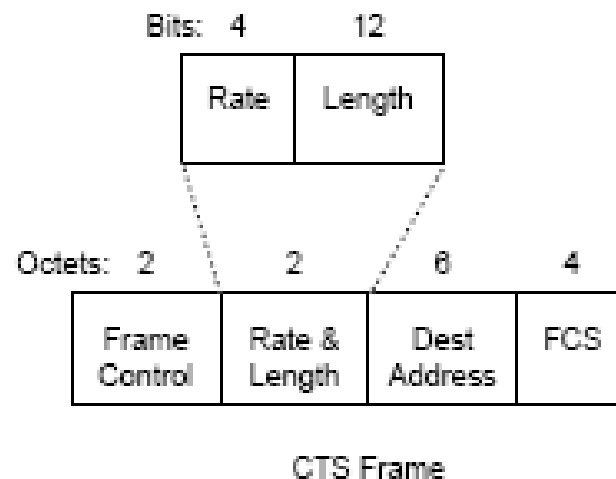
Relay-based Multi-rate MAC Protocol Process



- Relay node discovery
 - Let A know that a relay node C which exists between A and B can help A transmitting to B via C.
- Relay-based transmission
 - A sends data to B via C if $T_{AC} + T_{CB} < T_{AB}$



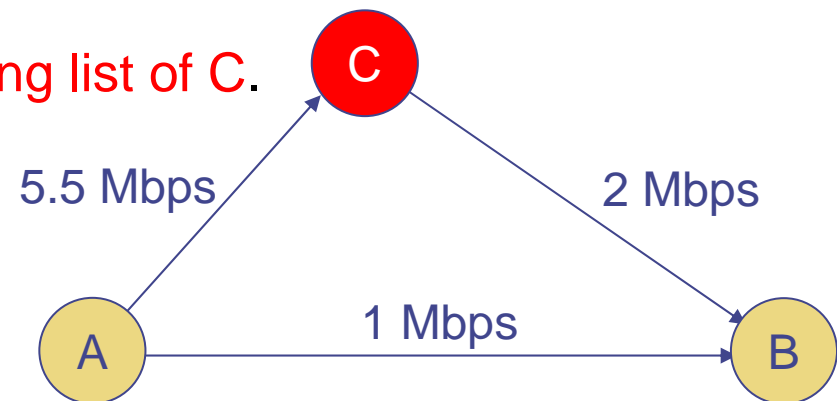
- Assumption
 - Each node transmits its packets using a constant transmission power.
 - The wireless channel between the sender and the receiver is to be almost symmetric.
- Based on RBAR
 - Receiver notifies the sender of the transmission rate via CTS



rDCF (Relay node discovery)



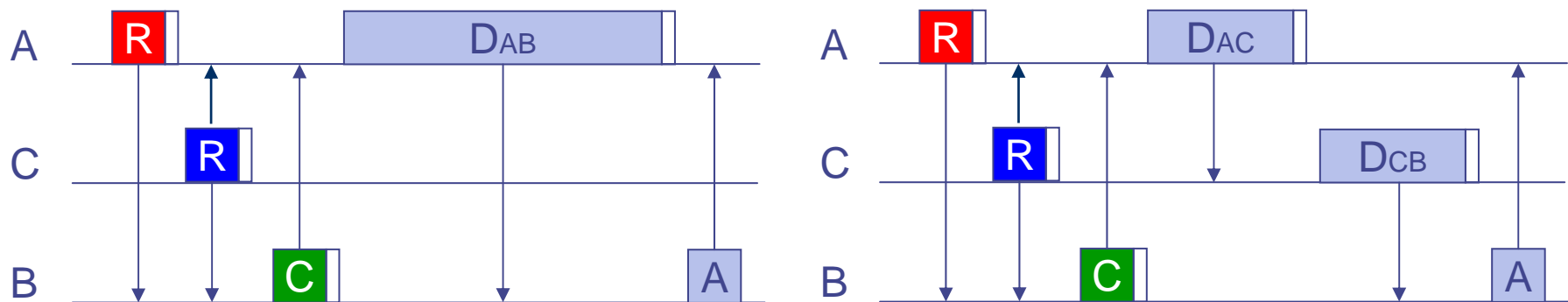
- **C** measures channel quality for a given flow between a pair of sender and receiver.
 - **C** obtains R_{AB} by extracting the piggybacked transmission rate in the CTS.
 - **C** estimates RTS and CTS to acquire R_{AC} and R_{CB} .
- if satisfying relay condition
 - Adding the identity of **A** and **B** into its willing list.
 - Periodically advertising its willing list to its neighbors
- **A** adds **C** into its relay table
 - If finding that **A** -> **B** is in the willing list of **C**.



rDCF (Relay Transmission) (Decision of B)



- **A** don't find a relay node
 - RBAR
- **A** finds a relay node
 1. **A** broadcasts **RRTS1** (**C** estimates R_{AC})
 2. **C** broadcasts **RRTS2** (carry R_{AC} , **B** estimates R_{CB})
 3. if the packet can't be transmitted faster with relay
B broadcasts **CTS** (carry R_{AB})
else
B broadcasts **RCTS** (carry R_{CB})



rDCF (How to Choose One of Relay Nodes)



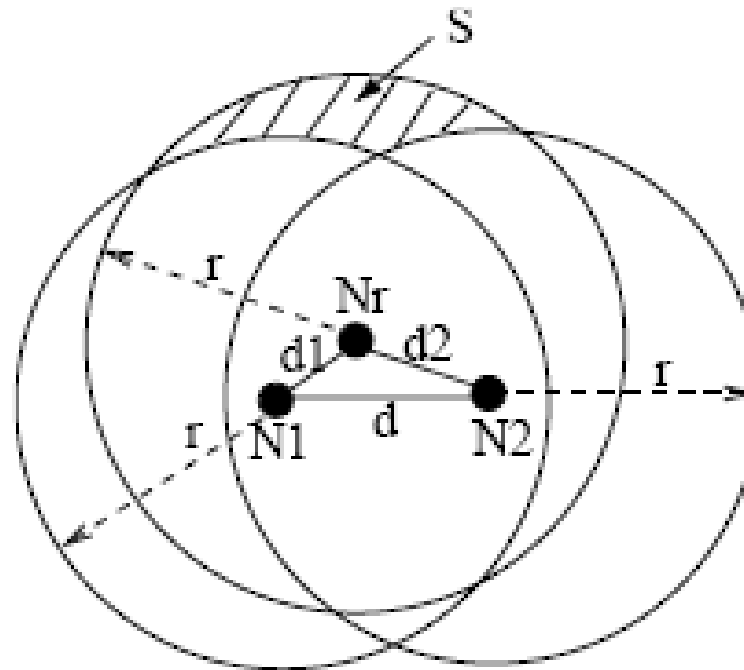
- The channel condition may change frequently in wireless networks.
 - Relay node may suffer **hidden terminal**.
- Each relay node in the relay table of A
 - Be associated with a **credit** ranging [0.0, 1.0]
- A chooses the one with the **largest credit**
 - Generating a random number in [0.0, 1.0]
 - If random number \geq credit
 - A dos rDCF
 - if rDCF is success
 - the credit of C is increased
 - else if rDCF is failed
 - the credit of C is decreased
 - else if random number $<$ credit
 - A dos RBAR



Carrier Sensing Zone Analysis

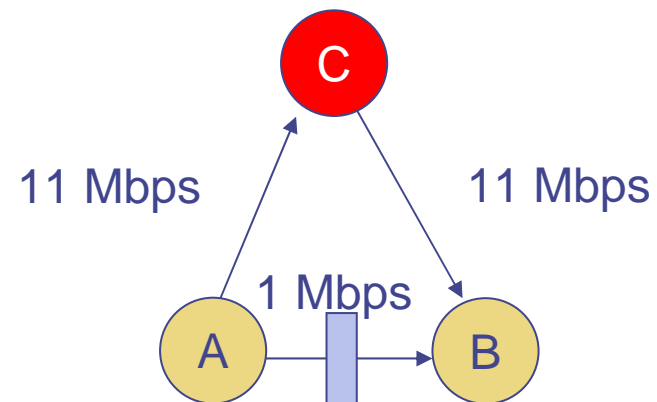
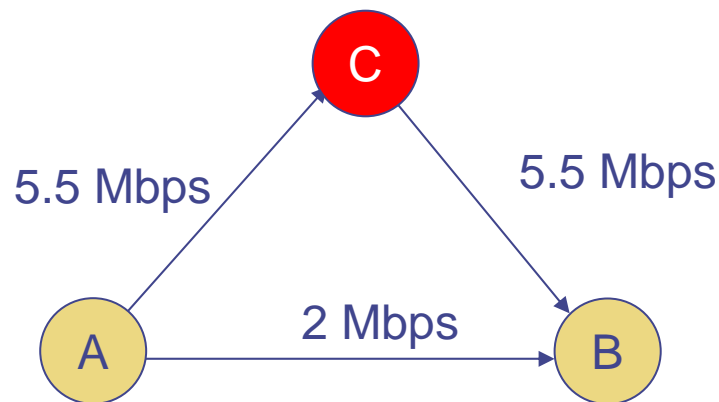
- Increased sensing zone is small

d (meters)	210	220	230	240	250
Upper bound of increased sensing area (%)	11.5	10.5	9.2	8.2	7.2





- Assumption
 - In DCF, each node must transmit with the same power.
 - Channel gain between the two nodes is the same in both directions.
Based on RBAR



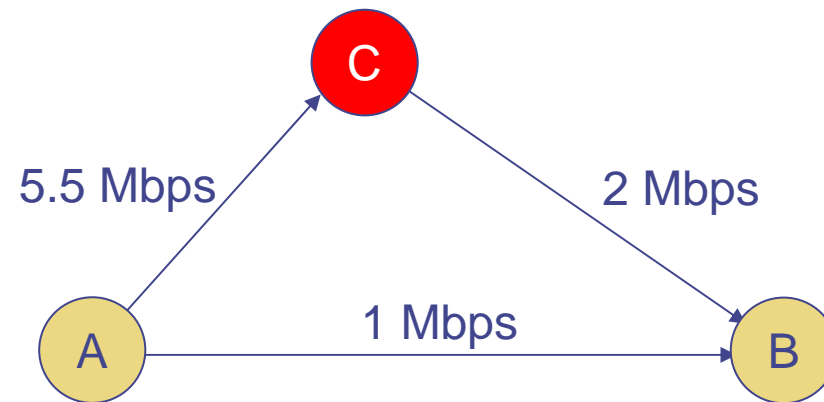
RAMA (Relay node discovery)



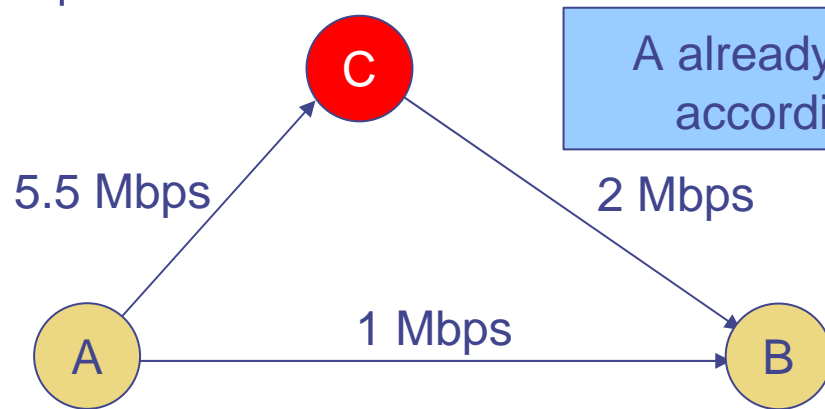
- **C** obtains R_{AB} from PHY header of $DATA_{AB}$.
- **C** estimates $DATA_{AB}$ and ACK to acquire R_{AC} and R_{CB} .
if satisfying relay condition

C will broadcast an **invitation frame** to A

- **Source, Relay, Destination, R_{AC} and R_{CB}**
- A will record it in **Relay List**.



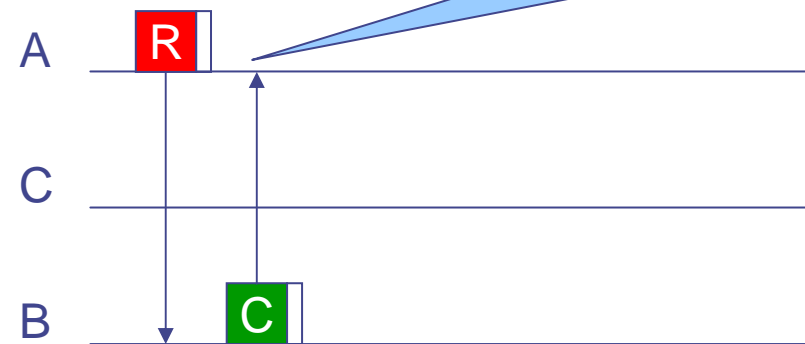
RAMA (Relay Transmission) (Decision of A)



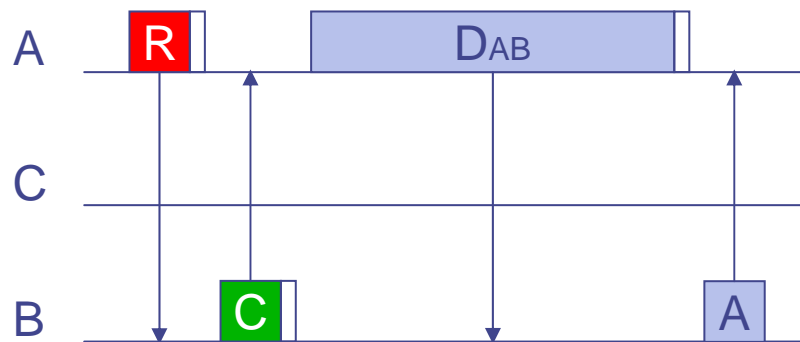
A already has R_{AC} and R_{CB} according to Relay List

A knows R_{AB}

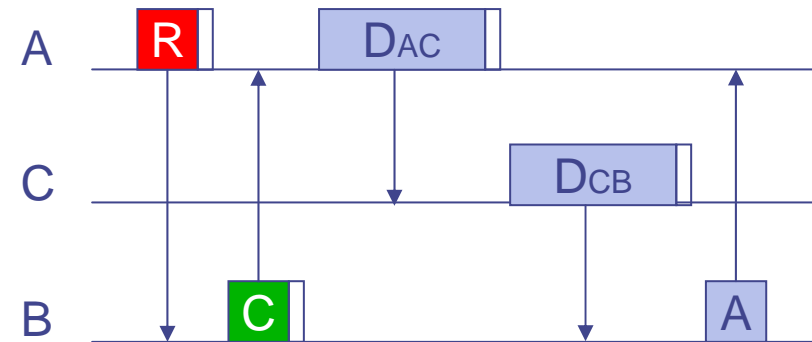
Relay List:
Source, Relay, Destination, R_{AC} and R_{CB}



Case 1



Case 2

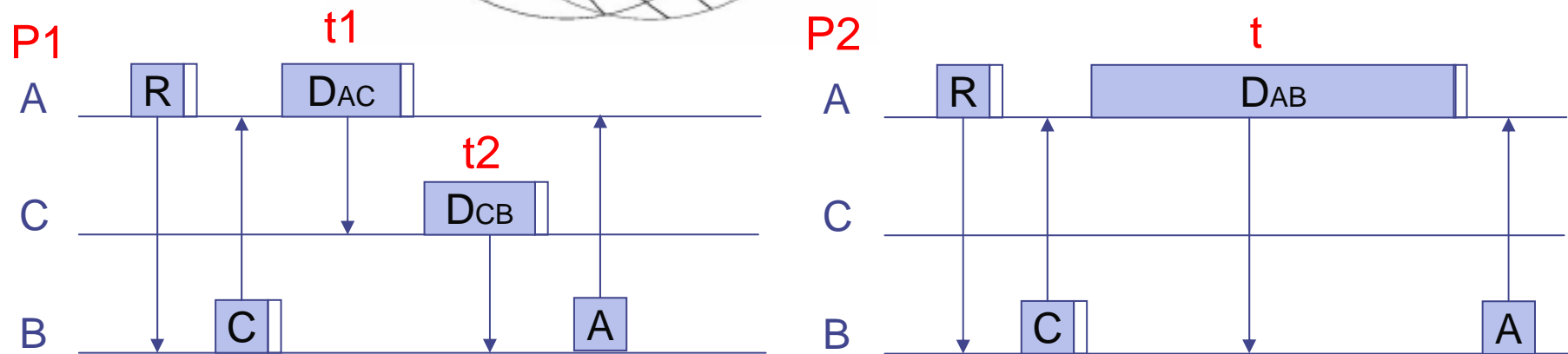
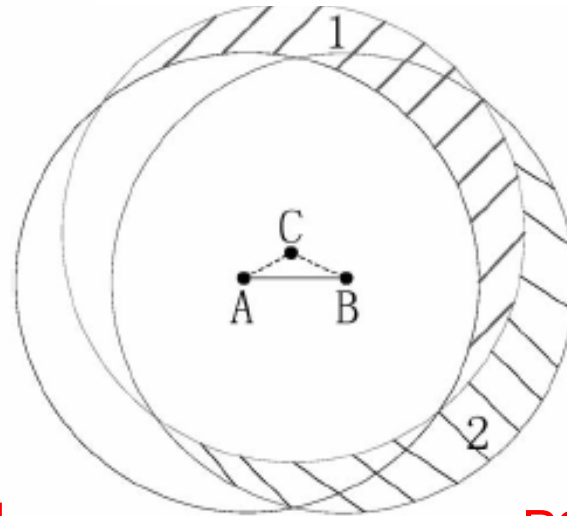


Carrier Sensing Zone Analysis



$a_1 < a$ and $a_2 < a$ because $d_{AC} < d_{AB}$ and $d_{CB} < d_{AB}$

$$t_1 + t_2 < t \quad p_1 = e^{-a_1 \lambda t_1} \times e^{-a_2 \lambda t_2} > p_2 = e^{-a \lambda t}$$



Summary



- According to the channel condition, data can be transmitted with different data rate modulation.
- Multi-rate transmission vs. single-rate transmission
 - Increasing overall throughput
 - Decreasing transmission time
- Data also may be delivered faster through a relay node than through the direct link if the direct link has low quality and low data rate.

