Qos support and adaptive video

QoS support in ad hoc networks

- **MAC layer techniques:**
  - 802.11 e - alternation of contention based and contention free periods; differentiated (per class) Interframe Spacing and CW_{min}
  - Cluster TDMA – reservation of slots (via PRMA)
  - MACA PR: neighbors defer to stream packets (periodic reservations)
  - Ad Hoc MAC: reservation of slots via PRMA ; CAC (Call Acceptance Control)
  - Etc, etc

- **All the above methods can guarantee reservations if nodes do not move and channel quality does not change**
- **What if the nodes move?**

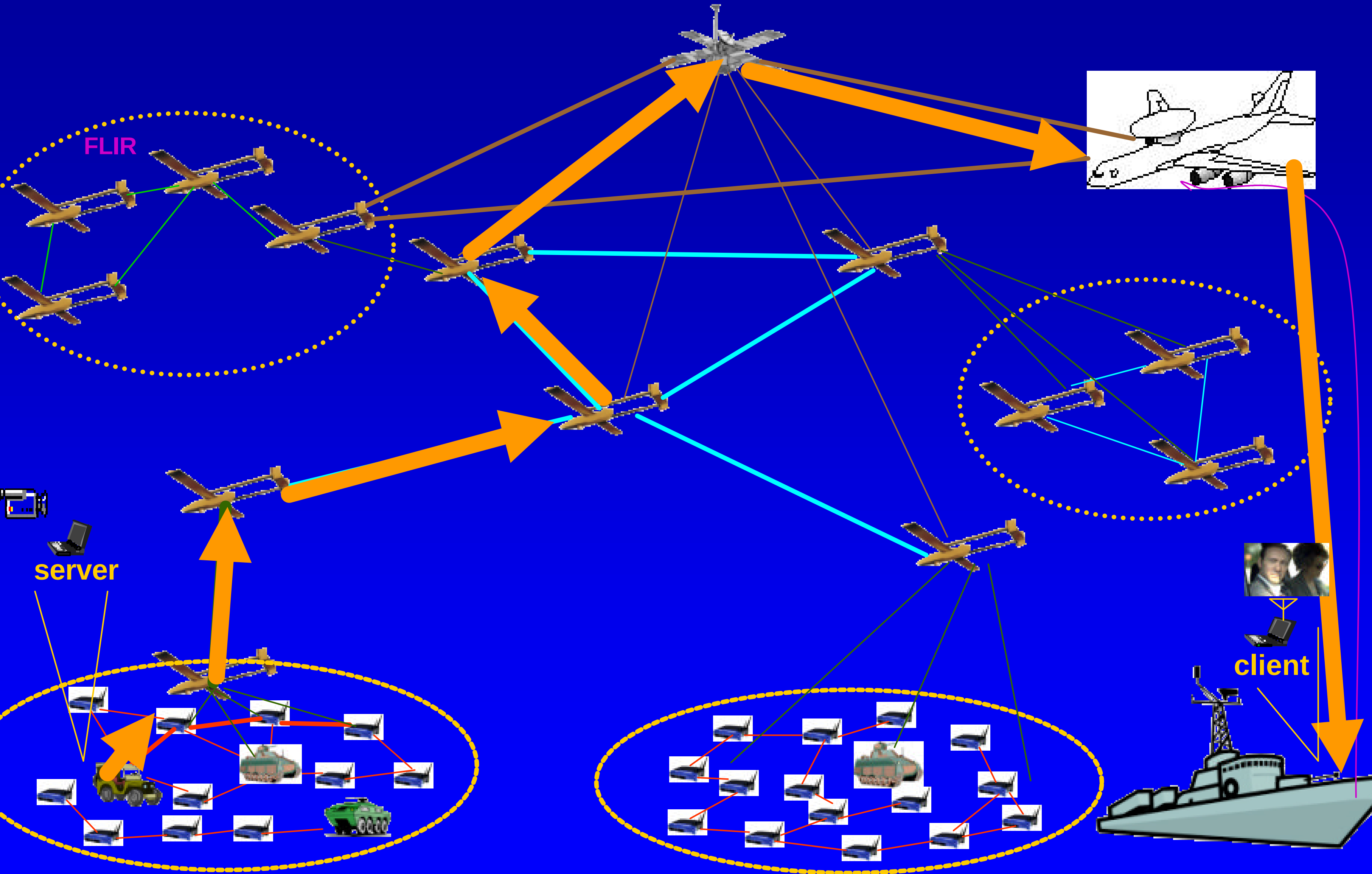
802.11 e (review)

- **QoS guarantees desirable for real time traffic**
- **IEEE 802.11 e is the answer**
- **EDCF mode (Enhanced DFC):**
  - Traffic class dependent CW_{min} and DIFS
  - Frame bursting: RTS-CTS-DATA-ACK-DATA-ACK-DATA-ACK…..
- **HCF mode (Hybrid Coordination Function):**
  - Similar to the PCF of 802.11b
  - Alternation of CP (contention periods) and CFP (cont free periods)
  - During the contention period EDCF mode is enacted, except that the AP can issue a QoS poll to specific stations (using PIFS)
  - High priority stations can tell the AP about their needs (to get the Poll)
- **Clearly, the Best Effort traffic is second citizen in this case!**
- **Another challenge is the coexistence of 802.11b and e**

Adaptive QoS support

- **If nodes move, the end to end path capacity can change dynamically:**
  - The connectivity and topology change
  - The channel propagation characteristics change (eg, multipath fading)
  - The external interference can change
- **A possible answer:**
- **Renegotiable QoS; rate adaptation; preemption of lower priority users**
- **Case study: adaptive video streaming**

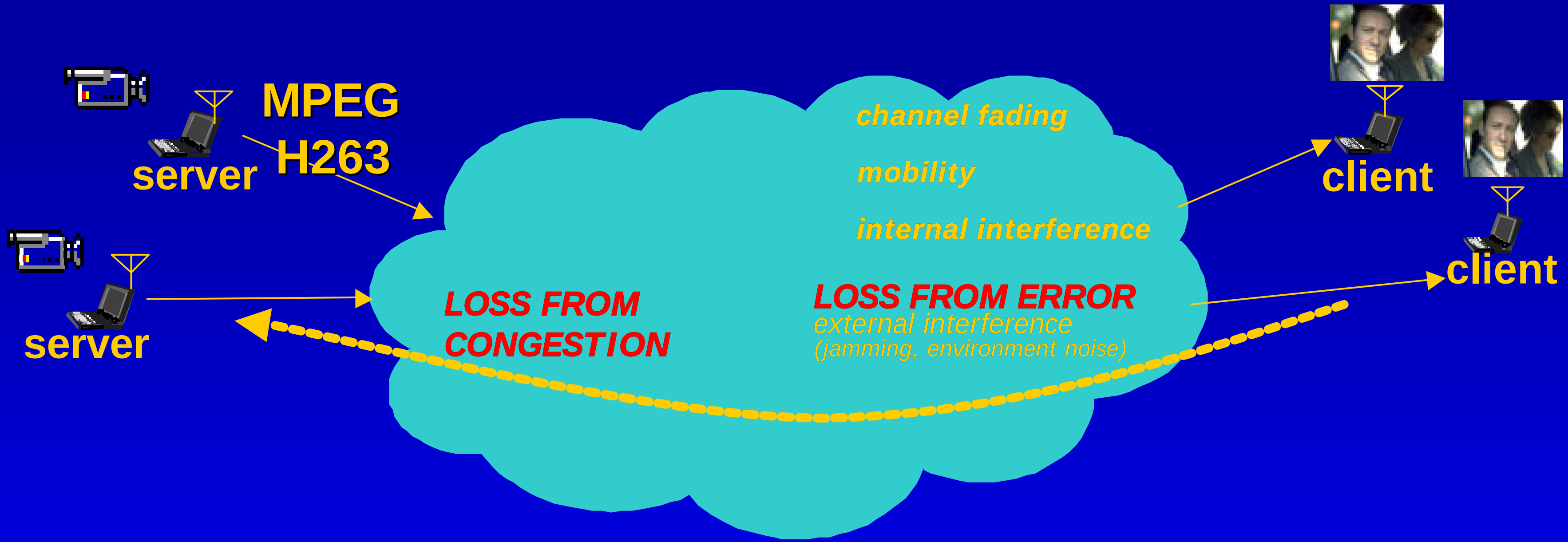
Scalable, Adaptive Video Streaming



Why Adaptive Video?

- **To prevent traffic congestion**
  - Adjust the stream rate so that it "fairly" shares the available bandwidth
- **To deal with channel random interference, propagation, jamming**
  - Adjust (reduce) video packet size, strengthen the channel encoding to combat random/burst errors
- **Challenge:**
  - Distinguish between congestion (must reduce rate) and random errors (keep same rate but strengthen the code)

The concept



- **End to End Feedback Adaptation Approach**
  - Traditional approach
  - Transport and Application employ end-to-end measurements to perform flow control
- **Network Feedback Adaptation Approach**
  - Network layer propagates channel measurements to source
  - Ability to detect cause of degradation and react properly
- **Implemented in simulation, testbed and hybrid simulation**

Adaptation Techniques

- **RTP Loss rate Adaptation (Trial And Error)**
  - It constantly 'tries' to support higher rates
  - Backs up when loss is detected
- **Available Bandwidth (AB Probe)**
  - Av. Bdw. estimated from inter-packet intervals
  - Can distinguish error loss from congestion
- **Network Feedback**
  - Link channel quality and bdw info piggybacked on routing pkts
  - Gives accurate picture of network path state to source

Network feedback

- **Goal: dynamic estimation of available bandwidth AP from source to destination**
- **Approach: MAC and network layer cooperation**
- **At the MAC layer:**
  - estimate the permissible throughput from a node to each of its neighbors
  - estimate the “available bandwidth” AvBd for a node
- **At the network layer:**
  - Finally, propagate the AvBd estimate to source using routing control packets

MAC layer computation

(a) Estimate link throughput:

$$\text{Throughput} = S / (T_{ack} - T_{tx})$$

Where:

- S = packet size (bits)
- Ttx : time when packet tx is first attempted
- Tack : time when ACK is received

This estimate accounts for collision avoidance, retransmissions, backoffs etc

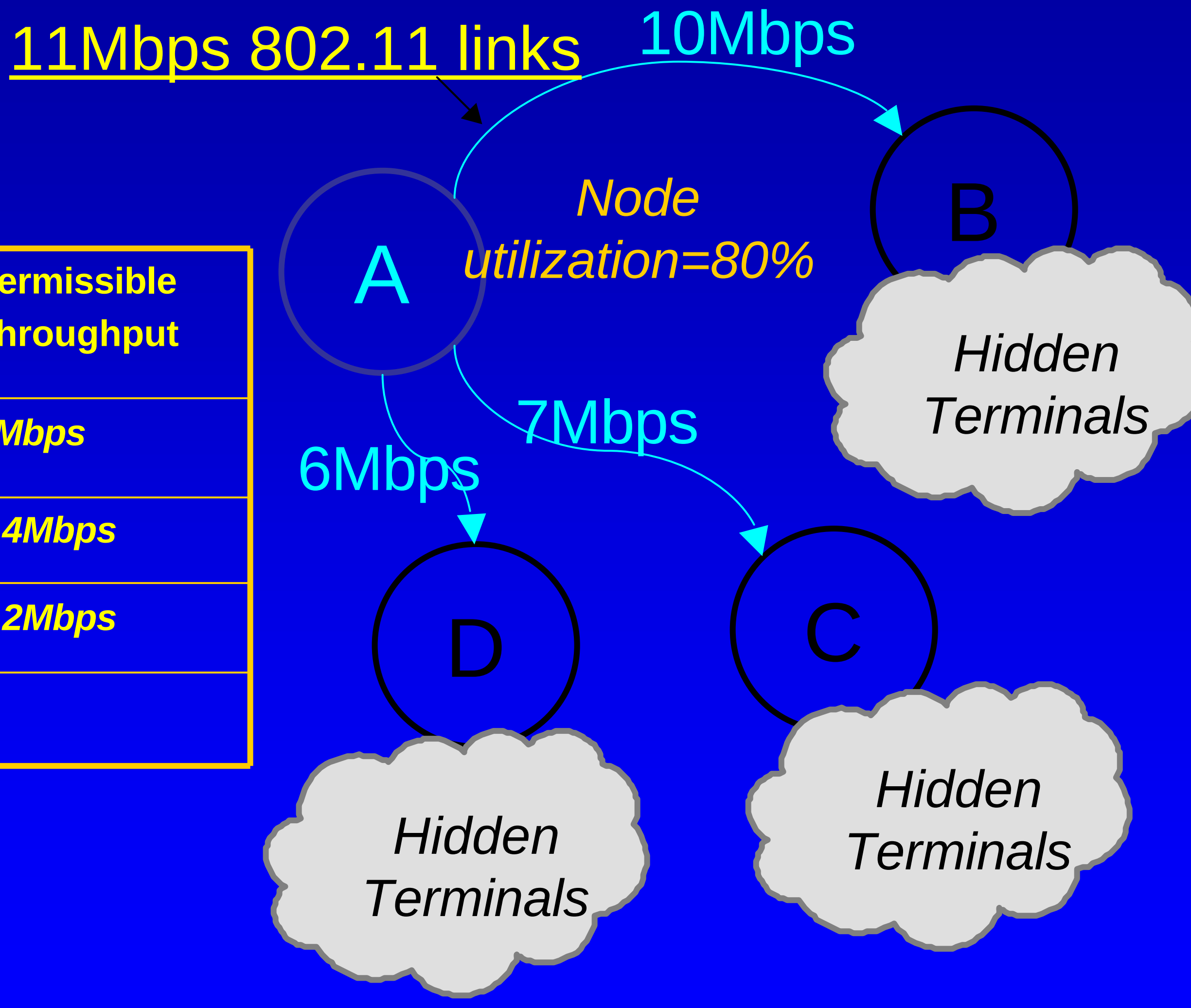
The estimate is averaged over a measurement window

(b) Measure node utilization u = fraction of time node is busy (ie, it has packets in the queue)

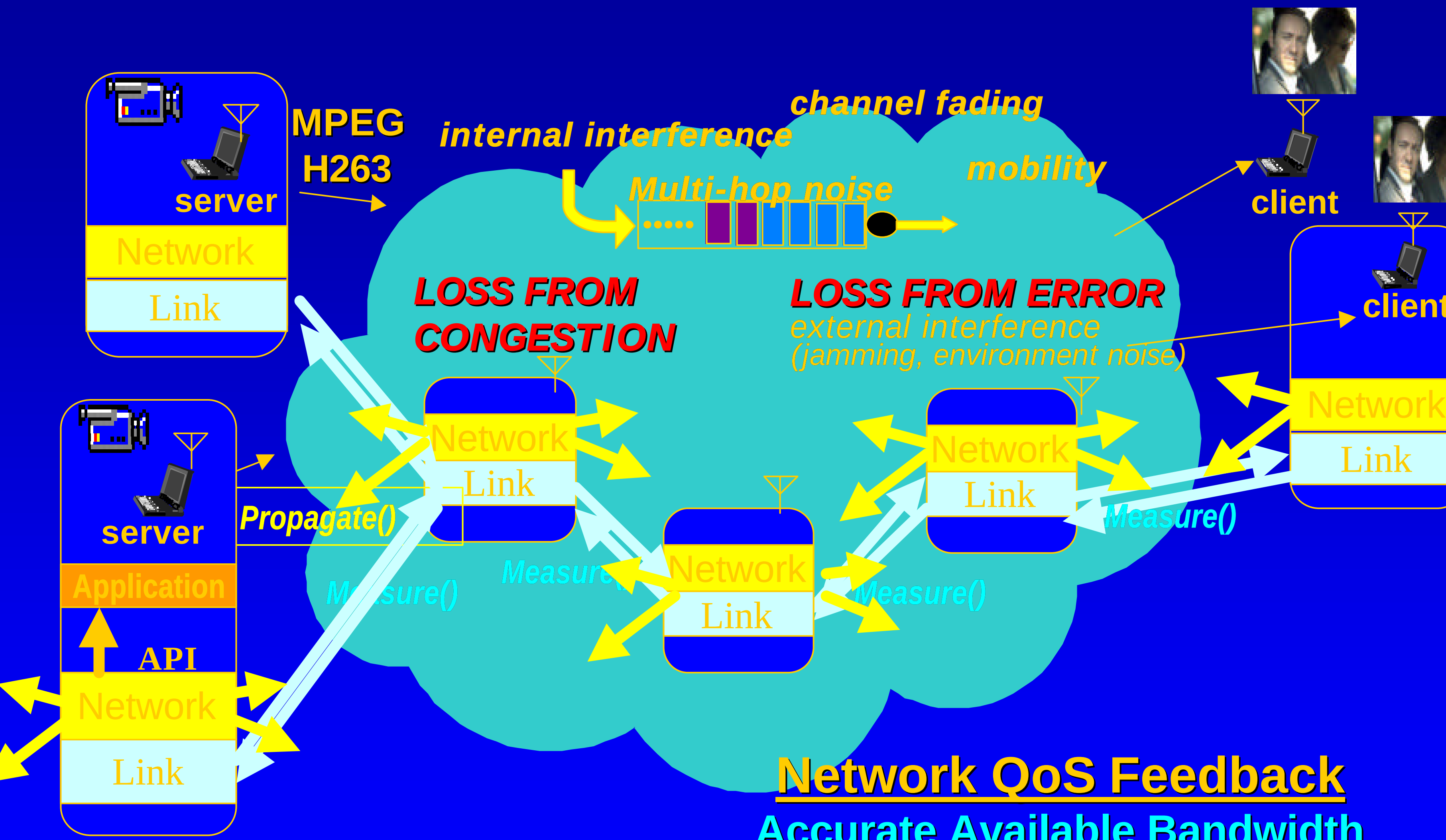
$$\text{Available Bdw} = (1 - u) \times \text{Throughput}$$

Measurement Example

	Throughput	Permissible Throughput
AB	***10Mbps(<11)***	***2Mbps***
AC	***7Mbps (<11)***	***1.4Mbps***
AD	***6Mbps (<11)***	***1.2Mbps***



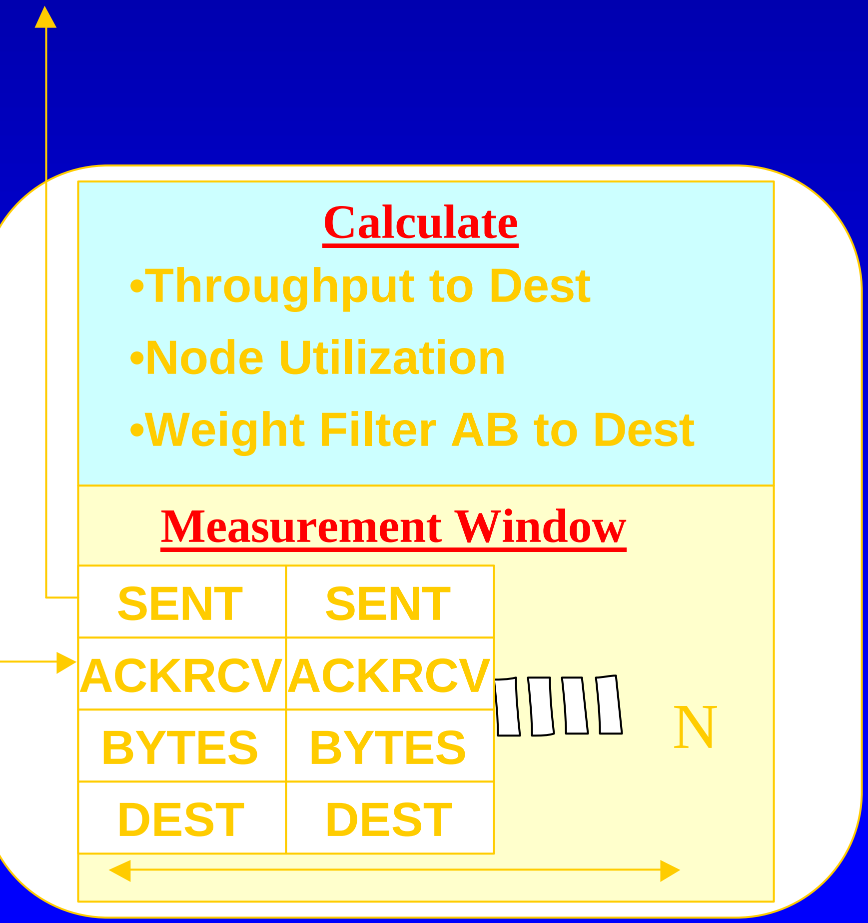
Link Assisted/Network Feedback



Network QoS Feedback

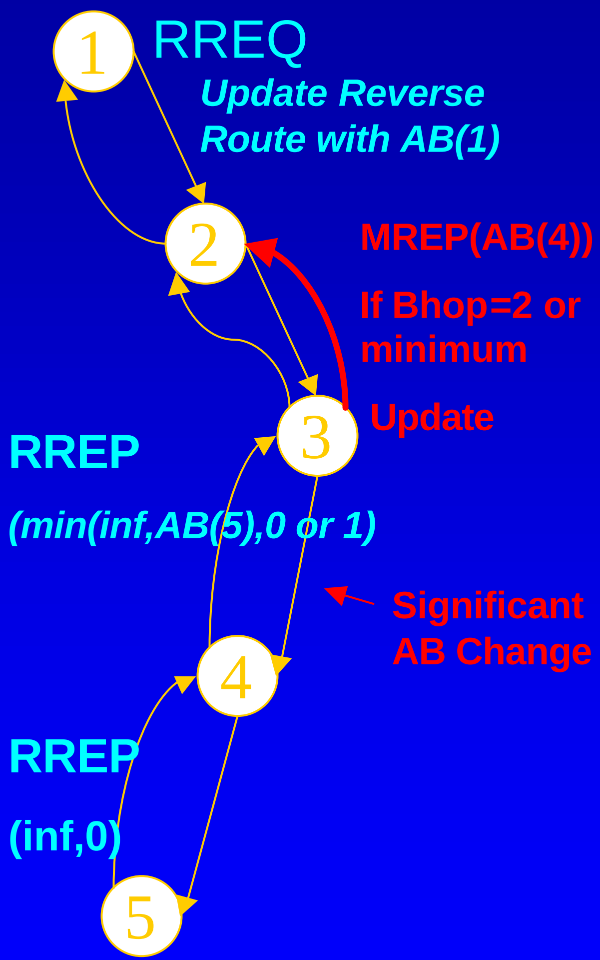
Accurate Available Bandwidth Measurement and Advertising

802.11 Available Bandwidth



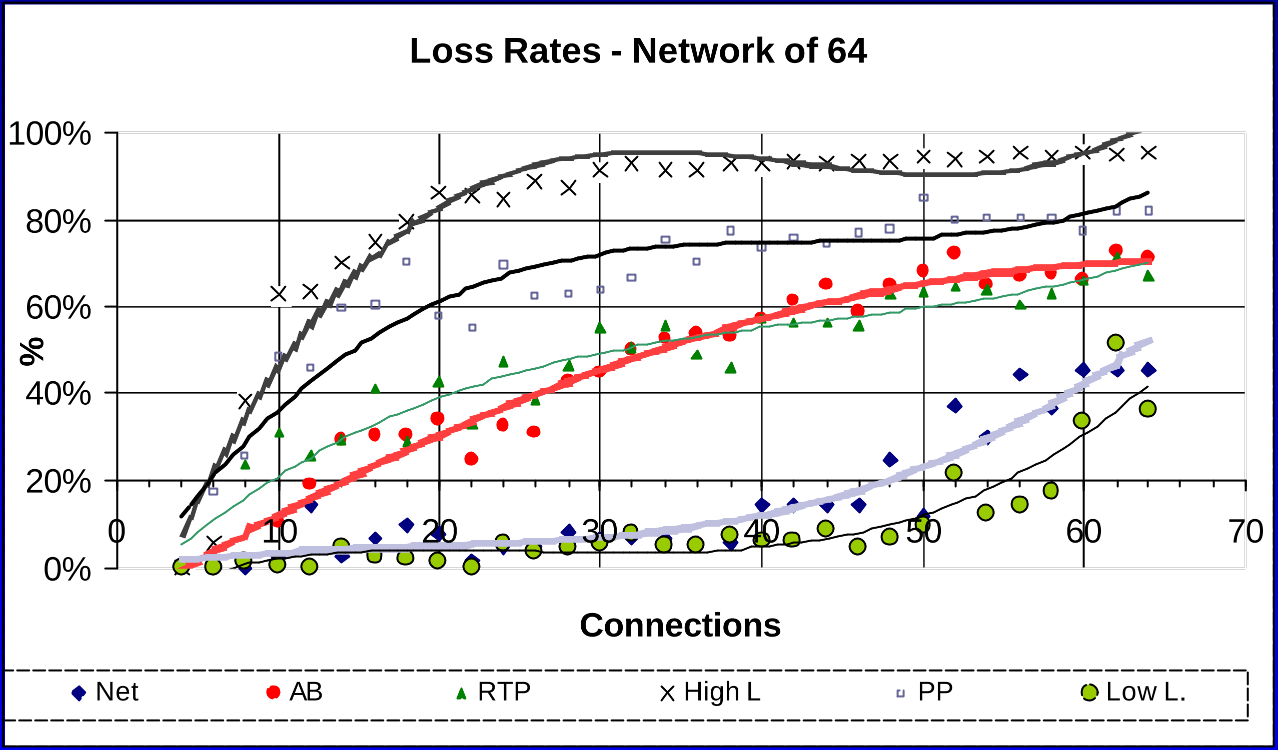
- **Maintain Per Neighbor:**
  - Throughput Estimates, AB estimates
- **Maintain Per Node:**
  - Busytime, Wndtime, iQin, iQout
- **Maintain Per Measurement Window:**
  - Sent, Recv, Dest, Bytes
- **Note Utilization is calculated per node**
- **Throughput per (S,D) pair**
- **Has Network layer implementation with ACK/LF**

How to propagate to sources? QM-AODV



- **Q-AODV – extension of AODV for QoS routing**
  - **Finds routes given: minimum bandwidth and maximum delay constraint**
  - **Does not deal with measurement aggregation**
  - **Does not have to propagate measurements**
- **AvBd propagation - QM-AODV**
  - Use Q-AODV packet format
  - Add bottleneck hop information
  - Use an MREP special reply packet
  - Use Measurement Relay Factor to trigger Measurement updates

802.11 Multi-hop – Loss Rates



AB-probe performs best initially, then worse than RTP when load is high

RTP adaptation works better than direct PP (Packet Pair) method

Network Feedback is best