Seamless VoWLAN Handoff Management based on Estimation of AP Queue Length & Frame Retries

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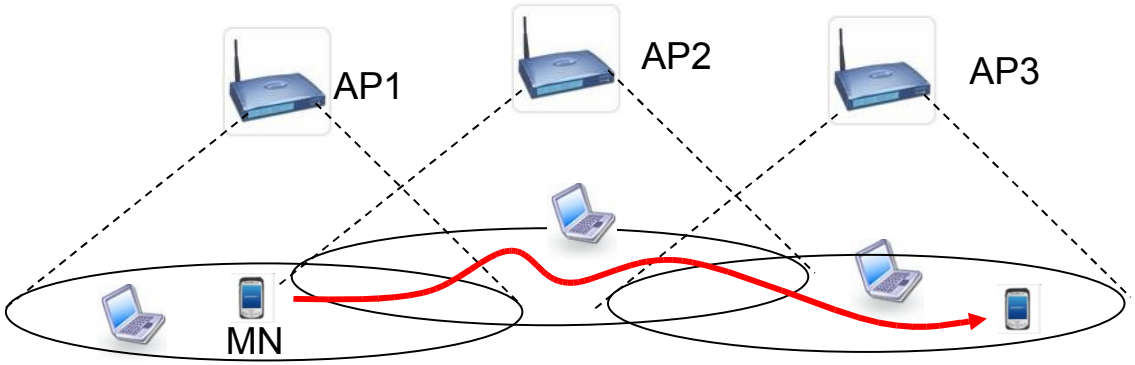
Outline

- Background
- VoWLAN Challenges
- Existing Handoff Schemes
- Objectives
- Proposed Handoff Decision Metrics
- Evaluation of Proposed Handoff Decision Metrics
- Proposed Handoff Strategy
- Evaluation of Proposed Handoff Strategy
- Conclusion

Background

- Huge demand for Voice over IP (VoIP) service over WLANs
- Dominant WLAN today: IEEE802.11
- Mobile Node (MN) more likely to traverse several hotspots during VoIP call
- Need reliable Handoff Management for real-time applications such as VoIP



VoIP over WLAN (VoWLAN) Challenges (1)

- VoIP sensitive to delay and packet loss
- IEEE802.11-based WLAN not originally designed to support delay & packet loss sensitive applications
- Physical characteristics of wireless much worse than wired lines

VoIP over WLAN (VoWLAN) Challenges (2)

- VoIP quality mainly degraded due to
  - Poor Wireless Link Quality
    - movement, radio interference and obstacles
  - Congestion at AP
    - Increase number of Mobile Terminals
- MN need to detect degradation of VoIP quality & handoff to another WLAN
- Require Handoff Management to maintain VoIP quality during handoff

Existing Handoff Management

- Network Layer
  - Mobile IP
  - FMIPv6
  - HMIPv6
- Transport Layer
  - M-TCP
  - M-UDP
  - M-SCTP

Limitation of Existing Handoff Management

- Handoff decision metric and criteria are not discussed in detail
- Rely on only upper layer information
  - Packet loss
  - Delay
  - MOS

Selecting Handoff Decision Metric

- Common Handoff Decision Metric
  - Received Signal Strength
  - Delay
  - Packet Loss
- Handoff Decision Metric from Layer 2
  - Information of MAC layer has potential to be significant metric
  - Frame retries inevitably occur before packet loss

    allows an MN to detect wireless link condition quickly

Objectives

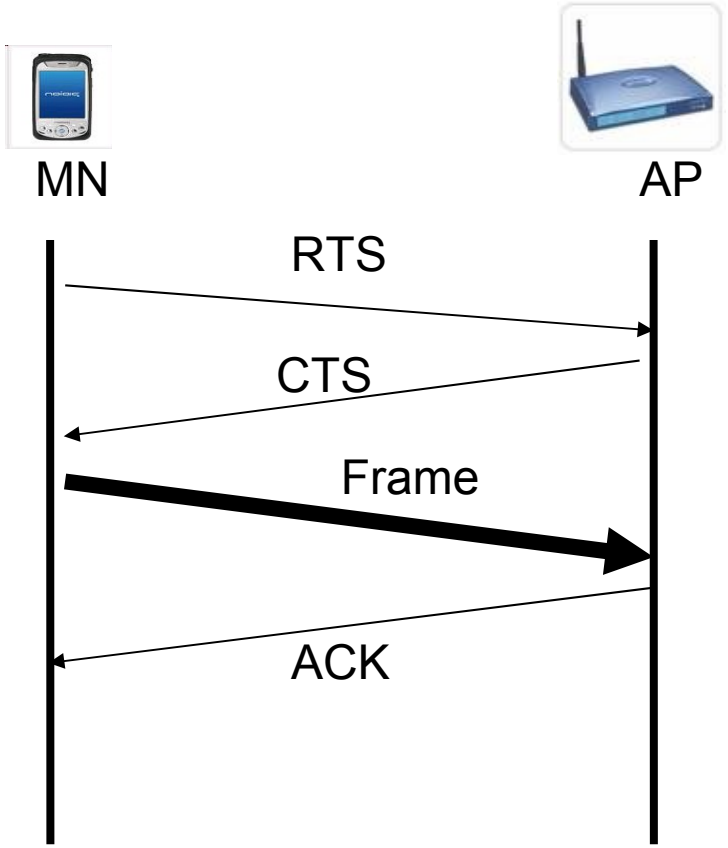
- Propose reliable Handoff Decision Metrics
- Develop Mobile Terminal-based Handoff Management to maintain VoIP call quality during handoff

Proposed Handoff Decision Metrics

- Retransmission of Request-To-Send (RTS) Frame
  - Metric for indicating wireless link condition
- AP Queue Length
  - Metric for indicating congestion state at AP

Proposed Handoff Decision Metrics:
Request To Send (RTS) Retries

- To prevent collision in wireless network due to hidden node
- To clear out area
- RTS Retries can indicate condition of wireless link



Proposed Handoff Decision Metrics:
Why RTS Frame Retries?

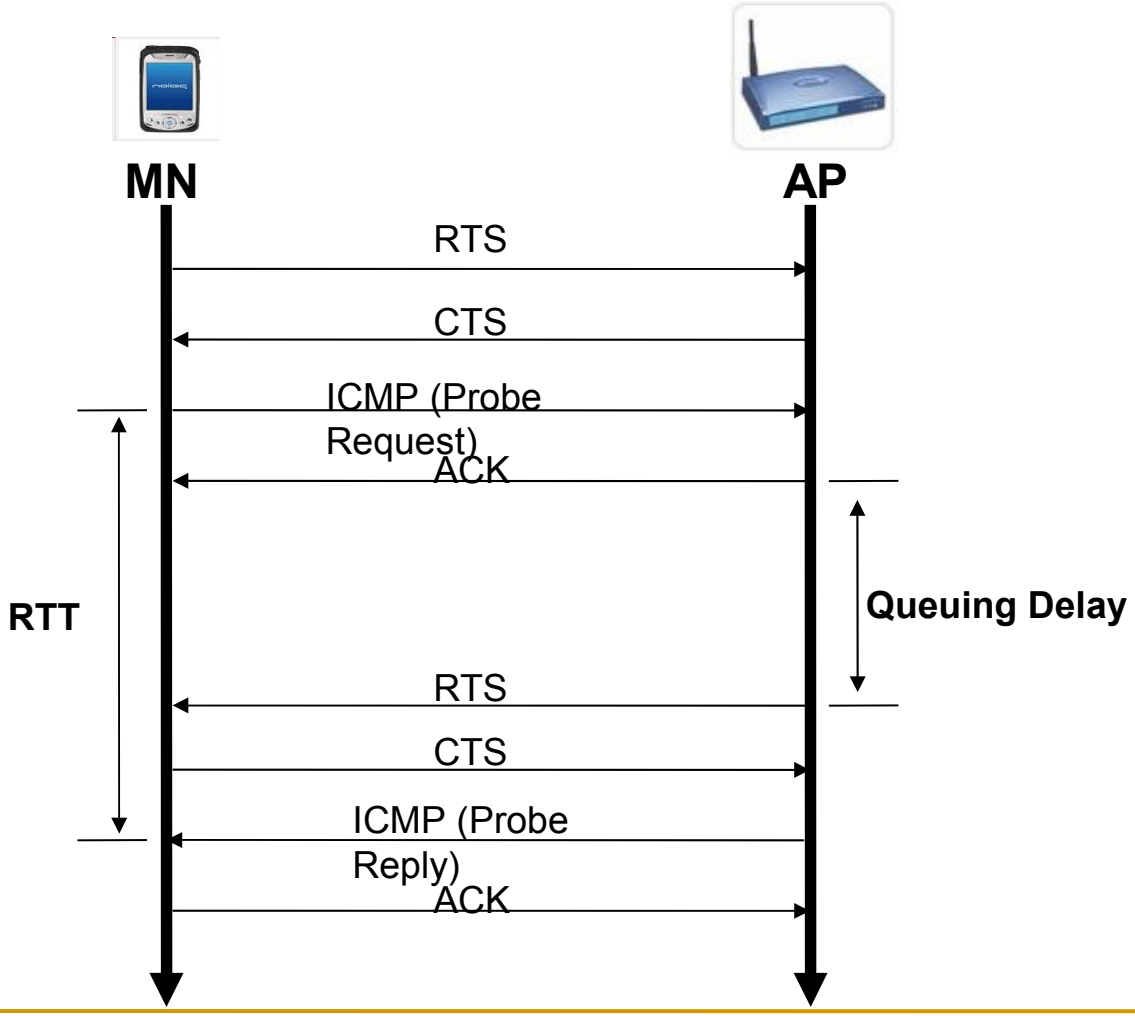
- Current WLANs employ multi-rate function
  - Dynamically change transmission rate
- RTS frame always transmitted at lowest rate (6 Mb/s)
  - MN can properly detect wireless link condition in fixed transmission rate

Proposed Handoff Decision Metrics:
AP Queue Length

- With increase of MNs in WLAN, packets queued in AP buffer also increase
- Current widely deployed IEEE802.11(a/b/g) standard does not provide mechanism to report AP Queue Length Status
  - Estimated from MN

Proposed Handoff Decision Metrics:

Estimating AP Queue Length using ICMP message



Simulation Experiment

- To evaluate performance of proposed Handoff Decision Metrics and Handoff Strategy
- Simulation Tools:
  - Qualnet 4.0.1

Simulation Parameters

VoIP Codec	G.711
WLAN Standard	IEEE 802.11g
Supported Data Rate	6, 9, 12, 18, 24, 36, 48, 54Mbps
Fading Model	Nakagami Ricean K = 4.84
SIFS	16 us
Slot Time	9 us
CW min, CWmax	15, 1023

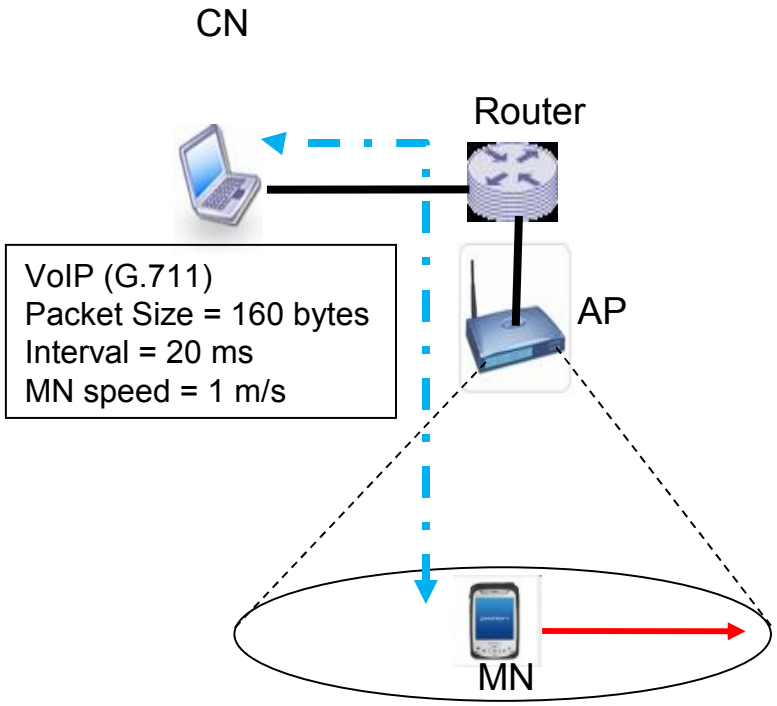
Assessment of VoIP Quality

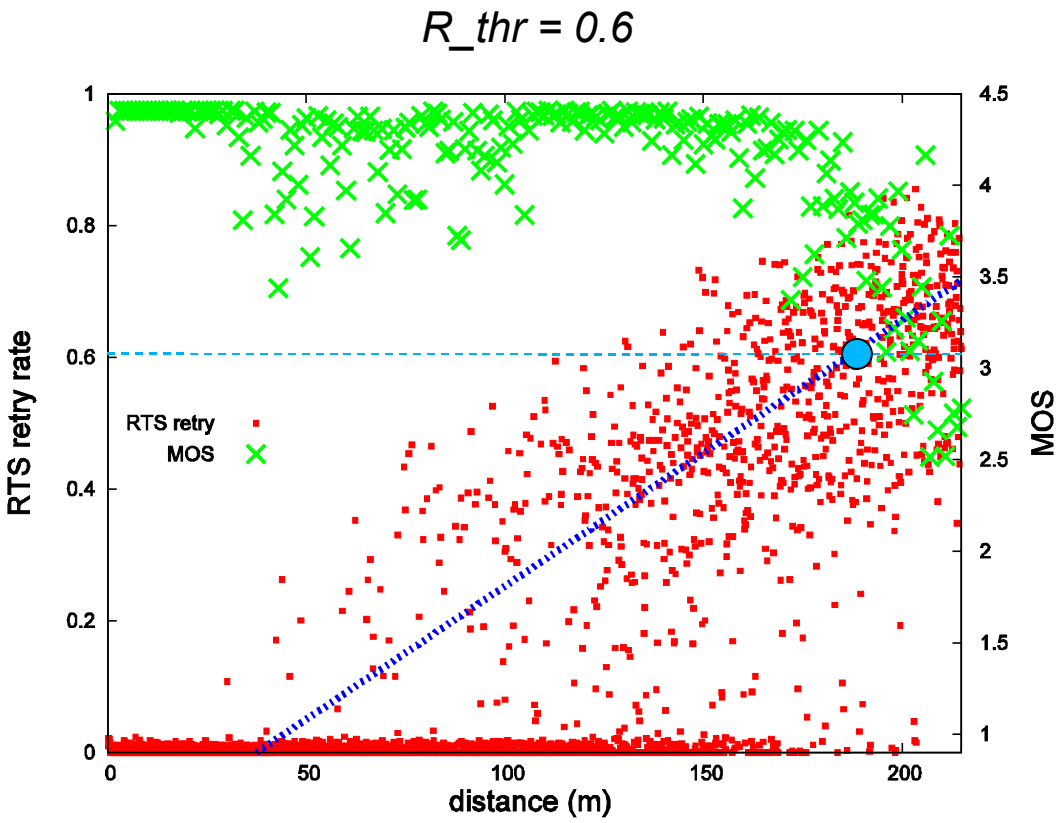
- Mean Opinion Score (MOS)
  - E-model standardized by ITU-T
  - Determined based on R-factor
  - $R = 94.2 - I_d - I_e$
  - MOS > 3.6 indicates adequate VoIP call quality

R-factor	MOS	User Experience
90	4.3	Excellent
80	4.0	Good
70	3.6	Fair
60	3.1	Poor
50	2.6	Bad

Evaluation of Proposed Handoff Metric (RTS Retries):

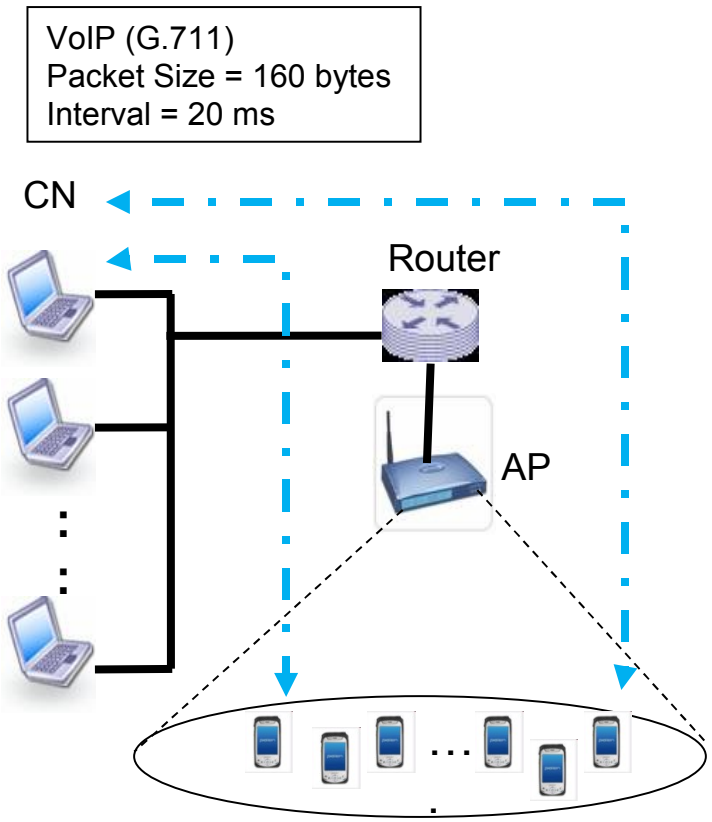
Simulation Model & Result for RTS Retries

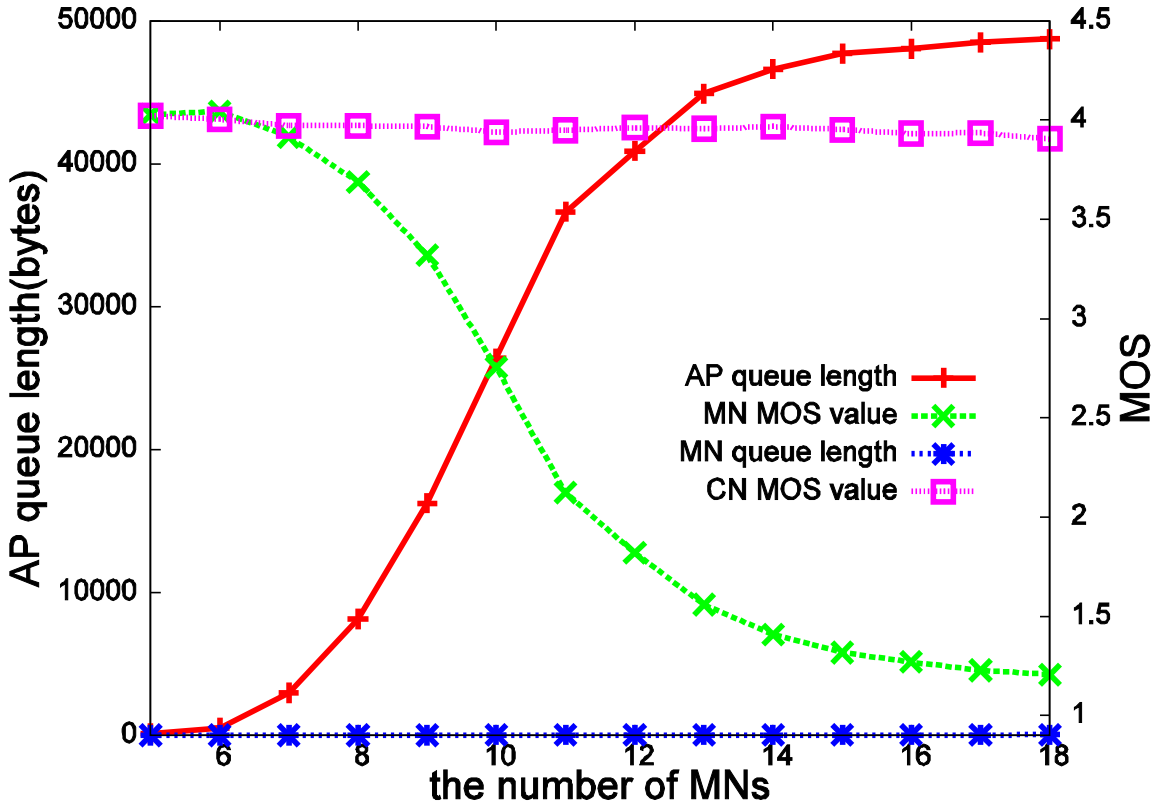




Evaluation of Proposed Handoff Metric (AP Queue Length):

Simulation Result for AP Queue Length

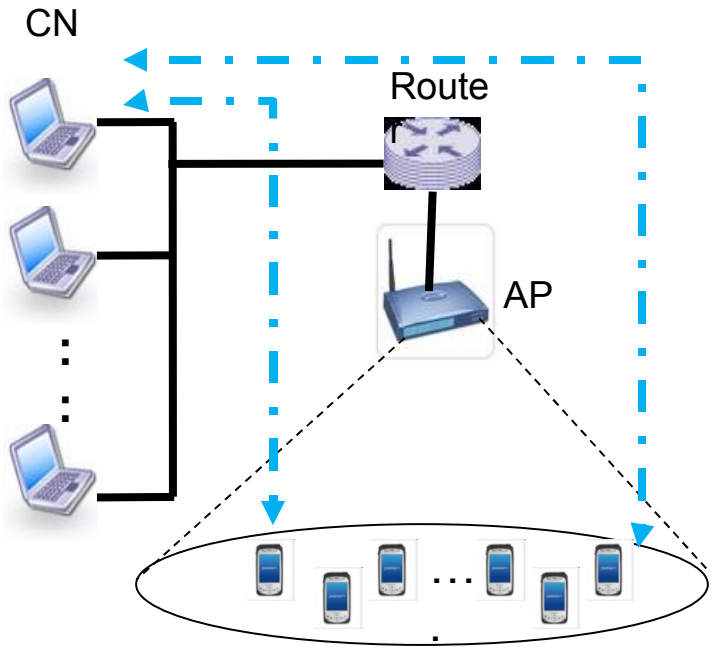


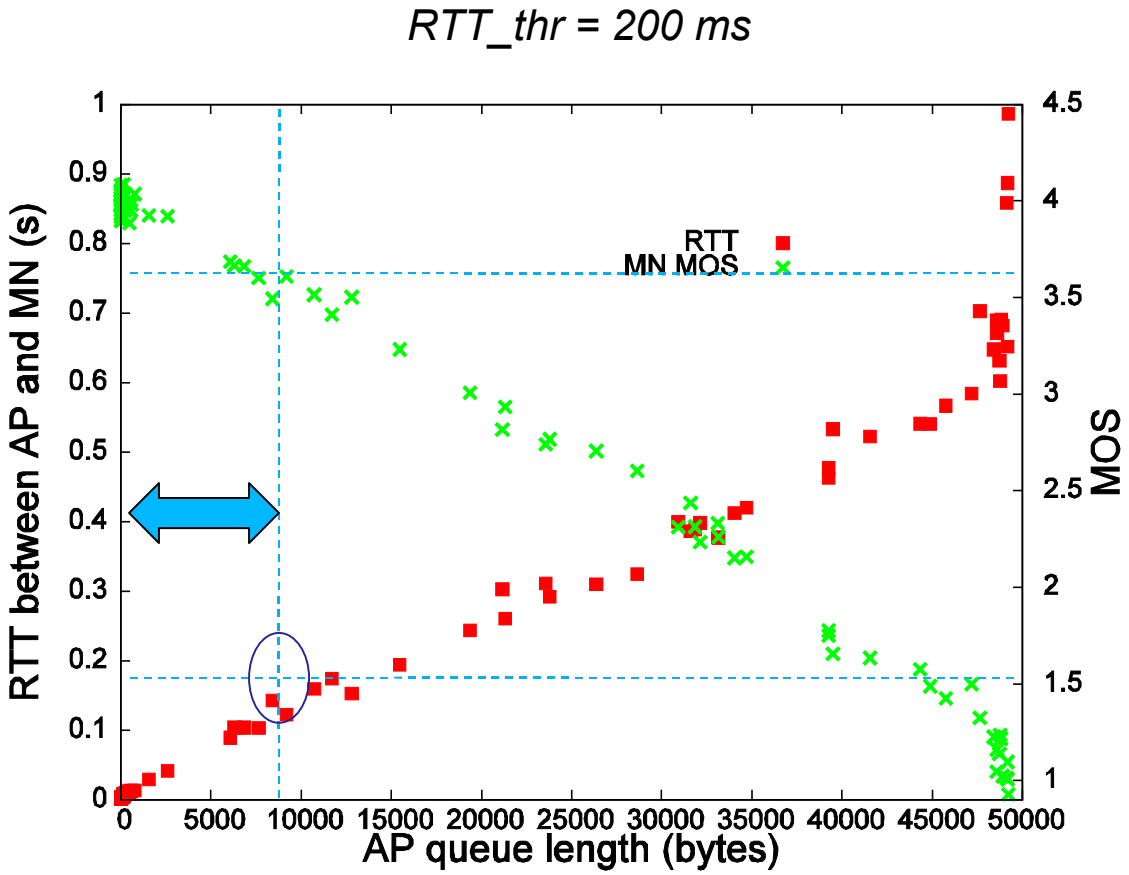


Evaluation of Proposed Handoff Metric (AP Queue Length):

Relationship among AP Queue Length, RTT & MOS

VoIP (G.711)
Packet Size = 160 bytes
Interval = 20 ms





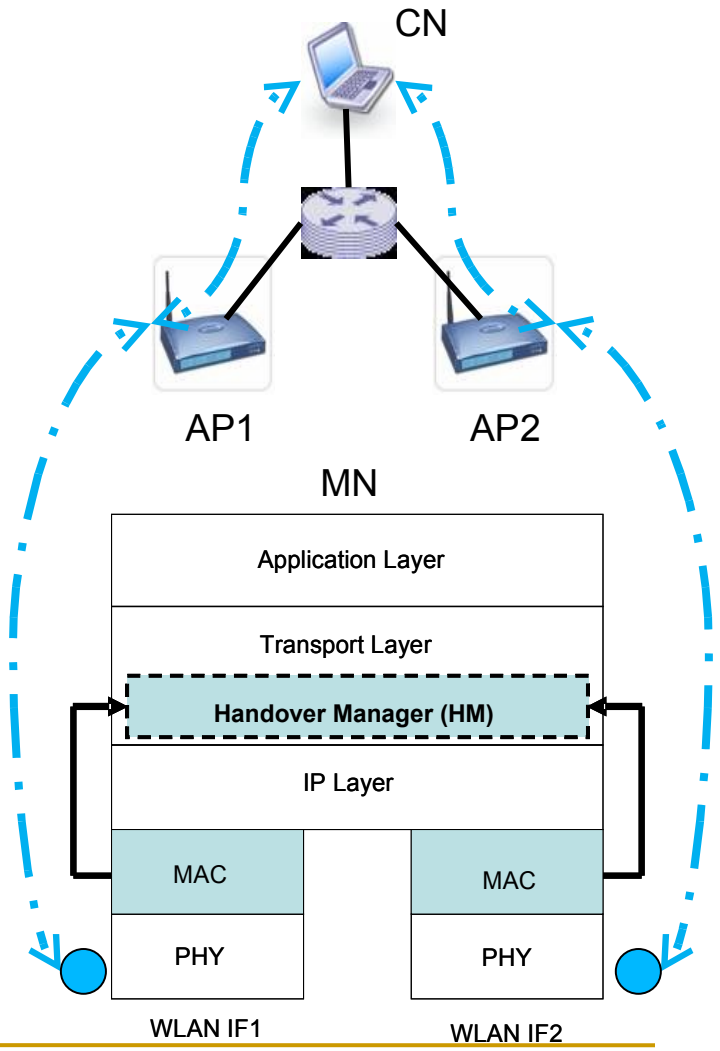
Evaluation of Handoff Decision Metric

Simulation Results

- To satisfy adequate VoIP calls
  - RTS retry ratio < 0.6
  - RTT < 200 ms

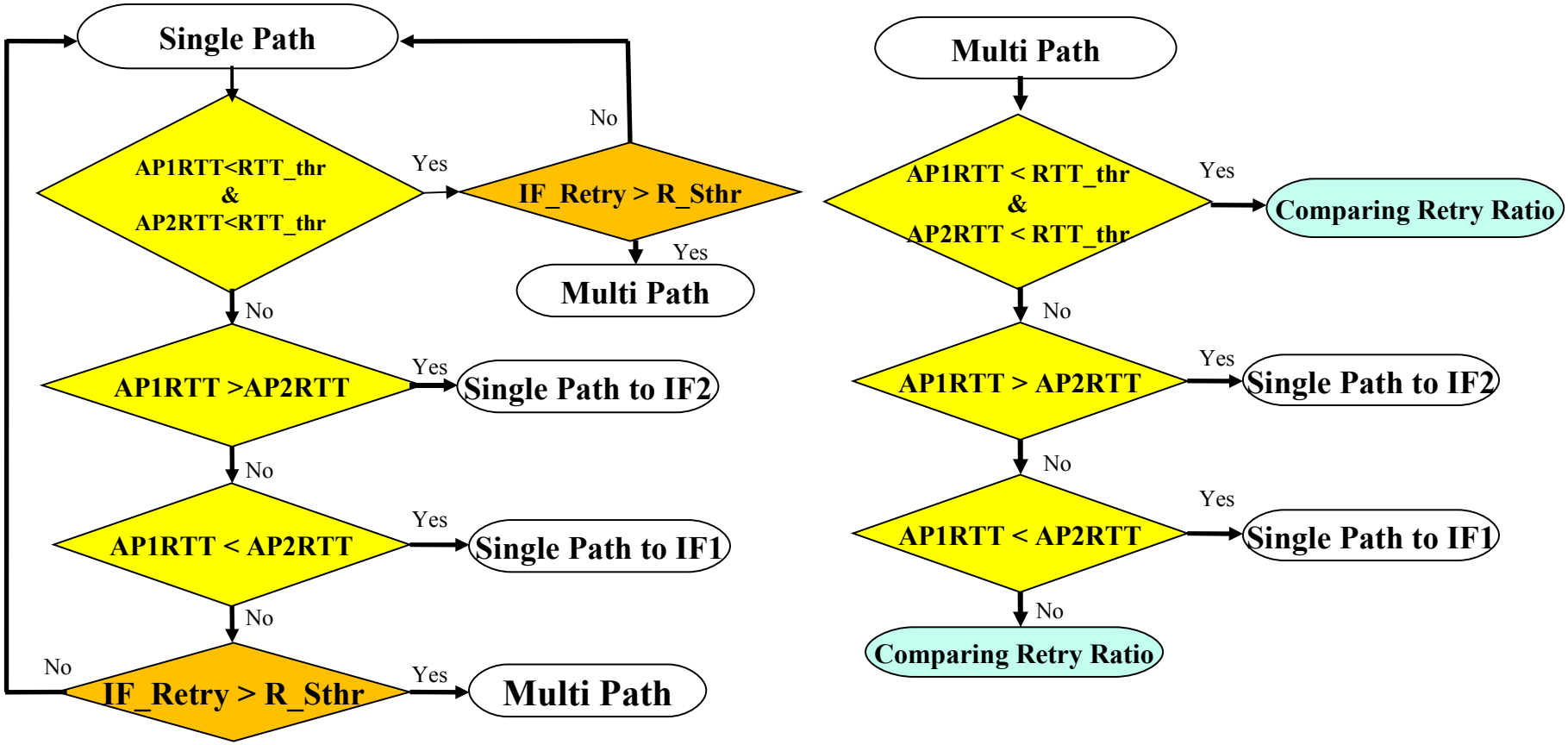
Proposed Handover Strategy

- Multi-homed MN
- Handoff manager (HM) on transport layer to control handoffs
- Employ RTS retries & ICMP message to estimate of AP Queue length (RTT) as handoff decision metrics
- Employ Single-Path & Multi-Path Transmission to support Soft-Handoff



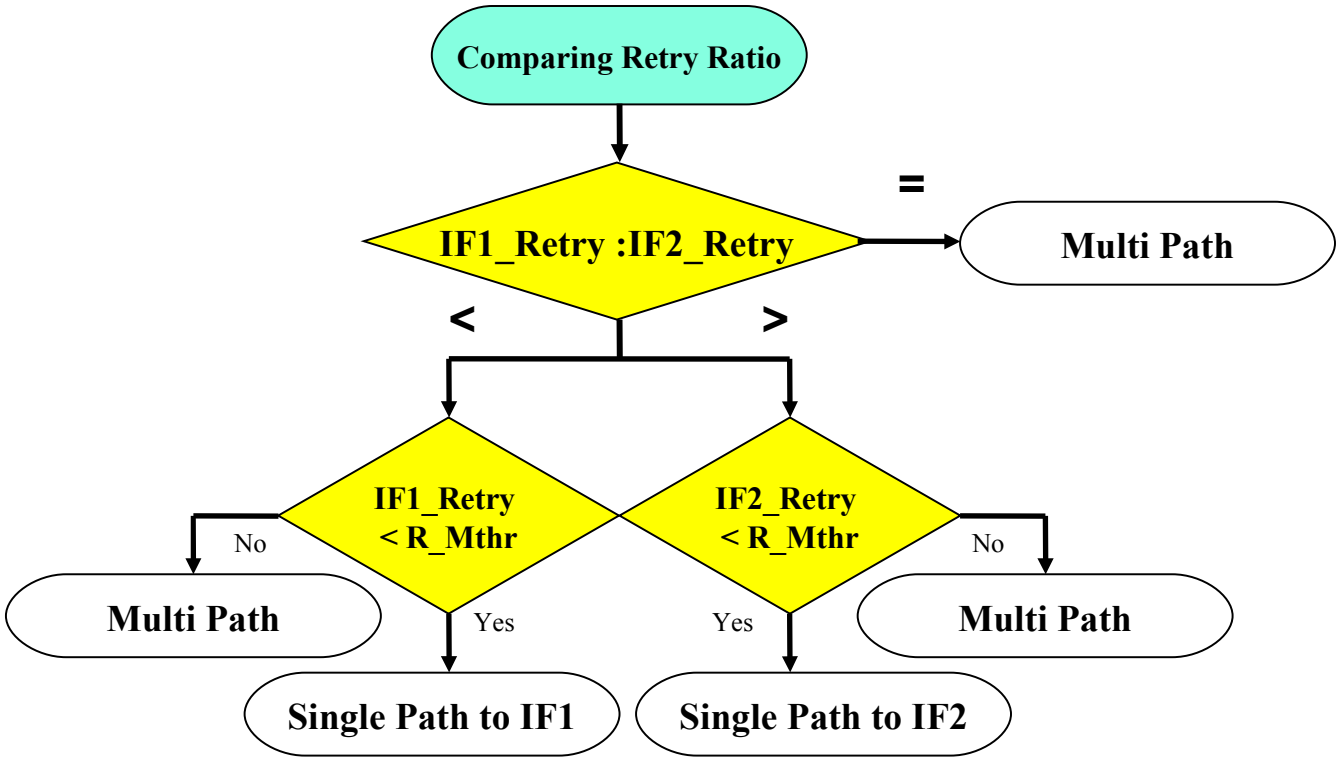
Proposed Handoff Strategy:

Switching of Single Path/Multi-Path Transmission



Proposed Handoff Strategy:

Comparing Retry Ratio



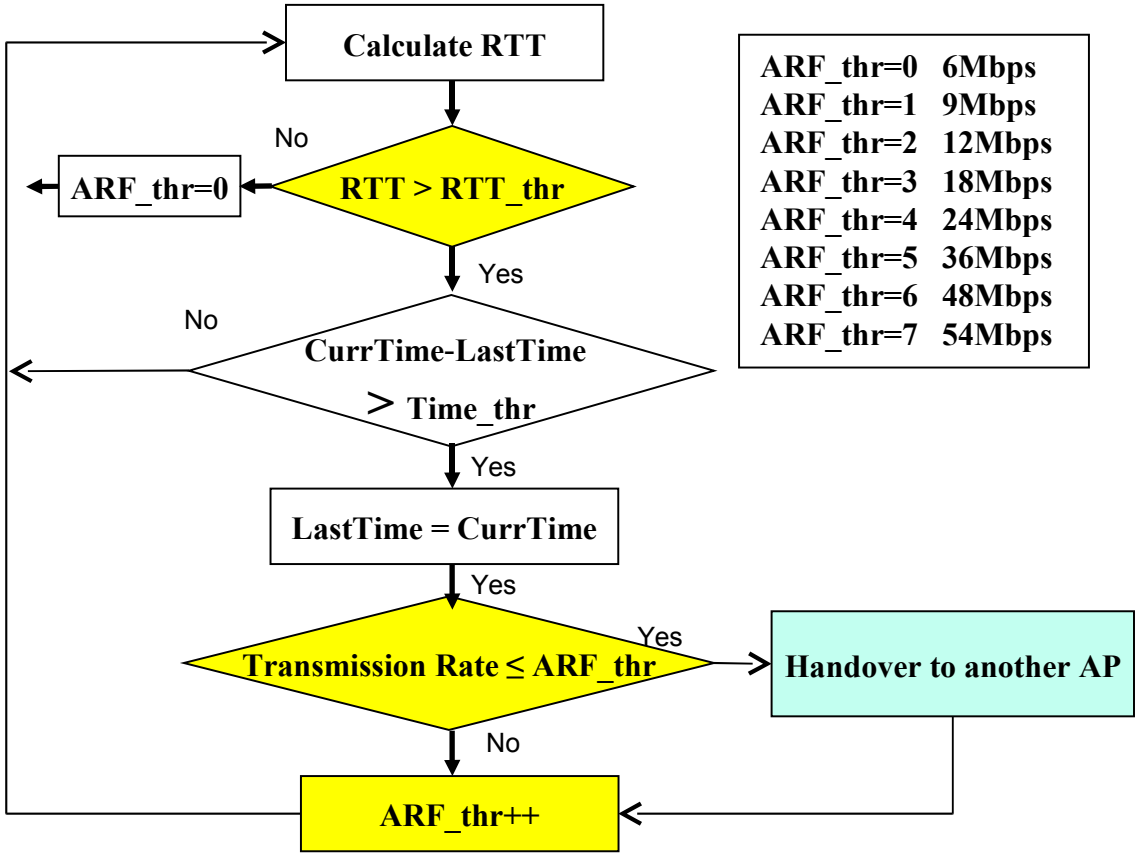
Proposed Handoff Strategy:

Avoiding Ping-Pong Effect

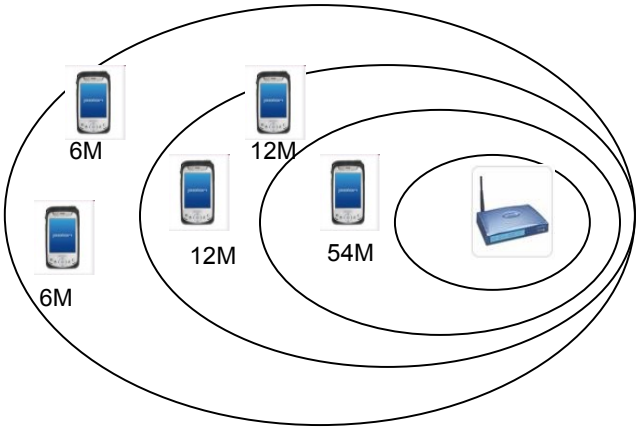
- When traffic load in WLAN abruptly increases, all MNs employ RTT information as HO decision criterion
- All MNs simultaneously handoff to neighbor AP
- Neighbor AP suddenly congested and all MNs switch back to previous AP
- Leads to ping-pong effect
- **Solution:**
  - MN with lowest transmission rate executes HO first followed by next lowest transmission

Proposed Handoff Strategy:

Avoiding Ping-Pong Effect



ARF_thr=0	6Mbps
ARF_thr=1	9Mbps
ARF_thr=2	12Mbps
ARF_thr=3	18Mbps
ARF_thr=4	24Mbps
ARF_thr=5	36Mbps
ARF_thr=6	48Mbps
ARF_thr=7	54Mbps

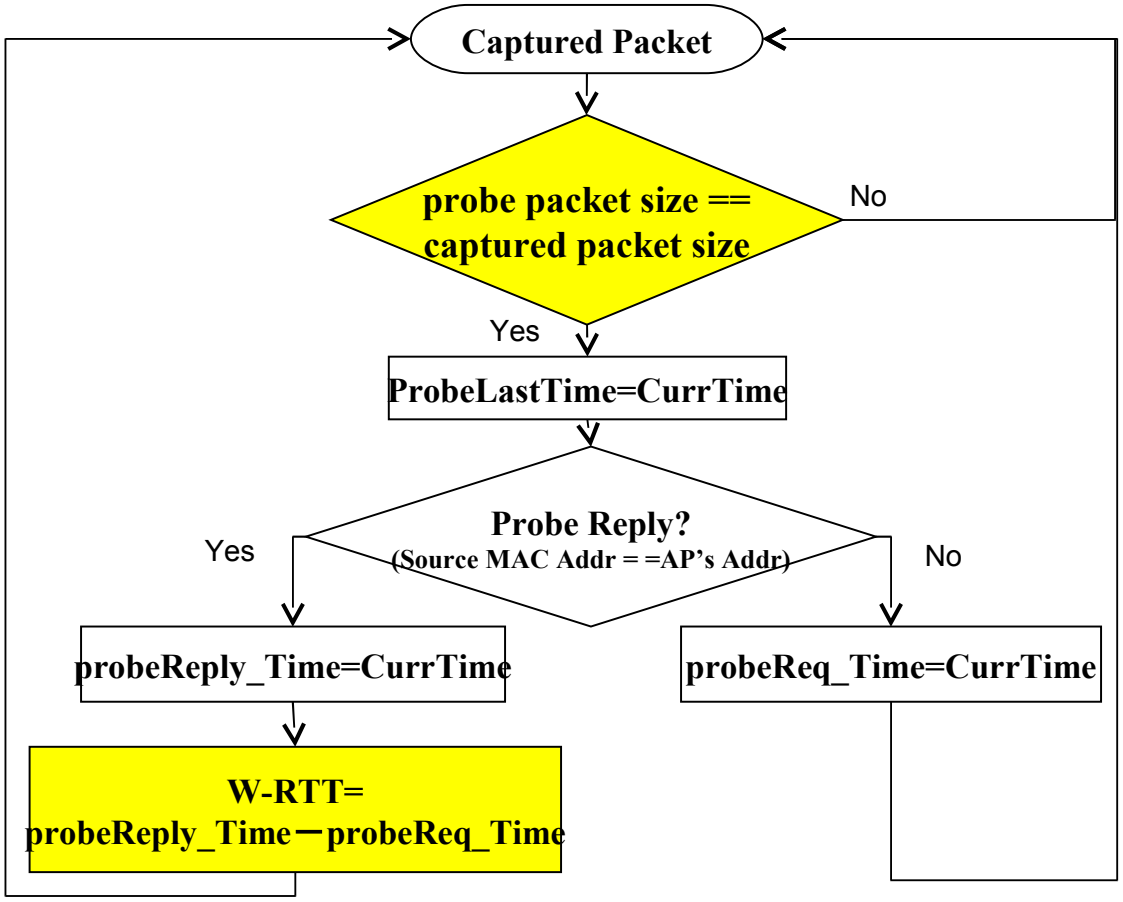


Proposed Handoff Strategy:
Elimination of Redundant Probe Packets

- Every MN measures RTT using probe packets
- Packets produce redundant traffic leading to unnecessary network overload
- **Solution:**
  - Only one MN sends probe packets
  - Rest of MNs measure RTT by capturing existing probe packets over wireless link

Proposed Handoff Strategy:

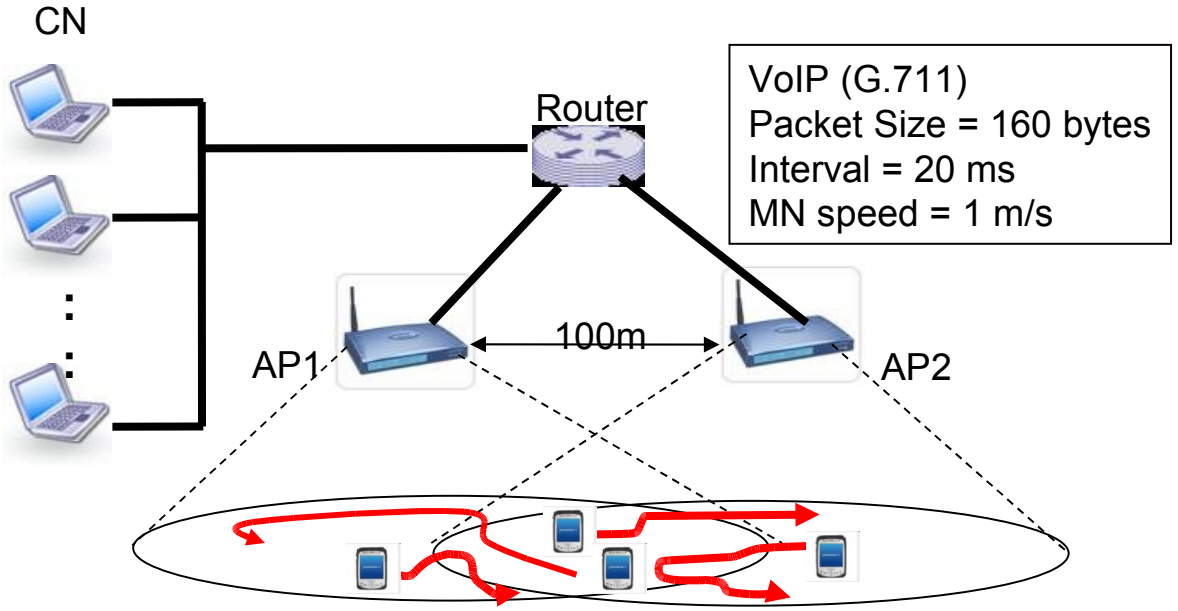
Elimination of Redundant Probe Packets



Evaluation of Proposed Handoff Strategy

Simulation Scenarios

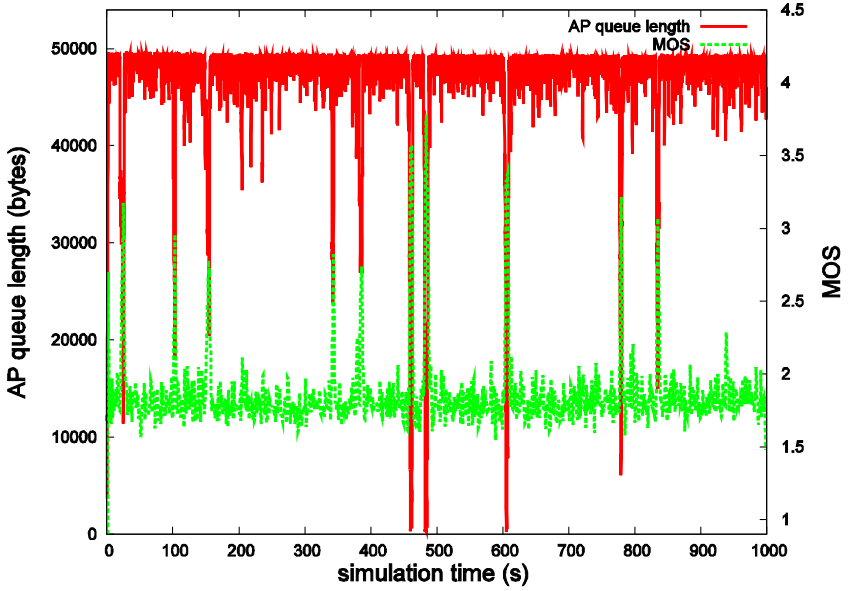
- Proposed Handoff Strategy vs. Handoff Strategy based on Data Frame Retries
- MNs establish VoIP call with their CNs
- 15 MNs randomly move between two APs



Evaluation of Proposed Handoff Strategy:

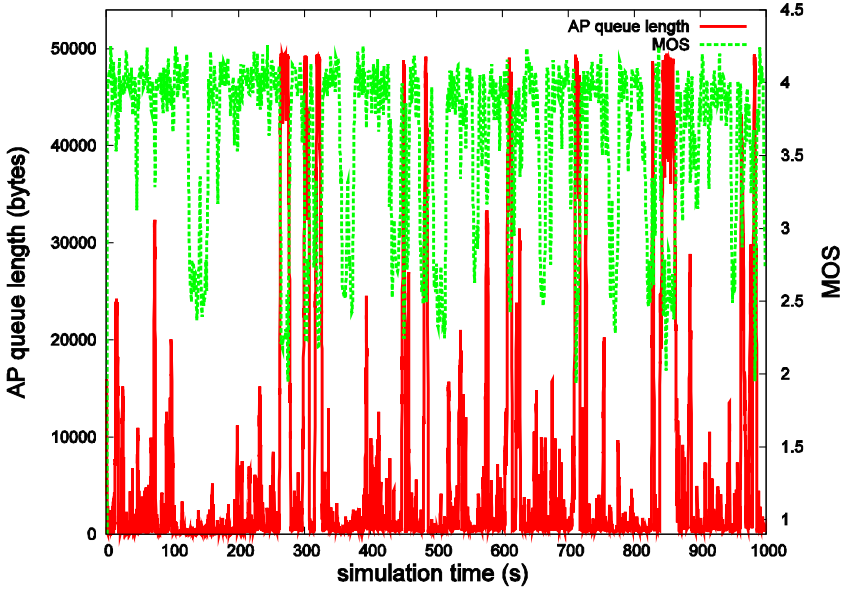
Simulation Results

Average MOS: 1.80



Handoff Strategy based on Data Frame Retries

Average MOS: 3.60



Proposed Handoff Strategy

Conclusion

- Proposed Handoff Decision Metrics
  - RTS Retries
  - Estimation of AP Queue Length (RTT)
- Proposed Handoff strategy for VoIP application
  - Execute Handoff based on wireless link condition & congestion state at AP
  - Able to detect congested AP, not to execute Handoff to congested AP
- Contributions:
  - Seamless Handover
  - Load-balancing between APs

Thank You