Údarás na Gaeltachta

NUI Galway OÉ Gaillimh

Optimization of VoIP over 802.11e EDCA based on synchronized time

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Outline

- Introduction & Background
- 802.11(e)
- VoIP optimization due to Time Synch’
- NS-2 Extension
- Wireless Test-bed
- Conclusion

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Background – Research Overview

- Research Goal
  - Investigation into how Synchronized Time implemented in wireless networks can aid in dynamically optimizing 802.11e parameters to improve QoS for VoIP
- Two concurrent research paths
  - NS-2 simulation – Development of NS-2 extension
  - Wireless Test-bed

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Background

- 802.11
  - DCF – First Come First Serve basis, no traffic differentiation
  - PCF – Provides QoS to an extent with CP & CFP
    - Beacons from AP send synch' & network info
    - Not implemented in industry
- 802.11e
  - IEEE standard for QoS sensitive data
  - Includes contention based (EDCA) and controlled channel access mechanism (HCCA)
    - Extensions of DCF and PCF respectively
  - HCCA not implemented to large extent in industry so we opted with EDCA

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Background - 802.11e

- Enhanced Distributed Channel Access (EDCA) defines four Access Categories (ACs)
  - Voice (AC_VO)
  - Video (AC_VI)
  - Best Effort (AC_BE)
  - Background (AC_BK)
- Each AC has its own transmission queue with its own adjustable MAC parameters
  - AIFSN – Interframe Space number
  - CWmin / CWmax – Contention Window
  - TXOP – Transmission Opportunity
- We will prioritize **<u>within</u>** AC

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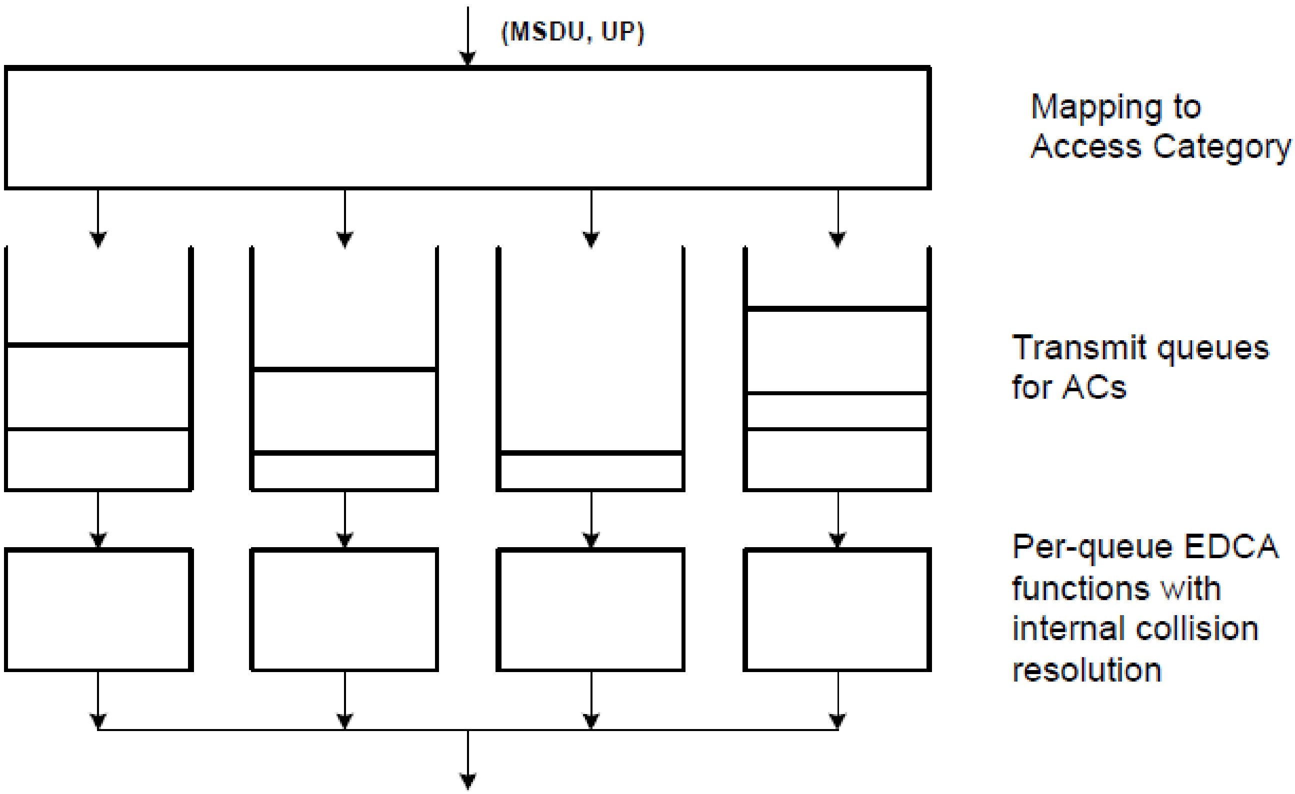
EDCA Access Categories



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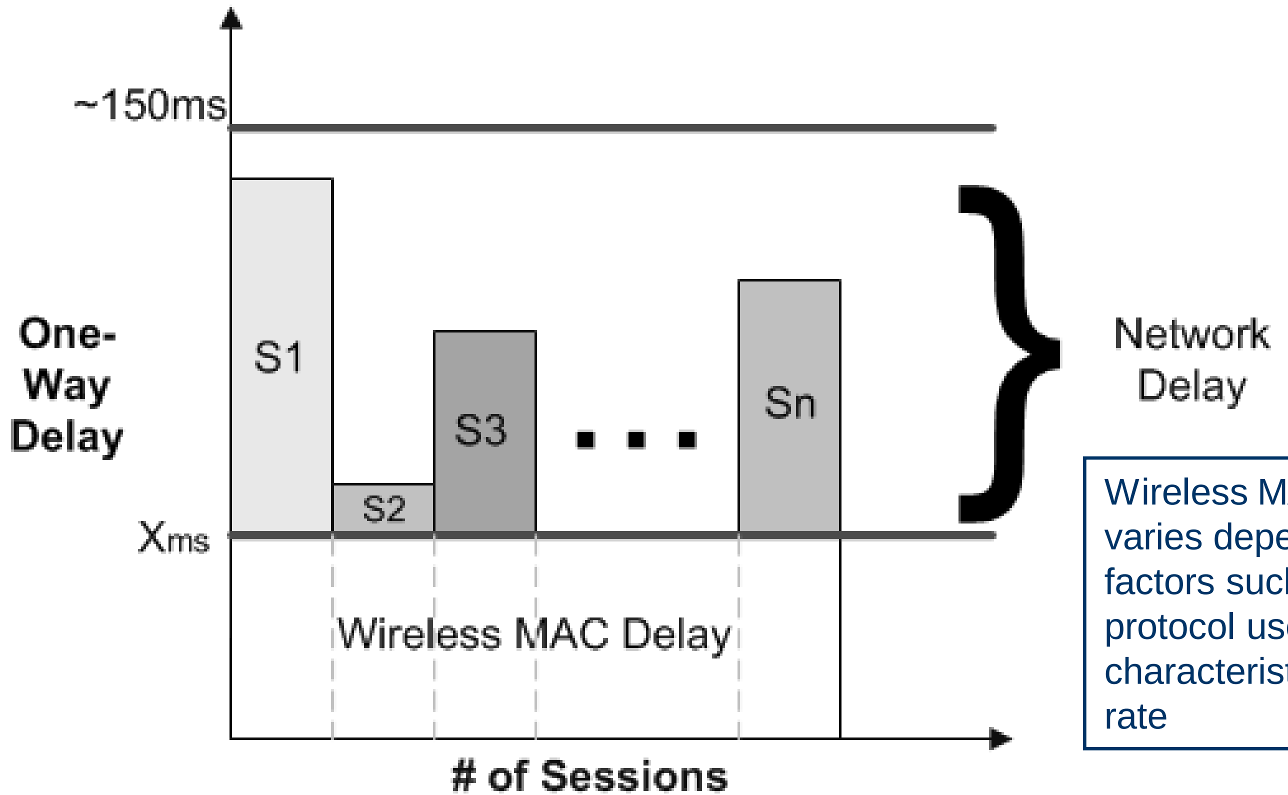
Delay variations in VoIP

- One-way delay for simultaneous VoIP calls can vary
  - LAN (typical network delay < 10ms),
  - Long distance International call (network delay > 100ms)
- Total one-way delay of packets could be close to, or may exceed the (ITU-T) 150msec
  - Due to sender / MAC contention, network delays, receiver
- N stations have the same contention delays at the Wireless MAC layer

Problem – Default VoIP End-to-End delay



Wireless MAC delay (X ms) varies depending on many factors such as wireless protocol used, traffic characteristics, transmission rate

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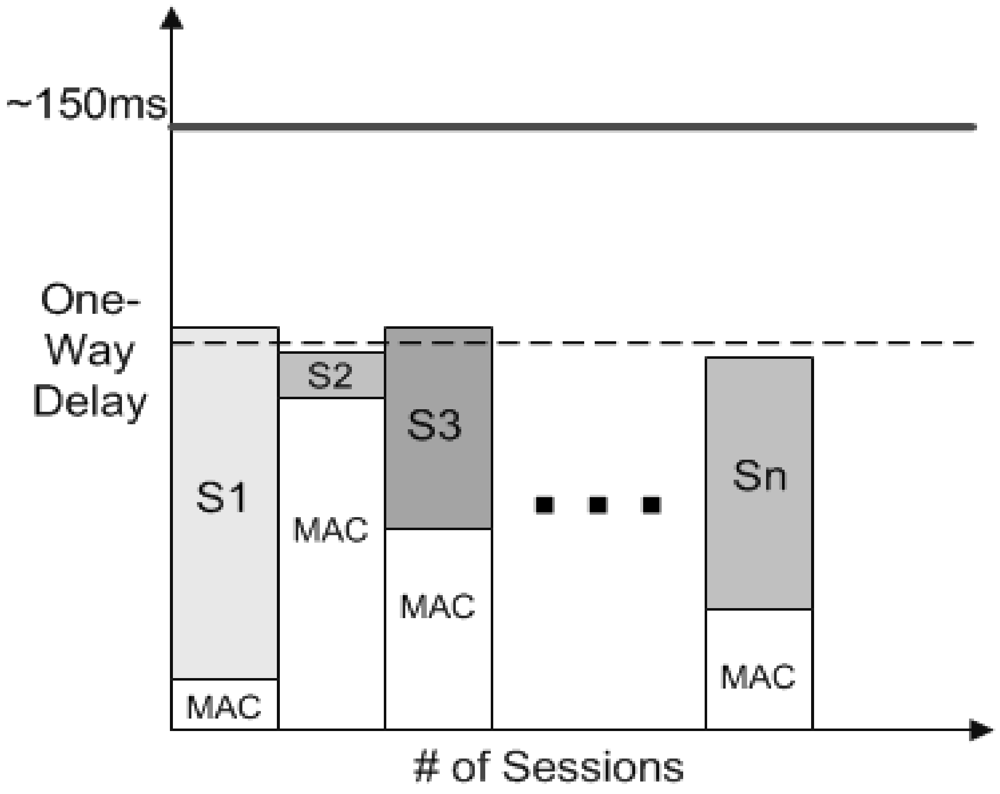
Default End-to-End Delay

Solution – Tune MAC param's (802.11e)



Equalise overall One-Way Delay

Vary Wireless MAC Delay – EDCA Tuning

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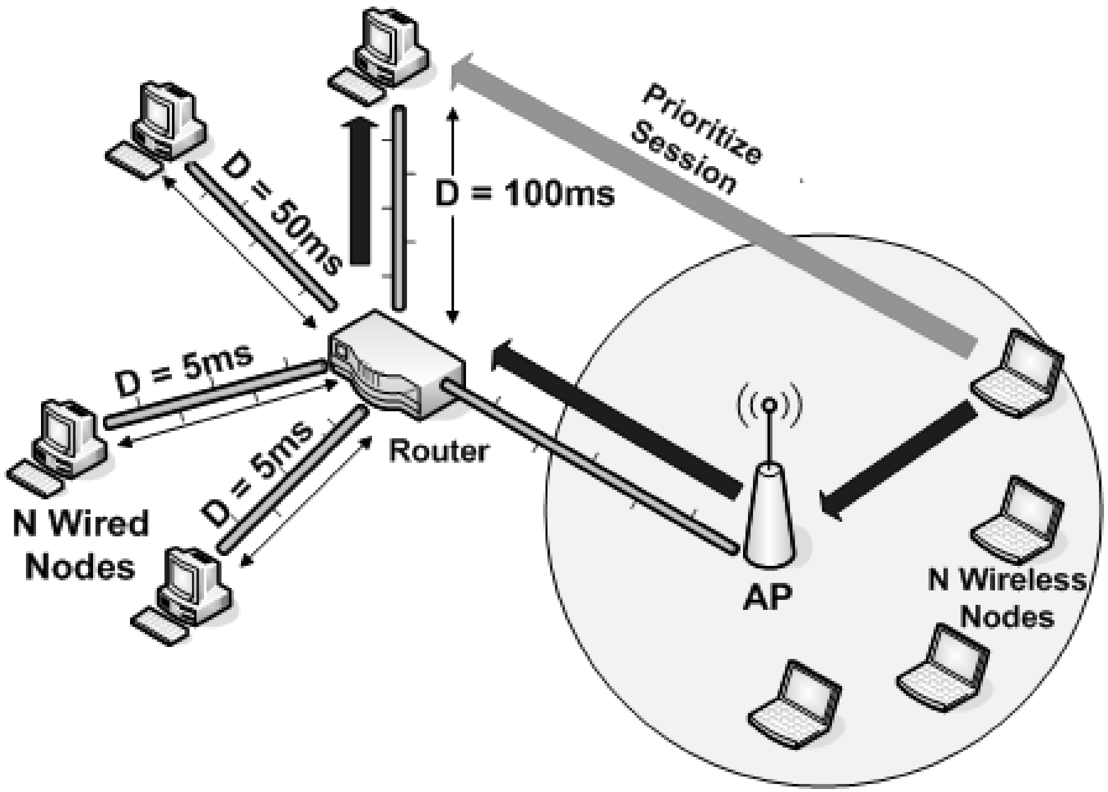
Simulation Setup



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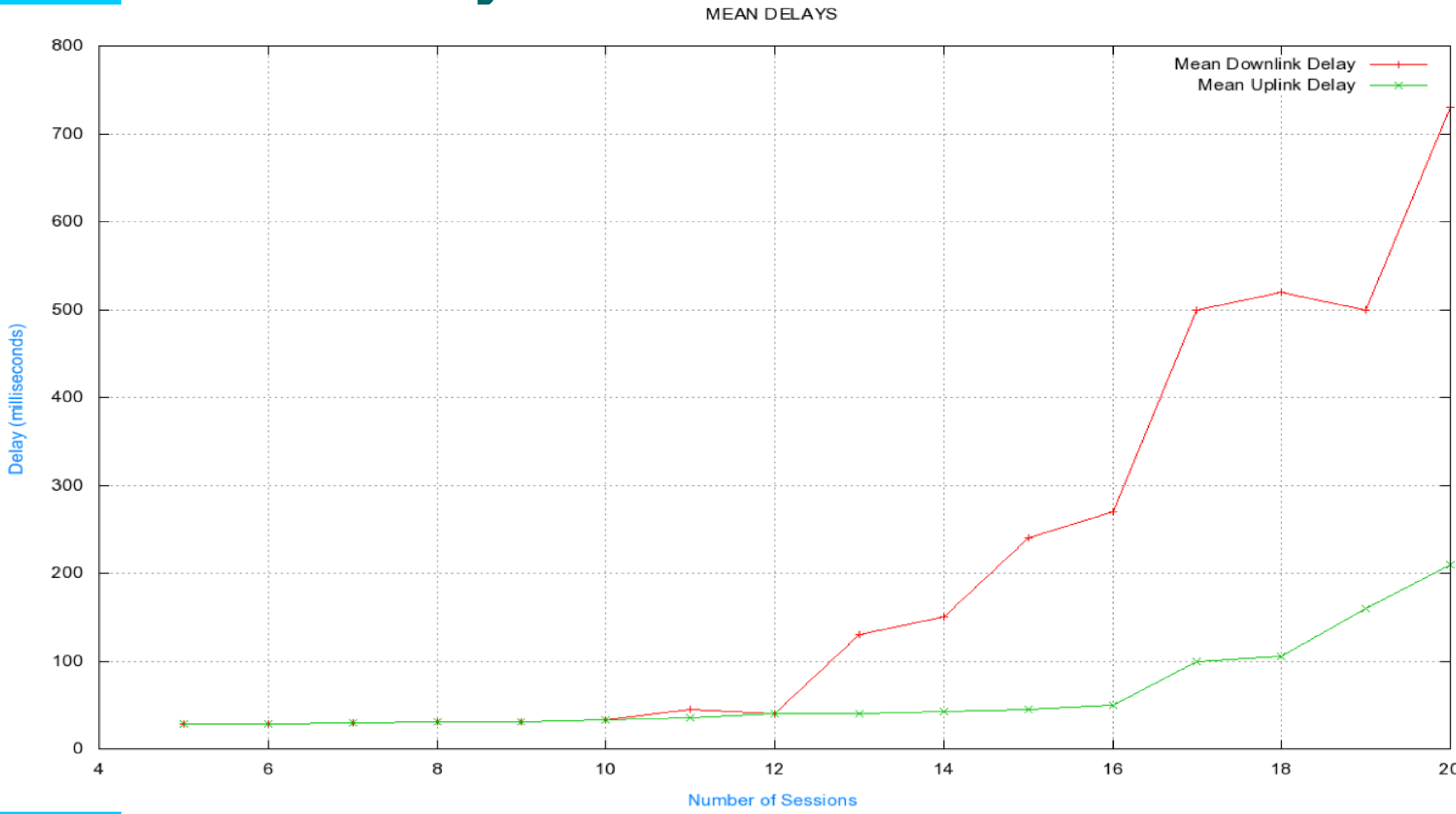
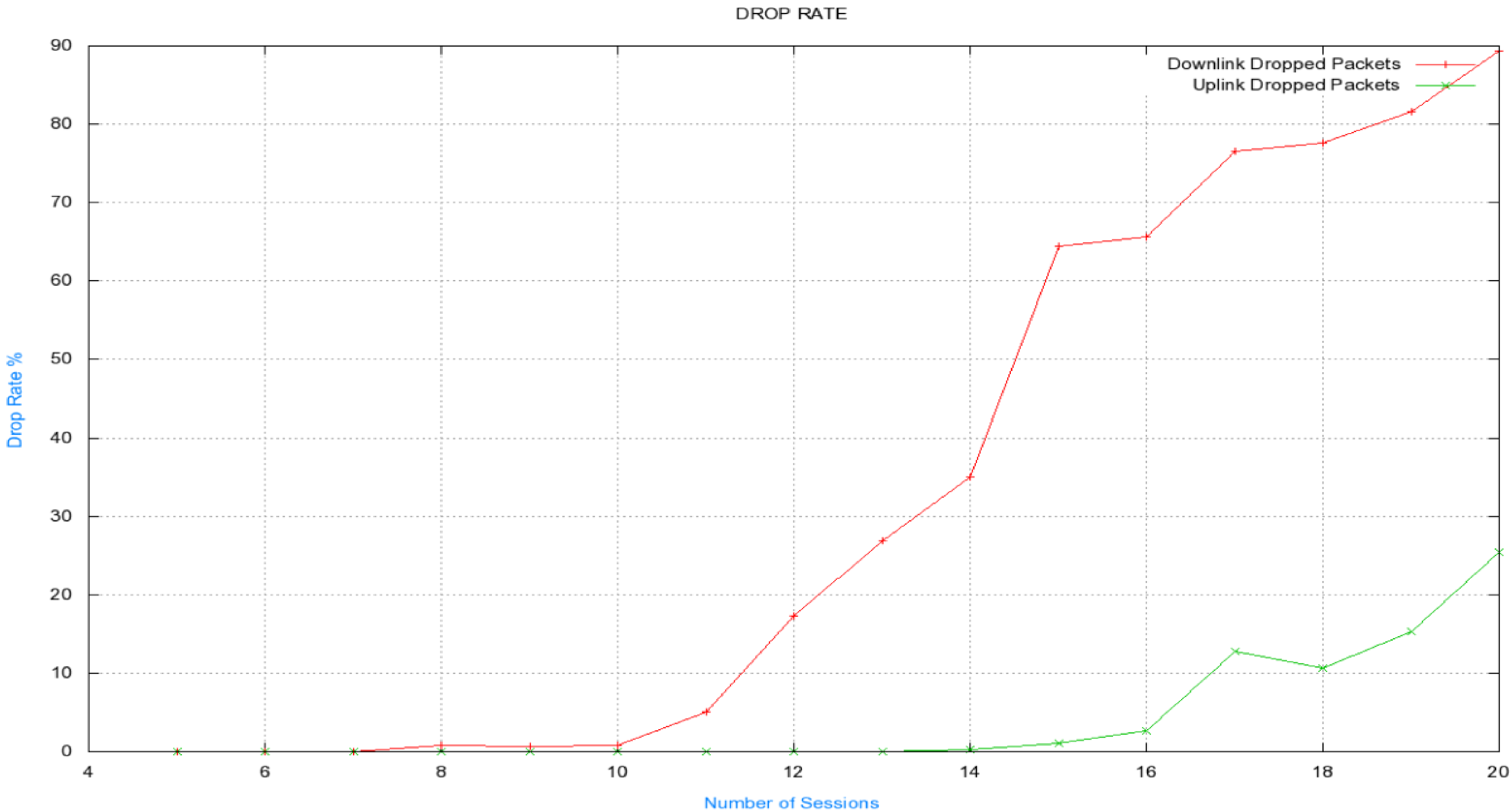
Results

Optimal number of nodes in an 802.11b BSS - Delay



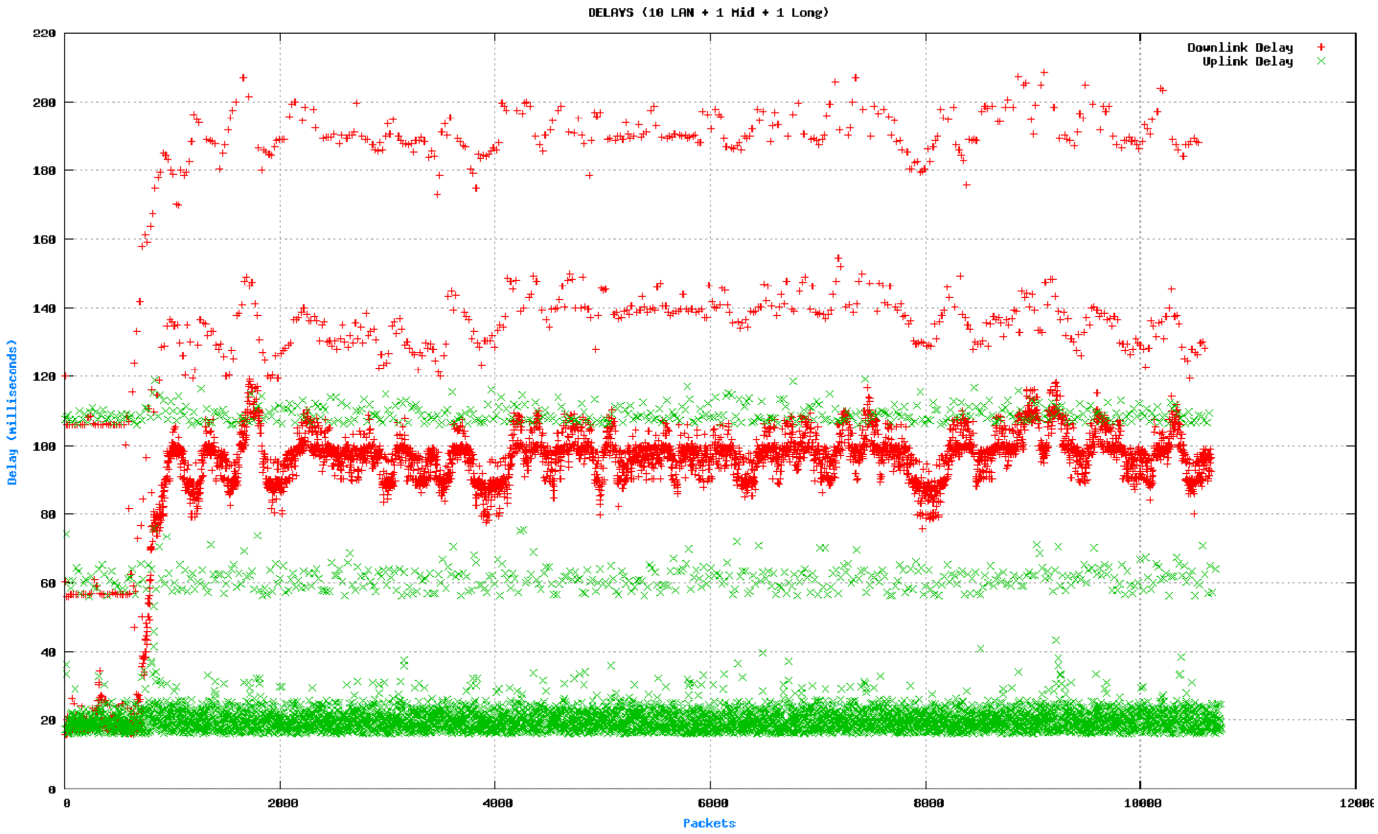
Optimal number of nodes in an 802.11b BSS – Drop Rate



Multiple VoIP session - Simulation

- In simulation, 12 simultaneous sessions possible when delay & drop rate considered
- Asymmetry in Up/Downlink delays due to downlink congestion at AP (AP Throttling)
  - Drop rate also due to congestion at AP
    - Trade-off between drop rate and delay by varying Queue length
- Wireless MAC delays equal among VoIP sessions
  - Contention
- We will introduce **different wireless MAC delays** for different sessions

Scenario 1 – Default End-to-End delay



Voice only scenario-

All Sessions have equal priority

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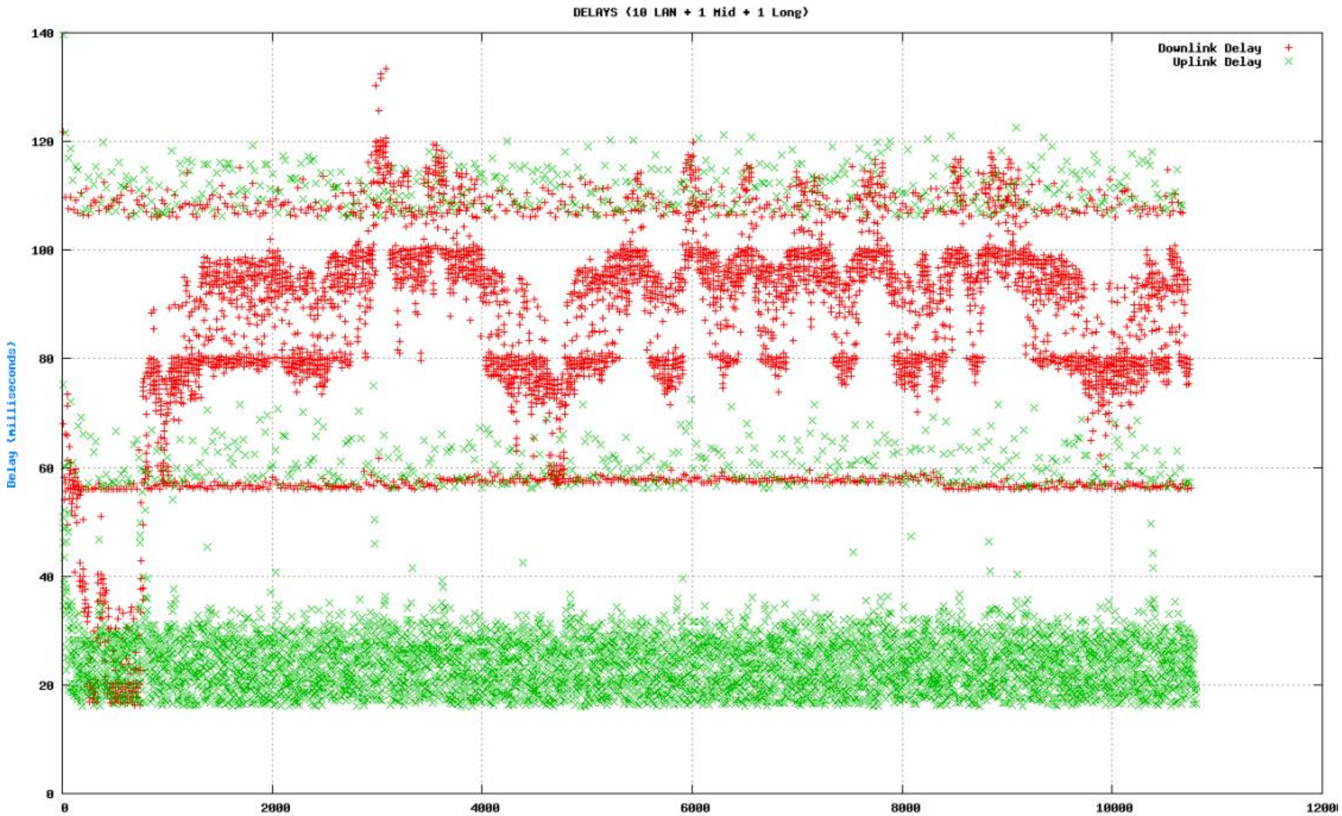
Role of Access Point (AP)…

- Scenario 2 prioritizes uplink and downlink long distance traffic
  - In the real world this would require a virtual queue on the AP….
- If only Uplink traffic receives priority
  - Parameter tuning takes place at end terminal
  - No need for intelligence in AP

Scenario 2 - Prioritization of long distance traffic



Packet delay values "equalised", as low priority packets wait longer to transmit.

(Downlink [Red] due to congestion at AP)

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QoS Measurement – E-Model

- Need for quality improvement measurement
  - Based on Delay, Drop rate, Echo, codec type, Noise and network characteristics into consideration
  - Produces a single QoS **“R”** rating…

R Value	*Speech Transmission Quality Category*	*User Satisfaction*
$90 \leq R<100$	Best	very satisfied
$80 \leq R < 90$	High	satisfied
$70 \leq R < 80$	Medium	some dissatisfied
$60 \leq R < 70$	Low	many dissatisfied
$50 \leq R < 60$	Poor	most dissatisfied

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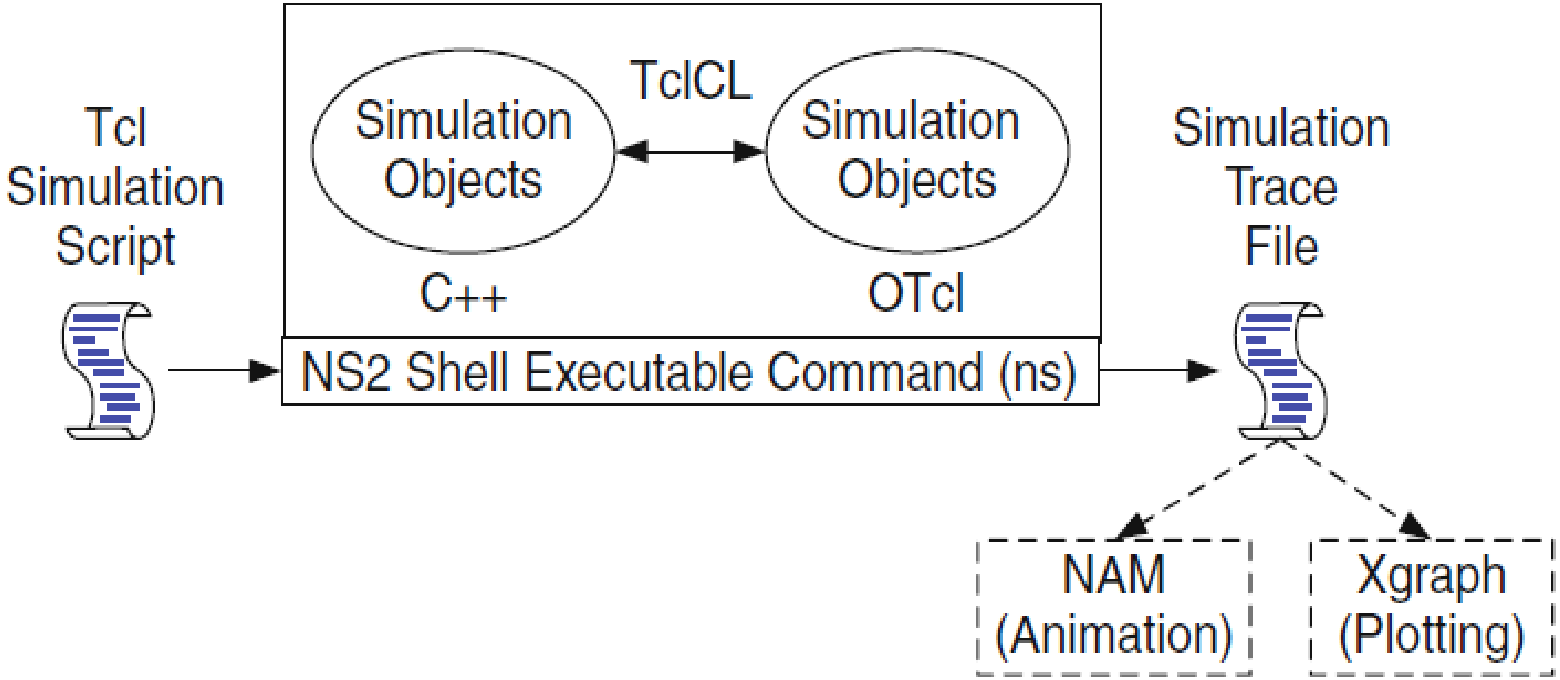
NS-2

NS-2 Network Simulator Extension

NS-2

- Network Simulator
  - Unix based discrete event driven open source simulator
    - Extendable
  - Developed in C++, OTcl
  - TCL user interface
  - Supports many networking protocols over Wired & Wireless networks
    - Including TCP, UDP, 802.11(e)
  - Widely used in Networking Research
  - Runs on Linux, and Windows (Cygwin)

Basic Architecture of NS



NS-2 Working Extension

- Build an NS-2 extension that will dynamically carry out parameter optimization
  - Based on one-way delay values
- Built on existing EDCA NS model
- Working Model
  - Multiple voice sessions begin
  - One-Way delays calculated for each session
  - Prioritize VoIP sessions based on one way delay values
  - Continue to monitor sessions to maintain an equalisation of delay values

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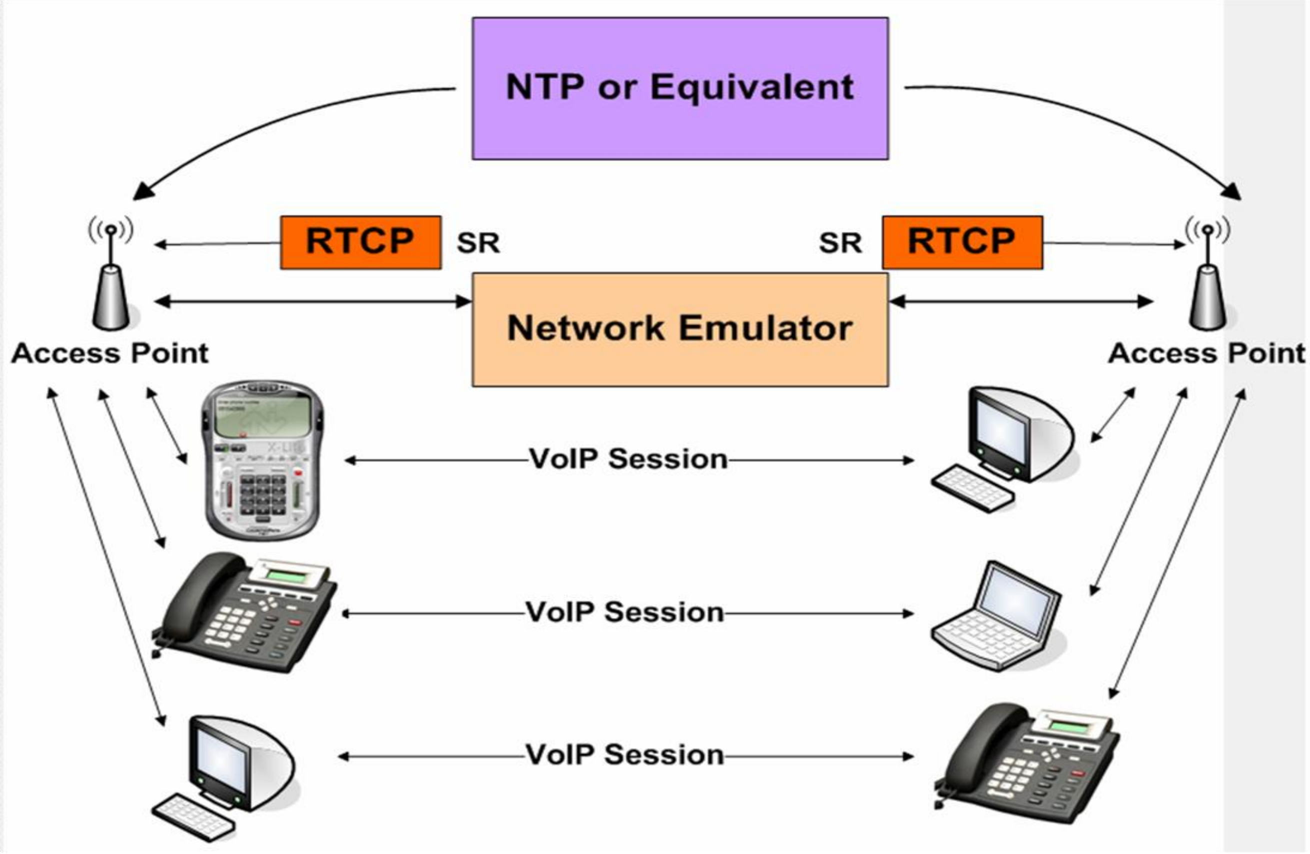
Wireless Test-bed

Wireless Testbed



Wireless Test-bed

- Consists of
  - 2 Access Points
  - Multiple VoIP clients
  - Network Emulator
  - NTP or equivalent time synchronization
- NISTNet can introduce different delays for different sessions
- NTP/RTCP will determine delays of incoming packets
  - Using this information along with Round Trip Delay (RTD) from RTCP, can determine outgoing delays
- Wireshark – Packet capture & Analysis

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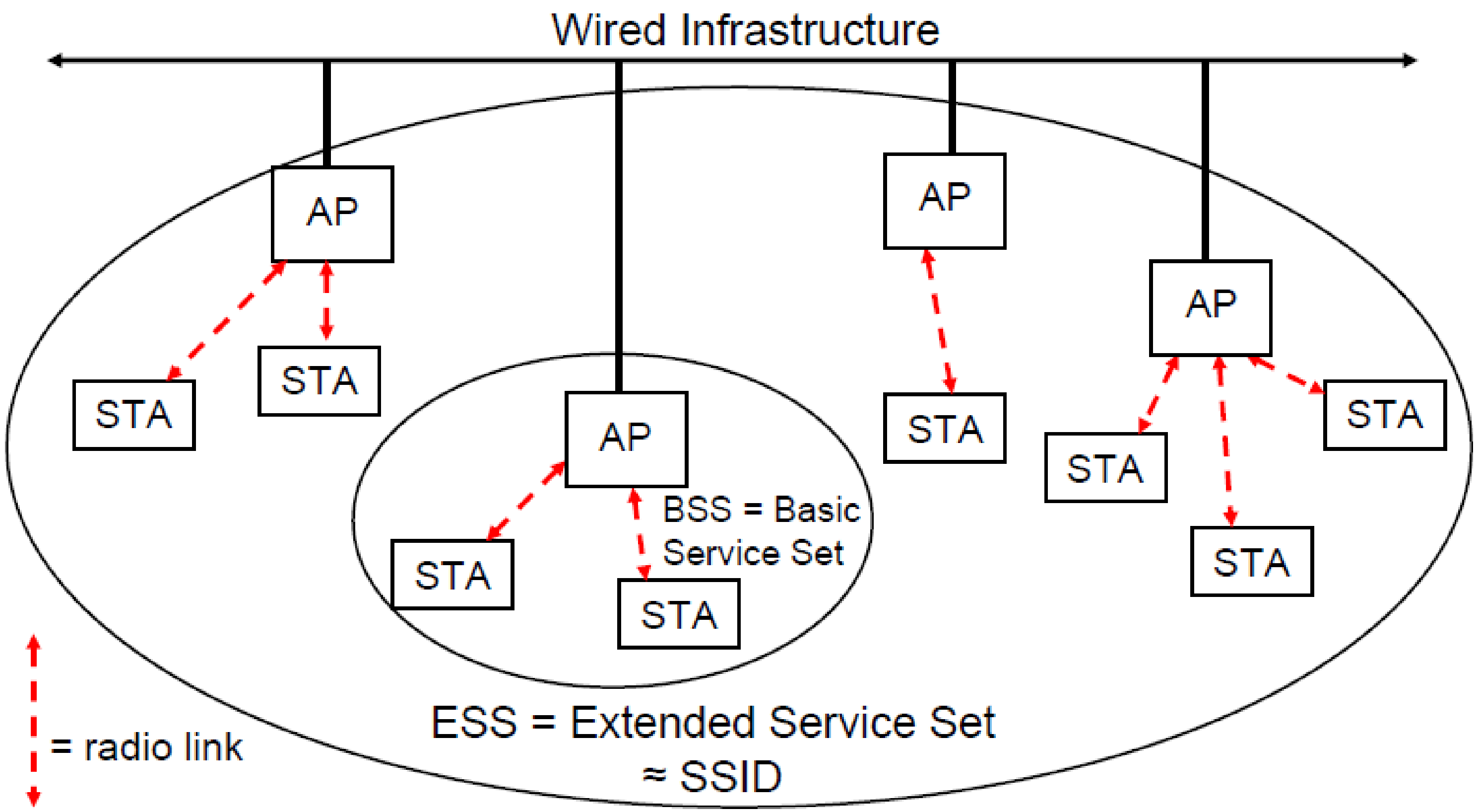
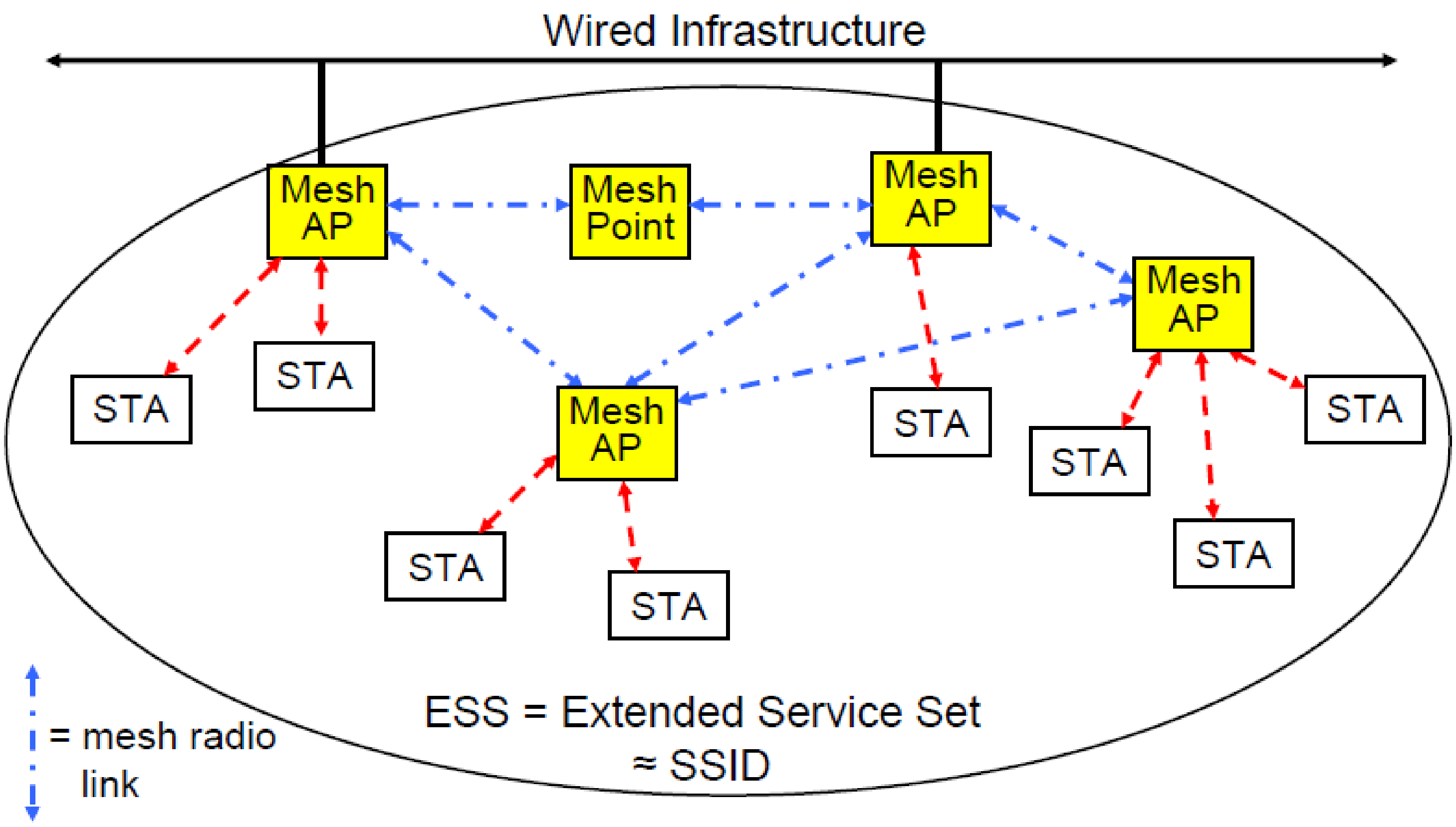
Future Work - Mesh-Network Application

- 802.11s IEEE Draft standard for wireless mesh networking
- Enables rapid WLAN deployment with lower-cost
- Self-healing, resilient, extensible
- Compatible with 802.11 MAC (EDCA)
- Draft provides Mesh-Wide Time Synchronization (TSF)
  - Timing Synchronization Function
  - Power saving functionality

Classic 802.11 Infrastructure WLAN



802.11 Mesh WLAN



Conclusion

- QoS Improvement due to prioritization of voice packets with large baseline delays using 802.11e
  - Some packets can afford to wait longer at Wireless MAC layer
  - Equalise overall one-way delay
- Two Research Paths
  - NS-2 extension
    - Builds on 802.11e EDCA module
  - Wireless Test-bed
    - Aims to back up improvements found in NS-2
- Wireless Mesh Network Application
  - Wide research area

Go raibh míle maith agaibh,
Any questions??