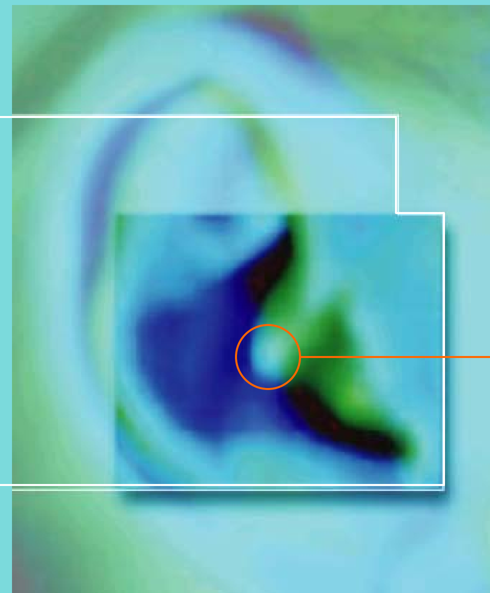

ETSI STQ Workshop “Compensating for Packet Loss in Real-Time Applications”, Feb 2003

VoIP on WLAN, QoS issues and VoIP specifics

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Agenda

- 802.11 standards overview
- Wireless QoS principles
- The draft 802.11e standard supplement
- Current situation and lessons from the past
- Summary

Introduction

- IEEE 802.11 wireless networking is the foundation for a whole new class of mobility and application scenarios
- The WLAN industry is in the midst of an exponential growth and as well in the midst of a transition (and turmoil) from 802.11b (Wi-Fi) and 802.11a (Wi-Fi5)

802.11 overview

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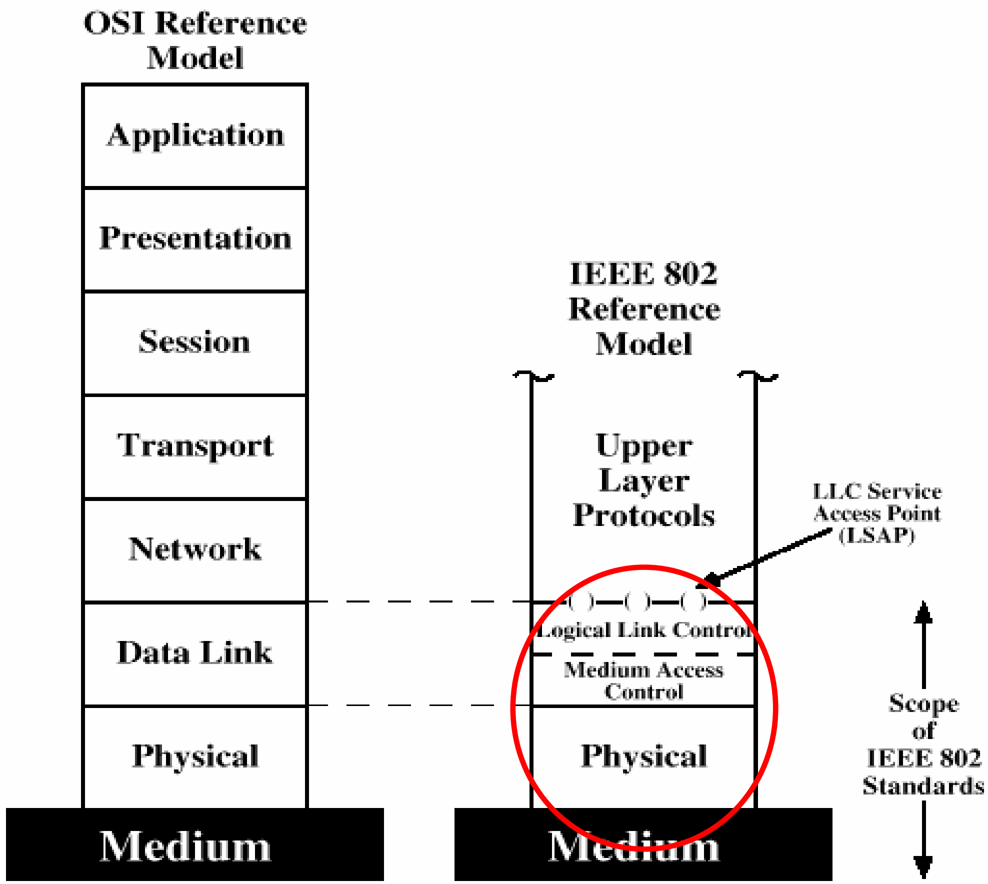
Top-down perspective



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802.11 standards

higher	supplements 802.11c and 802.11f
802.11 MAC	supplements 802.11d, 802.11e, 802.11i and 802.11h
802.11 PHY	supplements 802.11a, 802.11b and 802.11g

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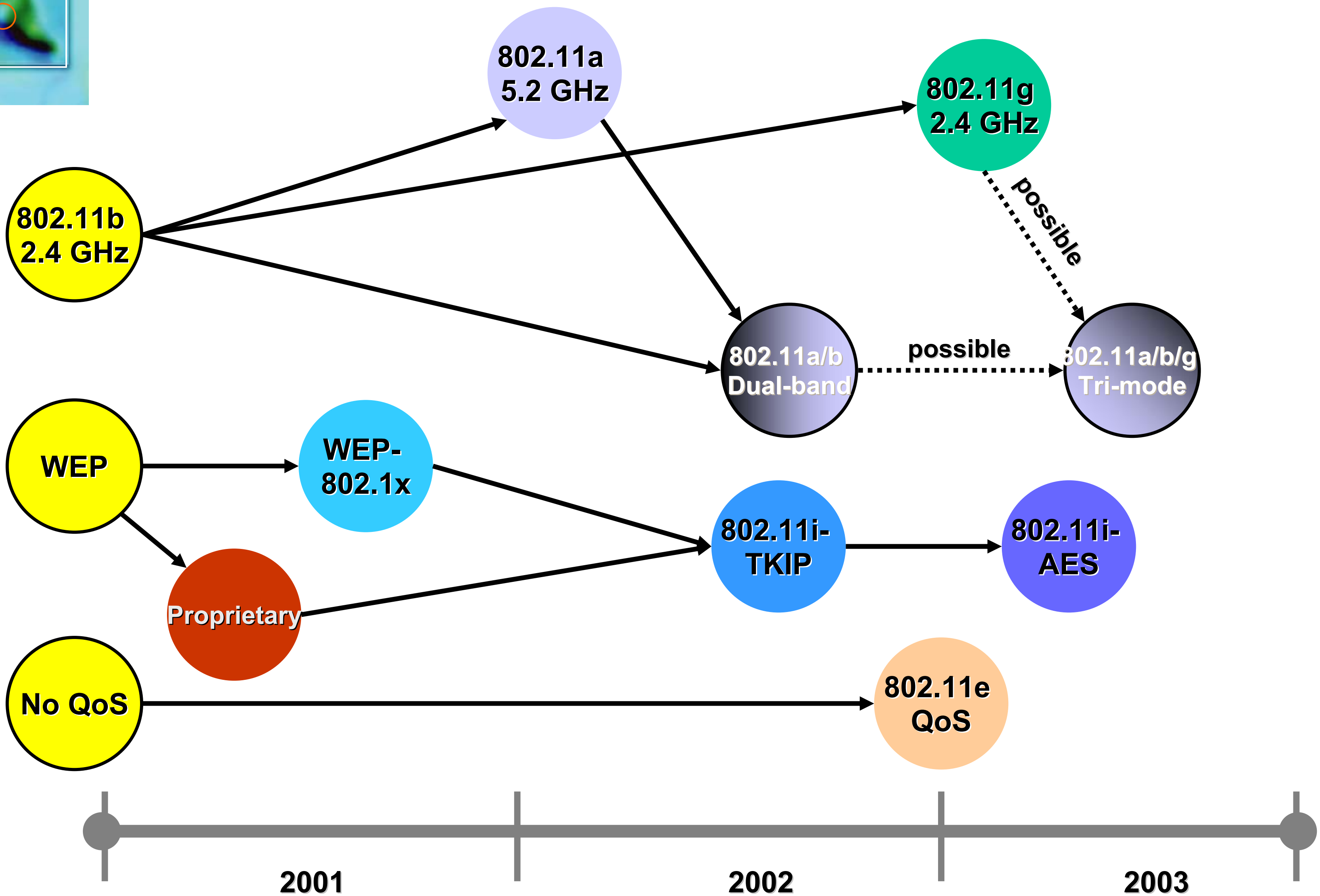
802.11 Stds and WGs

- 802.11a – 5GHz OFDM PHY layer
- 802.11b – 2.4GHz CCM PHY layer
- 802.11c – bridging tables
- 802.11d – international roaming
- 802.11e – quality of service
- 802.11f – inter-access point protocols
- 802.11g – 2.4GHz OFDM PHY
- 802.11h – European regulatory extensions
- 802.11i – enhanced security

802.11 stds (trends) overview



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Techincal summary 802.11a/b/g

- 802.11a
  - MAC Layer: Same CSMA/CA MAC as 802.11b
  - Modulation: Orthogonal Frequency Division Multiplexing (OFDM)
    - 20 MHz channels, multi-carrier
  - RF: UNI-II and ISM bands
- 802.11b
  - MAC Layer: Same CSMA/CA MAC as 802.11a
  - Modulation: Complementary Code Keying (CCK)
    - 22 MHz channels, single-carrier
  - RF: ISM bands (2.4 GHz)
- 802.11g
  - MAC Layer: Same CSMA/CA MAC as 802.11b
  - Modulation: Complementary Code Keying (CCK) and Orthogonal Frequency Division Multiplexing (OFDM)
    - 22 MHz channels, single-carrier (CCK) and multi-carrier (OFDM)
  - RF: ISM bands (2.4 GHz)

802.11 standard & supplements summary

- Base standard divided into two layers
  - medium access control (MAC) layer
  - physical (PHY) layer
- Standard supplements extend one of these layers or provide higher layer functions
- Supplements at different layers can be intermixed
  - 802.11e applies to 802.11b, 802.11a and 802.11g

Wireless QoS Principles

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Wireless QoS Principles

- What works in a wired network doesn't necessarily work in a wireless network
  - too many broken assumptions
- System aspects
  - division of functions across layers
  - application expectations

Wireless QoS Principles

- Many previous attempts at WLAN QoS (and non-QoS channel access schemes), show that strategies that work well in a wired environment don't translate to WLAN
- Things that break assumptions:
  - Packet error rate can be in the range 10 – 20%
  - Bit rates vary according to channel conditions – you can't do a bandwidth reservation at connection setup time and expect it to stick
  - The "rubber pipe problem" – a bandwidth manager doesn't know how much bandwidth it has to manage, since a neighboring, unrelated bandwidth manager can take some of it at any time
- Questions:
  - what does "guaranteed QoS" mean in a system with a 20% packet error rate?
  - what does "connection admission control" mean in an unlicensed RF band?

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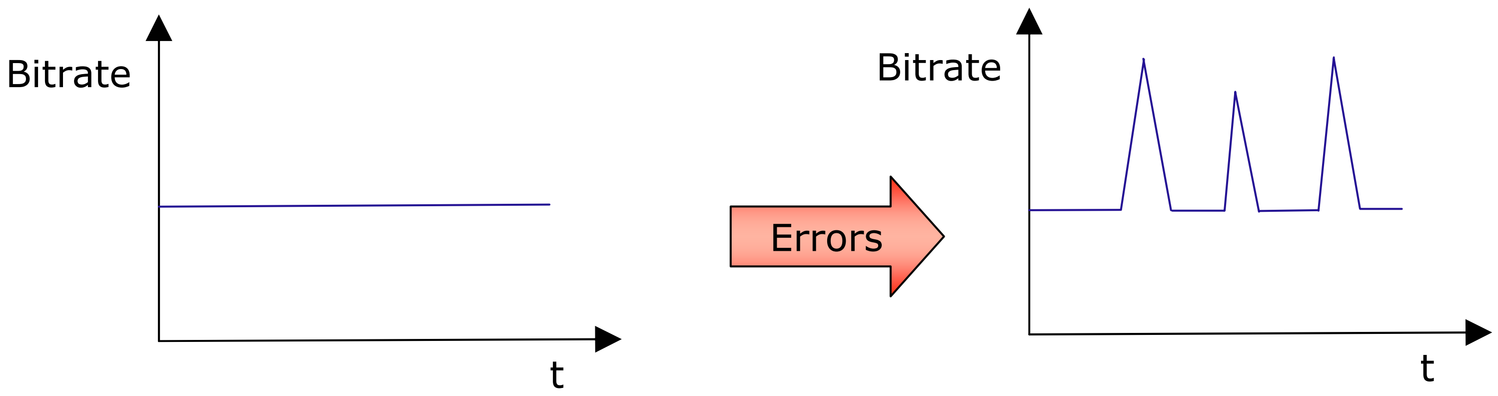
CBR traffic in a wireless LAN

- Multimedia traffic is frequently modeled as predictable, constant bit rate
  - but CBR traffic acquires a significant bursty component in the presence of packet errors that force retries
  - constant slot allocation strategy alone does not work well any more



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The draft 802.11e standard supplement

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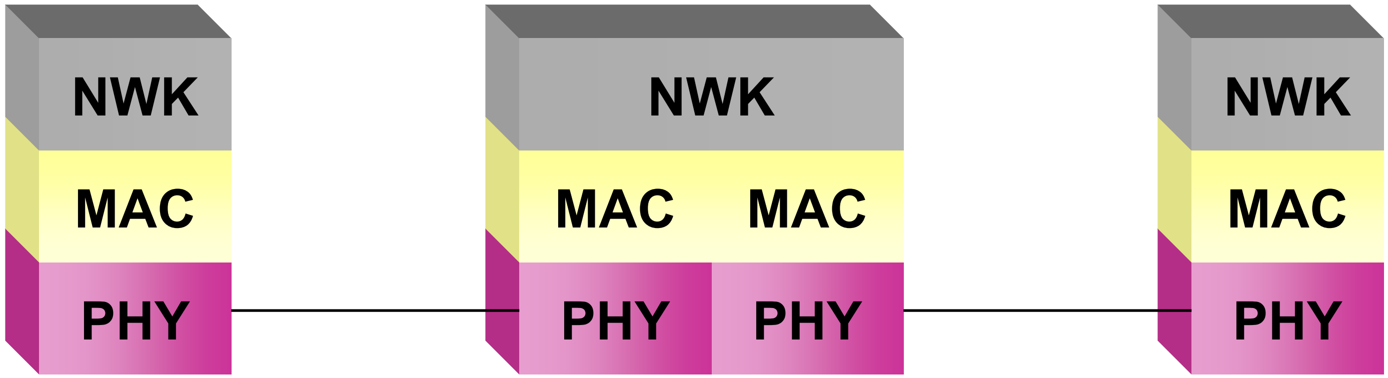
System aspects

- Not all functions need to be contained in the MAC layer
  - 802.11e targeting Ethernet equivalence
  - connection admission control considered a higher layer problem
  - MAC needs only to provide priority separation
- Different applications make different assumptions about connection admission control
  - 802.11e trying to target all of these applications

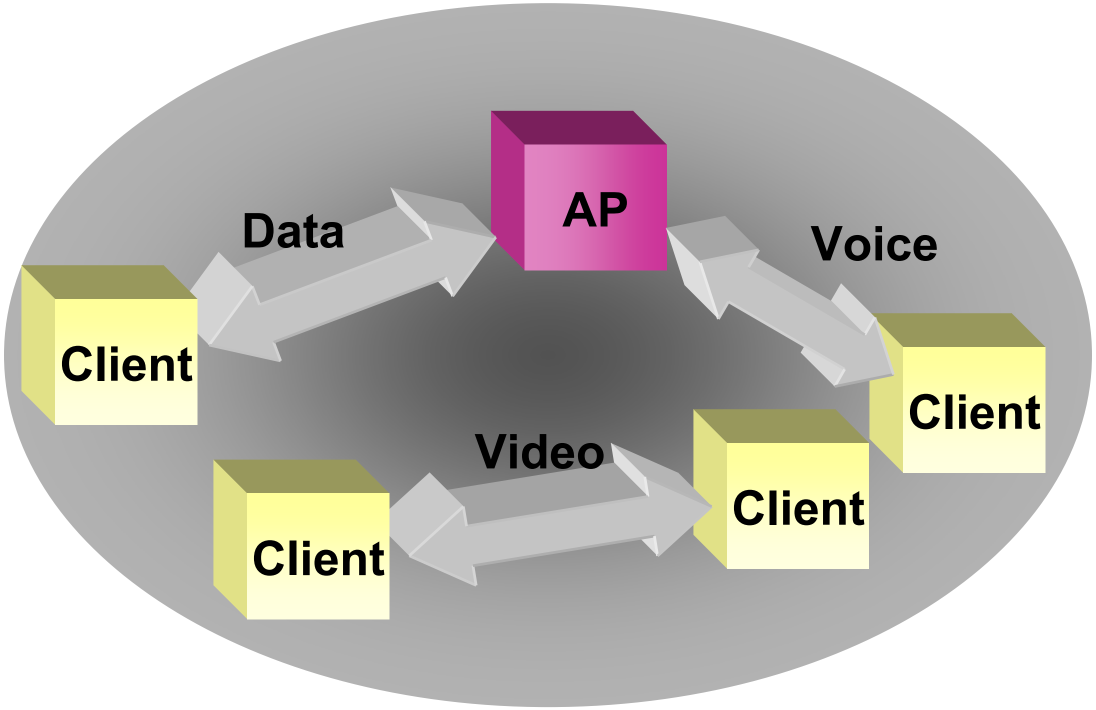
Division of functions accross layers

- MAC layer can only see its own network segment
- Connections are end to end, and not in the domain of the MAC
- Packets that are part of a stream are labeled with a priority and passed to the MAC



Example of usage

- Voice call is highest priority, gets lowest latency
- Video is next priority, will get sufficient bandwidth if it is there
- Data will get whatever bandwidth is left over

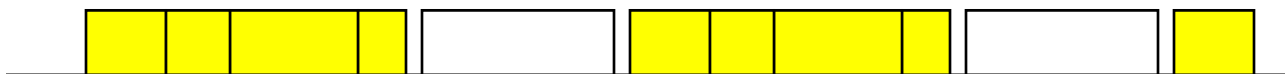


802.11e HCF – best of both

CSMA/CA

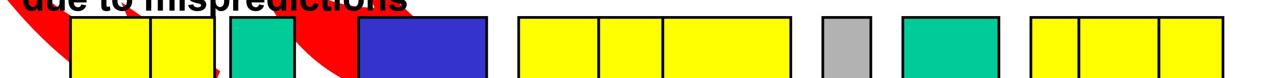
- Most efficient, lowest latency for bursty traffic
- Per-packet channel access overhead, not exploiting optimization opportunity for predictable traffic

Point Coordinated



- Per stream channel access overhead, larger than CSMA per-packet overhead, but more efficient for predictable traffic
- Very inefficient with bursty traffic; scheduler assigns slots in the wrong places due to mispredictions

802.11e



- "Hybrid Coordination Function" uses both techniques
- Short point-coordinated bursts provides efficient channel access for data that the coordinator can predict
- CSMA provides efficient access for bursty traffic, retransmissions

Implications for 802.11e

- 802.11e must support 802.1D priority marking
  - makes its behavior identical to Ethernet
- 802.11e cannot assume that RSVP is present
  - but can be designed to take advantage of additional information if it is there

Application of 802.11e

- Focus on two usage models:
  - IP-based multimedia
    - Streaming protocols such as RTP/RTCP
    - Applications have been built on the assumption of very little guarantee of service from the network
    - Robust to sudden changes – built in adaptability
    - Require only on 802.1D-based priority, where available
    - Seamless bridging across Ethernet and 802.11
  - 1394 over 802.11a
    - Proposals under discussion in 1394 wireless working group
    - May run directly over the 802.11e MAC, or using IP encapsulation
    - Seamless interworking between 1394 and 802 LANs, particularly 802.11 is required
    - Attach PC and other IP devices to the 1394 bus
    - No brainer installation and configuration

Issues with 802.11e

- Not efficient for adhoc networks when load increases
- EDCF parameters are difficult to set (static) and can cope with change of conditions on the network
- EDCF is backwards compatible to DCF – making it practiucaly useless when DCF nodes present
- Collision number increases with increased number of stations (severely decreases network throughput and increases latency/jitter)

Lessons from the past and current situation

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Previous Attempts for QoS on WLAN

- Hiperlan 1 (EY-NPMA)
  - early (1996) fully distributed prioritized scheme
  - focused on time bounds rather than 802.1p-style flow separation
  - theoretically highly efficient and delivers on time bounds, but fragile in presence of errors and hidden stations
- Hiperlan 2 (Wireless ATM)
  - fully centralized – all scheduling pushed to the AP, which broadcasts time allocation for each 2ms superframe
  - theoretically highly efficient, given a perfect scheduling algorithm (nearly all publicly available papers assume this)
  - efficiency drops dramatically in adverse (bursty) traffic conditions, because efficiency is dependent on ability of scheduler to predict requirements
  - immensely complex

Previous Attempts ... ctd

- HomeRF (DECT/802.11)
  - combines CSMA/CA for data, slots with retransmission for voice
  - works well within stated objectives – efficient data transfer, good for voice, but not quite for video etc.
  - let down by inadequate PHY layer

Issue with Frequencies

- 2.4 GHz ISM band is very congested
  - Everything from 2.4 GHz phones to microwave ovens to Bluetooth 1.1 transmit here
- 802.11a in the 5 GHz frequency band is a primary or co-primary user
  - Shared with navigation and satellite equipment, *not* other consumer equipment
  - Designed for wideband transmissions as opposed to narrowband (phones, garage door openers, etc.)
  - No guarantees it will stay this way; still unlicensed spectrum
- Reduces concerns over “co-existence” issues
  - 5 GHz is the best place for Radio LANs

Bonus Material - 802.11 at home

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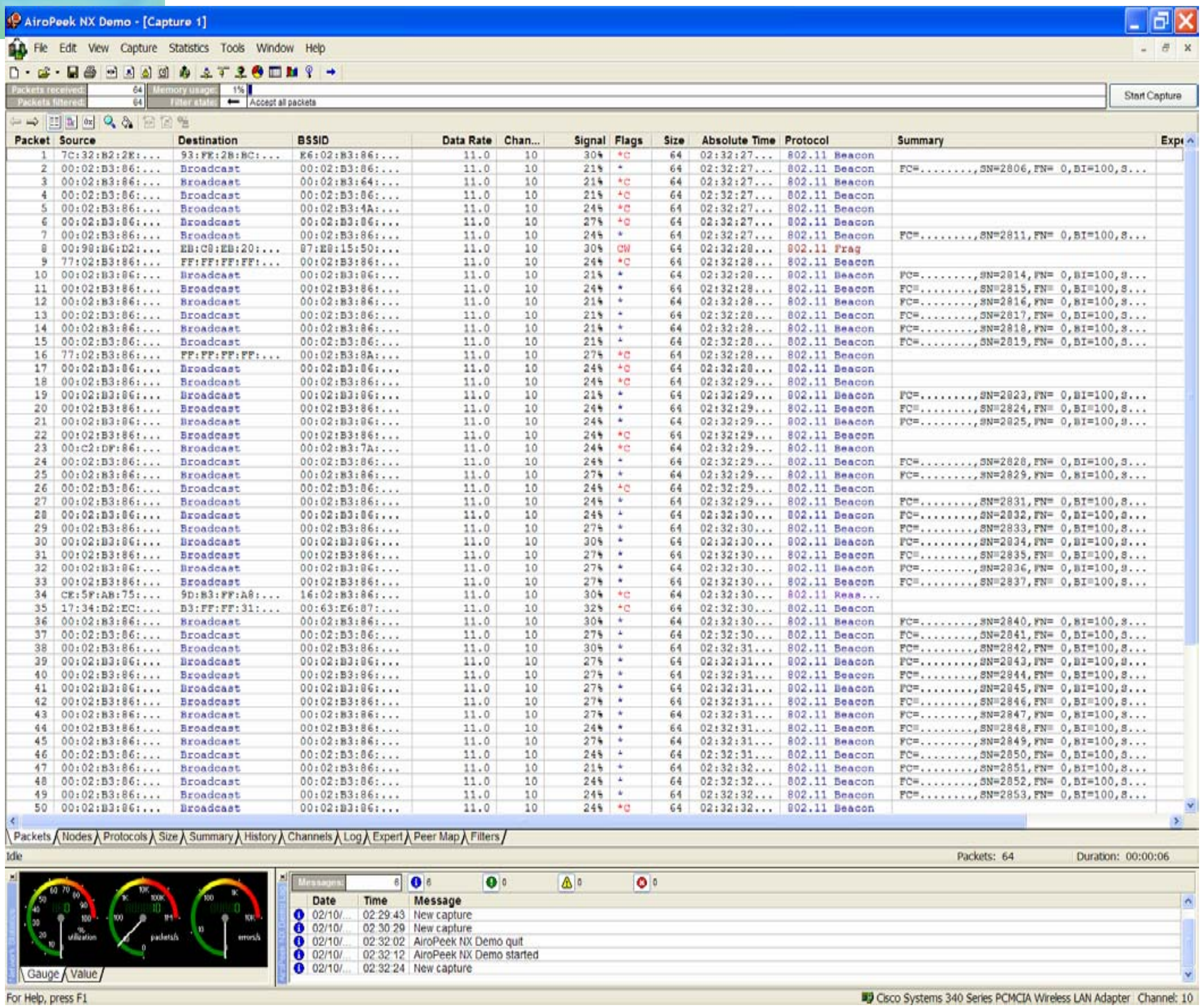
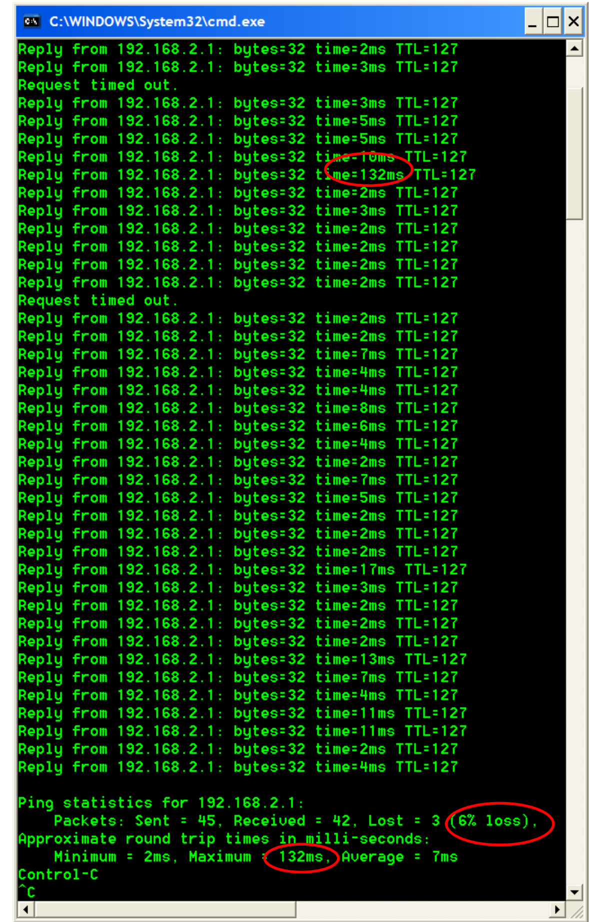
Bonus Material - 802.11 at home -issues





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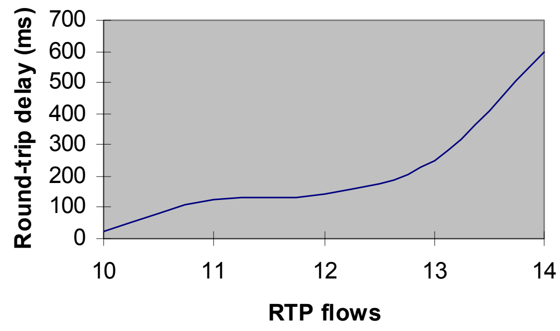
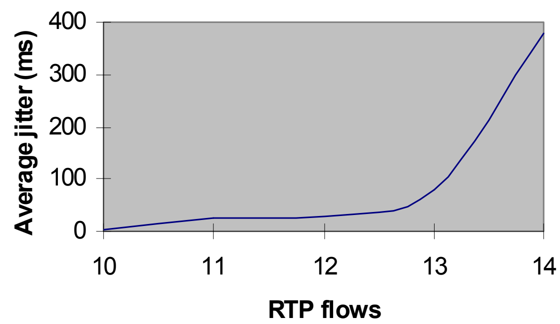
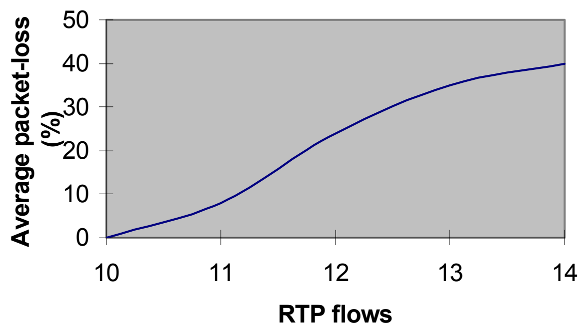
Internal test results







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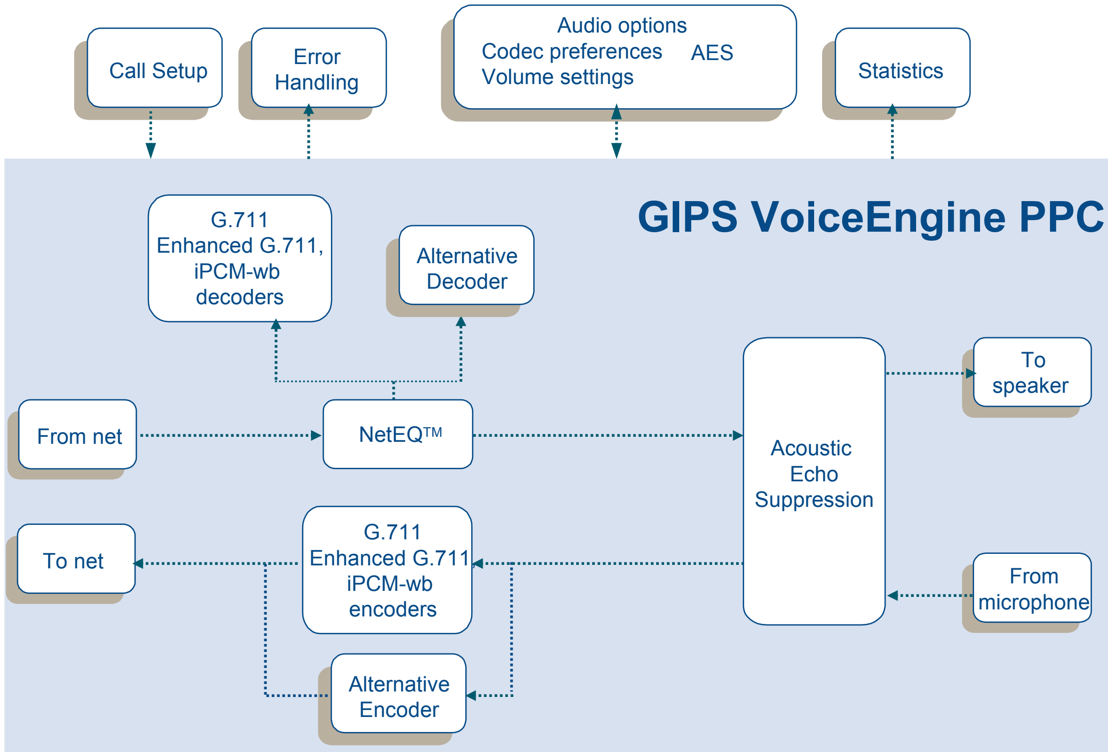
GIPS VoiceEngine™ - PPC



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Acoustic Echo Supression (AES)

Features

- Interoperability with different speech coders
- Handle both 8kHz and 16kHz sampled signals
- Suitable for small devices like PDAs
  - Play out and recording speech flows are not required to be synchronized
  - Can handle changing delay caused by soundcards and drivers in the PDA
  - Low complexity
- Comfort noise insertion
- High level API
- ITU G.167 compliant

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Summary

- WLAN is ubiquitous technology and as well brings some ubiquitous QoS issues
  - If I run VoIP over WLAN at home, whose going to guarantee me QoS level?
- Usage of technology that can deal with some of WLANs intrinsic imperfections (or ones who are operating it) can accelerate its wide acceptance