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# Wireless VoIP in the Enterprise

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# Session Introduction

- The general interest in IP Voice and Wireless LAN makes their combination almost inevitable
- Health care, retail, and higher education have been the primary vertical markets for WLAN voice:
  - Mobile workforce
  - High volume of voice communications
- Wireless PBX products (e.g. SpectraLink Link WTS) have been available for a decade or more, but they were expensive as the entire wireless infrastructure had to be built before the first phone could be activated
- With a wireless LAN in place, we merely buy handsets and possibly a controller
- However, users have high expectations for voice systems in the areas of performance, reliability, and security.

# Current Environment

- The 802.11/Wi-Fi wireless LAN technology was not designed for voice!
- Voice devices represent less than 1% of WLAN stations today
- The QoS standard is complete, but the standard for hand-offs is still in development
- WLAN voice security is catching up (WPA2)
- Conclusion:
  - The basic capabilities are defined in the standards, but the enhanced capabilities required for large-scale deployments still required vendor-proprietary extensions

# Session Outline

Section 1: WLAN Basics

Section 2: Voice Over WLAN Configuration

Section 3: Quality of Service Options

Section 4: Hand-offs, Security, and Other Issues

Section 5: Conclusion: Planning Recommendations

# Section 1: WLAN Basics

# Wireless LAN Basics

## Basic Characteristics of 802.11 Wireless LANs

- Half Duplex: Only one device can send at a time
- Shared Media: One channel shared by multiple users
- Range: Up to 300 feet indoors- Farther outdoors
- Capacity/Range: Actual data rate depends on:
  - Distance from the access point
  - Obstructions in the radio path
  - Interference from other transmitters in the same radio band
- Protocol Overhead: Reduces network throughput by 50%

– Voice Impact: Increased latency and causes more dropped packets

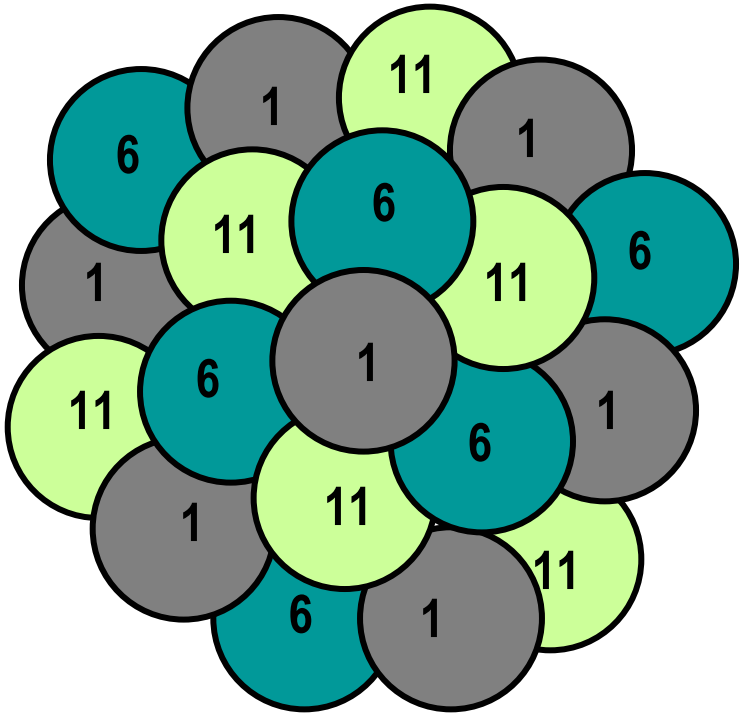
# IEEE 802.11 Radio Links

| Interface | Max. Bit Rate | Independent Channels | Frequency Band | Radio Technique |
|---|---|---|---|---|
| 802.11b | 11 Mbps | 3 | 2.4 GHz | DSSS |
| 802.11a | 54 Mbps | 23 | 5 GHz | OFDM |
| 802.11g | 54 Mbps | 3 | 2.4 GHz | OFDM |
| 802.11n | 289 Mbps (20 MHz)<br>600 Mbps (40 MHz) | 26 (20 MHz) | 2.4 or 5 GHz | OFDM/MIMO |

Each wireless LAN requires a radio channel (Selected in the AP)

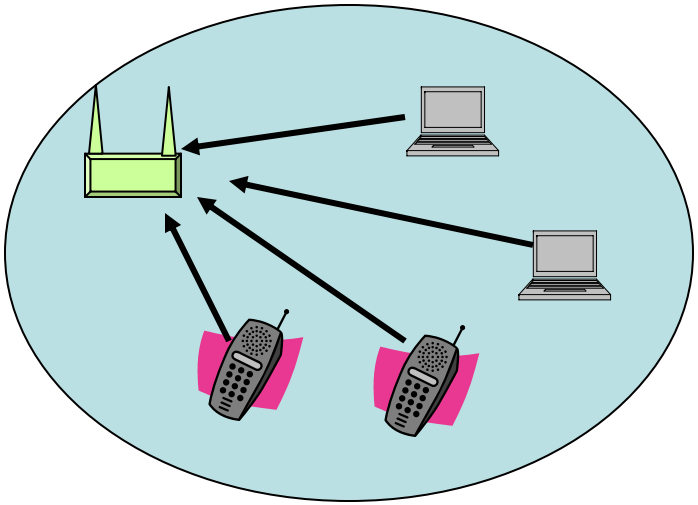
- Home/small office networks require only one channel
- Large-scale networks are configured with overlapping cells
  - There are 3 non-interfering channels in the 2.4 GHz band, and 23 in the 5 GHz band
  - Channels cannot be reused in adjacent cells
  - Some coverage overlap is recommended
  - Excessive overlap causes "association thrashing"

**Layout of a 3-Channel 2.4GHz Network**



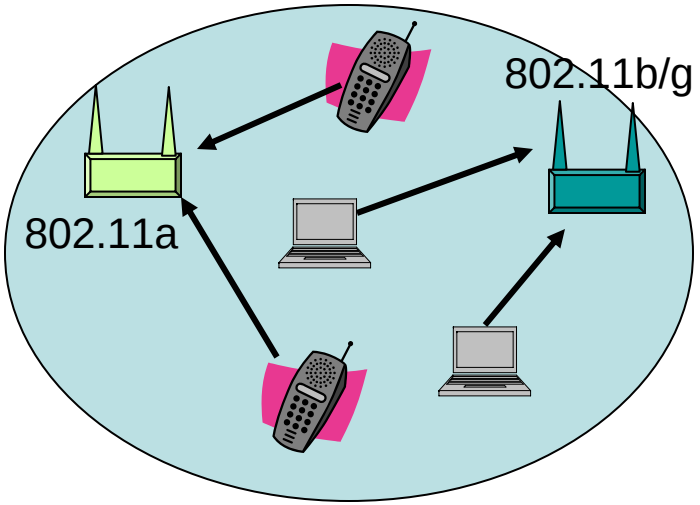
# Potential Configurations

Integrated Voice/Data WLAN



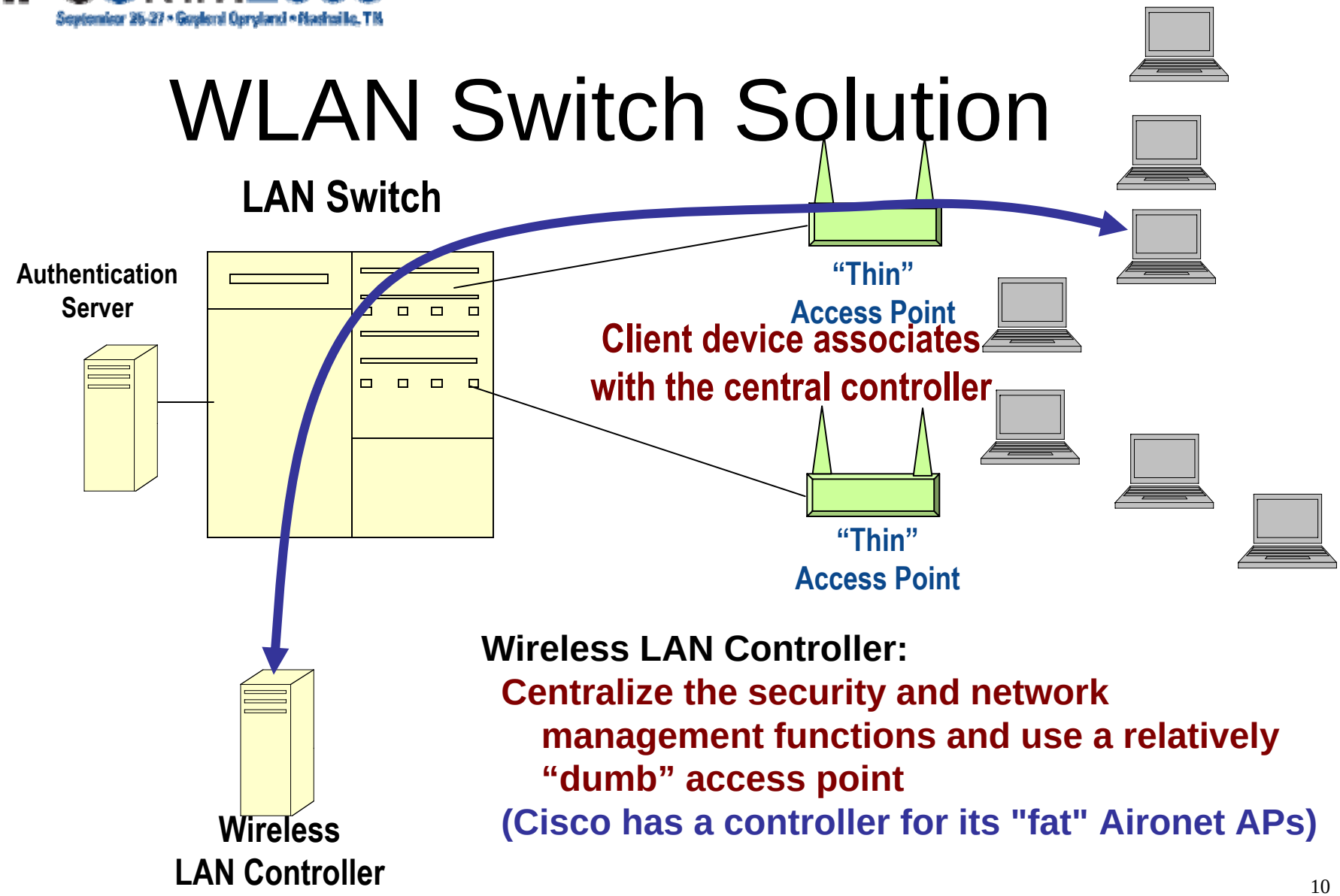
QoS Required to Prioritize Voice

Dual Overlay Network




- 802.11a has more channels (23)
- 802.11b provides longer battery life

# WLAN Switch Solution




**Wireless LAN Controller:**

**Centralize the security and network management functions and use a relatively "dumb" access point**

**(Cisco has a controller for its "fat" Aironet APs)**

# WLAN Switch Capabilities

- Integrated Design Tools
  - Assist in site planning and initial AP placement
- RF Management/Power Adjustment
  - Automatically selects channels and adjusts power levels on installation and when new cells are added to the network
- Centralized Authentication and Encryption
  - Users associate with the switch rather than the access point
- Hand-off Capability
  - User connections can be handed-off from one access point to another usually in <50 msec
- Rogue/Spoofed Access Point Detection
  - The WLAN switch will recognize any transmissions that are not from its access points
  - Some will launch attacks to disable them
- Rogue/Spoofed Access Point Location
  - Some products provide tools to assist in locating rogues

# Major WLAN Switch Suppliers

- Aruba (Alcatel, Juniper)
- Cisco Systems
- Meru Networks (Avaya)
- Siemens (formerly Chantry Networks)
- Symbol Technologies
- Trapeze Networks (Nortel, Enterasys)
- Xirrus (ADC)

# Section Conclusion

- The first step in supporting voice on a WLAN is to have a functional WLAN infrastructure
- Some critical issues to bear in mind:
  - If voice and data devices share the same channel, QoS will be needed to prioritize voice (or you can build a separate WLAN for voice)
  - Data service may be restricted to conference rooms, but voice service must be available throughout the facility
  - The received signal strength of a voice device will be diminished as it is held close to the body
  - Wi-Fi is a "power hog" so battery life will be an important consideration in network design
  - Voice users have high expectations regarding quality and reliability

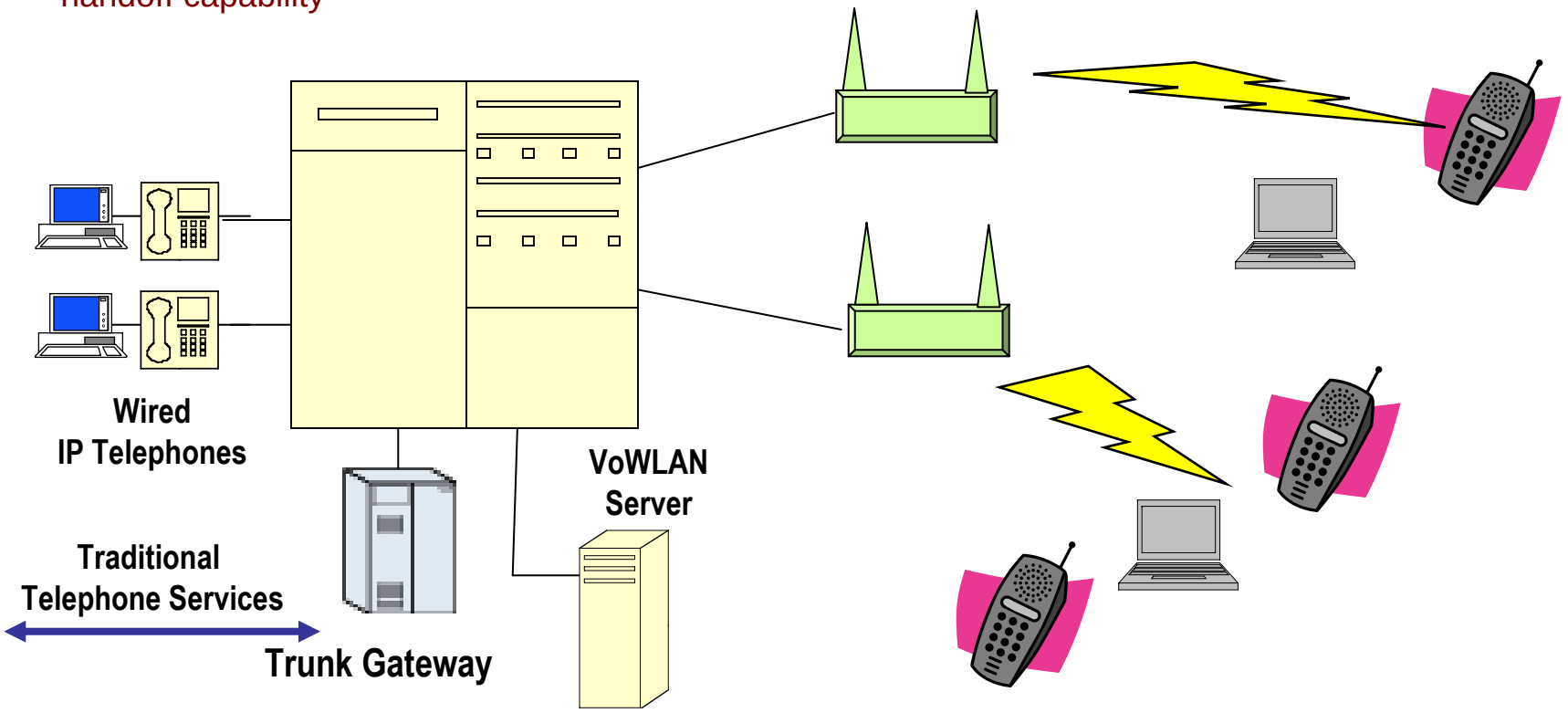
# Section 2:
# Voice over WLAN Configuration

# Elements in the VoWLAN Network

- WLAN Voice Handsets
  - Small number of models currently available
  - Two primary categories: General office and "ruggedized"
  - Ruggedized models typically support push-to-talk (PTT)
  - Laptops or PDAs with softphone client software are an option
- Voice Signaling
  - Proprietary: Cisco SCCP ("Skinny"), SpectraLink, Vocera
  - SIP-based: Works with any SIP-compliant server
- WLAN Infrastructure
  - Normally shared with data, so QoS is essential to insure voice quality in high traffic periods
  - Separate voice WLAN becoming more practical (Dual radio APs)
- Interface to Wired PBX System
  - Exchange calls and support feature transparency
  - Feature transparency varies by product

# VoWLAN Configuration

- VoWLAN Handsets: Cisco, SpectraLink, Siemens, RIM, Vocera, etc.
- Server/Gateway: Manages connections for VoWLAN Handsets
- Wireless LAN: WLAN Switch-based solutions are preferred as they typically include handoff capability



# Voice over WLAN Handsets

- Cisco:
  - 7920
- RIM Blackberry
  - Blackberry 7270
- Spectralink:
  - NetLink e340- General Office Use
  - NetLink h340- Healthcare
  - NetLink i640- Ruggedized
- Siemens
  - optiPoint WL1
  - optiPoint WL2
- Vocera
  - Communications Badge
- WLAN/Cellular

- Prices start at around $350

**SpectraLink H340**

**Siemens optiPoint WL2**

**Vocera**
**Communications Badge**

# VoWLAN Handset Comparison

| | Cisco 7920 | Blackberry 7270 | SpectraLink e340 | Siemens optiPoint WL2 | Vocera Comms Badge |
|---|---|---|---|---|---|
| WLAN | 802.11b | 802.11b | 802.11b | 802.11b/g | 802.11b |
| Voice Coding | G.711 G.729a | G.711 | G.711 G.729a | G.711 G.729a/723 | G.711 Prop. 8K |
| Encryption | WEP/WPA & 2 | WEP | WEP/WPA & 2 | WEP/WPA | WEP/WPA |
| Authen-tication | 802.1x LEAP | 802.1x LEAP | 802.1x LEAP | 802.1x LEAP, EAP-TLS | 802.1x LEAP |
| WMM QoS | Yes | No | Yes | Yes | No |

# WLAN/Cellular Handsets

- The Wi-Fi Alliance lists 26 Certified Models (July 2006)
  - D-Link: 1 model
  - Motorola: 2 models
  - Nokia: 10 models
  - Phillips: 1 model
  - Samsung: 10 models
  - Sanyo: 1 model
  - Sony: 1 model
- All use SIP-based signaling
- Most are not available in the US!

# Other Handset Issues

- Battery Life: Major convenience issue
- Form Factor:
  - Utilitarian Look
  - Small number of models
- Radio Link: Most are 802.11b only
  - 802.11a and g radios use more power!
- Security: Can be a problem in mixed voice/data networks ("least common denominator" security)

# Section 3:
# Quality of Service Options

# Voice on Wireless LANs

**Shared Media LANs are not recommended for voice**

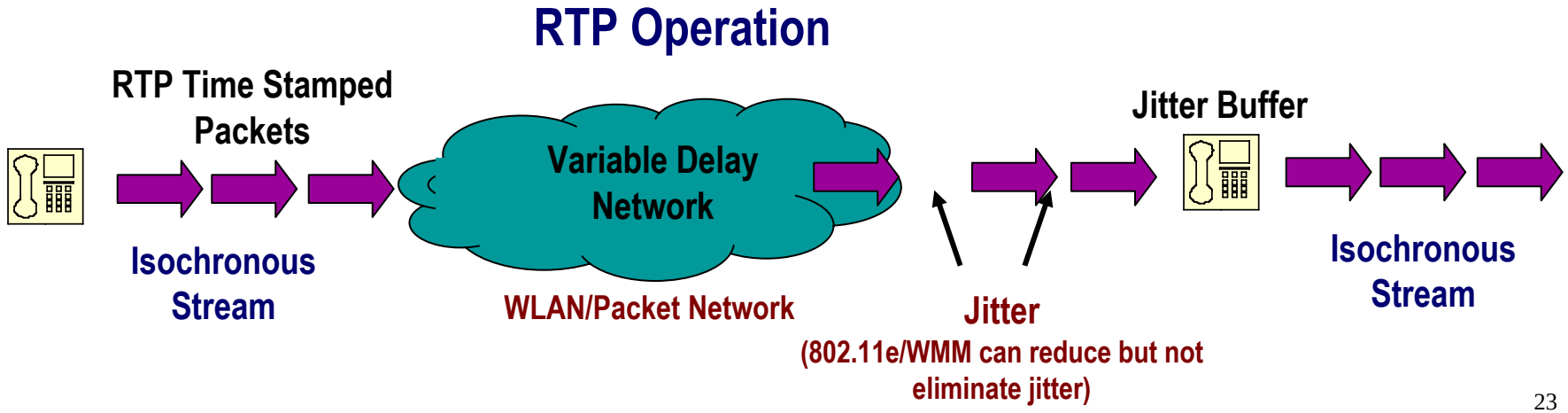
- Channel sharing inevitably introduces variable delay into the path- "Non-isochronous" service

**Major Issues:**

1. Capacity/Quality of Service
   - Impacts Latency
   - Increases likelihood of dropped packets
2. Call Access Control/Load Balancing
3. Hand-off Capability
4. Security

# Capacity and Quality of Service

- Capacity and QoS
  - WLANs are low-capacity, contention-based, shared media networks
  - Protocol includes no provision for maintaining consistent timing
- Real Time Protocol (RTP)
  - RTP time stamps voice packets before sending
  - Receiver buffers packets and delivers them based on time stamps
- Voice Activity Detection/Silence Suppression typically not used



# WLANs Impact on Latency

- Network Latency has been the major complaint with packet voice systems
- Requirement: One-way latency <150 msec

| | Alcatel OMNI PCX | Avaya S8700/G650 | Cisco IP Com Sys | ShoreTel ShoreTel5 | Siemens HiPath 4000 |
|---|---|---|---|---|---|
| **Hardwired IP** | | | | | |
| G.711 (64 K) | 57 msec | 67 msec | 54 msec | 47 msec | 54 msec |
| G.729 (8 K) | 42 msec | 76 msec | 71 msec | 55 msec | 81 msec |
| **WLAN** | | | | | |
| G.711 (64 K) | 81 msec | 92 msec | 90 msec | N/A | N/A |
| G.729 (8 K) | 87 msec | 89 msec | 92 msec | N/A | N/A |

Source: Miercom,
Business Communications Review , January 2005

# MAC Protocol- CSMA/CA

Carrier Sense Multiple Access with *Collision Avoidance* (CSMA/*CA*)
*Contention-based access results in variable transit delay*

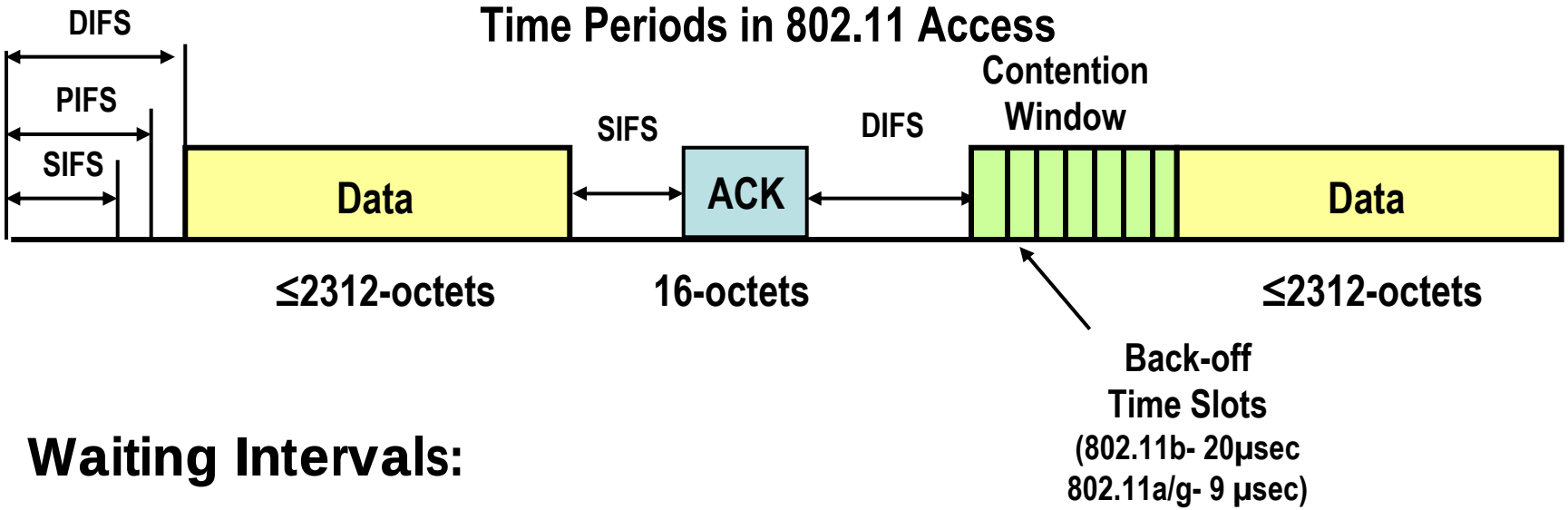
- Four primary MAC options:
  1. Distributed Control Function (Most typical)
  2. RTS/CTS Mode: For “Hidden Nodes” and Mixed b/g networks
  3. Point Control Function: For time sensitive traffic (Never used)
  4. Hybrid Coordination Function: WMM/IEEE 802.11e for QoS
- Different from Ethernet- Can't "hear" while sending:
  Must ***Avoid*** rather than ***Detect*** collisions
  - Pre-transmission delay timers (SIFS, PIFS, and DIFS) provide priority access to the shared radio channel
  - All correct receptions are acknowledged

# Distributed Control Function

Overall Concept: Stations collaborate to avoid collisions

- Some Definitions:
  - Inter-Frame Spacing: Intervals a station will wait before sending (when the radio channel is idle)
    - DIFS: Waiting interval to send a frame
    - SIFS: Waiting interval to send an ACK
    - PIFS: Waiting interval to seize the channel for PCF
    - AIFS: In 802.11e, 4-values for different priority levels
  - Back-off Counter: Used when the channel is busy or when a collision occurs. Stations back-off an integral number of Time Slots (e.g. 20 µsec or 9 µsec) before attempting to access the channel

# CSMA/CA Operation




## Waiting Intervals:

DIFS- DCF Inter-Frame Spacing (Sending Frames)
SIFS- Short Inter-Frame Spacing (Sending ACKs, CTS messages, or Fragments)
PIFS- PCF Inter-Frame Spacing (Enter PCF or HCCA Modes)
AIFS- Arbitrated Inter-Frame Spacing: Defined in IEEE 802.11e- Four different values for four different priority levels

# IEEE 802.11e for QoS

The IEEE developed a new protocol option designated 802.11e that will provide Quality of Service (QoS) capability

## Hybrid Coordination Function (HCF) defines two options:

1. Enhanced Distributed Control Access (EDCA):
   - Contention-based protocol with priority access
   - Provides priority channel access, not consistent delay

2. Hybrid Controlled Channel Access (HCCA):
   - Contention-free, polled access with consistent delay
   - The AP takes control of the network periodically and polls selected stations
   - Includes a signaling protocol where stations provide requirements for bandwidth, latency, and jitter
   - Wi-Fi Alliance suspended certification due to "lack of interest"

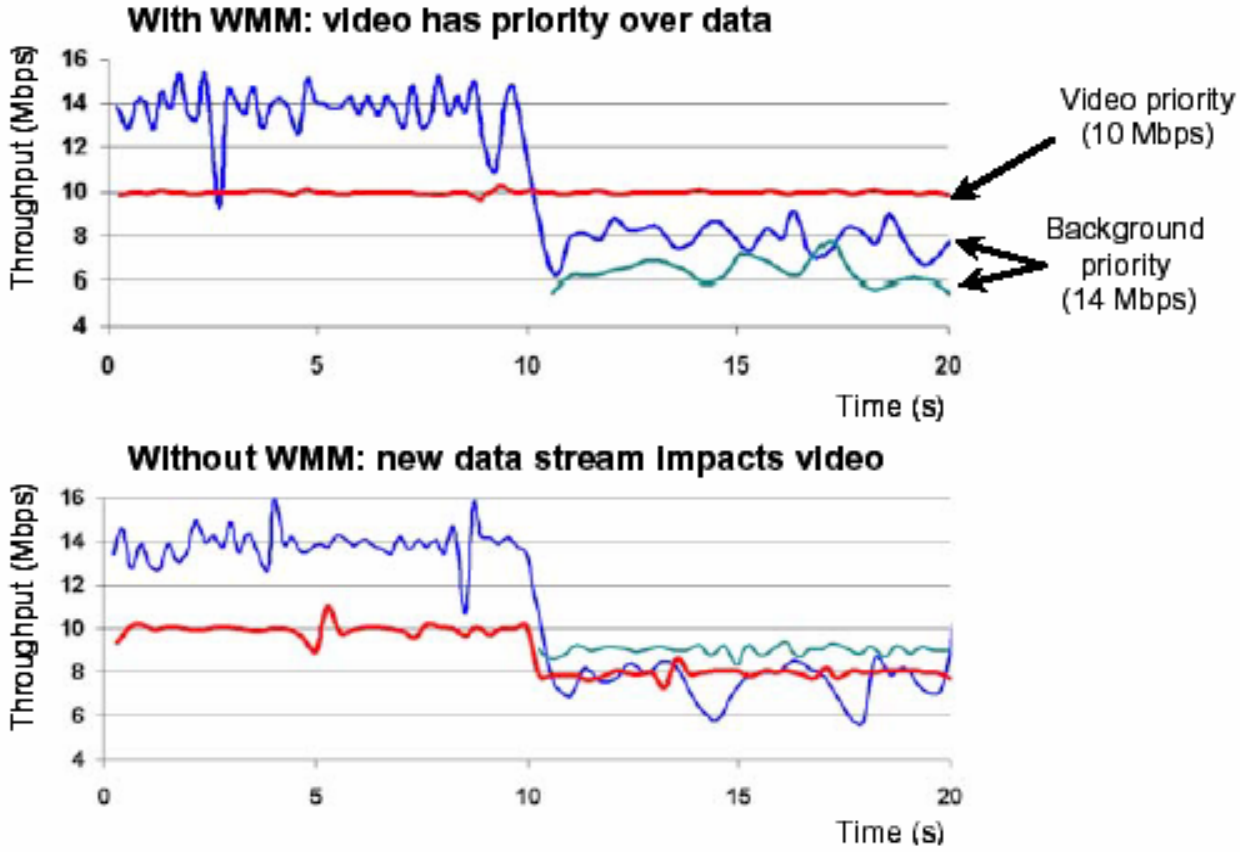
# 802.11e/Wi-Fi Multimedia (WMM)

- Only EDCA is being implemented at this time
  - Four Access Categories are Defined
    - Voice
    - Video
    - Data (Same as current DCF traffic)
    - Background Data
  - Different waiting intervals (AIFS) and back-off counters for each
- Wi-Fi Alliance calls EDCA compatibility:
  "Wi-Fi Multi Media (WMM) Certified"

# 802.11e Default Parameters

| Parameter | DSSS PHY (802.11b) | | | | ODFM PHY (802.11a/g) | | | |
|---|---|---|---|---|---|---|---|---|
| | Access Category | | | | Access Category | | | |
| | 4 | 3 | 2 | 1 | 4 | 3 | 2 | 1 |
| AIFS (SIFS + *x* Time Slots) | 7 | 3 | 2 | 2 | 7 | 3 | 2 | 2 |
| AIFS Time (µsecs) | 150 | 70 | 50 | 50 | 73 | 37 | 28 | 28 |
| Tx Op Limit (µsecs) | 0 | 0 | 6016 | 3264 | 0 | 0 | 3008 | 1504 |
| CW min | 31 | 31 | 15 | 7 | 15 | 15 | 7 | 3 |
| CW max | 1023 | 1023 | 31 | 15 | 1023 | 1023 | 15 | 7 |

# WMM Impact on Performance




**Source: Wi-Fi Alliance**

# Theoretical Maximum Calls

| Theoretical Maximum Calls Per WLAN (20 msec Voice Sampling) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 802.11b Network | | | | 802.11a or g Network | | | |
| **Codec** | **11 Mbps** | **5.5 Mbps** | **2 Mbps** | **1 Mbps** | **54 Mbps** | **36 Mbps** | **18 Mbps** | **6 Mbps** |
| **G.711** | 23 | 16 | 8 | 4 | 78 | 69 | 51 | 24 |
| **G.729A** | 30 | 24 | 14 | 8 | 92 | 86 | 73 | 45 |
| **G.723.1** | 44 | 36 | 21 | 13 | 138 | 129 | 110 | 66 |
| **Skype iLBC** | 28 | 22 | 13 | 7 | 89 | 83 | 69 | 40 |
| Source: www.oreilly.com, Matt Gast, "How Many Voice Callers Fit on the Head of an Access Point", 12/13/2005 | | | | | | | | |

# Expected Capacity for Voice

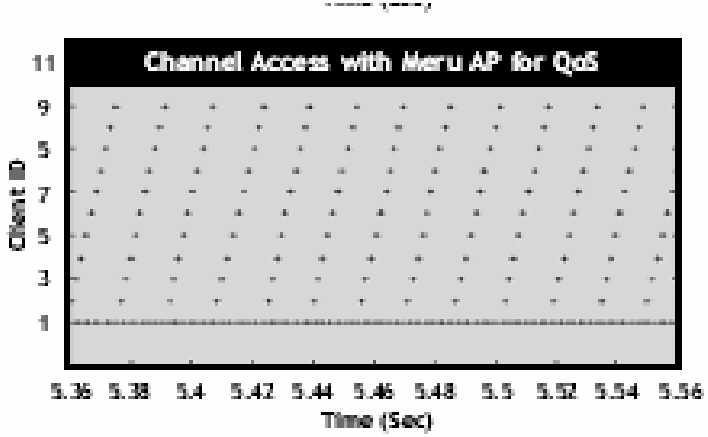
- General Capacity Expectations:
  - 11 Mbps Network (802.11b or shared b/g Network)
    - 6 to 8 Simultaneous calls per AP
  - 54 Mbps Network (802.11a or "Pure-g" Network- if supported)
    - 20 Simultaneous calls per AP
  - Shared 802.11b/g Network
    - 10 Simultaneous calls per AP
- QoS Impact
  - Will not increase the number of calls supported, but will insure the quality of the calls (lower latency, fewer dropped packets)

# Vendor Proprietary Techniques

- SpectraLink Voice Priority (SVP)
  - Most Popular technique used today
  - Operates only through approved access points
  - Basic Capabilities
    - Prioritize Outbound Voice Packets
      - Requires compliant access point
    - Stream Voice Packets
      - Send sequential packets after SIFS interval
    - Prioritize Voice Retransmissions
      - In the event of a collision, voice back-off set to zero

# Vendor Proprietary Techniques

- Meru Networks- Air Traffic Control™
  - Full overlay (rather than cellular) RF layout
  - Proprietary over-the-air scheduling algorithm
    - By reducing collisions, they can support 30 simultaneous 8 Kbps voice conversations on an 802.11b network




*Meru ATC technology overcomes latency and jitter issues by using near-deterministic channel access to deliver over-the-air QoS. Traffic types are automatically detected to apply QoS policies for a dynamic mix of voice and data with support for up to five times more voice calls per AP.*

**Source: Meru Networks**

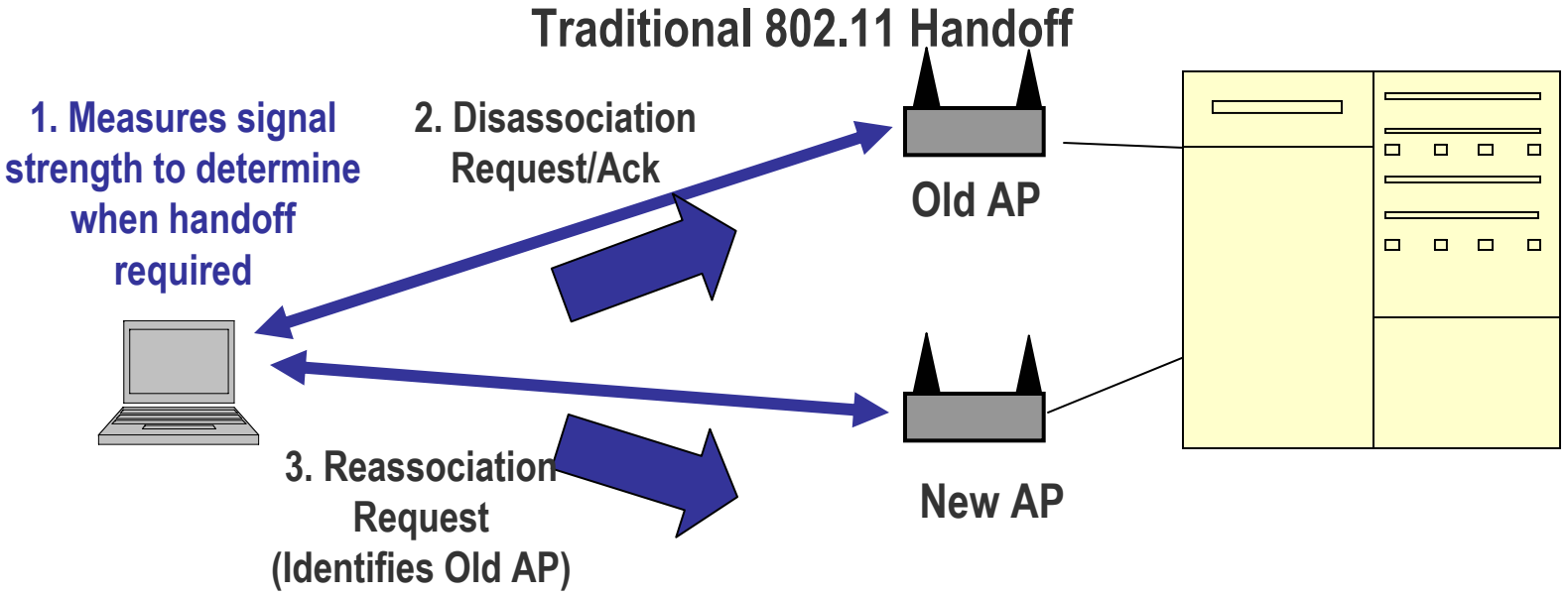
# Emerging Issues for Voice

- Features identified in the standards, but implemented with vendor proprietary solutions
  - Call Access Control (802.11e)
    - Ability to limit the number of voice calls the AP will accept is critical
  - Load Balancing (802.11u)
    - Ability to reroute calls to less congested access points
  - Neighbor Reporting (802.11k)
    - Ability to have the AP query client stations regarding signal strength from alternate APs to guide handoff decisions

# Section 4:
# Handoffs, Security and Other Issues

# Security and Hand-offs

- Problem:
  - The basic 802.11 hand-off process could take over a second, or several seconds if the station had to reauthenticate for security!
  - Handoff is far more common in voice than data applications, and it must be done quickly (<50 msec) while security is maintained



# Hand-off Options

Voice devices will be far more mobile than data devices, so the ability to hand-off calls between APs will be critical

- IEEE 802.11r
  - Developing standard for fast, secure WLAN handoffs
  - Standard not expected before late-2007!!
- IEEE 802.21:
  - Standard for Local and Metropolitan Area Networks: Media Independent Handover Services defining hand-offs among all 802-series technologies (LANs, Bluetooth, WiMax, etc.)
- Vendor Proprietary Options- WLAN Switch
  - Most WLAN switches can provide fast (<50 msec), secure handoffs
  - Actual time may increase if the handoff must cross IP subnets

# WLAN Security: Three Generations

1. Pre-Security
   - Wired Equivalent Privacy (WEP)
   - Not recommended for enterprise installations
2. Wi-Fi Protected Access (WPA)
   - Temporal Key Integrity Protocol (TKIP)
   - 802.1x Authentication: Enterprise WPA
   - Available on most WLAN voice devices
3. 802.11i-Based Security/WPA2
   - Advanced Encryption Standard (AES) encryption
   - State-of-the-art and recommended
   - Availability increased significantly during 2006

# Feature Transparency/ Presence

- All WLAN voice devices will be able to make and receive calls
- Greater feature availability requires a more functional interface between the VoWLAN controller and the wired PBX system
- Wide range of feature capabilities with different VoWLAN and PBX combinations
- One particular area of interest is the ability to link a WLAN location tracking capability to presence management applications in the PBX

# Section 5: Conclusion

# Key Points to Take Home

- WLAN voice is still in its infancy
- Acceptable voice quality will require a sound network design that insures both coverage and sufficient network capacity
- Available QoS techniques should be used to insure priority handling for voice packets in mixed voice/data networks

  … but QoS does not create capacity, it merely manages scarcity!
- Emerging capabilities will be key in large-scale networks:
  - Call Access Control/Load Balancing
  - Neighbor Reporting
  - Network Monitoring, Capacity Planning

# Key Points to Take Home

- We should see a new line of VoWLAN handsets in 2006/07.
- Key features to look for:
  - Support for 802.11 a and g radio links
  - Security based on WPA2/802.11i as well as WPA
  - Support for WMM/802.11e QoS (EDCA option at least)
  - WMM Power Save: For improved battery life
  - Monitoring and Maintenance: Troubleshooting wireless networks is inherently difficult due to the vagaries of radio transmission.

# Web-based Resources

- www.wi-fi.org
- www.standards.ieee.org/wireless
- www.Palowireless.com
- www.wi-fiplanet.com
- www.networkworld.com/topics/wireless.html
- www.SearchMobileComputing.com
- www.networkcomputing.com/channels/wireless.jhtml
- www.Fiercewireless.com
- www.wirelessdesignmag.com

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# QUESTIONS?

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