



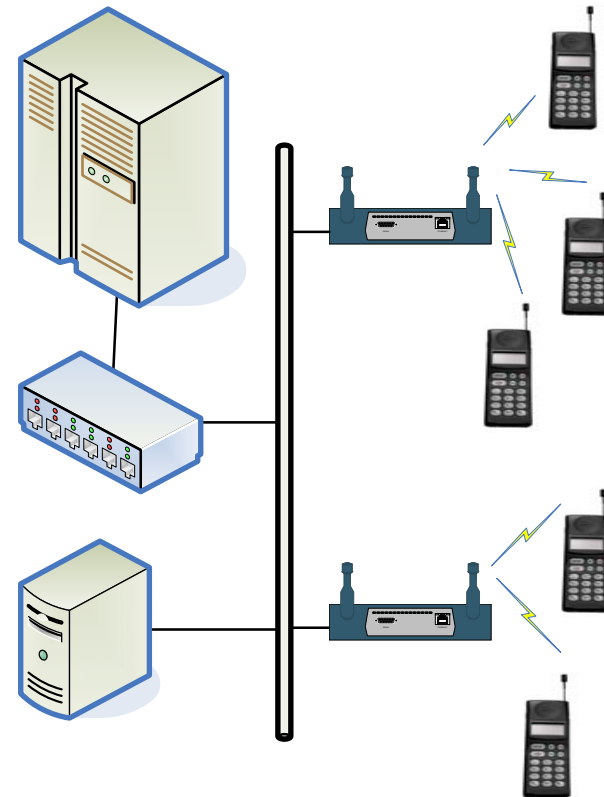
Enterprise-Class Telephony on Wireless LANs

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VeriWave, Inc.

The Leader in Wireless LAN Testing

The Converging Network

- ❖ **Voice over IP (VoIP) enables convergence of traditional PBXs and enterprise LANs**
 - Advantages: reduced infrastructure, reduced operating costs, advanced services
- ❖ **Voice over WLAN (VoWLAN) drives further integration**
 - Adds mobility
- ❖ **Equipment available today**
 - First products in 1996
 - Cisco, Symbol, SpectraLink, Alcatel, Avaya, NEC, Nortel ...
 - IP-PBXs being installed
 - Protocols: H.323, SIP, Megaco
- ❖ **Cellular/WLAN convergence on the horizon**



Cellular/WLAN Convergence

❖ Unlicensed intra-building access attractive to carriers

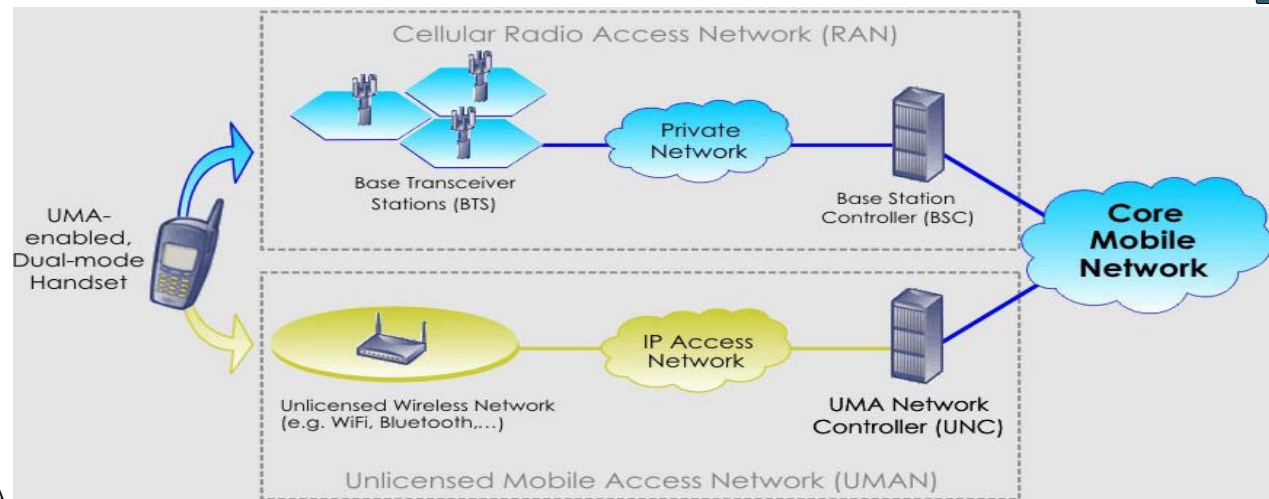
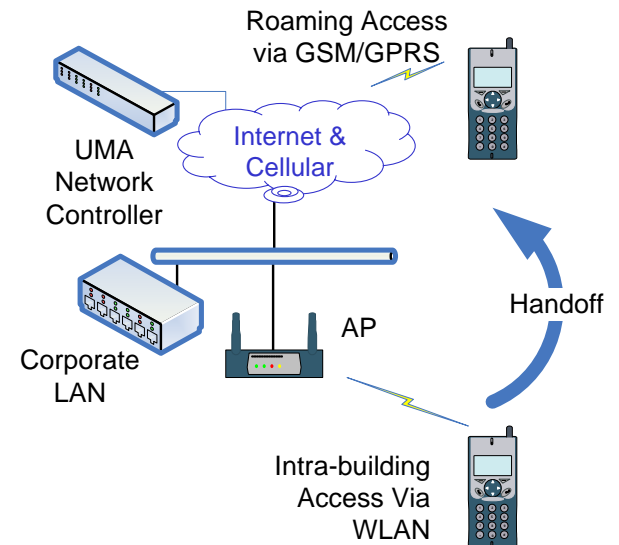
- Bundled services
- Cingular, T-Mobile, Verizon, etc.

❖ Standards being developed

- Handover, multi-radio handsets

❖ Example: Unlicensed Mobile Access

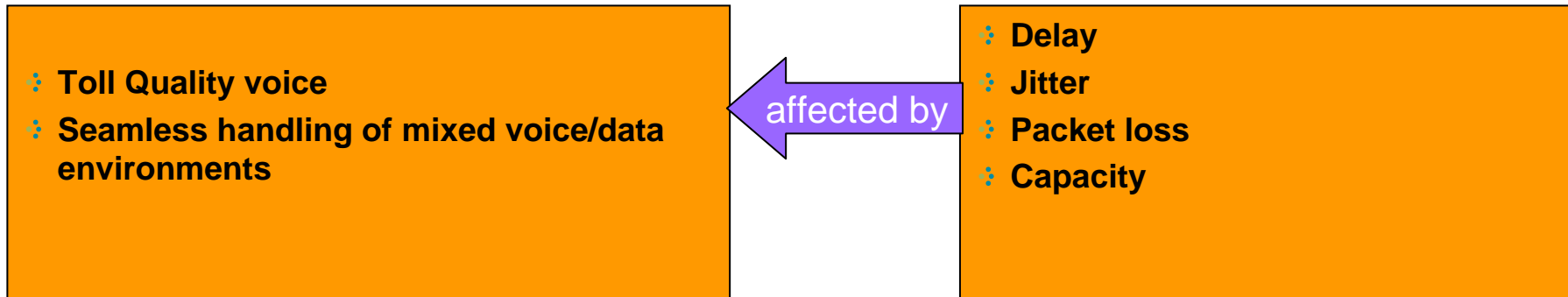
- GSM/GPRS & 802.11 WLANs
- Now part of 3GPP



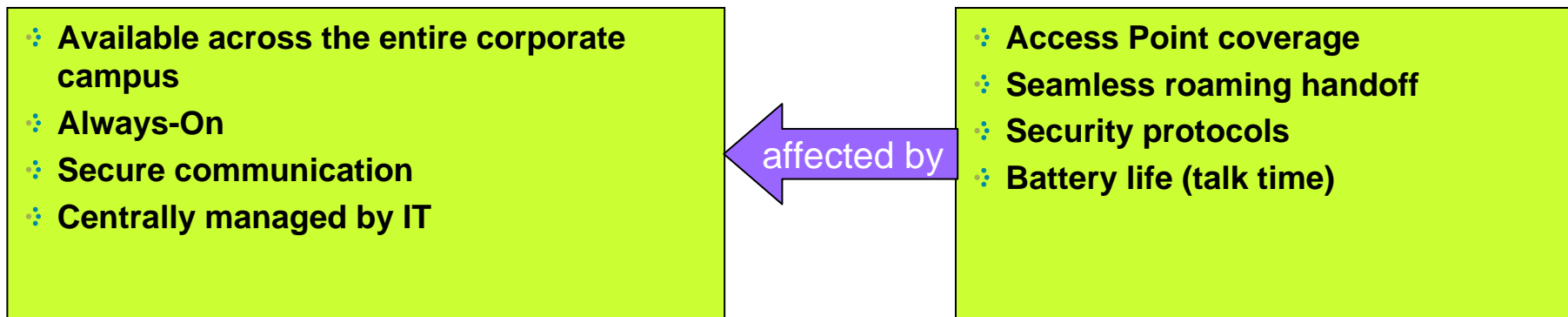
Source: UMA Technology website

Enterprise Voice Requirements

Performance



Reliability & Usability



Wireless vs. Wired

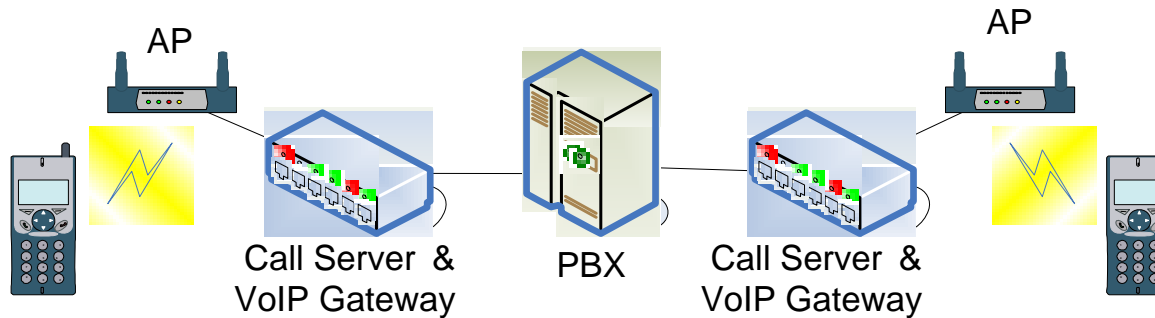
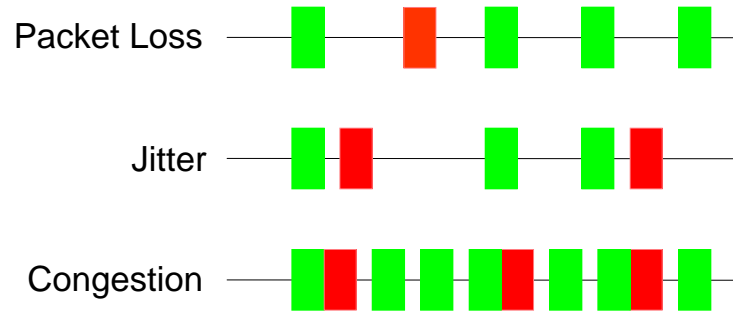
❖ **Wired network attributes:**

- High bandwidth
- Secure
- Isolated
- Predictable and fixed topology

❖ **Wireless network attributes:**

- Limited bandwidth, shared among many users
- Insecure against both eavesdropping and Denial of Service (DoS)
- Prone to interference from other networks and from non-WLAN devices
- Highly dynamic topology with special mobility issues

Network Impairments



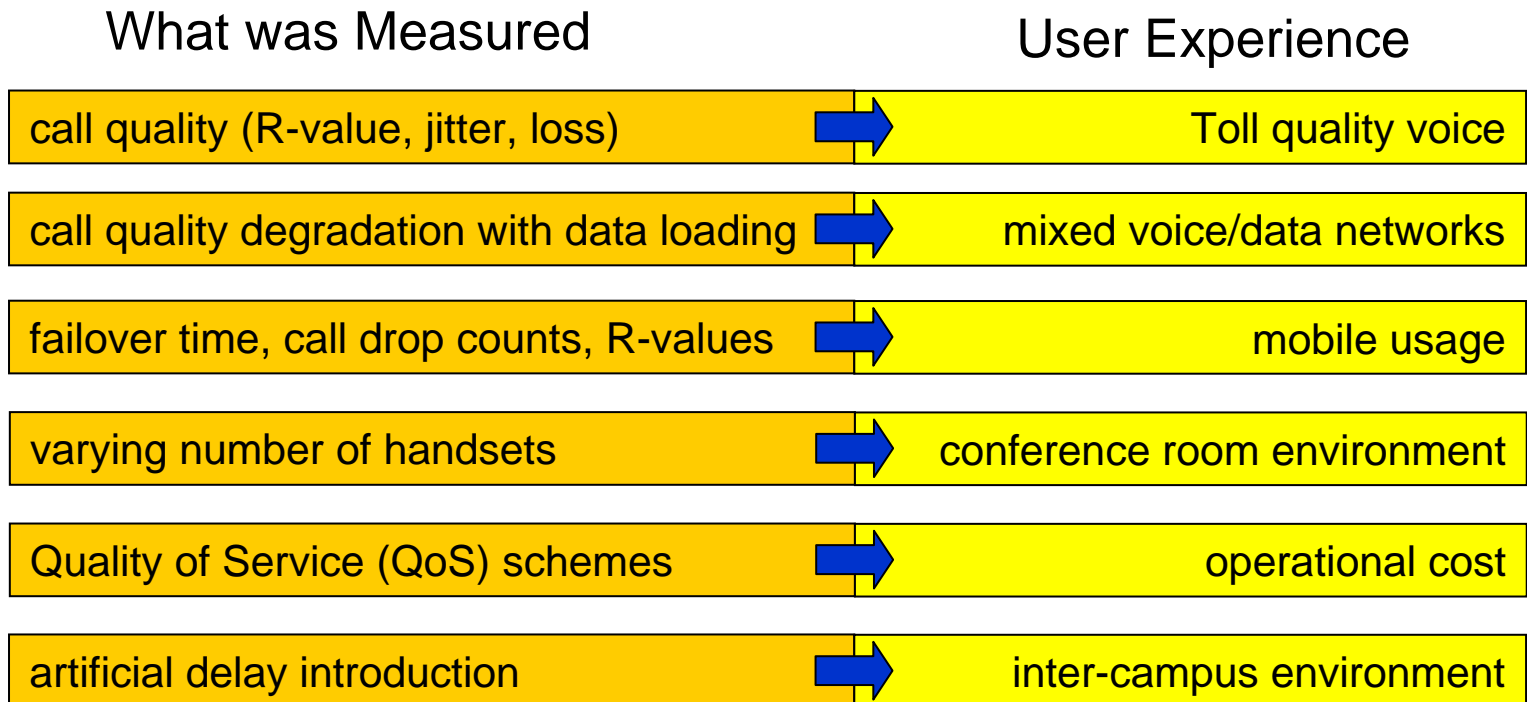
❖ LAN infrastructure introduces impairments into voice traffic

- Delay, jitter and packet loss
- Congestion resulting in collisions and dropouts
- Roaming delays
- Issues due to contention-based 802.11 MAC protocol

Measuring The Reality – recent test

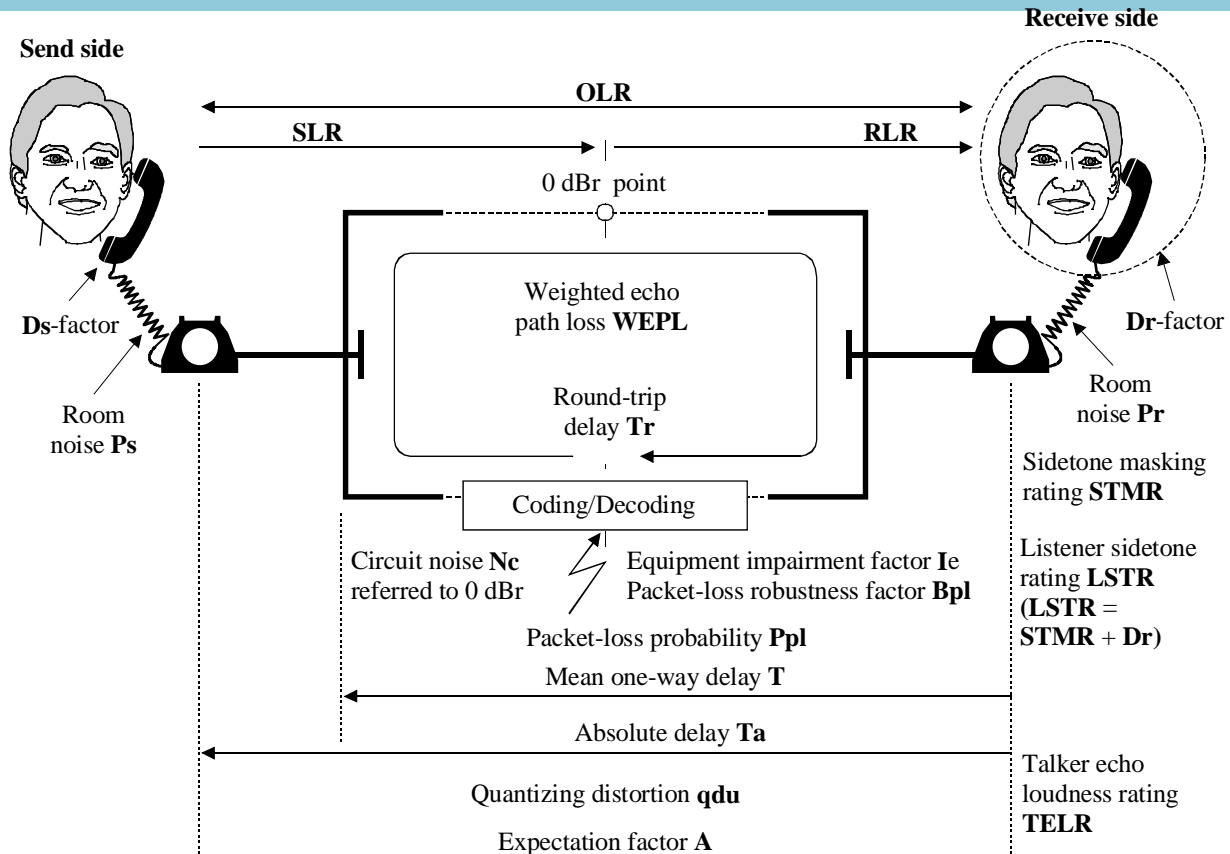
❖ The goal: characterize network performance

- Real network: VoIP phones, Access Points & switch
- Enterprise-class voice and data applications



Results: <http://www.nwfusion.com/reviews/2005/011005rev.html>

The ITU-T E-Model of Speech Quality



G.107_F01

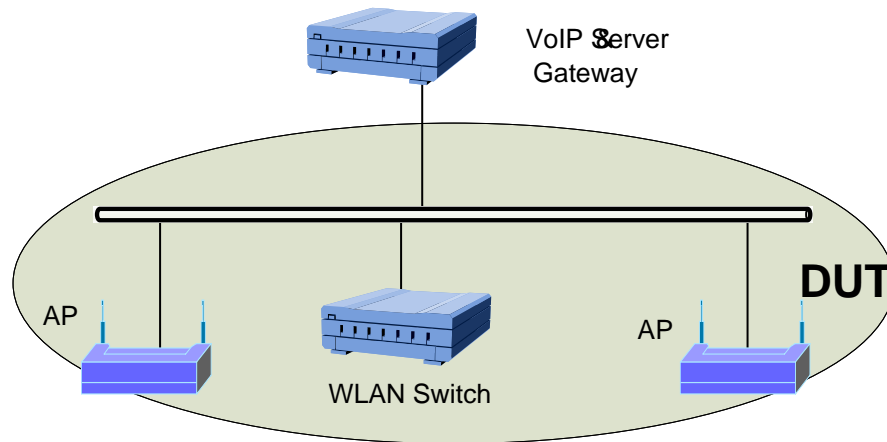
❖ ITU-T G.107 Objective speech quality metric

- Measures system characteristics, then calculates voice quality as 'R Value' (0-100)

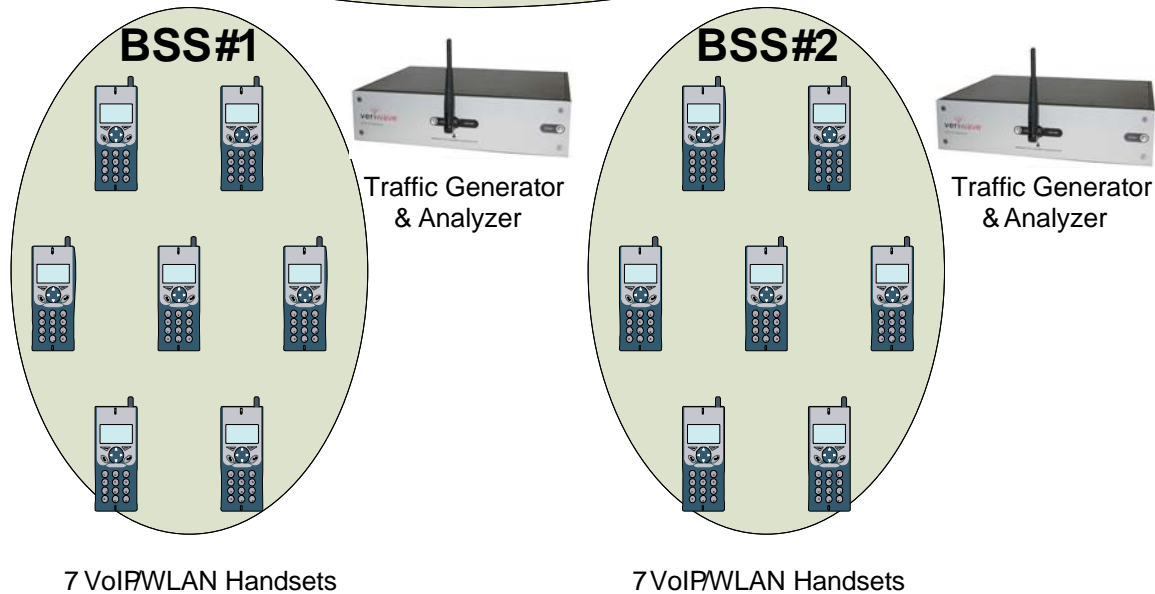
❖ Directly relates to user satisfaction metrics such as Mean Opinion Score

- R Value of 80 is approximately equivalent to toll-quality voice (MOS = 4.0)

The Measurement Setup



- ❖ **18 WLAN devices**
 - 14 VoIP handsets
 - 2 Enterprise APs
 - 2 Traffic Generator / Analyzer units
- ❖ **Wired network**
 - VoIP call server/gateway
 - WLAN switch/router
 - Other LAN devices



The Performance Challenge

❖ VoIP places significant load on enterprise WLAN equipment

- Without QoS enabled, very few calls could be supported
 - Sometimes no more than 4-5 calls per AP

scalability

- With QoS, more calls supported, but frequent call drops and poor voice quality scores measured in some cases

voice quality

- Injection of small amounts of data (1 Mb/s) caused precipitous R value reduction, dropped calls

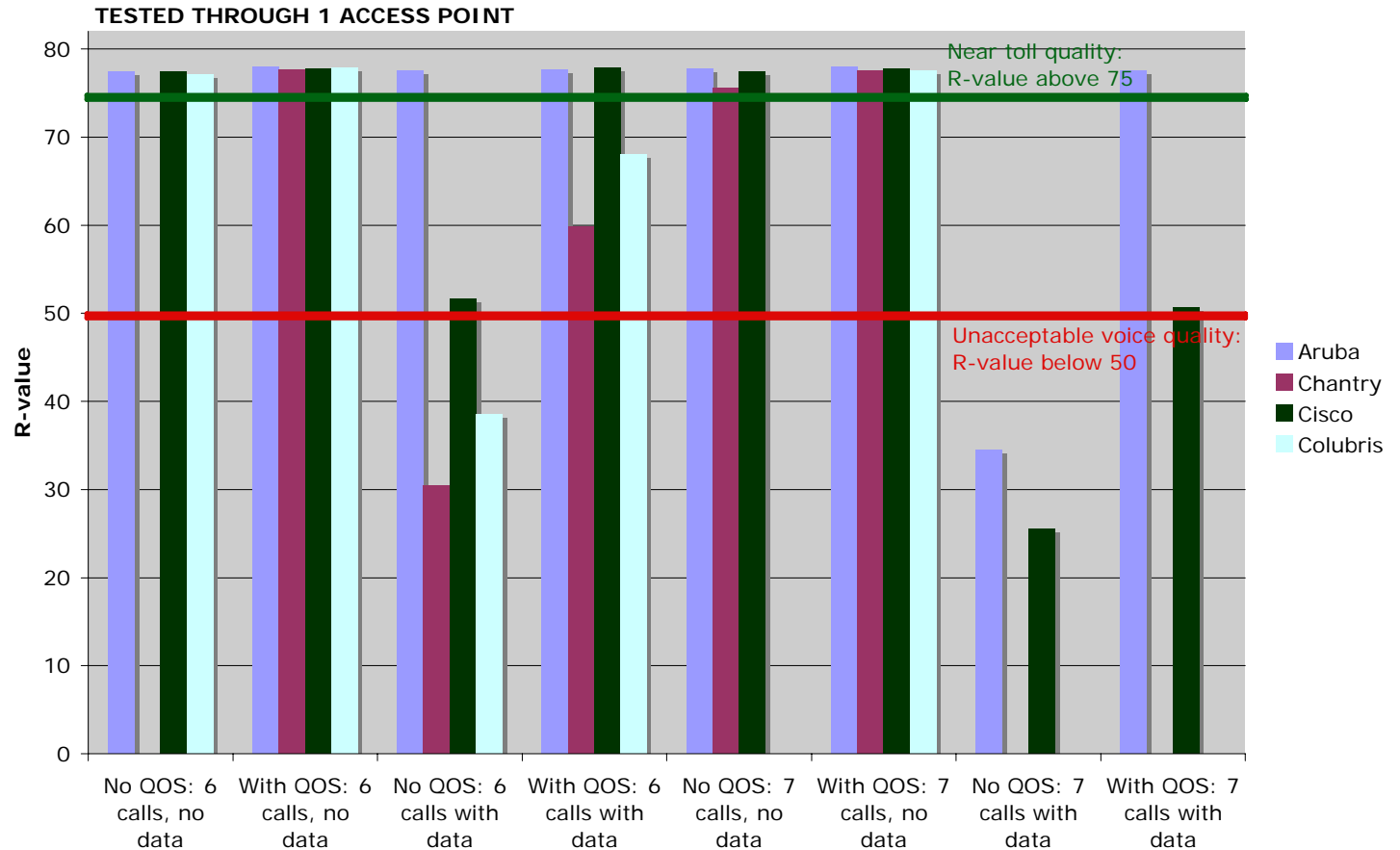
mixed networks

❖ High roaming times seen for failover from primary to backup AP

- On one particular enterprise WLAN switch:
 - Total time for 128 “golden” Layer 4 data clients to roam: 307 milliseconds
 - Average time for 14 VoIP handsets to roam: 4.324 seconds
 - **Worst-case handset roaming time >10 seconds!**
- Call outages and drops likely

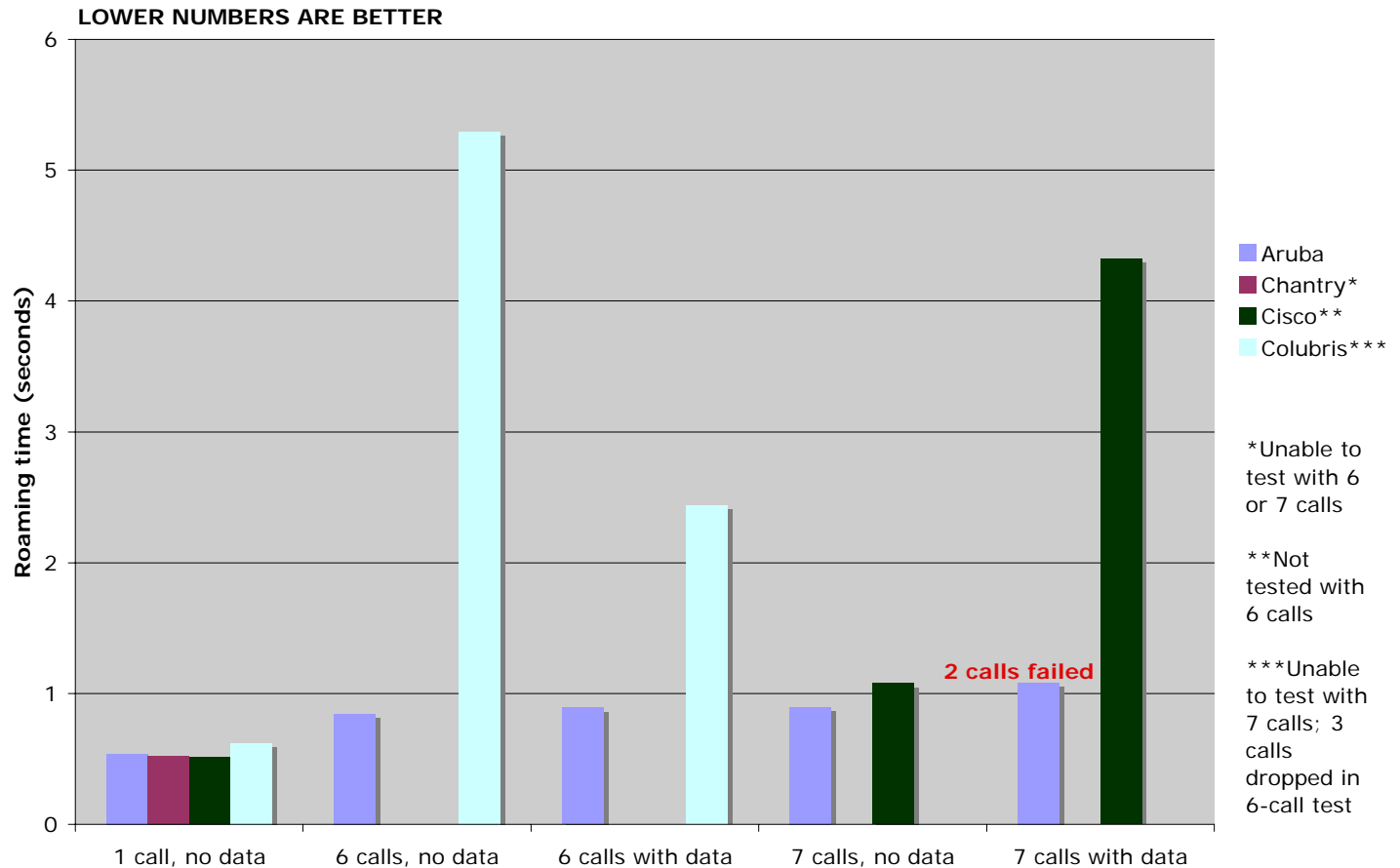
mobility

R Value Scores Measured



Source: David Newman, Network Test
 Published in Network World Fusion, Jan 2005

Roaming Times Measured



Source: David Newman, Network Test

Published in Network World Fusion, Jan 2005

Selecting For Success

❖ **WLAN Access Points & switches are key**

- Must support QoS
 - Preferential treatment of voice over data
 - Minimize jitter and packet loss for VoIP traffic
 - Efficient use of wireless medium
- Fast roaming support is also essential
 - Minimize call drops when users move
 - Avoid dropped calls or dead times when backups take over on equipment failure

❖ **Network infrastructure must be matched to handsets and VoIP gateways**

- Handsets and APs work together to provide service
- Roaming is a co-operative function of *both* handsets and APs

The Future

❖ **WLAN QoS protocols**

- 802.11e QoS over WiFi
- Protocol also assists in better power management for handsets and clients – longer battery life

❖ **Faster roaming support**

- 802.11r Fast Roaming protocols
- 802.11k Radio Resource Management assists handsets in locating and selecting APs during roaming

❖ **Better security**

- 802.11i / WPA2 WiFi security protocol
- 802.11i provides for *pre-authentication* to speed up roaming