Voice over Wireless LAN via IEEE 802.16 Wireless MAN and IEEE 802.11 Wireless Distribution System

張佑竹

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Outline

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Introduction

- *In this paper, we exam the capacity challenges in delivering voice traffic over WLANs which are connected to*
  - *IEEE 802.16 WMAN*
    - *This paper show that the capacity is limited by the WLAN bottleneck and this paper propose a multiplex-multicast (M-M) scheme [1] to double the capacity.*
  - *IEEE 802.11 WDS.*
    - *This paper show that the M-M scheme should also be adopted in WDS.*

Introduction

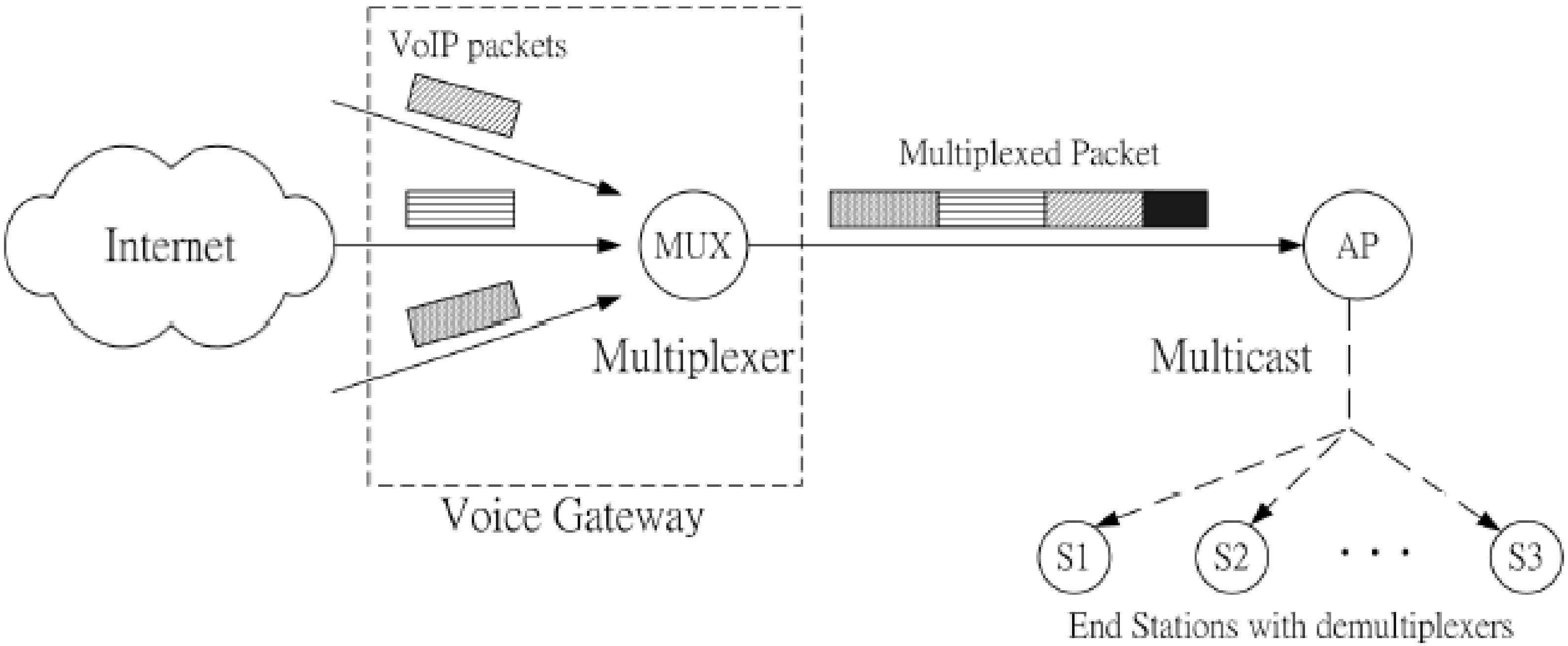
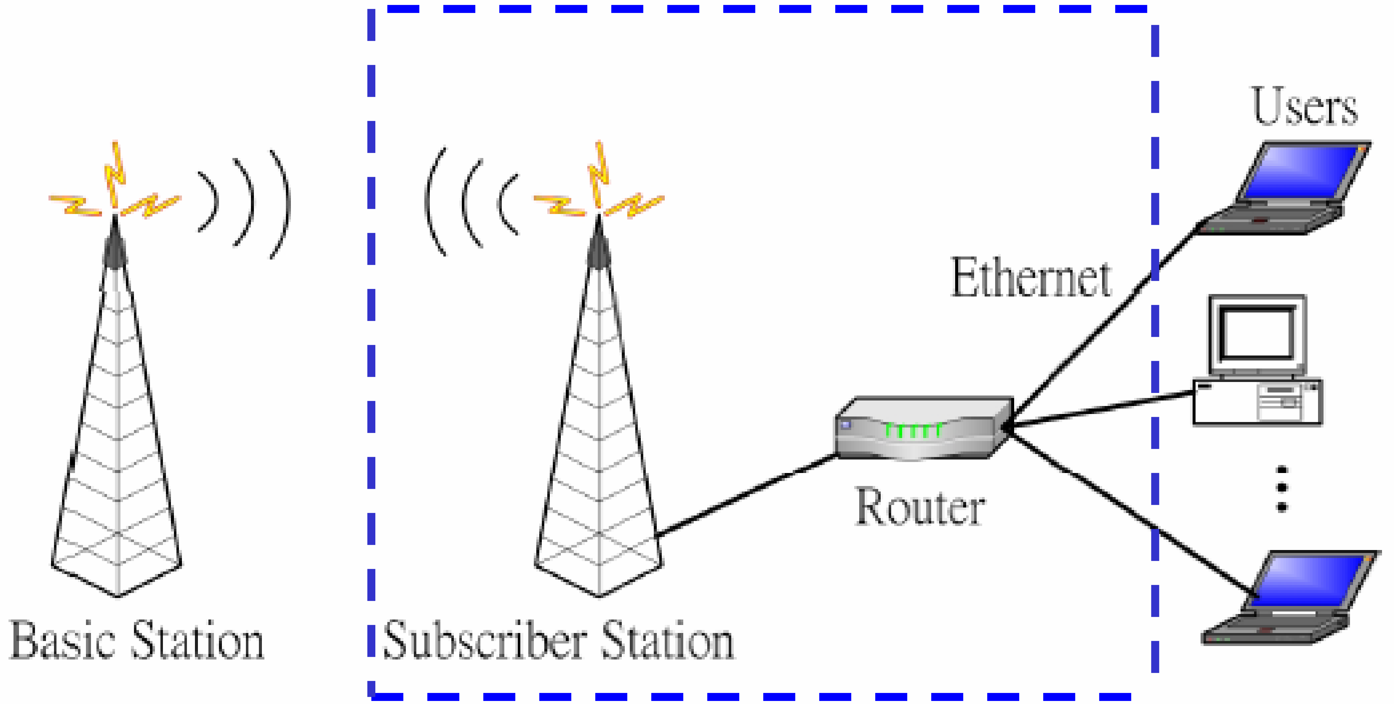


Figure 1. The M-M Scheme in Infrastructure BSS

Voice over Ethernet via IEEE 802.16 WMAN



A wired Ethernet network is connected to an IEEE 802.16 Wireless MAN (WMAN)

Voice over Ethernet via IEEE 802.16 WMAN

- The Base Station (BS) packs the incoming VoIP packets for several users into a downlink (DL) – burst and then transmits them to the Subscriber Station (SS) in a single DL-subframe as shown in Figure 3.
- The SS then extracts its packets and forwards them to the VoIP applications in the Ethernet.

Voice over Ethernet via IEEE 802.16 WMAN

- Similarly, the SS combines the upstream VoIP packets into an uplink (UL) – burst and transmits them to the BS in a single UL-subframe.
- The BS then extracts the original VoIP packets and forwards them to the Internet.

Voice over Ethernet via IEEE 802.16 WMAN

- The above process has similar functionality as the M-M scheme proposed by us in [1]. Both of them multiplex small packets into larger ones for transmissions so as to reduce the overheads induced by the MAC and PHY layers.

Voice over Ethernet via IEEE 802.16 WMAN

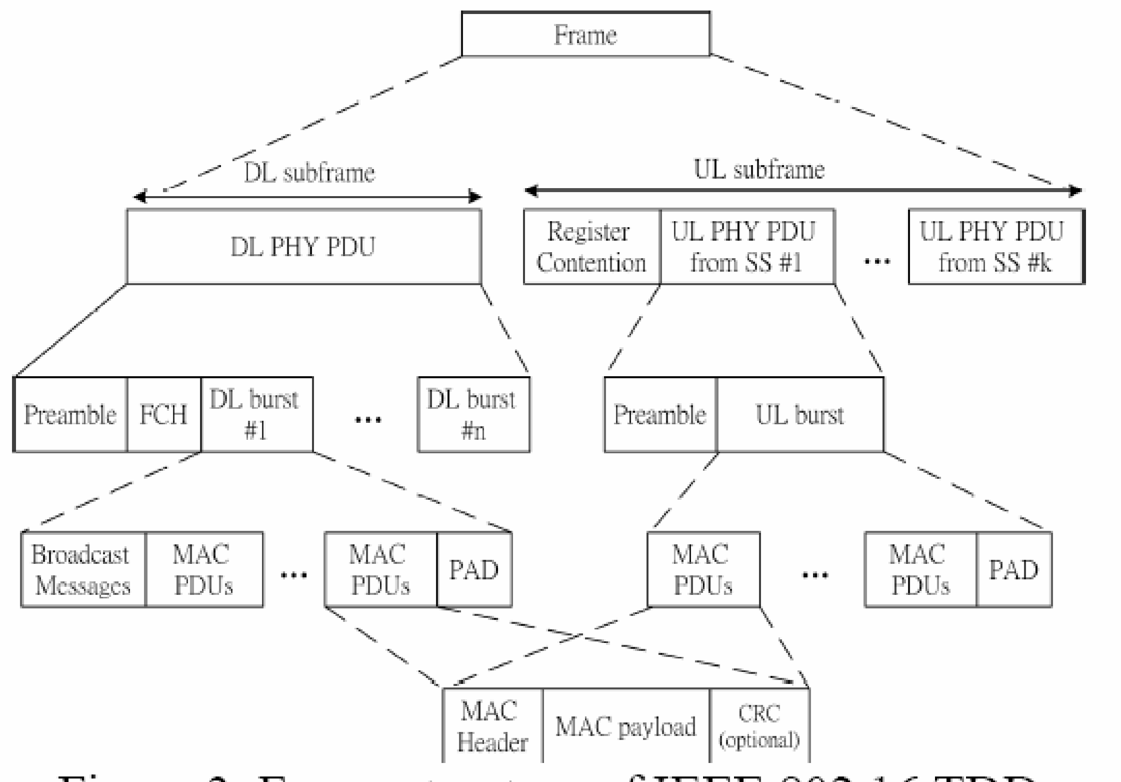


Figure 3. Frame structure of IEEE 802.16 TDD

Voice over Ethernet via IEEE 802.16 WMAN

$$T \approx 2 * P + B + RC + 2 \cdot C \cdot (V + MAC) \qquad (1)$$

$$C \approx 60$$

- T is the transmission time of a fixed-size frame
- P is the transmission time of the preambles
- B is the transmission time of broadcast messages(UL-MAP, DL-MAP,….)
- RC is the register contention time(BW-REQ, Initial Ranging)
- $MAC\ V +$ is the transmission time of a voice payload with MAC header

Voice over Ethernet via IEEE 802.16 WMAN

TABLE I. PARAMETER SETTINGS OF IEEE 802.16 TDD

Number of Subscriber Station	1
Preamble + FCH (P)	3us
Broadcast messages (B)	10us
Register Contention (RC)	1us
Fixed frame size (T)	1ms
Voice packet size (V)	7.2us (45bytes)
MAC Header (MAC)	0.96us (6bytes)
PHY rate	50Mbps
VoIP Session Capacity (C)	$\approx$ 60

The above equations are approximations as parameter settings may vary in different implementations and be modified in future IEEE 802.16 standards.

Voice over Ethernet via IEEE 802.16 WMAN

$$T \approx 2 * P + B + RC + 2 \cdot C_{MUX} \cdot V + MAC \qquad (2)$$

$$C_{MUX} \approx 68$$

- The voice session capacity only slightly increases from 60 to 68 after using the multiplex scheme.

Voice over WLAN via IEEE 802.16 WMAN-Long Range Extension

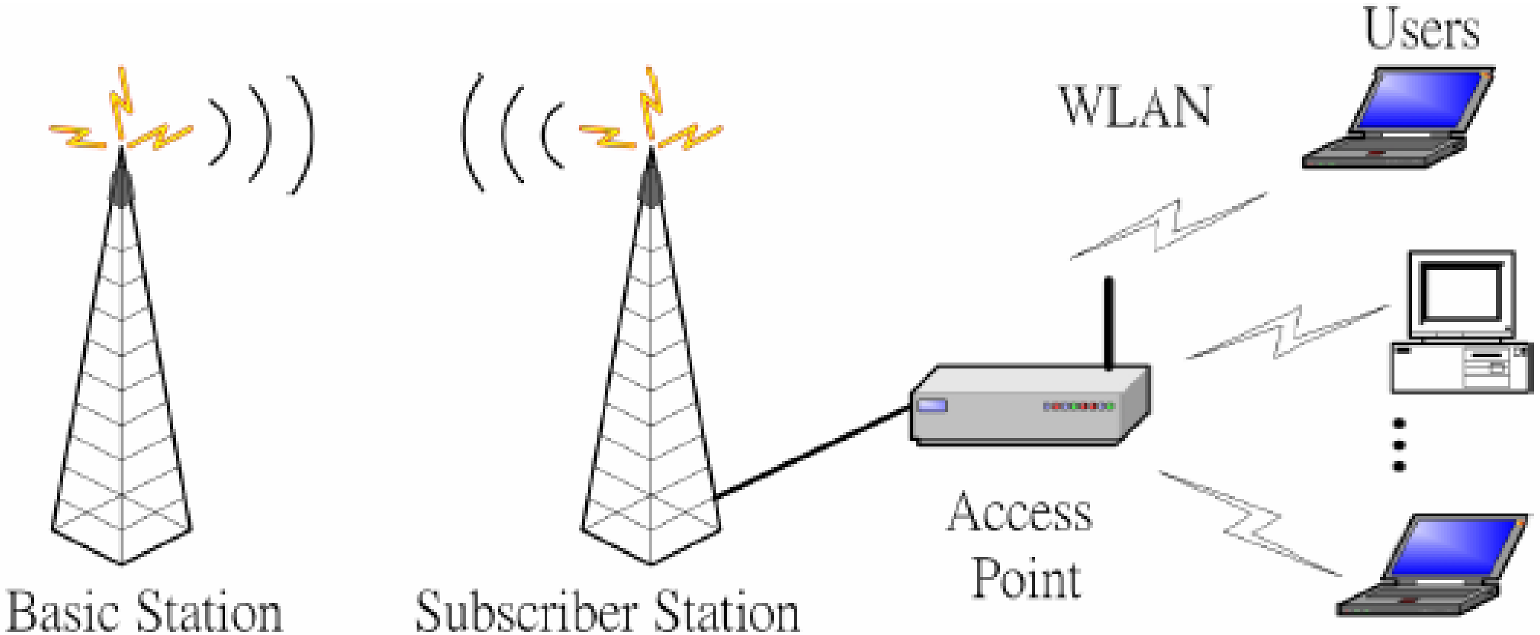


Figure 4. Conventional VoIP scheme in WLAN connected to WMAN

Voice over WLAN via IEEE 802.16 WMAN-Long Range Extension

- The transmission rate of WMAN is much faster than that of IEEE 802.11.
- An IEEE 802.11b WLAN can support only 12 voice sessions
- The 802.16 WMAN, can support 60 voice sessions as discussed in Section 2.
- Therefore, the VoIP capacity bottleneck is at the WLAN rather than the WMAN.

Voice over WLAN via IEEE 802.16 WMAN-Long Range Extension

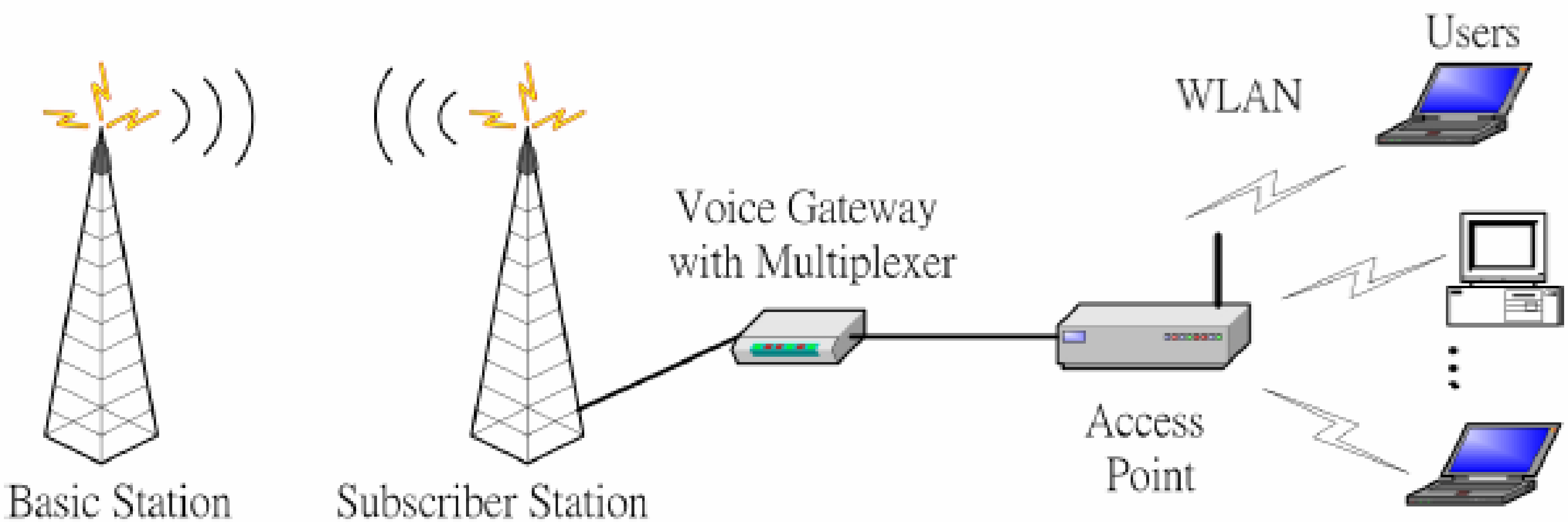


Figure 5. M-M scheme in WLAN connected to WMAN

Voice over WLAN via IEEE 802.16 WMAN-Long Range Extension

- To boost the capacity, we suggest using the M-M scheme proposed in [1] to install a multiplexer between the WMAN and WLAN as illustrated in Fig.5.
- This sufficiently increases the VoIP capacity of each WLAN from 12 to 22 sessions.

Voice over WLAN via IEEE 802.11 WDS-Short Range Extension

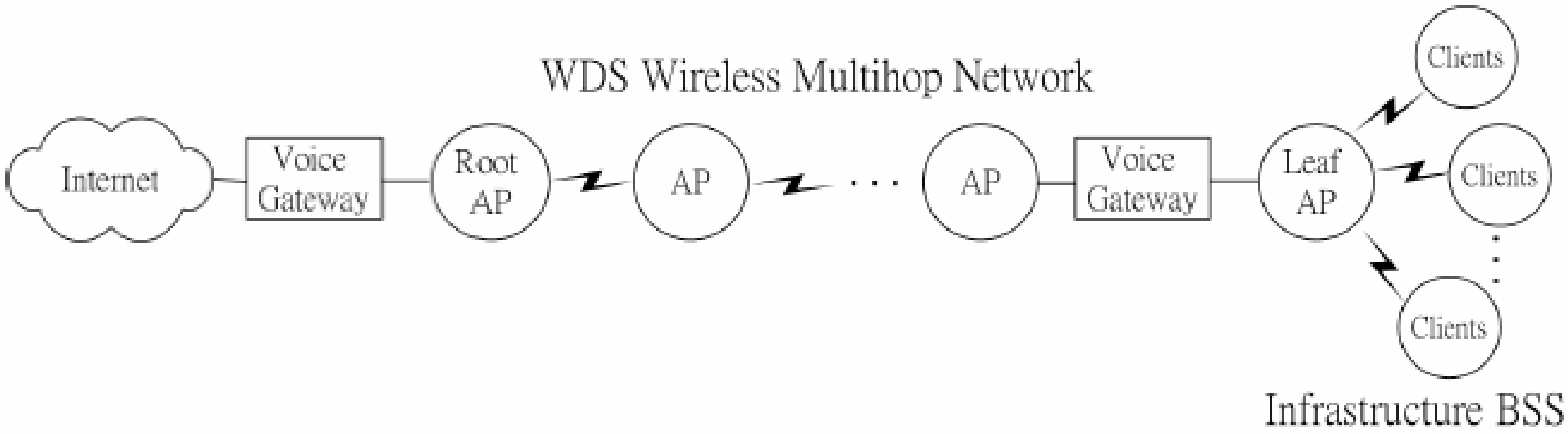


Figure 6. M-M Scheme in WDS

Voice over WLAN via IEEE 802.11 WDS-Short Range Extension

- WDS can be deployed to provide short range coverage extension while WMAN for long range. An advantage of WDS over WMAN is its lower initial costs.
- However, transmitting VoIP traffic over WDS to a WLAN in the straightforward way fails to fulfill the tight delay requirement, and severely limits the system capacity.

Voice over WLAN via IEEE 802.11 WDS-Short Range Extension

Figure 7. A 5-node multi-hop wireless network

Voice over WLAN via IEEE 802.11 WDS-Short Range Extension

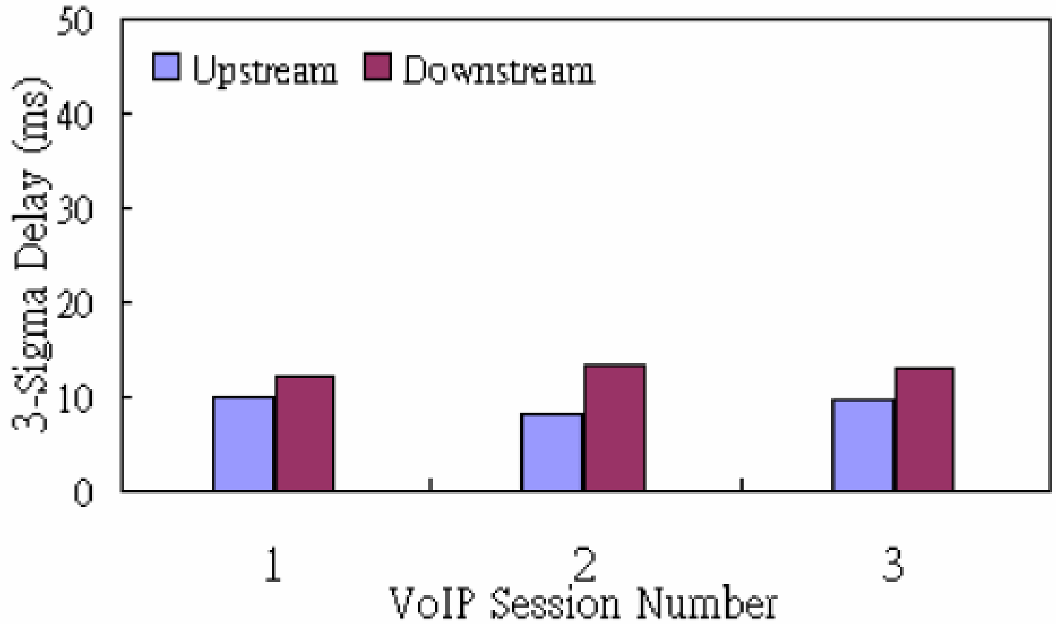


Figure 8. Three-sigma delays of three VoIP sessions in the 4-hop WDS

Voice over WLAN via IEEE 802.11 WDS-Short Range Extension

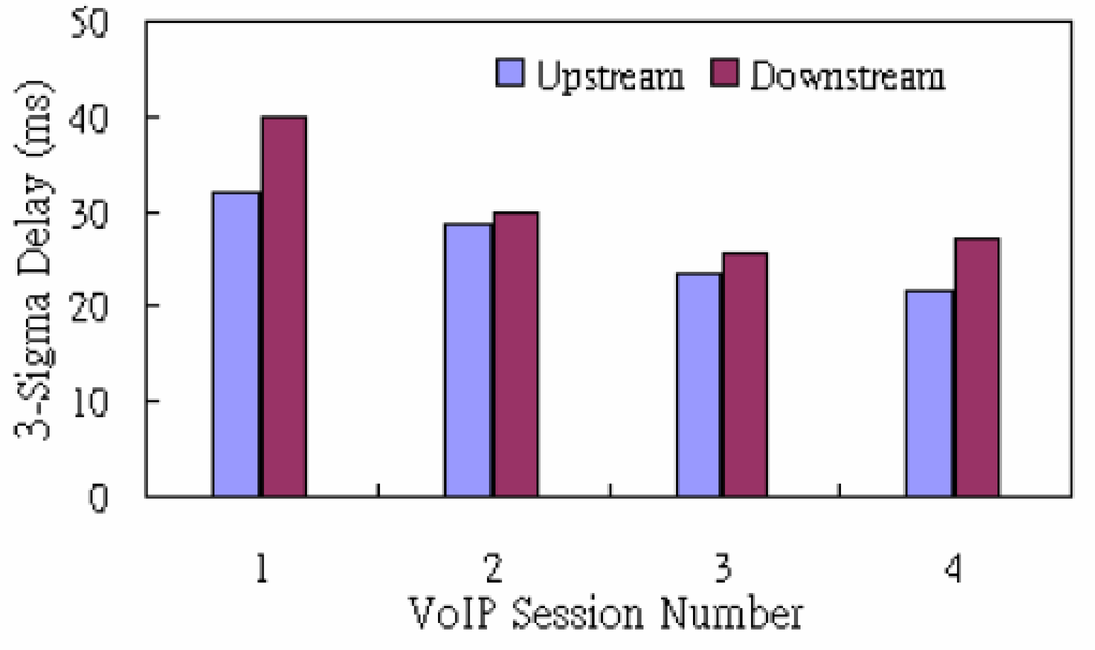


Figure 9. Three-sigma delays of four VoIP sessions in the 4-hop WDS

Voice over WLAN via IEEE 802.11 WDS-Short Range Extension

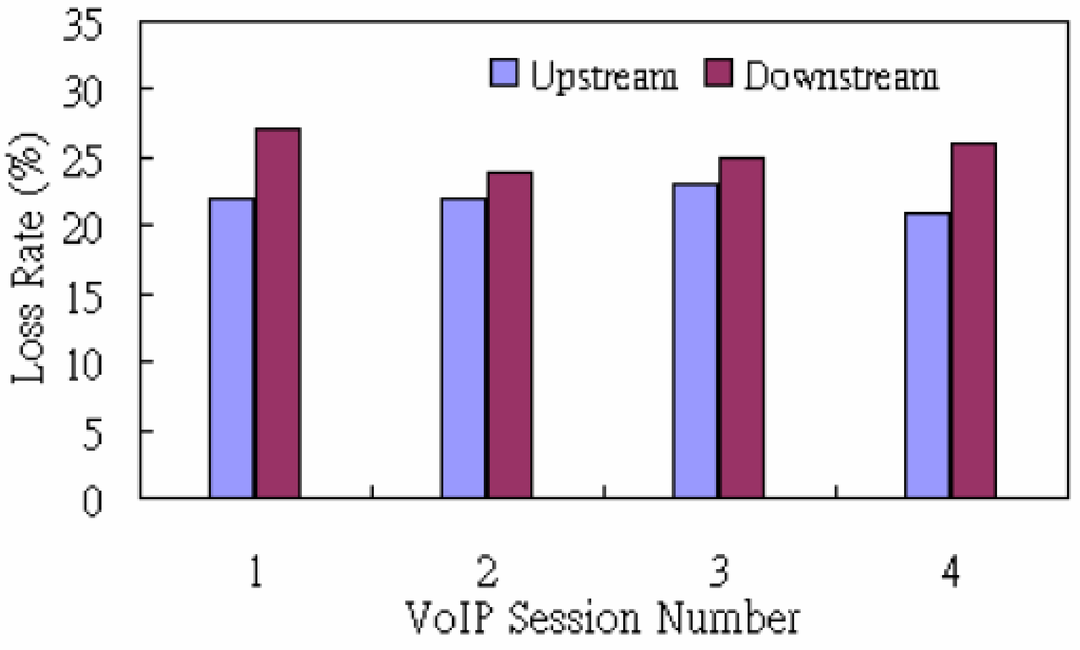


Figure 10. Average packet loss rates of four VoIP sessions in the 4-hop WDS

Voice over WLAN via IEEE 802.11 WDS-Short Range Extension

TABLE II. EXPERIMENTAL MEASUREMENTS FOR 4-HOP WDS WITH M-M SCHEME

	Upstream	Downstream
C (capacity)	22	
N (coverage)	4 hops	
M_{avg}	10 ms	
σ_{mux}	5.8 ms	
D_{avg}	1.34 ms	2.24 ms
σ_{delay}	0.65 ms	0.95 ms
S	30.70 ms	32.50 ms
P_{loss}	0.0067%	0.033 %

Voice over WLAN via IEEE 802.11 WDS-Short Range Extension

TABLE III. EXPERIMENTAL MEASUREMENTS FOR 4-HOP WDS WITH CONVENTIONAL VOIP SCHEME

	Upstream	Downstream
C (capacity)	22	
N (coverage)	4 hops	
D_{avg}	314.74 ms	544.89 ms
σ_{delay}	113.71 ms	141.57 ms
S	655.87 ms	969.60 ms
P_{loss}	97%	99%

Voice over WLAN via IEEE 802.11 WDS-Short Range Extension

TABLE IV. EXPERIMENTAL MEASUREMENTS FOR 1-HOP WDS WITH CONVENTIONAL VOIP SCHEME

	Upstream	Downstream
C (capacity)	22	
N (coverage)	1 hops	
D_{avg}	6.48 ms	6.91 ms
σ_{delay}	5.41 ms	5.85 ms
S	22.70 ms	24.46 ms
P_{loss}	41%	43%

Voice over WLAN via IEEE 802.16 and IEEE 802.11 WDS

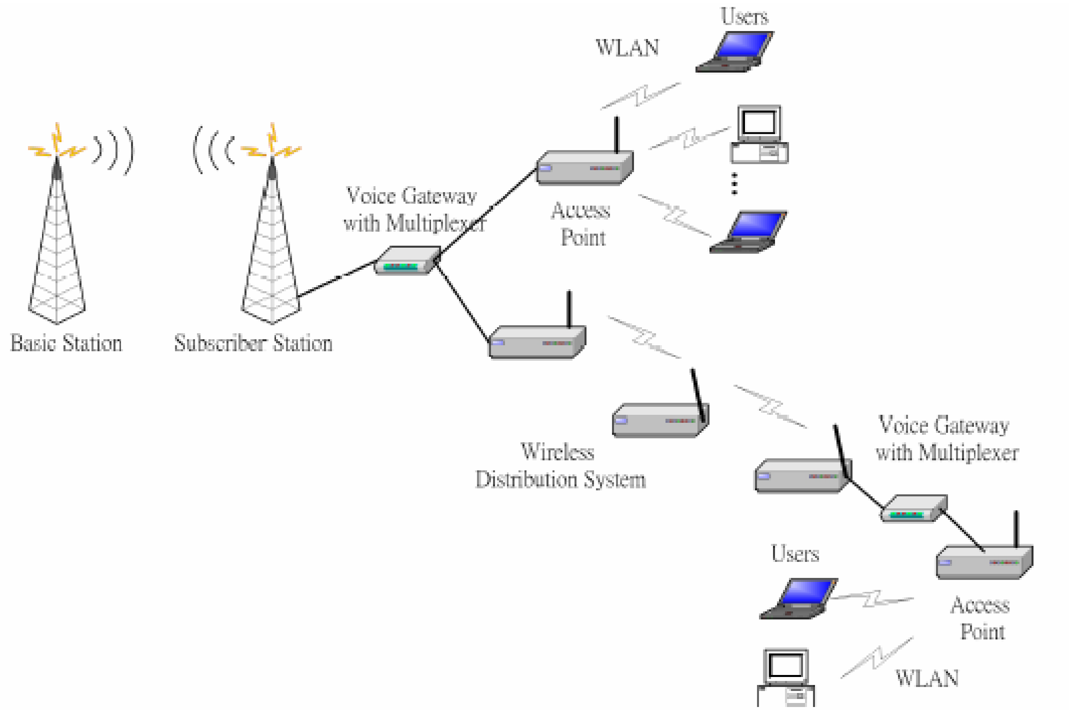


Figure 11. M-M scheme in WLAN connected to WDS and/or WMAN

Conclusion

- W-TCP
- Adaptive Frame Size
- TCP Header Compress
- Handoff Procedure ???

Conclusion

- 802.16e will be not compatible with 802.16-2004
- Application
  - 802.16-2004
    - Home Gateway.
  - 802.16e
    - Notebook, PDA.

References

- [1] W. Wang, S. C. Liew, and V. O. K. Li, “Solutions to Performance Problems in VoIP over 802.11 Wireless LAN,” *IEEE Trans. on Vehicular Technology,* Jan 2005.
- [2] P. C. Ng, S. C. Liew, and W. Wang, “Voice over WLAN via Wireless Distribution System,” *IEEE Vehicular Technology Conference*, Los Angeles, U.S.A., Sept. 2004.
- [3] H. P. Sze, S. C. Liew, J.Y.B. Lee, D.C.S. Yip, “A multiplexing scheme for H.323 voice-over-IP applications”, *IEEE J. Select. Area Commun*, Vol. 20, pp. 1360-1368, Sept. 2002.
- [4] S. Garg, M. Kappes, “On the Throughput of 802.11b Networks for VoIP”, *Technical Report ALR-2002-012, Avaya Labs*, 2002. http://www.research.avayalabs.com/techreportY.html
- [5] “IEEE Standard for Local and Metropolitan Area Networks”, (*IEEE Std. 802.16-2004*)
- [6] “Understanding Wi-Fi and WiMAX as Metro-Access Solutions”, *Intel White Paper*, 2004
- [7] C. Eklund, R. Marks, and K. Stanwood, “IEEE Standard 802.16: A Technical Overview of Wireless MAN Air
- Interface for Broadband Wireless Access”, *IEEE Communication Magazine*, June 2002.
- [8] D. Cho, J. Song, M. Kim, and K. Han, “Performance Analysis of the IEEE 802.16 Wireless Metropolitan Area
- Network”, *IEEE DFMA’05*, Feb. 2005.
- [9] S. Bansal, R. Shorey, A. A. Kherani, “Performance of TCP and UDP Protocols in Multi-Hop Multi-Rate Wireless
- Networks”, *IEEE WCNC’04*, April 2004.
- [10] G. Nair, J. Chou et al., “IEEE 802.16 Medium Access Control and Service Provisioning”, *Intel Technology Journal*, Vol. 8, Issue 3, Aug. 2004.
- [11] “HostAP” driver, http://hostap.epitest.fi/
- [12] G. Anastasi, E. Borgia et al., “Wi-Fi in Ad Hoc Mode: A Measurement Study”, *IEEE PERCOM’04*, March 2004.

802.11 and 802.16 QoS Comparison

- **802.11: contention-based MAC (CSMA)**
- **No QoS support today**
  - **802.11e working to standardize**
  - **a single connection.**
  - **eight user priorities**
- **Support multiple connections that are characterized with the complete set of QoS parameters.**
- **802.16: grant request MAC**
- **the scheduler in the BS has complete control of the wireless media access among all SS's.**