Solutions to Performance Problems in VoIP Over a 802.11 Wireless LAN

Wei Wang, Soung C. Liew, and VOK Li,
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Outline

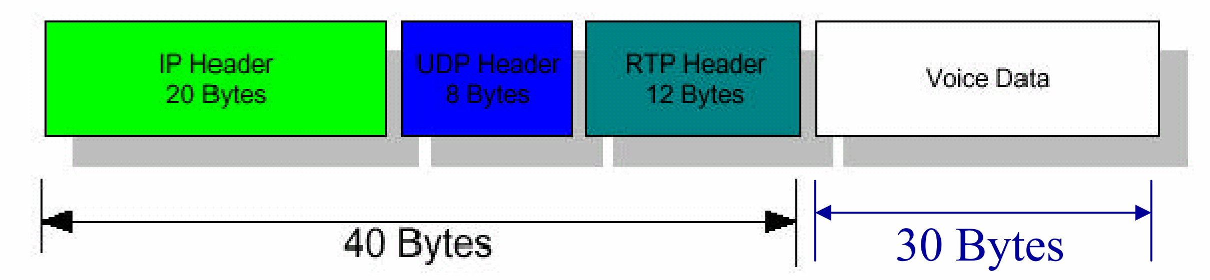
- Introduction
- VoIP M-M scheme
- Capacity analysis
- Delay performance
- VoIP coexisting with TCP interference traffic
- Conclusion
- Discussion

Introduction

- VoIP over WLAN :Two major technical problems need to be solved
  - **Capacity for voice can be quite low in WLAN.**
    - the added packet-header overheads as the short VoIP packets traverse the various layers of the standard protocol stack.
    - the inefficiency inherent in the WLAN medium-access control (MAC) protocol
  - **VoIP traffic and data traffic (from traditional applications such as Web, e-mail, etc.) can interfere with each other and bring down VoIP performance.**

Introduction

- A typical VoIP packet at the IP layer consists of 40-B IP/UDP/RTP headers and a payload ranging from 10 to 30 B, depending on the codec used.



40 x 8 /11 = 29 us
at 11 M

30 x 8 /11 = 22 us
at 11 M with a 30-B payload

Introduction

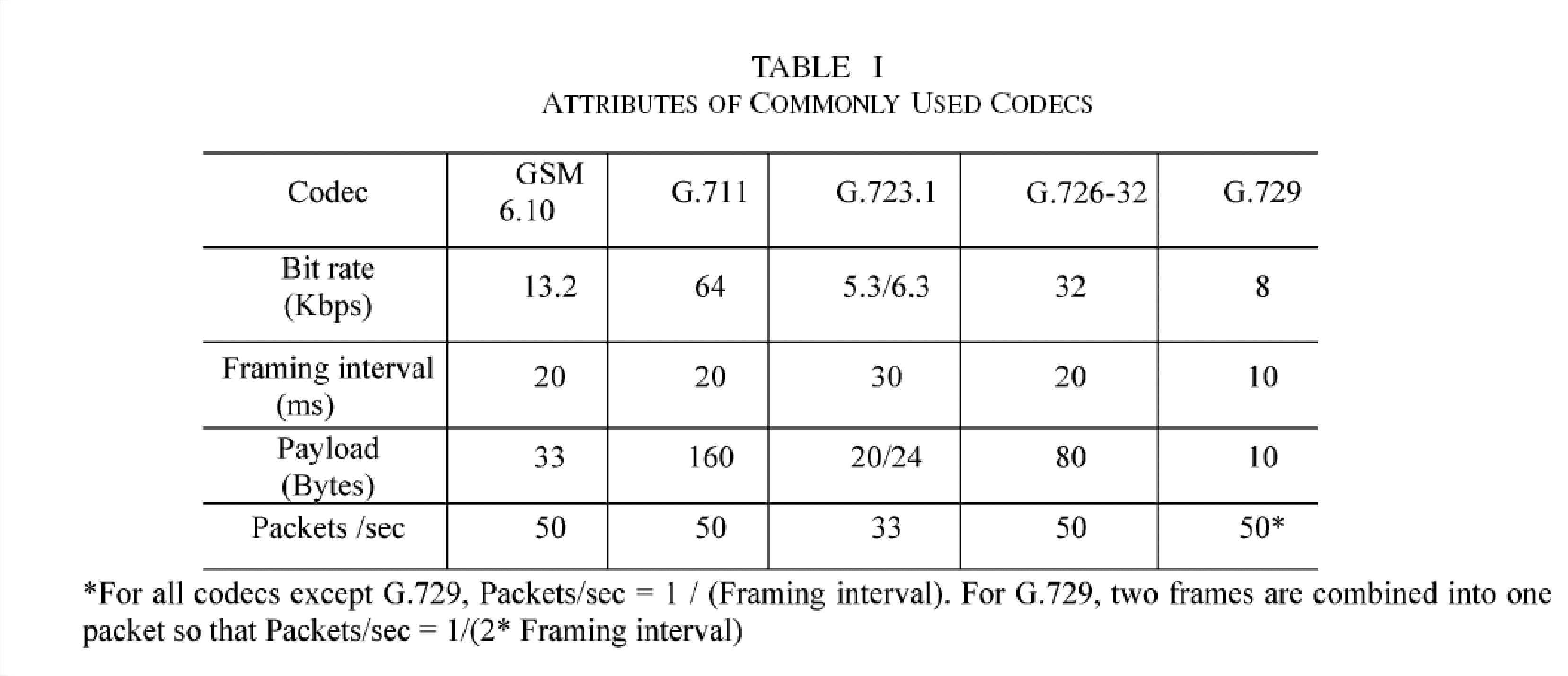


TABLE I
ATTRIBUTES OF COMMONLY USED CODECS

Codec	GSM 6.10	G.711	G.723.1	G.726-32	G.729
Bit rate (Kbps)	13.2	64	5.3/6.3	32	8
Framing interval (ms)	20	20	30	20	10
Payload (Bytes)	33	160	20/24	80	10
Packets /sec	50	50	33	50	50*

For all codecs except G.729, Packets/sec = 1 / (Framing interval). For G.729, two frames are combined into one packet so that Packets/sec = 1/(2 Framing interval)

Introduction

- The 802.11 MAC/PHY layers have additional overhead of more than 800 us.
  - physical preamble, MAC header, MAC backoff time, MAC acknowledgment (ACK), and intertransmission times of packets and acknowledgment(IFS).
- As a result, **the overall efficiency drops to less than 3%.**

Introduction

- This paper propose a voice multiplex-multicast (M-M) scheme for overcoming the large overhead effect of VoIP over WLAN.
    - not require modifications on the 802.11 hardware and firmware at the client stations.

Introduction

- In an enterprise WLAN or public WLAN hotspot, supporting VoIP becomes even more complicated, since the WLAN needs to simultaneously support other applications besides VoIP.
  - It will cause unacceptably large increases in the delay and packet-loss rate of VoIP traffic.

Introduction

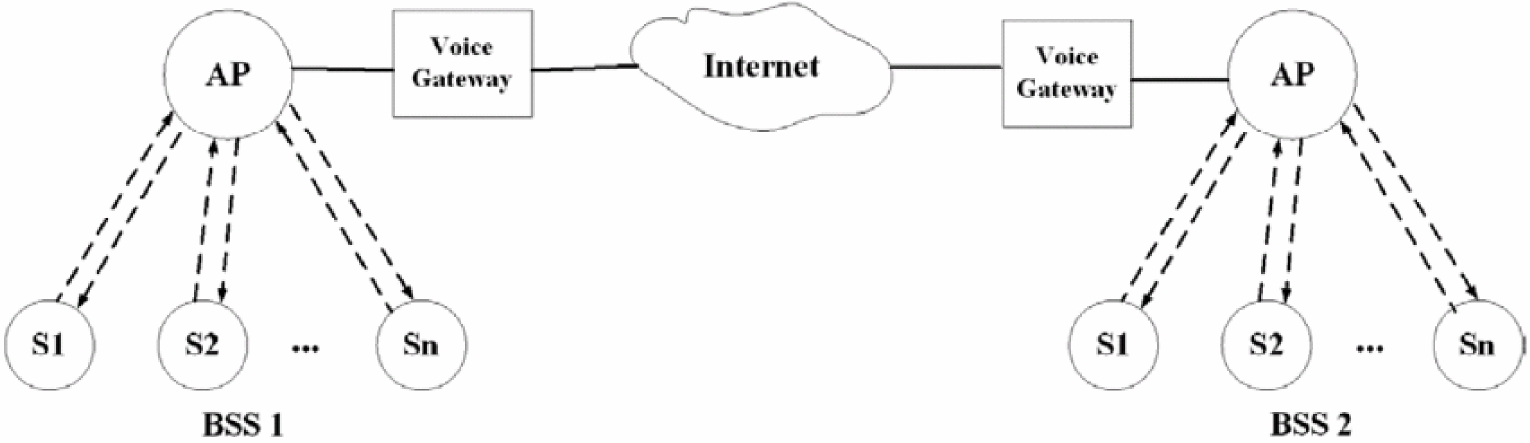
- Two complementary schemes proposed for solving the performance problem when there is coexisting TCP traffic in the WLAN.
  - PQ(Priority Queuing)
  - MMP(MAC-layer multicast priority)

The solutions only require some minor modifications at the AP.

VoIP M-M scheme

System Architecture

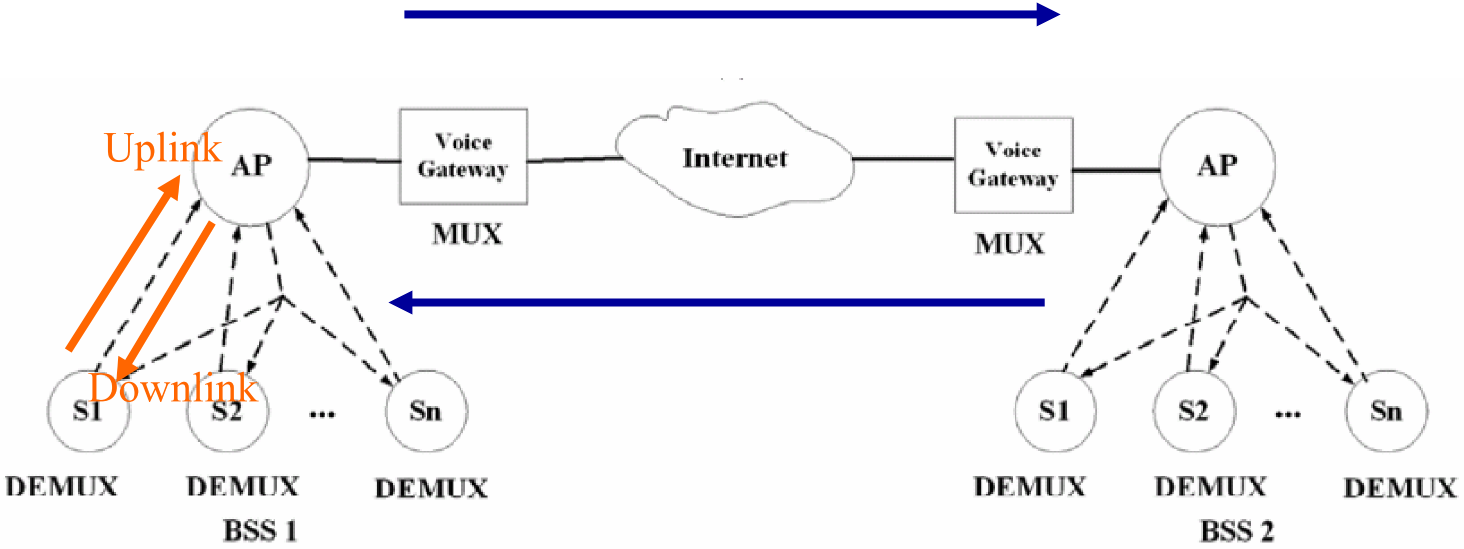
- This paper focuses on infrastructure BSSs. We assume that all voice streams are between stations in different BSSs, since users seldom call their neighbors in the same BSS.



VoIP M-M scheme

System Architecture

- voice multiplexer resides in the voice gateway.



VoIP M-M scheme

Packet Multiplexing and Multicasting

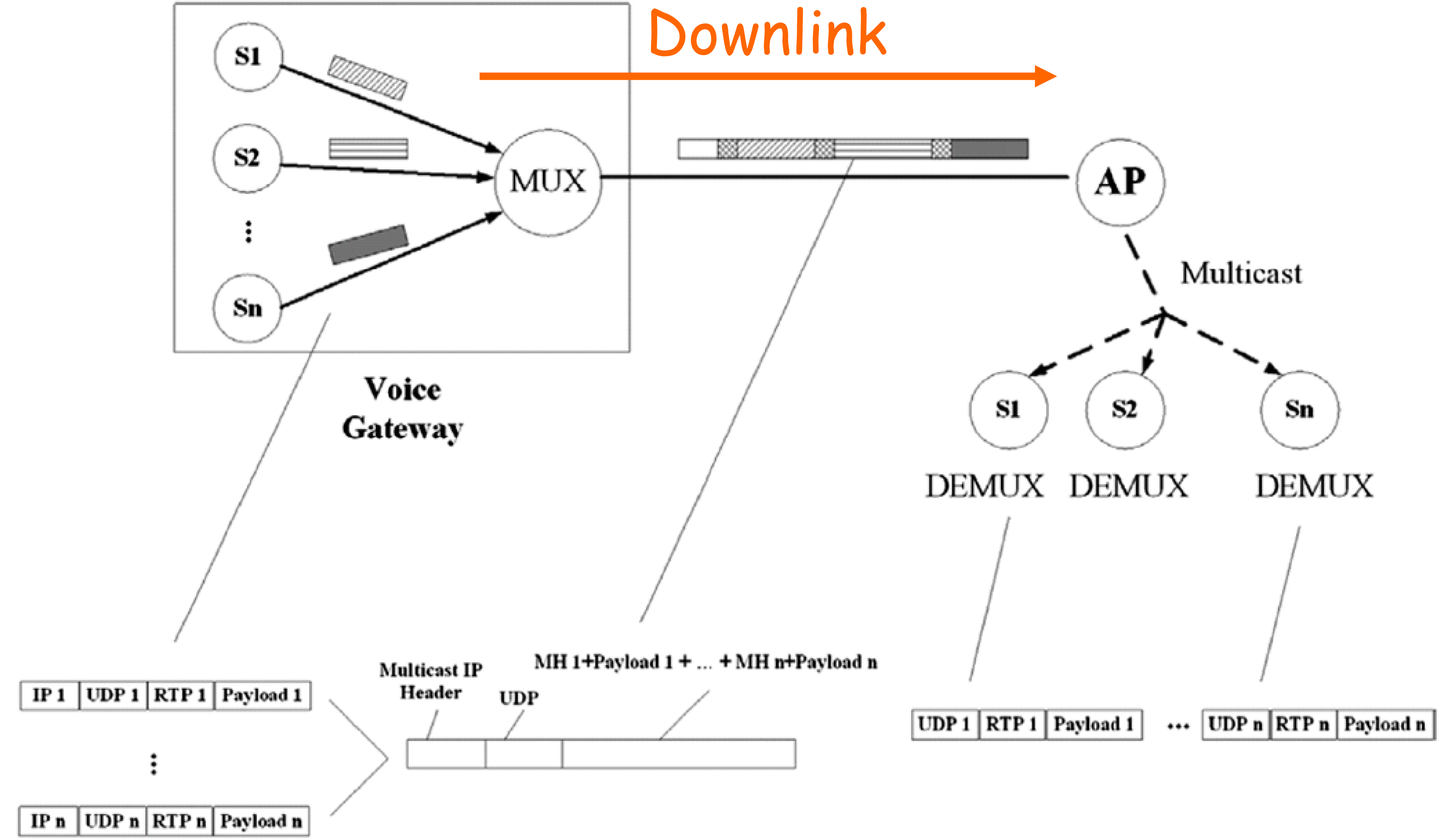


Fig. 3. MUX/DEMUX procedure.

VoIP M-M scheme

Packet Multiplexing and Multicasting

- The main idea of the packet M-M scheme is to combine the data from several downlink streams into a single larger packet.
  - In this way, the overheads of multiple VoIP packets can be reduced to the overhead of one packet.
  - Then we use multicast to transmit this multiplexed packet so that all the stations can receive it by a single transmission.

VoIP M-M scheme

Packet Multiplexing and Multicasting

- All the stations will use the normal unicasting to transmit uplink streams.
- We see that this scheme can reduce the number of VoIP streams in one BSS from 2n to n+1, where n is the number of VoIP sessions. (uplink n+ downlink n = 2n, M-M uplink n + downlink 1)

VoIP M-M scheme

Packet Multiplexing and Multicasting

- The MUX sends out a multiplexed packet every T ms, which is equal to or shorter than the VoIP interpacket interval.
- Larger values of T can improve bandwidth efficiency, since more packets can be multiplexed, but the delay incurred will also be larger.
  - the tradeoff between bandwidth efficiency and delay

VoIP M-M scheme

Packet Multiplexing and Multicasting

- security
- power-saving mode

VoIP M-M scheme

Header Compression

- With this Header Compression scheme the RTP+UDP+IP header can be replaced with a 2-B miniheader(MH) for most voice packets.

H. P. Sze, S. C. Liew, J. Y. B. Lee, and D. C. S. Yip, "A multiplexing scheme for H.32 voice-over-IP applications," *IEEE J. Sel. Areas Commun.*, vol. 20, no. 9, pp. 1360–13 Sep. 2002.

Capacity Analysis

VoIP Capacity Analysis for 802.11b

- Let n be the maximum number of sessions that can be supported.
- The transmission times for downlink and uplink packets are T_{down} and T_{up}, respectively.

Capacity Analysis

VoIP Capacity Analysis for 802.11b

- Let T_{avg} be the average time between the transmissions of two consecutive packets in a WLAN.
  - That is, in 1 s, there are totally $1/T_{avg}$ packets transmitted by the AP and all the stations.

$$1/T_{\text{avg}} = \text{number of streams} * \text{number of packets} \\ \text{sent by one stream in 1 s.} \qquad (1)$$

Capacity Analysis

VoIP Capacity Analysis for 802.11b

- Capacity of Ordinary VoIP Over WLAN:
  - For a VoIP packet, the header overhead OHhdr consists of the headers of RTP, UDP, IP, and 802.11 MAC layer

$$\mathrm{OH}_{\mathrm{hdr}} = H_{\mathrm{RTP}} + H_{\mathrm{UDP}} + H_{\mathrm{IP}} + H_{\mathrm{MAC}}. \tag{2}$$

$(H_{\mathrm{RTP}} + H_{\mathrm{UDP}} + H_{\mathrm{IP}} = 40\mathrm{B},\ H_{\mathrm{MAC}} = 24\mathrm{B})$

Capacity Analysis

VoIP Capacity Analysis for 802.11b

- At the MAC layer, the overhead incurred at the sender is

$$\mathrm{OH}_{\mathrm{sender}} = \mathrm{DIFS} + \mathrm{averageCW} + \mathrm{PHY}. \qquad (3)$$

(DIFS = 50us, averageCW = 20us x (32-1)/2, PHY = 192us)

- If it is the unicast packet, the overhead incurred at the receiver is

$$\mathrm{OH}_{\mathrm{receiver}} = \mathrm{SIFS} + \mathrm{ACK} \qquad (4)$$

(SIFS = 10us, ACK = 248us)

Capacity Analysis

VoIP Capacity Analysis for 802.11b

- Therefore, we have

$$T_{\text{down}} = T_{\text{up}} = (\text{Payload} + \text{OH}_{\text{hdr}}) * 8/\text{dataRate} + \text{OH}_{\text{sender}} + \text{OH}_{\text{receiver}}. \quad (5)$$

Capacity Analysis

VoIP Capacity Analysis for 802.11b

- In the ordinary VoIP case, we have n downlink and n uplink unicast streams. On average, for every downlink packet,there is a corresponding uplink packet. Therefore

$$T_{\text{avg}} = (T_{\text{down}} + T_{\text{up}})/2. \qquad (6)$$

From (1), we have

$$1/T_{\text{avg}} = 2n^* N_p \qquad (7)$$

where Np is the number of packets sent by one stream per secon

Capacity Analysis

VoIP Capacity Analysis for 802.11b

- For 802.11b, The data Rate is 11 Mb/s. Solving (7), we get 11.2(when GSM 6.10 is used) .
- We see that 802.11b WLAN can only support around 11 VoIP sessions from the analysis.

Capacity Analysis

VoIP Capacity Analysis for 802.11b

- Capacity of the M-M Scheme Over WLAN:
  - In this case, the RTP, UDP, and IP header of each un-multiplexed packet is compressed to **2 B**.
  - n packets are aggregated into one packet and they share the same header overhead, which includes UDP, IP, and MAC headers of the multiplexed packet.

Capacity Analysis

VoIP Capacity Analysis for 802.11b

- There is no RTP header in the multiplexed packet.
- In addition, since the multiplexed packet is sent using multicast, it does not have $\text{OH}_{\text{receiver}}$

$$T_{\text{down}} = [(\text{Payload} + 2)^{*} n + H_{\text{UDP}} + H_{\text{IP}} + H_{\text{MAC}}] \\ {*}8/\text{dataRate} + \text{OH}_{\text{sender}}. \quad (8)$$

Capacity Analysis

VoIP Capacity Analysis for 802.11b

- on average, for one downlink packet, there are totally n corresponding uplink packets. We have

$$T_{\text{avg}} = (T_{\text{down}} + n * T_{\text{up}})/(n+1) \tag{9}$$

- where T_{up} is the same as (5). Solving (8) and (9) with

$$1/T_{\text{avg}} = (n+1)^{*} N_p \tag{10}$$

- we get n = 21.2.

Capacity Analysis

VoIP Capacity Analysis for 802.11b

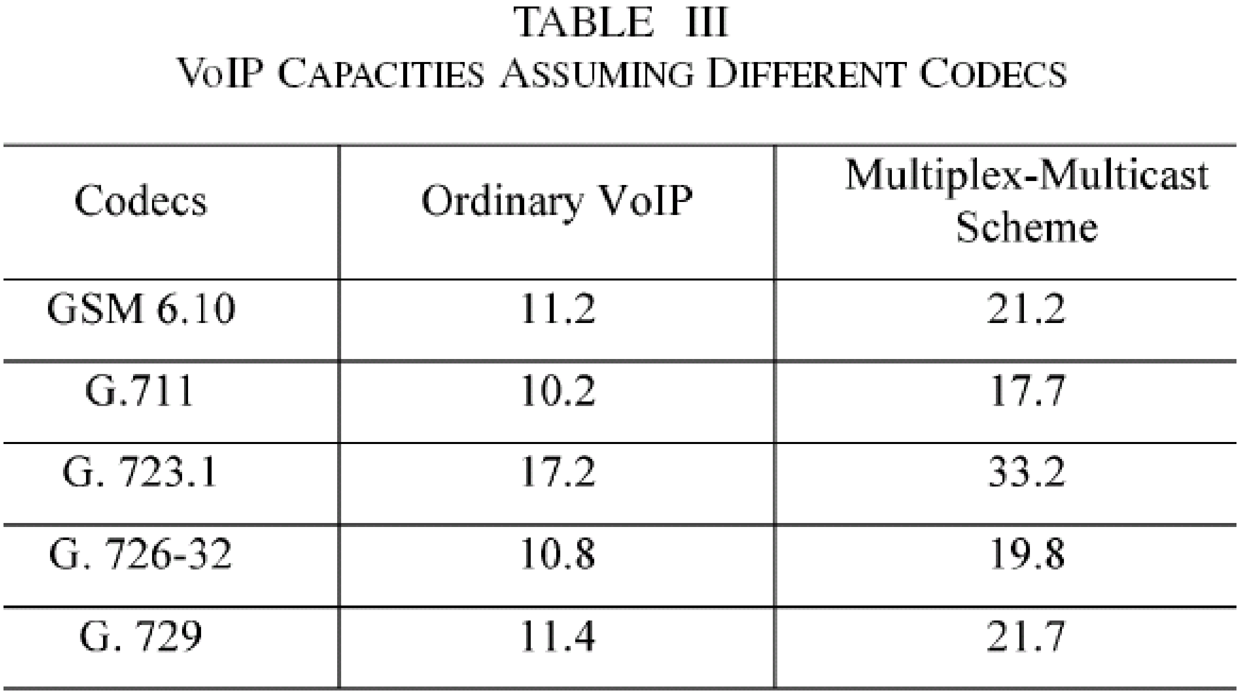


TABLE III

VoIP CAPACITIES ASSUMING DIFFERENT CODECS

Codecs	Ordinary VoIP	Multiplex-Multicast Scheme
GSM 6.10	11.2	21.2
G.711	10.2	17.7
G. 723.1	17.2	33.2
G. 726-32	10.8	19.8
G. 729	11.4	21.7

Capacity Analysis

VoIP Capacity Analysis for 802.11a and 802.11g

- 802.11a
  - uses the same MAC protocol as 802.11b
  - but with a different set of parameters.
  - the PHY preamble, and the contention time slot are shorter
  - the maximum data rate is much larger (see Table IV)
  - it is not compatible with 802.11b

Capacity Analysis

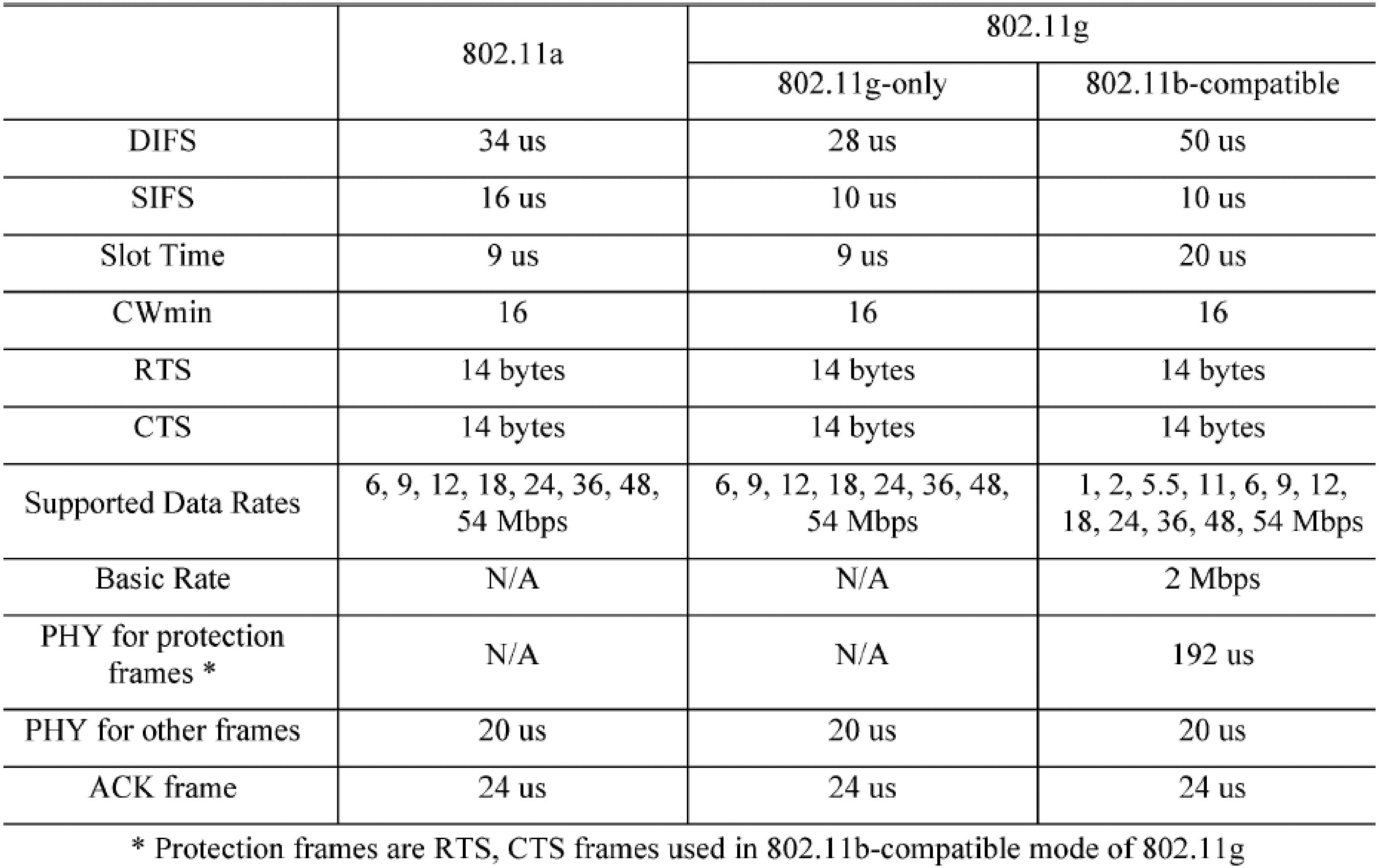
VoIP Capacity Analysis for 802.11a and 802.11g

- 802.11g
  - the same maximum data rate as 802.11a
  - 802.11g only mode
    - timing spaces even smaller than when those in 802.11a are used (Table IV)
  - 802.11b-compatible mode
    - the DIFS, SIFS, and contention slot time are the same as those in 802.11b
    - 802.11g has to enable "protection".

Capacity Analysis

VoIP Capacity Analysis for 802.11a and 802.11g

TABLE IV
PARAMETER VALUES OF 802.11a AND 802.11g



	802.11a	802.11g	
		802.11g-only	802.11b-compatible
DIFS	34 us	28 us	50 us
SIFS	16 us	10 us	10 us
Slot Time	9 us	9 us	20 us
CWmin	16	16	16
RTS	14 bytes	14 bytes	14 bytes
CTS	14 bytes	14 bytes	14 bytes
Supported Data Rates	6, 9, 12, 18, 24, 36, 48, 54 Mbps	6, 9, 12, 18, 24, 36, 48, 54 Mbps	1, 2, 5.5, 11, 6, 9, 12, 18, 24, 36, 48, 54 Mbps
Basic Rate	N/A	N/A	2 Mbps
PHY for protection frames *	N/A	N/A	192 us
PHY for other frames	20 us	20 us	20 us
ACK frame	24 us	24 us	24 us

* Protection frames are RTS, CTS frames used in 802.11b-compatible mode of 802.11g

Capacity Analysis

VoIP Capacity Analysis for 802.11a and 802.11g

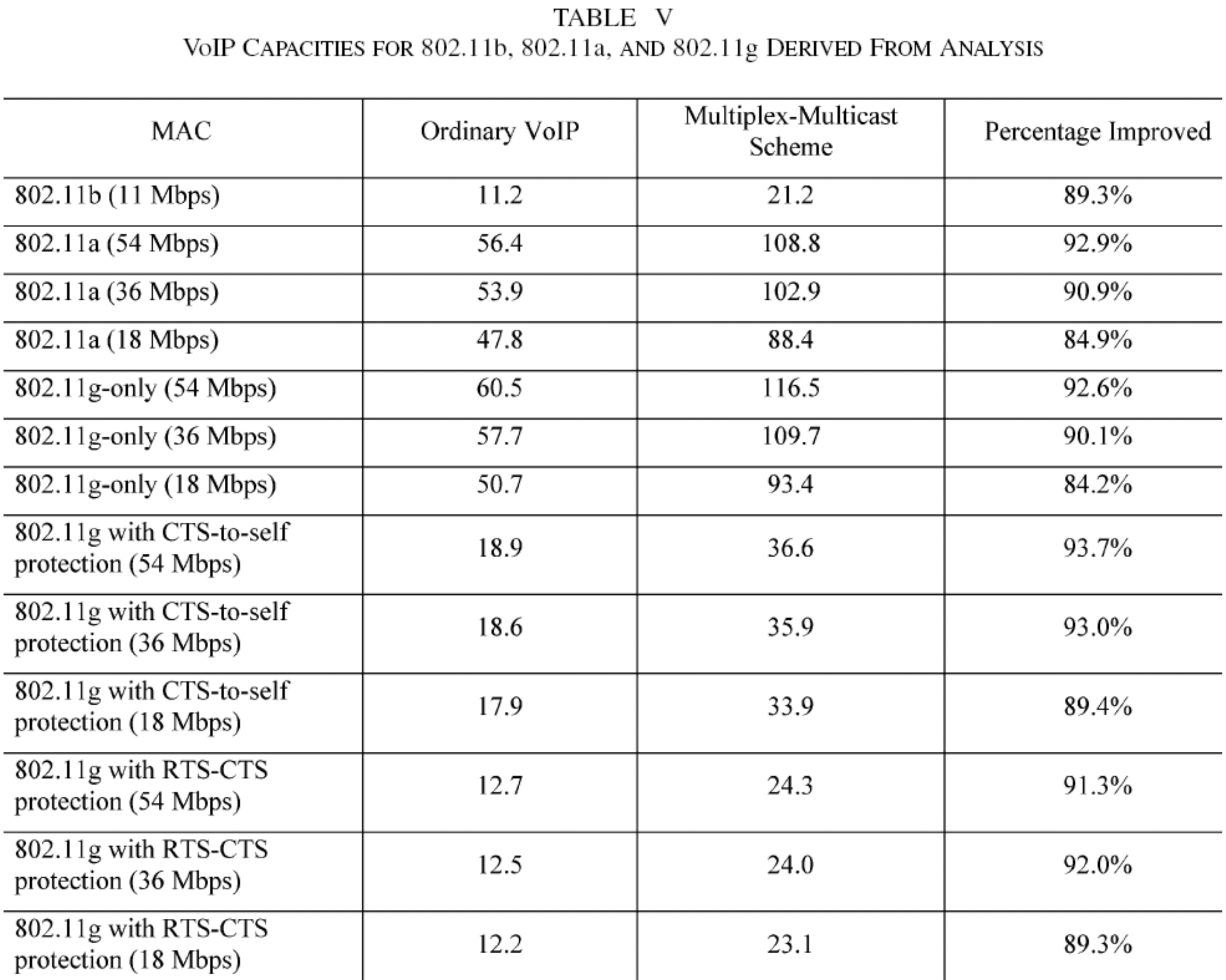


TABLE V

VoIP CAPACITIES FOR 802.11b, 802.11a, AND 802.11g DERIVED FROM ANALYSIS

MAC	Ordinary VoIP	Multiplex-Multicast Scheme	Percentage Improved
802.11b (11 Mbps)	11.2	21.2	89.3%
802.11a (54 Mbps)	56.4	108.8	92.9%
802.11a (36 Mbps)	53.9	102.9	90.9%
802.11a (18 Mbps)	47.8	88.4	84.9%
802.11g-only (54 Mbps)	60.5	116.5	92.6%
802.11g-only (36 Mbps)	57.7	109.7	90.1%
802.11g-only (18 Mbps)	50.7	93.4	84.2%
802.11g with CTS-to-self protection (54 Mbps)	18.9	36.6	93.7%
802.11g with CTS-to-self protection (36 Mbps)	18.6	35.9	93.0%
802.11g with CTS-to-self protection (18 Mbps)	17.9	33.9	89.4%
802.11g with RTS-CTS protection (54 Mbps)	12.7	24.3	91.3%
802.11g with RTS-CTS protection (36 Mbps)	12.5	24.0	92.0%
802.11g with RTS-CTS protection (18 Mbps)	12.2	23.1	89.3%

Capacity Analysis

VoIP Capacity Analysis for 802.11a and 802.11g

- when 802.11g needs to be compatible with 802.11b, the capacity decreases drastically.
- when 802.11g adopts RTS-CTS protection, the capacity is not much higher than that in 802.11b

Capacity Analysis

VoIP Capacity Analysis for 802.11a and 802.11g

- This shows that the higher data rate of 802.11g fails to bring about a corresponding higher VoIP capacity if compatibility with 802.11b is to be maintained.

Capacity Analysis

VoIP Capacity Analysis for 802.11a and 802.11g

- 54-Mb/s data rate for 802.11a and 11g may not be very reasonable, because the coverage area is very small.
- 802.11b has advantages on cost, size, & power consumption, so will continue to be popular, especially with PDA's, phones.

Capacity Analysis

VoIP Capacity With VBR Sources

- VoIP Capacity With VBR Sources:
  - The VBR VoIP capacity is simply

$$C_{\mathrm{VBR}} = C_{\mathrm{CBR}}/\rho \tag{11}$$

  - where C_{CBR} is the capacity for CBR source, P = ON(1)/(ON(1) + OFF(1.35)) = 42.5%. The ordinary VBR VoIP capacity is 11.2/42.5% = 26.3 and the M-M VBR VoIP capacity is 21.2/42.5% = 49.8 .

P. Brady, "A model for generating on-off speech patterns in two-wa
conversation," *Bell Syst. Tech. J.*, vol. 48, no. 7, pp. 2245–2272, 1

Capacity Analysis

Simulations

- In the simulations, we only consider the loca part of the network, since our focus is on WLAN, not the Internet.
- The simulator ns-2 is used.
- We define the system capacity to be the number of VoIP sessions that can be supported while maintaining the packet-loss rate of every stream to be below 1%.

Capacity Analysis

Simulations

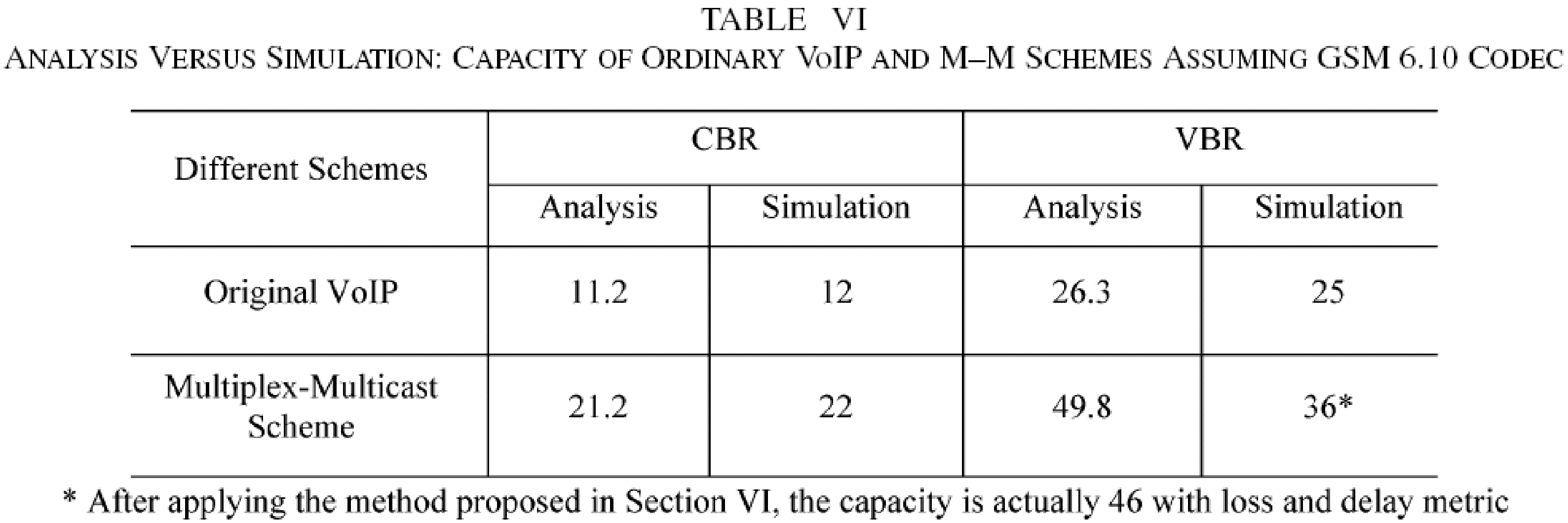


TABLE VI

ANALYSIS VERSUS SIMULATION: CAPACITY OF ORDINARY VoIP AND M–M SCHEMES ASSUMING GSM 6.10 CODEC

Different Schemes	CBR		VBR	
	Analysis	Simulation	Analysis	Simulation
Original VoIP	11.2	12	26.3	25
Multiplex-Multicast Scheme	21.2	22	49.8	36*

* After applying the method proposed in Section VI, the capacity is actually 46 with loss and delay metric

Capacity Analysis

Simulations

- For ordinary VoIP over WLAN, the simulations yield capacities of 12 and 25 for CBR and VBR, respectively. These results match the analysis very well.
- We also tried to increase the number of sessions by one beyond the capacity. We observed that this leads to a large surge in packet losses for the downlink streams.

Capacity Analysis

Simulations

- With M-M scheme, the CBR capacity can be improved to 22, which matches the analysis quite well.
- The VBR capacity can only be improved to 36 which is far below the result of analysis.

Capacity Analysis

Simulations

- In the analysis we have ignored collisions.
- Thanks to link-layer ARQ, unicast frame can tolerate several collisions before being discarded.
- The lack of ARQ causes multicast packets in the M-M scheme to experience a high packet loss rate, especially when the voice sources are VBR.

Capacity Analysis

Simulations

- It can be solved by applying a minor modification on the *AP MAC* layer to reduce the collision probability of multicast frames.(MMP)
- **This modification allows the M-M VBR VoIP scheme to have capacity of 46, which is closer to the analytical result in Table VI.**

Delay Performance

Access Delay

- To provide good voice quality, besides low packet-loss rates, we also need to consider the delay performance.
  - Access delay
    - a VoIP packet is the time from when the packet is generated(arrival) until it leaves the interface card (Queue).
  - Local delay
    - MUX delay
      - With a multiplexing interval of 20 ms,Ex. the MUX delays are distributed between 0 and 20 ms.

Delay Performance

Access Delay

- In this paper, we set a requirement that no more than 1% of the downlink or uplink VoIP packets should suffer a local delay of more than 30 ms.
- When there is no other non-VoIP traffic, the quality of servive (QoS) of VoIP in terms of loss rate and delay is good enough for both ordinary and M-M VoIP.

Delay Performance

Access Delay

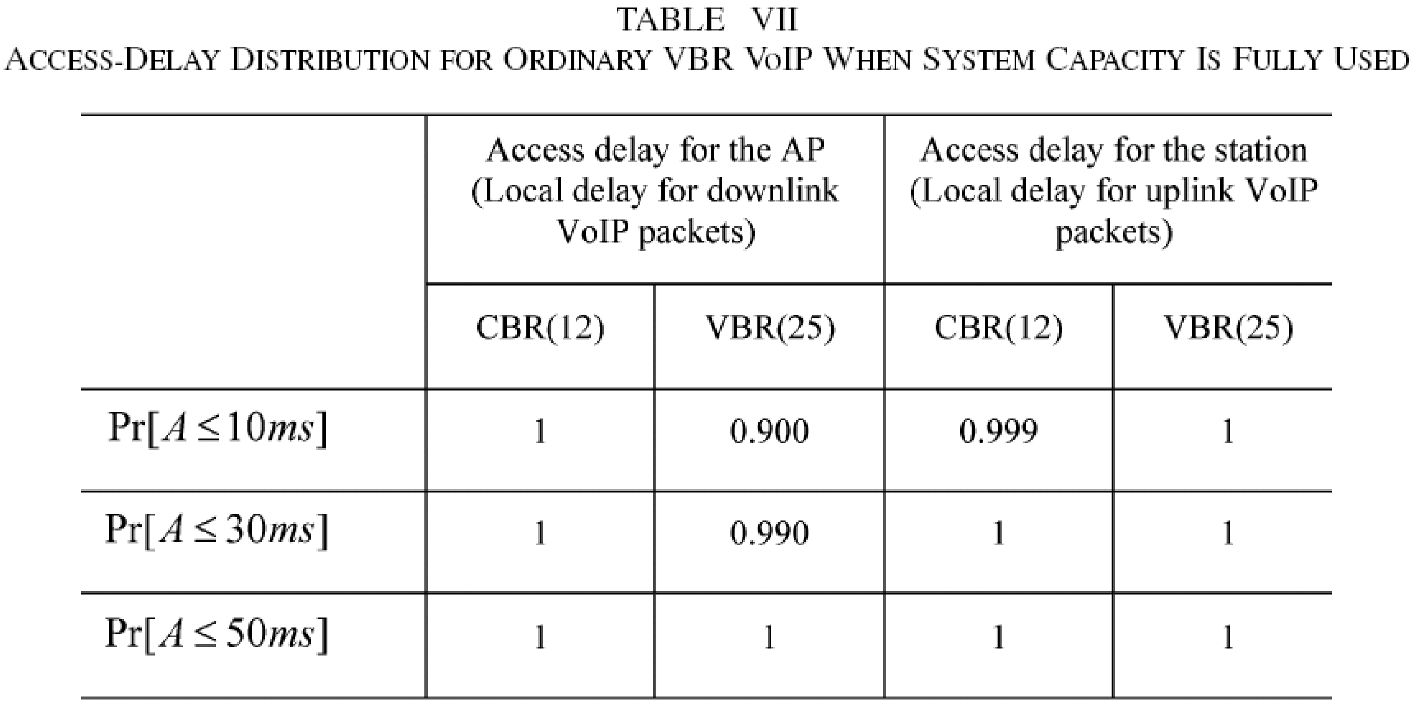


TABLE VII

ACCESS-DELAY DISTRIBUTION FOR ORDINARY VBR VoIP WHEN SYSTEM CAPACITY IS FULLY USED

	Access delay for the AP (Local delay for downlink VoIP packets)		Access delay for the station (Local delay for uplink VoIP packets)	
	CBR(12)	VBR(25)	CBR(12)	VBR(25)
$\Pr[A \le 10ms]$	1	0.900	0.999	1
$\Pr[A \le 30ms]$	1	0.990	1	1
$\Pr[A \le 50ms]$	1	1	1	1

Delay Performance

Extra Delay Incurred by the M-M Scheme

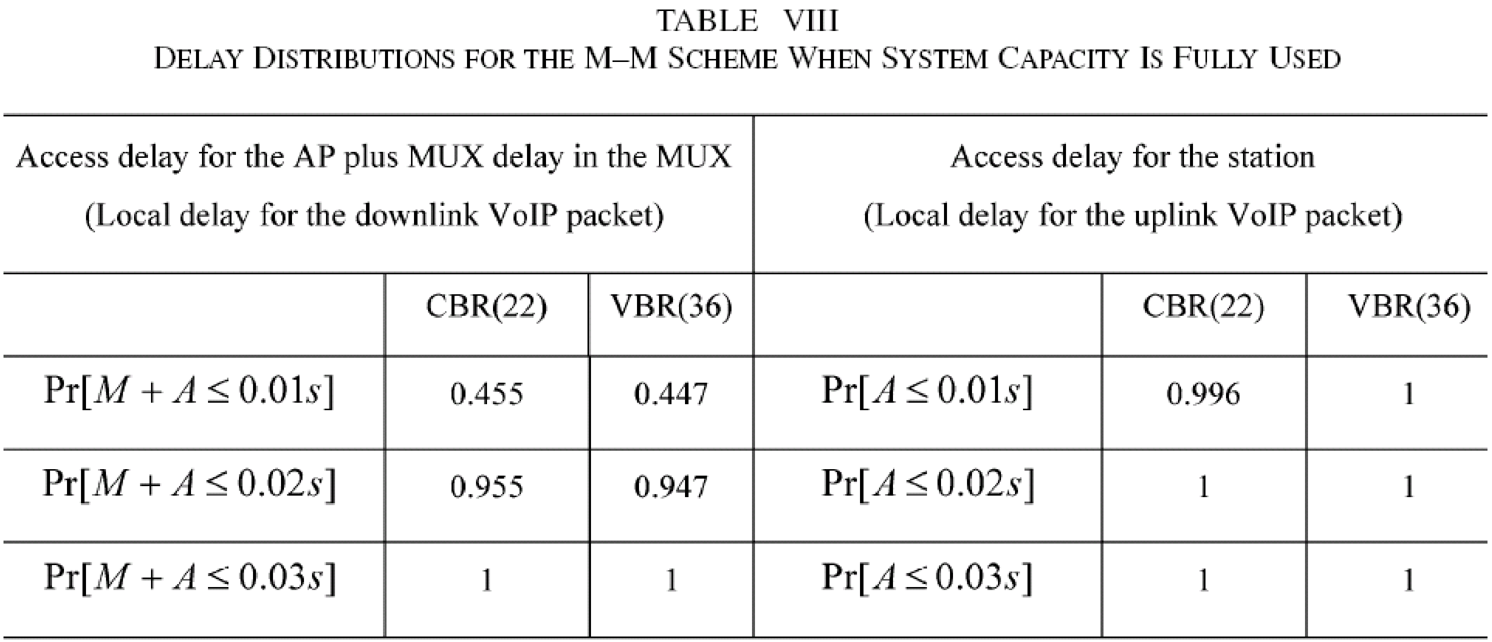


TABLE VIII

DELAY DISTRIBUTIONS FOR THE M–M SCHEME WHEN SYSTEM CAPACITY IS FULLY USED

Access delay for the AP plus MUX delay in the MUX (Local delay for the downlink VoIP packet)			Access delay for the station (Local delay for the uplink VoIP packet)		
	CBR(22)	VBR(36)		CBR(22)	VBR(36)
$\Pr[M + A \le 0.01s]$	0.455	0.447	$\Pr[A \le 0.01s]$	0.996	1
$\Pr[M + A \le 0.02s]$	0.955	0.947	$\Pr[A \le 0.02s]$	1	1
$\Pr[M + A \le 0.03s]$	1	1	$\Pr[A \le 0.03s]$	1	1

VoIP Coexisting with TCP interference traffic

- So far, we have considered VoIP without other coexisting traffic in the WLAN.
- To make room for the TCP traffic, the number of VoIP sessions should be limited to below the VoIP capacity derived in the previous sections.
- In addition, the fluctuations of the TCP traffic will also affect the QoS of VoIP.

VoIP Coexisting with TCP interference traffic

Ordinary VoIP Coexisting With TCP Over WLAN

- TCP generates two-way traffic in the WLAN.
  - After the sender's TCP DATA packets must be acknowledged by receiver's TCP ACK packets.
  - Although the payload of TCP ACK is small, transmission of TCP ACK can consume a considerable amount of bandwidth due to the header and other overheads.

VoIP Coexisting with TCP interference traffic

Ordinary VoIP Coexisting With TCP Over WLAN

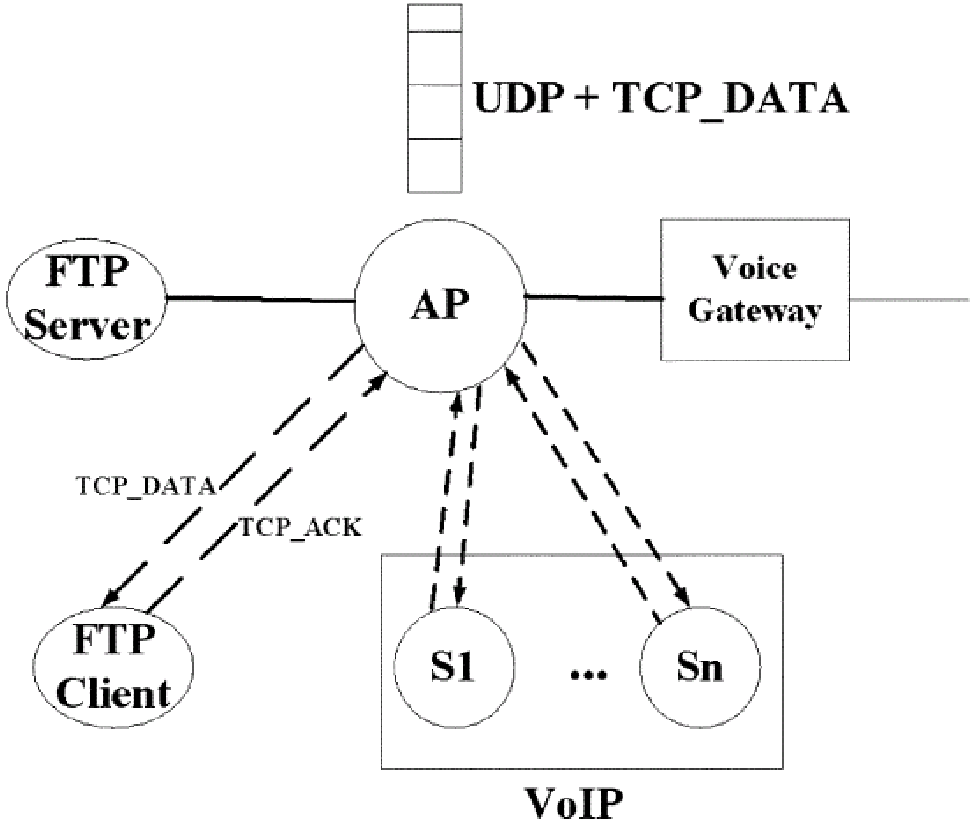


Fig. 8. Setup for experimental studies of VoIP–TCP interference.

VoIP Coexisting with TCP interference traffic

Ordinary VoIP Coexisting With TCP Over WLAN

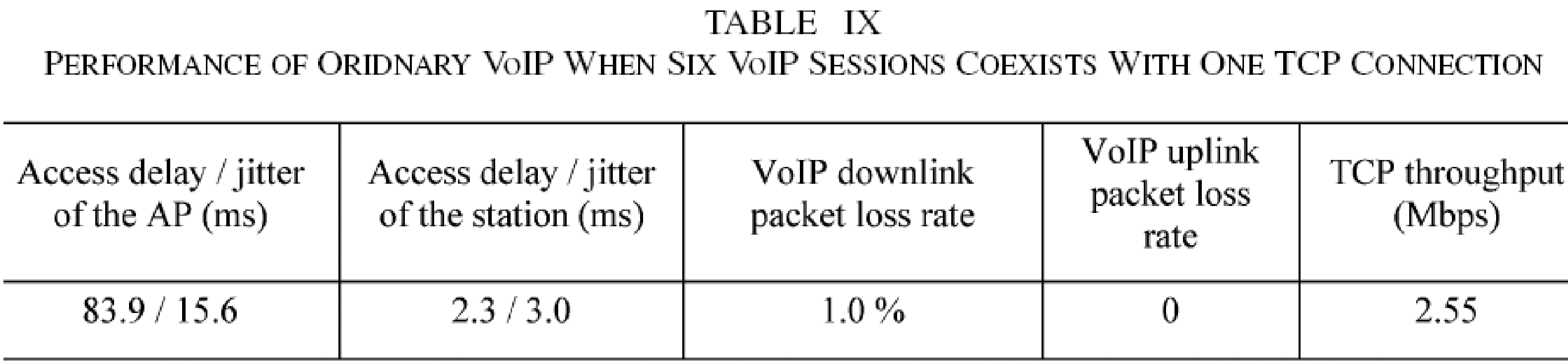


TABLE IX

PERFORMANCE OF ORIDNARY VOIP WHEN SIX VOIP SESSIONS COEXISTS WITH ONE TCP CONNECTION

Access delay / jitter of the AP (ms)	Access delay / jitter of the station (ms)	VoIP downlink packet loss rate	VoIP uplink packet loss rate	TCP throughput (Mbps)
83.9 / 15.6	2.3 / 3.0	1.0 %	0	2.55

VoIP Coexisting with TCP interference traffic

Ordinary VoIP Coexisting With TCP Over WLAN

- As can be seen, the voice quality is unacceptable even when there is only one TCP interference connection.
- Solutions: A natural solution to the problem is priority queuing (PQ), in which voice packets are given priority over the TCP packets within the AP buffer.

VoIP Coexisting with TCP interference traffic

Ordinary VoIP Coexisting With TCP Over WLAN

- The performance gain for VoIP is not at the expense of TCP throughput.

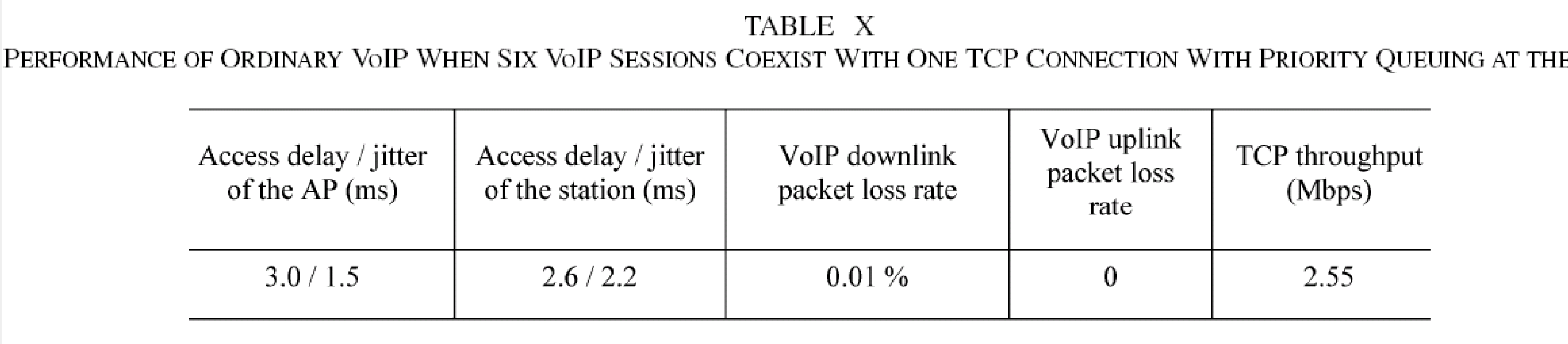


TABLE X

PERFORMANCE OF ORDINARY VOIP WHEN SIX VOIP SESSIONS COEXIST WITH ONE TCP CONNECTION WITH PRIORITY QUEUING AT THE

Access delay / jitter of the AP (ms)	Access delay / jitter of the station (ms)	VoIP downlink packet loss rate	VoIP uplink packet loss rate	TCP throughput (Mbps)
3.0 / 1.5	2.6 / 2.2	0.01 %	0	2.55

VoIP Coexisting with TCP interference traffic

M-M VoIP Coexisting With TCP Over WLAN

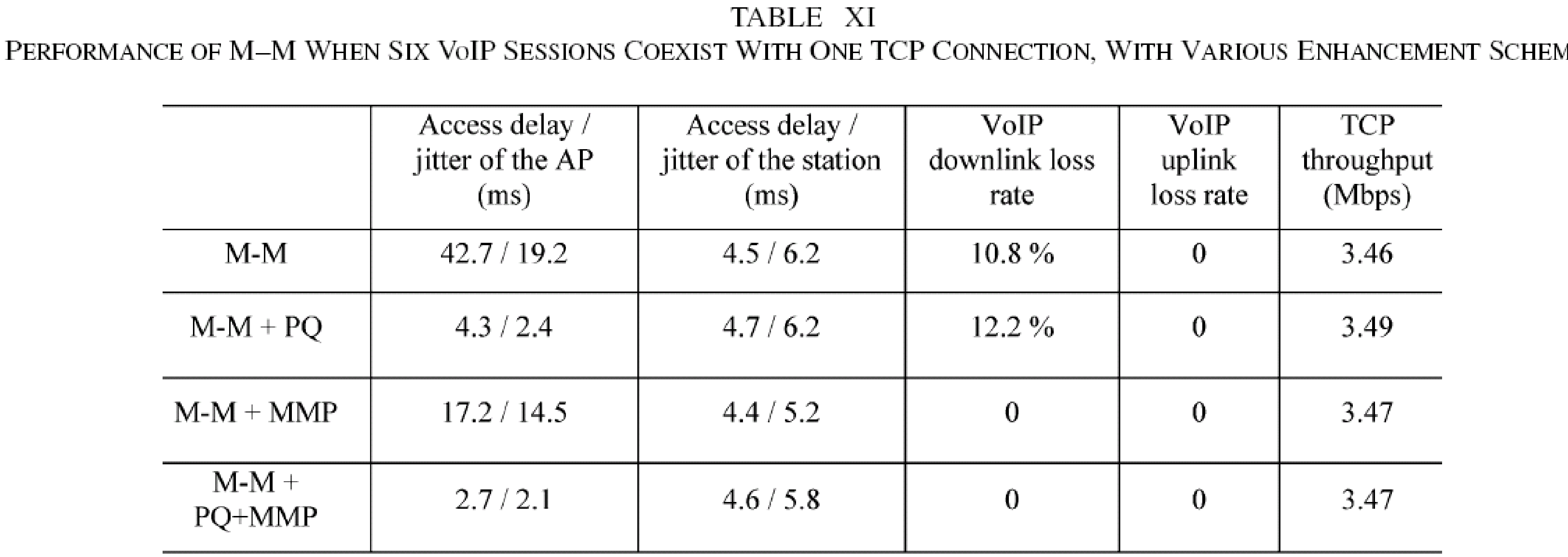


TABLE XI

Performance of M–M When Six VoIP Sessions Coexist With One TCP Connection, With Various Enhancement Schem

	Access delay / jitter of the AP (ms)	Access delay / jitter of the station (ms)	VoIP downlink loss rate	VoIP uplink loss rate	TCP throughput (Mbps)
M-M	42.7 / 19.2	4.5 / 6.2	10.8 %	0	3.46
M-M + PQ	4.3 / 2.4	4.7 / 6.2	12.2 %	0	3.49
M-M + MMP	17.2 / 14.5	4.4 / 5.2	0	0	3.47
M-M + PQ+MMP	2.7 / 2.1	4.6 / 5.8	0	0	3.47

VoIP Coexisting with TCP interference traffic

M-M VoIP Coexisting With TCP Over WLAN

- With the M-M scheme, The TCP throughput is higher. This is because the downlink VoIP packets are multiplexed into fewer multicast packets, leaving more bandwidth to TCP.

VoIP Coexisting with TCP interference traffic

M-M VoIP Coexisting With TCP Over WLAN

- Although the delay problem is solved, the loss rate remains excessively high. This is because the packet losses are caused by collisions with uplink unicast packets, not buffer overflow.

VoIP Coexisting with TCP interference traffic

M-M VoIP Coexisting With TCP Over WLAN

- the solution as the MAC-layer multicast priority scheme (MMP).
- To reduce collisions, we must give priority to the AP multicast packets over unicast packets from other nodes. This requires us to look into the CSMA/CA scheme of 802.11 to find a solution.

VoIP Coexisting with TCP interference traffic

M-M VoIP Coexisting With TCP Over WLAN

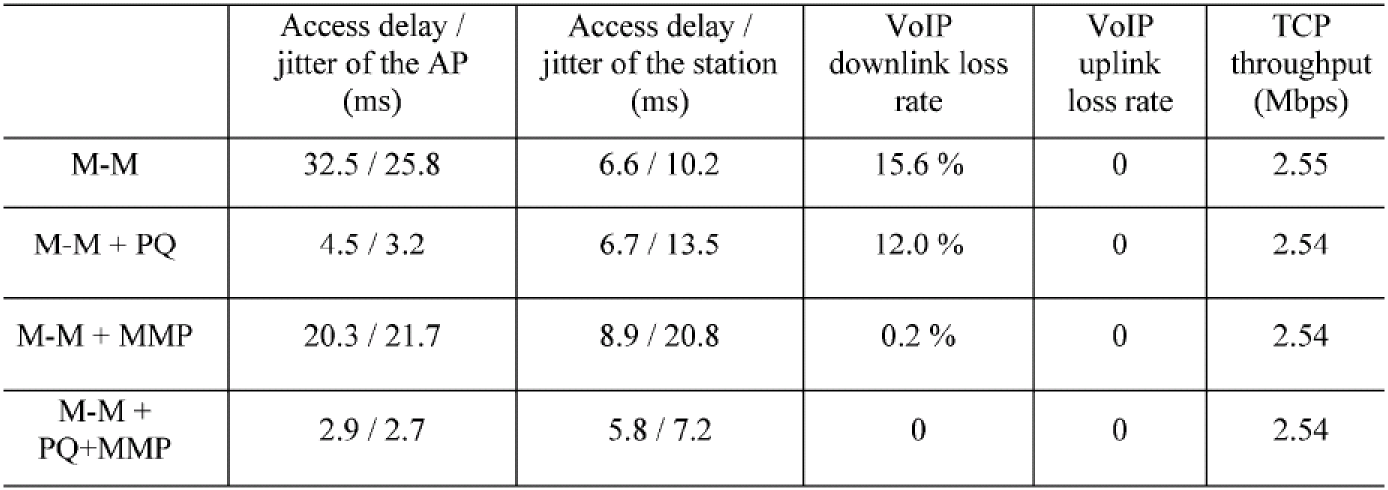
- With MMP, when the AP has a multicast frame to transmit, instead of waiting for DIFS and then a contention backoff period, it just waits for a MIFS before transmission.
- The value of MIFS should be a value less than DIFS, but larger than SIFS.
- we set MIFS to be 30 us .

VoIP Coexisting with TCP interference traffic

M-M VoIP Coexisting With TCP Over WLAN

TABLE XII

Performance of M–M When 11 M–M VoIP Coexist With One TCP Connection, With Various Enhanacement Schem



	Access delay / jitter of the AP (ms)	Access delay / jitter of the station (ms)	VoIP downlink loss rate	VoIP uplink loss rate	TCP throughput (Mbps)
M-M	32.5 / 25.8	6.6 / 10.2	15.6 %	0	2.55
M-M + PQ	4.5 / 3.2	6.7 / 13.5	12.0 %	0	2.54
M-M + MMP	20.3 / 21.7	8.9 / 20.8	0.2 %	0	2.54
M-M + PQ+MMP	2.9 / 2.7	5.8 / 7.2	0	0	2.54

CONCLUSION

- This paper investigates two critical technical problems in VoIP over WLAN
  - low VoIP capacity in a WLAN
  - unacceptable VoIP performance in the presence of coexisting traffic from other applications.

CONCLUSION

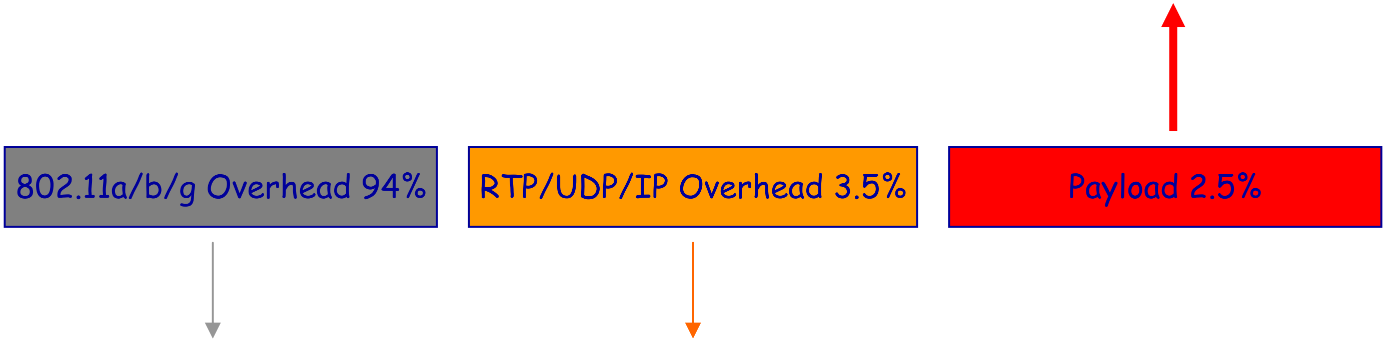
- This paper shows that a M-M scheme can improve the VoIP capacity by close to 100%.
- The performance is unacceptable when there is coexisting TCP traffic in the WLAN
  - PQ.
  - MMP

Discussion

- VBR(?)+TCP(?)
- CBR(?)+VBR(?)+TCP(?)
  - Optimal CBR+VBR+TCP

Discussion

- Capacity for voice can be quite low in WLAN.
  - Multiplexer-Multicast.
    - Packet assemble/de-assemble.
      - Complexity.
      - Local Delay.
  - Header Compression.



802.11a/b/g Overhead 94%

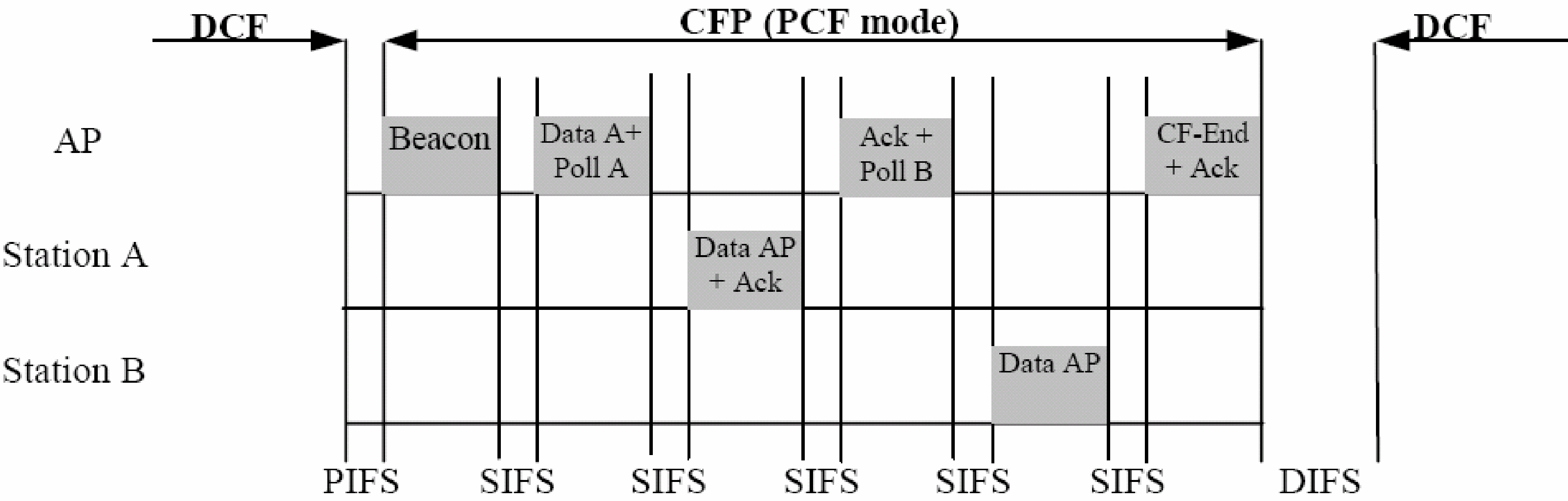
RTP/UDP/IP Overhead 3.5%

Payload 2.5%

Discussion

- **VoIP traffic and data traffic (from traditional applications such as Web, e-mail, etc.) can interfere with each other and bring down VoIP performance.**
  - **Priority Queuing.**
  - **Reduce/Avoid Collision.**
    - PCF+DCF(Scheduling).
    - Back-off Contention Windows.
    - Inter-frame Space.

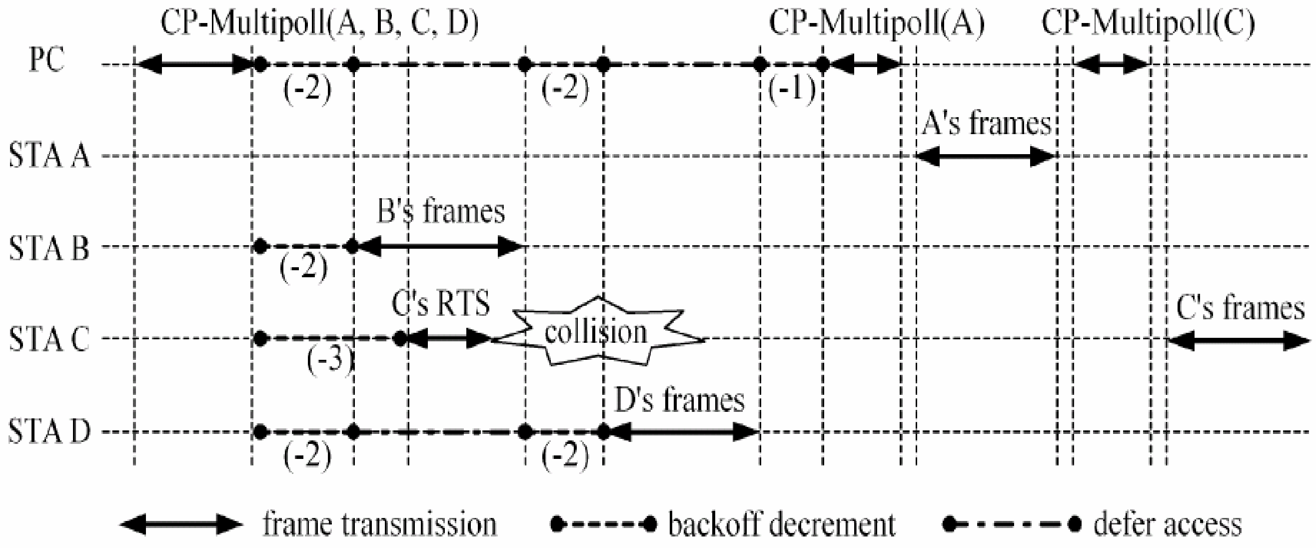
Discussion



Polling mechanism in PCF.

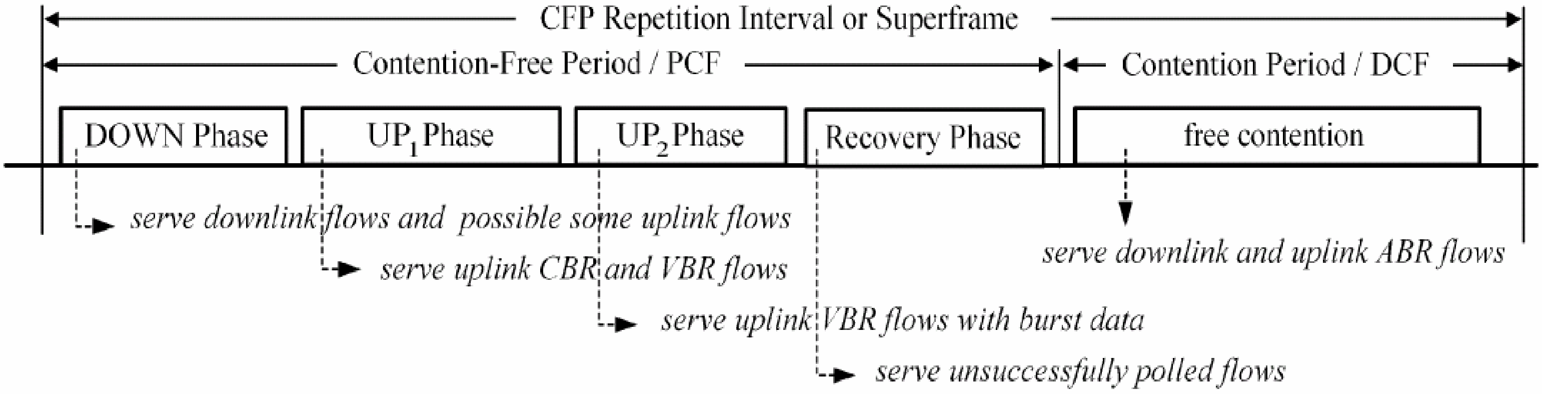
D: Downlink
U: Uplink

Discussion



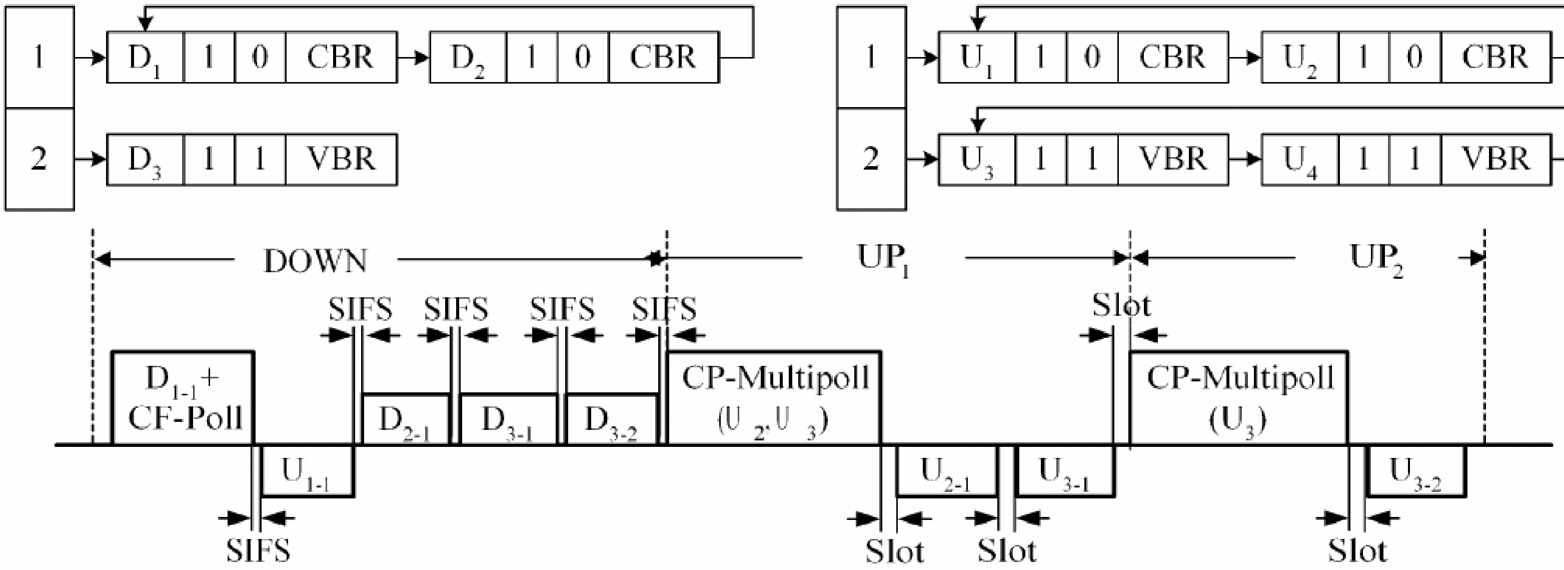
An example of CP-Multipoll.

Discussion



Our proposed scheduling model.

Discussion



An example of the polling schedule.

Discussion

- Reduce/Avoid Collision
  - PCF.
  - Contention Windows.
  - Inter-frame Space.
- Priority Queuing
  - Classification.
  - Scheduling.
- Admission Control

Problems with DCF and PCF

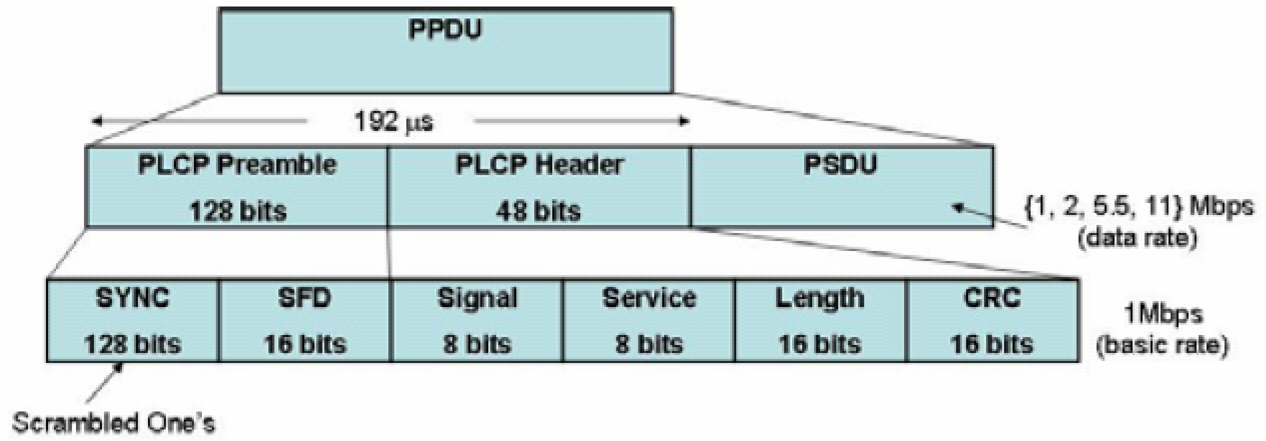
- PROBLEM WITH DCF:
  - Hard to implement QOS
  - Poor performance under heavy load conditions
  - Low bandwidth
  - Limited number of VoIP connections
- PROBLEM WITH PCF:
  - AP keeps polling regardless of whether data is available for transmission
  - When no of stations in the BSS is large –polling overhead is large.
  - Without service differentiation-poor performance
  - **Support for PCF is not so commonly available**

Long Preamble

- Long Preamble In a "noisy" network environment, the Preamble Type should be set to Long Preamble.
- Short Preamble The Short Preamble is intended for applications where minimum overhead and maximum performance is desired.In a "noisy" network environment, the performance will be decreased, if Short Preamble is used

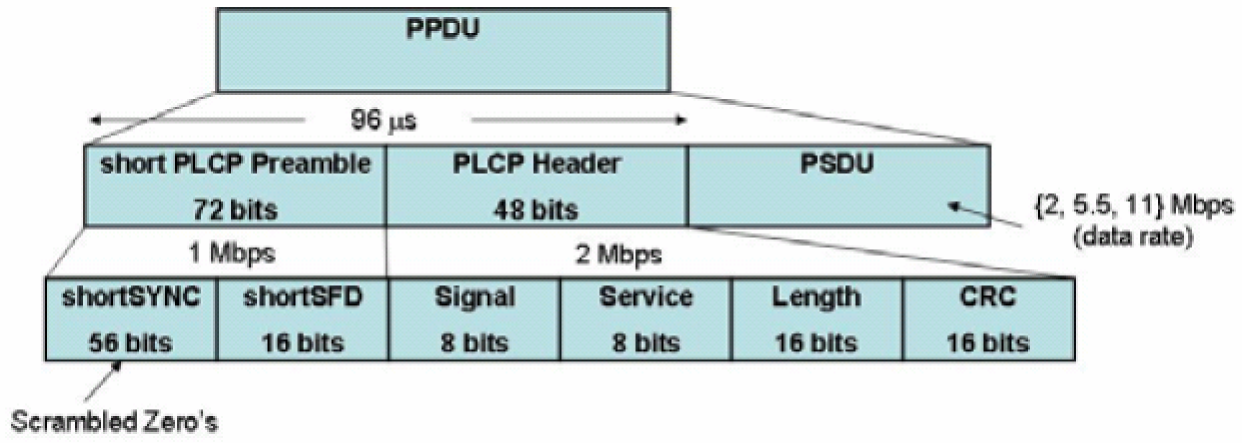
short preamble

- The short preamble option improves throughput.performance while long preamble provides better synchronization.



Packetization on WLAN PHY layer with Long Preamble and Header

short preamble



Packetization op WLAN PHY layer with Short Preamble and Header

Background

IEEE 802.11

- There are two access mechanisms specified in the IEEE 802.11 standard: distributed coordination function (DCF) and point coordination function (PCF).

Background

IEEE 802.11

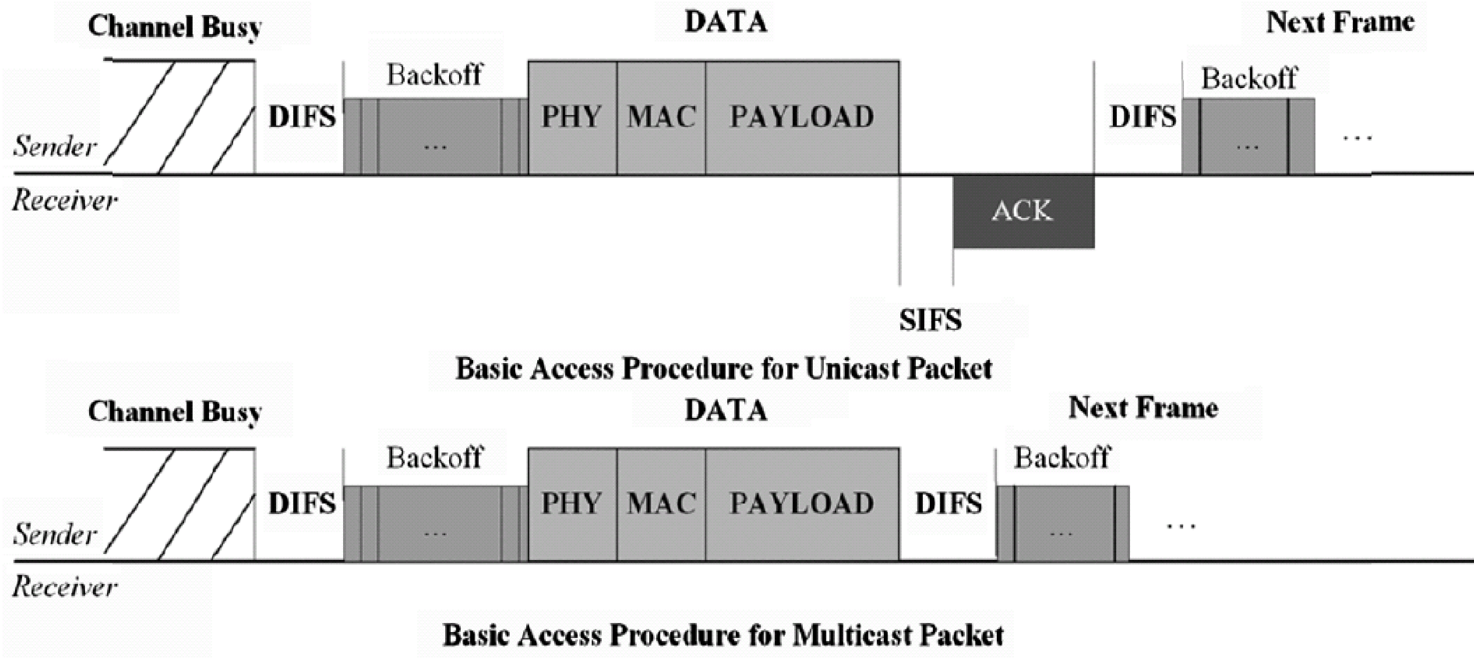


Fig. 1. Basic operation of 802.11 DCF.

Background

IEEE 802.11

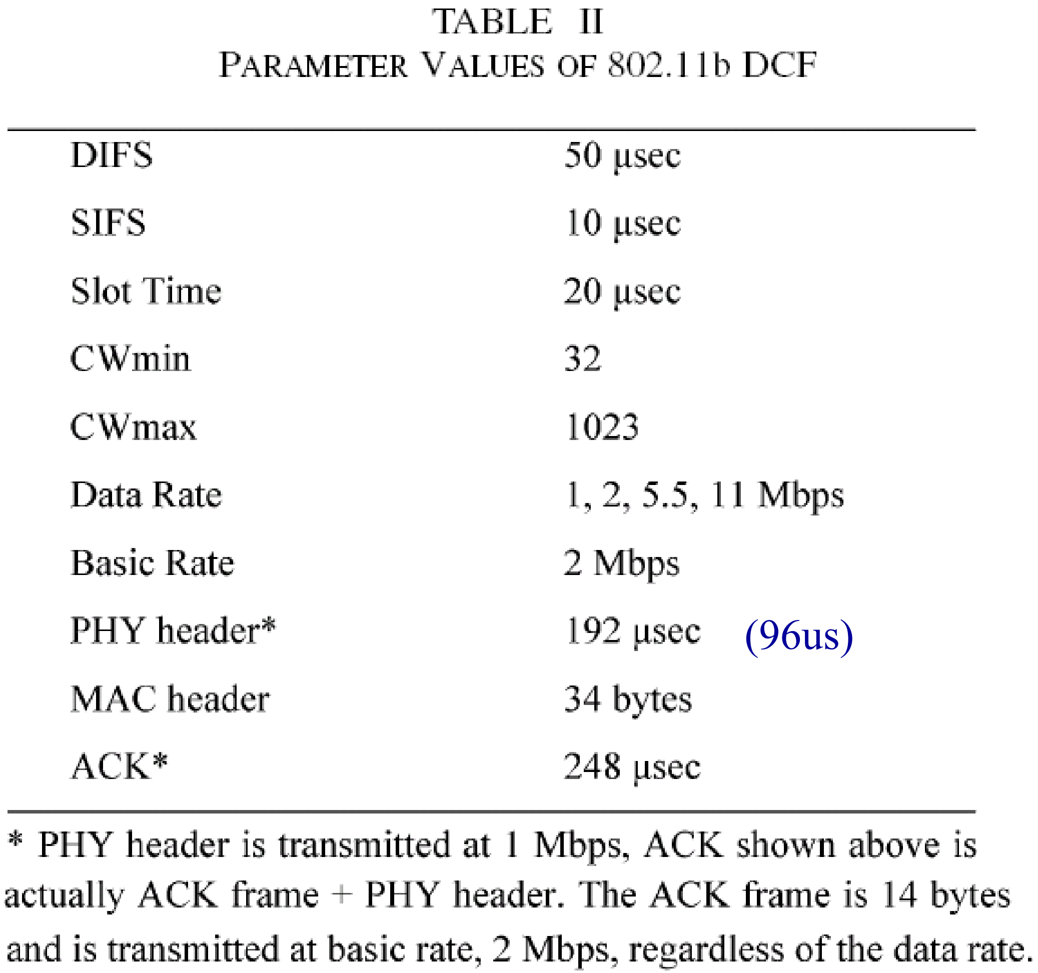


TABLE II
PARAMETER VALUES OF 802.11b DCF

DIFS	50 μsec
SIFS	10 μsec
Slot Time	20 μsec
CWmin	32
CWmax	1023
Data Rate	1, 2, 5.5, 11 Mbps
Basic Rate	2 Mbps
PHY header*	192 μsec (96us)
MAC header	34 bytes
ACK*	248 μsec

* PHY header is transmitted at 1 Mbps, ACK shown above is actually ACK frame + PHY header. The ACK frame is 14 bytes and is transmitted at basic rate, 2 Mbps, regardless of the data rate.