Some Mechanisms to Improve TCP/IP Performance over Wireless and Mobile Computing Environment

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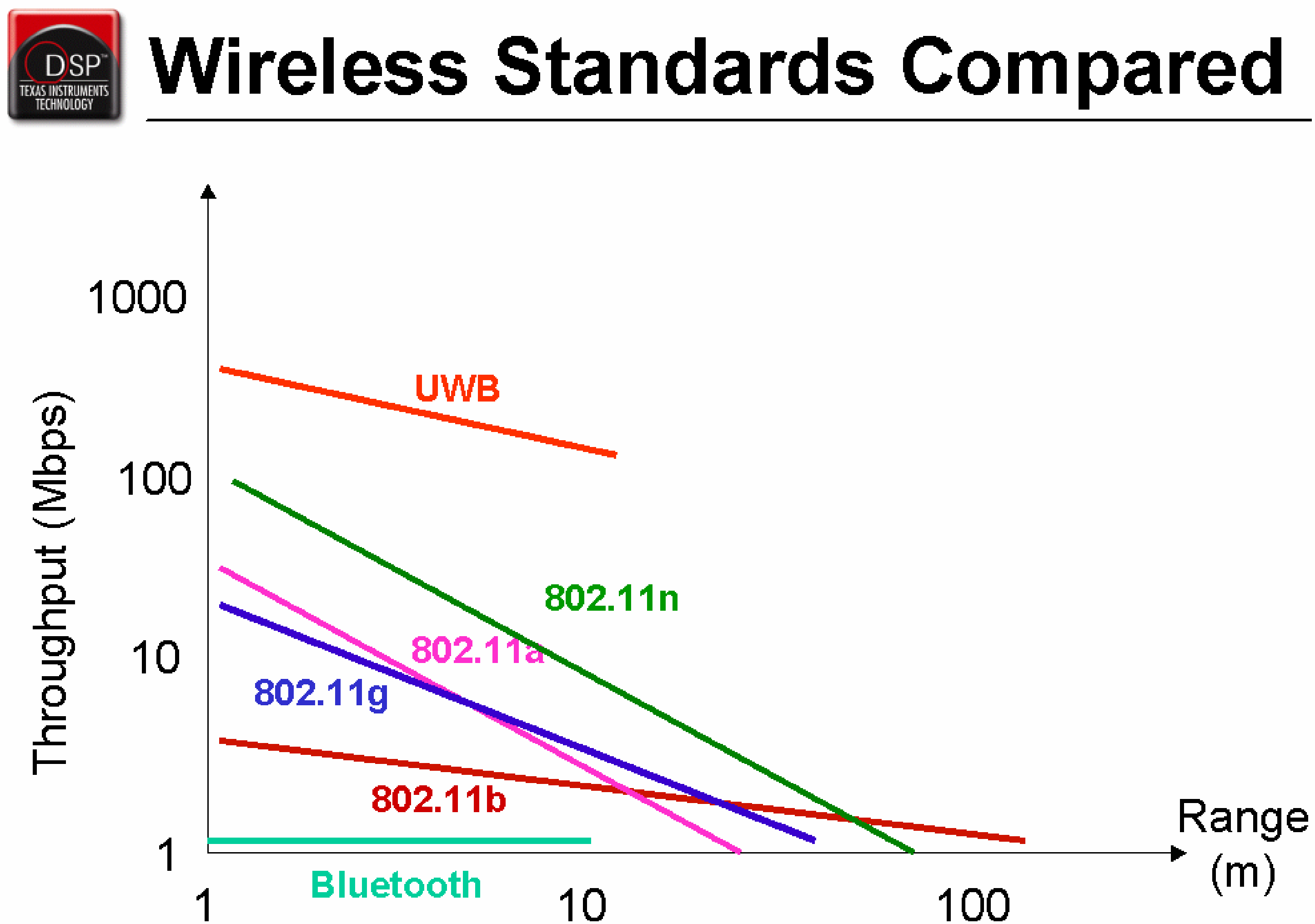
Outline

- Introduction
- Related Work
- Proposed Solution
- Simulation
- Conclusion and Future Work

Introduction

- The traditional TCP/IP, which was based on wired network, has been facing a great challenge due to the participation of wireless networks.
  - *high bit-error rate (BER).*
  - *less available bandwidth.*
  - *packet loss or packet delay during handoff procedures.*
  - *Asymmetry*
    - *the mobile host has limited power and smaller processing capability than base station.*

Introduction



Reference from TI

Introduction

- The aims of this paper are to provide ***high throughput*** and ***seamless communications*** without changing the existing TCP/IP implementations and applications at the fixed hosts .
- The only components of the network that we expect to modify are the base stations and mobile hosts.

Introduction

- First, this paper propose ***a data-link layer without transport layer retransmission*** to quickly recover packet losses, therefore simplifying the TCP/IP operations over the lossy wireless links.
- Second, a loss-tolerated ***TCP/IP header compression*** is used over wireless links to reduce header overhead and resist packet loss or out-of-order problems.

Introduction

- Third, an ***adaptive scheme for the size of MAC layer's frame*** is also presented to achieve optimal goodput under varying conditions of wireless networks.
- Finally, in order to provide seamless communication, this paper propose a ***direction-based selective multicast scheme to handle host mobility for real-time applications.***

Related Works

- End-to-End Schemes
- Link Layer Schemes
- Split Connection Schemes

End-to-End Schemes

- The end-to-end approaches attempt to make TCP senders be able to ***distinguish between congestion-related and other forms of packet losses*** by using an explicit loss notification (ELN) mechanism.
- The TCP congestion control procedures are invoked only when network congestion, and the appropriate procedures are performed to deal with other forms of packet loss.

End-to-End Schemes

- Drawback
  - The main problem of these approaches is that it need to **modify the TCP specifications** at fixed Internet hosts, however it is infeasible to modify all existing TCP implementations on the Internet.

Link Layer Schemes

- Link-layer schemes attempt to **hide the unreliable wireless networks from wired hosts by using local retransmissions or error correction scheme** over the wireless link.
- Results show that the application throughput would be improved with the retransmission protocols of link layer only when the **packet error rate exceeds a certain threshold.**

Link Layer Schemes

- Drawbacks:
  - Complexity.
  - does not consider packets loss and delay due to **handoff**

Split Connection Schemes

- The main idea of split connection approaches is that they hide the unreliable wireless link from hosts of wired network by terminating TCP connections at the base station.

Split Connection Schemes

- Drawbacks of I-TCP
  - The end-to-end semantics of TCP acknowledgments were violated.
  - The handoff latency is usually long.

Proposed Solution

- Link-Layer Retransmission and Reducing TCP/IP Operations
- TCP/IP Header Compression
- Adaptive MAC Frame Size
- Mobility and Handoff

Proposed Solution

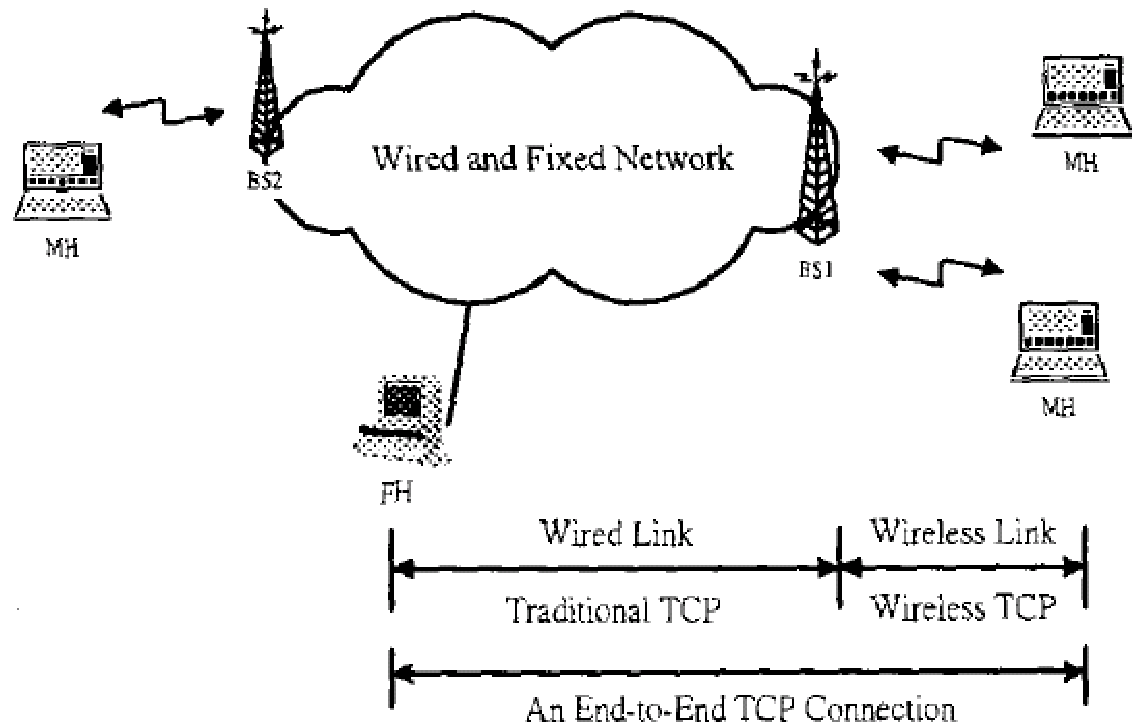


Figure 1: System Model

A specific Wireless TCP (W-TCP) is used over the wireless lin

Proposed Solution

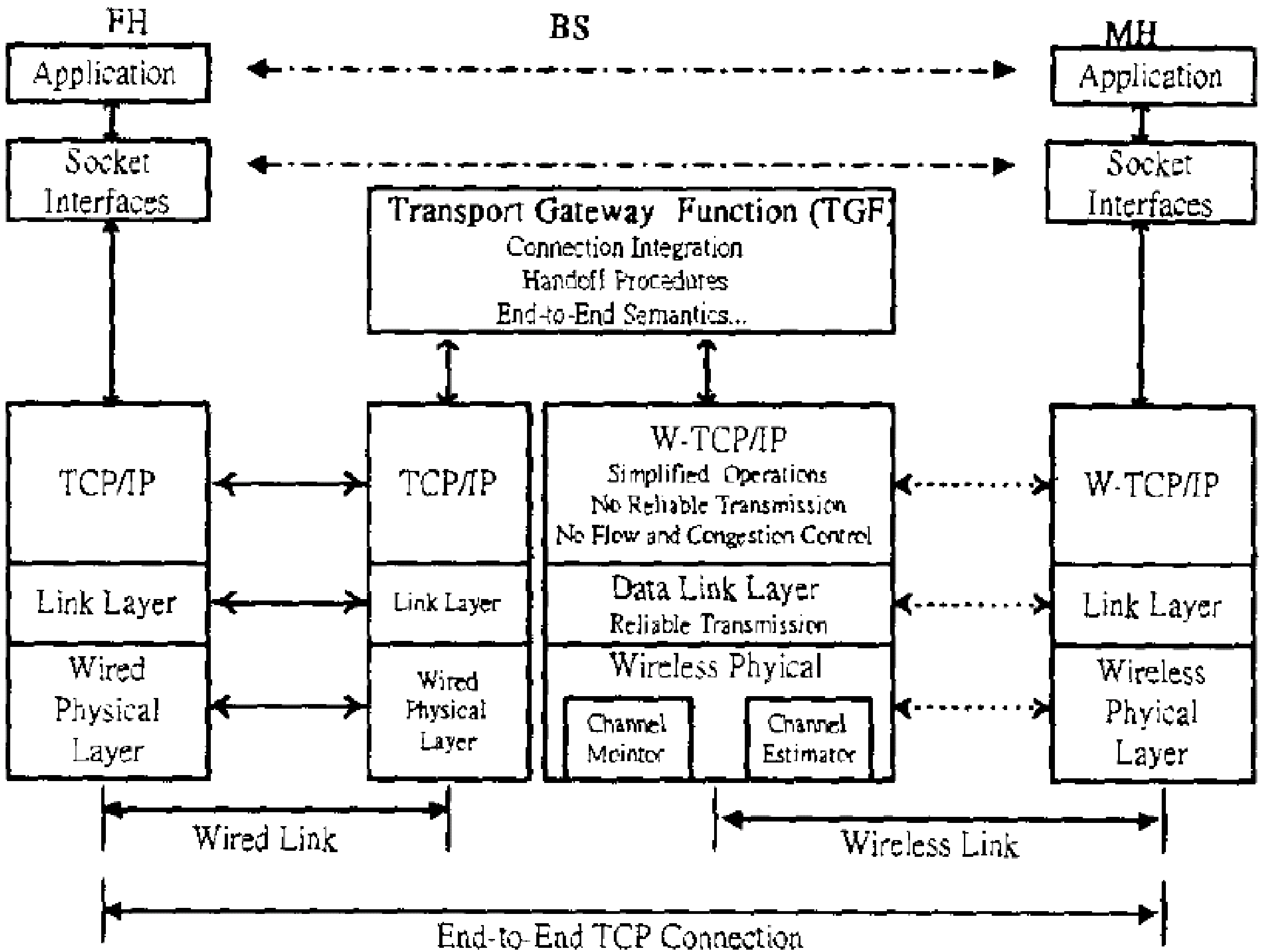


Figure 2: The Protocol Stack of Our System Model

Link-Layer Retransmission and Reducing TCP/IP Operations

- Using link-layer retransmission solely, the problem of interference between TCP retransmission and link-layer retransmission can be eliminated.

Link-Layer Retransmission and Reducing TCP/IP Operations

- Local retransmissions at the link-layer occur due to two conditions
  - Timeout
  - When the BS receives duplicate acknowledgements
- This paper use the Go-Back-N (GBN) strategy to retransmit the lost packets.

TCP/IP Header Compression

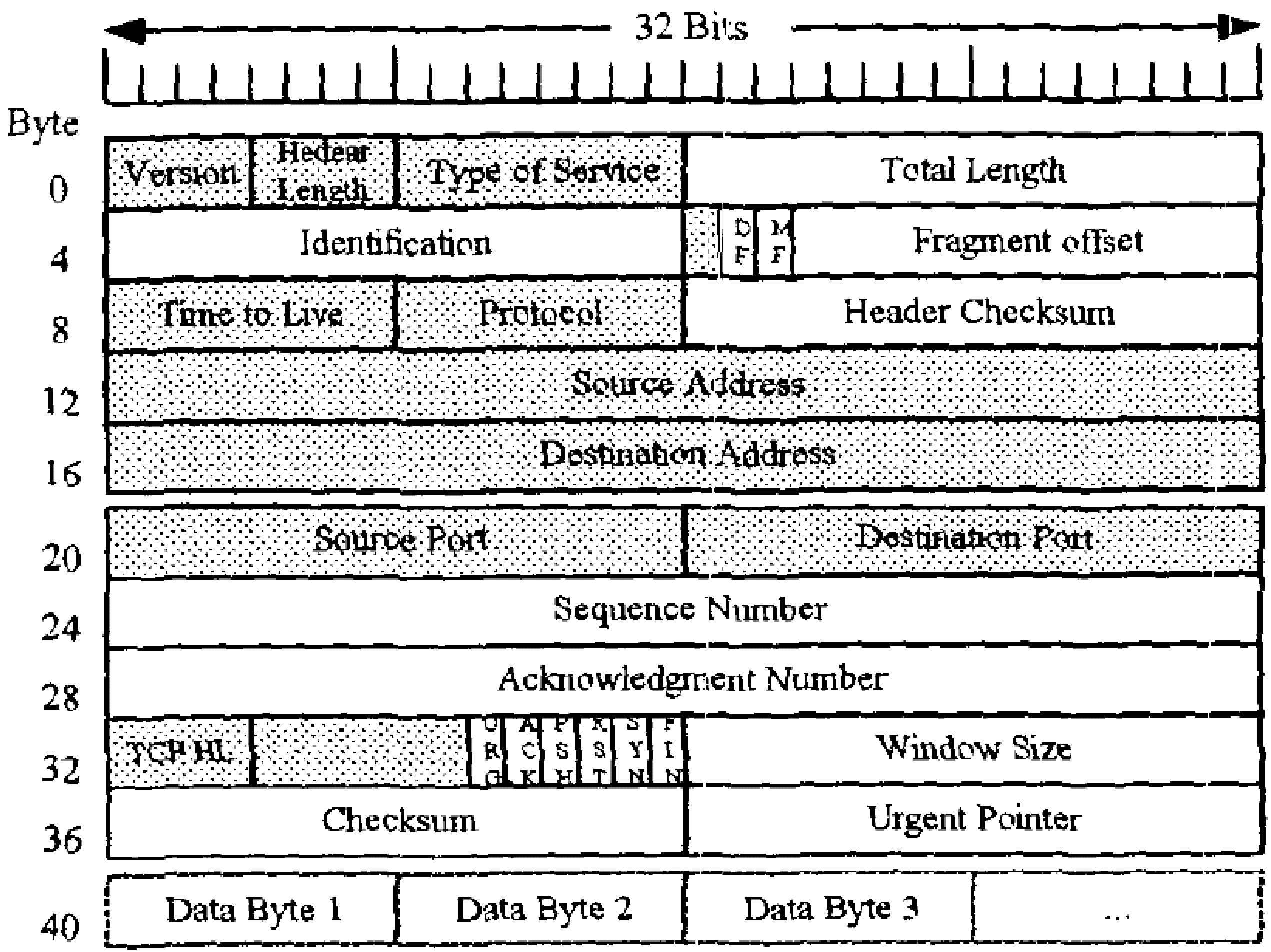


Figure 3: The Header of Traditional TCP/IP Datagram

TCP/IP Header Compression

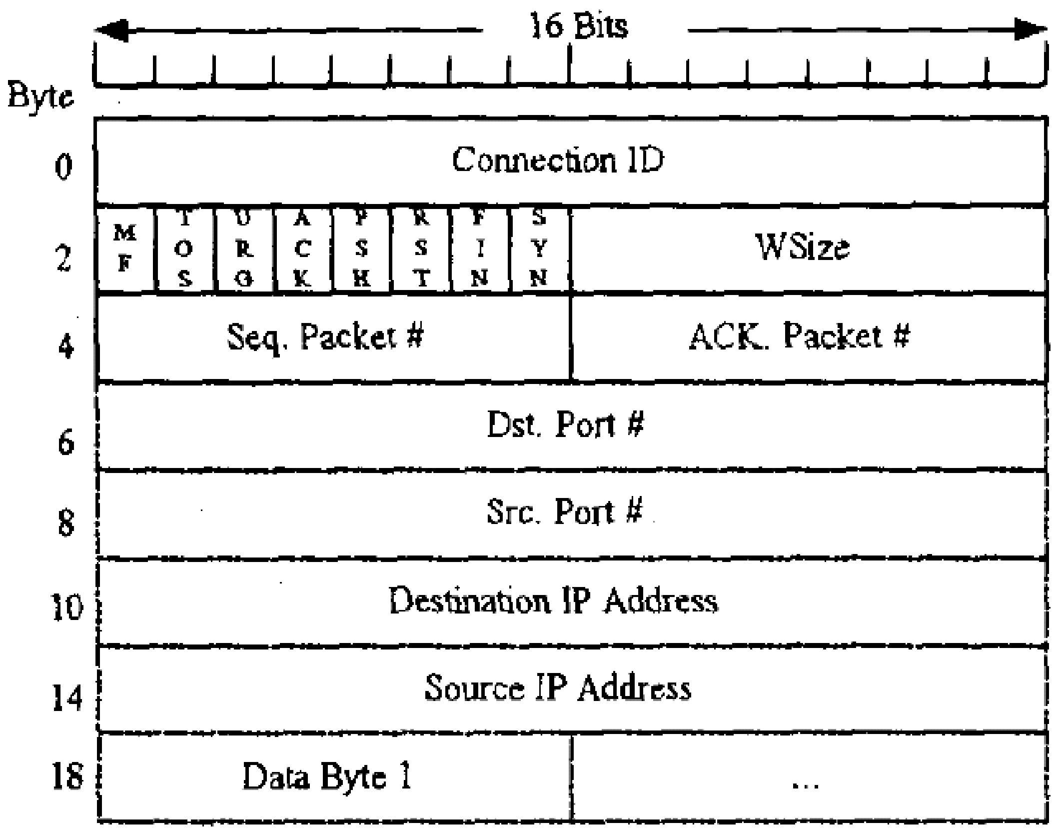


Figure 4: The Compressed Header of TCP/IP Datagram

Adaptive MAC Frame Size

- The shorter packets are less likely to encounter packet error than long packets, but on the other hand.
- The choice of the MAC frame size has a great impact on the performance of wireless networks.

Adaptive MAC Frame Size

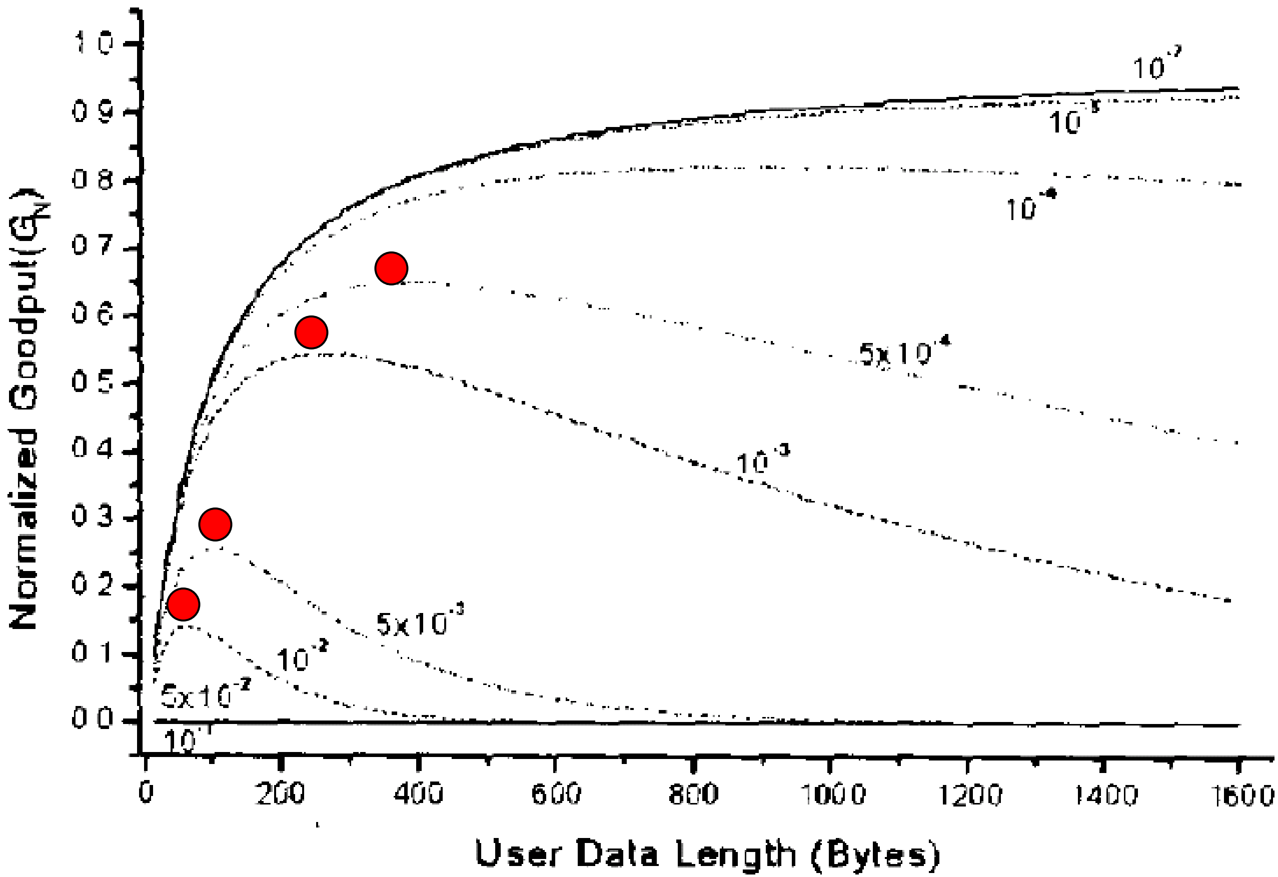


Figure 5: Normalized Goodput vs. User Data Length over Varying BER

Adaptive MAC Frame Size

- From the Figure 5, the optimal length of user data under time-varying conditions over wireless channels can be derived

Table 1: Optimum user data length (L) vs. bit-error rate (BER)

BER	10^{-1}	$5x10^{-2}$	10^{-2}	$5x10^{-3}$	10^{-3}	$5x10^{-4}$	10^{-4}	$< 10^{-5}$
L(Bytes)	10	20	60	100	260	390	920	1500

Adaptive MAC Frame Size

- It is difficult to distinguish how many bit-error were occurred in a packet.
- a ***channel monitor*** and a ***channel estimator*** are introduce at base stations.
- The ***channel monitor*** is used to monitor packet loss in its coverage area and count the ratio of packets loss,
- The ***channel estimator*** is used to derive the BER of wireless links.

Mobility and Handoff

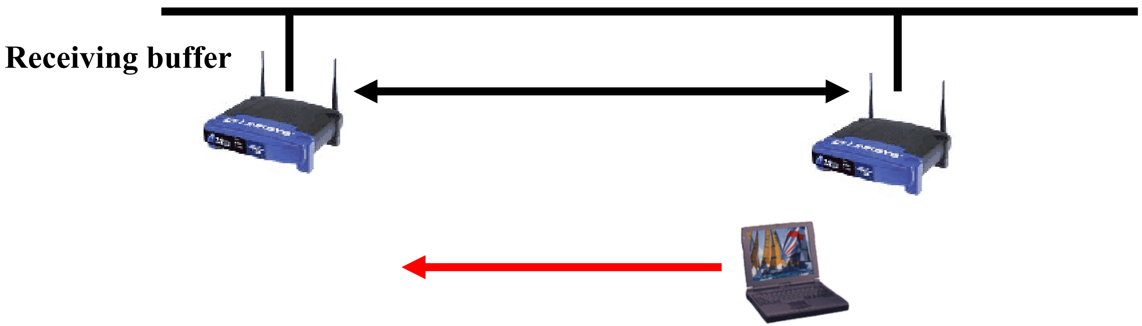
- Traditional multicast-based solution
  - The packets for a mobile host are multicast to th BSs of **the neighboring** cells so when the mobile host moves to a new cell, there are packets waiting for it. It can provide total guarantee for seamless communication.
  - However, it is evident that this scheme is not cost-effective. As the number of connection increases, the amount of network bandwidth use by the multicast is high.

Mobility and Handoff

- The main ideas of this paper approach to achieve seamless communication are to classify traffics into two classes, **real-time** and **non-real time** traffic, and avoid unnecessary multicast.

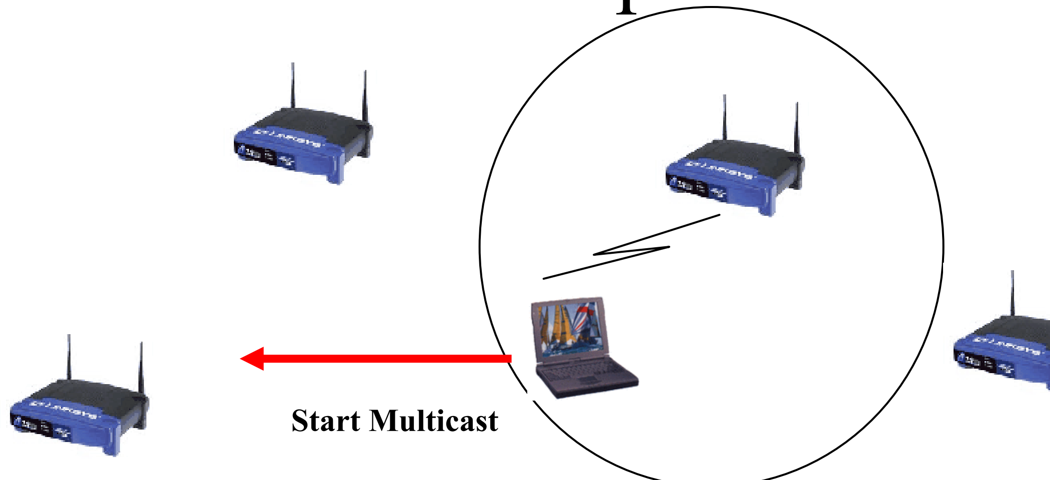
Mobility and Handoff

- For non-real time traffic, we propose to use ***forward-based*** scheme instead of ***multicast-based*** scheme.
- This approach would incur long latency, but it can save a lot of network bandwidth for multicast.



Mobility and Handoff

- For real-time traffic which are sensitive to delay, such as audio and video multimedia applications, we propose ***direction-based selective multicast*** scheme to reduce latency and packets loss due to handoff procedures.



Simulation

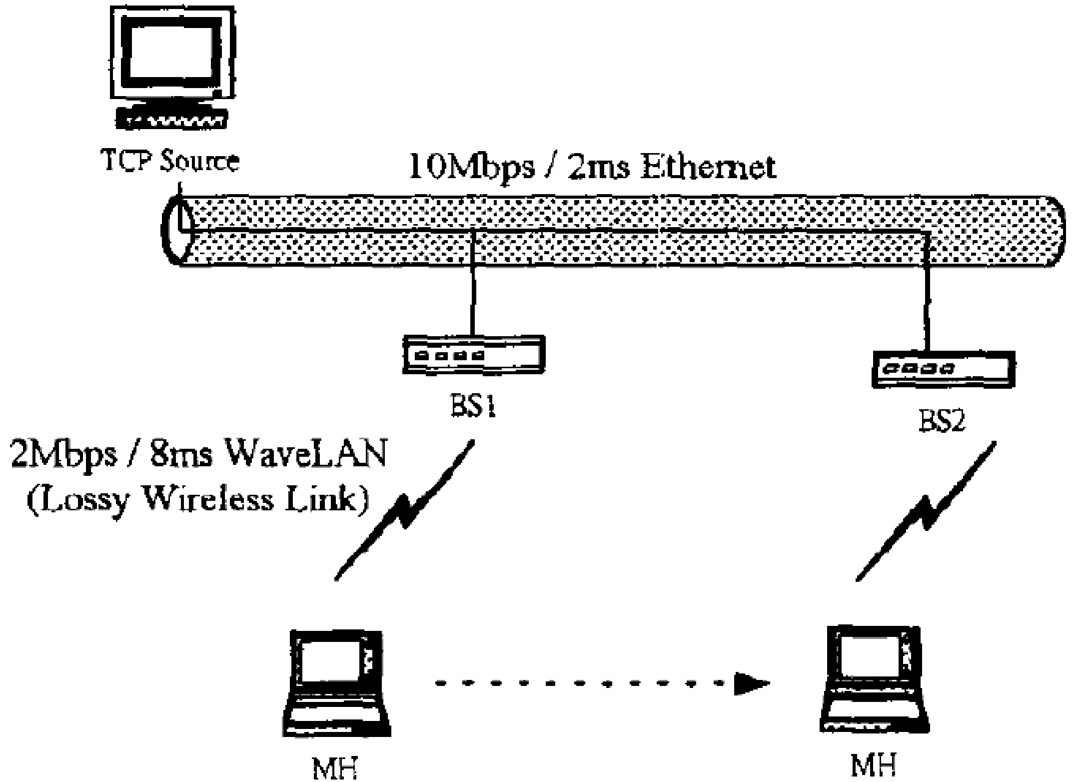


Figure 6: Experimental Topology for LAN Environment.

Simulation

Table 2: The Throughput (Kbps) of Various Protocols When Mobile Host Handoffs

Protocol	W-TCP	Snoop	TCP-FR	SACK	I-TCP	Reno-TCP
Throughput	608.69	475.14	392.49	345.40	209.88	192.95

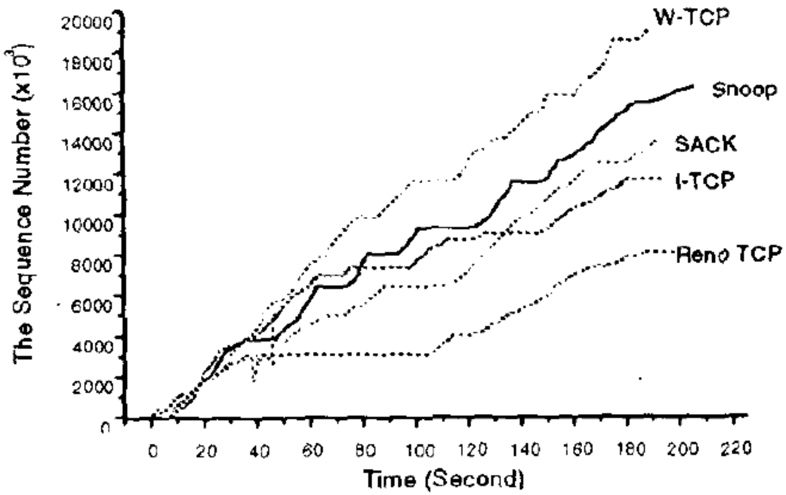


Figure 7: The Sequence Number that Received by the MH in LAN Environment.

Simulation

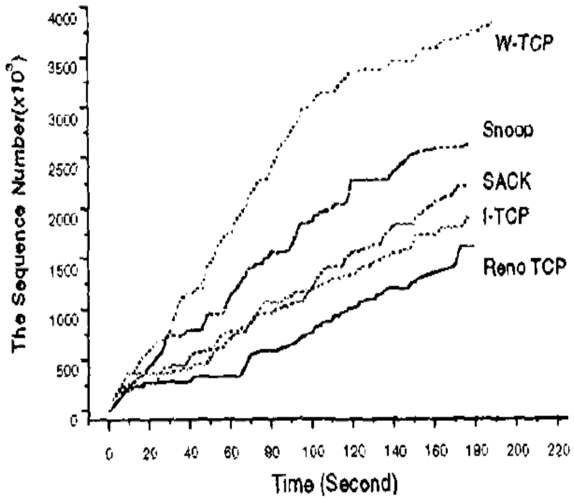
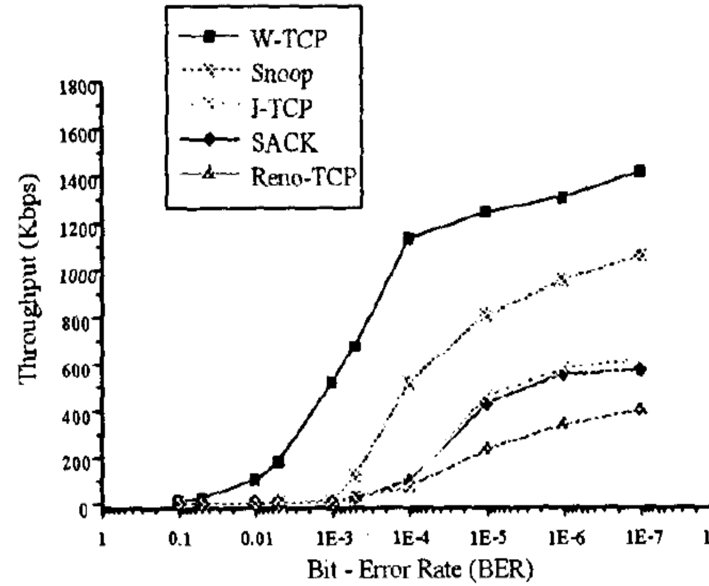


Figure 8: The Sequence Number that Received by the MH in WAN



Simulation

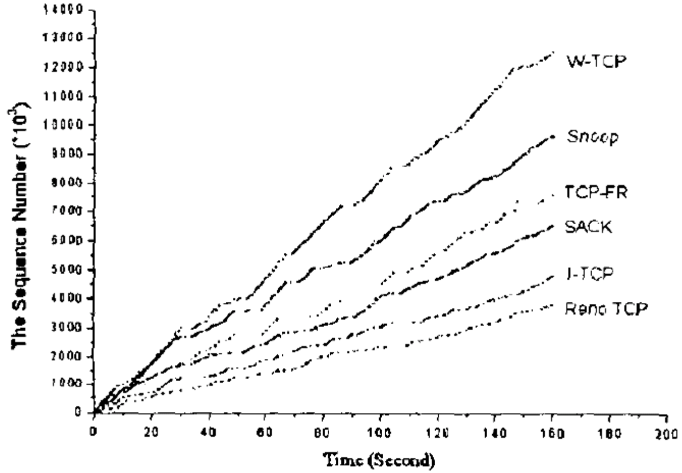


Figure 10: The Sequence Number for Non-Real-Time Traffic When MH Handoffs

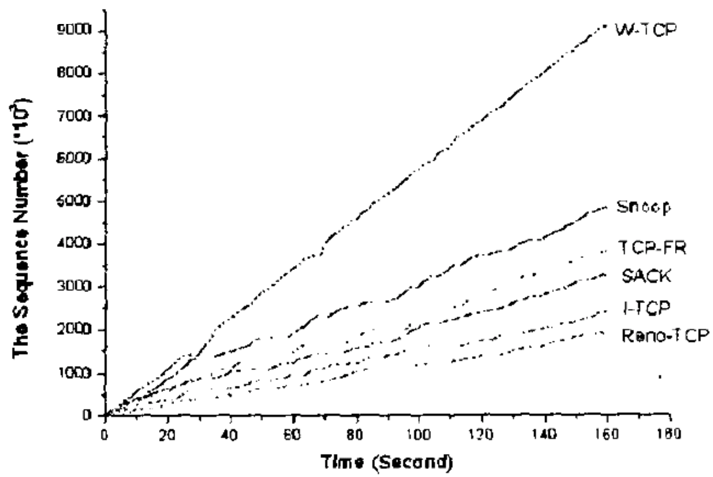
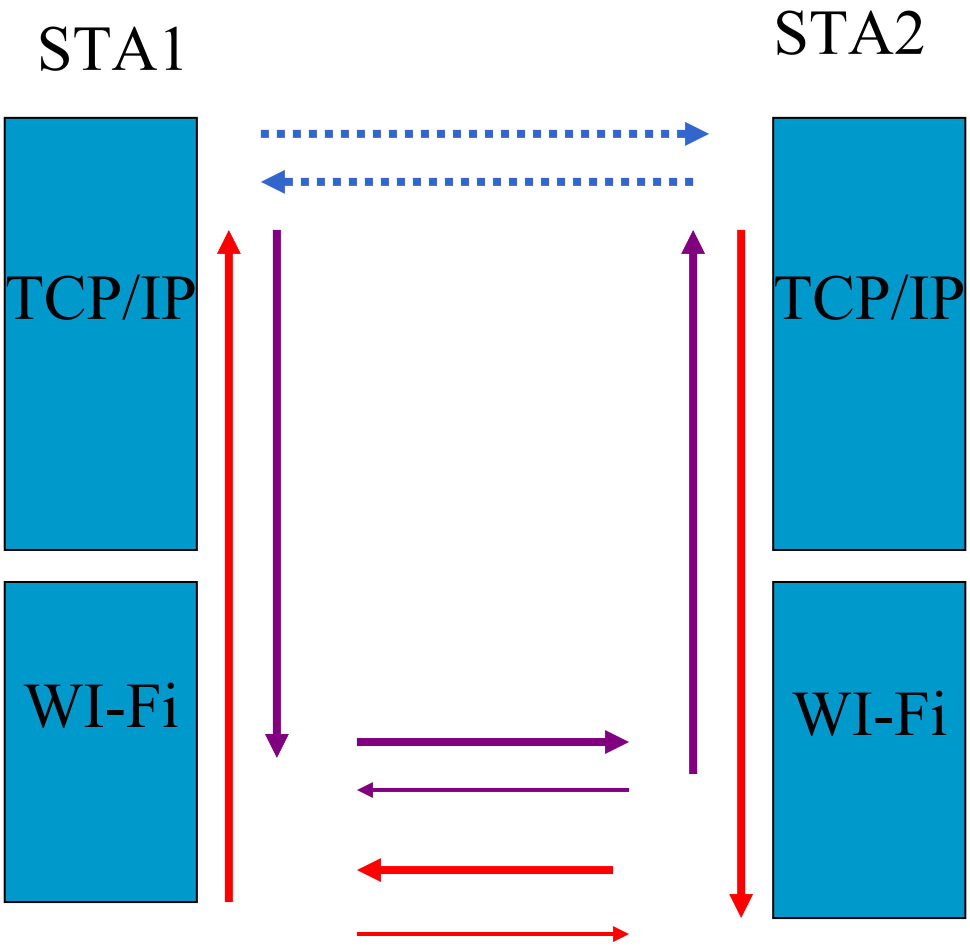


Figure 11: The Sequence Number for Real-Time Traffic When

Conclusion and future work

- For future works
  - To validate our result over other wireless network systems, such as **GSM** and Satellite networks
  - Apply the proposed protocol to multi-hop wireless ad-hoc network,in which the topology may rapidly change due to the movement of wireless hosts.

TCP/IP Layer Issue



TCP/IP Layer Issue

- Omit the Link Layer ACK with acceptive BER.
- Assumed it is Packet loss always, non-Congestion over the wireless link.
- If the Packet loss is increasing(High BER).
  - Adaptive the MAC frame size.
  - Degrade link speed.
- Traffic Congestion(Multiple-STAs)
  - Admission Control<->Congestion Control

TCP/IP Layer Issue

- Advantage
  - Increase Performance(moderate BER)
  - Save Bandwidth.
- Disadvantage
  - Frequency Collision.
  - High BER.

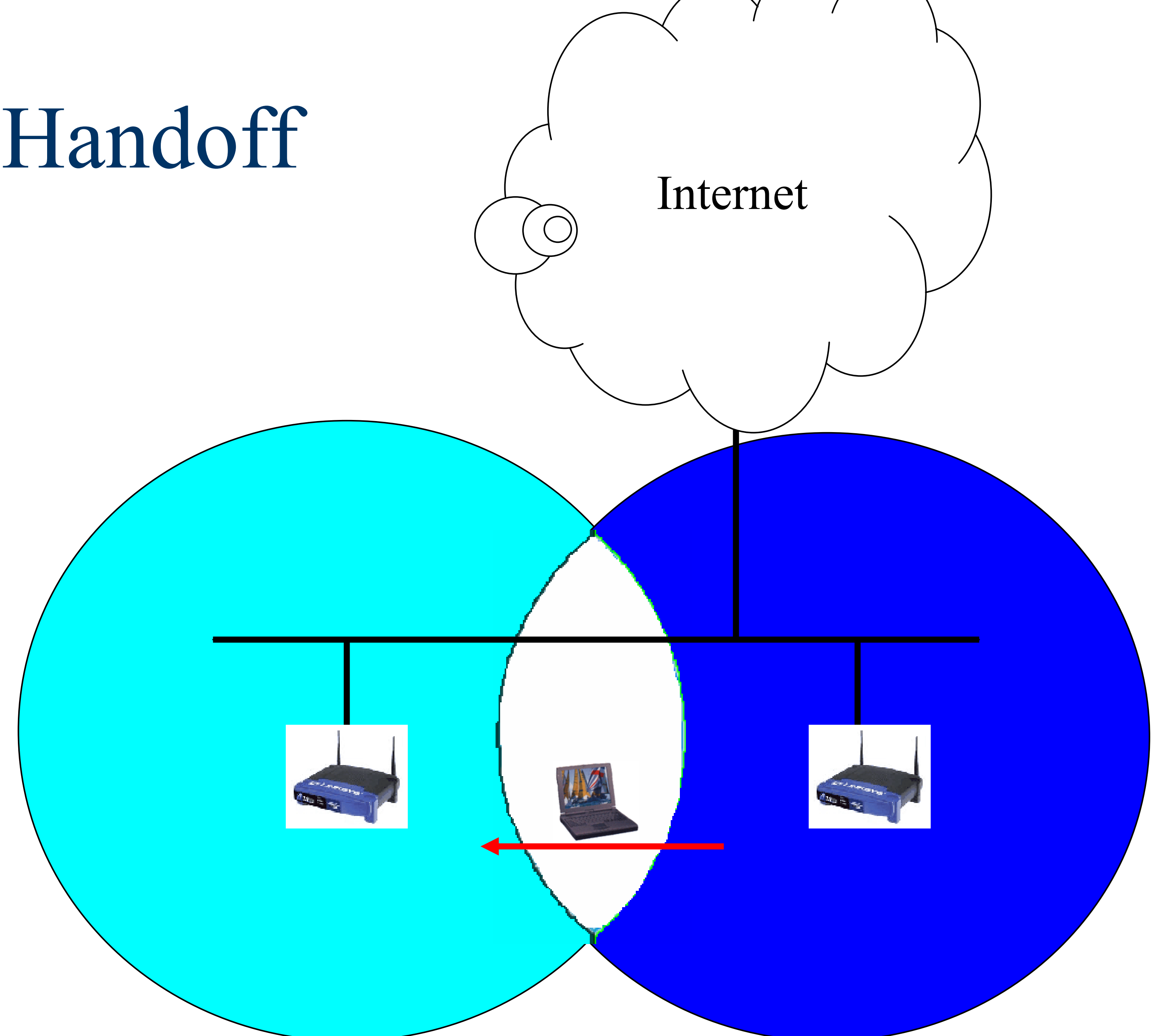
Adaptive MAC Frame Size

- 802.11 Standard MAC Fragmentation
  - – fixed size
- Factor
  - – packet lost or retransmit time
    - It is difficult to derive the BER of Wireless Links
- Dynamic Adaptive Fragmentation.
  - – Dynamic Degrade Frame Size step by step.

Handoff

- Pre-Authentication
- Pre-Association
- 802.11f.
- 802.11r.
- Real Time traffic
  - UDP

Handoff



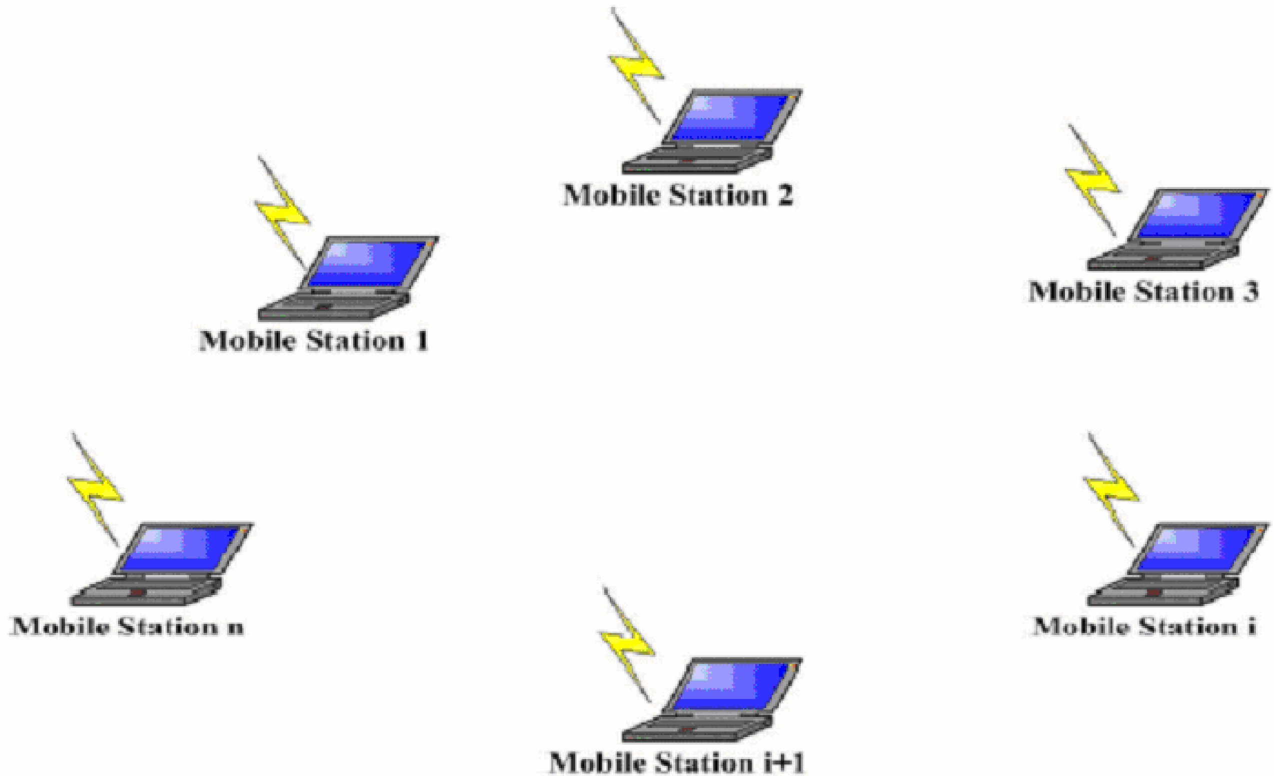
Multiple-STAs Admission Control

- Congestion Control.
- Real-Time Performance Guarantee.
- Bandwidth Allocation.
- Factor
  - Delay(Link Status, Packet Loss, BER)
  - Video(V)/Audio(A)/Background(B).
  - Variable V, A, B;
  - Max(V) + Max(A) + Max(B)

Simulation to evaluate the performance of DCF in ad-hoc mode

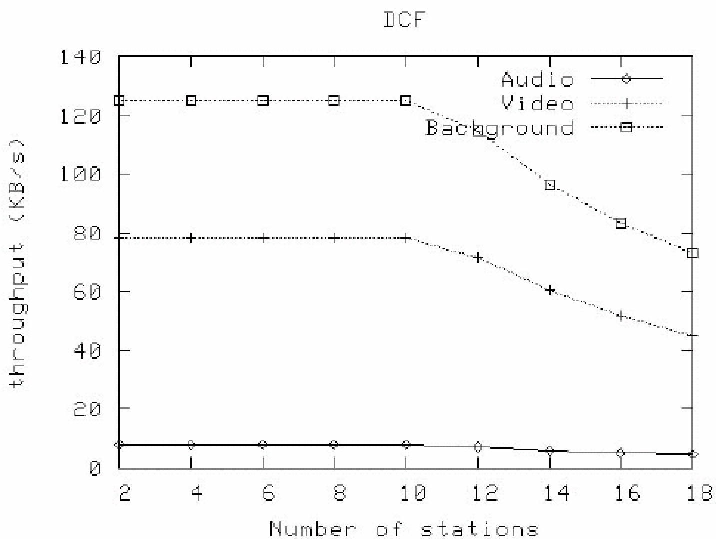
- 802.11a PHY mode-6 [23]
- Three types of traffic (audio, video and background traffic)
  - The packet size of audio is equal to 160 bytes and the inter-packet arrival interval is 20ms, which corresponds to 8KB/s PCM audio flow.
  - The video sending rate is 80KB/s with a packet size equal to 1280 bytes.
  - The sending rate of background traffic is 128 KB/s, using a 1600 bytes packet size.

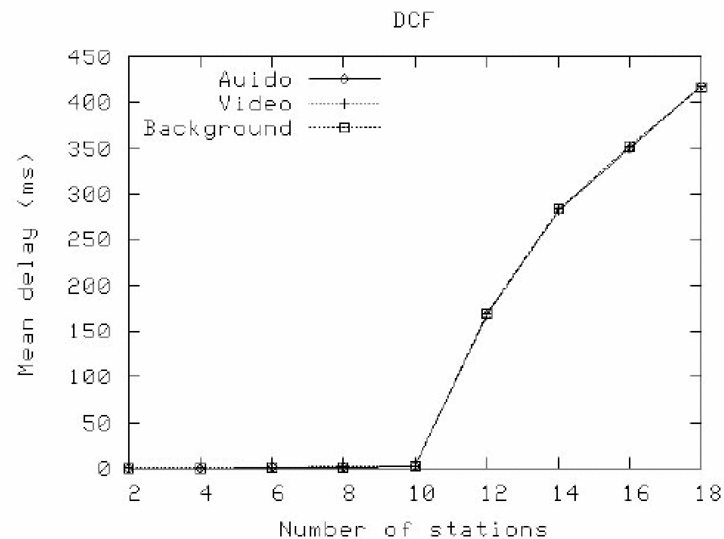
Simulation Topology of DCF in ad-hoc mode



Simulation topology of DCF in ad-hoc mode

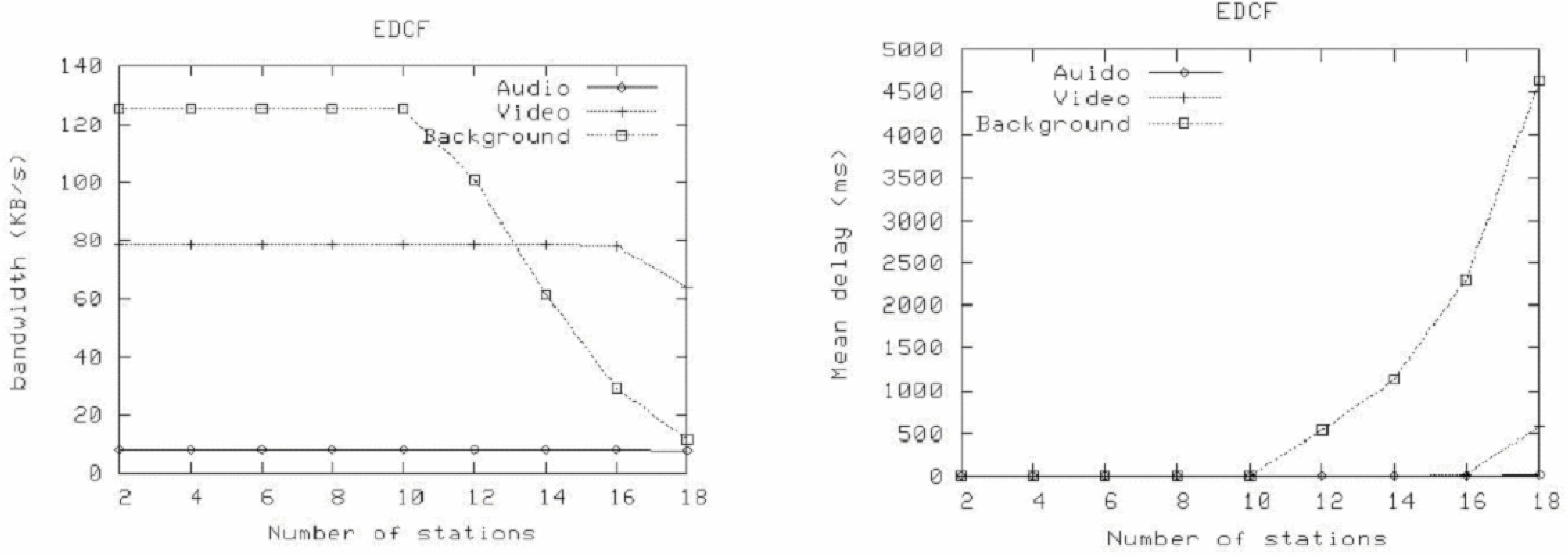
Throughput and delay performance for DCF





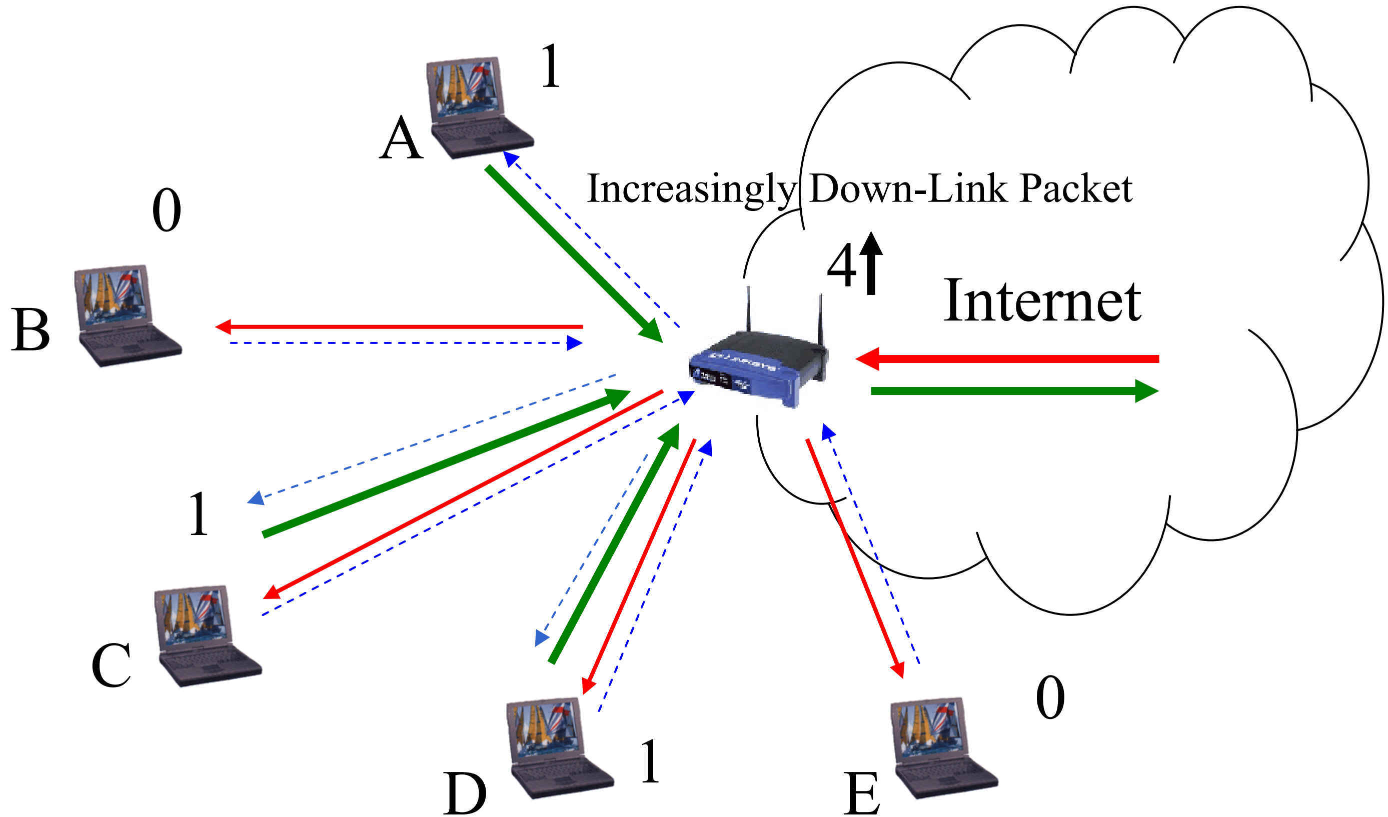
Throughput and delay performance for DCF

Throughput and delay performance for EDCF

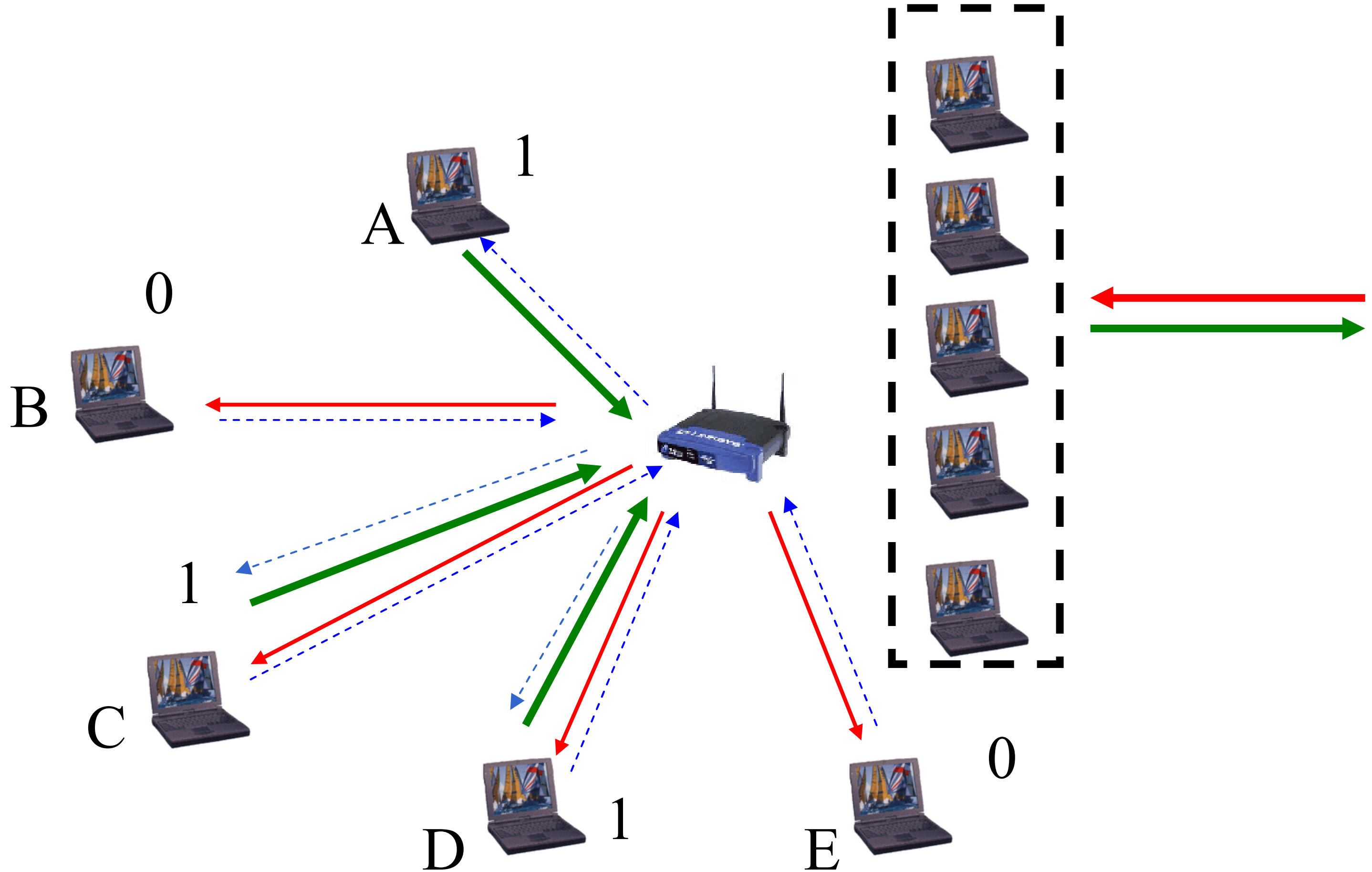


Throughput and delay performance for EDCF

Multiple-STAs
Up-link and Down-link Issue



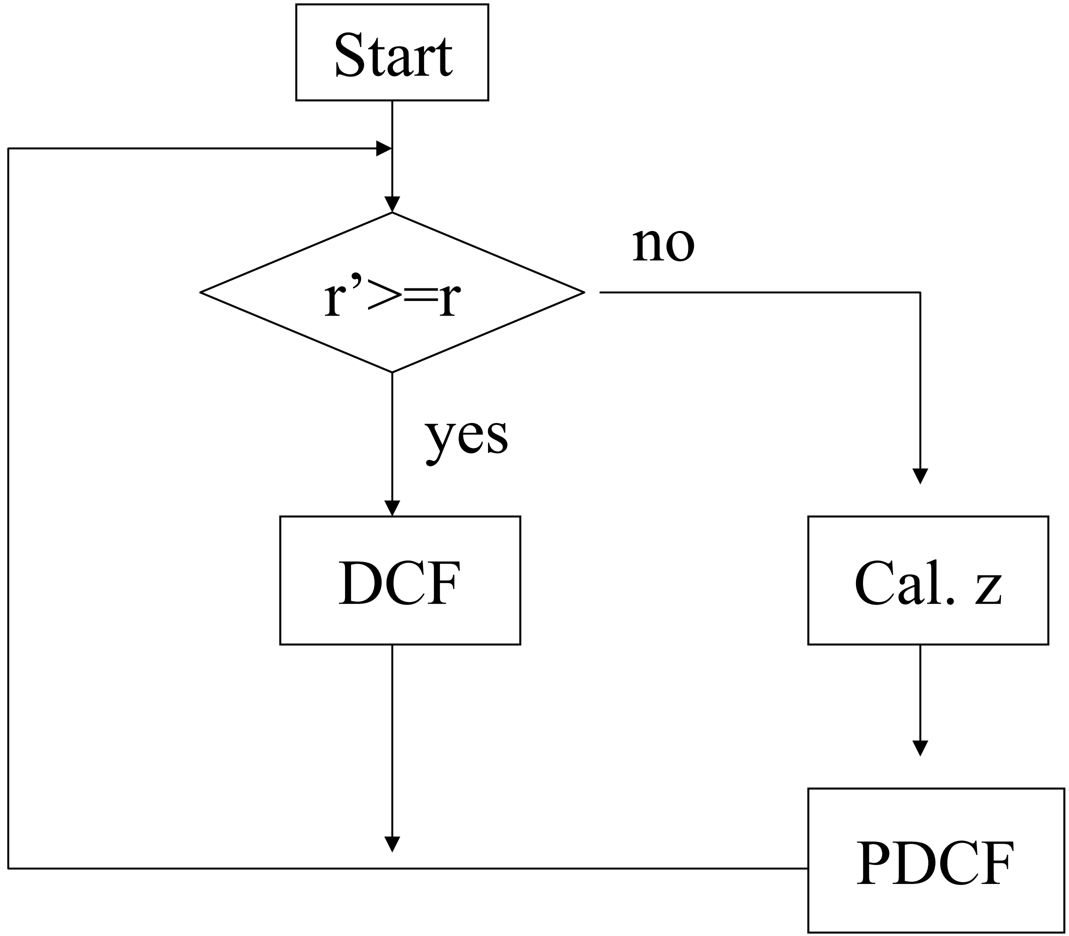
Multiple-STAs
Up-link and Down-link Issue



Multiple-STAs
Up-link and Down-link Issue

- SAT number = S;
- Up-Link's SAT number = Us (Variable) Us<=S;
- Down-Link's SAT number = Ds (Variable); Ds<=S;
- r = Ds/(Ds+Us); Initial r = 1/2;(Maybe We can fix r =1/2)
- transmitted Up-link packet number = x;
- transmitted Down-Link packet number = y;
- r'=y/(y+x);
- Dynamical tune z, Keep (y+z)/(y+z+x) ~r ;
- AP will transmit z packets continuous with shorter Inter-frame space(PIFS).

Multiple-STAs Up-link and Down-link Issue



Multiple-STAs
Up-link and Down-link Issue

- Assume all STAs and the AP will have the same opportunity to. acquire the channel.
- PDCF highest priority.
- Only for Up-link and Down-link Issue, Non-QoS Issue.

Reference

- Q. Ni, L. Romdhani, and T. Turletti, "A Survey of QoS Enhancements for IEEE 802.11 Wireless LAN," Journal of Wireless Communications and Mobile Computing, vol. 4, no. 5, pp. 547-566, August 2004.