Implementation of WiFiRe MAC

M. Tech. Project Presentation

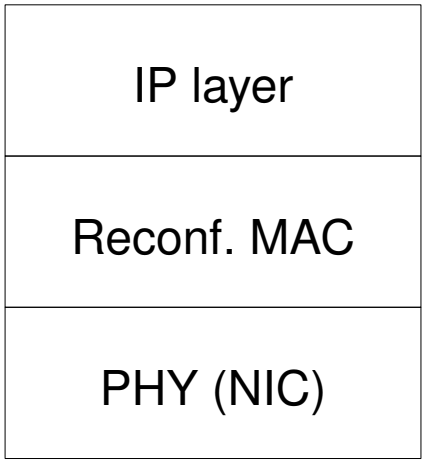
Janak Chandarana
Roll Number: 05329R04
CSE, IIT Bombay
Supervisor: Prof. Sridhar Iyer
Co-supervisor: Prof. Anirudha Sahoo

Outline

- Wireless testbed, PHY integration (7)
- Encapsulation, fragmentation of packets (4)
- GPSS mode, memory management, packet filters (4)
- Results, conclusions, future work (1-2)
- Implementation issues (1)

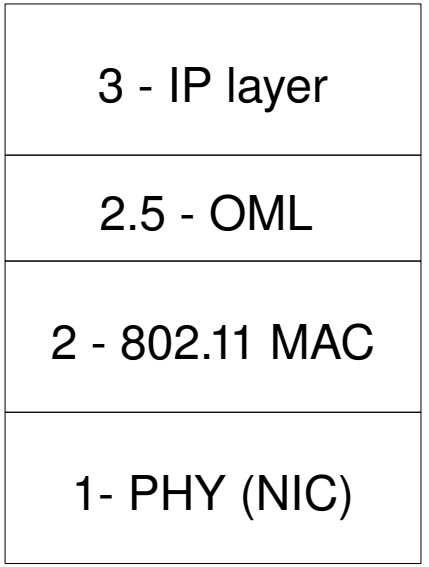
Replacing 802.11 MAC

- Reconfigure 802.11 MAC approach
  - Atheros HAL with madwifi drivers
  - Related work: softMAC
  - Direct control of framing
  - Fine time granularities (micro Sec)
  - Kernel/Driver level implementation




```
typedef struct _ieee_802_11_header {
        u16     ver:2,
                type:2,
                subtype:4,
                flags:8;
        u16     duration;
        u8      mac1[6];
        u8      mac2[6];
        u8      mac3[6];
        u16     SeqCtl;
} Ieee80211Header;
```

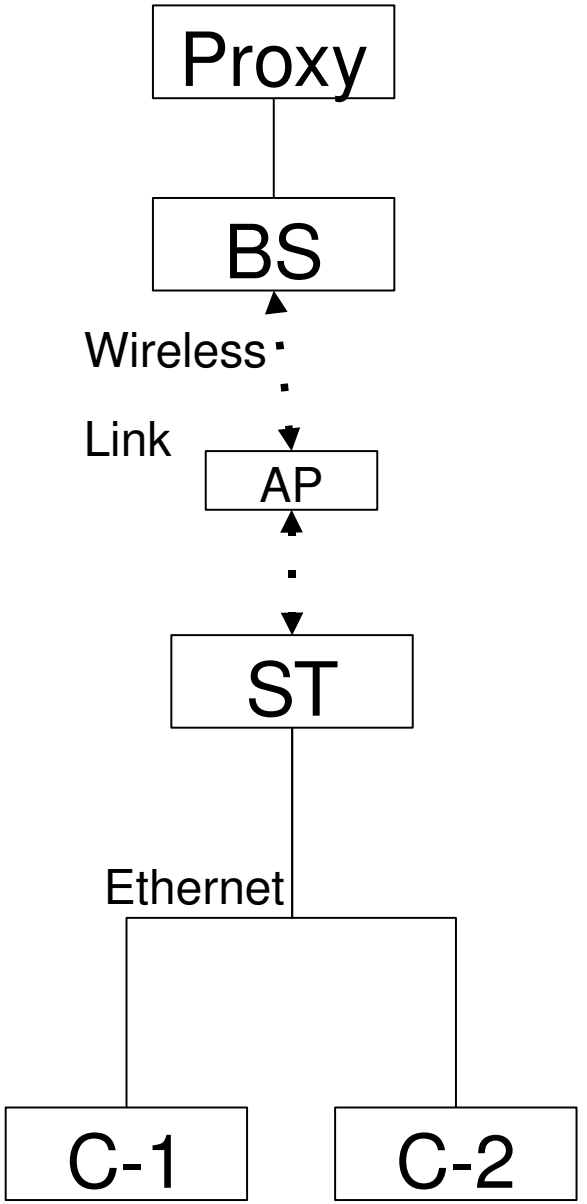
Replacing 802.11 MAC (cont.)



- Overlay approach
  - MAC at layer 2.5
  - Schedules Tx in pre-decided time-slot
  - Related work: Overlay MAC Layer (UC, Berkeley)
  - Loosely coupled with PHY
  - Relatively large slot time (large enough to ignore clock syn error)
  - Periodic SYN with BS clock

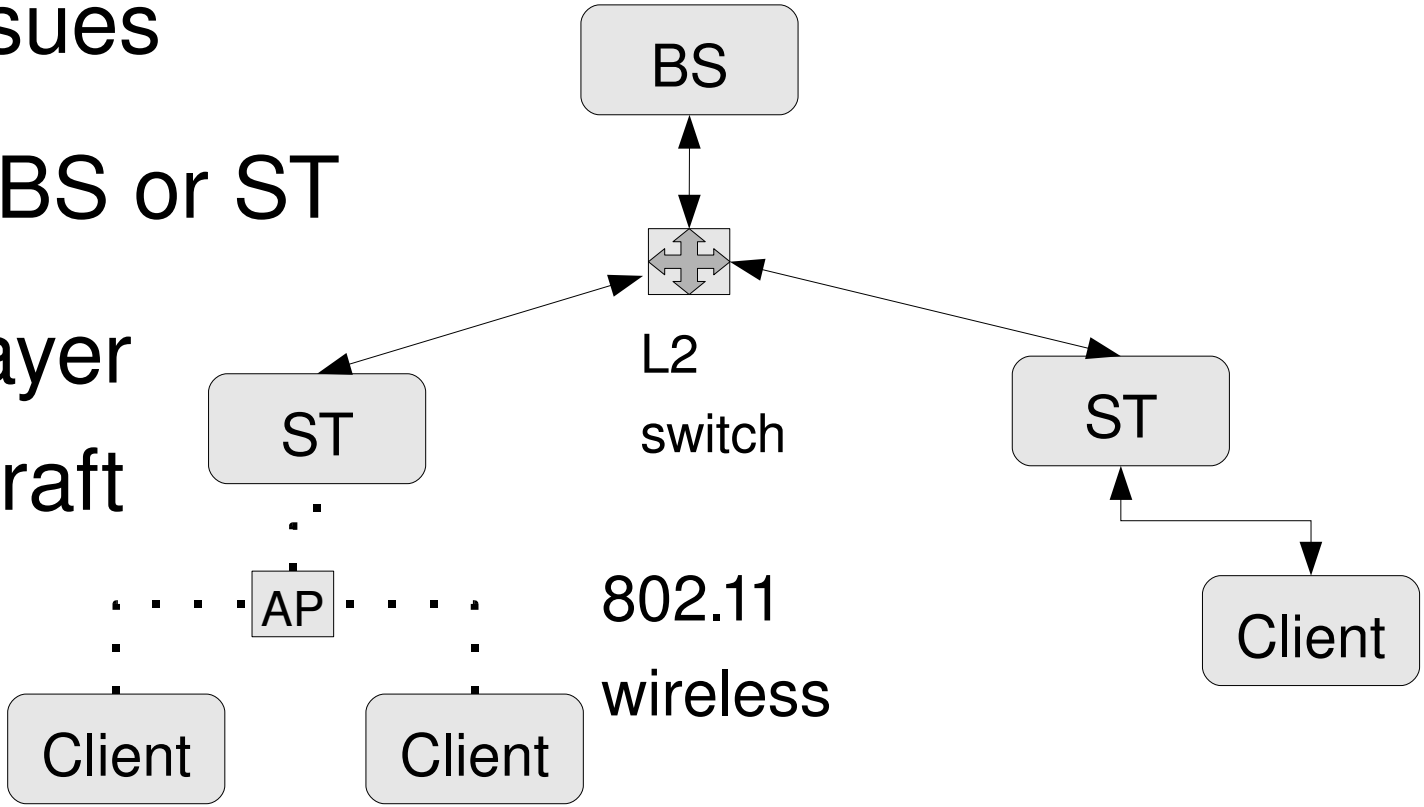
WiFiRe wireless link

- Using PF_SOCK and madwifi drivers
- Overlay approach
- Madwifi driver, D-link wireless cards
- Advantages – scheduled Tx (10mSec), better than CSMA/CA
- Disadvantages – not scalable, short range
- Packet header should be correct

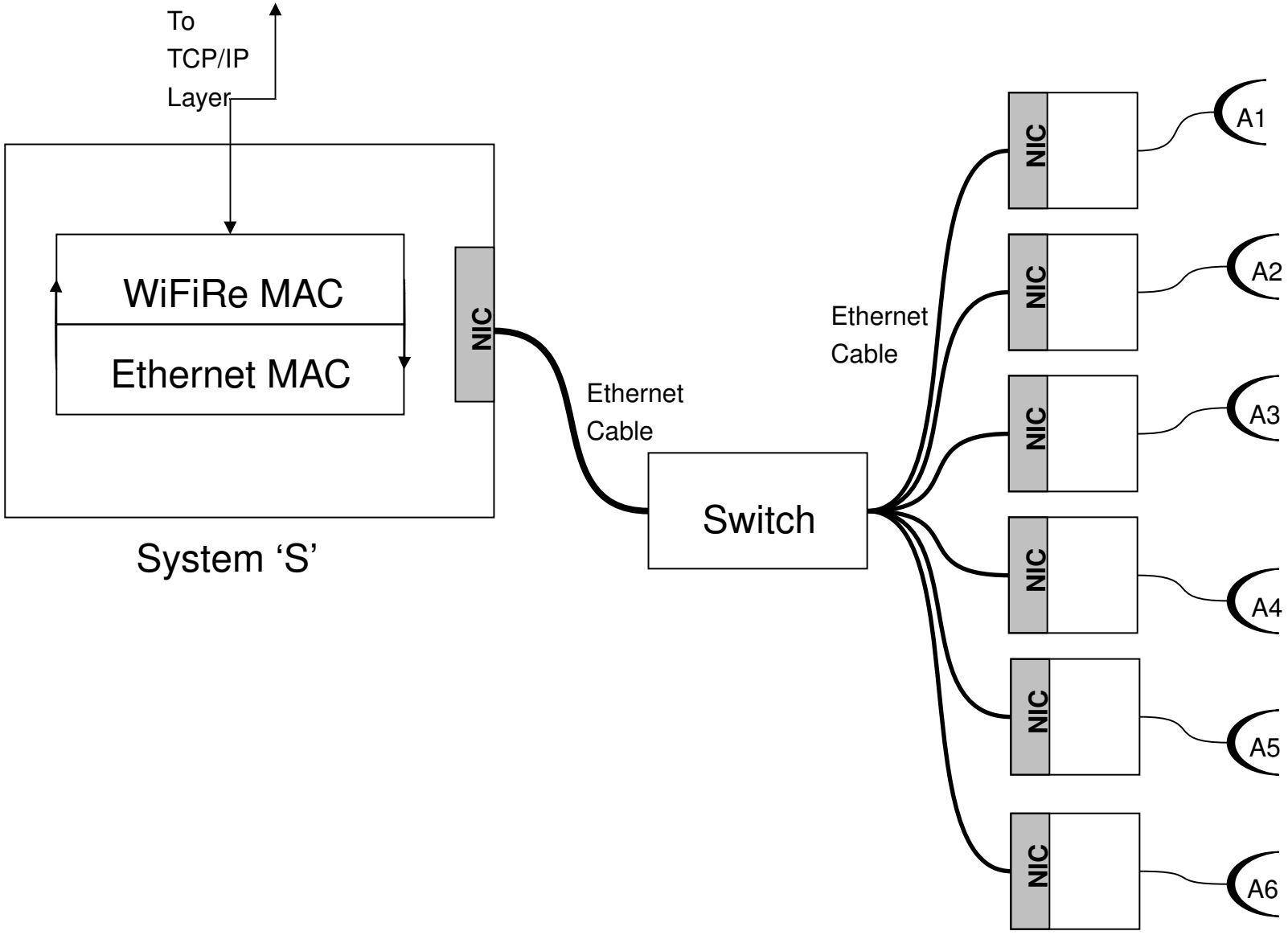


802.11 Clients

- Can be connected via AP or ad-hoc mode
- Interference issues
- No change on BS or ST
- Supports CS layer mentioned in draft
- DHCP issue

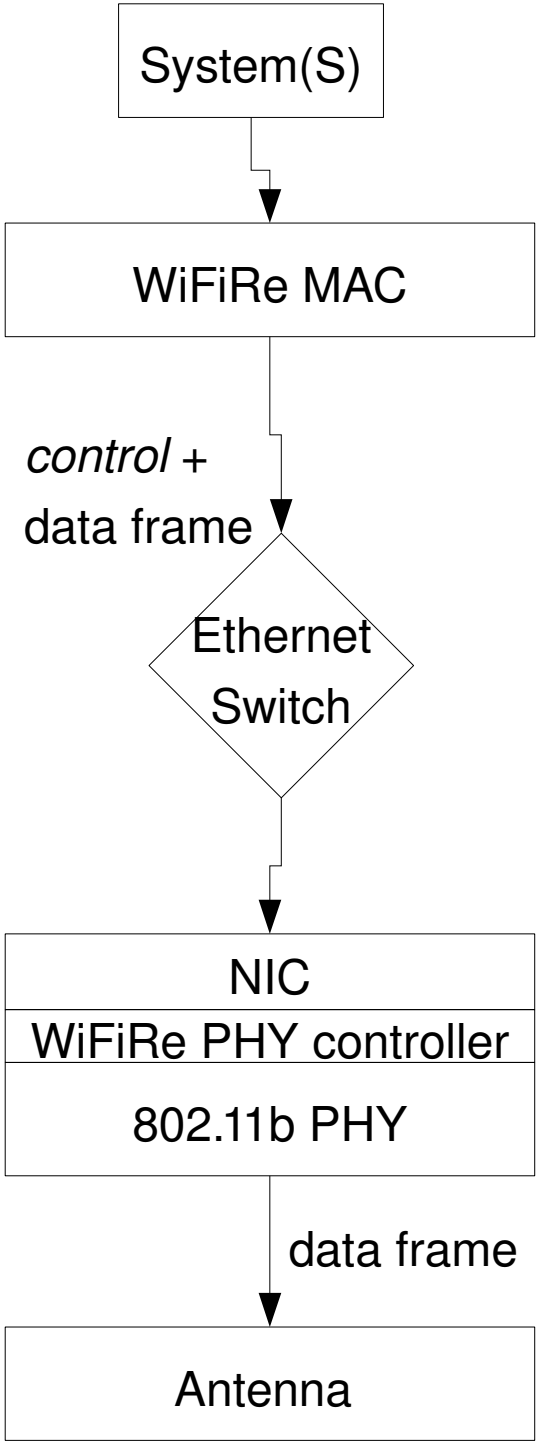


Integration with IITM-PHY board



WiFiRe PHY integration

- MAC and PHY are separate entities
- MAC to be delivered on Ethernet
- PHY to be developed independently by IITM
- WiFiRe MAC for BS and ST

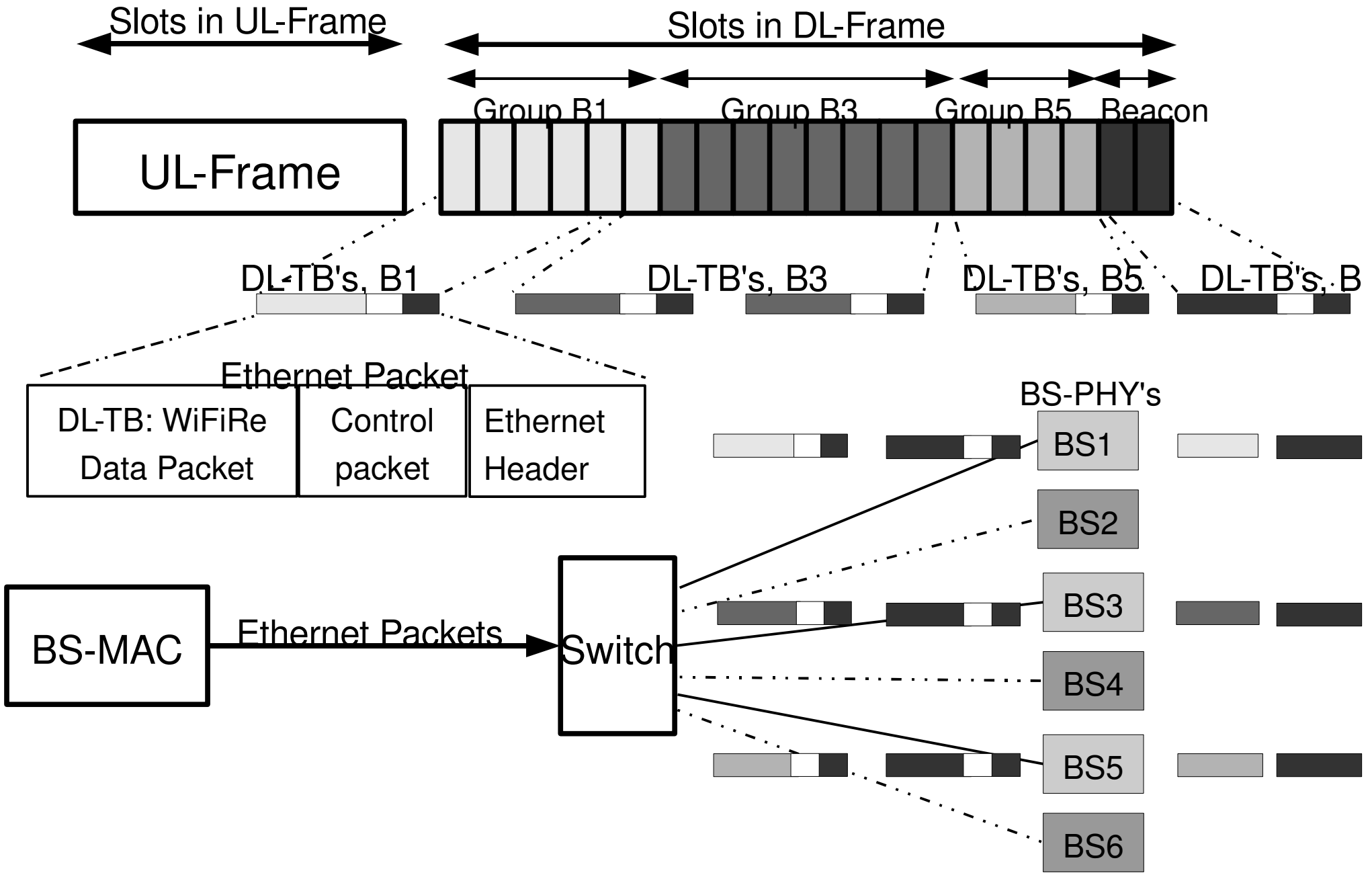


Assumption from IIT-M PHY board

- Give feedback to MAC about PHY characteristic (like modulation, bandwidth, timeslot, sync issue etc.)
- Able to send / receive packet on given time slot (for example: send 1000 bytes at t=50)
- Synchronisation among sectors (6 PHY issue)
- Understand Ethernet packets
- Buffer for bigger packets

Meta Frame Construction

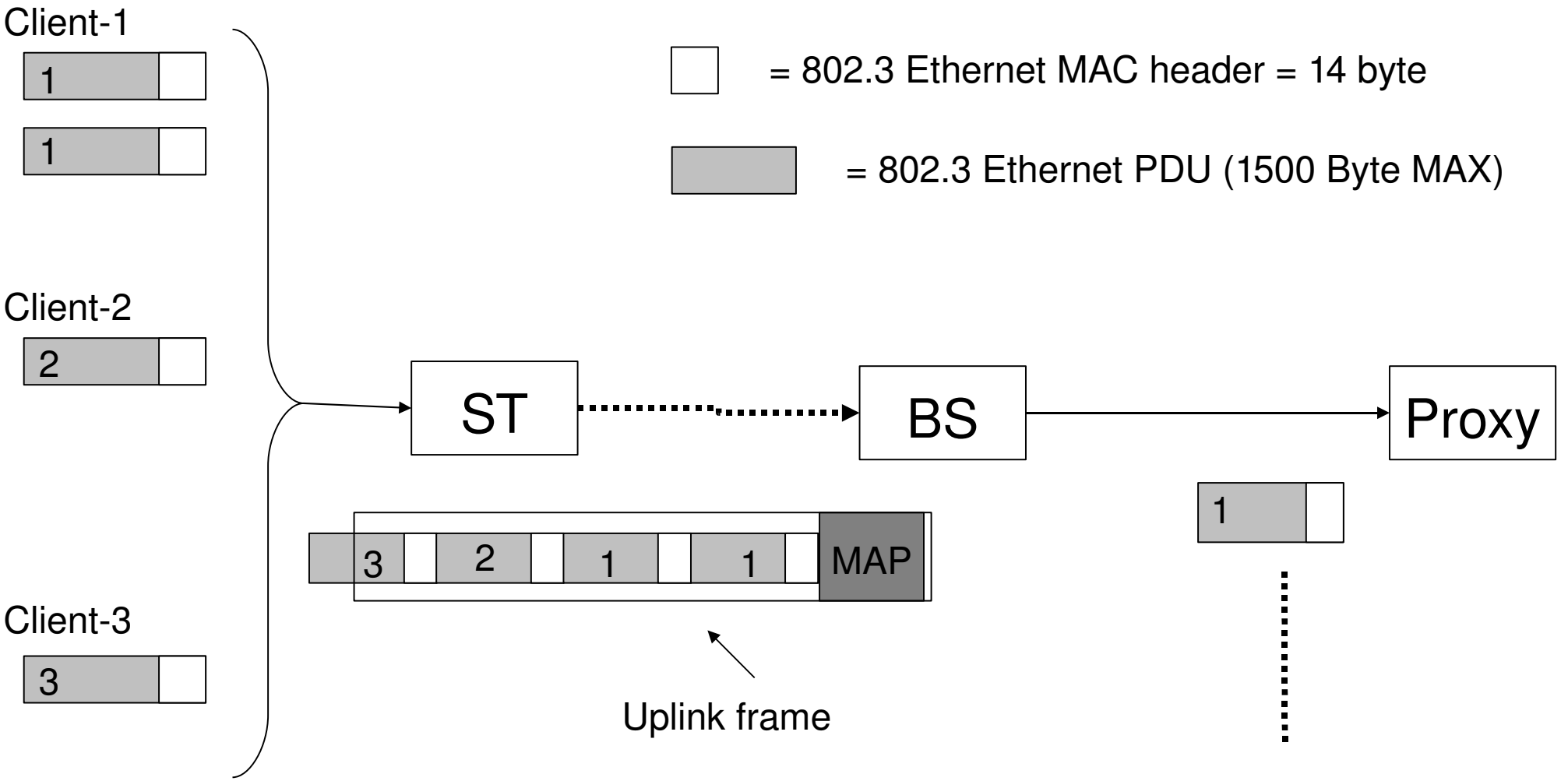
PLCP issue



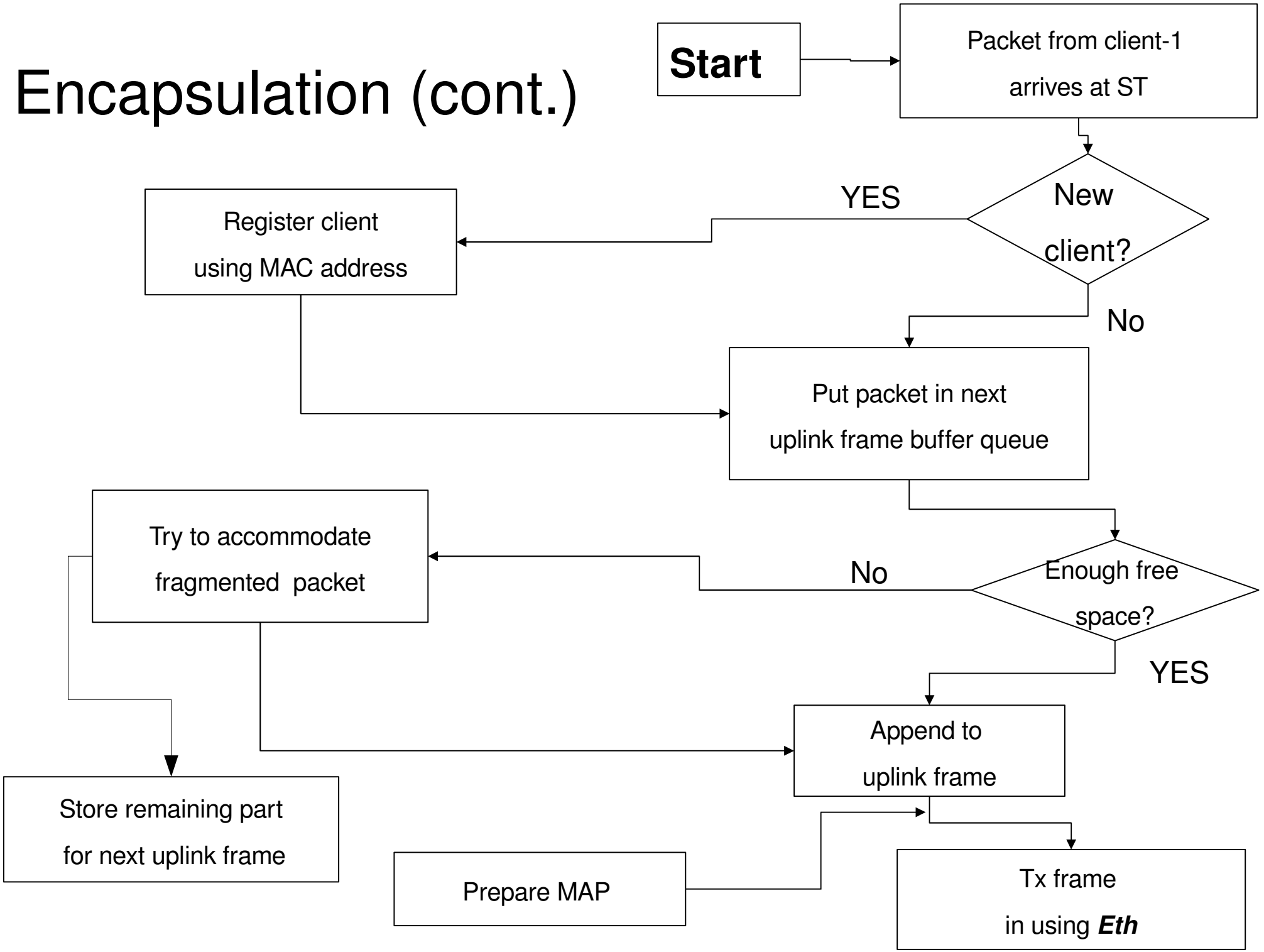
Encapsulation and Fragmentation

- ST will receive packets from client, keep them in buffer
- Encapsulate multiple MAC packets and make packet of 1450 bytes
- Fragment packet (if doesn't fit in frame)
- Takes care of Ethernet MTU
- Keep client Eth MAC header as it is
- Diagram - next slide

Encapsulation and Fragmentation (cont.)



Encapsulation (cont.)



Encapsulation and Fragmentation (cont.)

```
 98
 98  79
 98  79  98
 98  79  98  79
 98  79  98  79  98
 98  79  98  79  98  98
 98  79  98  79  98  98  79
 98  79  98  79  98  98  79  98
 98  79  98  79  98  98  79  98  98
 98  79  98  79  98  98  79  98  98  79
 98  79  98  79  98  98  79  98  98  79  98
 98  79  98  79  98  98  79  98  98  79  98  79
 98  79  98  79  98  98  79  98  98  79  98  79  98
 98  79  98  79  98  98  79  98  98  79  98  79  98  98
98 79 98 79 98 98 79 98 98 79 98 79 98 98 73
BYTES=25

25  25  79
 25  79  98
 25  79  98  98
 25  79  98  98  79
 25  79  98  98  79  79
 25  79  98  98  79  79  98
 25  79  98  98  79  79  98  98
 25  79  98  98  79  79  98  98  98
 25  79  98  98  79  79  98  98  98  79
 25  79  98  98  79  79  98  98  98  79  98
 25  79  98  98  79  79  98  98  98  79  98  98
 25  79  98  98  79  79  98  98  98  79  98  98  79
 25  79  98  98  79  79  98  98  98  79  98  98  79  98
 25  79  98  98  79  79  98  98  98  79  98  98  79  98  79
25 79 98 98 79 79 98 98 98 79 98 98 79 98 79 67
BYTES=31
```

Packet is divided

73 + 25 =98

ST collects packet and send them in single frame to BS

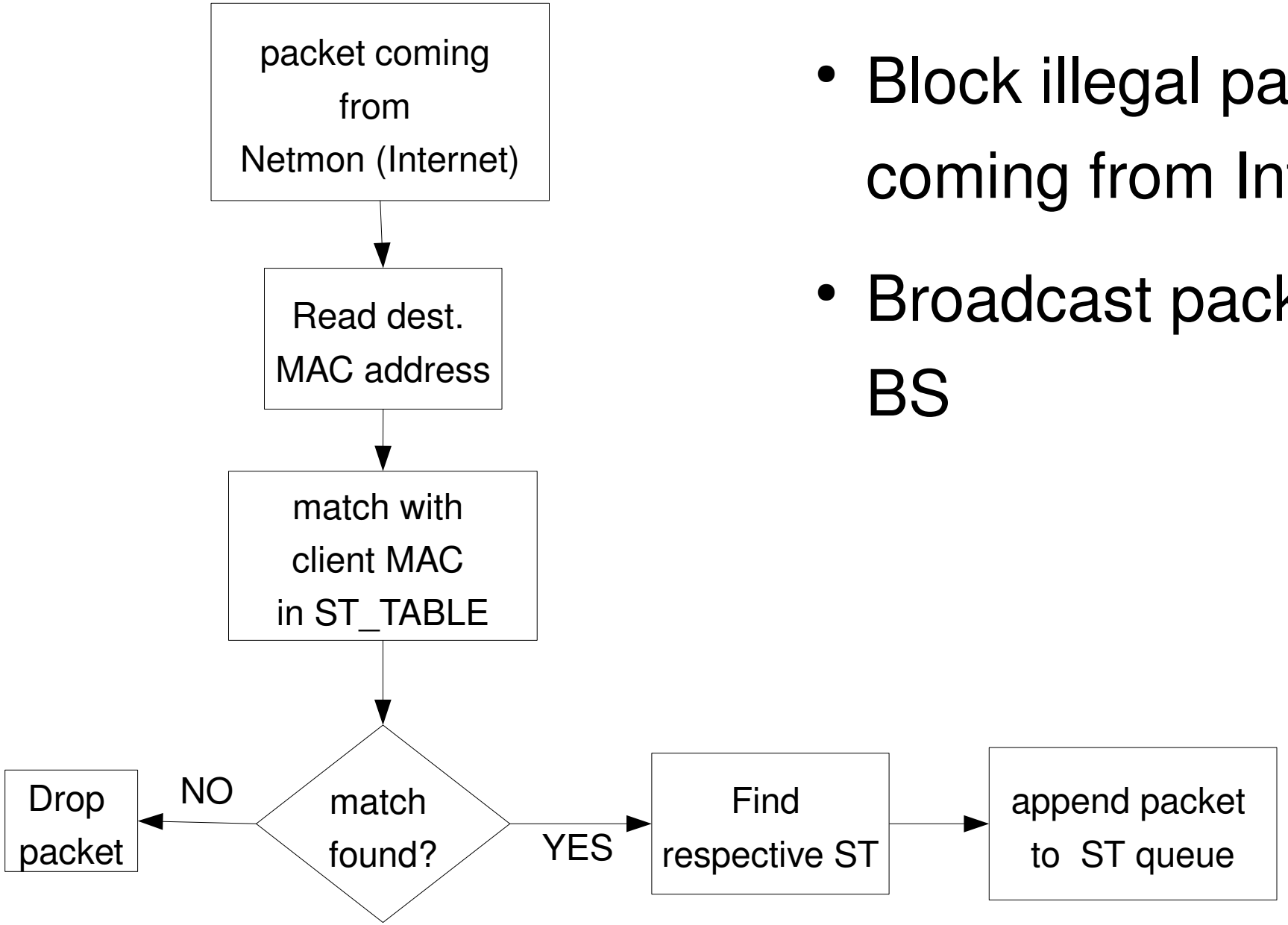
```
File  Edit  View  Terminal  Tabs  Help
broken packet flag=1 1 total_packets = 16 received

BEFORE MERGING: p 0 l=73  MERGED PACKET: p 0 l=98
packet 1 sent
packet 2 sent
packet 3 sent
packet 4 sent
packet 5 sent
packet 6 sent
packet 7 sent
packet 8 sent
packet 9 sent
packet 10 sent
packet 11 sent
packet 12 sent
packet 13 sent
packet 14 sent
packet 15 sent
BROKEN : packet 16 length=67

================================

Bytes received at BS: 1341

broken packet flag=0 0 total_packets = 15 received

BEFORE MERGING: p 0 l=67  MERGED PACKET: p 0 l=98
packet 1 sent
packet 2 sent
packet 3 sent
packet 4 sent
packet 5 sent
packet 6 sent
packet 7 sent
packet 8 sent
packet 9 sent
packet 10 sent
packet 11 sent
packet 12 sent
packet 13 sent
packet 14 sent
packet 15 sent
================================
Applications  Places  Desktop
WiFiRE BS
```

GPSS mode

- Grant per Subscriber station model followed (adapted from WiMAX)
- BS allocates slots (per ST basis)
- ST handles client level fairness, QoS
- SSID, CID on ST level
- Can be extended to support GPC, GPSF

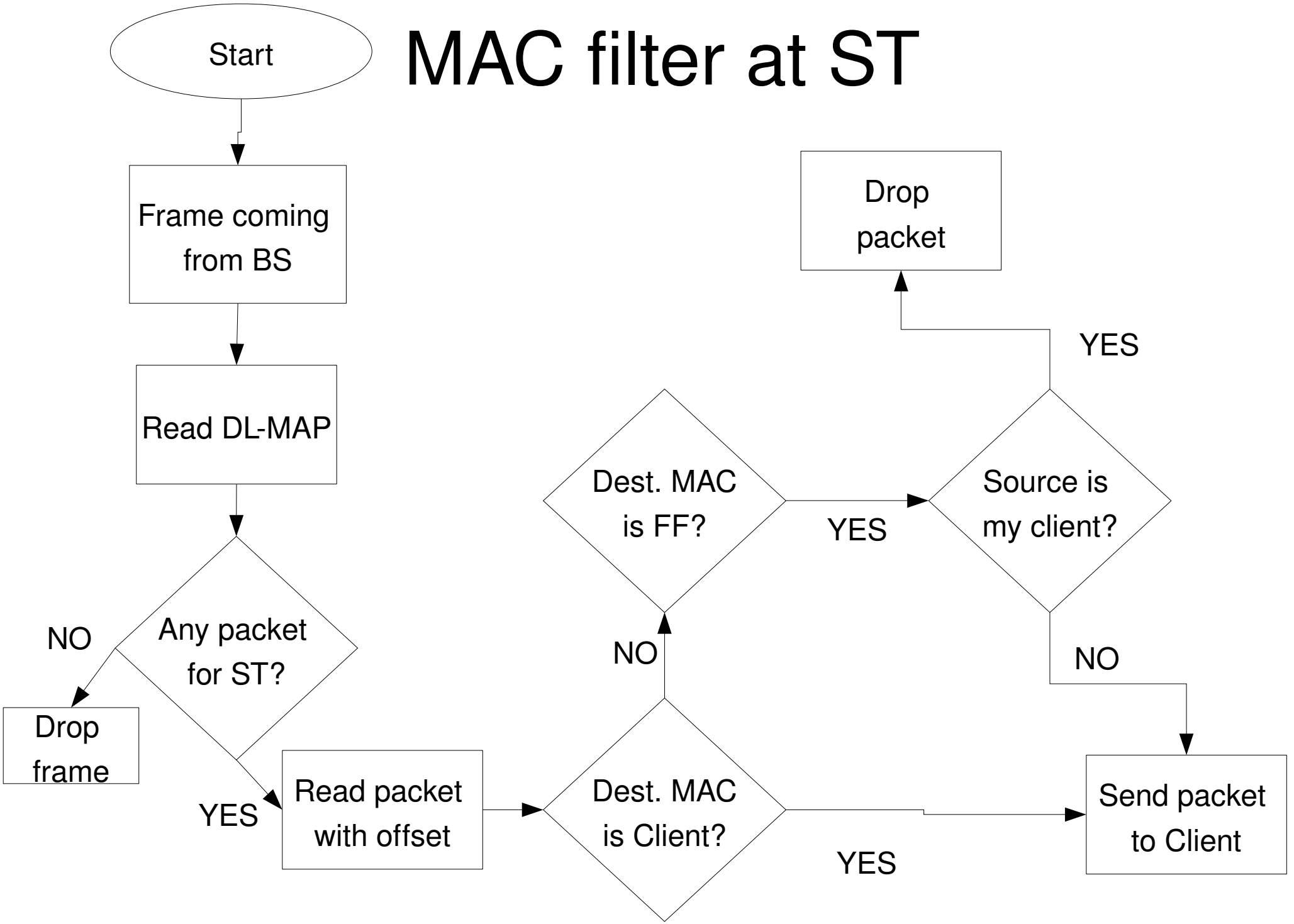
ST-ID	Client MAC
1	AA-AA-AA-AA-AA-AA
2	BB-BB-BB-BB-BB-BB
1	CC-CC-CC-CC-CC-CC
1	DD-DD-DD-DD-DD-DD
2	EE-EE-EE-EE-EE-EE

MAC filter at BS

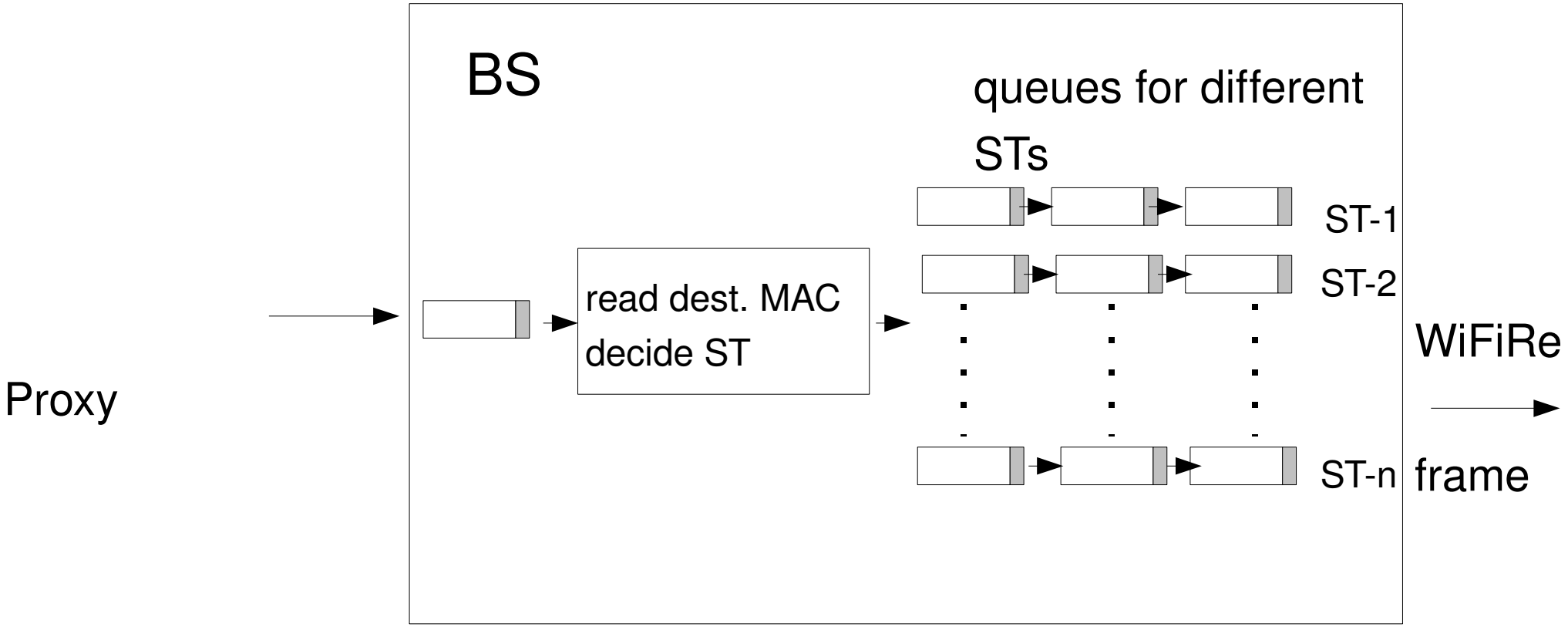


- Block illegal packets coming from Internet
- Broadcast packets at BS

MAC filter at ST



DL framing for GPSS



- FIFO scheme, supports scheduler
- Memory management unit

Results

- Delay within prescribed limit
  - Client to Proxy delay (avg. 15 ms)
  - Client to Client delay (avg. 30 ms)
- Data Rate: more than 120KBps
  - Depend on frame length, periodicity
  - Will increase with longer frame and multiple sectors
-

Result discussion

- Voice calls
  - VoIP to VoIP (G.711 with 214 bytes of packet, 20ms)
  - VoIP to PSTN (GSM codecs with 87 bytes, 20ms)
- SIG_ALRM accuracy 99.997%
- 56KB web page takes 5 sec to download

Future work

- Explore the possibility to implement MAC as part of kernel module
- Driver code of 802.11 and integration with WiFiRe
- Adding bulk ACK support for WiFiRe frame
- Performance analysis of WiFiRe testbed
- Time synchronization among 3 BSs
- Long range deployment and study of propagation delay
- Exploiting Ethernet MTU size of 1500 (with specialized hardware)

Implementation Issues

- RTP issue
- Firewall issue
- TCP checksum off-loading false alarm
- Multicast packet from Switch

WiFiRe Proxy machine

- Squid – web proxy and caching
- Asterisk – VoIP PBX
- Apache, maraDNS, DHCP server
- VoIP-PSTN gateway to work with WiFiRe client
- LAN environment (with TCP/IP) for clients
- Transparent L-2 system

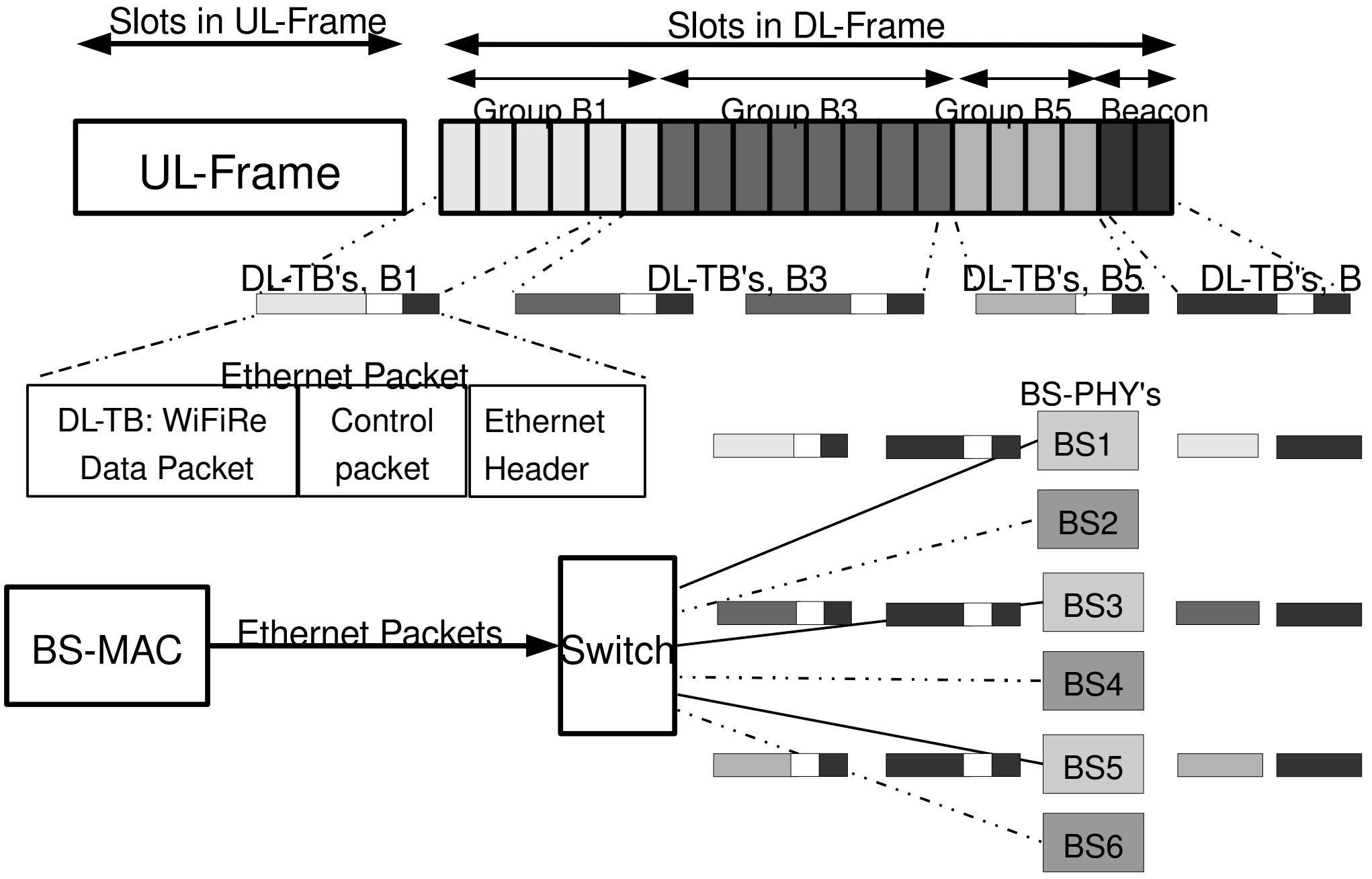
Future work

- Explore the possibility to implement MAC as part of kernel module
- Driver code of 802.11 and integration with WiFiRe
- Adding bulk ACK support for WiFiRe frame
- Performance analysis of WiFiRe testbed
- Time synchronization among 3 BSs
- Long range deployment and study of propagation delay
- Exploiting Ethernet MTU size of 1500 (with specialized hardware)

Backup slides

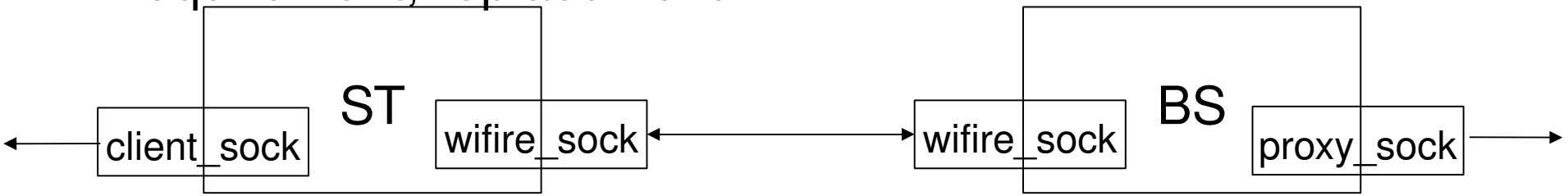
Meta Frame Construction

PLCP issue

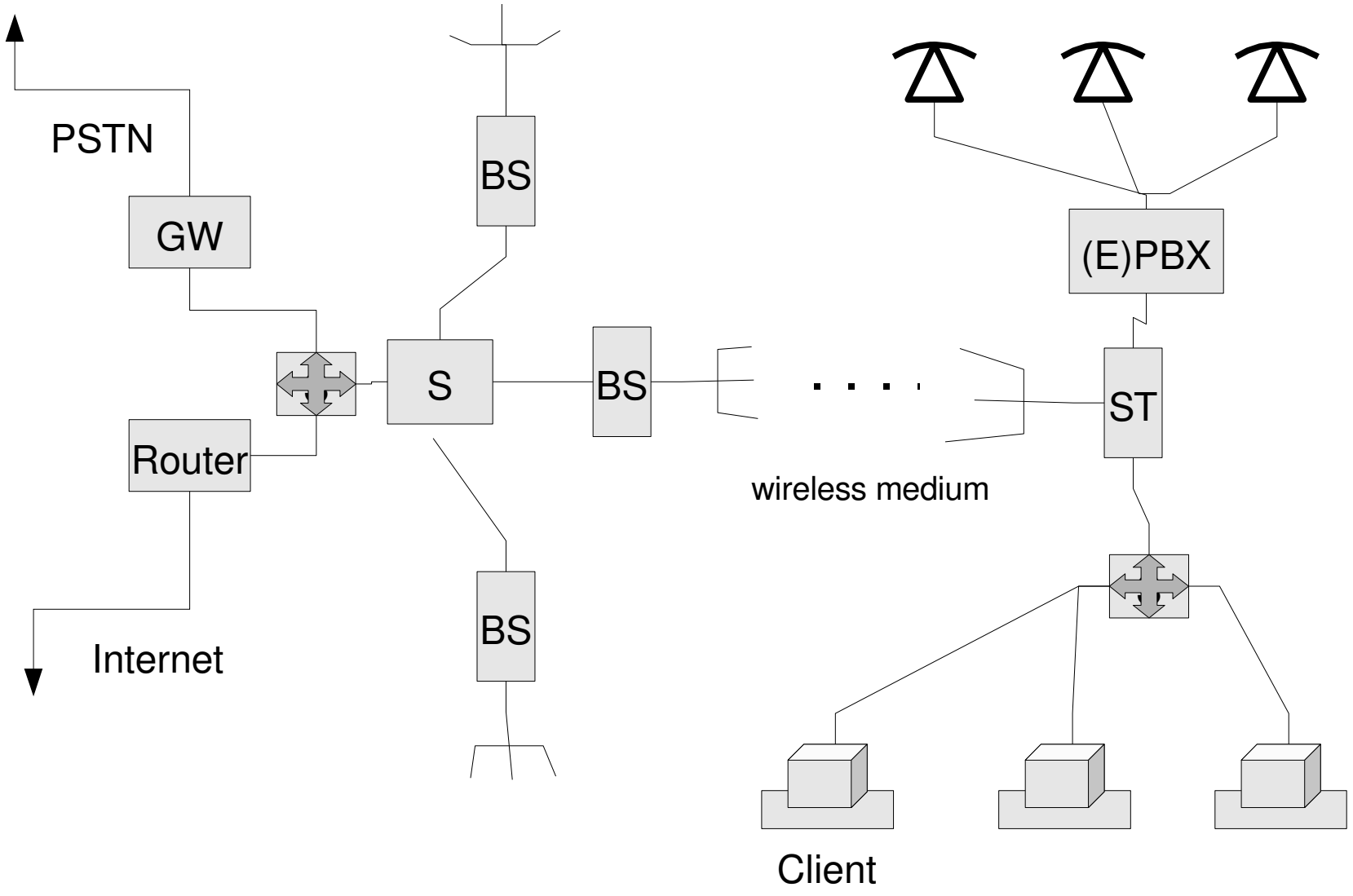


Ethernet sockets

- Using PF_SOCK with gcc
- Byte level access, Binding with particular NIC
- Send/receive data using sockets on MAC layer
- Allows non-Ethernet packets (like WiFiRe frame); Eth switch broadcast those packets, Eth MAC header not mandatory
- Why not in kernel module? PCAP?
- PHY requirement, replacement



WiFiRe architecture



- IP network for data and voice on wireless backbone

WiFiRe LAN emulation – basic setup

- Single Sector, 1 BS,

  multiple STs and clients

- Single proxy server to

  handle web and VoIP

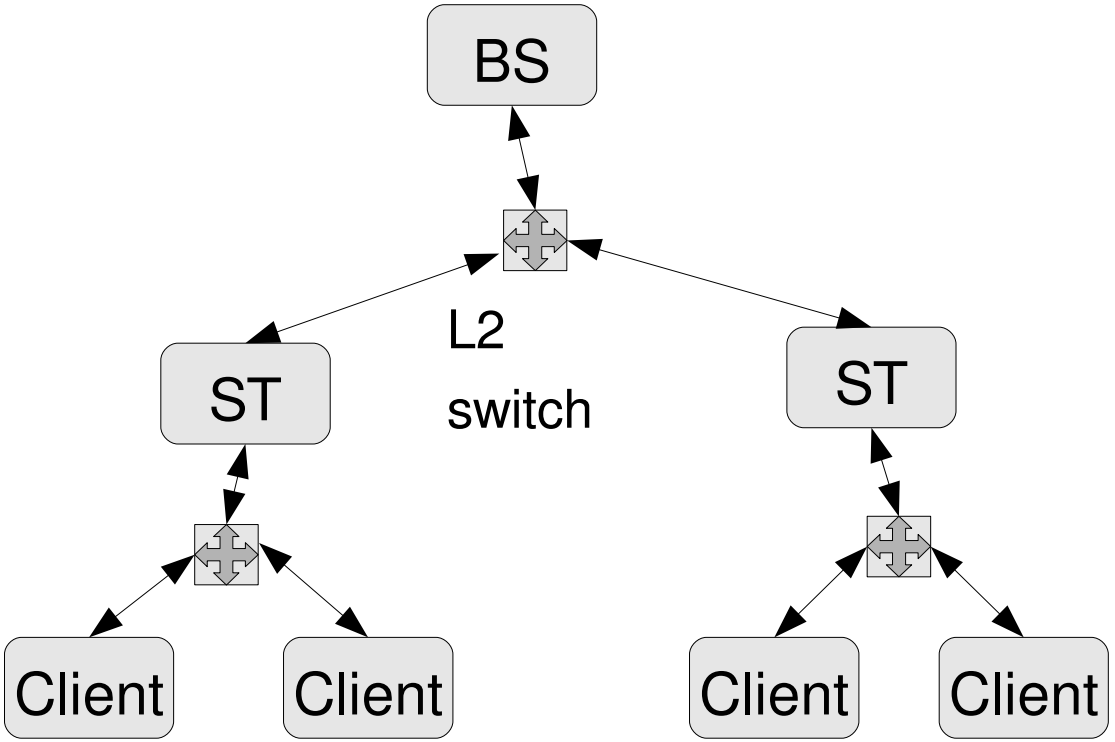
  requests

- All machines connected to

  ST using 802.3

- MAC code in user space

  with Ethernet Sockets

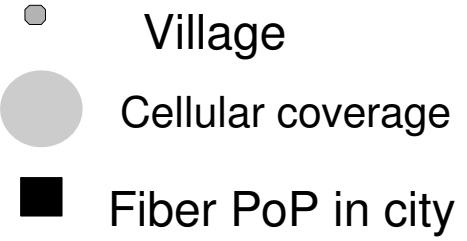


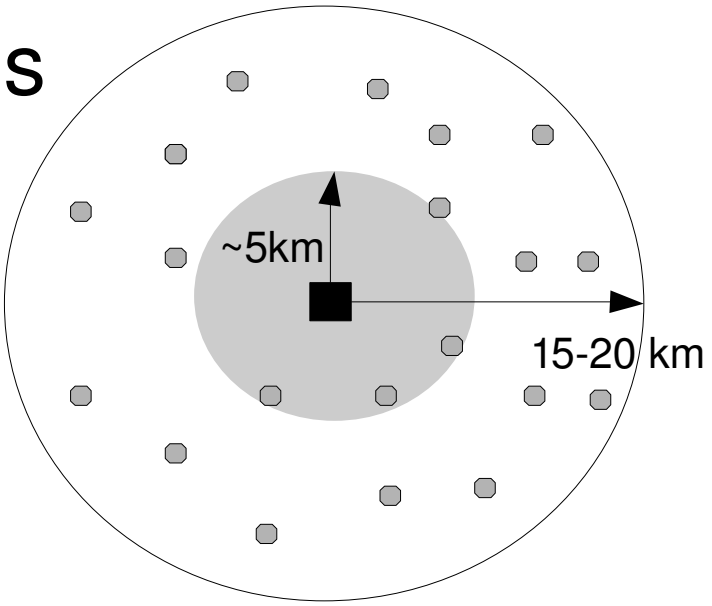
Motivation

- Low cost broadband Internet to rural India
- Applications
  - Voice calls (VoIP), E-commerce, E-gov, Day-to-day web-access
- Options
  - GSM/CDMA, DSL, WiMAX, WiFi

Background

- Fiber PoP in town and city (high quality backbone)
- Villages without any connectivity (wired or wireless)
- Need: low-cost, long range, less CAPEX
- Using popular technology
- Similar work: DGP, WilDNet





WiFiRe link as 802.11(cont.)

- Other options
  - with PF_PACK

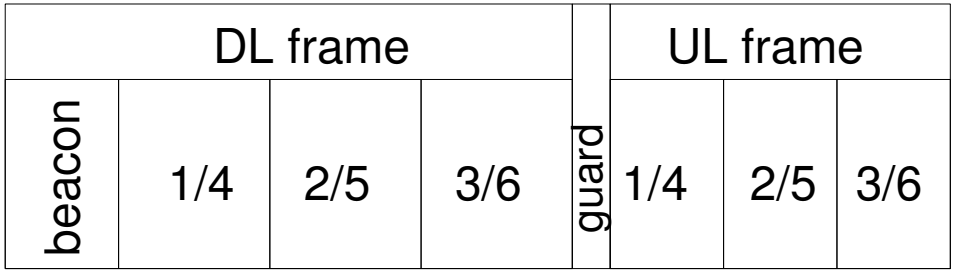
    and write(sock,..)

```
typedef struct _ieee_802_11_header {
        u16     ver:2,
                type:2,
                subtype:4,
                flags:8;
        u16     duration;
        u8      mac1[6];
        u8      mac2[6];
        u8      mac3[6];
        u16     SeqCtl;
} Ieee80211Header;
```

- Too complex to handle
- Not transparent from underlying PHY (like Eth)

WiFiRe MAC

- Replace WiFi MAC with TDMA



- WiMAX similar MAC with BS and ST
- Sectorized system, DL / UL
- Higher throughput, QoS, long range

WiFiRe console details

```
                ---------------------------------
ST_ID(STMAC)            BSID    BCID    PCID
-------------------------------------------------------------------------------
 0 50 bf 63 94 1b          1        1    4001
-------------------------------------------------------------------------------

               BS_TABLE entries(List of Clients) from System side
               -------------------------------------------------
Client MAC                      STID
-------------------------------------------------------------------------------
 0  8 a1 85  2 5b               4001
 0  c f1 2d c9 98               4001
 0 14 bf de d1 b3               4001
 0 1f f3 a3 17 c5               4001
 0 1c bf 75 9e 45               4001
-------------------------------------------------------------------------------

                               WiFiRe SYSTEM stats
-------------------------------------------------------------------------------
Current Time:(hh:mm:ss) = 2 : 34 : 0    Emulation Started at:(s):1215461432
OPR_ID  : 35                             Emulation Duration(s):89608
SYS_ID  : 10
Bytes Tx ( DL ) in B    : 995868353
Bytes Rx ( UL ) in B    : 549939952
Pkts  Tx ( DL )          : 158151
Pkts  Rx ( UL )          : 165053
Data Bytes  Tx ( DL )          : 27558987
Data Bytes  Rx ( UL )          : 15502271
Frames Tx from System    : 8960592
Packets Dropped at System: 8624
ST Count        : 1
BS Count        : 1
Client Count    : 5
-------------------------------------------------------------------------------
```

List of STs

List of clients

Traffic Details

DL and UL frame