Implementation of WiFiRe MAC

M. Tech. Project Presentation

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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

```c
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

To TCP/IP Layer

WiFiRe MAC

Ethernet MAC

System ‘S’

Switch

Ethernet Cable

A1

A2

A3

A4

A5

A6

Ethernet Cable

NIC
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

Slots in UL-Frame

UL-Frame

Slots in DL-Frame

Group B1
Group B3
Group B5
Beacon

DL-TB's, B1
DL-TB's, B3
DL-TB's, B5
DL-TB's, B

Ethernet Packet

DL-TB: WiFiRe
Data Packet

Control packet

Ethernet Header

BS-MAC

Ethernet Packets

Switch

BS-PHY's

BS1
BS2
BS3
BS4
BS5
BS6
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.)

Client-1

Client-2

Client-3

ST

BS

Proxy

1

2

3

1

= 802.3 Ethernet MAC header = 14 byte

= 802.3 Ethernet PDU (1500 Byte MAX)

Uplink frame

MAP
Encapsulation (cont.)

Start

Packet from client-1 arrives at ST

New client?

YES

Register client using MAC address

NO

Put packet in next uplink frame buffer queue

ENOUGH FREE SPACE?

YES

Append to uplink frame

NO

Try to accommodate fragmented packet

Store remaining part for next uplink frame

YES

Prepare MAP

NO

Tx frame in using Eth
Encapsulation and Fragmentation (cont.)

ST collects packets and send them in a single frame to BS.

Packet is divided
73 + 25 = 98

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
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

<table>
<thead>
<tr>
<th>ST-ID</th>
<th>Client MAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AA-AA-AA-AA-AA-AA-AA</td>
</tr>
<tr>
<td>2</td>
<td>BB-BB-BB-BB-BB-BB-BB</td>
</tr>
<tr>
<td>1</td>
<td>CC-CC-CC-CC-CC-CC-CC</td>
</tr>
<tr>
<td>1</td>
<td>DD-DD-DD-DD-DD-DD-DD</td>
</tr>
<tr>
<td>2</td>
<td>EE-EE-EE-EE-EE-EE-EE</td>
</tr>
</tbody>
</table>
MAC filter at BS

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

1. packet coming from Netmon (Internet)
   - Read dest. MAC address
   - match with client MAC in ST_TABLE

   - match found?
     - NO: Drop packet
     - YES: Find respective ST
       - append packet to ST queue
MAC filter at ST

- Frame coming from BS
  - Read DL-MAP
    - Any packet for ST?
      - NO: Drop frame
      - YES: Read packet with offset
    - Dest. MAC is Client?
      - NO: Drop packet
      - YES: Send packet to Client
    - Dest. MAC is FF?
      - NO: Source is my client?
        - NO: Drop packet
        - YES: Send packet to Client
      - YES: Dest. MAC is Client?
        - NO: Drop packet
        - YES: Send packet to Client
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

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Backup slides
Meta Frame Construction

PLCP issue

Slots in UL-Frame

Slots in DL-Frame

Group B1

Group B3

Group B5

Beacon

UL-Frame

DL-TB’s, B1

DL-TB’s, B3

DL-TB’s, B5

DL-TB’s, B

Ethernet Packet

DL-TB: WiFiRe Data Packet

Control packet

Ethernet Header

BS-MAC

Ethernet Packets

Switch

BS-PHY’s

BS1

BS2

BS3

BS4

BS5

BS6
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
• 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,..)

- 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

<table>
<thead>
<tr>
<th></th>
<th>DL frame</th>
<th>UL frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>beacon</td>
<td>1/4</td>
<td>2/5</td>
</tr>
<tr>
<td></td>
<td>3/6</td>
<td>1/4</td>
</tr>
<tr>
<td>guard</td>
<td>2/5</td>
<td>2/5</td>
</tr>
<tr>
<td></td>
<td>3/6</td>
<td>3/6</td>
</tr>
</tbody>
</table>
**WiFiRe console details**

### List of STs

<table>
<thead>
<tr>
<th>ST_ID(STMAC)</th>
<th>BSID</th>
<th>BCID</th>
<th>PCID</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 50 bf 63 94 1b</td>
<td>1</td>
<td>1</td>
<td>4001</td>
</tr>
</tbody>
</table>

### BS_TABLE entries(List of Clients) from System side

<table>
<thead>
<tr>
<th>Client MAC</th>
<th>STID</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 8 a1 85 2 5b</td>
<td>4001</td>
</tr>
<tr>
<td>0 c f1 2d c9 98</td>
<td>4001</td>
</tr>
<tr>
<td>0 14 bf de d1 b3</td>
<td>4001</td>
</tr>
<tr>
<td>0 1f f3 a3 17 c5</td>
<td>4001</td>
</tr>
<tr>
<td>0 1c bf 75 9e 45</td>
<td>4001</td>
</tr>
</tbody>
</table>

### 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

### Traffic Details

DL and UL frame