

# EXPERIMENTAL INDOOR DEPLOYMENT OF CLOUD-RAN GSM EMERGENCY SERVICE

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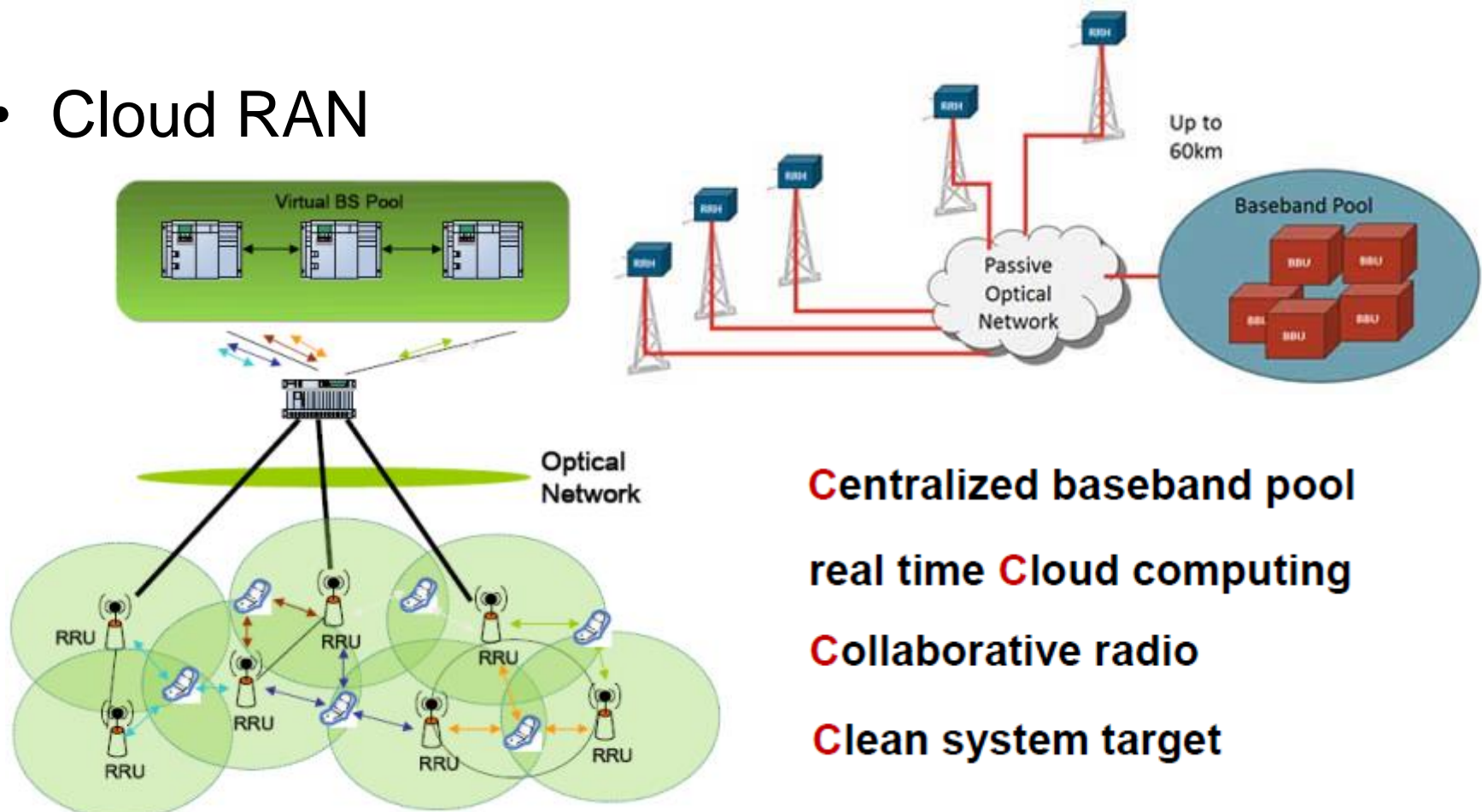
# Introduction

- Emergency communications
  - Private Networks for Responders and Authorities
  - Public Networks for Citizens and Rescue
- In case of Public Network failure
  - Fast Deployable GSM Network
  - Open Access and Registration
  - Voice and Messaging Services
  - Low Cost



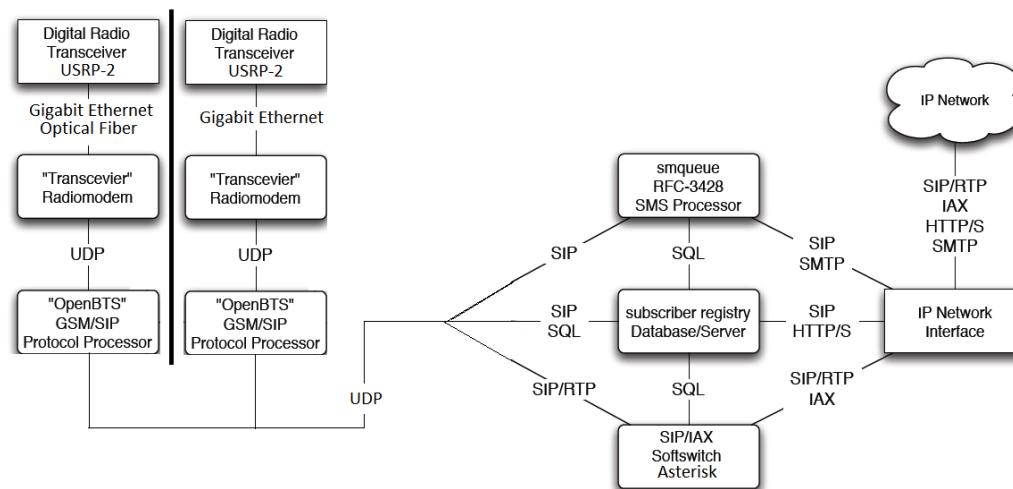
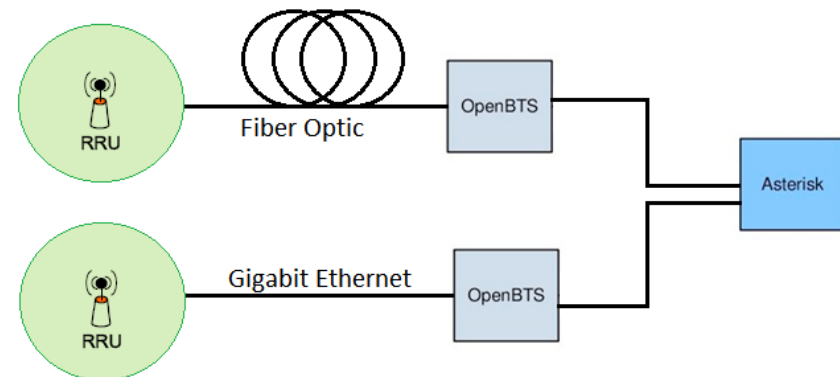
# Introduction

- Cloud RAN



# Cloud RAN Experiment

- 2 GSM Base stations
- Optical link
- Centralized Baseband
- VoIP (SIPv2) Interop.



# Experiment Objectives

- Multi-BTS indoor system setup
- Emergency Calls Support
- Tests
  - Quality of Experience
  - Network Usage
  - CPU/Power Resources
  - Radio Coverage
  - Latency

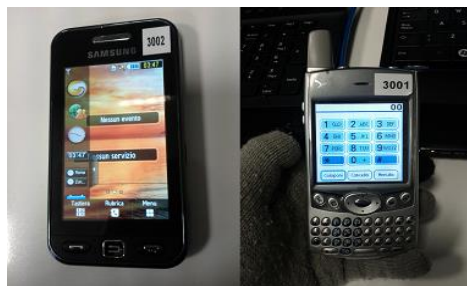
# Equipment

## Hardware

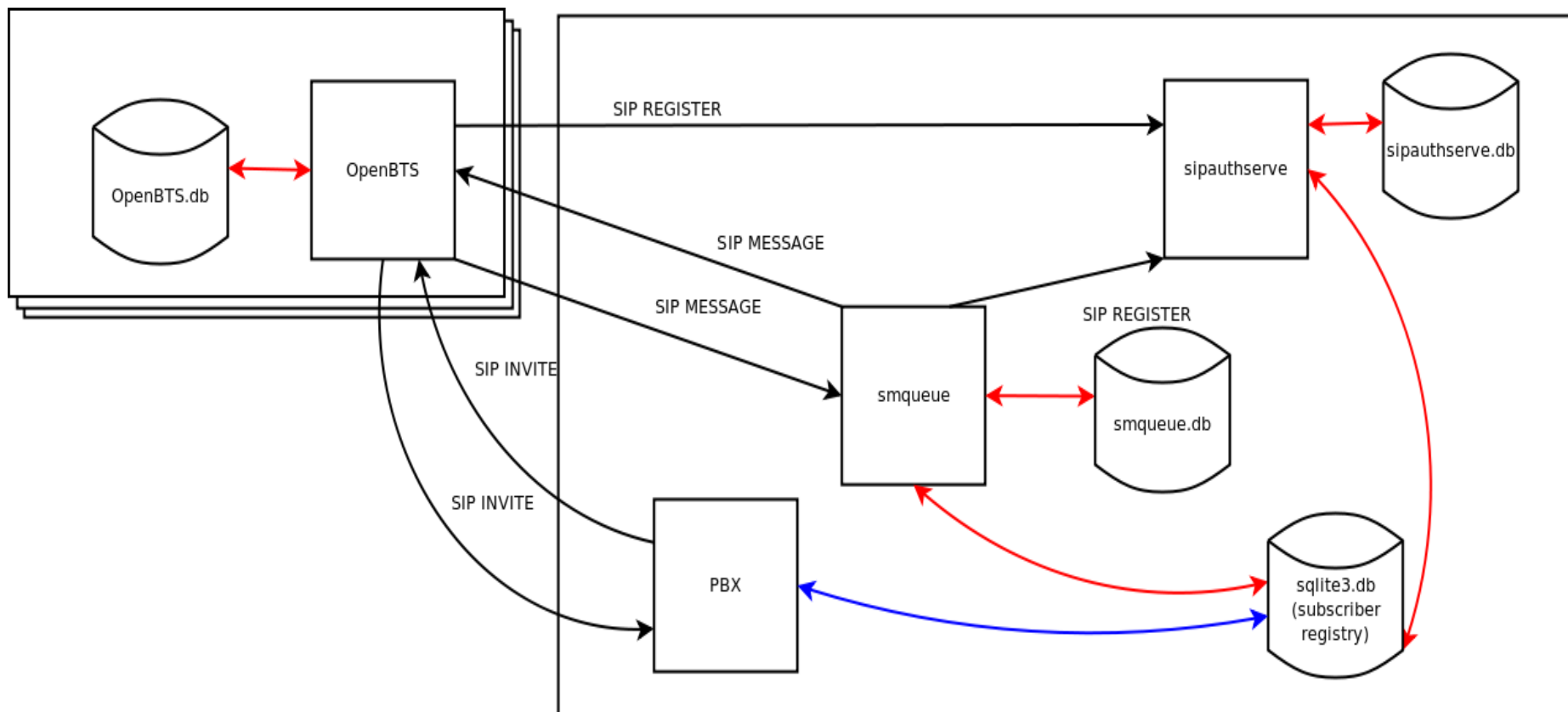
- 2 tri-band cell phones
- 2 USRP2 w 900MHz dgt
- HP Spectrum Analyzer
- Network Protocol Analyzer
- CPU1
  - Sony VAIO [i5@2.3GHz](#)
- CPU2
  - Dell P4@3GHz

## Software

- Ubuntu 12.04
- OpenBTS P2.8
- Smqueue
- Subscriber Registry
- Asterisk 1.8.10
- Mysql/sqlite3 3.7.9
- SqliteODBC 2.2.14
- Other SW
  - Matlab R2010a 7.10
  - Wireshark 1.6.7
  - Audacity 2.0
  - Pavucontrol 0.99
  - Twinkle 1.4.2
  - Powerstat 0.01.09

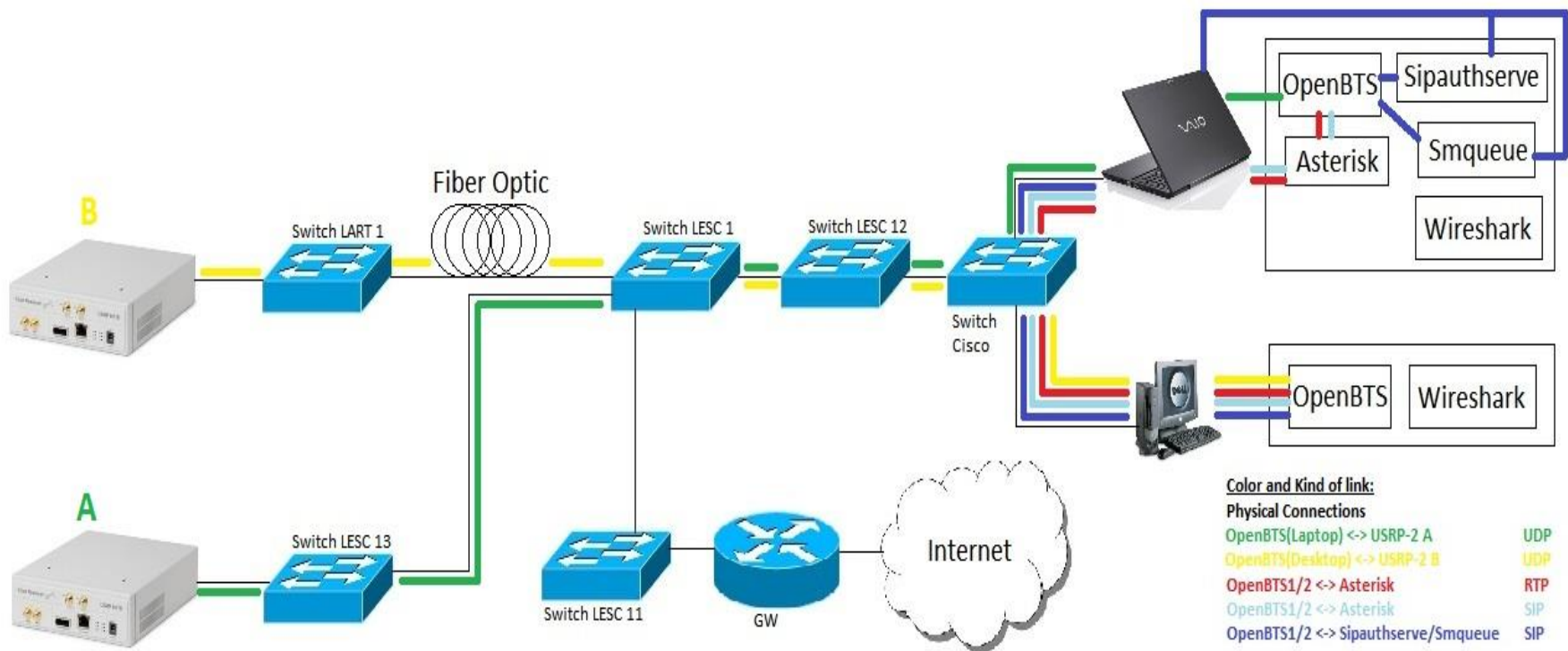


# Software Components

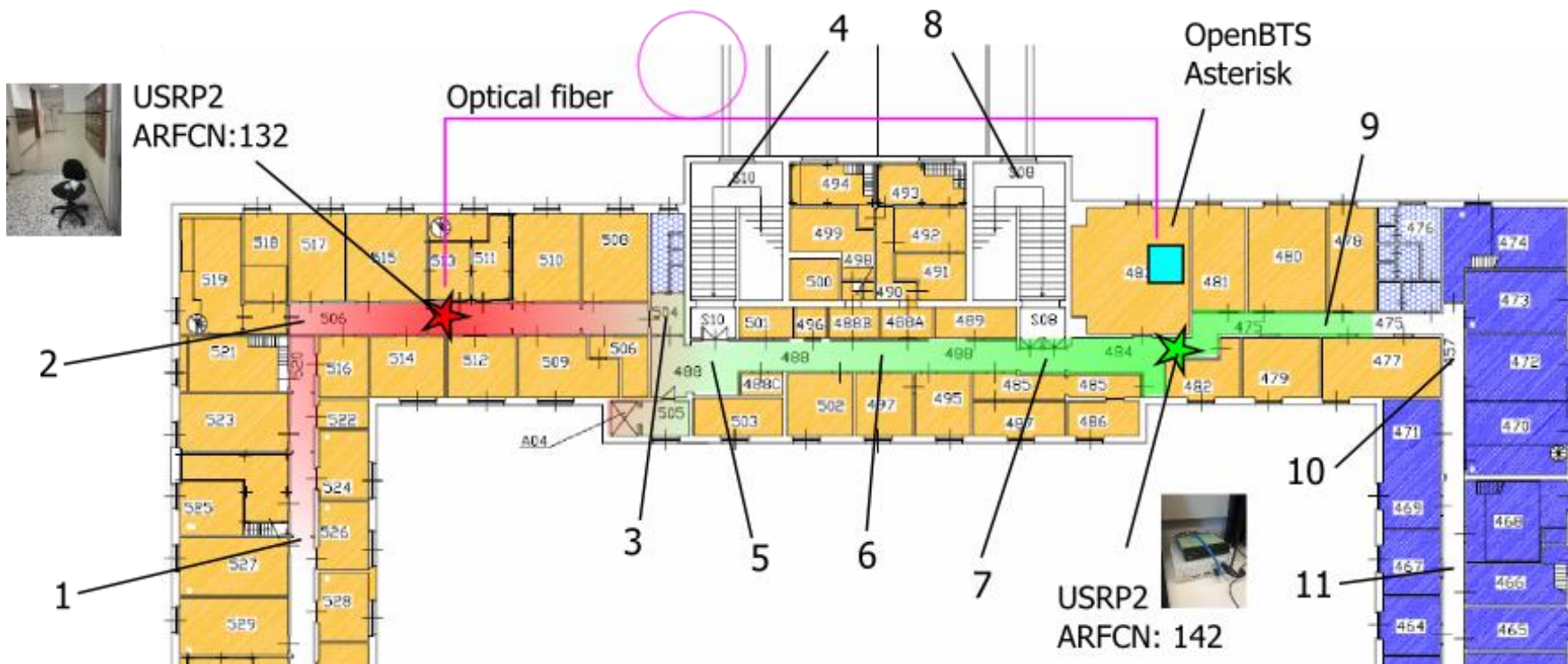




# Network Topology



# Deployment



# Results: Network

## • OpenBTS SIP Authentication [Sipauthserve]

No. ↓	Time	Source	Destination	Protocol	Info
1	0.000000	192.168.10.3	192.168.10.1	SIP	Request: REGISTER sip:192.168.10.1
2	0.292975	192.168.10.1	192.168.10.3	SIP	Status: 200 OK (1 bindings)
3	44.878376	192.168.10.3	192.168.10.1	SIP	Request: REGISTER sip:192.168.10.1
4	45.256808	192.168.10.1	192.168.10.3	SIP	Status: 200 OK (1 bindings)

### Session Initiation Protocol

Request-Line: REGISTER sip:192.168.10.1 SIP/2.0

#### Message Header

From: IMSI219021006202463 <sip:IMSI219021006202463@192.168.10.1>

No. ↓	Time	Source	Destination	Protocol	Info
1	0.000000	192.168.10.3	192.168.10.1	SIP	Request: MESSAGE sip:smc@192.168.10.1
2	0.002229	192.168.10.1	192.168.10.3	SIP	Status: 202 Queued
3	0.004777	192.168.10.1	192.168.10.3	SIP	Request: MESSAGE sip:IMSI219021006202463@192.168.10.3:5062

### Frame 3 (545 bytes on wire, 545 bytes captured)

Ethernet II, Src: 78:84:3c:df:9e:70 (78:84:3c:df:9e:70), Dst: DellPcba\_f6:c5:33 (00:0d:56:f6:c5:33)

Internet Protocol, Src: 192.168.10.1 (192.168.10.1), Dst: 192.168.10.3 (192.168.10.3)

User Datagram Protocol, Src Port: 5063 (5063), Dst Port: 5062 (5062)

### Session Initiation Protocol

Request-Line: MESSAGE sip:IMSI219021006202463@192.168.10.3:5062 SIP/2.0

#### Message Header

From: 3002 <sip:3002@192.168.10.1>;tag=zgnmkxrevlhzreg

To: 3001 <sip:3001@192.168.10.1>

## Results: Network

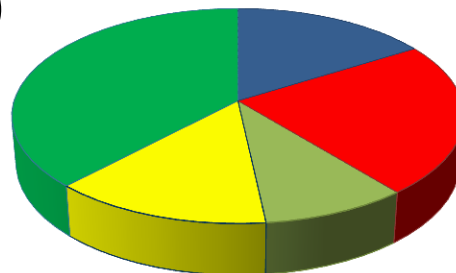
- SIP Call Establishment

No. -	Time	Source	Destination	Protocol	Info
1	0.000000	192.168.10.3	192.168.10.1	SIP/SDP	Request: INVITE sip:600@192.168.10.1, with session description
2	0.003313	192.168.10.1	192.168.10.3	SIP	Status: 100 Trying
3	0.008971	192.168.10.1	192.168.10.3	SIP/SDP	Status: 200 OK, with session description
4	0.702470	192.168.10.3	192.168.10.1	SIP	Request: ACK sip:600@192.168.10.3
103781	1074.472719	192.168.10.3	192.168.10.1	SIP	Request: BYE sip:600@192.168.10.3
103782	1074.473161	192.168.10.1	192.168.10.3	SIP	Status: 200 OK

- GSM Voice Bit Rate ~ 13 Kbps.
- RTP Payload Bit Rate ~ 13.2 Kbps
- Mean Delay between packets 20 ms

- Call Signaling (RTCP)

- 5 Seconds (0.41%)
- Packet number, jitter...



- Ethernet 16%
- IP 23%
- UDP 9%
- RTP 14%
- Payload 38%



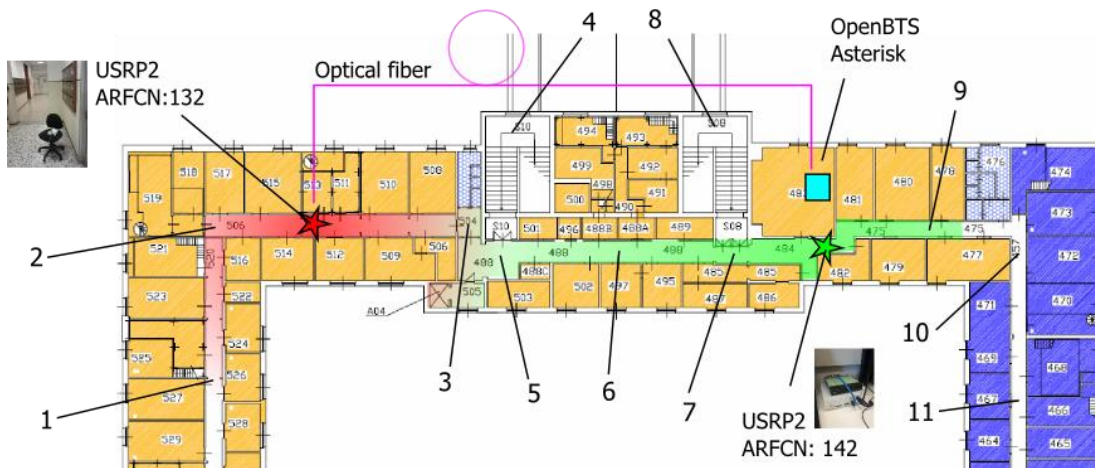
## Results: Network

- Baseband IP Traffic
  - Bit Rate ~ 13 Mbps
  - No difference Eth-FO
  - No need of Gigabit Ethernet (Fast Ethernet)
  - Bit rate keeps the same with one or two simultaneous conversations

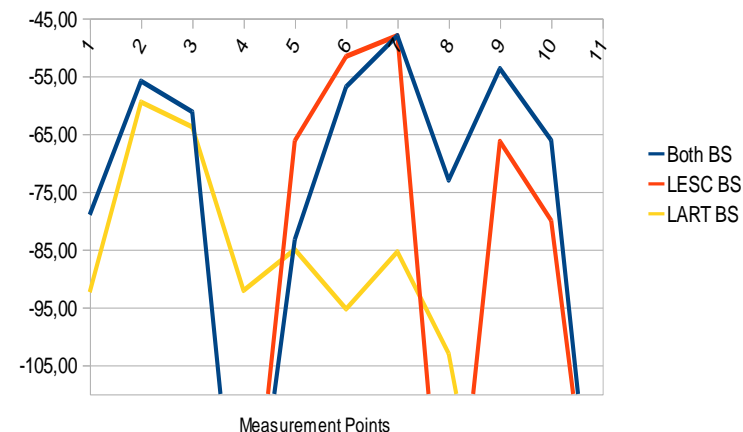
No. ↓	Time	Source	Destination	Protocol	Info
1	0.000000	192.168.10.1	192.168.10.255	UDP	Source port: 52990 Destination port: 49152
2	0.001658	192.168.10.4	192.168.10.1	UDP	Source port: 49152 Destination port: 52990
3	0.002137	78:84:3c:df:9e:70	Broadcast	ARP	who has 192.168.10.4? Tell 192.168.10.1
4	0.002875	EttusResea_02:23	78:84:3c:df:9e:70	ARP	192.168.10.4 is at 00:50:c2:85:32:23

# Results: Radio Signal

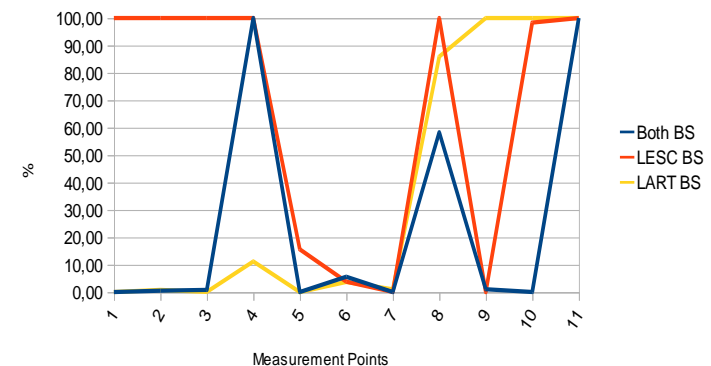
- Different BS transmission power
- Strict Cell Selection Parameters
- Problems around near field
- Uplink weakest path
- No Handover



DN LEV



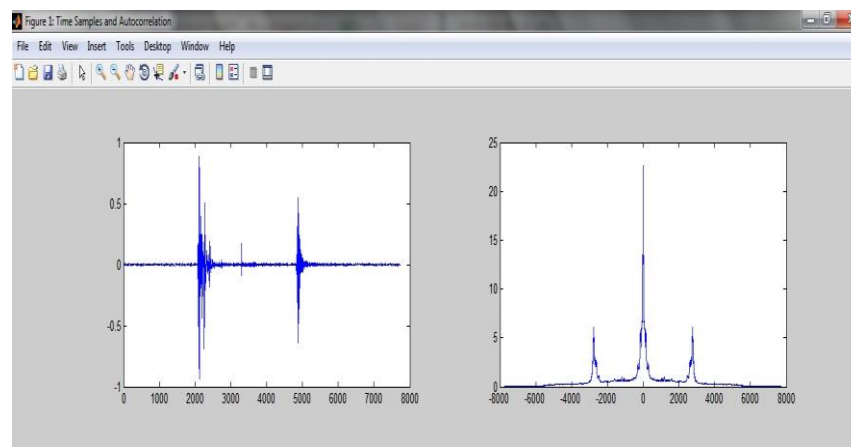
UP FrameER



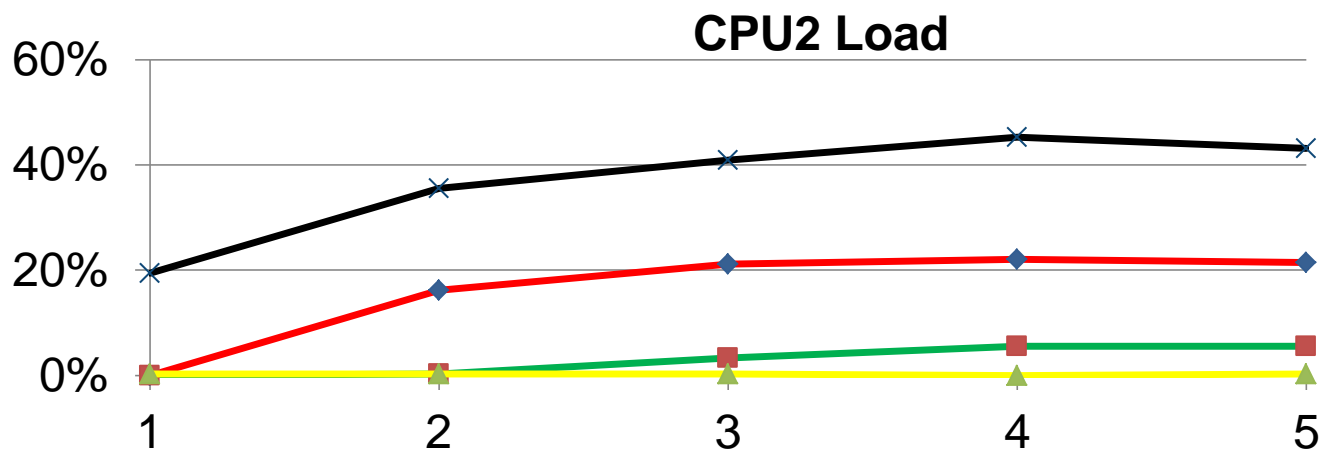
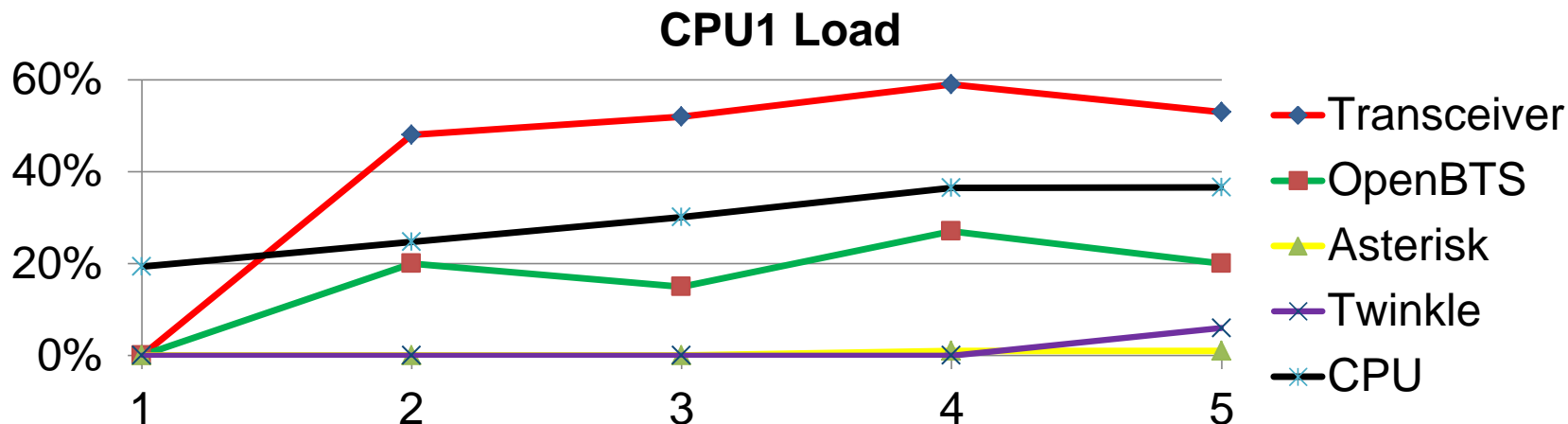
## Results: Latency

- Tools: Twinkle + pavucontrol + echo server
- Samples – short sounds/bumps- taken in LOS
- 4 Different Physical configurations
- Use of Matlab to analyze delay using autocorrelation and averaging results.

	Mean	Deviation
Twinkle	274.4 ms	64.5 ms
Echo	172.2 ms	6.5 ms
GSM	278.3 ms	1.6 ms

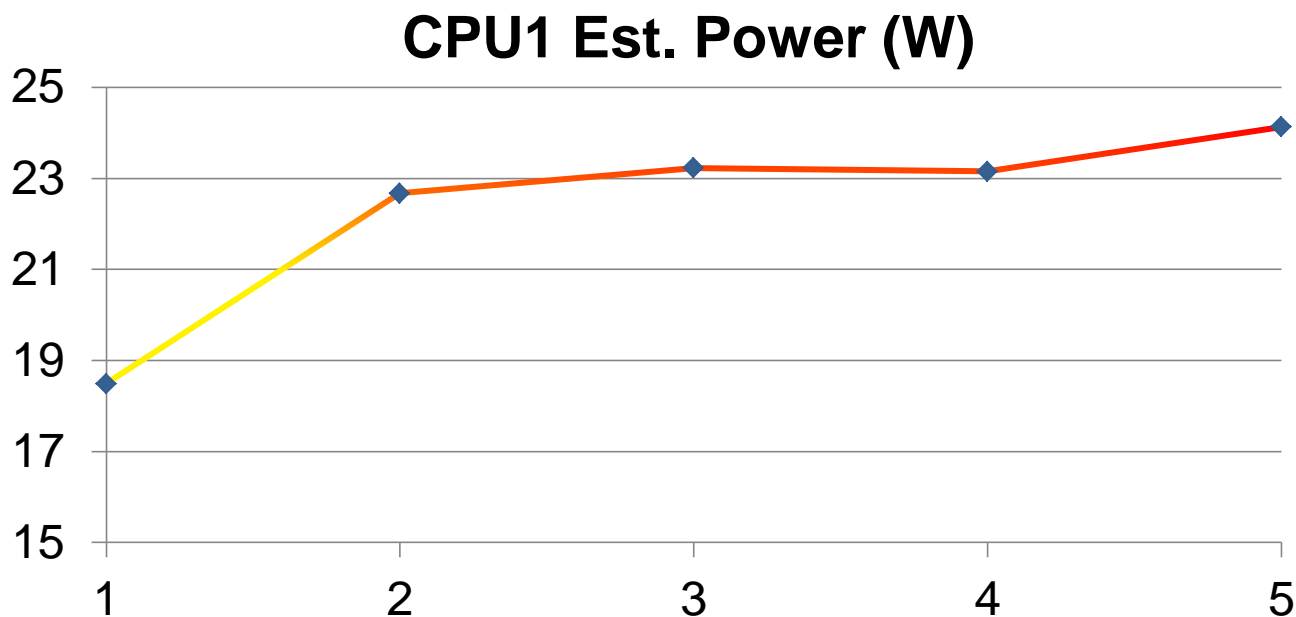


## Results: CPU Resources





# Results: Power Resources



## Conclusions

- Feasibility of GSM service coverage with low-cost generic hardware
- Low Network Traffic and CPU/Power usage
  - More than 75 BTS on Gbps optical link!
- Good Voice Quality (GSM Codec)
- Moderately high latency
- Next steps:
  - OpenLTE (network registration issue)