ENSC 427: COMMUNICATION NETWORKS
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VOIP Performance Over City-Wide WIFI and LTE

www.sfu.ca/~tly/webpage.html

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OVERVIEW

- Introduction
- Project outline
- Topology
- Simulation Result
- Discussion
- Conclusion
- Reference

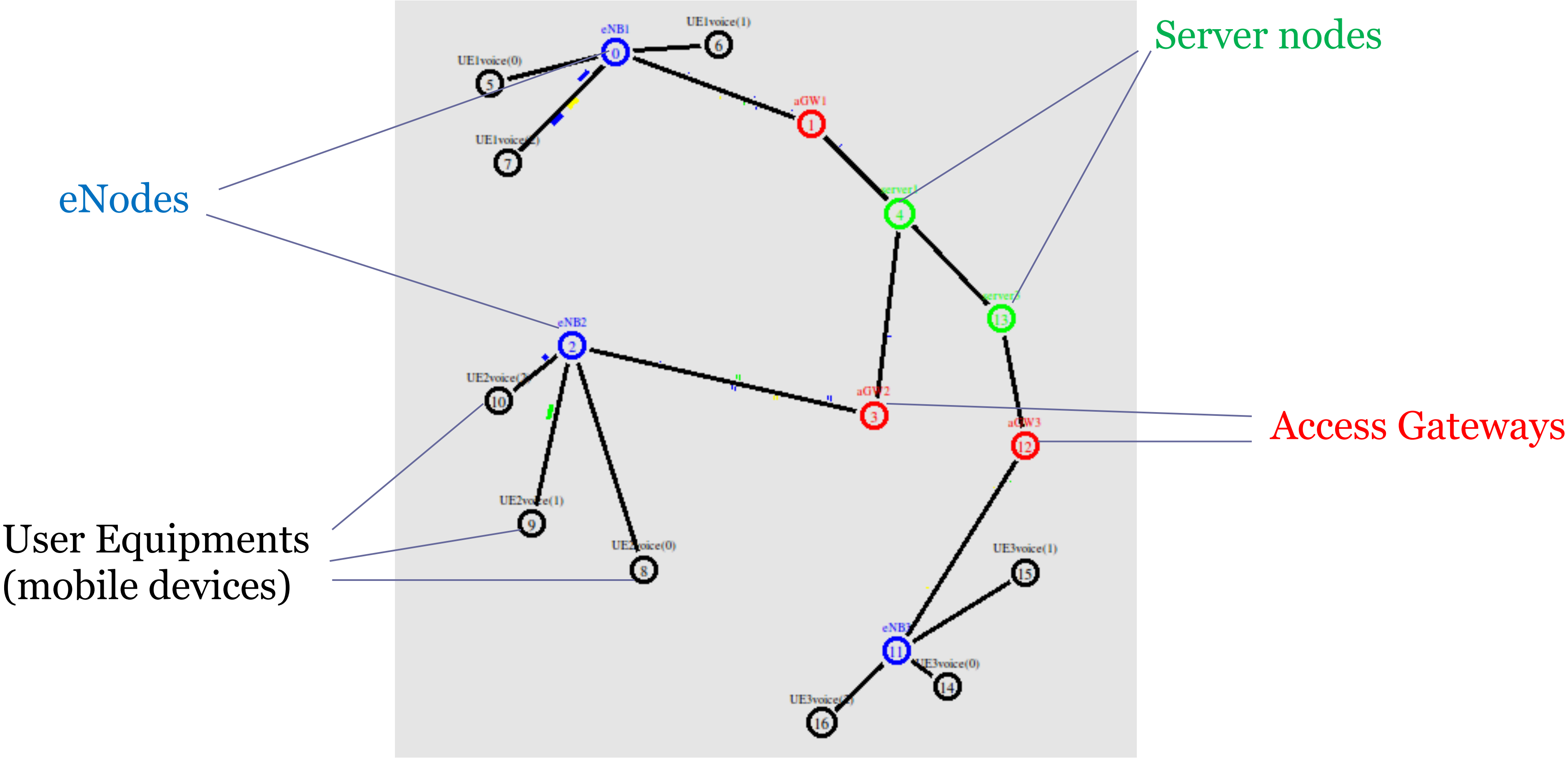
INTRODUCTION

- What is City-Wide WIFI?
  - Large area consisting of many wireless WIFI hotspots (access points)
  - Follows IEEE 802.11 standards; many devices now use WIFI to connect to the Internet
- What is LTE (Long-Term Evolution)?
  - Used for wireless broadband access
  - Increases capacity, reduces network complexity, and lowers costs for network operators
  - Major Bandwidth increases over previous technologies
- How does voice calling using IP work?
  - Analog voice => digital signal, then sent through internet
  - Can bypass charges invoked by telephone companies

Project Outline

- Simulate VoIP in LTE and WIFI using ns2
  - UDP agent with CBR traffic
  - Data exchange over User equipment in different location
- Successfully implement both individual and group calls
  - Data exchange between single node to single node and multi nodes to multi nodes.
- Compare differences in the two technologies
  - Throughput
  - Packet loss
  - Delay
  - Jitter

LTE Topology



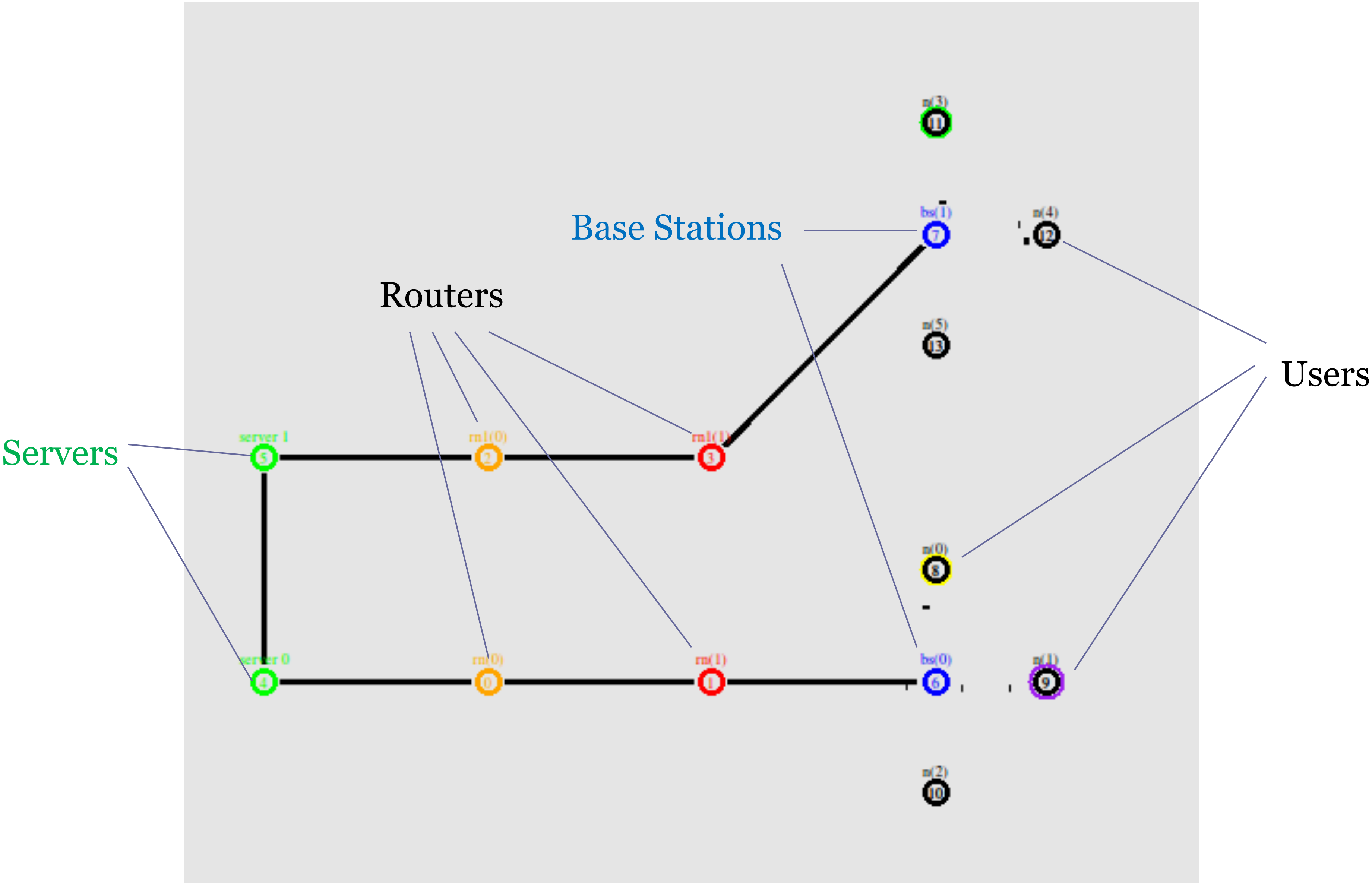
LTE Module

- LTE uplink and downlink queues for topology
  - Use simplex links to separate upload and download links
  - Module and installation instructions found on linuxquestions.org/forum

```
for {set i 0} {$i < $number} {incr i} {
    $ns simplex-link $UE1($i) $eNB1 500Mb 2ms LTEQueue/ULAirQueue
    $ns simplex-link $eNB1 $UE1($i) 1Gb 2ms LTEQueue/DLAirQueue
}

#LTE 1 links
$ns simplex-link $eNB1 $aGW1 5Gb 10ms LTEQueue/ULS1Queue
$ns simplex-link $aGW1 $eNB1 5Gb 10ms LTEQueue/DLS1Queue
$ns duplex-link $aGW1 $server1 10Gb 50ms DropTail
$ns duplex-link-op $aGW1 $server1 orient right-up
```

Wifi Topology



WIFI Parameters

```
#WIFI 802.11g settings
set opt(wifi_bw) 54Mb                          ;# link BW on wifi net
Phy/WirelessPhy set Pt_ 0.251622777             ;#transmit power
Phy/WirelessPhy set L_ 1.0                     ;#System loss factor
Phy/WirelessPhy set bandwidth_ 1                ;#opt(wifi_bw)
Phy/WirelessPhy set freq_ 2.472e9               ;#channel-13. 2.472GHz
Phy/WirelessPhy set CPThresh_ 10.0              ;#reception of simultaneous packets
Phy/WirelessPhy set CSThresh_ 5.011872e-12     ;#carrier sensing threshold
Phy/WirelessPhy set RXThresh_ 5.82587e-09      ;#reception threshold
Mac/802_11 set dataRate_ $opt(wifi_bw)
Mac/802_11 set basicRate_ 1Mb                   ;#for broadcast packets
```

802.11 protocol suite

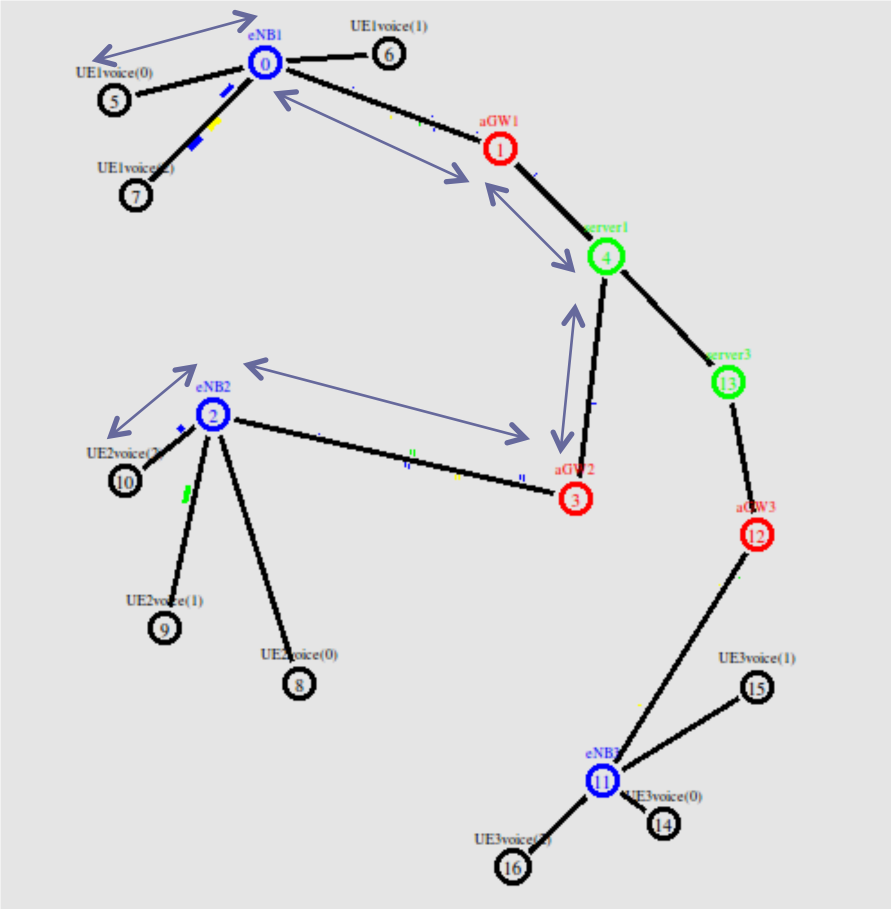
	802.11a	802.11b	802.11g
Year	1999	1999	2003
Products since	2001	1999	2003
Typical range	~15 m indoor ~100 m outdoor	~30 m indoor ~200 m outdoor	~30 m indoor ~200 m outdoor
Bandwidth	54 Mbps	11 Mbps	54 Mbps
Physical layer	OFDM	DSSS	OFDM
Frequency band	5 GHz unlicensed	2.4 GHz unlicensed	2.4 GHz unlicensed
Backward compatibility	None	802.11	802.11b

Simulation Scenarios

- VoIP is basically just UDP packets encapsulating RTP packets. Inside the packets are the voice data needed for transmission. We used CBR traffic and attached it to UDP agents for simulating voice data traffic transmission

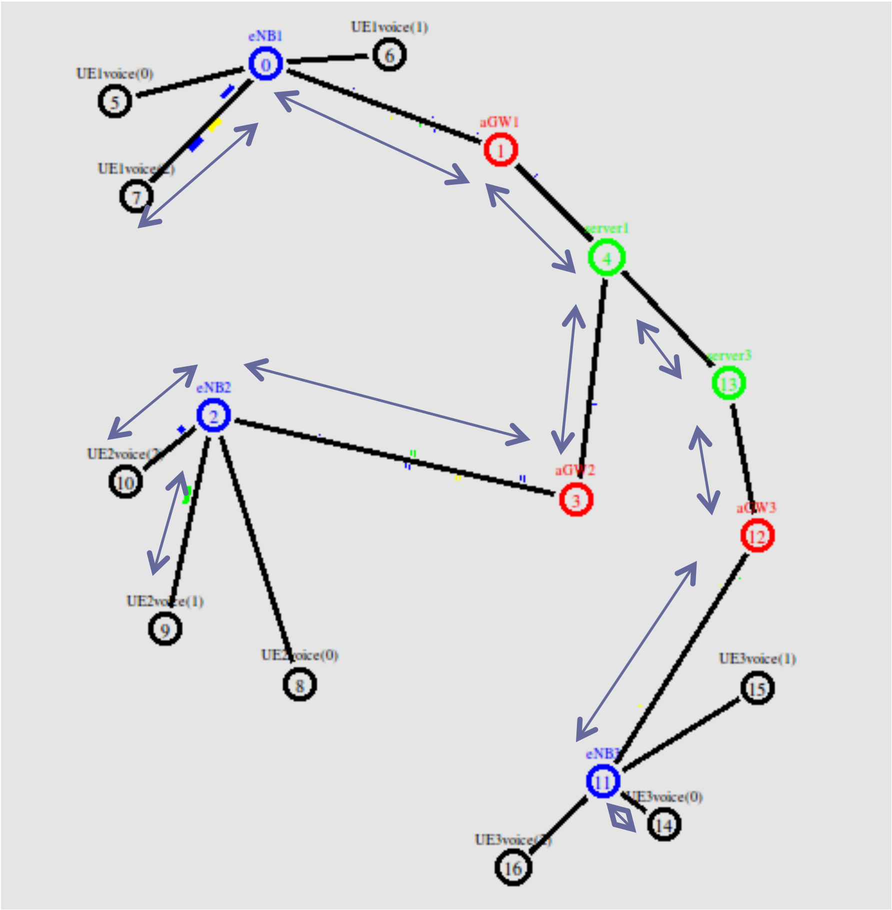
- From 1.0 to 14.0 seconds of both simulations, we have data exchange in two pairs of nodes (individual conversations). From 15.0 to 30 seconds, we have group chats between four nodes.

Simulation Scenario Continued



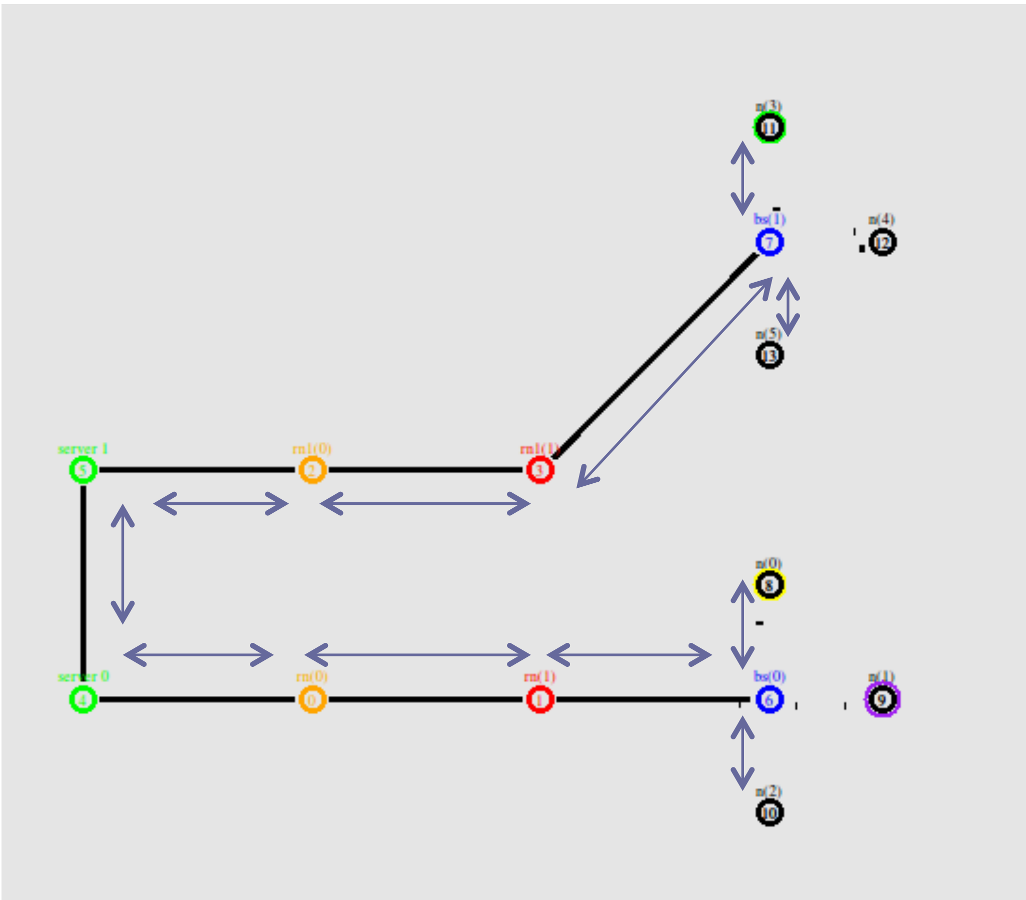
Individual voice calls from 1.0 to 14.0 seconds
UE1(0) to UE2(0)
UE1(1) to UE3(1)

Simulation Scenario Continued



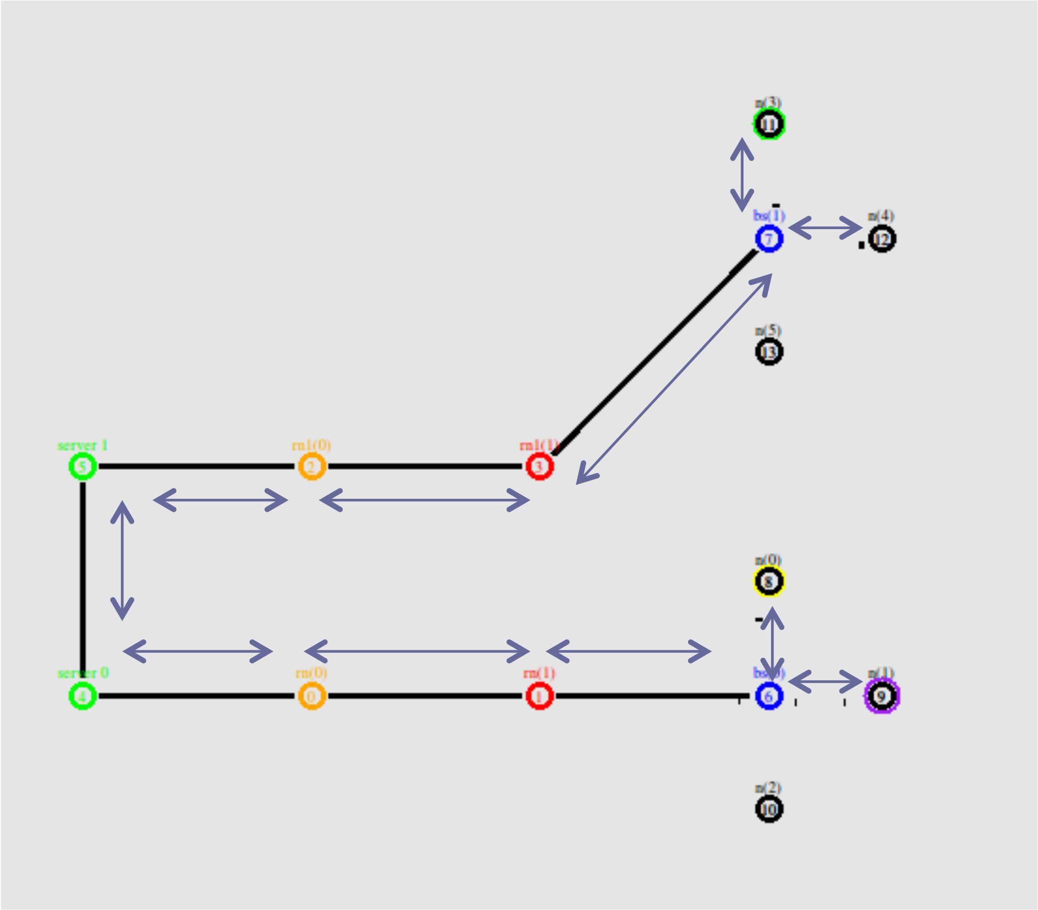
Group chat from 15.0 to 29.0 seconds
UE1(2), UE2(1), UE2(2), UE3(0)

Simulation scenario continued



Individual voice calls from 1.0 to 14.0 seconds
n(0) to n(3), n(2) to n(5)

Simulation scenario continued



Group chat from 15.0 to 29.0 seconds
n(0), n(1), n(3), n(4)

Data Output Algorithms

```
# Record Bit Rate in Trace Files
puts $f0 "$now [expr (($bw0+$holdrate1)*8)/(2*$time*1000000)]"
puts $f1 "$now [expr (($bw1+$holdrate2)*8)/(2*$time*1000000)]"
puts $f2 "$now [expr (($bw2+$holdrate3)*8)/(2*$time*1000000)]"
puts $f3 "$now [expr (($bw3+$holdrate4)*8)/(2*$time*1000000)]"
```

```
# Record Packet Loss Rate in File
puts $f4 "$now [expr $bw4/$time]"
puts $f5 "$now [expr $bw5/$time]"
puts $f6 "$now [expr $bw6/$time]"
puts $f7 "$now [expr $bw7/$time]"
```

```
# Record Packet Delay in File
if { $bw9 > $holdseq } {
        puts $f8 "$now [expr ($bw8 - $holdtime)/($bw9 - $holdseq)]"
} else {
        puts $f8 "$now [expr ($bw9 - $holdseq)]"
}
```

set bw($i) [$sinkGC set bytes_]
set bw($i8) [$sinkGC set lastPktTime_]

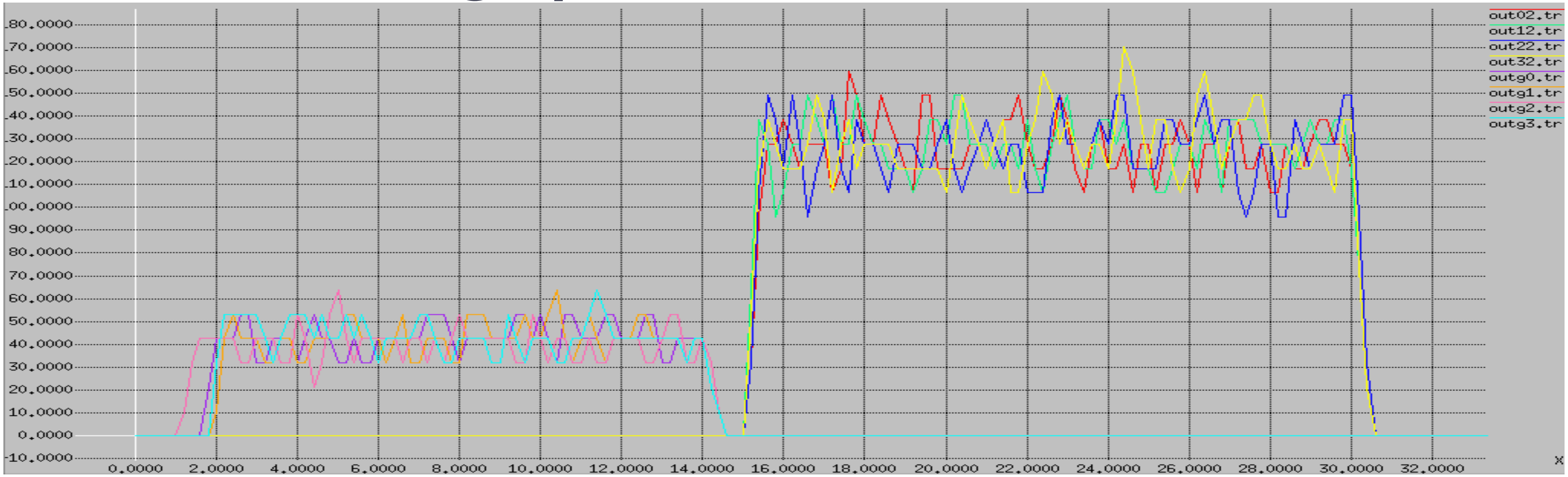
set bw($i) [$sinkGC set nlost_]
set bw($i)[$sinkGC set npkts_]

holdtime, holdrate and holdseq are all equal to respective bws' in order to use old values for next "record"

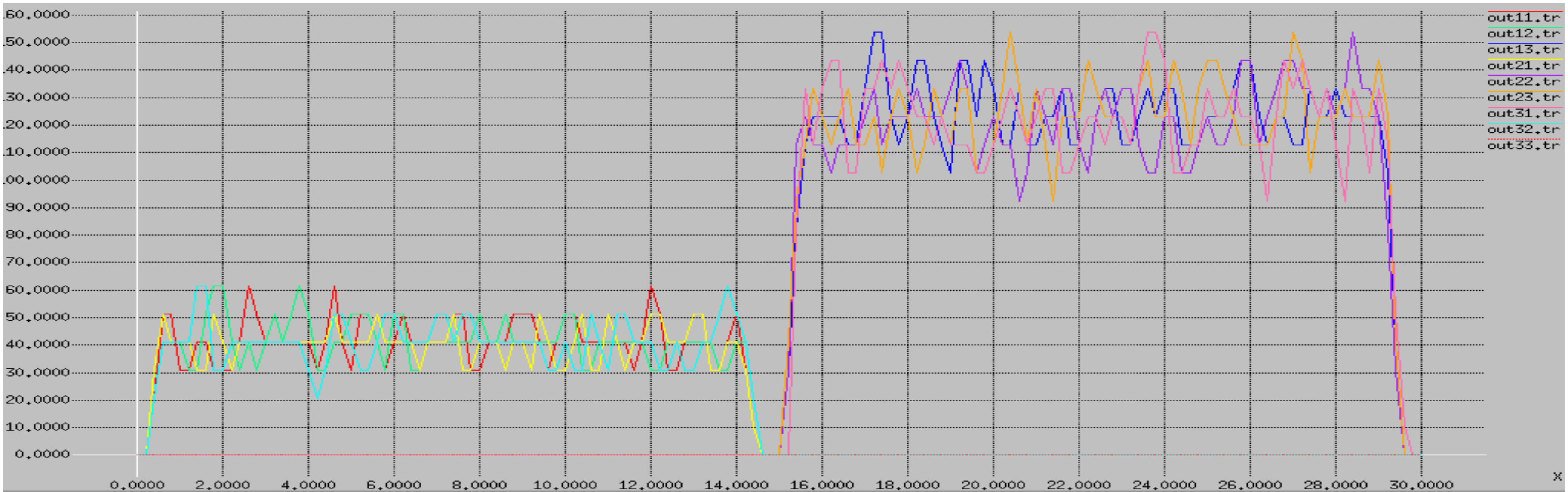
- Jitters were found by using the trace file of delays in excel to calculate the difference in delays for each packet.

Throughput

WIFI Throughput

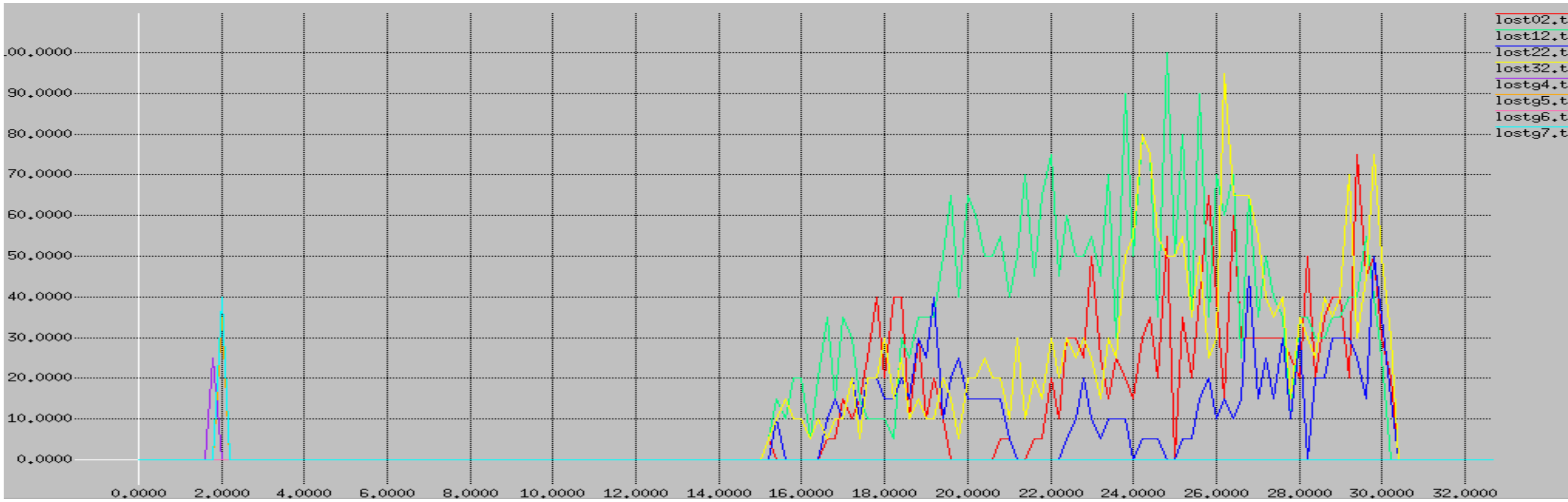


LTE Throughput

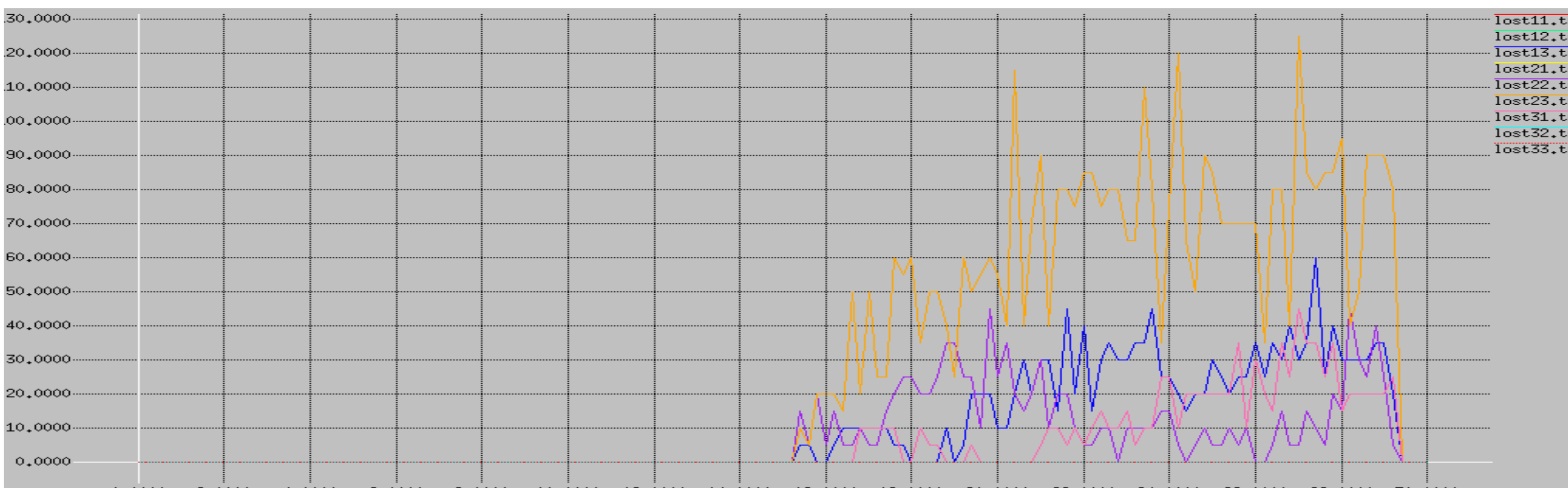


Packet Loss

WIFI Packet Loss

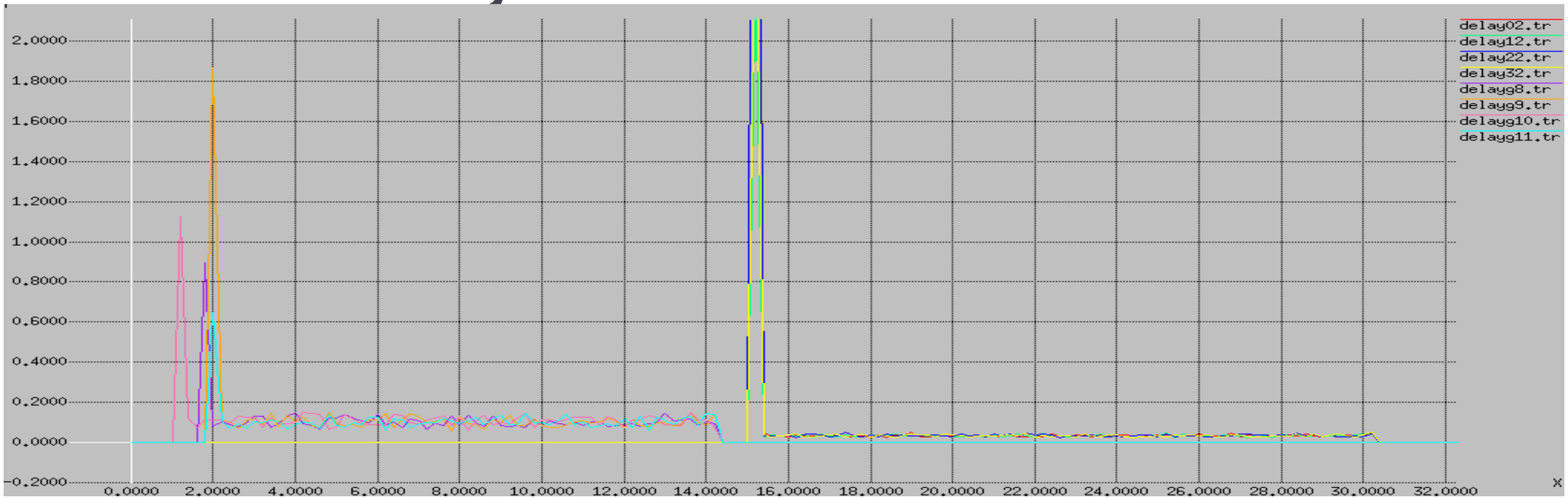


LTE Packet Loss

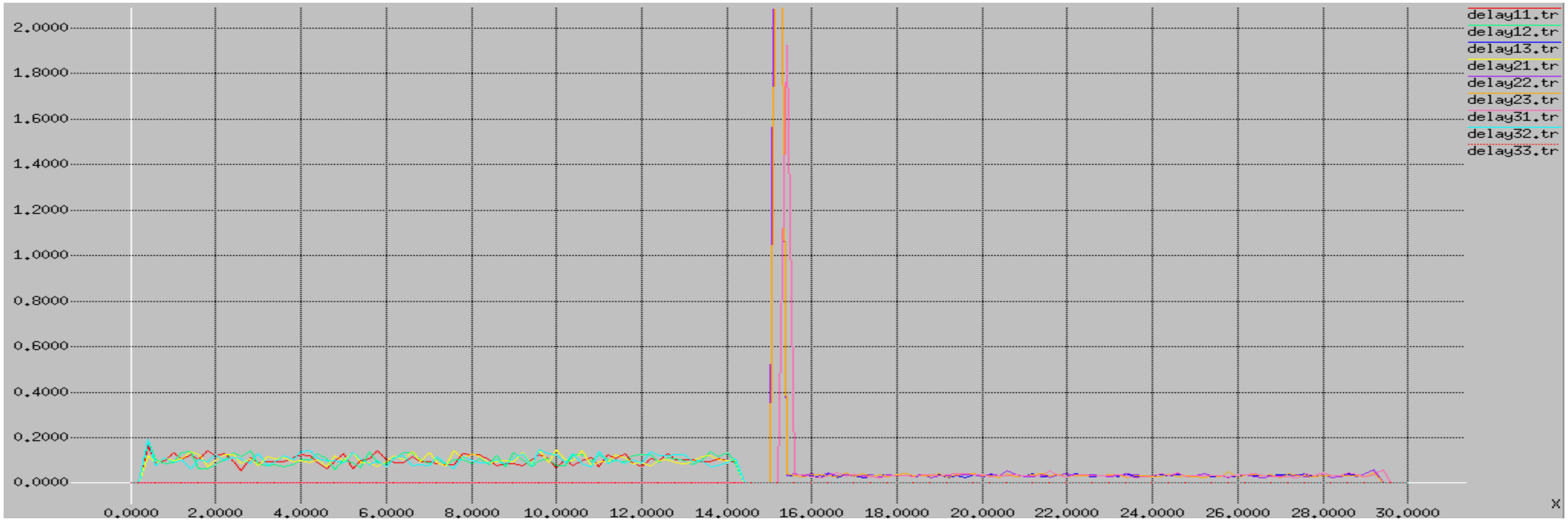


Delay

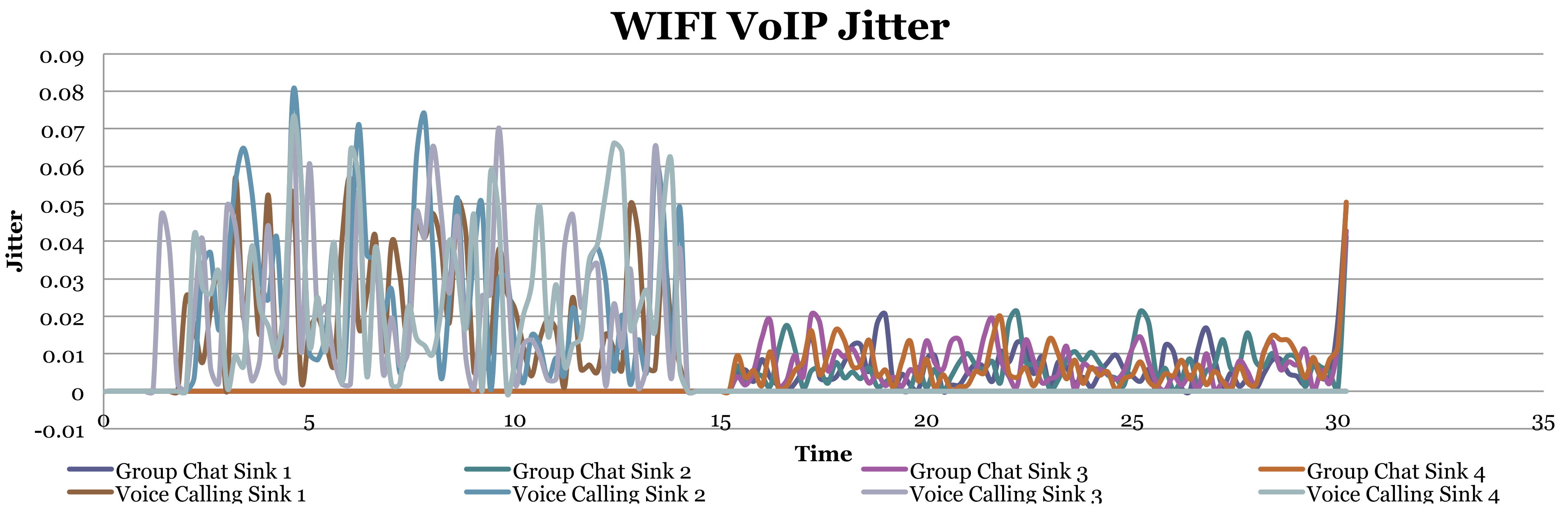
WIFI Delay

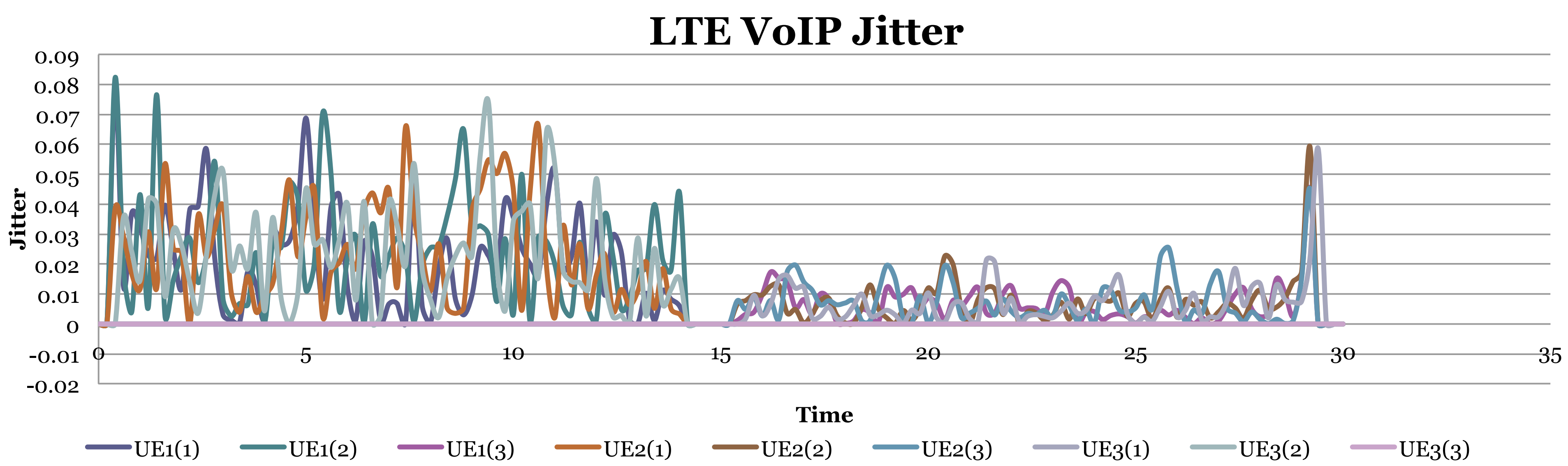


LTE Delay



Jitter


WIFI VoIP Jitter
Jitter
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
0
5
10
15
20
25
30
35
Time
Group Chat Sink 1
Group Chat Sink 2
Group Chat Sink 3
Group Chat Sink 4
Voice Calling Sink 1
Voice Calling Sink 2
Voice Calling Sink 3
Voice Calling Sink 4


LTE VoIP Jitter
Jitter
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
0
5
10
15
20
25
30
35
Time
UE1(1)
UE1(2)
UE1(3)
UE2(1)
UE2(2)
UE2(3)
UE3(1)
UE3(2)
UE3(3)

Discussion

- Difficulties
  - Installing and implementing LTE module and its requirements
  - Successfully transmitting data through topologies
  - Data algorithms and output graphs
  - WIFI hierarchy address for WIFI topology
- Desired Improvements(if we have more time)
  - Better WIFI topology
  - Movement of wireless nodes
  - Multicasting for group chat instead of adding individual UDP for every traffic
- Future Work
  - Use 802.11ac standard for WIFI
  - Larger traffic simulation on large scale uses of HD voice call

Conclusion

- 802.11g WIFI is competent enough for VoIP in today's daily requirement for stationary uses.
- LTE shows superior ability on adjusting to flow increases.
- Delay spikes appears only at the beginning of each voice call. However, the overall quality of voice call is about the same for both technologies.

Reference

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QUESTIONS?