CN Lab (17CSL57)

Exp 05-06:
Performance Study of GSM/CDMA

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Ex07 Resources

- References:
  - https://www.isi.edu/nsnam/ns/tutorial/index.html
  - https://www.nsnam.org/docs/release/3.8/tutorial/tutorial_27.html#Building-a-Wireless-Network-Topology
  - https://intronetworks.cs.luc.edu/current/html/ns2.html
  - https://www.isi.edu/nsnam/ns/doc/node29.html
  - https://www.cs.helsinki.fi/u/gurtov/papers/wireless-report.ps
  - github.com/rprustagi/VTU-CNLab/Exp05_06

Lab05/06 Program

- Program 05
  - Implement and study the performance of GSM on NS2/NS3 (Using MAC layer) or equivalent environment
- Program 06
  - Implement and study the performance of CDMA on NS2/NS3 (Using MAC layer) or equivalent environment

Wireless Links and Performance

- Congestion:
  - TCP works on basic premise that congestion in the network causes packet loss.
  - In wireless networks, packet loss primarily occurs because of packet corruption
- Wireless links have high variability of delay and bandwidth
  - Cellular links have high latency and thus high RTT.
  - High link level queues also adds to RTT
  - Link level error recovery causes delay variation
- A sudden increase in delay causes TCP timeout

Cellular links

- GSM network
  - Experimentally found even good radio network has moderate jitter.
  - A moderate jitter results in increased TCP retransmit timer (timeout)
    - Prevents detection of packet loss quickly, and
    - increases recovery time.
- Handover
  - causes high jitter
  - results in spurios timeouts
- Desiderata:
  - Choose model parameters to reflect real work scnearios.

Modeling of Cellular Networks

- Purpose
  - Evaluate the effect of link level mechanisms on end to end transport protocol e.g. TCP
    - We don't want to represent link level transmissions and handoff.
      - Purpose is not to build a complex model of link level transmissions and handoffs.
- Modeling requirements for Transport layer performance
  - Change link characteristics
  - Introduce packet loss
  - Introduce delays to traffic

Wireless Simulation

- Wireless networks
  - There are no point to point links (as in wired n/w)
  - All configuration work requires
    - Setting up of nodes
    - Setting up of traffic
    - Wireless behaviour (wireless specific attributes), e.g.
      - Antenna type
      - Radio propagation model
  - Nodes themselves need to take care of queueing
    - In wired n/w, queueing is with link
  - Nodes have positions coordinates
    - Nodes move (need to define velocity)
    - Signal loss varies with distance

Modeling Cellular Links

- Typical GSM/GPRS
  - Downlink
    - Latency: 400-500ms
    - Bandwidth: 9.6kbps - 40kbps
  - Uplink: Latency/BW: 200ms, 10kbps
  - Cell coverage: cities: 100+ meters, rural: 1+ Kms.
- CDMA links
  - Latency: 100ms-150ms
  - BW: 500kbps - 1Mbps
  - Cell coverage: 100+m to few Kms
- Radio propagation
  - Acquring a channel also causes delay
    - Every packet may require new channel allocation
  - Preserving battery power is equally a challenge

Performance Metrics

- Performance metrics for wireless links
  - Throughput
  - Delay
  - Fairness
- Important metric:
  - Goodput
    - defined as fraction of useful data from all data delivered
    - Goodput affects energy efficiency.
    - High goodput implies effective use of radio spectrum

Wireless Networks Attributes

- Propagation delay:
  - Distance / speed of light
  - In wired network, this is specified explicitly
- Bandwidth
  - Depends upon wireless model chosen, need to be specified (set) accordingly
    - `Mac/802_11`
      - defined by attribute `dataRate_`
      - default value in ns2 is `1mb`.
- Adhoc wireless networks
  - Routing protocol must be configured
    - Needed to find the path from one node to another
    - example: AODV, DSDV, DSR

Wireless Networks Attributes

- Defining wireless config attributes (related to each other)
  - Use attributes of a single tcl object `opt`
- Wireless channel
  - `Channel/WirelessChannel`
    - Defines physical terrestrial wireless medium
  - `Channel/Sat`
    - Define satellite radio
- Radio propagation
  - `Propagation/TwoRayGround`
    - Takes into account ground reflection
    - Received power level is $1/d^4$
    - `Propagation/FreeSpace`
    - Received power level is $1/d^2$

Wireless Networks Attributes

- Wireless node interface
  - `Phy/WirelessPhy`
    - Defines standard wireless interface
  - `Phy/WirelessPhyEst`
    - Standard wireless interface with addtional options
  - `Phy/Sat`
    - Satellite specific
  - `Mac/802_11`
    - Specifies Wi-Fi (WLAN) Behaviour
    - Other values: `Mac/Csma/Ca`, `Mac/802_3`
- Queueing behaviour for each node
  - `Queue/DropTail/PrioQueue`
  - `opt(ifqlen)` corresponds to `queue-limit` for wired networks

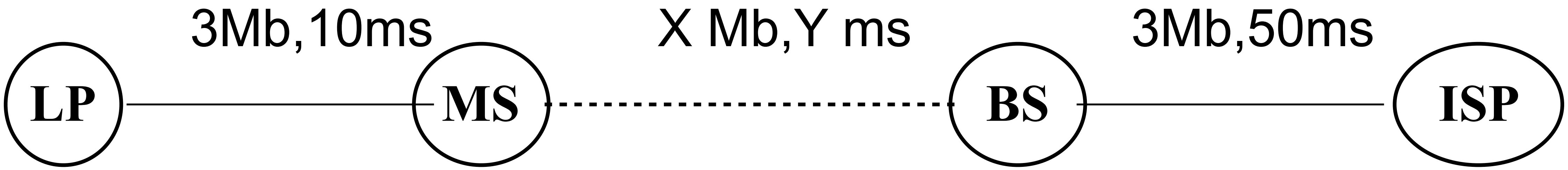
Wireless Networks Attributes

- Link Layer `-lltype`
  - `LL` sepcified behaviour of ARP packets
- Antenna types
  - `Antenna/OmniAntenna`
    - Defines standard omnidirectional antenna
  - Other antenna types
    - Parabolic, waveguide
- Layout
  - `opt(x)` and `opt(y)` defines layout dimension
  - By default these values are in meters

Wireless Networks Attributes

- Node movement
  - Nodes goes out of range when power loss becomes high, e.g.
    - At 250 m (x:200, y:150 → $200^2+150^2=250^2$)
      - Node moves out of range of current node
      - Default routing protocol kicks in
        - Searches for a new path
    - AODV takes about 50ms
    - DSR, DSDV may take much longer (seconds)

Modeling Cellular Networks



- Cellular network is between MS and BS
- Apply the cellular network characteristics parameters to link MS⟷BS
- TCP traffic betwee LP (low power) and ISP
  - Link between MS and LP is high speed, compared to Cellular link

Cellular Network Parameters

- Queue Management
  - RED (Random Early Detection)
    - Min Threshold (`minthresh`): `0`
    - Max Threshold (`maxthresh`): `30`
    - Adaptive (dynamically adjusts pkt drop rate) vs Plain
- Downlink details (BS→MS)
  - DL bandwidth [`bwDL(gsm)`] : 9600 bps
  - DL propagation delay [`propDL(gsm)`] : 500ms
- Uplink details (MS→BS)
  - UL bandwidth [`bwUL(gsm)`] : 9600 bps
  - UL propagation delay [`propUL(gsm)`] : 500ms

Cellular Network Parameters

- Link Characteristics
  - Length/duration of delays: (not used for good GSM)
    - `delayLen : 0.3`
  - Interval between delays (not used for good GSM)
    - `delayInt : 0.3`

Cellular Network Parameters

- Downlink details (BS→MS)
  - DL bandwidth [`bwDL(gsm)`]: `9600 bps`
  - DL propagation delay [`propDL(gsm)`]: `500ms`
  - Channel allocation delay: Uniform or Exponential
    - Uniform requires: Min and Max range `(0.16-0.19)`
    - Exponential requires average value `allocDelayDLAvg: 0.17`
  - Channel Hold Delay: Uniform or Exponential
    - `allocHoldDLAvg : 3`

Cellular Network Parameters

- Downlink details (BS→MS)
  - Rate of errors (currently not configured)
    - `errRateDL: 0`
  - Burstiness coefficients of errors (currently not configured)
    - `errBurstDL: 0` **(0 - no burst,)**
  - Queue Length of packets

Code Snippets (cellular.tcl)

```
# Active Queue Mgmt (AQM parameters)
# import config parameters GSM or CDMA radio
source ./$prefix.params
set minthresh 30;  # used for queueing RED
set maxthresh 0;  # used for queueing RED
set adaptive 1; ;  # used for queueing RED

set delayLen ""
set delayInt “"

# queue size
set ql(gsm) 10
```

Code Snippets (`cellular.tcl`)

```
# RED and TCP parameters

Queue/RED set adaptive_ $adaptive
Queue/RED set q_weight_ 0.0
Queue/RED set thresh_ $minthresh
Queue/RED set maxthresh_ $maxthresh

# Set up TCP connection characteristics
set pktSize 1460
Agent/TCP set window_ $window
Agent/TCP set packetSize_ $pktSize
```

Code Snippets (cellular.tcl)

```
# node creation
set nodes(isp) [$ns node]
$nodes(isp) label "isp"
set nodes(ms) [$ns node]
$nodes(ms) label "ms"
set nodes(bs) [$ns node]
$nodes(bs) label "bs"
set nodes(lp) [$ns node]; # low power device
$nodes(lp) label “lp"
```

Code Snippets (cellular.tcl)

```
# node creation
# link between Mobile node and Base station (mimicking)
$ns duplex-link $nodes(ms) $nodes(bs) 1 1 RED
# link between Mobile node and low power (e.g. bluetooth)
$ns duplex-link $nodes(lp) $nodes(ms) 3Mbps 10ms DropTail
# link between Base station  and ISP (wired)
$ns duplex-link $nodes(bs) $nodes(isp) 3Mbps 50ms DropTail
```

Code Snippets (cellular.tcl)

```
# mimic wireless link (radio) params
$ns bandwidth $nodes(bs) $nodes(ms) $bwDL(gsm) simplex
$ns bandwidth $nodes(ms) $nodes(bs) $bwUL(gsm) simplex
$ns delay $nodes(bs) $nodes(ms) $propDL(gsm) simplex
$ns delay $nodes(ms) $nodes(bs) $propUL(gsm) simplex
$ns queue-limit $nodes(bs) $nodes(ms) $ql(gsm)
# delay characteristics setup
set delayerDL [new Delayer]
set delayerUL [new Delayer]
$ns insert-delayer $nodes(bs) $nodes(ms) $delayerDL
$ns insert-delayer $nodes(ms) $nodes(bs) $delayerUL
```

Code Snippets (cellular.tcl)

```
#set_delay values
set al_dl [new RandomVariable/Exponential]
$al_dl set avg_ $allocDelayDLAvg
set ah_dl [new RandomVariable/Exponential]
$ah_dl set avg_ $allocHoldDLAvg
#
set al_ul [new RandomVariable/Exponential]
$al_ul set avg_ $allocDelayULAvg
set ah_ul [new RandomVariable/Exponential]
$ah_ul set avg_ $allocHoldULAvg

$delayerDL alloc $ah_dl $al_dl
$delayerUL alloc $ah_ul $al_ul
```

Code Snippets (cellular.tcl)

```
#delay length and interval
set dist_len [new RandomVariable/
Exponential]
set dist_int [new RandomVariable/
Exponential]
if {$delayLen != "" && $delayInt != ""} {
  $dist_len set avg_ $delayLen
  $dist_int set avg_ $delayInt
  $ns after [$dist_int value] "insertDelay"
}

# define procedure ‘insertDelay’
```

Code Snippets (cellular.tcl)

```
proc insertDelay {} {
  global ns dist_len dist_int delayerDL
delayerUL

  $delayerDL block
  $delayerUL block

  set len [$dist_len value]
  $ns after $len "$delayerUL unblock"
  $ns after $len "$delayerDL unblock"
  set next [expr $len + [$dist_int value]]
  $ns after $next "insertDelay"
}
```

Code Snippets (`cellular.tcl`)

```
# Setting up traffic
# create TCP Connection.
# Use selective Ack (like Select Repeat)
set tcp1 [$ns create-connection TCP/Sack1
$nodes(isp) TCPSink/Sack1 $nodes(lp) 0]

# define FTP Application
set ftp1 [[set tcp1] attach-app FTP]

# start the FTP application
$ns at 1.0 "[set ftp1] start"
```

External Programs

- Need 2 external programs
  - `getrc`
  - `raw2xg`
- These programs are in `ns-allinone-2.35.tar.gz`
  - `ns-allinone-2.35/ns-2.35/tcl/ex/wireless-scripts`
- Copy these programs in `bin` subdir of `$HOME`
- For general wireless study, use the programs
  - `mtp.tcl, runall-tr.cmd`

Code Snippets (cellular.tcl)

```
proc stop {} {
  global nodes opt tf prefix
  set wrap $opt(wrap)
  set sid [$nodes($opt(srcTrace)) id]
  set did [$nodes($opt(dstTrace)) id]
  set GETRC "~/bin/getrc"
  set RAW2XG "~/bin/raw2xg"
  exec $GETRC -s $sid -d $did -f 0 $prefix.tr |\
    $RAW2XG -s 0.01  -q > gsmplot.xgr
  exec $GETRC -s $did -d $sid -f 0 $prefix.tr |\
    $RAW2XG -a -s 0.01 -q >> gsmplot.xgr
  #exec xgraph -t $prefix -x time -y packets
[set prefix]plot.xgr &
  exit 0
}
```

Config GSM (gsm.params)

```
set type gsm;  #type of link:
set allocDelayDLAvg 0.17;   # Avg time to allocate a downlink channel
set allocHoldDLAvg  3; # Avg time to hold a downlink channel
set allocDelayULAvg 0.5;    # Avg time to allocate a uplink channel
set allocHoldULAvg  0.2;    # Avg time to hold a uplink channel
set bwDL($type) 9600
set bwUL($type) 9600
set propDL($type) 500ms
set propUL($type) 500ms
```

Config CDMA (cdma.params)

```
set type cdma;  #type of link:
set allocDelayDLAvg “”;     # Avg time to allocate a downlink channel
set allocHoldDLAvg  “”;     # Avg time to hold a downlink channel
set allocDelayULAvg “”;     # Avg time to allocate a uplink channel
set allocHoldULAvg  “”;     # Avg time to hold a uplink channel
set bwDL($type) 384000
set bwUL($type) 64000
set propDL($type) 100ms
set propUL($type) 150ms
```

GPRS Simulations

- Good GPRS

```
-allocLenDL 'U(0.16,0.19)' \
-allocHoldDL 'U(2,5)' \
-allocLenUL 'U(0.5,0.6)' \
-allocHoldUL 'U(0.01,0.4)'
```

- Mediocre GPRS

```
-allocLenDL 'U(0.16,0.19)' \
-allocHoldDL 'U(2,5)' \
-allocLenUL 'U(0.5,0.6)' \
-allocHoldUL 'U(0.01,0.4)' \
-delayInt 'E(0.1)' \
-delayLen 'E(0.1)' \
```

GPRS Simulations

- Poor GPRS

```
-allocLenDL 'U(0.16,0.19)' \
-allocHoldDL 'U(2,5)' \
-allocLenUL 'U(0.5,0.6)' \
-allocHoldUL 'U(0.01,0.4)' \
-delayInt 'E(0.3)' -delayLen 'E(0.3)' \
-errRateUL 0.01 \
-errBurstUL 0.3 \
-errSlotUL 3 \
-errRateDL 0.01 \
-errBurstDL 0.3 \
-errSlotDL 3
```

CDMA Parameters

- Good CDMA params

```
set bwDL(cdma) 384000
set bwUL(cdma) 64000
set propDL(cdma) .150
set propUL(cdma) .150
set ql(cdma)   20

-delayInt 'E(0.1)' \
-delayLen 'E(0.04)'
```

Run Simulation GSM/CDMA

- For GSM simulation

```
ns celluar.tcl gsm
nam cdma.nam
xgraph -t GSM -x time -y packets
gsmplot.xgr
```

- For CDMA simulation

```
ns celluar.tcl cdma
nam cdma.nam
xgraph -t CDMA -x time -y packets
cdmaplot.xgr
```

Summary

- Understanding radio params
- Define config parameters for GSM
- Define config parameters for CDMA
- Invoke the cellular simulation with required cellular parameters.
  - Analyze the packets sent and ack received
  - Study the animation