Computer Network Lab

Exp 05, 06:
GSM & CDMA Simulation

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Resources

- References:
  - NS2 and wireless nodes
    - 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/

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
  - Experimental found even poor 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 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 was with link
  - Nodes have postions coordinates
    - nodes moves (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
  - Faireness
- 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 attributed `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

- How to define various wireless config attributes
  - As the number of wireless config params are related
  - By convention, use them attributes of a single tcl object `opt` with attributes.
- Wireless channel
  - `Channel/WirelessChannel`
    - Defines physical terrestrial wireless medium
  - `Channel/Sat`
    - Define satellite radio
- Radio propagation
  - `Propagation/TwoRayGround`
    - Takes into account ground reflection
    - Larger node distances, Received power level is `1/d4`
  - Other values
    - `Propagation/FreeSpace`

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

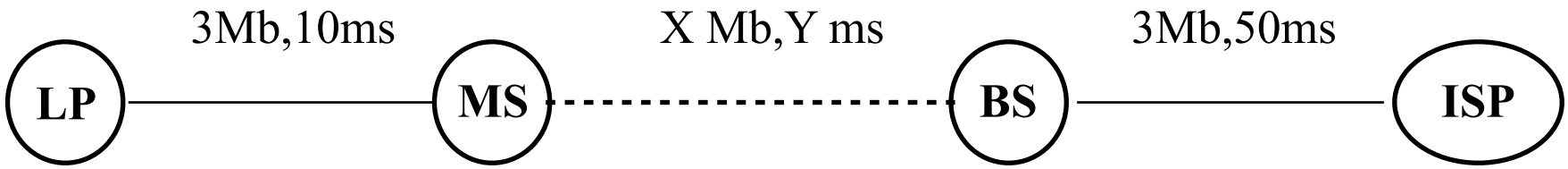
Wireless Networks Attributes

- 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 and 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

- Queue Management
  - RED (Random Early Detection)
    - Min Threshold (`minthresh`): `0`
    - Max Threshold (`maxthresh`): `30`
    - Adaptive (dynamically adjusts pkt drop rate) vs Plain
- 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`
  - Rate of errors (currently not configured)
    - `errRateDL: 0`
  - Burstiness coefficients of errors (currently not configured)
    - `errBurstDL: 0` (0 - no burst,)
  - Queue Length of packets

Cellular Network Parameters

- Iplink details (MS→BS)
  - DL bandwidth [`bwUL(gsm)`] : `9600 bps`
  - DL propagation delay [`propUL(gsm)`] : `500ms`
  - Channel allocation delay: Uniform or Exponential
    - Uniform requires: Min and Max range `(0.16-0.19)`
    - Exponential requires average value `allocDelayULAvg: 0.5`
  - Channel Hold Delay: Uniform (`2` to `5`) or Exponential
    - `allocHoldULAvg : 0.2`
  - Rate of errors (currently not configured)
    - `errRateUL: 0`
  - Burstiness coefficients of errors (currently not configured)
    - `errBurstUL: 0` (0 - no burst,)

Code Snippets (gsm.tcl)

```
# Active Queue Mgmt (AQM parameters)
set minthresh 30
set maxthresh 0
set adaptive 1;
set allocDelayDLAvg 0.17;
set allocHoldDLAvg  3;
set allocDelayULAvg 0.5;
set allocHoldULAvg  0.2;     #
set delayLen ""
set delayInt ""
```

Code Snippets (gsm.tcl)

```
# #default downlink/uplink bandwidth in bps
set bwDL(gsm) 9600
set bwUL(gsm) 9600

#default downlink/uplink propagation delay
set propDL(gsm) 500ms
set propUL(gsm) 500ms

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

Code Snippets (gsm.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 (gsm.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]
$nodes(lp) label “lp"

$ns duplex-link $nodes(ms) $nodes(bs) 1 1 RED
$ns duplex-link $nodes(lp) $nodes(ms) 3Mbps 10ms
DropTail
$ns duplex-link $nodes(bs) $nodes(isp) 3Mbps 50ms
DropTail
```

Code Snippets (gsm.tcl)

```
#set_link_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 (gsm.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 (gsm.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 (gsm.tcl)

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

  $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 (gsm.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"
```

Code Snippets (gsm.tcl)

```
proc stop {} {
  global nodes opt tf
  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 gsm.tr | \
  $RAW2XG -s 0.01  -q > gsmplot.xgr
  exec $GETRC -s $did -d $sid -f 0 gsm.tr | \
  $RAW2XG -a -s 0.01 -q >> gsmplot.xgr
  exec xgraph -t GSM -x time -y packets gsmplot.xgr &
  exit 0
}
```

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`

Run Simulation GSM

- `ns gsm`
- `nam gsm.nam`

- Get the sample program `gsm.tcl` and make changes to experience wireless mobility.

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 CDMA

- `ns cdma`
- `nam cdma.nam`

- Get the sample program `cdma.tcl` and make changes to experience wireless mobility.