Network Simulator: NS2

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Motivation for Simulations

- Cheap -- does not require costly equipment
- Complex scenarios can be easily tested
- Results can be quickly obtained – more ideas can be tested in a smaller timeframe
- The real thing isn't yet available
- Controlled experimental conditions
  - Repeatability helps aid debugging
- Disadvantages: Real systems too complex to model

Features of NS-2

- Protocols: TCP, UDP, HTTP, Routing algorithms, MAC etc
- Traffic Models: CBR, VBR, Web etc
- Error Models: Uniform, bursty etc
- Misc: Radio propagation, Mobility models , Energy Models
- Topology Generation tools
- Visualization tools (NAM), Tracing

NS Structure

- NS is an object oriented discrete-event simulator
  - Simulator maintains list of events and executes one event after another
  - Single thread of control: no locking or race conditions
- Back end is C++ event scheduler
  - Protocols mostly
  - Fast to run, more control
- Front end is oTCL
  - Creating scenarios, extensions to C++ protocols
  - fast to write and change

event : send pkt @ A @ t_1

T_1 : Txtime-1prog delay

deliver pkt @ B at t_2

$= t_1 + t_{xt} + prog$

event : Receive Pkt @ B at t_2

↳ Pkt @ B

Scripting Perl, Python

↳ object oriented Tool Command Language

TCL tutorial

- Variables:

```
set x 1
set y $x
```

- Arrays:

```
set a(0) 1
```

- Printing:

```
puts "$a(0) \n"
```

- Arithmetic Expression:

```
set z = [expr $y + 5]
```

- Control Structures:

```
if {$z == 6} then { puts "Correct!"}
for {set i =0} {$i < 5} {incr i }{
        puts "$i * $i equals [expr $i * $i]"
}
```

- Procedures:

```
proc sum {a b} {
        return [expr $a + $b]
}
```

NS programming Structure

- Create the event scheduler
- Turn on tracing
- Create network topology
- Create connections
- Generate traffic
- Insert errors etc

Creating Event Scheduler

- Create event scheduler: set ns [new simulator]
- Schedule an event: $ns at <time> <event>
  - event is any legitimate ns/tcl function

```
$ns at 5.0 "finish"
```

sec

```
proc finish {} {
        global ns nf
        close $nf
        exec nam out.nam &
        exit 0
}
```

animator

- Start Scheduler

```
$ns run
```

Tracing

- All packet trace

$ns trace-all [open out.tr w]

<event> <time> <from> <to> <pkt> <size>

<flowid> <src> <dst> <seqno> <aseqno>

```
+ 1.84375 0 2 cbr 210 ------- 0 0.0 3.1 225 610
- 1.84375 0 2 cbr 210 ------- 0 0.0 3.1 225 610
r 1.84471 2 1 cbr 210 ------- 1 3.0 1.0 195 600
r 1.84566 2 0 ack 40 ------- 2 3.2 0.1 82 602
+ 1.84566 0 2 tcp 1000 ------- 2 0.1 3.2 102 611
- 1.84566 0 2 tcp 1000 ------- 2 0.1 3.2 102 611
r 1.84609 0 2 cbr 210 ------- 0 0.0 3.1 225 610
+ 1.84609 2 3 cbr 210 ------- 0 0.0 3.1 225 610
d 1.84609 2 3 cbr 210 ------- 0 0.0 3.1 225 610
```

Tracing

- Variable trace

```
set par [open output/param.tr w]
$tcp attach $par
$tcp trace cwnd_
$tcp trace maxseq_
$tcp trace rtt_
```

Tracing and Animation

- Queue monitoring, Flow monitoring
- Network Animator

```
set nf [open out.nam w]
$ns namtrace-all $nf


 proc finish {} {
        global ns nf
        close $nf
        exec nam out.nam &
        exit 0
 }
```

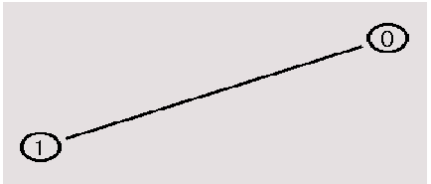
Creating topology

- Two nodes connected by a link
- Creating nodes

  set n0 [$ns node]
  set n1 [$ns node]

- Creating link between nodes
  - $ns <link_type> $n0 $n1 <bandwidth> <delay> <queue-type>

    $ns duplex-link $n0 $n1 1Mb 10ms DropTail



Sending UDP data

- Create UDP agent

```
set udp0 [new Agent/UDP]
$ns attach-agent $n0 $udp0
```

- Create CBR traffic source for feeding into UDP agent

```
set cbr0 [new Application/Traffic/CBR]
$cbr0 set packetSize_ 500
$cbr0 set interval_ 0.005
$cbr0 attach-agent $udp0
```

- Create traffic sink

```
set null0 [new Agent/Null]
$ns attach-agent $n1 $null0
```

Sending data

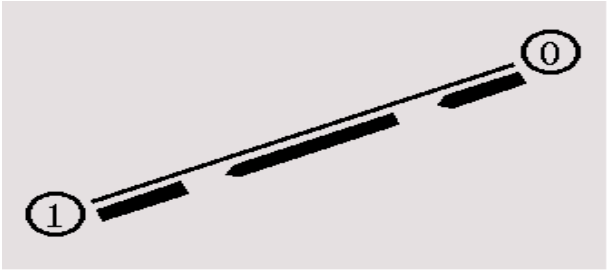
- Connect two agents

  $ns connect $udp0 $null0

- Start and stop of data

  $ns at 0.5 “$cbr0 start”

  $ns at 4.5 “$cbr0 stop”



Creating TCP Connections

- Create TCP agent and attach it to the node

```
set tcp0 [new Agent/TCP]
$ns attach-agent $n0 $tcp0
```

- Create a Null Agent and attach it to the node

```
set null0 [new Agent/TCPSink]
$ns attach-agent $n1 $null0
```

- Connect the agents

```
$ns connect $tcp0 $null0
```

Traffic on top of TCP

- FTP

  set ftp [new Application/FTP]
  $ftp attach-agent $tcp0

- Telnet

  set telnet [new Application/Telnet]
  $telnet attach-agent $tcp0

Introducing Errors

- Creating Error Module

```
set err [new ErrorModel]
$err unit pkt_
$err set rate_ 0.01
$err ranvar [new RandomVariable/Uniform]
$err drop-target [new Agent/Null]
```

- Inserting Error Module

```
$ns lossmodel $err $n0 $n1
```

Summary

- Simulators help in easy verification of protocols in less time, money
- NS2 offers support for simulating a variety of protocol suites and scenarios
- Front end is oTCL, back end is C++
- NS is an on-going effort of research and development (migrated to ns3)

Reference Material

- http://www.isi.edu/nsnam/ns/
  - Marc Greis' tutorial
  - Jae Chung tutorial
  - Ns manual