Network Simulator 2: Introduction

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NS-2 Overview

NS-2

- Developed by UC Berkeley
- Maintained by USC
- Popular simulator in scientific environment
- Other popular network simulators
  - Glomosim: UCLA, CMU; ParseC, Mobile Simulation mostly
  - OPNET: commercial software, graphical interface, not free;
  - Others: commercial ones, not free, e.g. IBM TPNS

NS2 Goals

- To support networking research and education
  - Protocol design, traffic studies, etc.
  - Protocol comparison;
  - New architecture designs are also supported.
- To provide *collaborative* environment
  - Freely distributed, open source;
  - *Increase confidence* in result

Two Languages: C++, OTcl

OTcl: short for MIT Object Tcl,
an extension to Tcl/Tk for object-oriented programming.

- Used to build the network structure and topology which is just the surface of your simulatoion;
- Easily to configure your network parameters;
- Not enough for research schemes and protocol architecture adaption.

Two Languages (Con’t)

C++: Most important and kernel part of the NS2

- To implement the kernel of the architecture of the protocol designs;
- From the packet flow view, the processes run on a single node;
- To change or “comment out” the existing protocols running in NS2;
- Details of your research scheme.

Why 2 Languages?

- **2 requirements of the simulator**
  - Detailed simulation of Protocol: Run-time speed;
  - Varying parameters or configuration: easy to use.
- C++ is fast to run but slower to code and change;
- OTcl is easy to code but runs slowly.

Protocols/Models supported by NS2

- Wired Networking
  - Routing: Unicast, Multicast, and Hierarchical Routing, etc.
  - Transportation: TCP, UDP, others;
  - Traffic sources: web, ftp, telnet, cbr, etc.
  - Queuing disciplines: drop-tail, RED, etc.
  - QoS: IntServ and Diffserv Wireless Networking
- Ad hoc routing and mobile IP
- Sensor Networks(hmmm)
  - SensorSim: built up on NS2, additional features, for TinyOS

NS2 Models

- Traffic models and applications:
  Web, FTP, telnet, constant-bit rate(CBR)

- Transport protocols:
  Unicast: TCP (Reno,Vegas), UDP Multicast

- Routing and queuing:
  Wired routing, Ad Hoc routing.

- Queuing protocols:
  RED(Random Early Drop), drop-tail

- Physical media:
  Wired (point-to-point, LANs), wireless, satellite

Researches based on NS2

- Intserv/Diffserv (QoS)
- Multicast: Routing, Reliable multicast
- Transport: TCP Congestion control
- Application: Web caching Multimedia
- Sensor Networks: LEACH, Directed Diffusion, etc. Most are routing protocols.
- etc.

NS2 Components

- NS2: the simulator itself, now version: ns-2.26
  We will work with the part mostly.

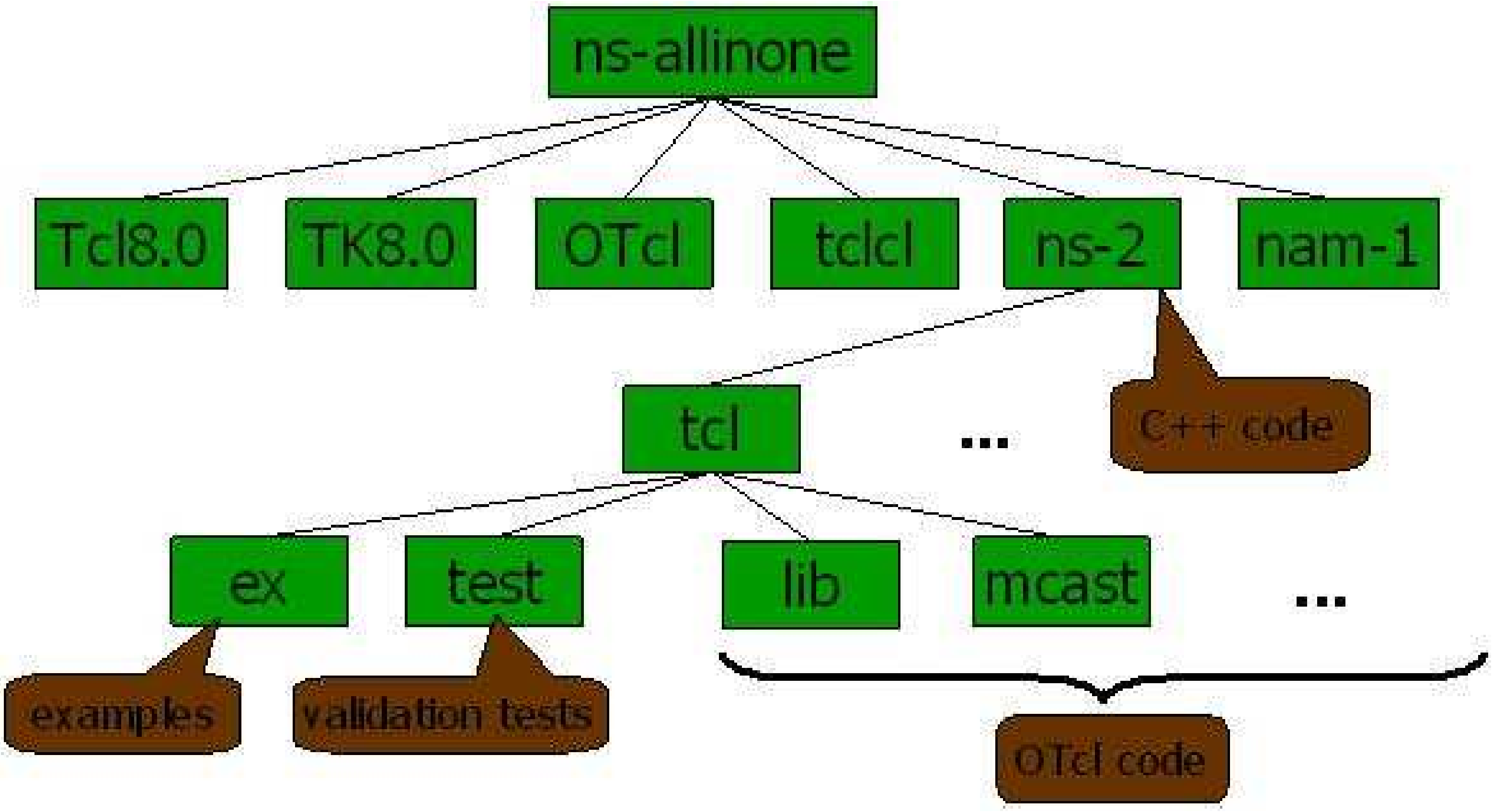
- NAM: Network animator. Visualized trace tool(not really).
  Nam editor: GUI interface to generate ns scripts
  Just for presentation now, not useful for research tracing.

- Pre-processing:
  Traffic and topology generators

- Post-processing:
  Simple trace analysis, often in Awk, Perl(mostly), or Tcl

Living under NS2

The NS2 Directory Structure



A Simple Example in OTcl

```
#Create a simulator object
set ns [new Simulator]

#Define different colors for data flows (for NAM)
$ns color 1 Blue
$ns color 2 Red

#Open the NAM trace file
set nf [open out.nam w]
$ns namtrace-all $nf

#Define a ’finish’ procedure proc finish {} {
        global ns nf
        $ns flush-trace
        #Close the NAM trace file
        close $nf
        #Execute NAM on the trace file
        exec nam out.nam &
        exit 0
}
```

A Simple Example in OTcl (Con’t)

```
#Create four nodes
set n0 [$ns node]
set n1 [$ns node]
set n2 [$ns node]
set n3 [$ns node]

#Create links between the nodes
$ns duplex-link $n0 $n2 2Mb 10ms DropTail
$ns duplex-link $n1 $n2 2Mb 10ms DropTail
$ns duplex-link $n2 $n3 1.7Mb 20ms DropTail

#Set Queue Size of link (n2-n3) to 10
$ns queue-limit $n2 $n3 10

#Give node position (for NAM)
$ns duplex-link-op $n0 $n2 orient right-down
$ns duplex-link-op $n1 $n2 orient right-up
$ns duplex-link-op $n2 $n3 orient right

#Monitor the queue for link (n2-n3). (for NAM)
$ns duplex-link-op $n2 $n3 queuePos 0.5
```

A Simple Example in OTcl (Con't)

```
#Setup a TCP connection
set tcp [new Agent/TCP]
$tcp set class_ 2
$ns attach-agent $n0 $tcp
set sink [new Agent/TCPSink]
$ns attach-agent $n3 $sink
$ns connect $tcp $sink
$tcp set fid_ 1

#Setup a FTP over TCP connection
set ftp [new Application/FTP]
$ftp attach-agent $tcp
$ftp set type_ FTP

#Setup a UDP connection
set udp [new Agent/UDP]
$ns attach-agent $n1 $udp
set null [new Agent/Null]
$ns attach-agent $n3 $null
$ns connect $udp $null
$udp set fid_ 2
```

A Simple Example in OTcl (Con’t)

```
#Setup a CBR over UDP connection
set cbr [new Application/Traffic/CBR]
$cbr attach-agent $udp $cbr
set type_ CBR $cbr

set packet_size_ 1000 $cbr
set rate_ 1mb $cbr
set random_ false

#Schedule events for the CBR and FTP agents
$ns at 0.1 "$cbr start"
$ns at 1.0 "$ftp start"
$ns at 4.0 "$ftp stop"
$ns at 4.5 "$cbr stop"

#Detach tcp and sink agents (not really necessary)
$ns at 4.5 "$ns detach-agent $n0 $tcp ;
$ns detach-agent $n3 $sink"

#Call the finish procedure after 5 seconds of simulation time
$ns at 5.0 "finish"
```

A Simple Example in OTcl (Con’t)

```
#Print CBR packet size and interval
puts "CBR packet size = [$cbr set packet_size_]"
puts "CBR interval = [$cbr set interval_]"

#Run the simulation
$ns run
```

Steps in writing a simulating script

- Create the event scheduler
- Turn on tracing
- Create network
- Setup routing
- Insert errors
- Create transport connection
- Create traffic
- Transmit application-level data

The trace file

- Turn on tracing on specific links

  ```
  $ns_ trace-queue $n0 $n1
  ```

- Each line in the trace file is in the format:

  $$< event > \quad < time > \quad < from > \quad < to >$$

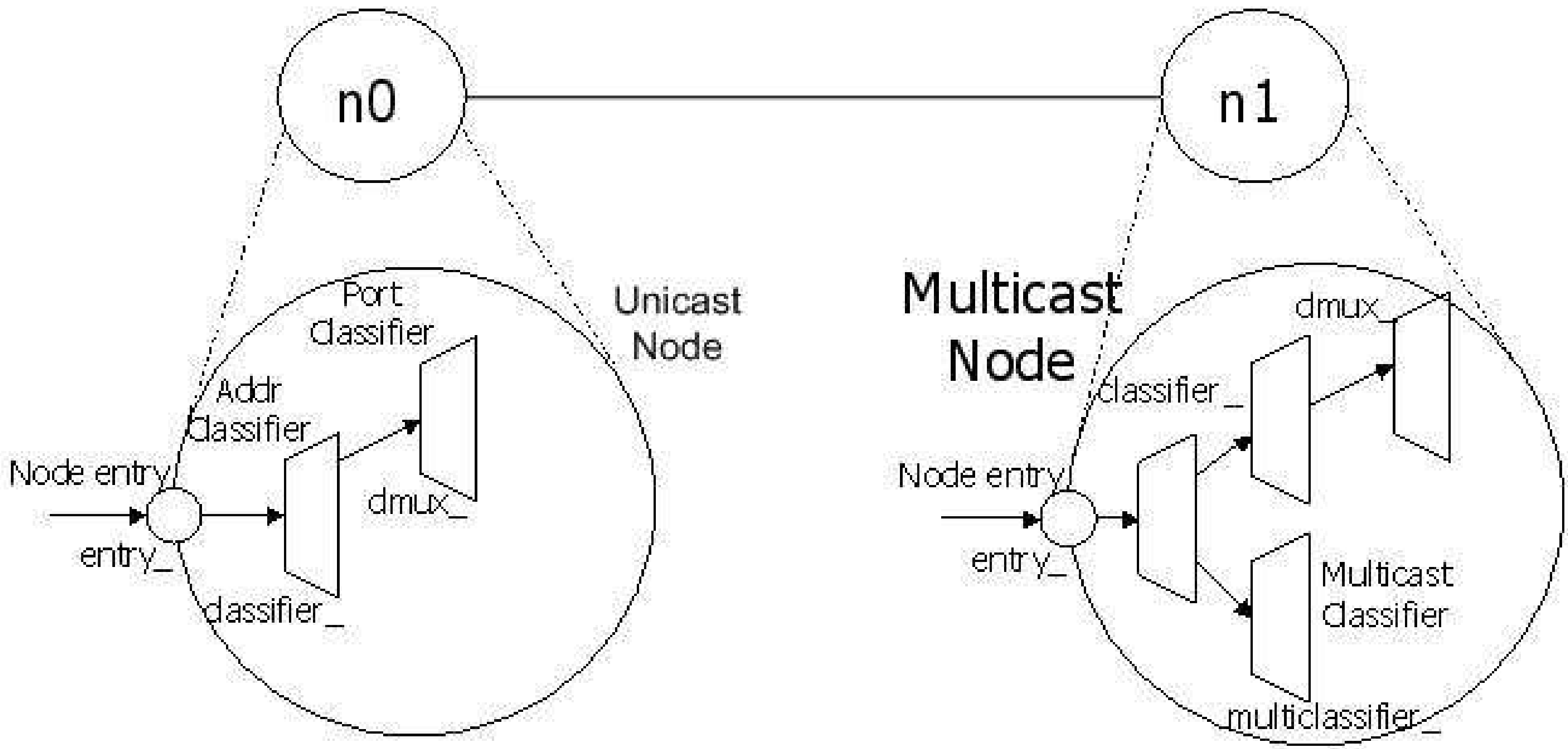
  $$< pkt - type > \quad < pkt - size > \quad < flags >$$

  $$< fid > \quad < src > \quad < dst > \quad < seq > \quad < uid >$$

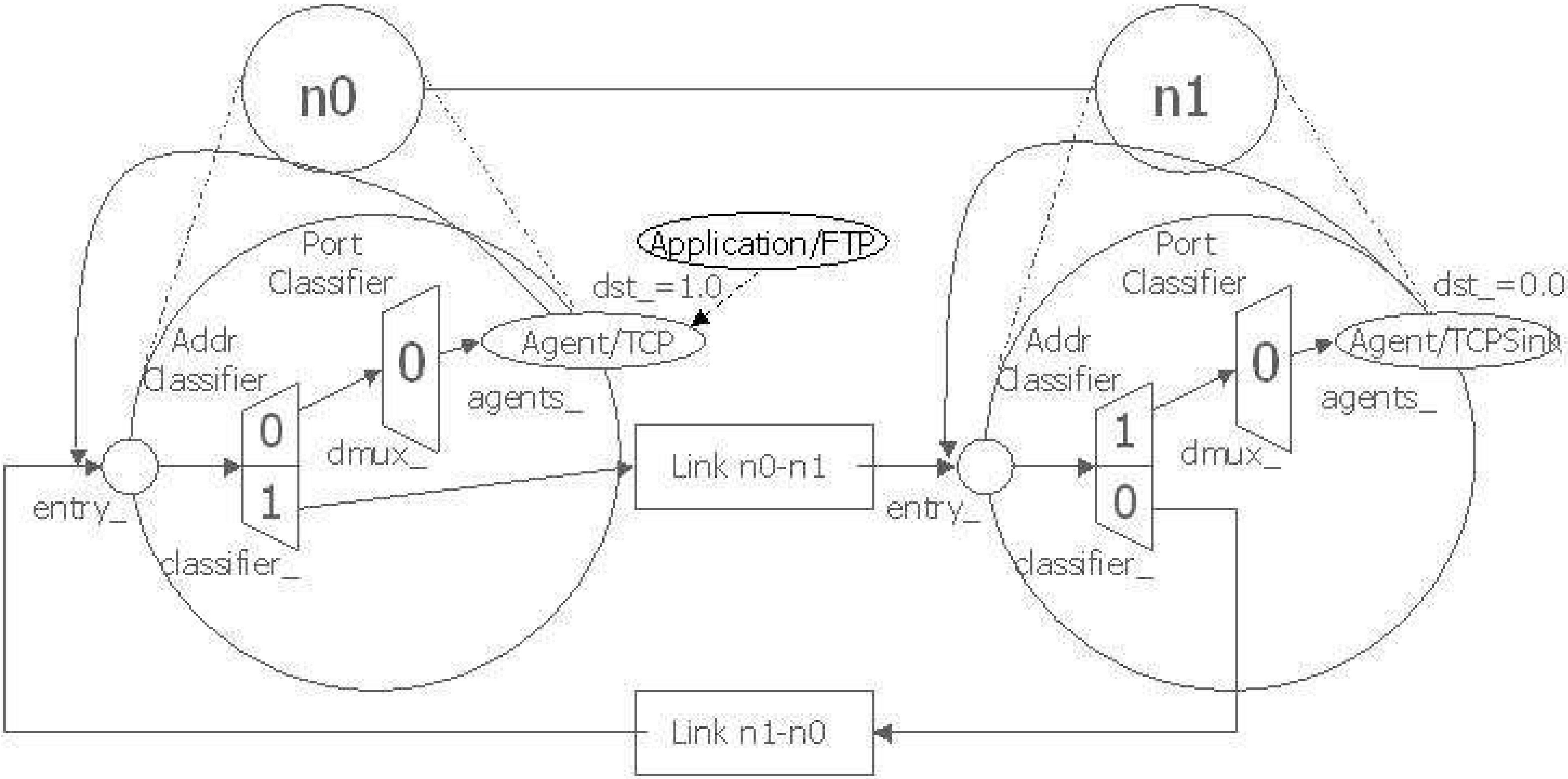
- Trace example:

  ```
  + 1 0 2 cbr 210 ------- 0 0.0 3.1 0 0
  - 1 0 2 cbr 210 ------- 0 0.0 3.1 0 0
  r 1.00234 0 2 cbr 210 ------- 0 0.0 3.1 0 0
  ```

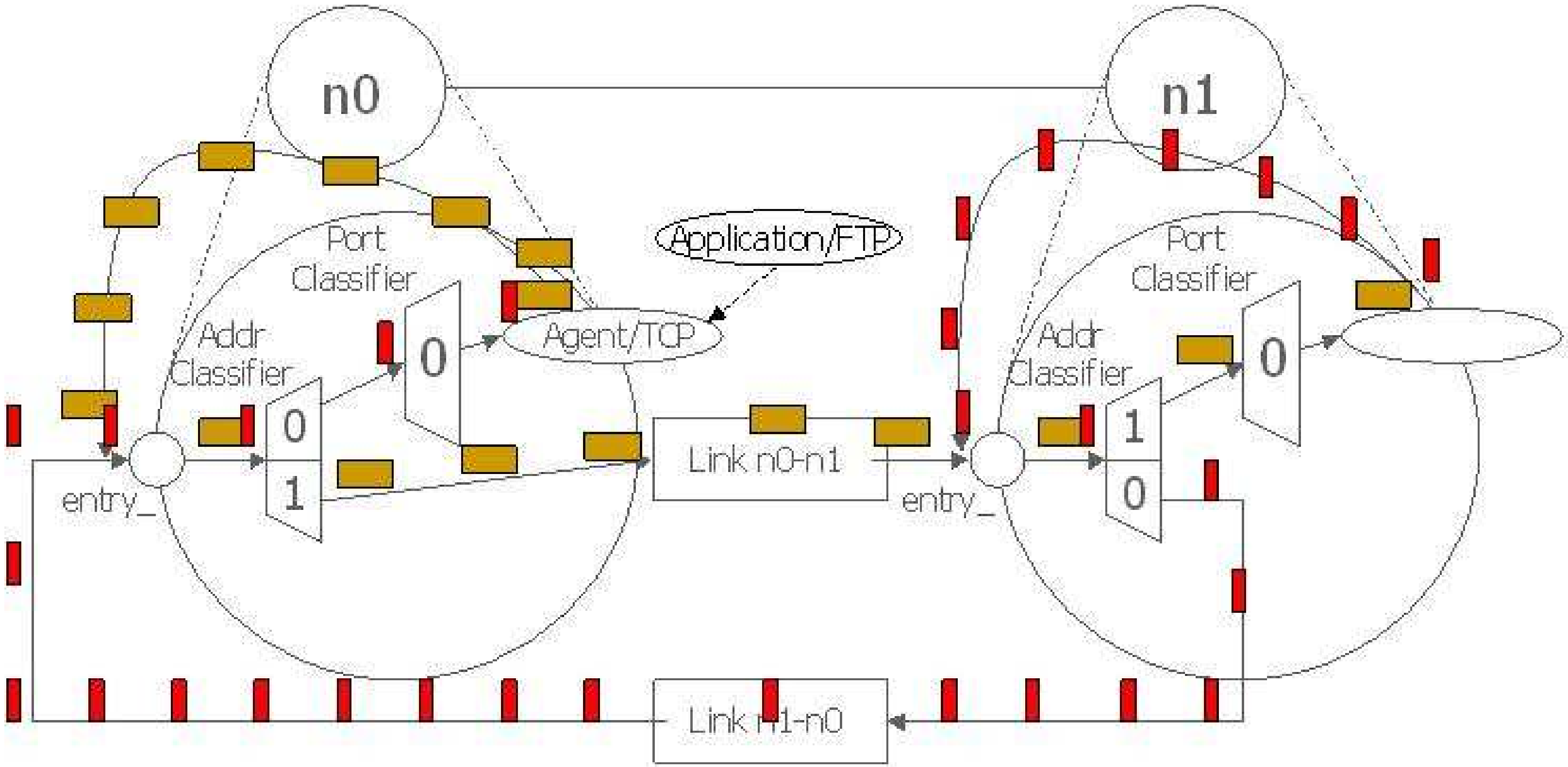
The network Topology



The Node Architecture

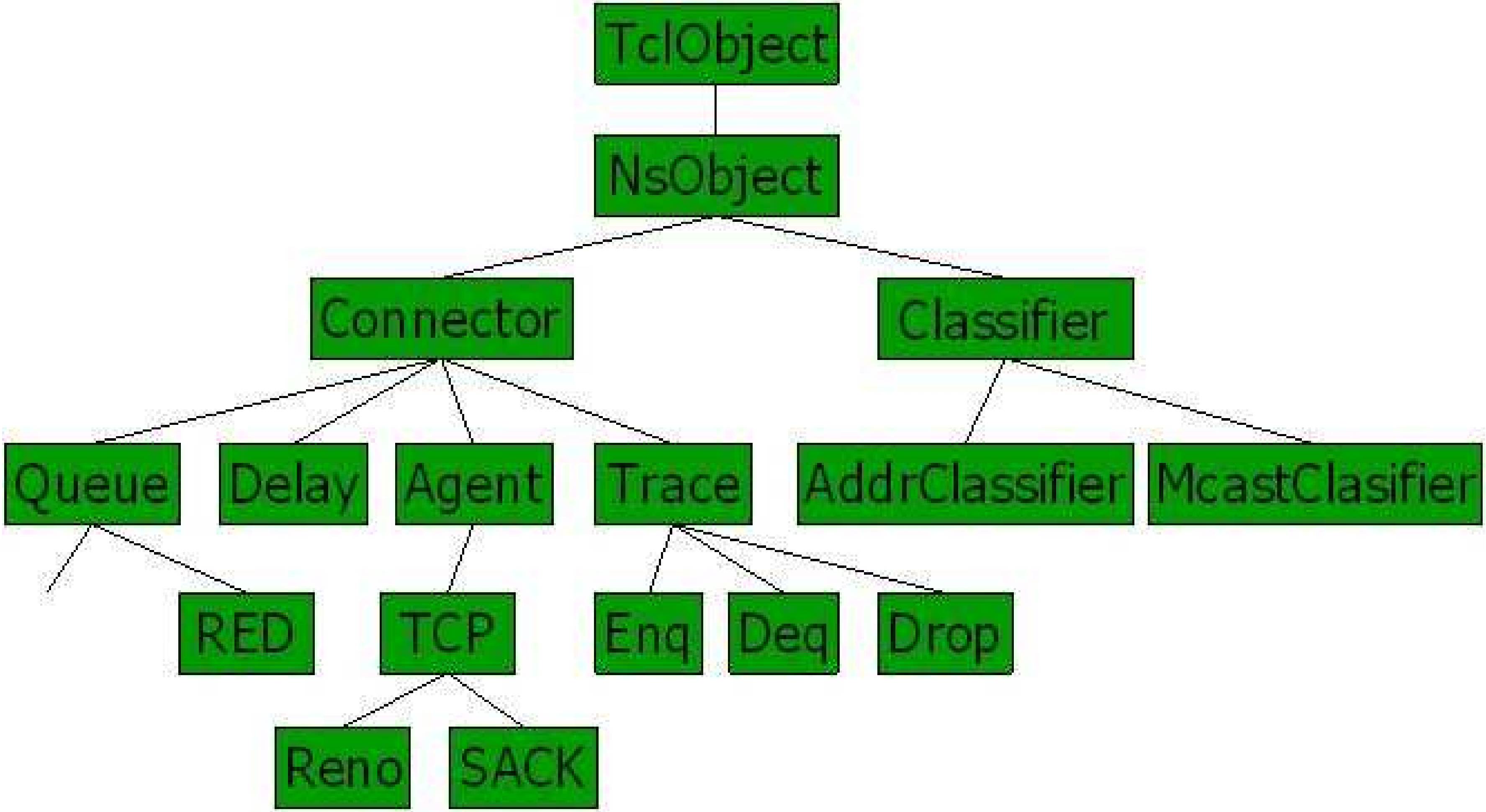


The Packet Flow



Extending to NS2

Class Hierarchy in NS2(Partial, C++ code)



Create New Component for NS2

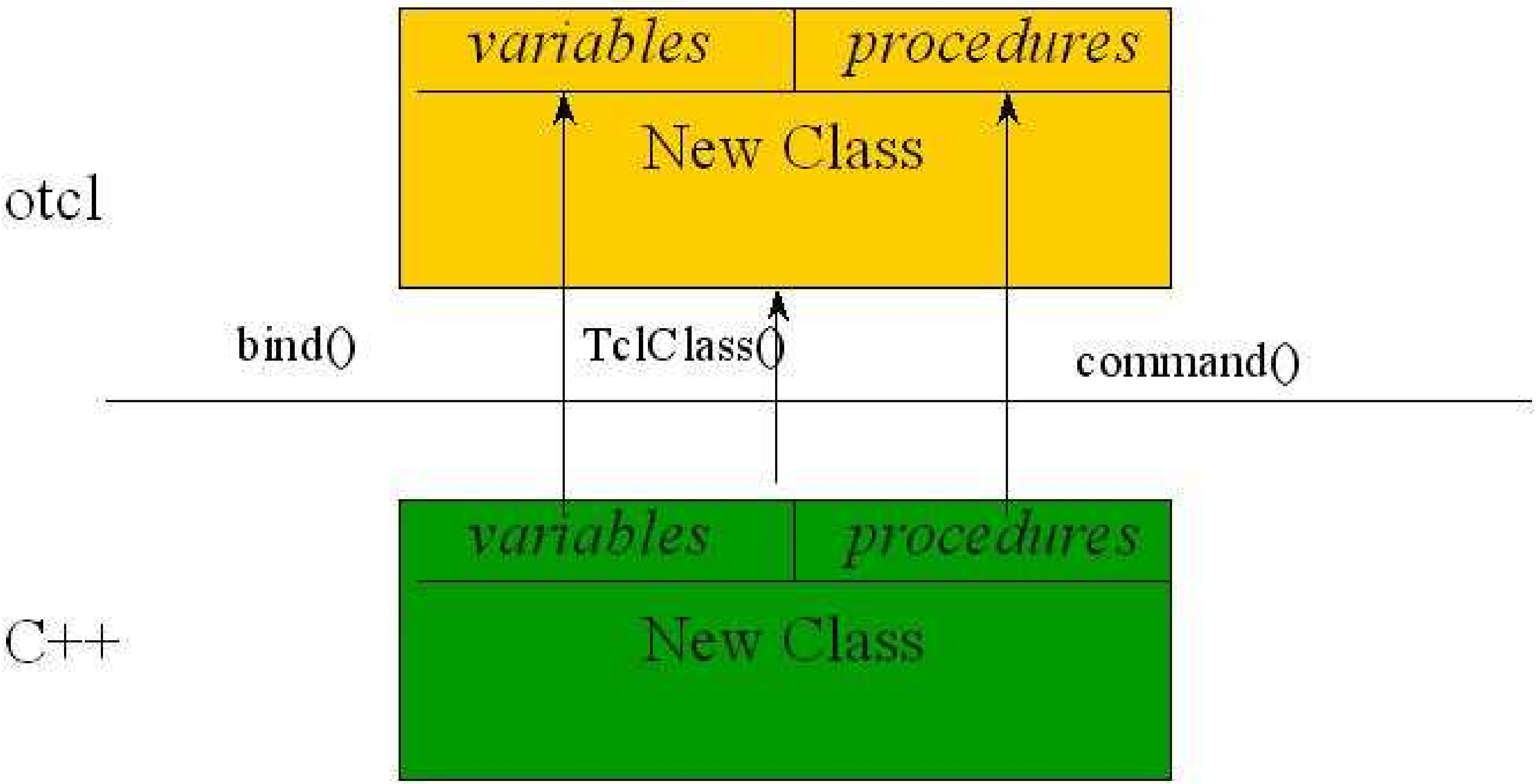
Your research needs you to do so, no escaping(crying!!!).

- Extending ns in Otcl

  source your changes in your simulation scripts

- Extending ns in C++
  - Change Makefile (if created new files)
  - make depend
  - recompile
  - Makefile is in the ”ns-2.26” directory

Adding New Class



A piece of my code

Applications based on Sensor Networks

- .h file:

```
class TmprSensorApp : public DiffApp {
    public:
        TmprSensorApp();
        int command(int argc, const char*const* argv);
        void run();
    ...
    }
```

A piece of my code (Con’t)

- .cc file:

```
static class TmprSensorAppClass : public TclClass {
    public:
        TmprSensorAppClass() : TclClass("Application/DiffApp/TmprSensor"){}
        TclObject* create(int, const char*const*){
            return (new TmprSensorApp());
        }
} class_tmpr_sensor;

int TmprSensorApp :: command(int argc, const char*const* argv){
    if(argc == 2){
        if(strcmp(argv[1], "publish") ==0){
            run();
            return TCL_OK;
        }
    }
    ...
```

Binding New C++Object to TclObject

Link C++ member variables to OTcl object variables

- C++:

```
NewClass() : TclClass("class hierarchy");
```

- OTcl:

```
set "object belongs to NewClass" [new "class hierarchy"]

set src_(0) [new Application/DiffApp/TmprSensor]
$ns_ attach-diffapp $node_(0) $src_(0)
$ns_ at 1.23456 "$src_(0) publish"
```

Thank You !

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