ssfnet

Scalable Modeling & Simulations of Networks
ssf and ssfnet

ssf: a modern simulation platform
- scalable, parallel kernel, open API
- model configuration database framework
- random stream management & statistics
- pure Java (C++ version available)

design & performance demonstrated at earlier PI meetings

network modeling layers: ssfnet

---- core ssf & ssfnet completed
ssfnet - overview 1

modeling aids:

- network configuration verification and management
- total reproducibility: management of random number streams
- strongest random number generators, statistics package
- automated IP address generation (VLSM/CIDR)
- traffic pattern configuration

practical good news:

- parallel performance from a desktop PC to a supercomputer
- fast topology construction and protocol configuration
- no programming style restrictions
walk-through example of multi-scale modeling:

- USA-scale multi-AS network
- full Internet protocol suite
- empirical model of the Web traffic

current research:

- networkers' IDE (integrated development environment)
- multiresolution analysis of spatio-temporal network dynamics
- wireless Internet problems
Java SSF performance 1

Basic event spin-loop experiment
Java gets pretty fast by now!

JDK1.2  Solaris2.7   14 CPU SUN Enterprise, 200MHz
Java ssfnet - parallel performance

- N networks (AS) connected as a ring
- OSPF in each AS (24 clients, 4 servers, 18 routers)
- BGP between ASs
- client-server TCP - large file transfer

- each clnt to local AS server
- each clnt to neighbor AS server
- each clnt to random AS server

Parallel speedup

all AS on one processor exec time
one AS per processor exec time

# processors = # AS

JDK 1.2  SUN Enterprise 200MHz
Java ssfnet on a Windows PC

6 networks (AS) connected as a ring
OSPF in each AS (24 clients, 4 servers, 18 routers)
BGP between ASs
each client-server TCP - 3MB file transfer
3,000 TCP packets
each client connects to a random AS server

1.7 times faster for parallel simulation

440 seconds
260 seconds

1 CPU
2 CPU

Windows NT4.0  JDK1.2  PentiumPro 250 MHz
network modeling packages

SSF.Net
- host, router, queues, network interfaces
- links & LANs
- nested Net import, hierarchical component addressing
- IP address generation

SSF.OS
- ProtocolGraph - ProtocolSession - ProtocolMessage
  x-kernel-like protocol design framework
- protocol and application models
ssfnet protocol validation

ssfnet distribution includes validation tests

- test network configurations, HTML docs, traces
- TCP, UDP, BGP4, OSPF in distribution
- validation against RFCs and other test suites
Example: ssfnet TCP validation

generic Tahoe, Reno, delayed ACK option

- BSD socket-like interface to app protocols
- validation against RFCs and ns-2 test suite (thanks!)
- full documentation and plots:

www.winlab.rutgers.edu/~ato/ssf/tcp/
TCP validation 2

- Binary tcpdump (standard)
- Fully instrumented TCP implementation (DML selectable)
- Matlab plotting in ssfnet distribution
Network configuration design/management database

- hierarchical object-oriented schemas: simple & powerful
- strong configuration reuse: substitution & multiple inheritance
- automatic verification of configuration correctness
- target for CAD and analysis tools
- separation of config database and executable code
  reduces modeling errors

examples follow...
Total reproducibility of parallel simulations

- control of seed distribution via cryptographic techniques (MD) on random stream pathnames
- creation of random stream instances at multiple levels (per distribution, protocol, host, timeline)

Strongest, fast random number generators & statistics

- Mersenne Twister, Ranlux, Ranmar, Ranecu, RandomShuffle,..
- 24 common prob. distributions...statistics (CERN packages)

examples follow...
walk-through a large model

router + 4 LANs,
LAN = 25 hosts,
= 100 hosts

add a router
and connect together
DML database entry

from database of network cards........ inheritance

from database of protocol graphs....... substitution

walk through a large model 2

networks [ network100 [ Net [ router [ id 0 interface [ id 0 _extends .dictionary.100Mb ] ] # LAN
 interface [ id 1 _extends .dictionary.100Mb ] ] # LAN

......

interface [ id 5 _extends .dictionary.1Gb ] ] # to be attached
 interface [ id 6 _extends .dictionary.1Gb ] ] # to be attached

_find .dictionary.routerGraph.graph

] # all hosts are identical. 4 lans @ 25 hosts per lan = 100 hosts
host [ idrange [from 1 to 25]

_find .dictionary.client100Mb.interface
_find .dictionary.client100Mb.graph

 nhi_route [dest default interface 0 next_hop 0(0 )]

] # LAN 0
link [ delay 0.001 attach 0(0)
 attach 1(0) attach 2(0) attach 3(0) attach 4(0) attach 5(0)

......

attach 21(0) attach 22(0) attach 23(0) attach 24 (0) attach 25(0)
]
combine submodels together
... make a small Autonomous System:
1,300 client hosts, 4 big servers,
26 internal routers (OSPF),
1 AS boundary router (OSPF + BGP)

DML database entry:

```dml
as2 [
  Net [
    AS_status_boundary
    ospf_area 0

    Net [id 0 _extends .networks.network1.Net]  # backbone
    Net [id 1 _extends .networks.network4.Net]  # server farm
    Net [id 2 _extends .networks.network33.Net]
    Net [id 4 _extends .networks.network34.Net]
```

......Net import from a database
- a powerful concept
now connect 25 copies of an **as2** network
...and we have 33,325 hosts & routers
... do you recognize the ISP?
Traffic pattern databases

**local**

```plaintext
client100Mb [  
  graph [  
    ProtocolSession [  
      name client use SSF.OS.WWW.httpClient
    
    # HTTP session empirical model.  
    inter_session_time [  
      distribution [  
        name "Exponential"  
        lambda 0.01
      ]
    ]

    inter_page_time [  
      distribution [  
        name "Pareto"  
        k 25.0 alpha 2.0
      ]
    ]
  ]  
]  
```

**global**

```plaintext
randomstream [  
  generator "MersenneTwister"  
  stream "seedstarter4"  
  reproducibility_level "host"
]

traffic [  
  pattern [  
    client 10  
    servers [ port 80  
      nhi_range [  
        from 10:1:2(0) to 10:1:5(0)
      ]
    ]
  ]
]
```

......... more
Current research: net dynamics

AT&T Research - DIMACS - Princeton

- collaboration on multiresolution analysis of spatio-temporal behavior of large networks (Willinger, Feldmann, Daubechies, Ogielski and others)
- towards "new theory of networks"
- very challenging - drives ideas for new methodologies & tools
- simulated & real traffic studies

examples follow...
Scalable Simulation Framework

Challenge:
manipulate & visualize
1000s of flows
Current research: wireless Internet

WINLAB & affiliated corporations
(Motorola, Lucent, Cisco,...)

- SSF is the platform for various wireless Internet and 3G projects
- TCP over adaptive radio link protocols (like cdma2000)
- ad-hoc Bluetooth-based IP networks
- signal level multicell 3G systems: waveform to IP

examples follow...
ssfnet2 - integration of Internet & Wireless models

Scale and Details matter!
wireless access + wired global net
scalable design & analysis tools

Internet software radios,
inter-protocol interactions,
traffic, service design,...
Research on TCP - RLP interactions: towards better protocols for wireless Internet

phase 1: correlated fading losses
1 wireless host, 1 TCP connection, RLP, fading, simplified IP cloud

phase 2: add multiaccess
N wireless hosts, many connections, MAC + RLP, fading, interference, simplified IP cloud

phase 3: add wired congestion
phase 2 plus realistic IP cloud: correlated wireline delays/losses
Current research: network IDE

Integrated Design Environment for networking research

- graphical **DML-based network editor**
  topology generation, protocol configuration, database generation, validation (prototype exists, needs some more work)
- High-volume stream data collection (~ 1000s of tcpdumps) and multiscale analysis package (challenging...)

**dual-use for model & real networks**
ssfnet '99 development team

Andy Ogielski  DIMACS & WINLAB
James Cowie  Cooperating System
David Nicol  Dartmouth College

Students (wired Internet)
Myongsu Choe
Philip Kwok
Hongbo Liu
Brian Premore

Students (wireless Internet)
Yong Bai
Vikram Kaul
Wenfeng Zhang

DARPA ITO project administered by DIMACS, Rutgers U.
ssfnet web site

ssfnet software distribution

www.ssfnet.org

Open source modeling packages, protocols, networks.