Hybrid Internet Simulation Testbed

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Development Team

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Motivations and Goals

- Internet technology extended to combine with a variety of technologies, involving satellite channel
  - Feasibility study
  - Trade-off analysis
  - System integration
- Simulation is a powerful tool to parallel with real system implementation
- To make a set of reusable modules upon which complex systems can be built to study standard protocols, their variations and interactions.
Approaches and Project Outline

- Separate module development
  - Source/Traffic models
  - TCP/IP protocols and enhancements
  - Scheduling and buffer management

- Model testing and verification
  - Real traffic trace and duplicated trace from simulation
  - Simulation results v.s. documented results and real implementation

- System integration using developed modules -- Application example
  - Satellite gateway
  - DirecPC system
Source/Traffic Model

- Single process model traffic generators
  - Auto-Regression
  - Pareto
  - Weibull
  - Log-Normal
  - Markov Modulated Poisson Process

- Aggregated On-Off sources to approximate self-similar traffic
Source/Traffic Model (Cont’d)

Traffic trace of 20 on-off sources
Source/Traffic Model (Cont’d)

- Using dynamic processes for Fractional Brownian Motion:
  \[ X(t) = m_0 t + m \]
  - Root process generates rate \( m \) using M/G/∞ model (G: Pareto)
  - Child process takes rate \( m \) and generates packet stream
Source/Traffic Model (Cont’d)

- Model correctness and applicability verification
  - Develop parameter estimator for theoretical models
  - Estimate parameters for real traffic traces using a particular model
  - Feed estimated parameters to corresponding simulation model to generate duplicated traces
  - Goodness of fit test on real trace and duplicated trace
TCP Protocol Enhancements

- Implemented all RFC[1323] and RFC[2018] enhancements to TCP
  - Fast Recovery, Fast Retransmit
  - Window Scaling
  - SACK, FACK
  - Time Stamp Option
- (Developed before OPNET release of version 6, which contains the Mil3 implementations of the above)
TCP Spoofing/Connection Splitting

- End-to-End TCP connection is split into separate TCP connections from end hosts to gateways and in-between gateways

- Models modified: tcp_man, tcp-conn, ip_rte, ip_encap
Scheduling and Buffer Management

- Developed a comprehensive set of Scheduling and buffer algorithms in the IP module in OPNET 5.1 including:
- Flow Classification Module
- Scheduling algorithms implemented are:
  - First Come First Serve (FCFS)
  - Round Robin (RR)
  - Start-time Fair Queuing (SFQ)
- Buffer Management algorithms:
  - Tail Drop; Drop from Front
  - Longest Queue Drop (LQD); Random Longest Queue Drop (RND)
  - RED
  - Probabilistic Fair Drop (PFD)
Protocol Boosters

- Implemented the Forward Erasure Correction (FZC) Booster
  - Simulated by specifying a level of correction and the reduction in data rate resulting from it
  - Implementation involved modifications to the error correction pipeline stage as well as the transmission delay pipeline stage

- Enhances the performance of TCP/UDP over wireless channels
Application Example -- DirecPC

-All significant components
  - Hybrid Hosts
  - Information Server
  - Hybrid Gateway
  - Satellite Gateway
  - DBS Satellite

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Application Example -- DirecPC (Cont’d)

- Completely model the DirecPC system including the following features:
  - All important system components-
    - Hybrid Hosts
    - Satellite gateway and Hybrid Internet gateway
    - Satellite and terrestrial links

- Emphasis on accurate implementation of simulations for:
  - HGW spoofing, connection splitting and TCP options
  - SGW flow control

- Sanity-check: Evaluated the testbed for accuracy and have obtained preliminary results demonstrating the performance gain from TCP spoofing
Conclusion and Future Work

- We have built a comprehensive set of modules in OPNET related to the Internet which can be assembled into any given simulation scenario, and used to perform comparison/trade-off studies.
- Continue working on traffic analysis to provide realistic traffic input for simulations.
- Simulation study of caching and multicasting systems.