

Workload Generation for ns Simulations of Wide Area Networks and the Internet ¹

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Outline of the talk

- The ns network simulator
- Simulating wide area networks: Issues
 - Traffic composition and protocol differences
 - Traffic generation
 - Topology
- Simulating wide area networks: Solutions
 - Traffic composition
 - Traffic generation
- Simulation results
- Summary and conclusions

Simulation platform: ns

- ns: Network simulator developed by UCB /LBLN and the VINT project
- Open source code and particularly easy to modify
- Includes libraries of topology and traffic generators and visualization tools
- Wide acceptance in the networking research community

Simulating wide area networks:

Issues

- Traffic composition and protocol differences
 - Simulated traffic should maintain the proper composition
 - Sources select their destinations randomly
 - Different applications generate sessions with different distributions
 - Number of sessions in a network varies continuously
 - *ns* is incapable of accounting for these effects

Simulating wide area networks:

Issues (Cont.)

- Traffic generation
 - Trace based traffic generators: Unable to account for changing network conditions and feedback
 - Source based traffic generators
 - *ns* does not use application specific stochastic models to generate traffic
 - *ns* does not have generators for long-range dependent (Self-similar) network traffic

Simulating wide area networks: Issues (Cont.)

- Topology issues
 - WANs and the Internet can be viewed as a diverse collection of interconnected domains
 - Each domain has its own internal topology
 - Large networks also have wide variations in their link bandwidths
 - *ns* has libraries for topology generation

Simulating wide area networks: Solutions

- Traffic composition
 - We have implemented mechanisms to control the percentage of TCP and UDP sessions in the traffic
 - Our implementation randomly chooses source-destination pairs from the nodes in the network
 - Capability to use any suitable distribution to characterize workload division between nodes and use it to select the source-destination pairs

Simulating wide area networks: Solutions (Cont.)

- Session generation
 - We introduce application specific traffic generators in *ns* for Telnet, WWW, FTP and SMTP
 - We use empirical distributions to characterize the inter-arrival times, duration and data transferred by each application
 - Sessions generated by each application characterized by
 - * mean number of sessions (MNS)
 - * mean inter-arrival time of sessions (MIATS)
 - * mean duration time of sessions (MDTS)

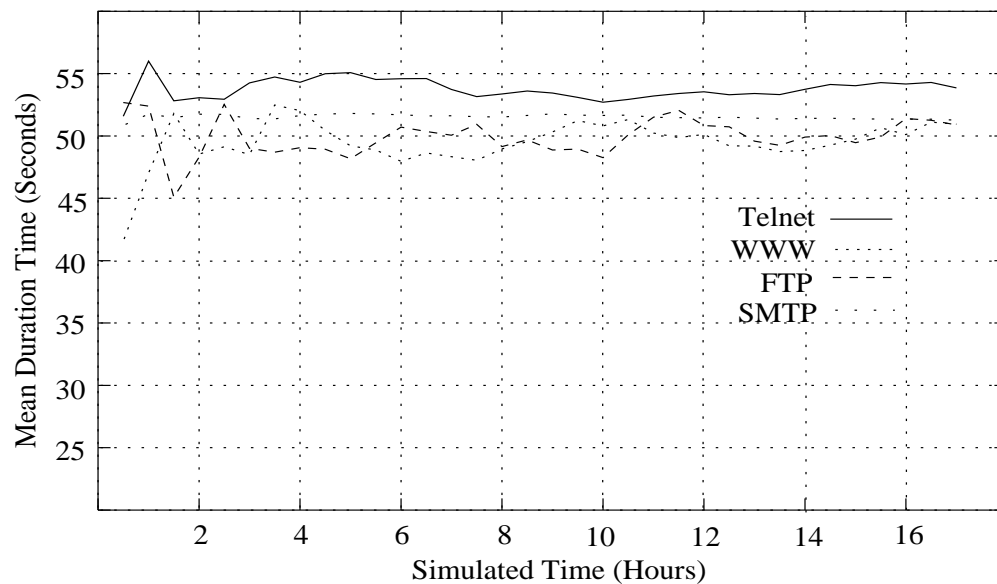
Simulating wide area networks: Solutions (Cont.)

- Session generation
 - Each expiring session replaced by random number of sessions
 - Continuous variation in the number of active sessions giving a more realistic network scenario

Simulating wide area networks: Solutions (Cont.)

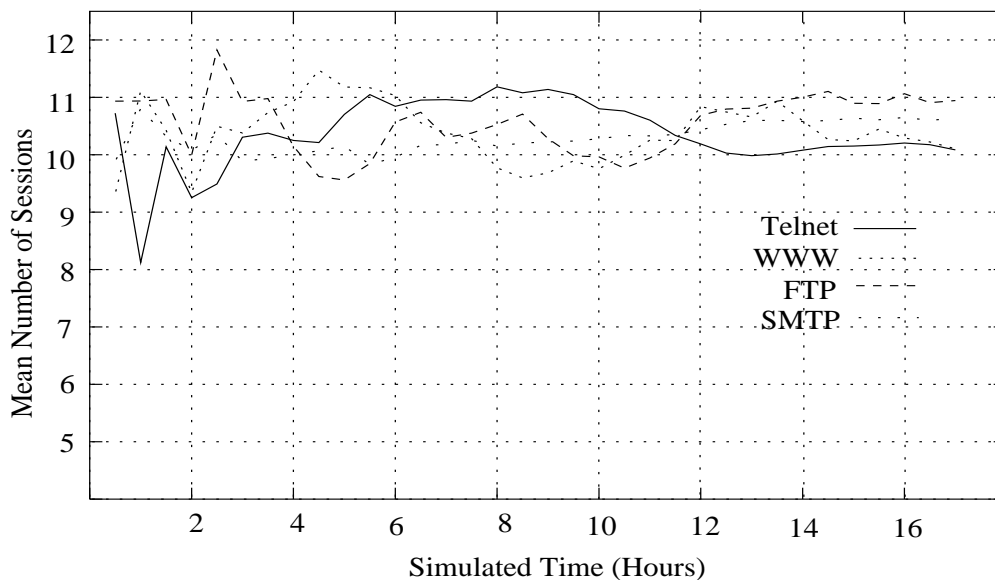
- Traffic generation: Self-similar traffic generators
 - Long-range dependence in aggregated WWW, Ethernet and WAN traffic
 - We implemented two self-similar traffic generators in *ns*
 - `Application/Traffic/SupFRP`: Based on superposition of Fractal renewal processes
 - `Application/Traffic/SS`: Based on superposition of Markov modulated Poisson processes

Simulation results: Mean duration times of sessions



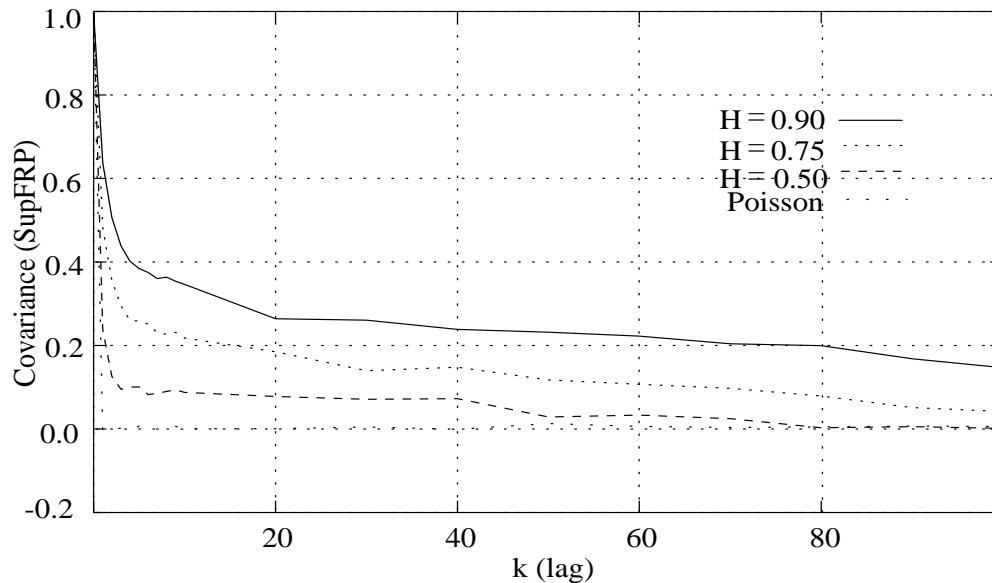
- Mean number of sessions for various application as a function of the simulation length
- The mean duration times of sessions converges to the desired value (50 sec) within a short simulation time

Simulation results: Mean number of sessions



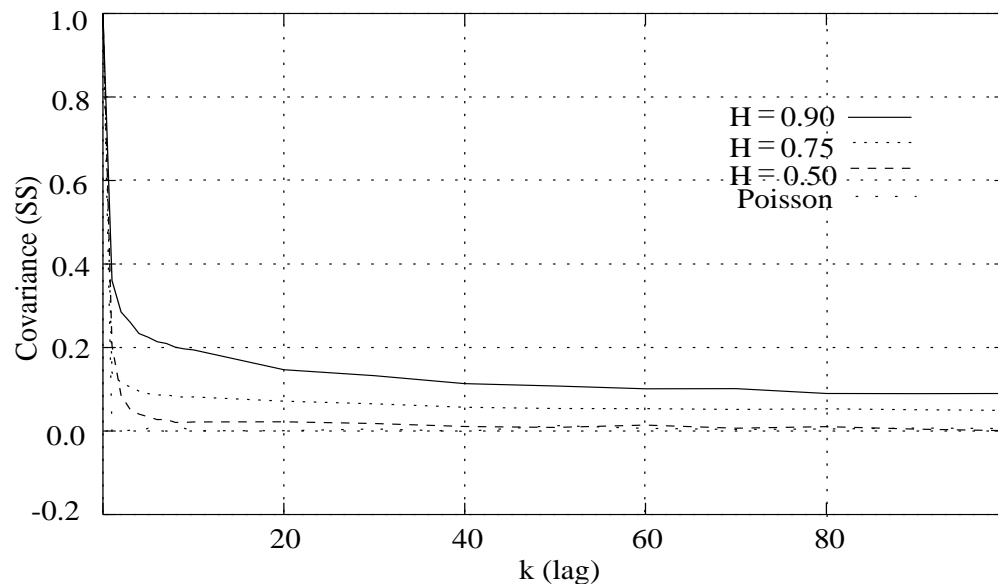
- Mean number of sessions for various application as a function of the simulation length
- The continuous variation of the number of sessions results in a closer model of real networks

Simulation results: Self-similar traffic generators



- Variance-lag plot for the traffic generated SupFRP compared with a Poisson process
- We note that the correlations decay extremely slowly and follow a power law characteristic of self-similar processes

Simulation results: Self-similar traffic generators



- Variance-lag plot for the traffic generated SS compared with a Poisson process
- We note that the correlations decay extremely slowly and follow a power law characteristic of self-similar processes

Summary and conclusions

- We presented a methodology for generating realistic workloads for WANs using the network simulator ns
- Our method captures the temporal and spatial correlation in network traffic
- We created tools to generate traffic specific to applications like Telnet, FTP, WWW and SMTP
- Implemented two accurate self-similar traffic generators in ns to simulate long-range dependent aggregate traffic