THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Evolution of Networking Research into a Science

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"Greetings from Chapel Hill," ca. 1940. Durwood Barbour's collection of post-cards at UNC Chapel; Hill Libraries

DTH-CAMPUS - Sep 11, 2012

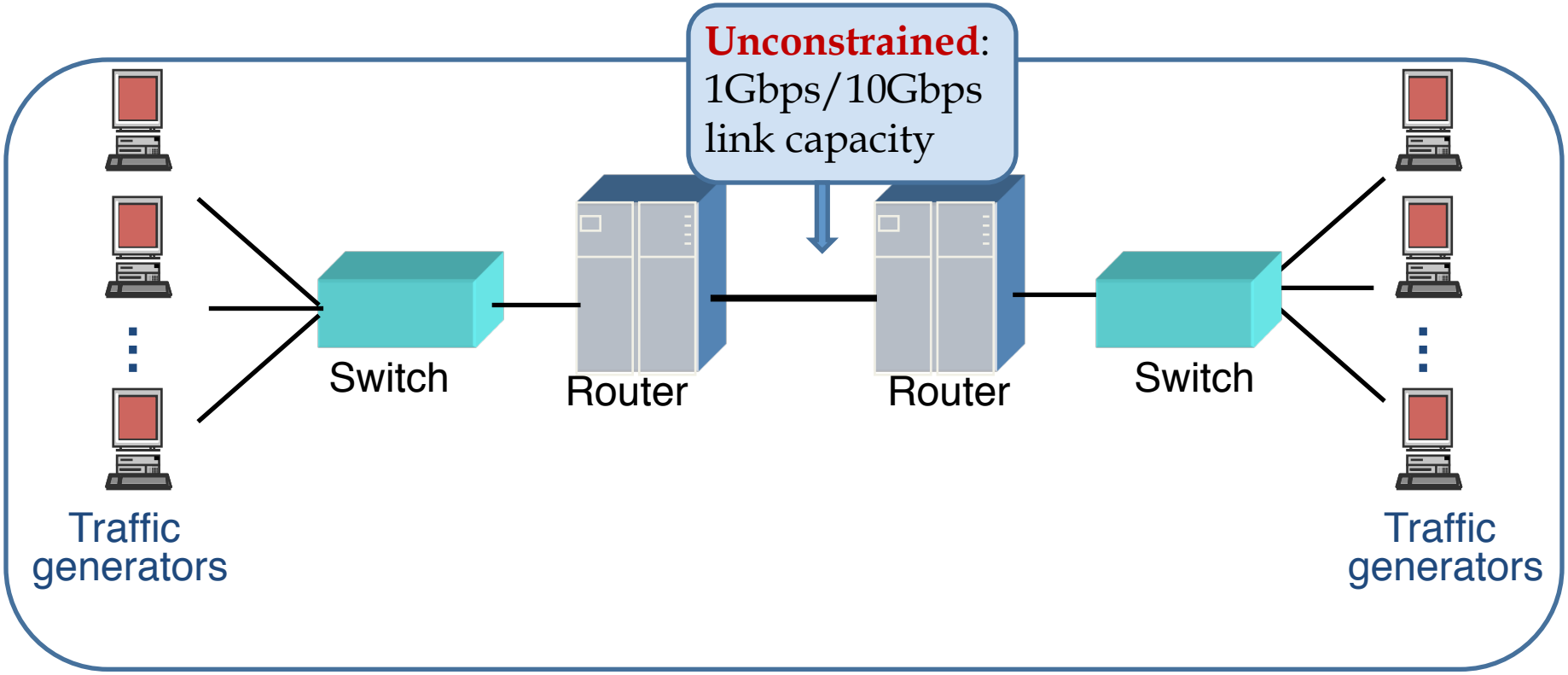
UNC Networking Laboratory

Lab, left wall

Lab, center wall

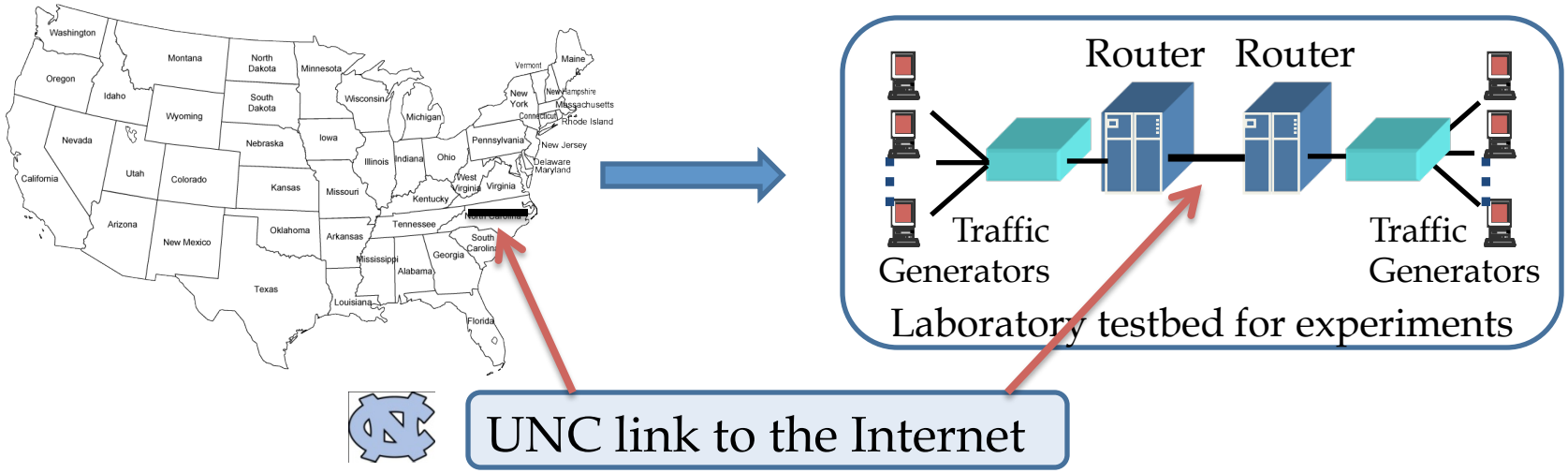
Lab, right wall

UNC Testbeds



Laboratory **testbed** for experiments

Simulate Network Traffic in the Lab

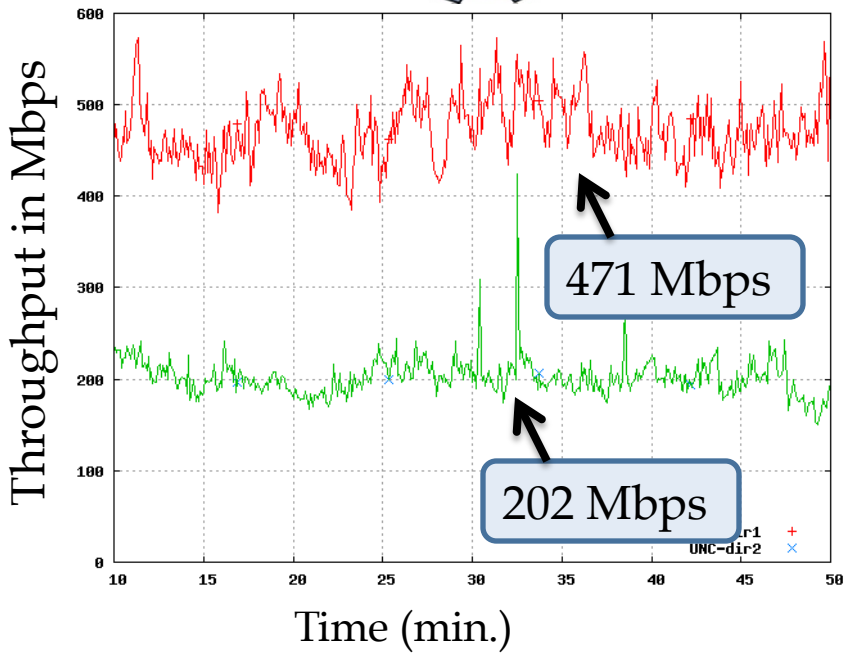


Running a networking **experiment**:

- Build a network **testbed** in the lab
- **Design** experiments to answer research questions
- **Generate realistic traffic** on the lab testbed
- Collect **measurement** data at various points in the testbed
- **Results**

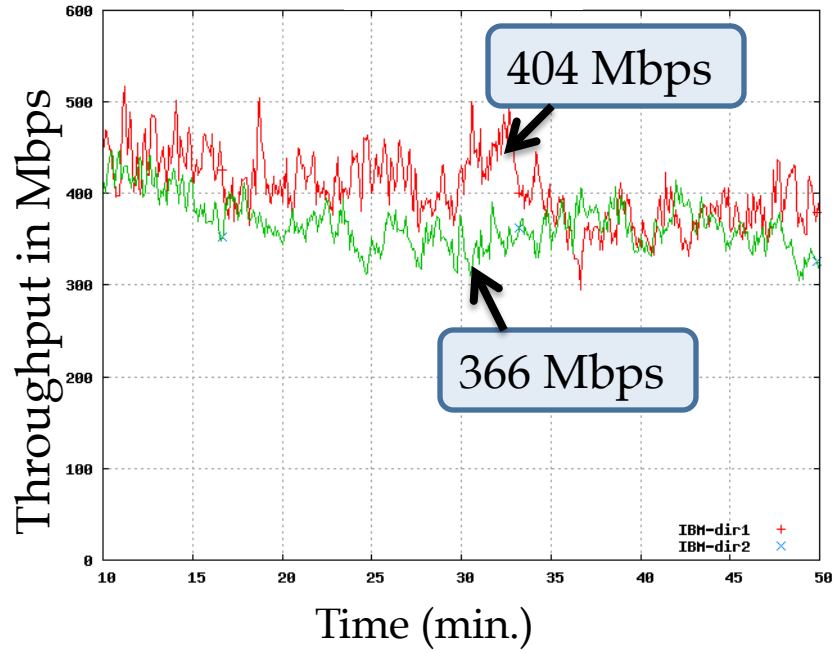
Traffic Data for Experiments

UNC



4.7 million connections carrying 290 GB of application data

IBM



2.8 million connections carrying 320 GB of application data

Experimental Design

Different application workload models

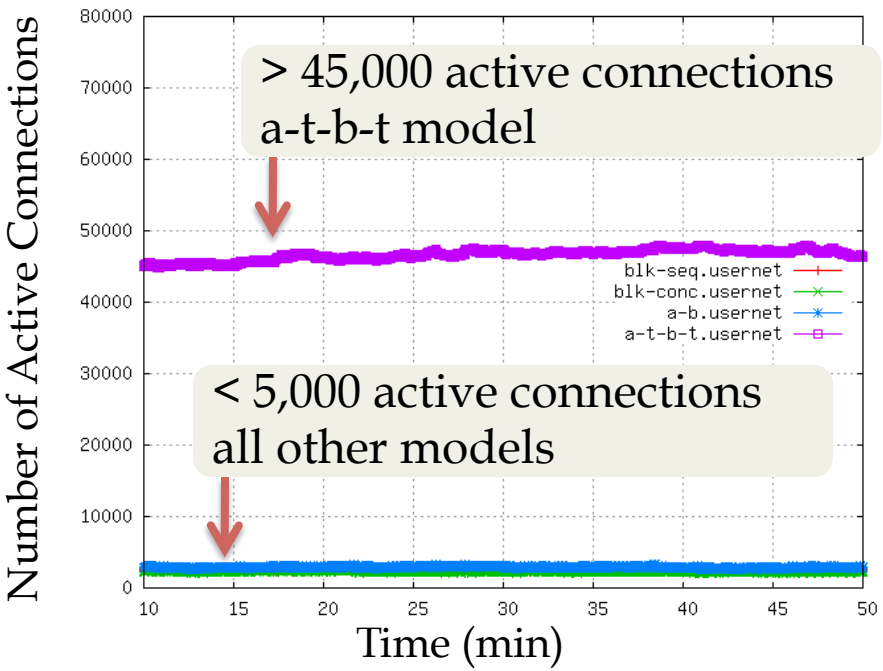
Different Round Trip Time methods

Four performance metrics:
- Connection duration
- Response time
- Router queue length
- Active connections

Two traffic inputs: UNC and IBM

Two network environments: unconstrained and constrained

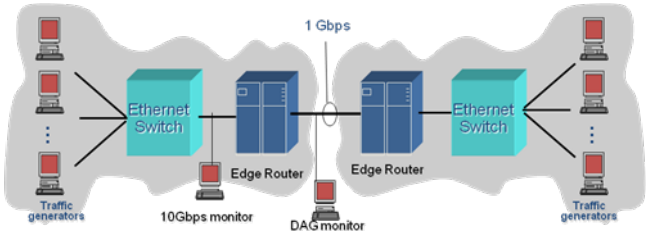
Number of Active Connections



- Same traffic input
- Same path characteristics
- Different application models
- ***Very different outcomes!***

- **Modeling endpoint latencies** significantly affects the **number of active connections in the network**

UNC NetLab → GENI clusters



- Laboratory experiments
  - Experiments on a testbed in a controlled environment.
- GENI experiments
  - Experiments using one or more GENI clusters

GENI (Global Environment for Network Innovations)

- Virtual laboratory for exploring future internets at scale
- Support at-scale experimentation on shared, heterogeneous, highly instrumented infrastructure

GENI Projects

BEN
Breakable Experimental Network

ORBIT

PLANETLAB
An open platform for developing, deploying, and accessing planetary-scale services

ProtoGENI

UIC

UMASS LOWELL

THE QUILT

UPMC PARISUNIVERSITAS

THE UNIVERSITY of WISCONSIN MADISON

at&t

ARISTA

Battelle

ca

ciena

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NEC

Qwest

Radio Technology Systems

SPARTA

Status of Networking Research…

- Built and instrumented large testbeds
- Software framework for building different topologies
- Reserve resources remotely to run large-scale experiments

- **So, what's the problem?**

Status of Networking Research…

- Methodology has evolved in an ad-hoc manner
- Experiments conducted by one research group cannot be repeated and tested by another
- **NO agreed-upon Scientific Methods for Network Experimentation!**

Problem in Networking Research…

- Best experimental practices?
- No agreed-upon scientific methods for running experiments
- No benchmark workload models
- No network emulation standards

Problem in Networking Research…

- **The networking research community lacks a coherent, shared view of best practices for the scientific evaluation in networking research**

Next Steps…

- Develop standard (or best) practices for:
  - maintaining traffic datasets
  - generating traffic
  - designing and running experiments
  - Performance evaluations

Next Steps…

- Develop models for experimentation:
  - workload modeling
  - network path emulations
  - network topologies
  - measurement methodologies

Research goal

Develop

"**networking research**"

into a science

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Thank you!

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