

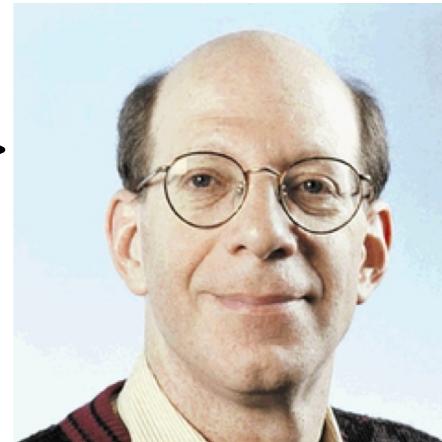
CS 5450

Introduction to Distributed Systems

Vitaly Shmatikov

What's a Distributed System?

“a collection of independent computers that appear to the users of the system as a single computer”

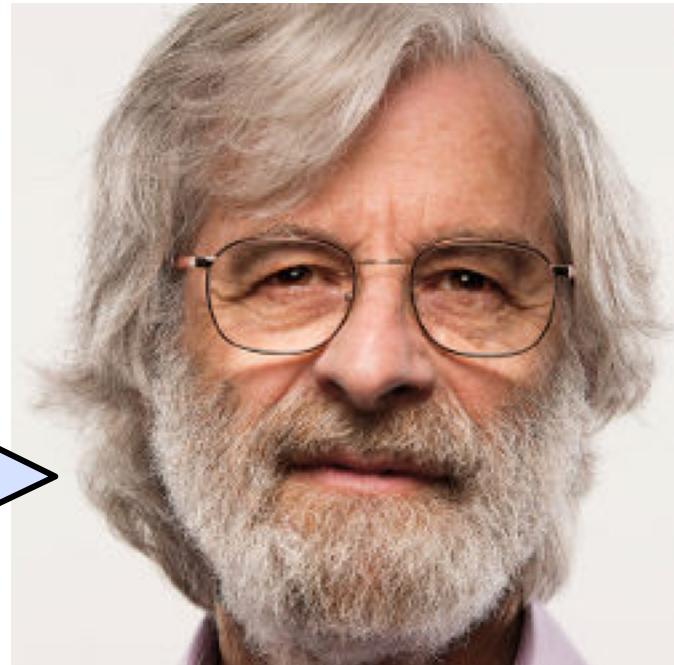


“several computers doing something together. Thus, a distributed system has three primary characteristics: multiple computers, interconnections, and shared state”



Back in 1990

“A distributed system is one where you can’t get your work done because some machine you’ve never heard of is broken.”



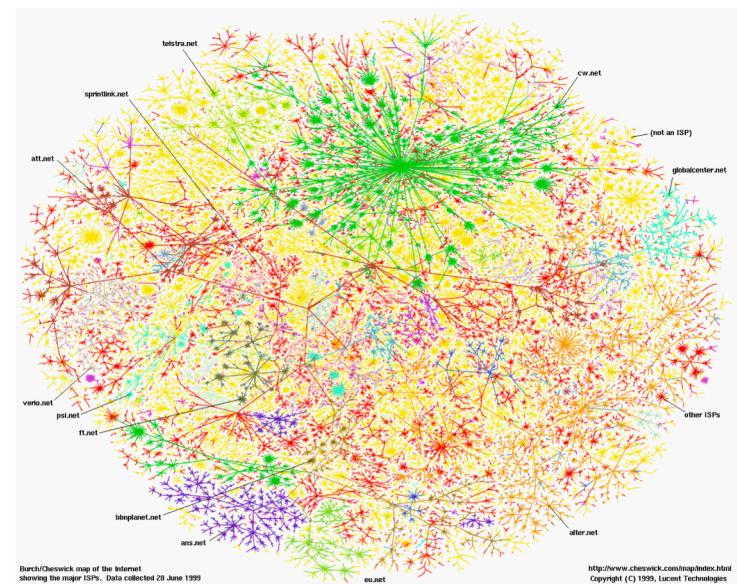
What's a Distributed System?

- ◆ Multiple interconnected computers that cooperate to provide some service (**examples?**)
- ◆ FOLDOC: A collection of (probably heterogeneous) automata whose distribution is transparent to the user so that the system appears as one local machine
 - ... contrast to a network, where the user is aware that there are several machines, and their location, storage replication, load balancing and functionality is not transparent

Which of These is a DS?

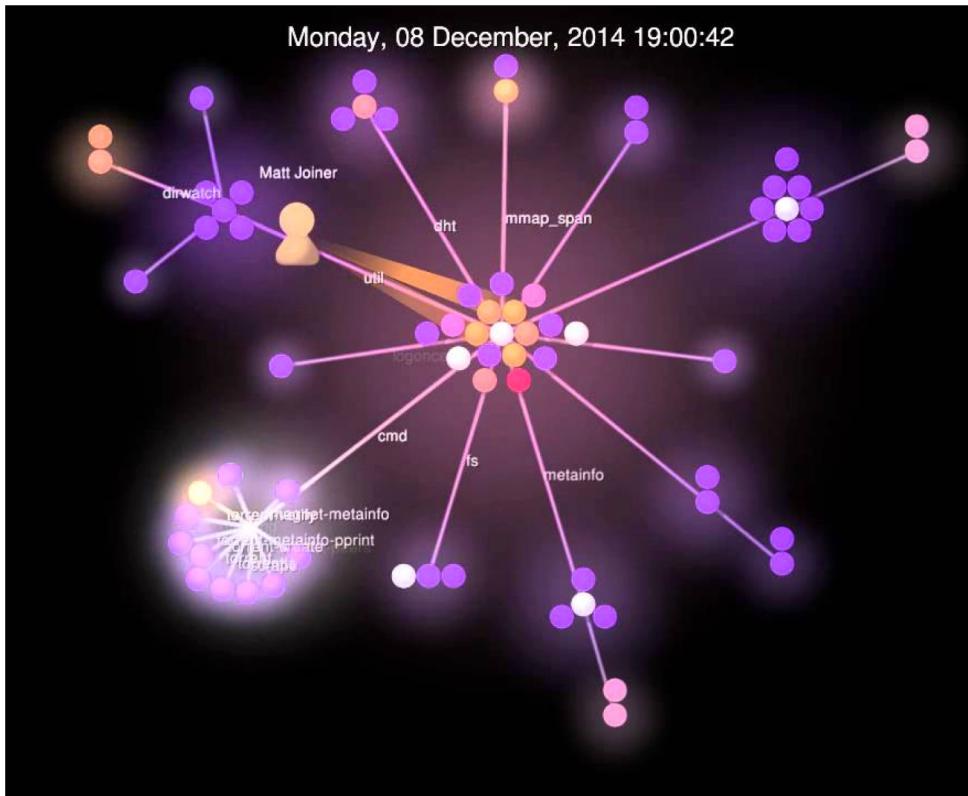


Facebook social network graph

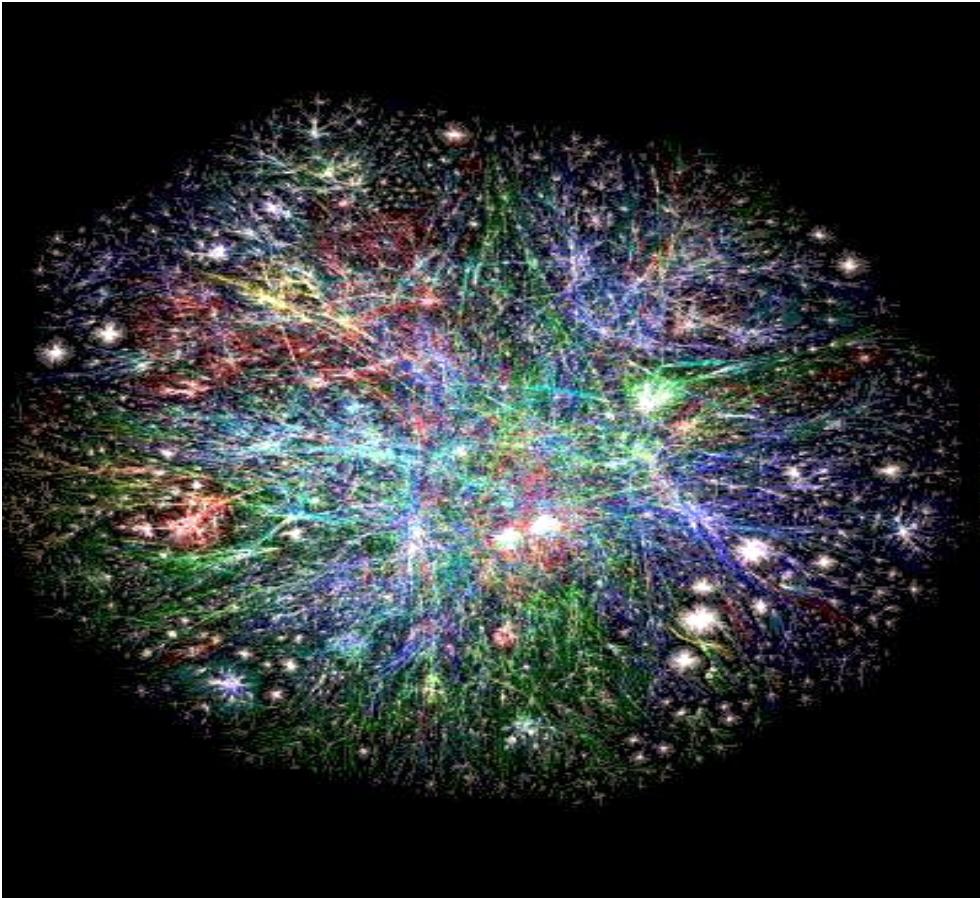


Internet ISP map

BitTorrent



Web Domains



Nodes?

Communication links?

Data Center



Nodes?

Communication links?

Goals

- ◆ Overcome geographic separation
 - Think Google, Facebook ...
- ◆ Build reliable systems out of unreliable components
 - How many computers in a modern data center? How many disks? How often do they fail?
- ◆ Aggregate systems for higher capacity, customize for specific tasks
 - Example: Web server

What We Want from a DS

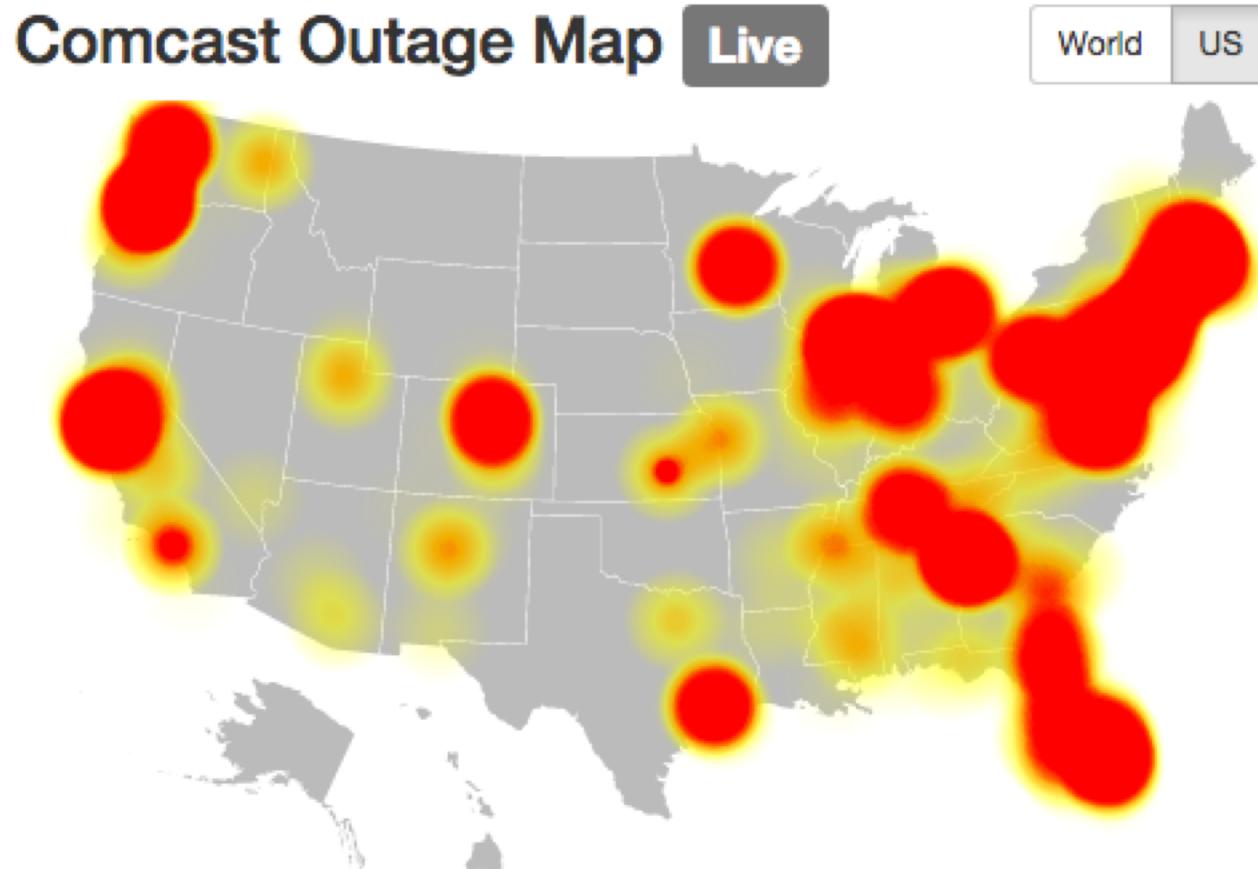
- ◆ Fault tolerant
- ◆ Highly available
- ◆ Recoverable
- ◆ Consistent
- ◆ Scalable
- ◆ Transparent
- ◆ Predictable performance
- ◆ Secure

Failure is what
distinguishes distributed
from local programming

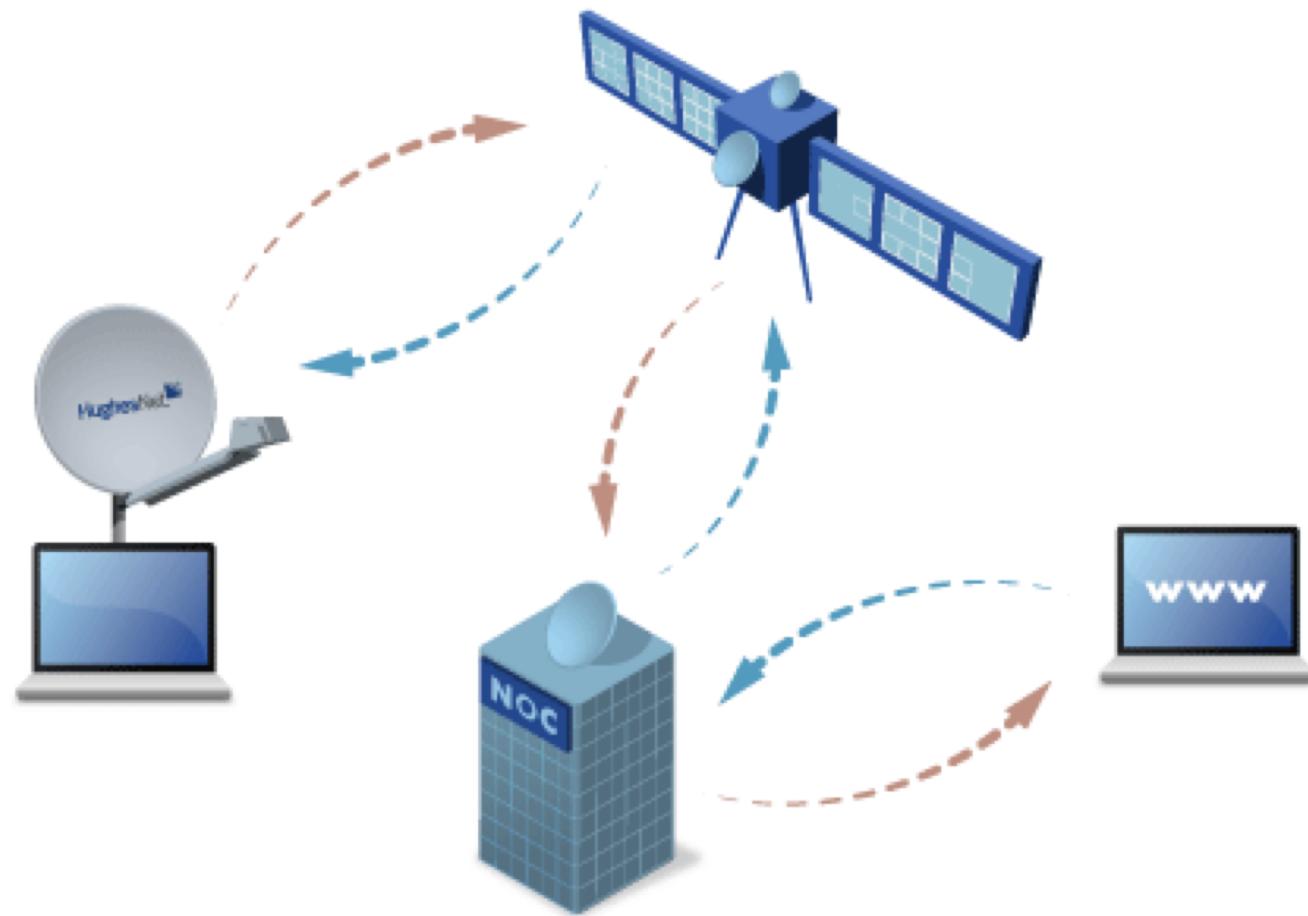
The 8 Fallacies

- ◆ The network is reliable
- ◆ Latency is zero
- ◆ Bandwidth is infinite
- ◆ The network is secure
- ◆ Topology doesn't change
- ◆ There is one administrator
- ◆ Transport cost is zero
- ◆ The network is homogeneous

“The Network is Reliable”



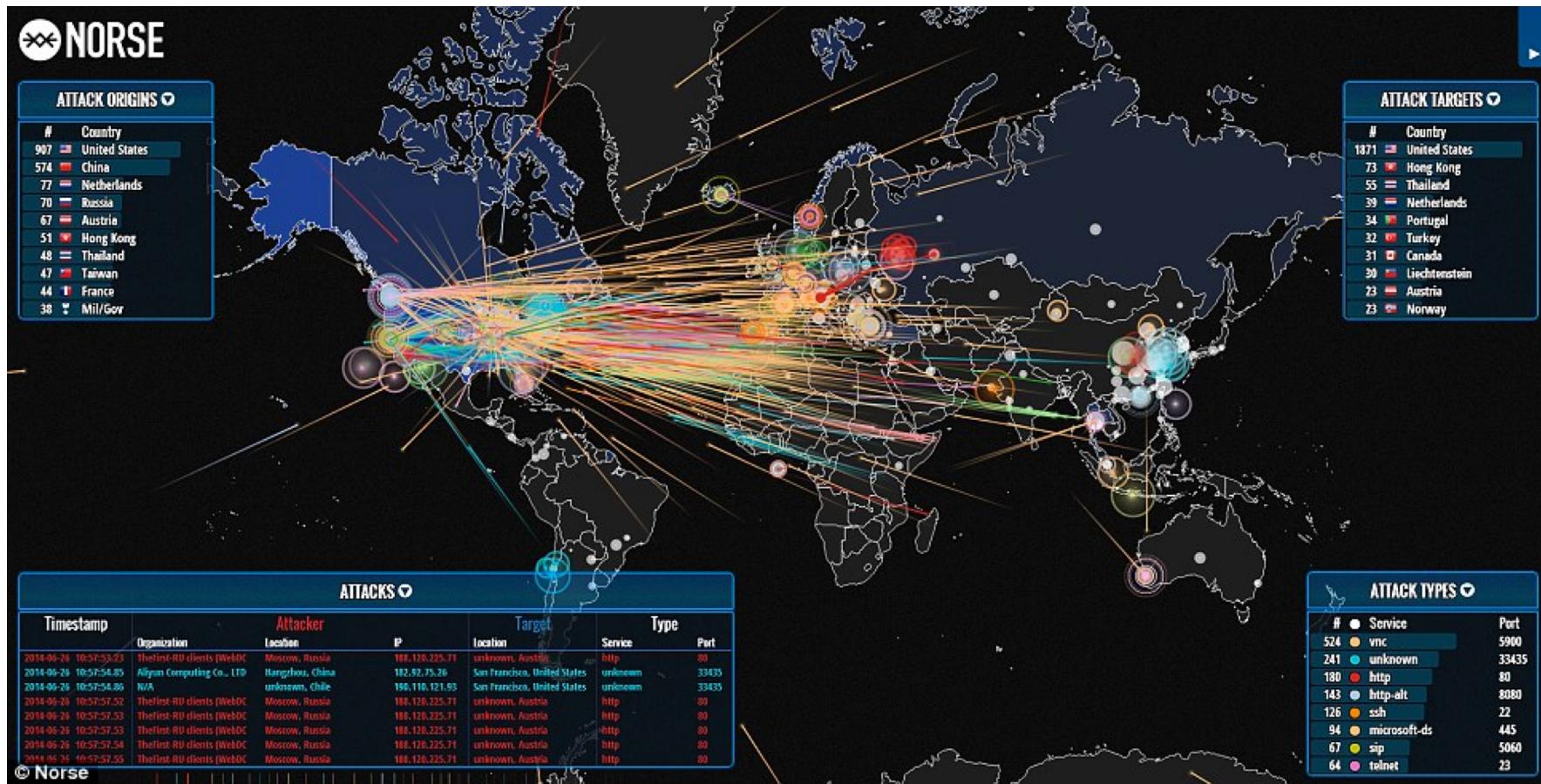
“Latency Is Zero”



“Bandwidth Is Infinite”

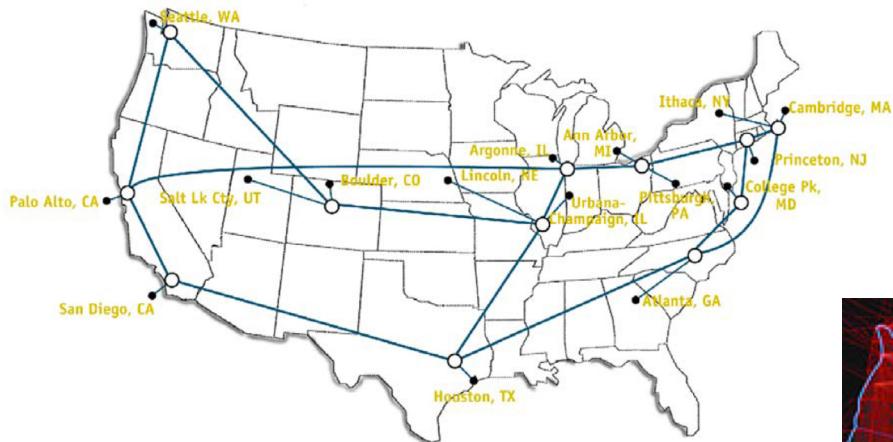


"The Network Is Secure"

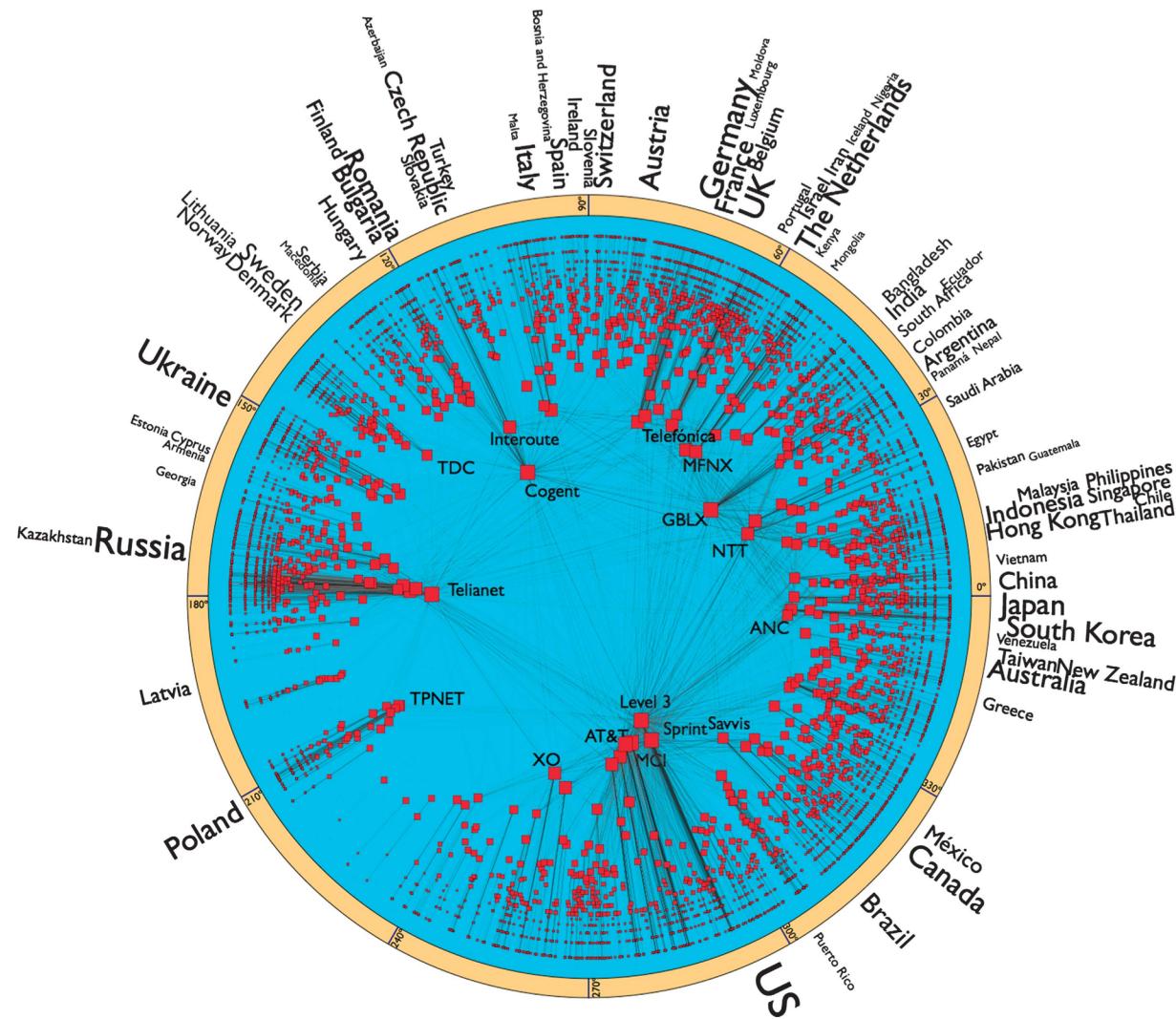


“Topology Doesn’t Change”

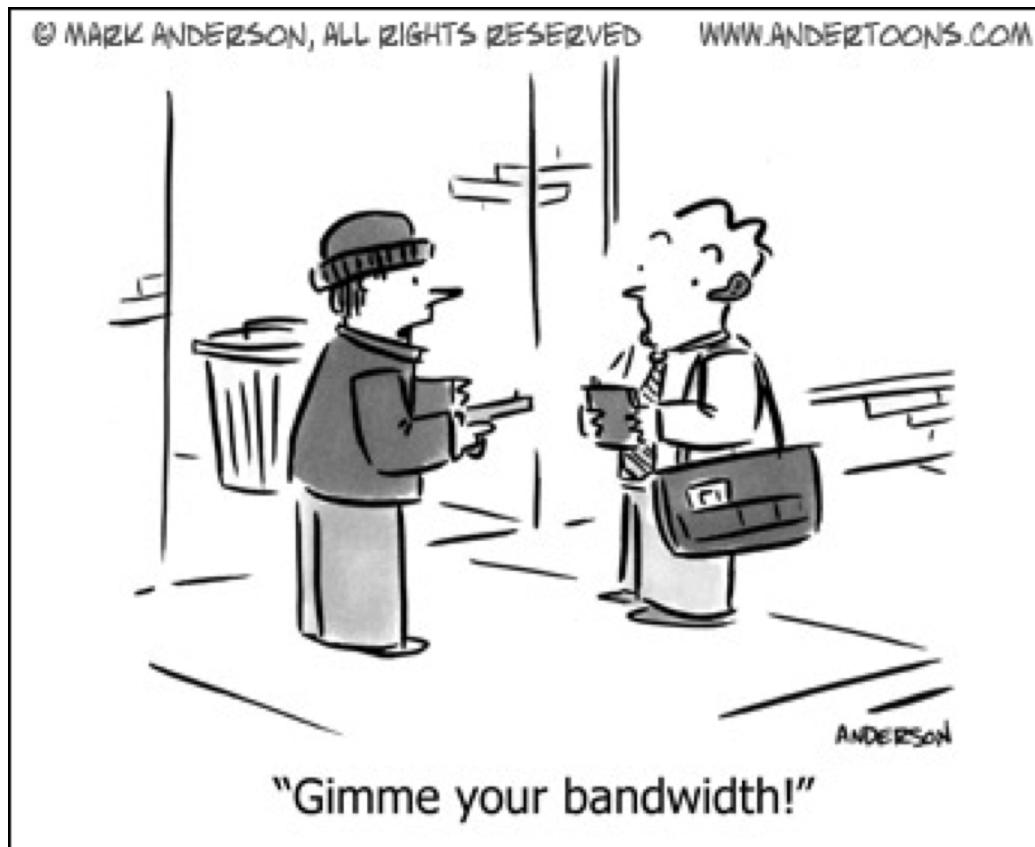
NSFNET T3 Network 1992



“There Is One Administrator”



"Transport Cost Is Zero"



"The Network Is Homogeneous"



How Things Goes Wrong

- ◆ Halting failure (stop silently)
- ◆ Fail-stop (notify other components)
- ◆ Omission failure (silently fail to send message)
- ◆ Network failure
- ◆ Network partition failure
- ◆ Timing failure (unsynchronized clocks, long delays, etc.)
- ◆ **Byzantine failure**
 - Data corruption or loss, malicious attack, etc.

Too Many Abstract Concepts?

- ◆ Yes!
- ◆ In the rest of the course, will illustrate them using concrete systems
- ◆ But concepts are important, too...

Which is the more important invention?

- “Car”
- “Wheel”
- “Bicycle”