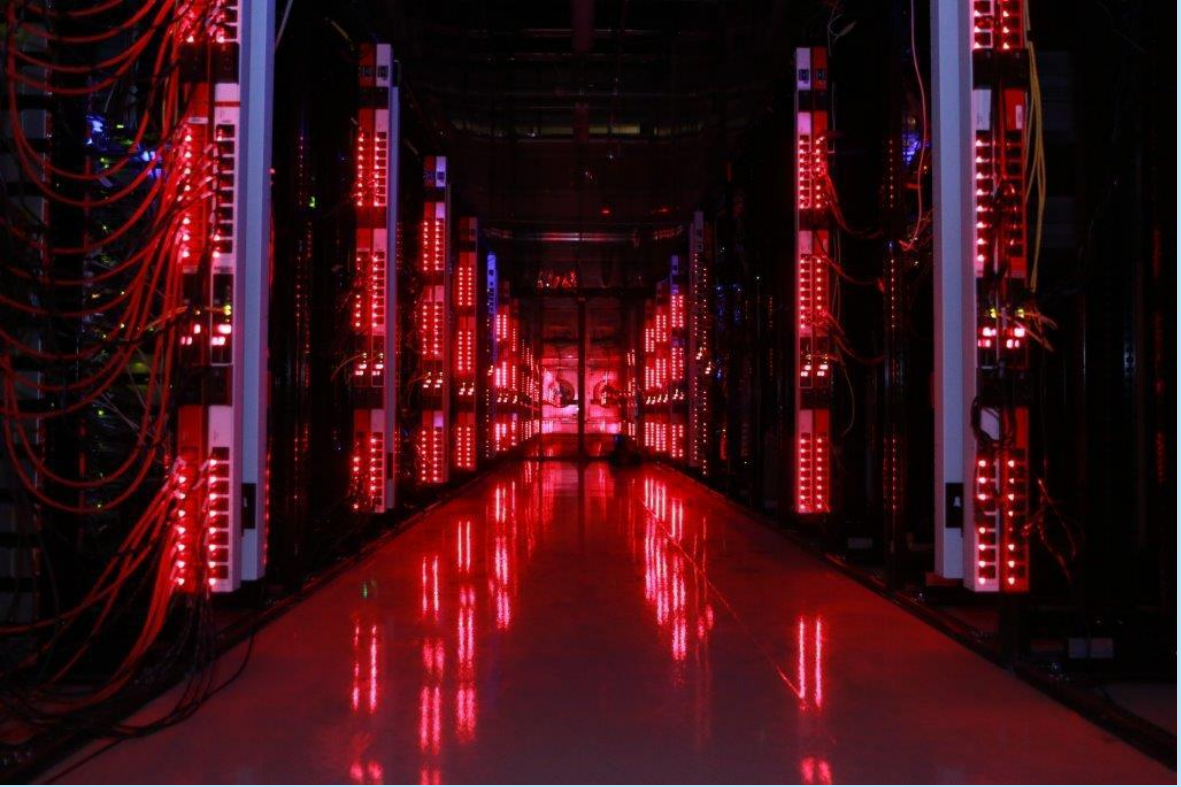


Towards a Next Generation Internet

Jack Brassil

PRINCETON UNIVERSITY

Why NGI now?

Driven by advances across key enabling technologies

- Transparent core
  - Software-defined exchanges (SDX)
  - Photonic ICs
- Programmable switches
  - Packet processors
  - Disaggregated data & control planes
- Wireless Radio Access Networks (RANs)
  - mmWave
  - CloudRAN
- Pervasive analytics
  - Network inference
  - Data-driven networking/ML

Key NGI Technical Challenges - Long term

Challenge #1

- **Improving Network Understanding**
  - Our understanding of Internet behavior on various time scales is surprisingly poor
  - Need comprehensive and pervasive measurement capabilities
  - Associated network analytics operating in a closed loop to optimize traffic engineering

Challenge #2

- **Expanding Capacity**
  - Aggregate global internet data communications is roughly tripling every 5 years
  - Assumes no innovation-driven `success disaster' that would lead to an unanticipated traffic surge
  - No technology on the horizon that can readily absorb this capacity increase in a sustainable, cost-efficient fashion

Challenge #3

- **Connecting Everything**
  - *More mice* -- A confluence of technology advances ‘stretch’ the internet to connect previously unconnected physical objects
  - Device heterogeneity will place new demands on networking protocols for communicating with limited capability network-attached objects
  - *Bigger elephants too* -- massive information flows from concentrated computing `aggregates’ such as public compute clouds

Challenge #4

- **Diagnosing Failures**
  - Intrinsic capabilities to identify points of failure are needed to combat network sprawl
  - Network admins should need less expertise
  - Tolerance of outages diminishes as our social systems' increasing dependence on the network grows

Challenge #5

- **Improving Affordable Access**
  - Increased citizen dependence on emerging internet-based services
  - Access to critical health, financial and legal records reside in the network, affordable communication might be closely tied to improving living standards
  - Need to support ‘public interest’ traffic at low cost

Challenge #6

- **Resisting Attack**
  - Network sprawl increases attack entry points available to malicious parties
  - No network security approaches are known that can protect a network with an unknown and growing attack surface from adversaries that themselves are increasing in sophistication
  - Need to develop new methods to control access to infrastructure and data

Challenge #7

- **Supporting Scientific Discovery**
  - Need to support campus-based discovery and wide-area data distribution (e.g., `science DMZ' and direct cloud connect)
  - Creating science experiments that span multiple facilities or infrastructures (i.e., DoE superfacilities)
    - Illustrative example – telescope dynamically connecting to Chameleon cloud with compute resources scaling up on demand

Challenge #8

- **Maintaining Communications Privacy**
  - Surveilling and computing on a citizen's personal communications is likely to be profoundly easier than it is today
  - Need educational tools to provide a real-time assessment of what personal information will be revealed to third parties by an analysis of one's communications.

Challenge #9

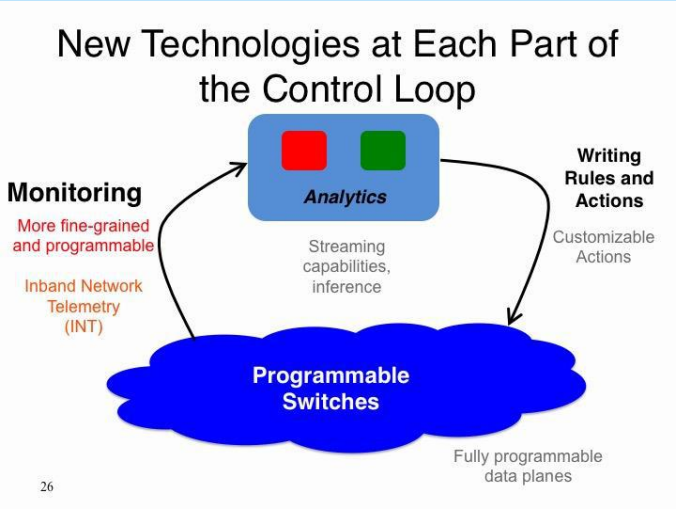
- **Supporting Emerging Demanding Applications**
  - Need support for low-latency CPS applications
  - *Progressive computing* – bump-in-wire processing from the edge to the core

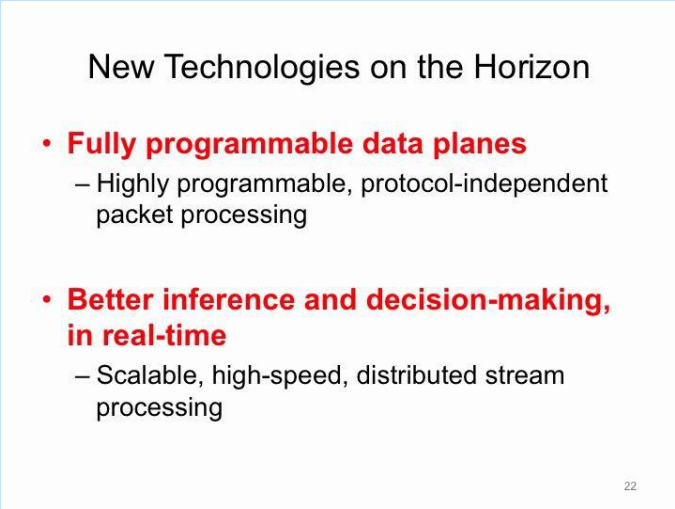
Mapping network capabilities to values

- Resilience to attack (National Security)
- Massive Flows (Science)
- Wireless edge (Citizens)
- Demanding applications (Vehicles/Transport)
- Rapid reconfiguration (Disasters)
- Progressive computing (Environmental sensing)
- Understanding (Network Research)
- Transparency (Net Neutrality)

Addressing these technical challenges might require major architectural disruption

Hinting at an Emerging NGI Vision?





Nick Feamster,
"SDX: Software-Defined Internet Exchange Points: Where We've Been, and Where We're Going"
*NSF **"Looking Beyond the Internet"*** Workshop on Software-defined Infrastructure and Software-defined Exchanges (Jan/Feb. 2016)

Questions to ponder

- **There is a clear, organic trend toward software-ization of networks**
- **Is the eventual outcome a fully programmable internet?**
  - **What are the implications?**
  - **What are the fixed points?**
  - **Should the research community embrace/reject this outcome as a long term vision?**