



Towards a Next Generation Internet

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Why NGI now?

Driven by advances across key enabling technologies

- ⑩ Transparent core
 - ⑩ Software-defined exchanges (SDX)
 - ⑩ Photonic ICs
- ⑩ Programmable switches
 - ⑩ Packet processors
 - ⑩ Disaggregated data & control planes
- ⑩ Wireless Radio Access Networks (RANs)
 - ⑩ mmWave
 - ⑩ CloudRAN
- ⑩ Pervasive analytics
 - ⑩ Network inference
 - ⑩ 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

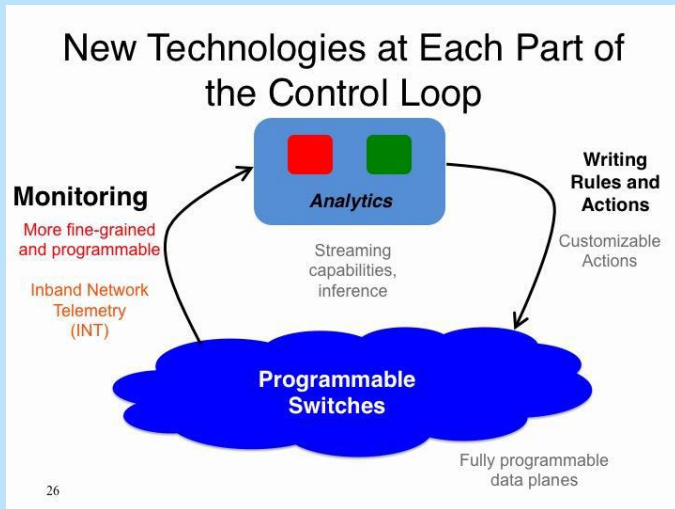
- **Supporting Emerging Demanding Applications**
 - Need support for low-latency CPS applications
 - *Progressive computing* – bump-in-wire processing from the edge to the core

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?



New Technologies on the Horizon

- **Fully programmable data planes**
 - Highly programmable, protocol-independent packet processing
- **Better inference and decision-making, in real-time**
 - Scalable, high-speed, distributed stream processing

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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?**