Understanding the Evolving Internet

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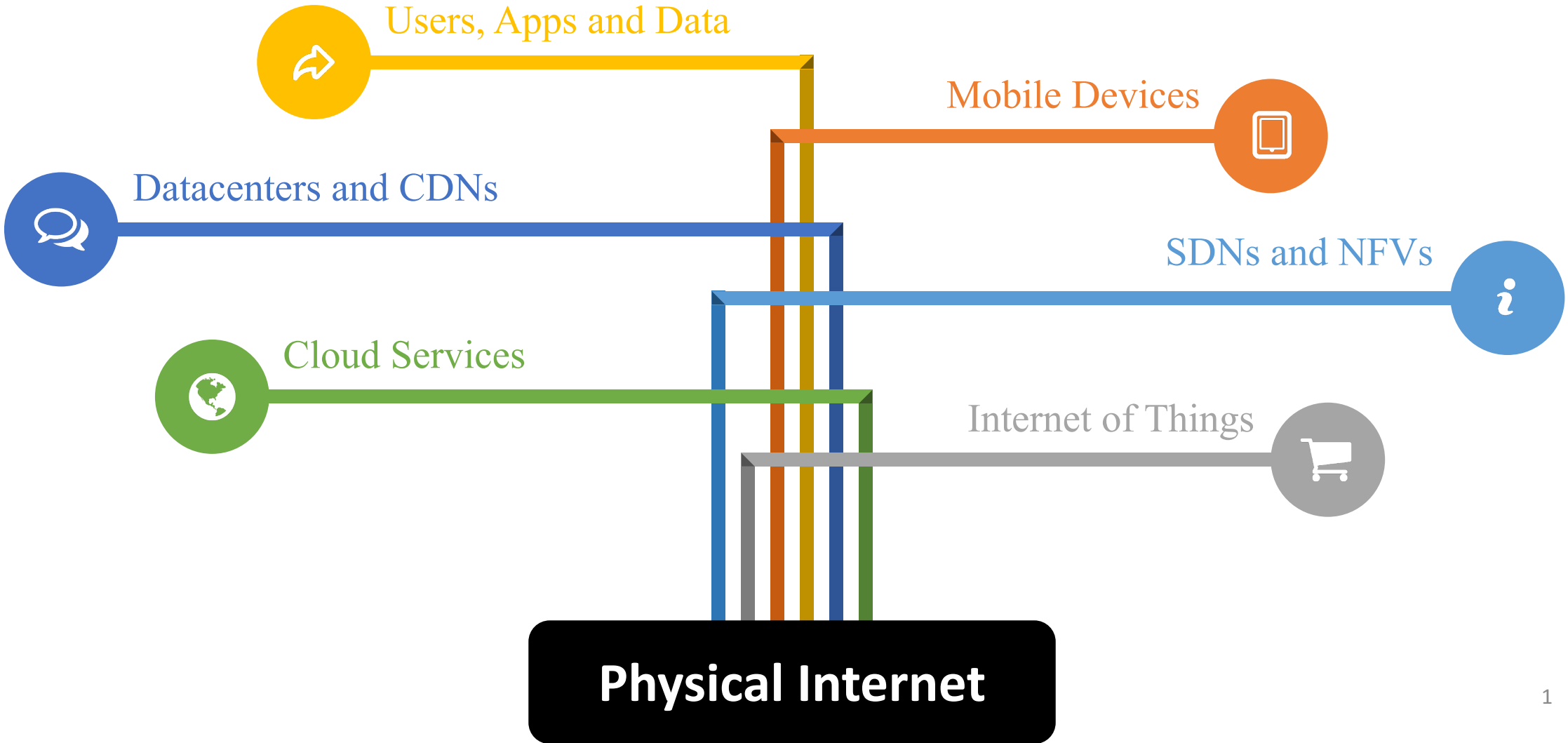
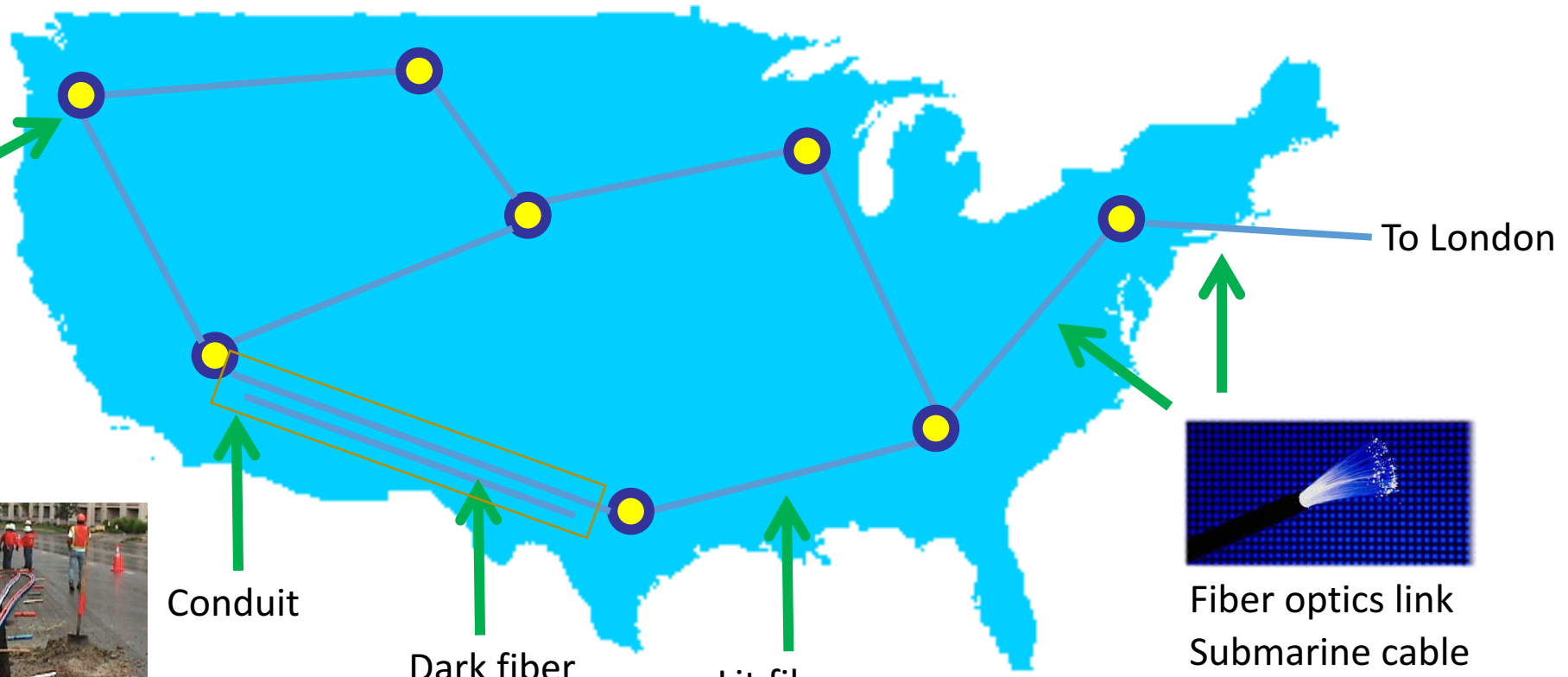
Internet is a complex system



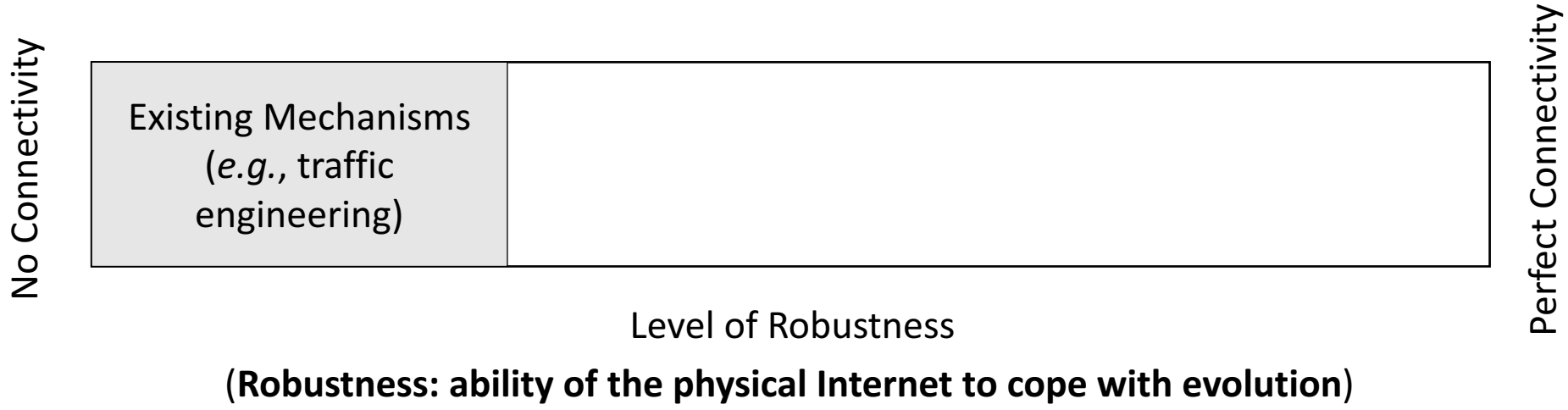
Physical Internet

Point of Presence (POP)
Datacenter
Colocation facility
…



Fiber optics link
Submarine cable

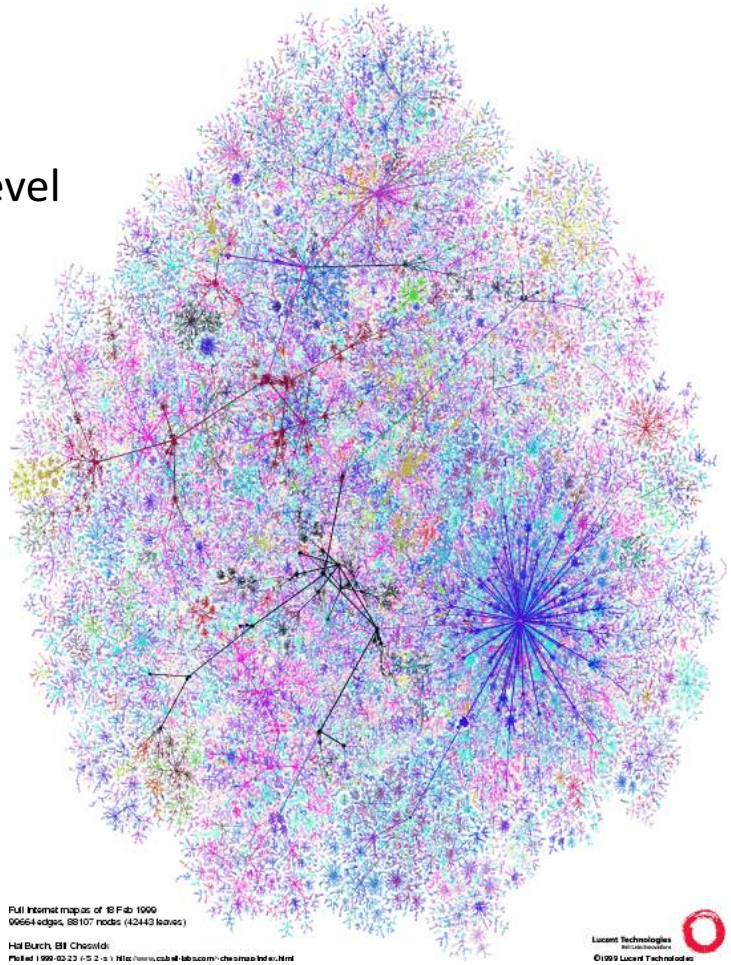
Problem



- Given the claim that Internet's design is robust, why do we have outages? Performance issues? Bandwidth on demand?

No one has a complete view of the Internet

Router-level Topology

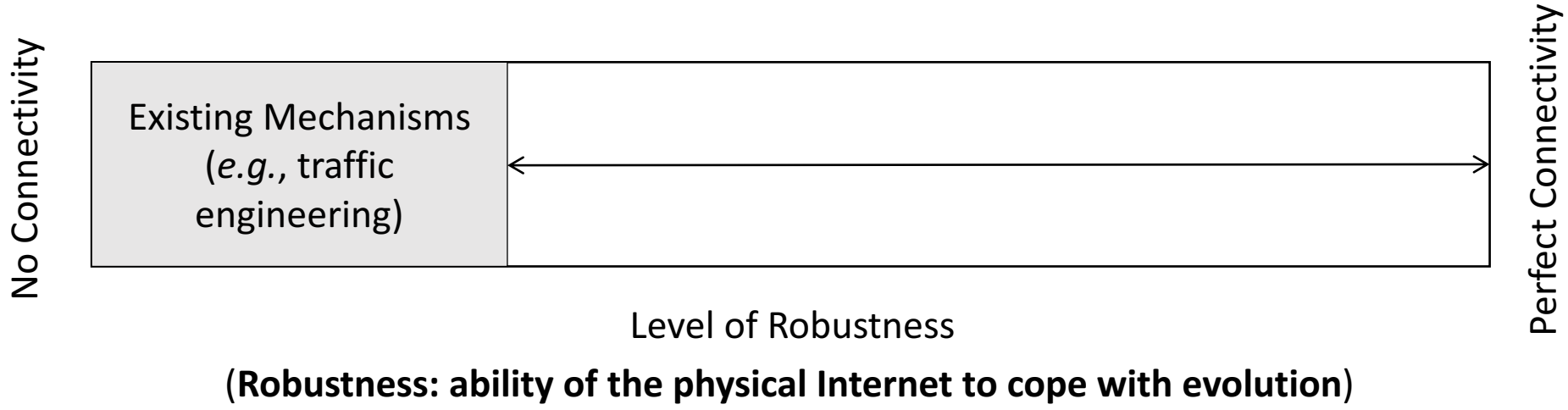


Source: Lumeta

Autonomous Systems-level Topology

Source: Peer1

Problem



(**Robustness: ability of the physical Internet to cope with evolution**)

- Given the claim that Internet's design is robust, why do we have outages? Performance issues? Bandwidth on demand?
- What about evolving components? IoTs? Private interconnects?
- How do we transcend this robustness gap to build a better Internet?

Outline

Introduction and Motivation

Unravelling the Structural Complexity

- Mapping the Internet Ecosystem

Providing Flexible Decision Support

Mapping the Internet ecosystem

- XConnects, Cloud connects and Private Interconnects
- Internet of Things
- Long-haul and Metro

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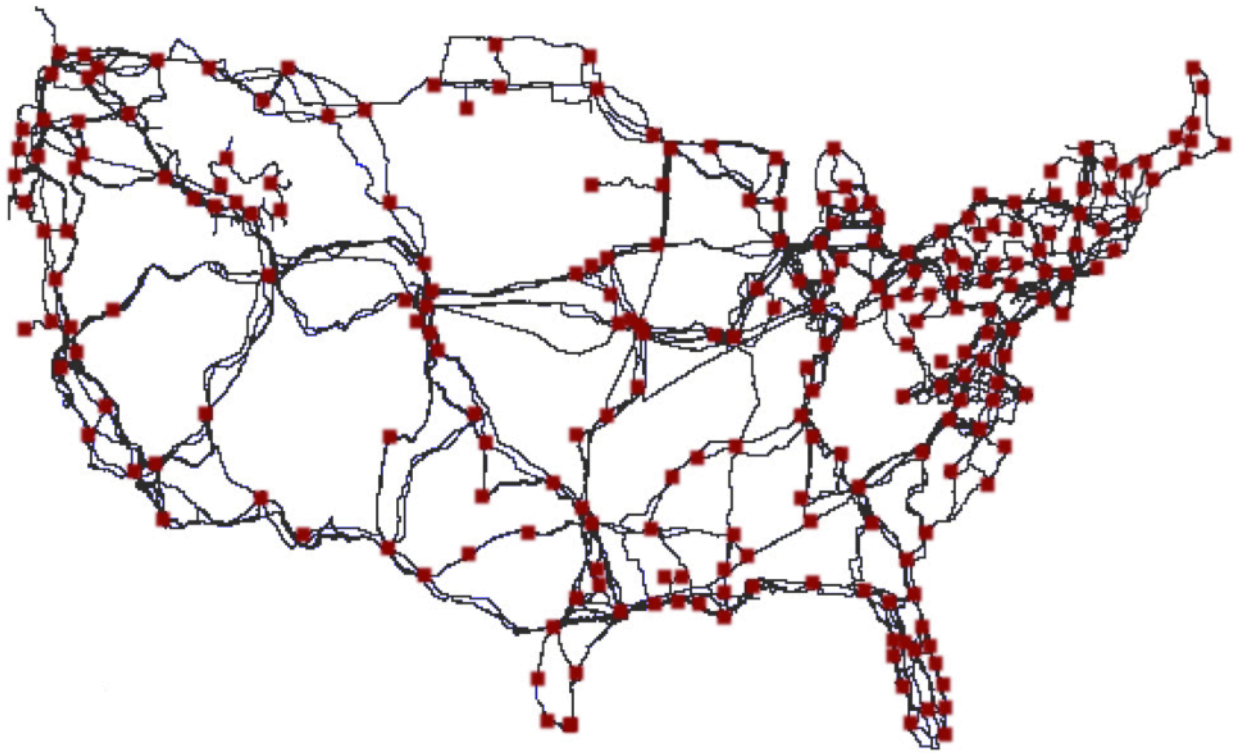
Mapping the Internet of Things

- Map and Characterize the IoT devices and deployments
  - An active measurements-based approach
  - Specific focus on IPv6-enabled IoT devices
- Challenges
  - IPv6 address space is large. How to efficiently scan IPv6 prefixes?
  - How to differentiate IoT vs. non-IoT devices?
- Apply this to problems of interest
  - Security and privacy, census and survey, business intelligence, etc.

Mapping long-haul and metro

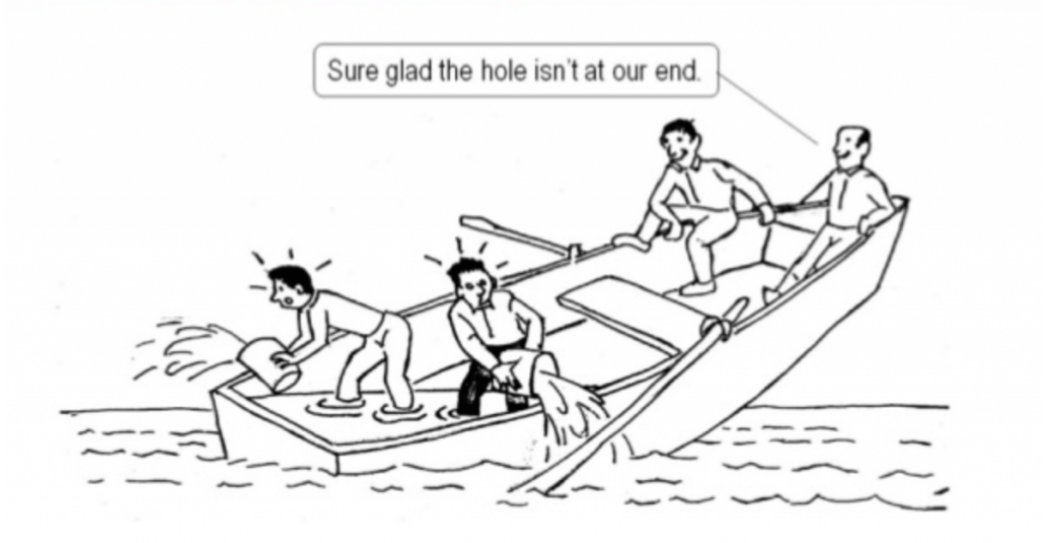
- Internet Atlas: a comprehensive repository of the Physical Internet
  - Search-based data
  - Maps nodes, links, fiber strands, etc.
  - Repository has over 1,400 maps
- Apply this to problems of interest
  - Robustness, performance, security, resilience, etc.
- Popular Science
  - Best of What's New, Security Category, 2017
  - One of the 100 Greatest Innovations of 2017

Map of US long-haul fiber



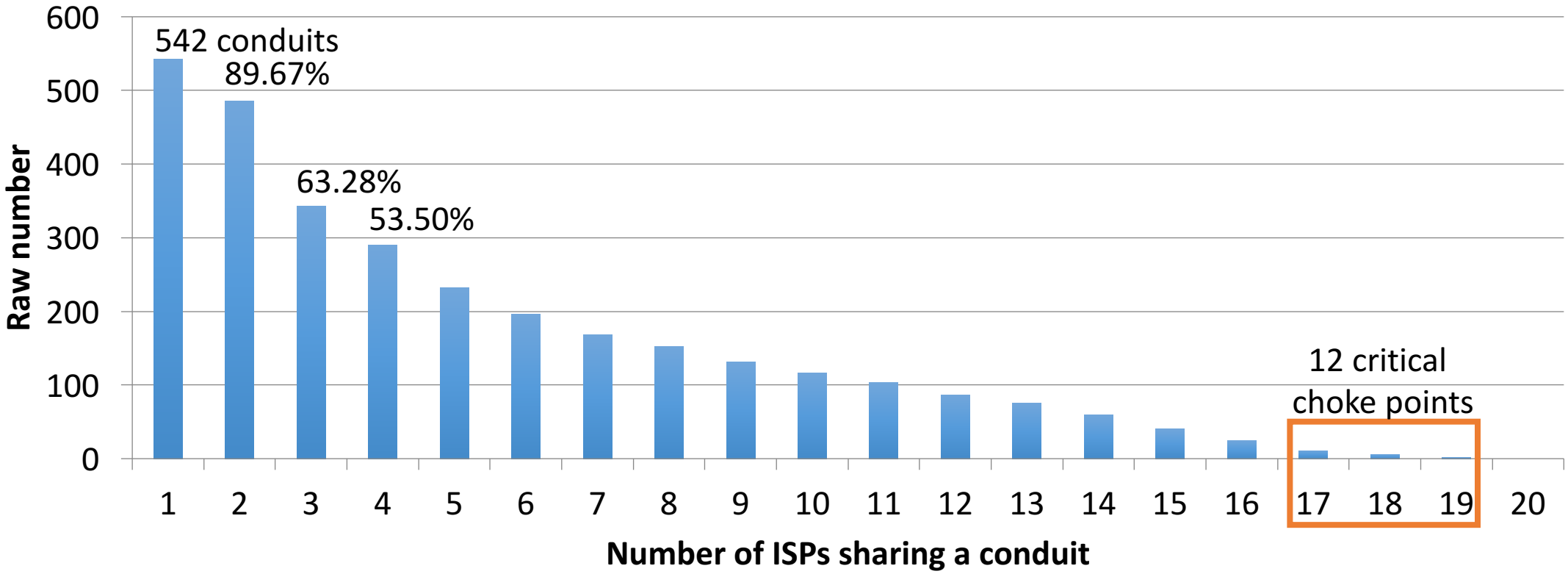
Assessing infrastructure sharing

- Striking characteristic of constructed maps is conduit sharing
  - 20-year fiber IRU to reduce costs



Connectivity-only shared risk

- How many ISPs share a conduit?



Physical connectivity lacks much diversity that is a hallmark of commonly-known models.

Key observation

- There is a lot of sharing in the Internet
  - Risks and outages
- Optical connections cannot be reconfigured
  - Inflexibility
- Risks + outages + inflexibility = NOT robust!

Outline

Introduction and Motivation

Unravelling the Structural Complexity

Providing Flexible Decision Support

- Building systems to create a better Internet

Need for flexible decision support

- Flexible decision support is important
  - Enhance robustness, resilience, security
    - Resilience: remove the inflexible leasing model (and reduce shared risk)
    - Security: connectivity/bandwidth on demand to counter volumetric DDoS attacks

- Given the understanding of the physical Internet, what radical change can we introduce to build a better Internet?
  - Wide-area Connectivity as a Service
    - Agility meets the Internet
    - E.g., Deploy NFVs in the wild

Wide-area Connectivity as a Service

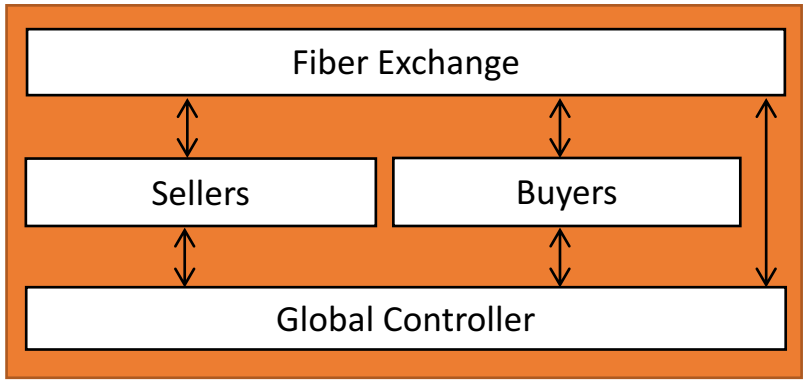
- Objective: a system (called GreyFiber) for cloudification of the physical Internet
  - Cloud: Rent cycles, use resources, and release
  - GreyFiber: Rent connectivity, transfer data, and release connectivity

- System considers
  - Infrastructure abundance (*e.g.*, unused fiber)
  - Market economics (*e.g.*, CAPEX, OPEX)
  - Technology trends (*e.g.*, fast remote reconfigurations in routers)

- Flexible access to fiber-optic paths between endpoints (*e.g.*, IXP) over a range of use scenarios

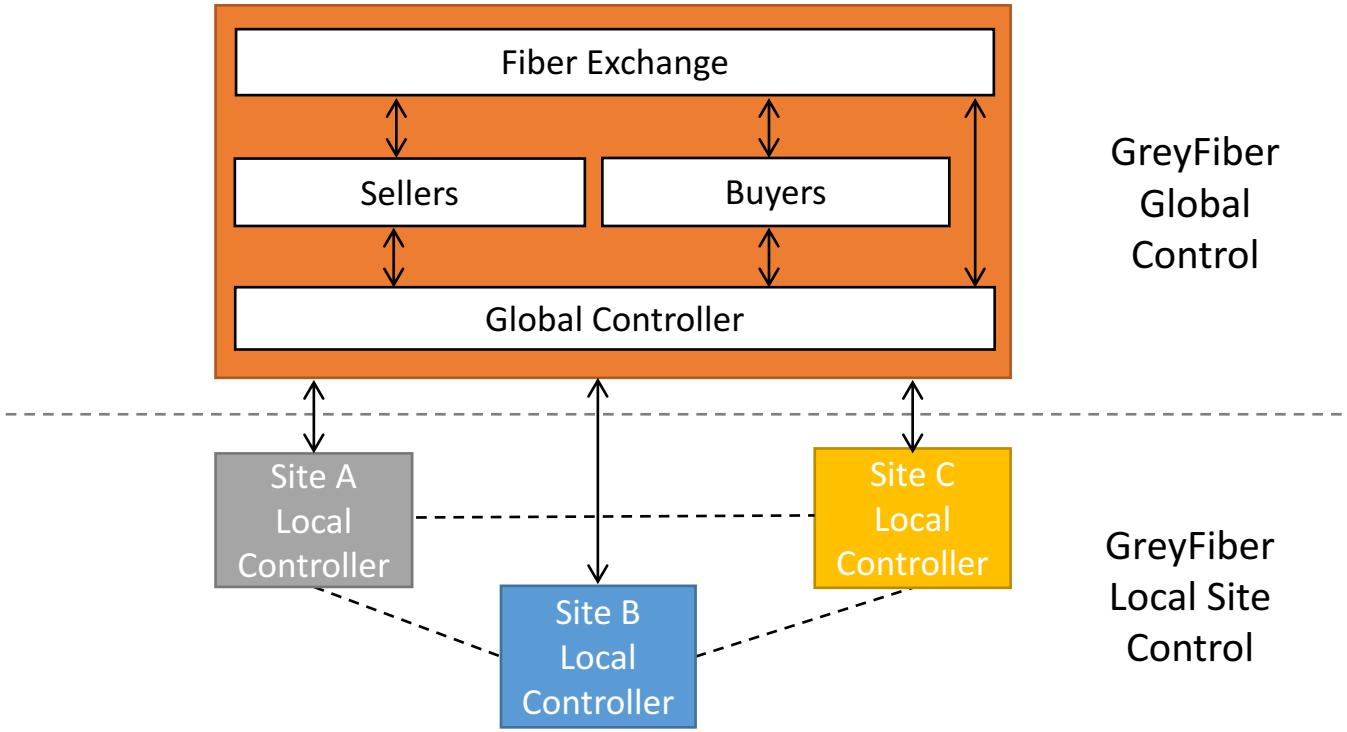
GreyFiber system design

- GreyFiber consists of three components
  - Global control, local site control and physical infrastructure substrate

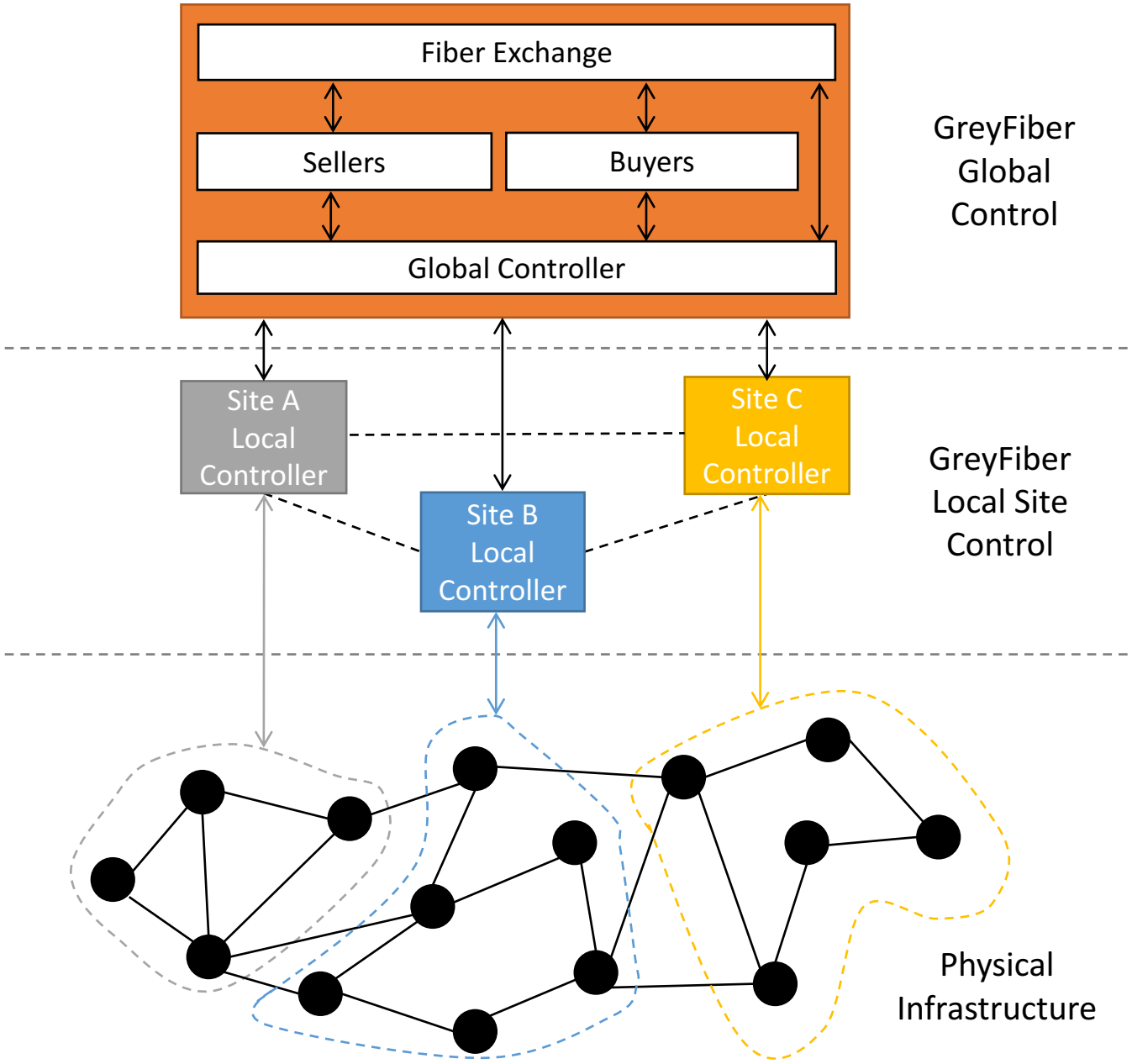


GreyFiber Global Control

- Control and command center
- *Sellers* are major fiber/major cable providers
- *Buyers* are the customers (e.g., CDNs, enterprise networks)
- *Fiber exchange* to enable economic viability
  - Runs GSP auctions
- Global controller
  - Traffic engineering
  - Time-based circuit provisioning
  - Network management
  - Backup restoration



- Local control over marked geographic region (*e.g.*, IXP)
- Mimics minimal functionalities from global control
  - *Configure* links
  - *Monitor* connectivity
  - *Report* statistics to global control



- Composed of traditional nodes and links (*e.g.*, fiber paths)
- Assumption
  - Fiber is already lit

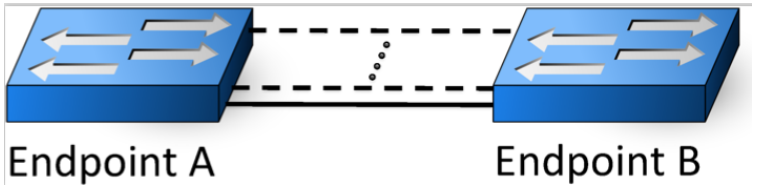
GreyFiber system design

- GreyFiber consists of three components
  - Global control, local site control and physical infrastructure substrate

- Supports a range of use scenarios
  - Small (seconds to minutes), medium (hours), large (days to months) and extra-large (years)
  - Short lifetime to address unexpected outages and demands
  - Medium-to-large to service unexpected demands without deadlines
  - Extra-large to support traditional lease

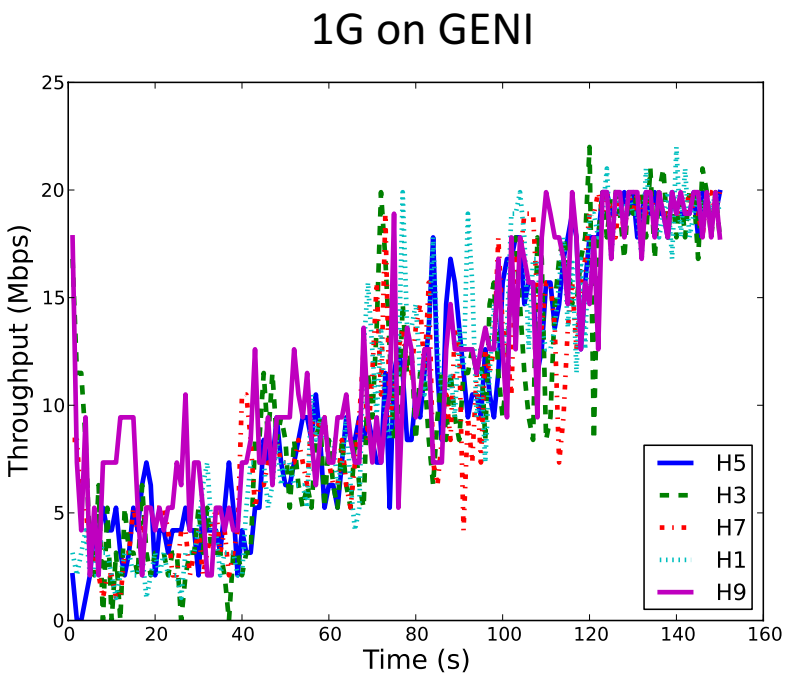
GreyFiber implementation and evaluation

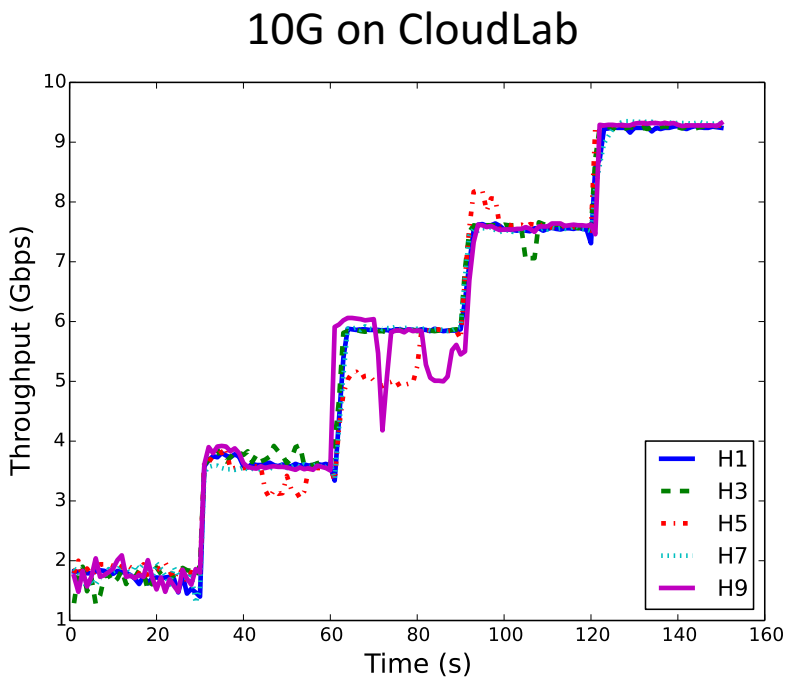
- Implemented in ~22K lines of Python code
- Evaluated in GENI and CloudLab testbeds



Key results

- Performance benefits of GreyFiber?





Questions?

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