Net SILOs: An Architecture to Enable Software Defined Optics

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http://net-silos.net/

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Outline

- Context: The Clean-Slate Debate
- Motivation: Software Defined Optics
- SILO Network Architecture: The Story So Far
- Summary and Future Directions
The Internet is broken!
The Internet is broken! (has ossified / reached an impasse)
The Internet is broken!

Security is a mess: it is hard to

- identify users
- prevent them from causing harm
- hold them accountable
The Internet is broken!

Middleboxes violate end-to-end principle:

- firewalls
- NAT
- proxies
The Internet is broken!

Fixed layer architecture is outdated
The Internet is broken!

Fixed layer architecture is outdated

![Layered network diagram]
The Internet is broken!

Fixed layer architecture is outdated
The Internet is broken!

Cross-layer interactions difficult: TCP over wireless
The Internet is broken!

Clear need for clean-state initiatives → NSF FIND, EU FIRE, ⋯

1. research in new network architectures
2. large-scale experimental facilities → GENI
The Internet is doing just fine, thank you!
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- Biological metaphor: mutation and natural selection
- Evolutionary designs: more robust, less expensive
- Mid-layer protocols must be conserved – not ossified
  → innovation at lower/upper layers of architecture
The Internet is doing just fine, thank you!

- Biological metaphor: mutation and natural selection
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→ Evolution beats revolution
Our View

- Internet architecture successful in accommodating change
Our View

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- But: current practice of patches/tweaks cannot continue forever
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- **But:** current practice of *patches/tweaks* cannot continue forever
- New architecture must be designed for *adaptability/evolvability*
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- SILO objective:
Our View

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- New architecture must be designed for *adaptability/evolvability*
- SILO objective:

  The goal is not to design the “next” system, or the “best next” system, but rather a system that can sustain continuing change
OBS And The Layer Stack

Where does OBS fit in the stack?
OBS And The Layer Stack

App  App  App

Transport

Network

Data Link

Physical

?
OBS And The Layer Stack

App

Transport

Network

Data Link

Physical

?
OBS And The Layer Stack

- Application
- Transport
- Network
- Data Link
- Physical

MPLS

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OBS And The Layer Stack

- App
- App
- App

- Transport
- Network
- Data Link
- Physical

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Cross-Layer Interactions: TCP Over OBS

Does “TCP Over OBS” make sense?
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Yes!

TCP carries $\approx 95\%$ of Internet traffic

good understanding of TCP performance is crucial
Cross-Layer Interactions: TCP Over OBS

Does “TCP Over OBS” make sense?

No!

- which TCP flavor?
- which OBS flavor?
- transport and OBS layers must be optimized for each other
- not as straightforward as “TCP over wireless”
Optical substrate can no longer be viewed as black box.
Software Defined Optics

- Optical substrate can no longer be viewed as black box
- Collection of intelligent and programmable resources:
Software Defined Optics

- Optical substrate can no longer be viewed as black box.
- Collection of intelligent and programmable resources:
  - optical monitoring, sensing mechanisms
  - amplifiers, impairment compensation devices
  - tunable optical splitters
  - configurable add-drop
  - programmable mux-demux (e.g., adjust band size)
  - adjustable slot size
  - ...
Cross-Layer Interactions

- Impairment-aware routing
- Traffic grooming
- Network resiliency
- ...
SILO Architecture Highlights

- Generalizes traditional layer stack:
  - **services**: building blocks of fine-grain functionality
  - **silo**: per-flow vertical composition of services
  - decoupling of layers and services

- Enables inter-layer interactions:
  - **knobs**: explicit control interfaces

- Facilitates introduction of new services:
  - **ontology**: describes services and their relationships
  - **composition algorithm** to construct silos
  - standard ontology languages and reasoning engines may be used
SILOs

Net SILOs: A New Network Architecture

Ontology

Service

Method

Control agent

Policies

Application

Silos

Physical layer

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Ontology – Networking Knowledge

Diagram:
- **Primitive**
  - Method
  - Service
  - Segmentation
  - Encryption
  - ErrorCorrection
- **ServiceFunction**
- **ServiceType**
  - Functional
  - Ordering
- **Constraint**
  - Simple
  - Compound
- **Primitive**
  - Simple
  - Compound
Constraints on composing services A and B:

- A requires B
- A forbids B
- A must be above (below) B
- A must be immediately above (below) B
- Negations, AND, OR

Minimal set:

- Requires, Above, ImmAbove, NotImmAbove

All pairwise condition sets realizable

- Forbids = (A above B) AND (B above A)
- Above = NOT Below
Composition Problem

- Given: a set of essential services ↔ application
- Obtain a valid ordering of these and additional services
  - or, identify conflicts with constraints
- Simple composition algorithm
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Summary

Vision – enable flexibility, evolution: “design for change”
- fine-grain, reusable services, explicit control interface
  - enables experimentation, flexibility, community of innovation
- per-flow service composition (silos)
  - ease of evolution, policies

Framework – provide architectural support to vision:
- constrained composition
- commoditize cross-layer interaction / optimization

Ongoing efforts:
- extend the prototype
- new research directions: software defined optics, virtualization
- influence GENI development efforts