NC STATE UNIVERSITY

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

Context (1)

The Internet is broken!

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The Internet is broken! (has ossified / reached an impasse)

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Security is a mess: it is hard to

- identify users
- prevent them from causing harm
- hold them accountable

Context (1)

The Internet is broken!

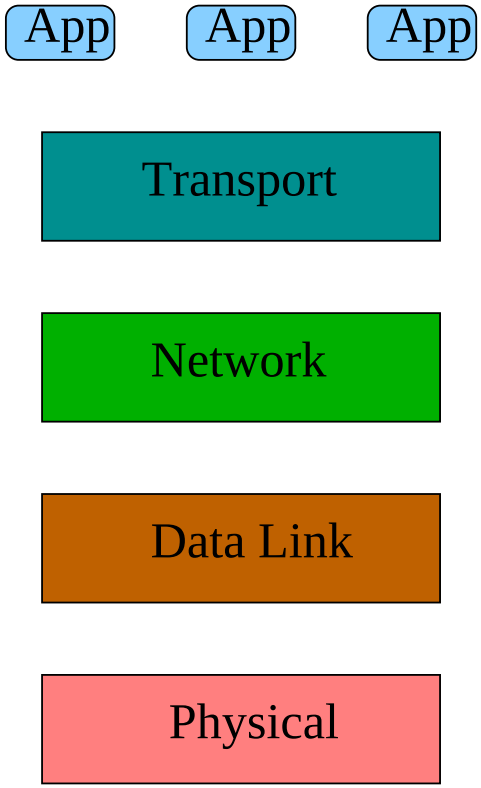
Middleboxes violate end-to-end principle:

- firewalls
- NAT
- proxies

Context (1)

The Internet is broken!

Fixed layer architecture is outdated



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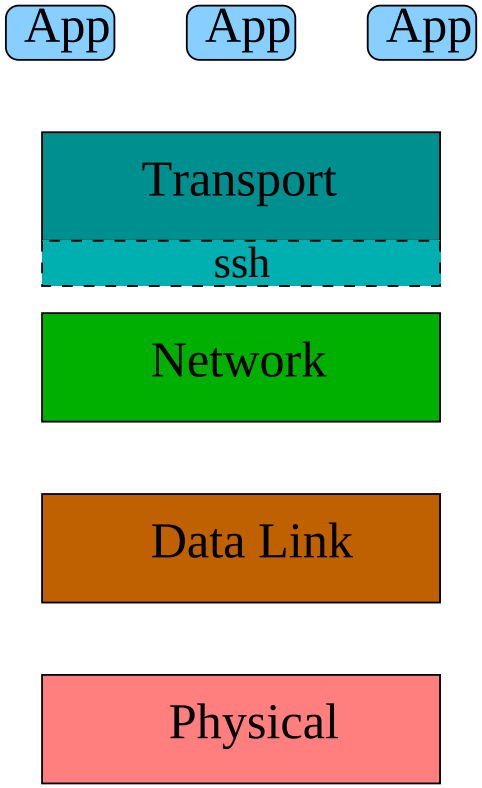

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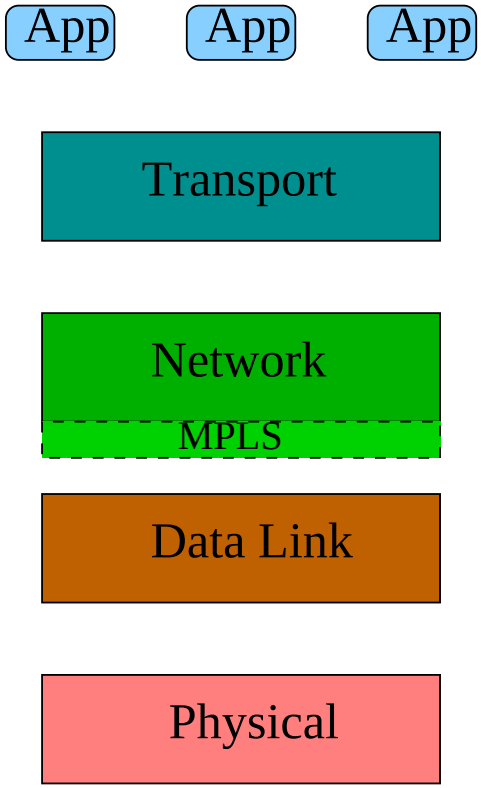
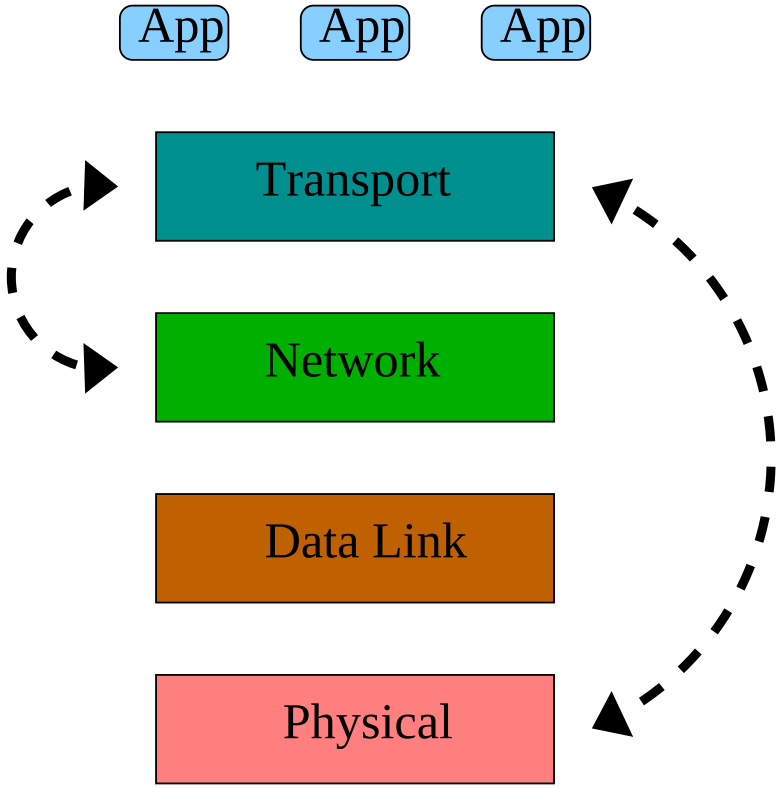


Context (1)

The Internet is broken!

Cross-layer interactions difficult: TCP over wireless



Context (1)

The Internet is broken!

Clear need for clean-state initiatives $\longrightarrow$ NSF FIND, EU FIRE, $\cdots$

1. research in new network architectures
2. large-scale experimental facilities $\longrightarrow$ GENI

Context (2)

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- Biological metaphor: mutation and natural selection
- Evolutionary designs: more robust, less expensive
- Mid-layer protocols must be conserved – not ossified
  $\longrightarrow$ innovation at lower/upper layers of architecture

Context (2)

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  $\longrightarrow$ innovation at lower/upper layers of architecture

$\longrightarrow$ Evolution beats revolution

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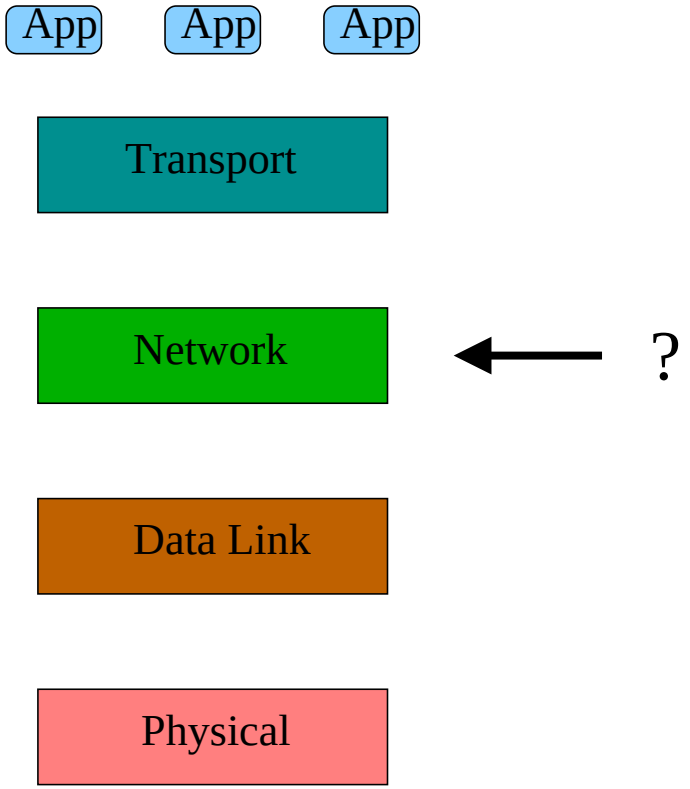
- SILO objective:

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



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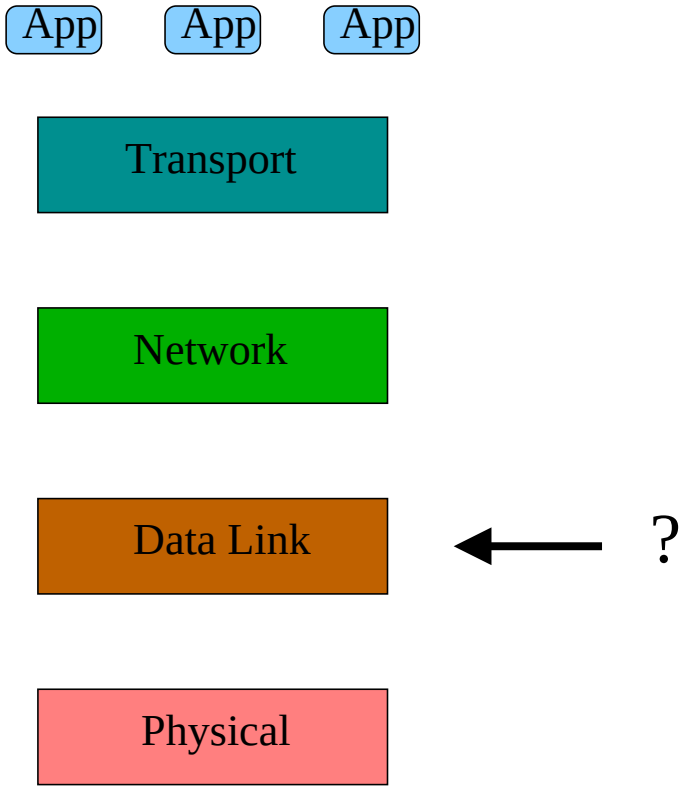

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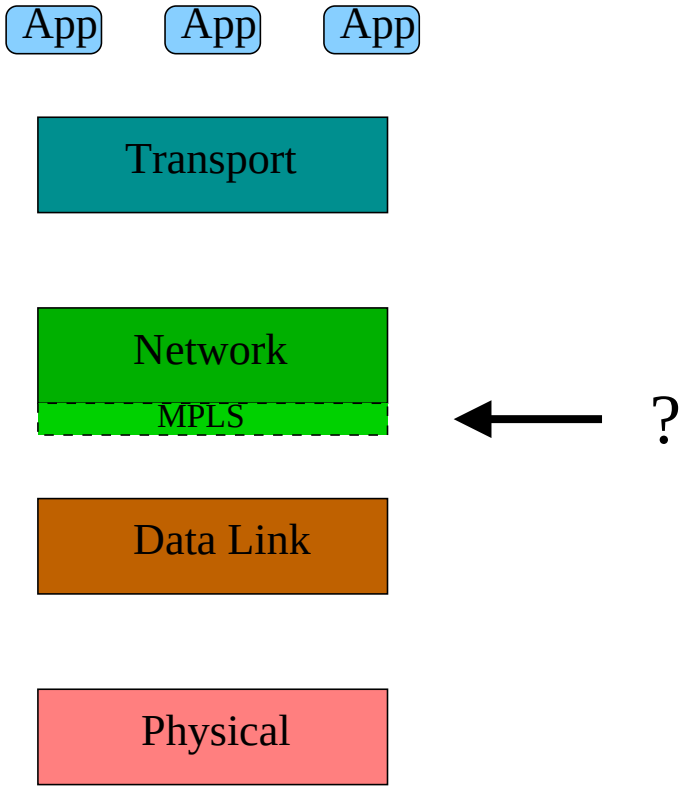

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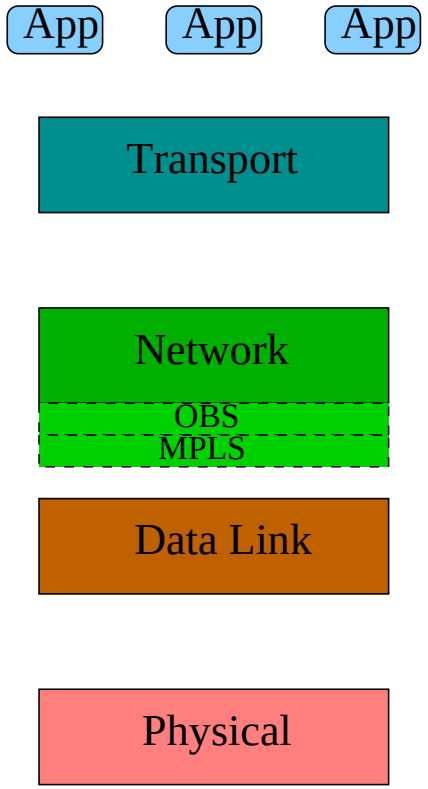


Cross-Layer Interactions: TCP Over OBS

Does “TCP Over OBS” make sense?

Cross-Layer Interactions: TCP Over OBS

Does “TCP Over OBS” make sense?

Yes!

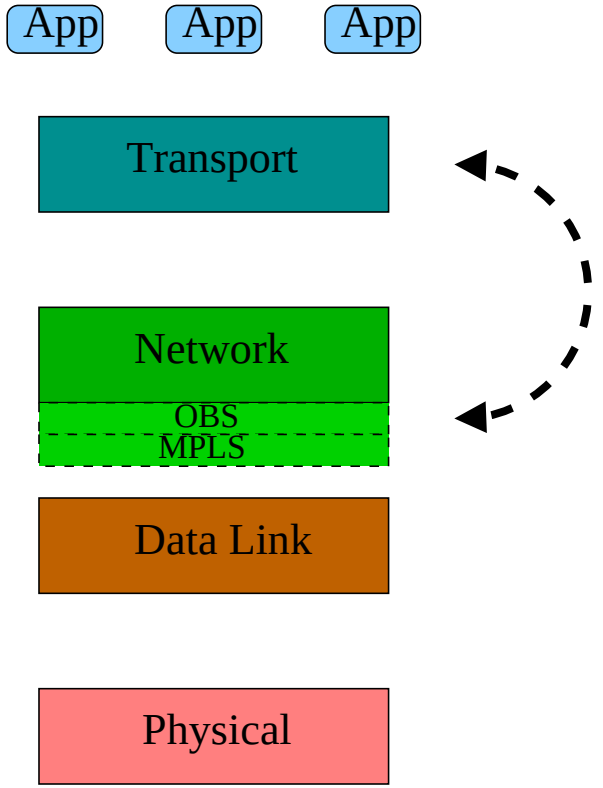
- TCP carries ≈95% of Internet traffic
- good understanding of TCP performance is crucial

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”



Software Defined Optics

- Optical substrate can no longer be viewed as black box

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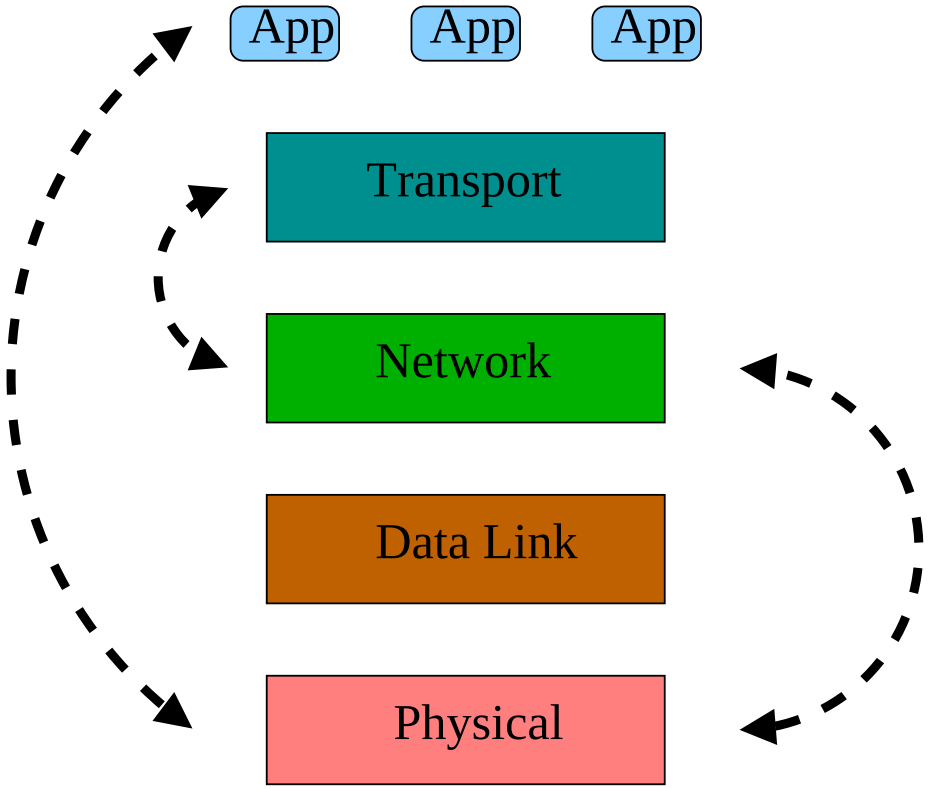
- Collection of intelligent and programmable resources:

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
  - . . .

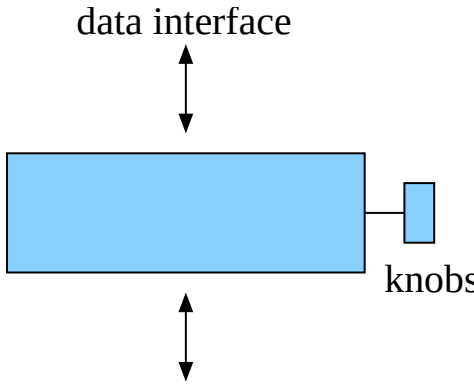
Cross-Layer Interactions

- Impairment-aware routing
- Traffic grooming
- Network resiliency
- . . .

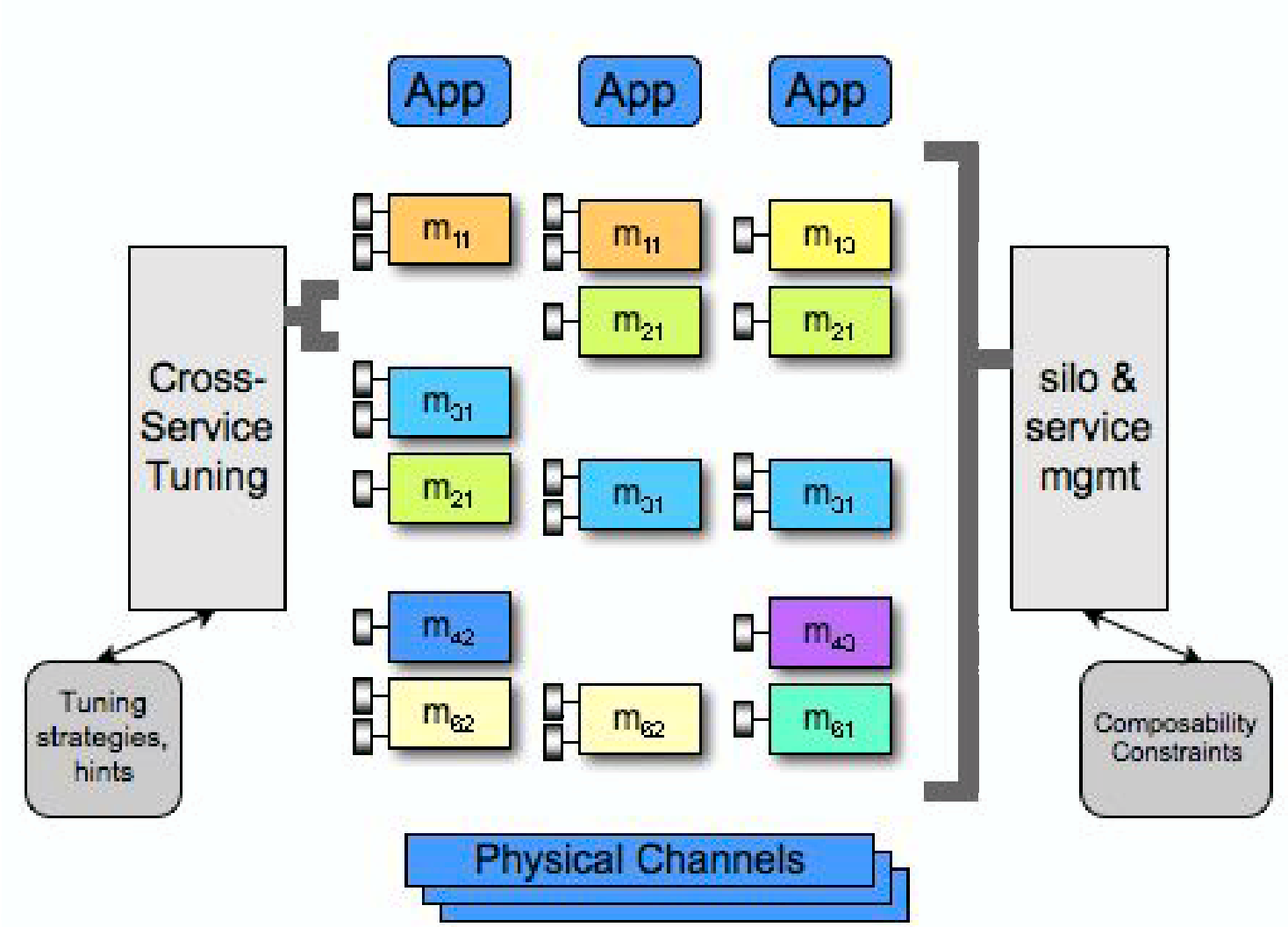


SILO Architecture Highlights

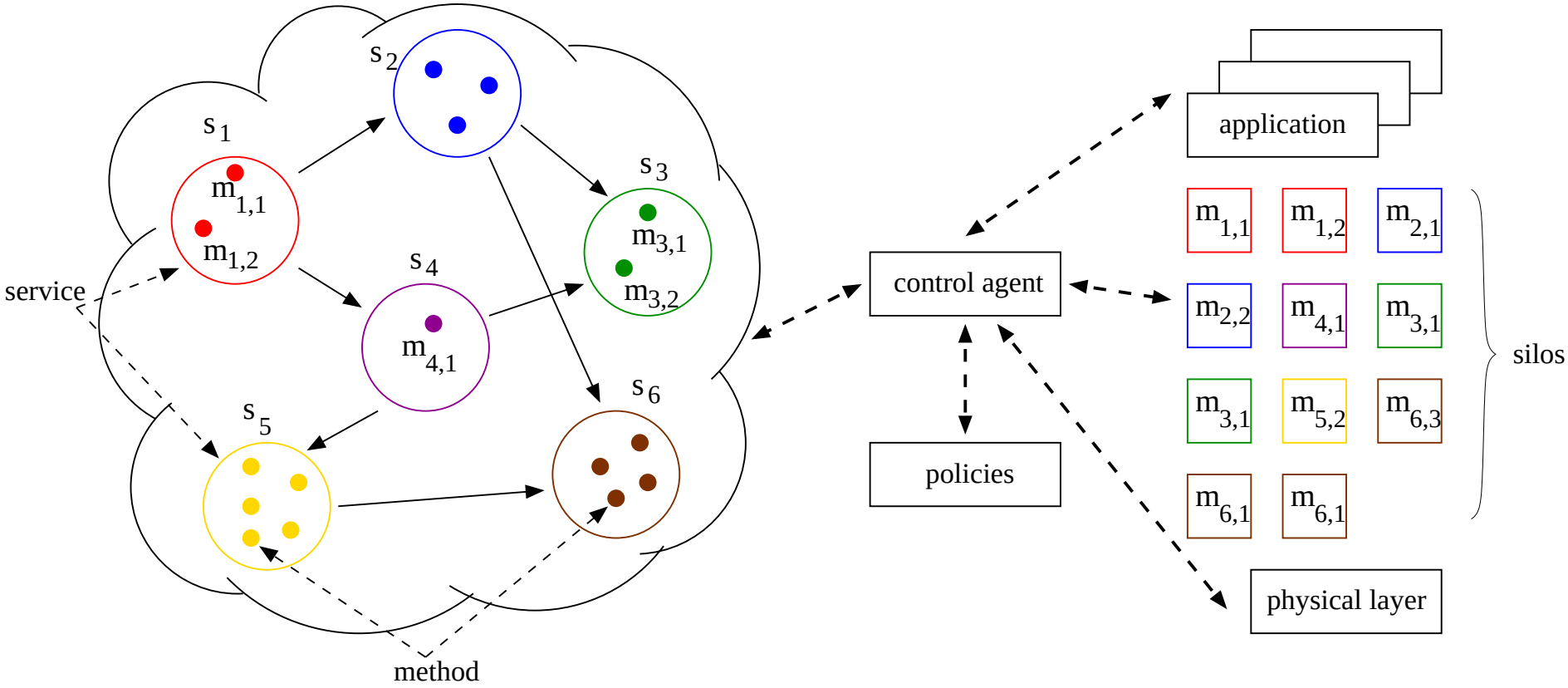
- Generalizes traditional layer stack:
  - services: building blocks of fine-grain functionality
  - silo: per-flow vertical composition of services
  - decoupling of layers and services
- Enables inter-layer interactions:
  - knobs: explicit control interfaces
- Facilitates introduction of new services:
  - ontology: describes services and their relationships
  - composition algorithm to construct silos
  - standard ontology languages and reasoning engines may be used



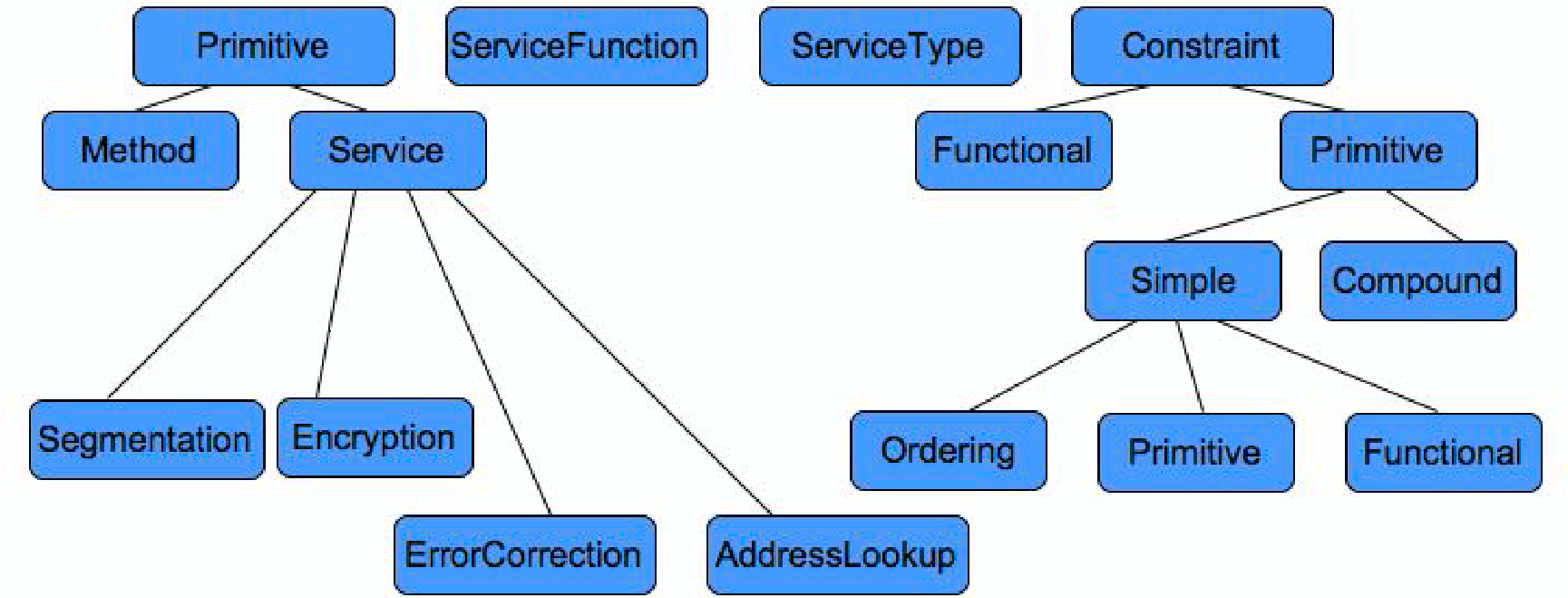
SILOs


App
App
App
Cross-Service Tuning
silo & service mgmt
Tuning strategies, hints
Composability Constraints
Physical Channels

Ontology


s 1
s 2
s 3
s 4
s 5
s 6
m 1,1
m 1,2
m 3,1
m 3,2
m 4,1
service
method
control agent
policies
application
physical layer
m 1,1
m 1,2
m 2,1
m 2,2
m 4,1
m 3,1
m 3,1
m 5,2
m 6,3
m 6,1
m 6,1
silos

Ontology – Networking Knowledge

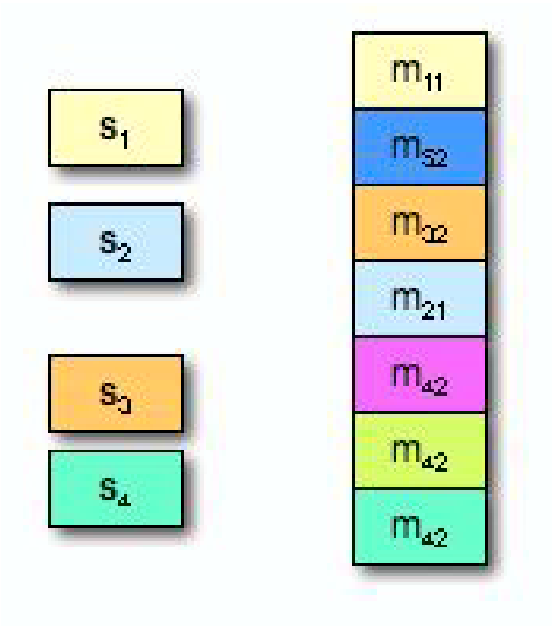


Service Composition

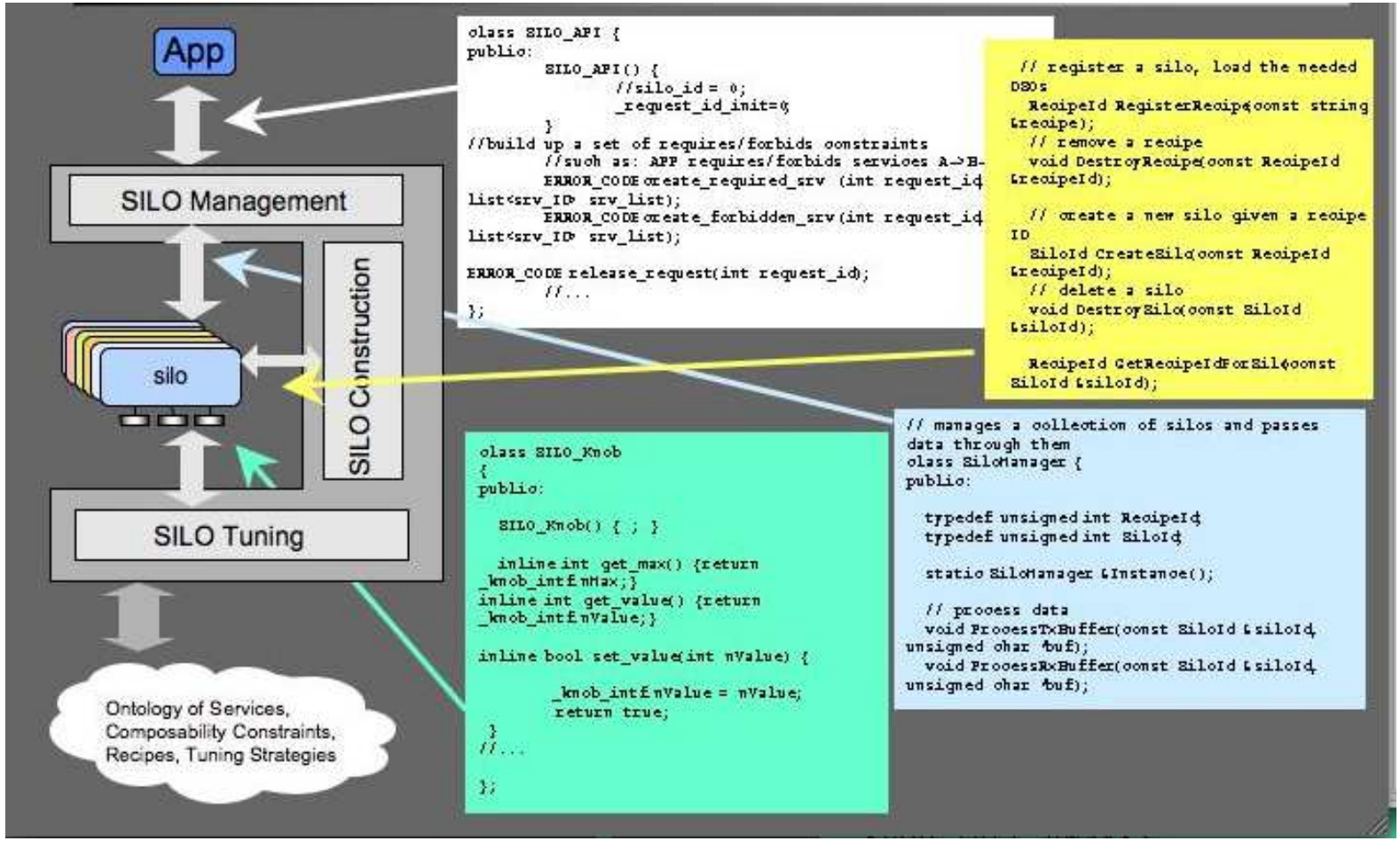
- Constraints on composing services A and B:
  - A requires B
  - A forbids B
  - A must be above (below) B
  - A must be immediately above (below) B
  - Negations, AND, OR
- Minimal set:
  - Requires, Above, ImmAbove, NotImmAbove
- All pairwise condition sets realizable
  - Forbids = (A above B) AND (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



SILO Software Prototype



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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, virtualzation
  - influence GENI development efforts