Software Defined Networking

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In this course, you will learn about software defined networking and how it is changing the way communications networks are managed, maintained, and secured.

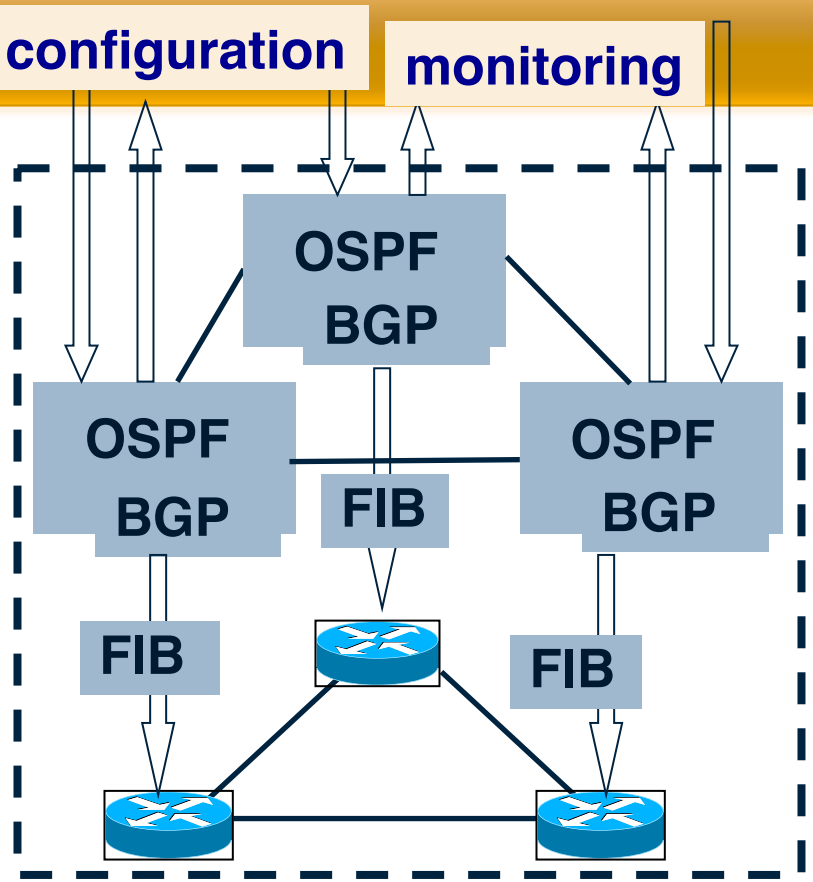
This Module: 4D Network Architecture

- The “4D” Network Architecture
  - Motivation
  - Defining the 4Ds
- How 4D Terminology Relates to SDN Today

Albert Greenberg et al. "A clean slate 4D approach to network control and management". ACM SIGCOMM *Computer Communication Review*. 2005.

Conventional IP Routers

- Management plane
  - Construct network-wide view
  - Configure the routers
- Control plane
  - Track topology changes
  - Compute routes and install forwarding tables
- Data plane
  - Forward, filter, buffer, mark, and rate-limitpackets
  - Collect traffic statistics



Goal: Remove (Conventional) Control Plane

- Faster innovation
  - Remove dependence on vendors and the IETF
- Simpler management systems
  - No need to “invert” control-plane operations
- Easier interoperability between vendors
  - Compatibility necessary only in “wire” protocols
- Simpler, cheaper routers
  - Little or no software on the routers

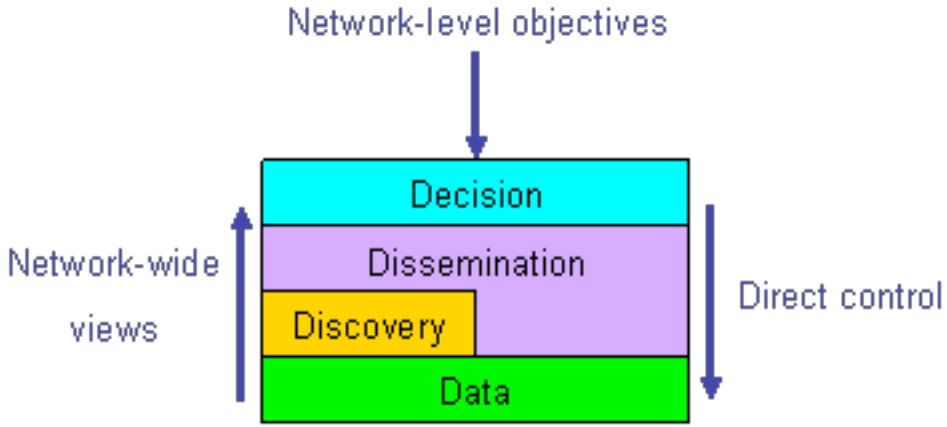
Removing the Control Plane From Routers

- Control software can run elsewhere
- State and computation is reasonable
- System overhead can be amortized
- Easier access to other information
- Some control can move to end hosts

Three Goals of 4D Architecture

- Network-level objectives
  - Configure the *network*, not the routers
  - Minimize the maximum link utilization
  - Connectivity under all layer-two failures
- Network-wide views
  - Complete *visibility* to drive decision-making
  - Traffic matrix, network topology, equipment
- Direct control
  - Direct, sole control over data-plane configuration
  - Packet forwarding, filtering, marking, buffering…

The "4D" Planes



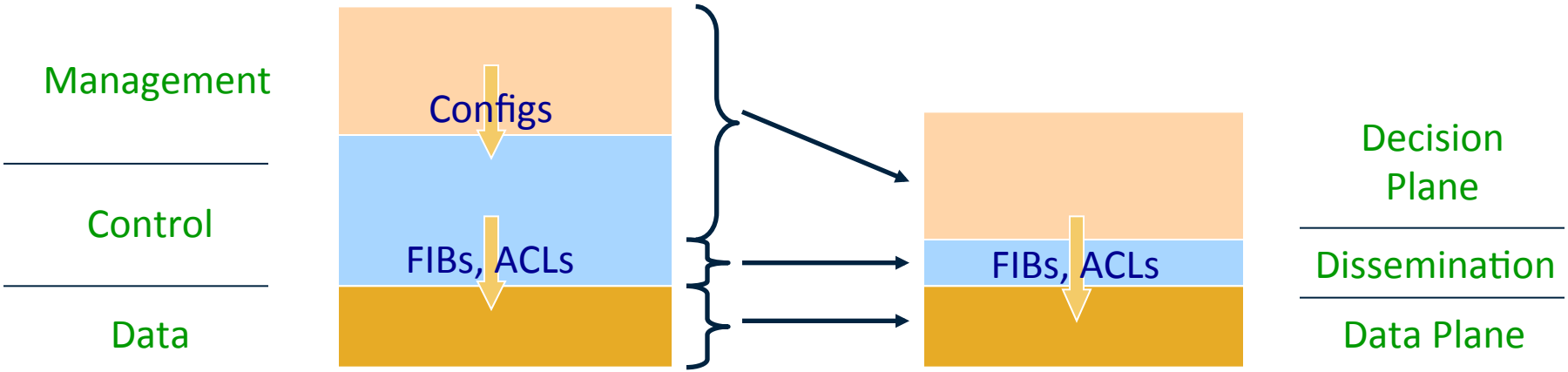
- **Decision:** all management and control
- **Dissemination:** communication to/from routers
- **Discovery:** topology and traffic monitoring
- **Data:** traffic handling

Dissemination and Decision Planes

- **Decision Plane:** Functions that operate on **view of entire network** and network objectives
  - Path selection and traffic engineering
  - Reachability control and VPNs

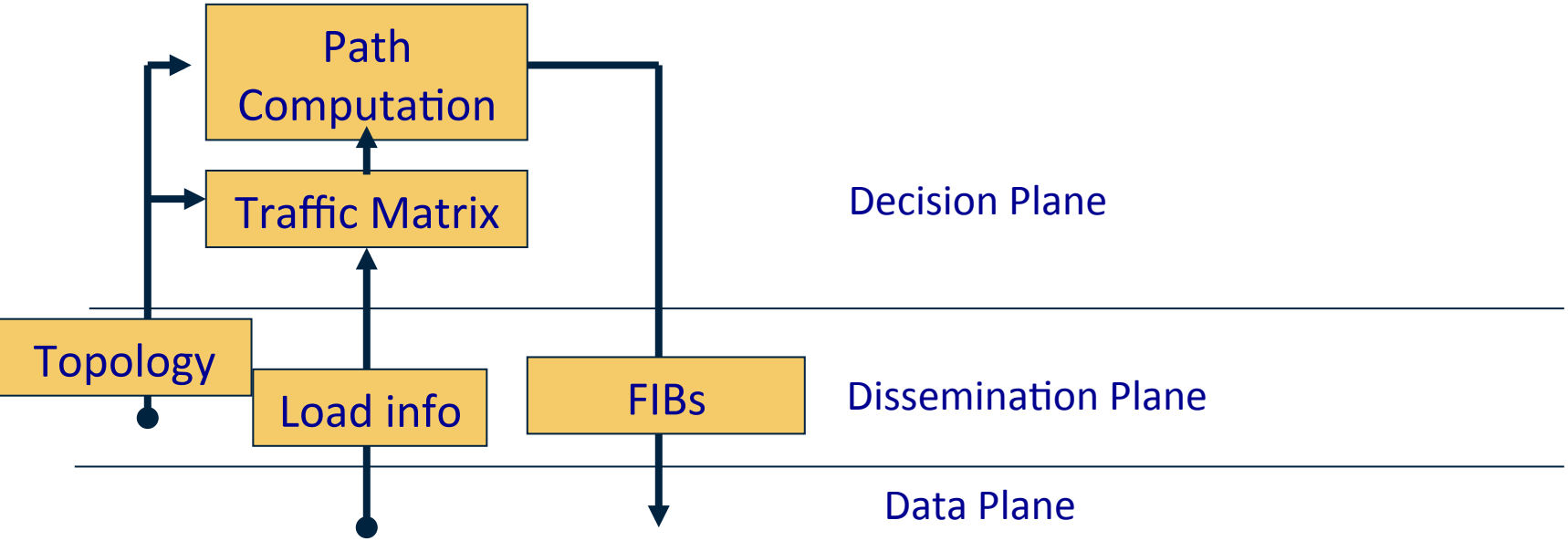
- **Dissemination Plane:** Functions that **support creation of a network-wide view**
  - Topology discovery
  - Report measurements, status, resources
  - Install state (*e.g.*, FIBs, ACLs) into data-plane

Good Abstractions Reduce Complexity



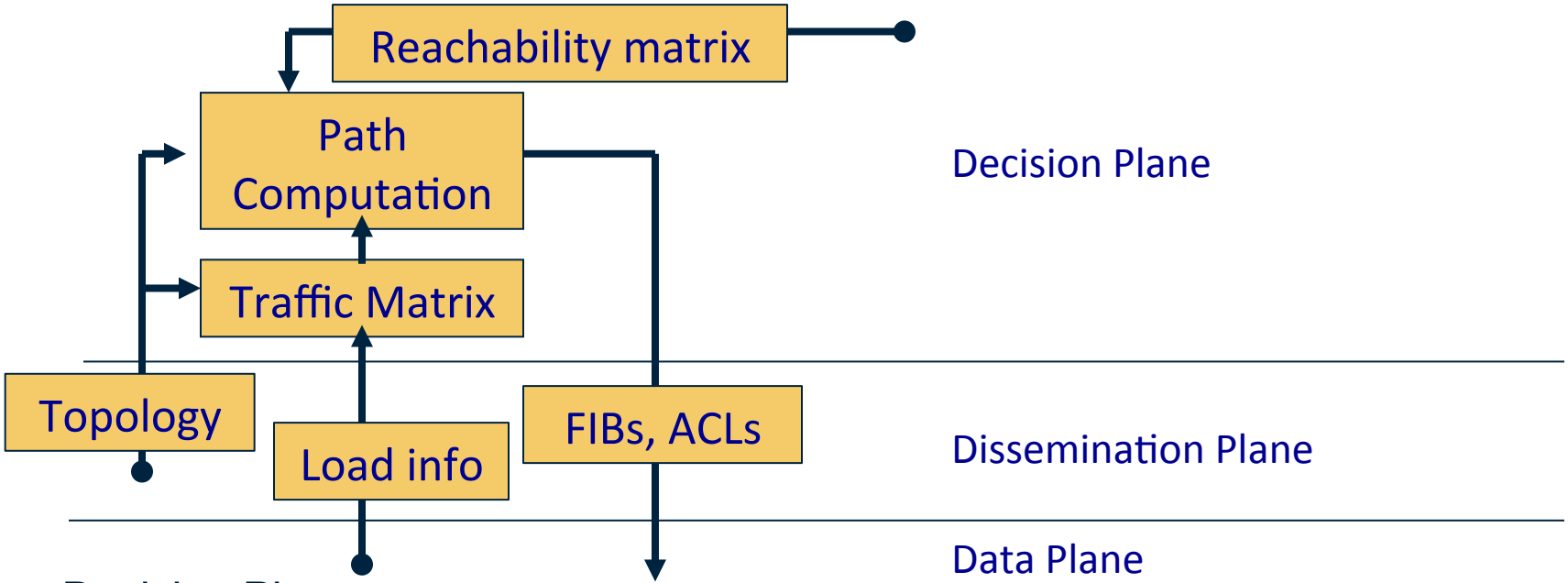
- Dissemination plane is a control channel between the decision plane and the data plane
- Routing protocols become a control channel. Complex logic in decision plane.

Traffic Engineering in 4D



- **Dissemination Plane:** Consistent network-wide view
- **Decision Plane:** Decision Logic that directly expresses desired solution

Traffic Isolation in 4D



- Decision Plane
  - Reachability matrix **directly expresses** goal
  - Path computation can **jointly** optimize traffic load and obey reachability constraints
- Packet filters installed only where needed

SDN Still Have a "Control Plane", but It's Not What 4D Called a Control Plane

- What the 4D calls the "control plane" is actually distributed routing protocols
- What we refer to as the "control plane" today is the "decision plane" in 4D
- The "dissemination plane" lives on, but we call it a "control channel"
  - In RCP, dissemination plane is BGP
  - In OpenFlow, it's "secchan"

Summary

- Four layers
  - **Data:** for processing packets
  - **Discovery:** for collecting topology and traffic
  - **Dissemination:** installing packet-processing rules
  - **Decision:** logically centralized controllers convert objectives into packet-handling state
- 4D is a generalization of RCP
  - Others followed up with more general implementations