Thoughts on control and management planes to enhance manageability of future carrier networks

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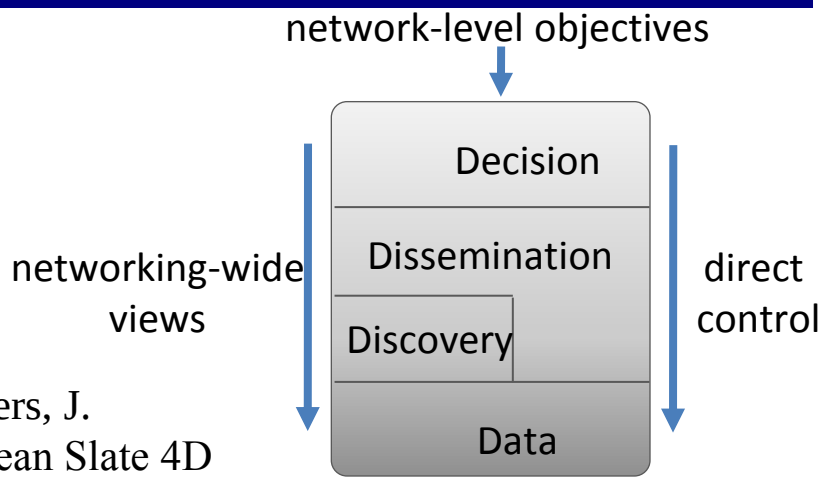
Headache in today's carrier network operation

- Carrier network is huge.
- Today's carrier network is IP-based.
- Simple best-effort routing is not enough.
- It is difficult to tweak OSPF and BGP.

4D architecture [2]

- Clean-slate approach for control and management planes
- Principle for control and management
  - (1) network-level objectives, (2) network-wide view, (3) direct control
- Centralized architecture with four planes
  - (1) decision, (2) dissemination, (3) discovery, (4) data



[2] A. Greenberg, G. Hjalmtysson, D. A. Maltz, A. Myers, J. Rexford, G. Xie, H. Yan, J. Zhan, and H. Zhang, "A Clean Slate 4D Approach to Network Control and Management," In ACM SIGCOMM Computer Communication Review, 2005.

Network-level objectives: Principle in 4D architecture [2]

- Network should be configured via specification of the requirements and goals for its performance. Ex.
  - a traffic-engineering objective could be stated as “keep all links below 70% utilization, even under single-link failures.”
  - a reachability policy objective could be stated as “do not allow hosts in subnet B to access the accounting servers in subnet A.”
- But,… Today’s networks require these goals to be expressed in low-level configuration commands on the individual routers.
  - Objectives can be easily violated due to semantic mistakes in translating the network-level objectives into specific protocols and mechanisms.

Network-wide view: Principle in 4D architecture [2]

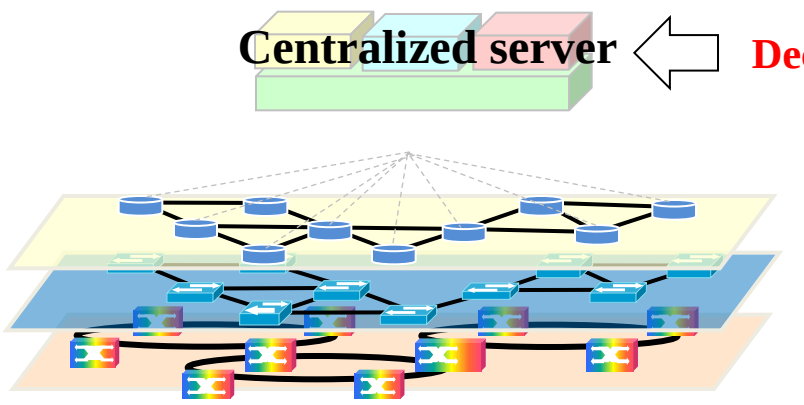
- Timely, accurate, network-wide views of topology, traffic, and events are crucial.
- The network-wide view must accurately reflect the current state of the data plane.

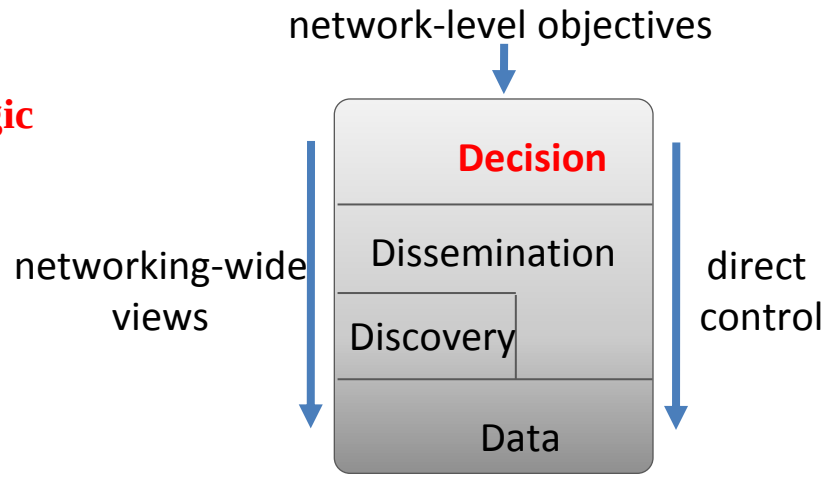
Direct control: Principle in 4D architecture [2]

- Control and management system should have both the ability and the responsibility for setting all the state in the data plane that directs packet forwarding.
- The decision logic should not be hardwired in protocols distributed among routers/switches.
  - Rather, only the output of the decision logic should be communicated to the network elements.
- Satisfying network-level objectives is much easier with direct control over the configuration of the data plane.

Decision plane: Plane in 4D architecture [2]

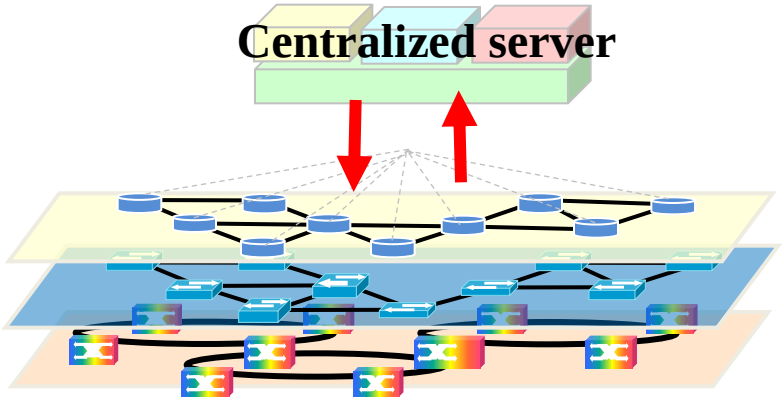
- Decision on network control
- Replace today's control plane
  - Capture network-wide view.
  - Compile network-level objective to primitives for data-plane commands.
- Centralized control
  - Logic for Decision plane is not implemented in distributed protocols between routers. Rather it is implemented in centralized server.

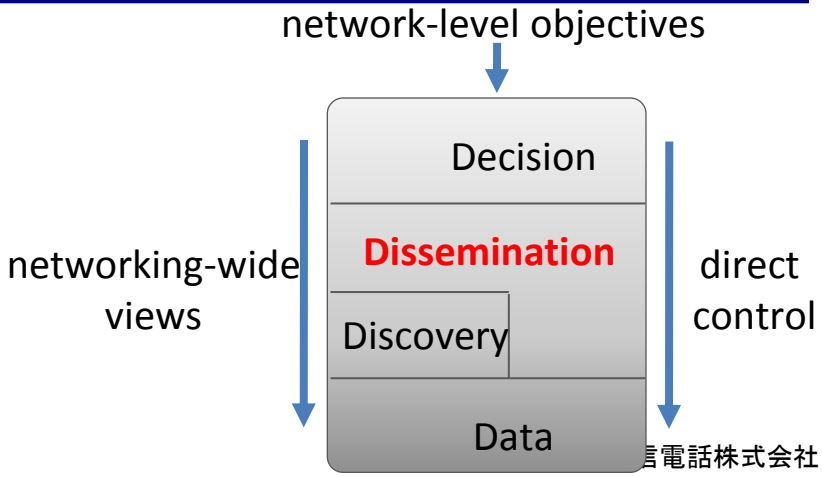




Dissemination plane: Plane in 4D architecture [2]

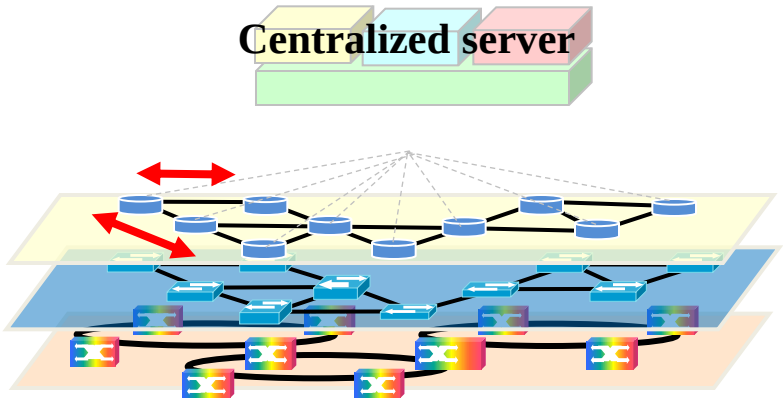
- Communication between server and router
  - Result of Decision plane is transmitted (Server to Router)
  - Result of Discovery plane is transmitted (Router to Server)
- Robust and efficient mechanism is required
  - Direct control over router (Decision plane logic result is directly transmitted to routers)
- Separation of Decision logic from routers
  - Pros 1: Simplify distributed protocols between routers.
  - Pros 2: Complicated algorithm can be implemented in the server.
  - Pros 3: Simplify routers. Routers have only to execute instructions sent by the server for direct control over data-plane.

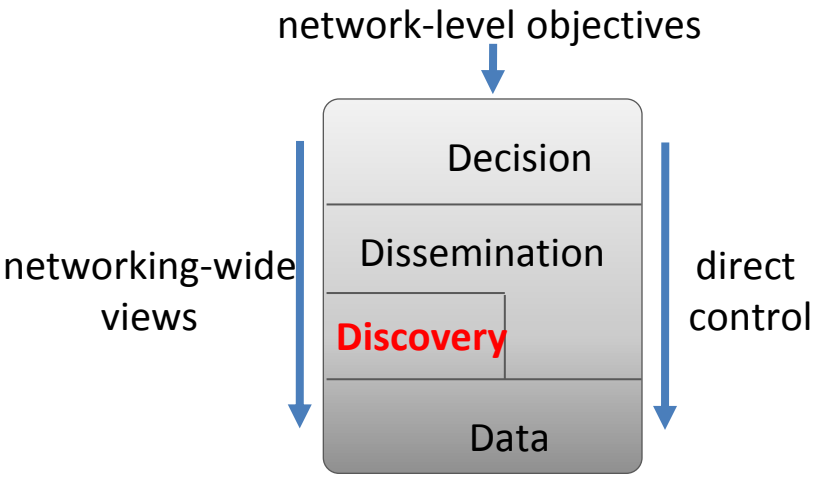




Discovery plane: Plane in 4D architecture [2]

- Routers run distributed protocol to discover network-wide view of topology and traffic.
  - Dissemination plane is used to notify the link information to the server
  - Decision plane is used to capture Network-wide view of topology and traffic

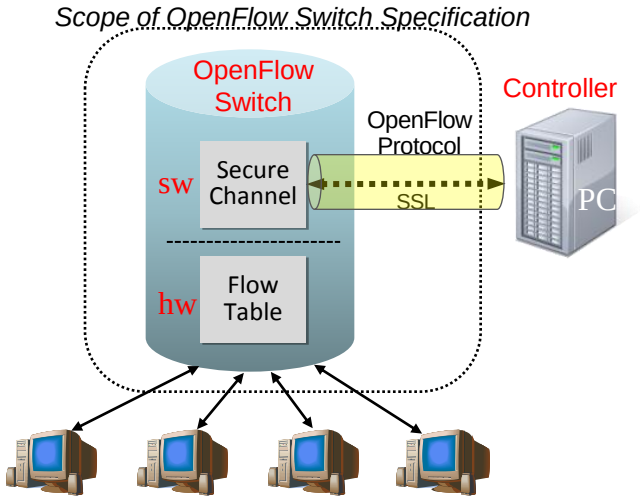


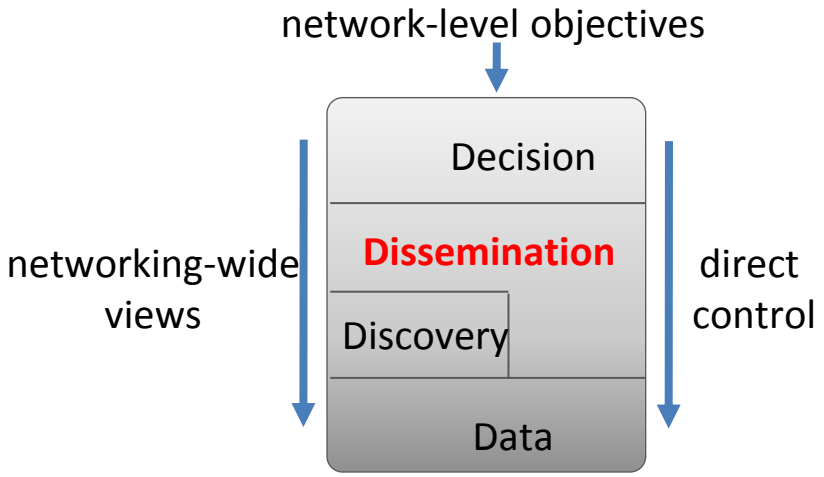


Openflow [3]

- Example of 4D architecture
  - Openflow protocol can be regarded as Dissemination plane
- Separation of control and data planes
  - Ground-up re-desing of control plane
  - 10-Tuple is defined for flow
  - Rule, action, counter

[3] N. McKeown, T. Anderson, H. Balakrishnan, G. Parulkar, L. Peterson, J. Rexford, S. Shenker, and J. Turner, "OpenFlow: Enabling Innovation in Campus Networks," ACM SIGCOMM CCR, vol. 38, no. 2, April 2008.pp.69-74





What is missing in Today's openflow?

- Topology discovery
- Traffic measurement data retrieval
- Fault notification
- Interaction to *fast-processing* features implemented in Hardware (protection switching, …)

- Dissemination plane, how to configure it?

CLI can be used as Dissemination plane?

- CLI can be regarded as a way to configure switches and routers in network.
- Configuration files of all routers can be used as database of network constructions.
- By analyzing CLI commands in configuration file, we could capture network-wide view.

CLI can be used as Dissemination plane?

- Today's carrier networks requires **thousands of lines of CLI commands** to configure switches and routers [1].
- CLI commands are highly dependent on manufactures who provided switch and/or router products.

[1] D. Caldwell, A. Gilbert, J. Gottlieb, A. Greenberg, G. Hjalmtysson, and J. Rexford, "The Cutting EDGE of IP Router Configuration," ACM CCR, vol. 34, no. 1: January 2004, pp.21-26.

CLI can be used as Dissemination plane?

- CLI should be simple.
- CLI should be vendor-neutral.
- CLI should have functionalities for network management
  - Direct control
  - Network-wide view
  - Fault management
- Providing the information necessary to construct a complete, consistent, network-wide view should be one of the primary functions of the routers and switches.
  - Topology discovery
  - Traffic measurement
  - Fault notification
  - Interaction to *fast-processing* features implemented in Hardware (protection switching, …)

Open research areas are here!