

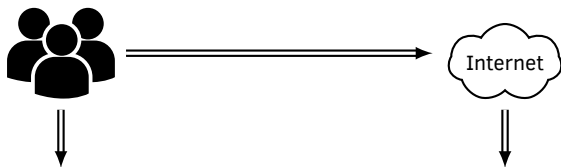
A Graph Model of the Topology of Physical, Link and Network Layers of an Enterprise Network

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Network Management in the Modern Enterprise Networks



Users

Services



Network Management in the Modern Enterprise Networks



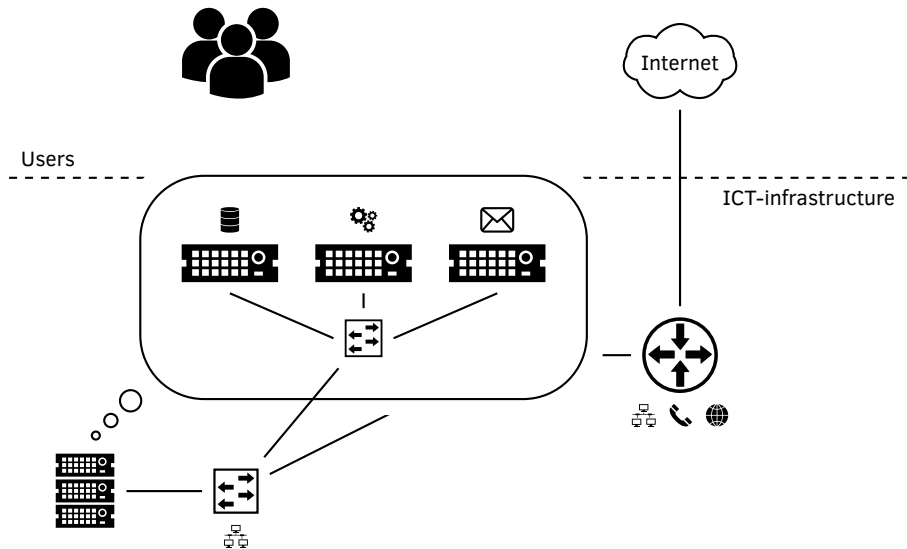
Users



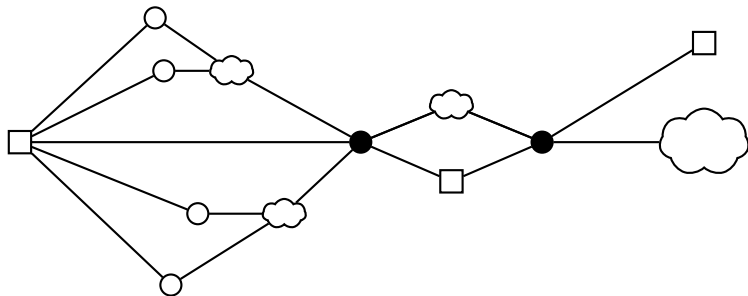
ICT-infrastructure



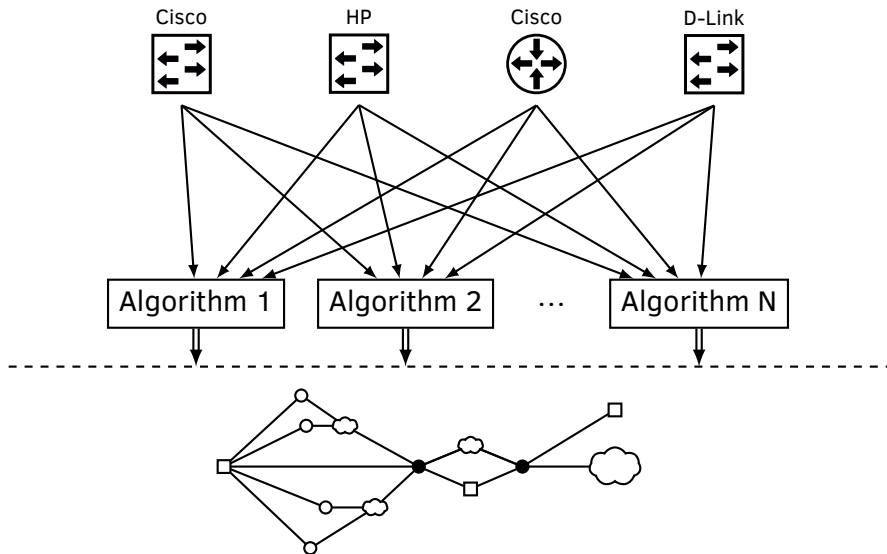
Network Management in the Modern Enterprise Networks



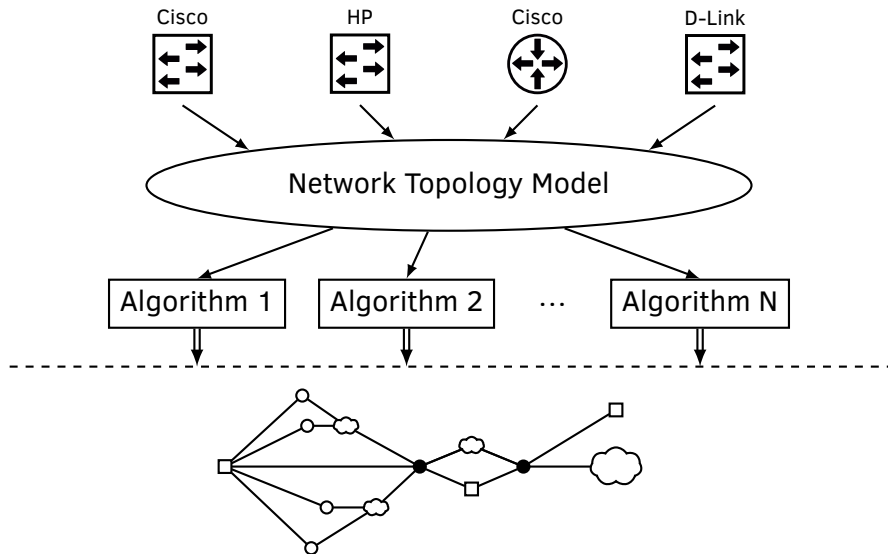
Network Topology Map



Network Topology Discovery Methods



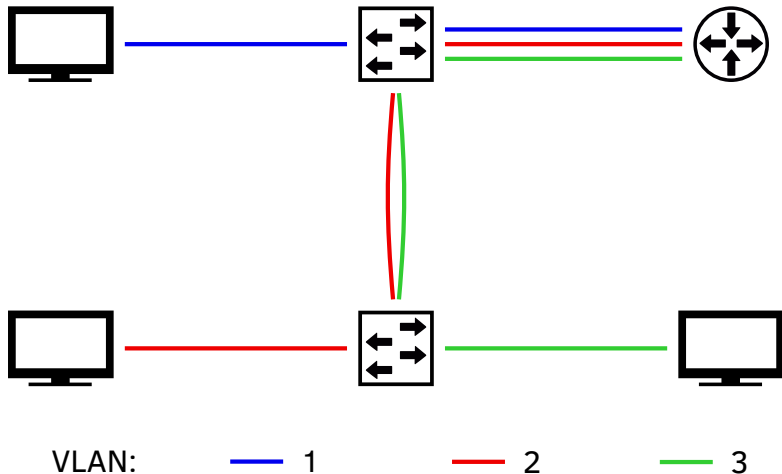
Network Topology Discovery Methods



Requirements to the Model

- ▶ Must be able to describe Ethernet- and IP- based networks.
- ▶ Physical layer: devices, ports, physical connections.
- ▶ Link layer: broadcast domains, VLANs, link layer connectivity.
- ▶ Network layer: IP subnetworks, routes between the subnetworks.
- ▶ Inference of the network topology fragments.

The Layout of the Sample Network

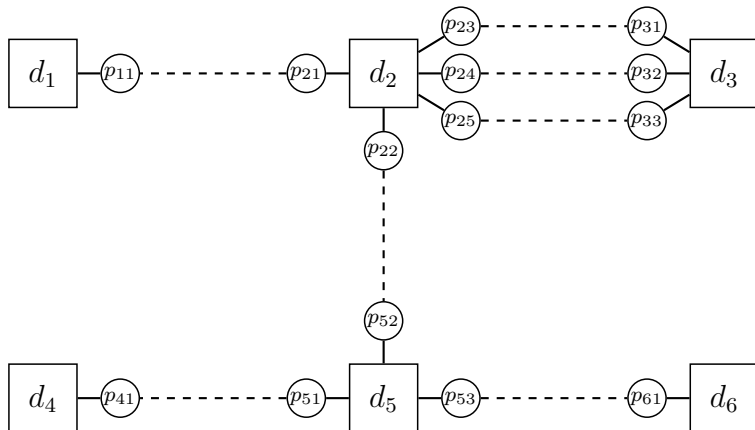


Graph Model of the Physical Layer

D — set of devices, P — set of ports.

A^1 — association relation between the ports and the devices.

L^1 — physical connection relation.

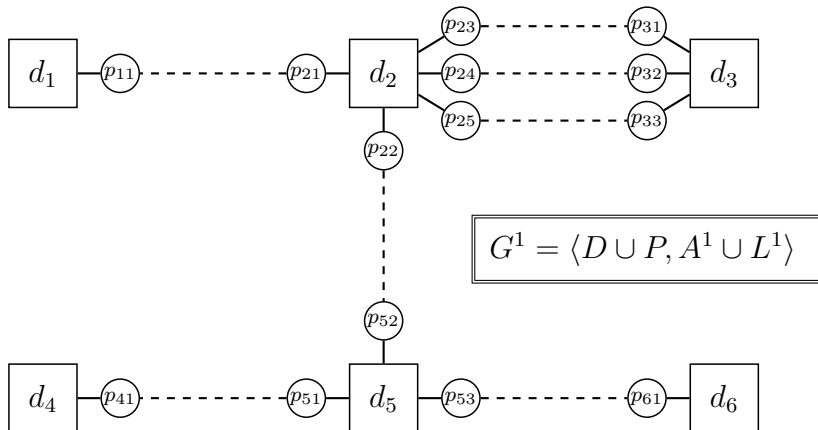


Graph Model of the Physical Layer

D — set of devices, P — set of ports.

A^1 — association relation between the ports and the devices.

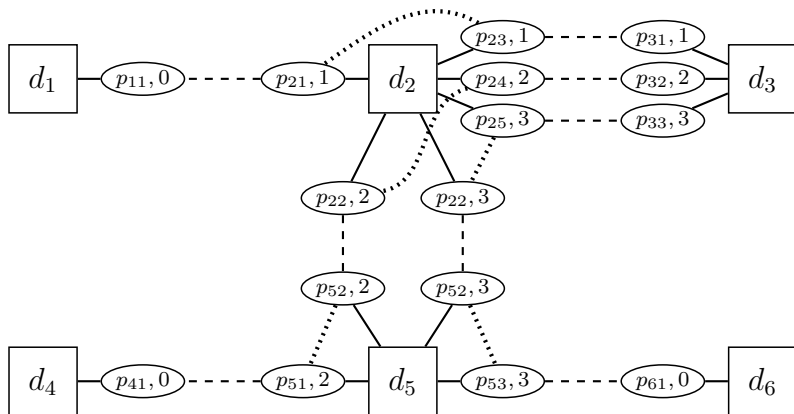
L^1 — physical connection relation.



Graph Model of the Link Layer

I^2 — set of link layer interfaces.

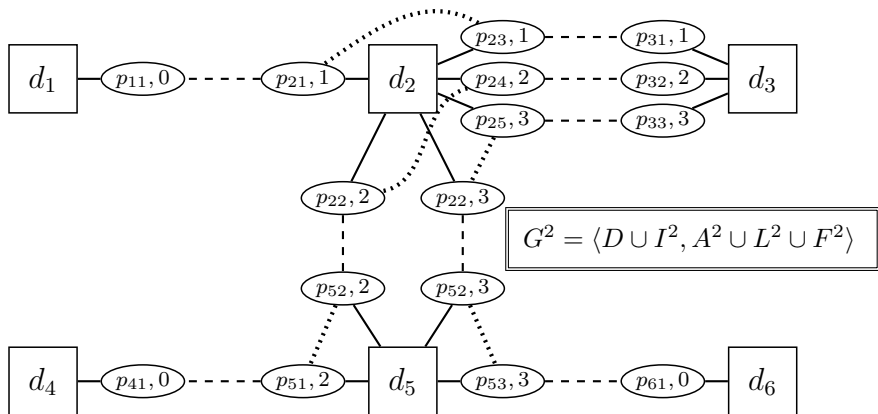
A^2 , F^2 , L^2 — relations of association, forwarding and link layer connection.



Graph Model of the Link Layer

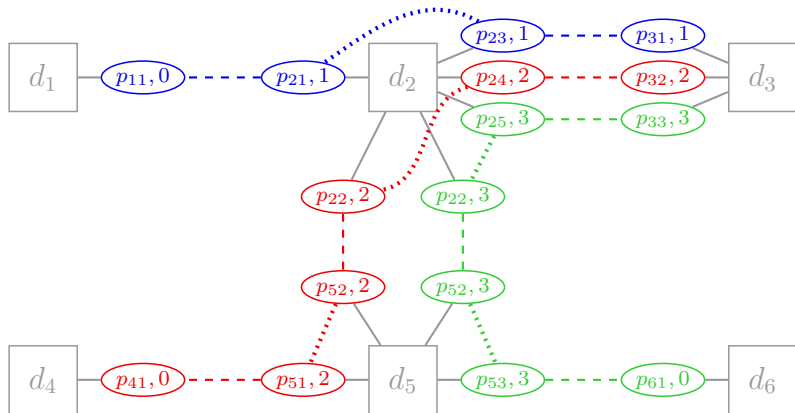
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Broadcast Domains in the Model

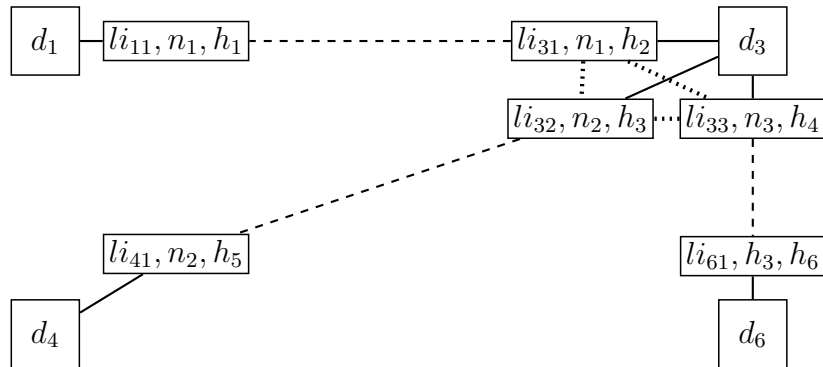
Connected components of the graph $\widehat{G}^2 = \langle I^2, F^2 \cup L^2 \rangle$



Graph Model of the Network Layer

I^3 — set of network layer interfaces.

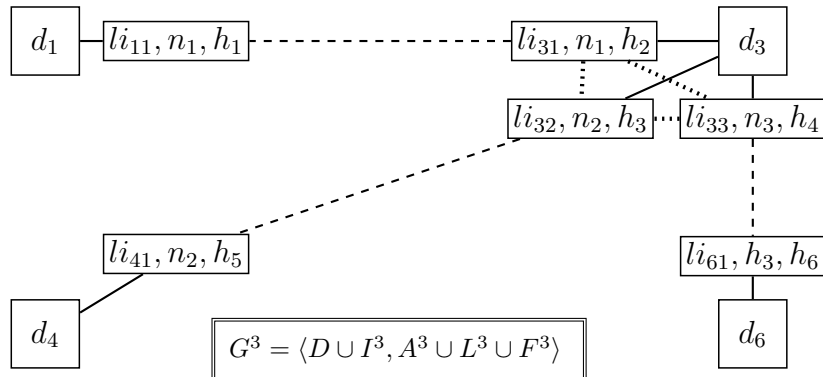
A^3, F^3, L^3 — relations of association, routing and network layer connections.



Graph Model of the Network Layer

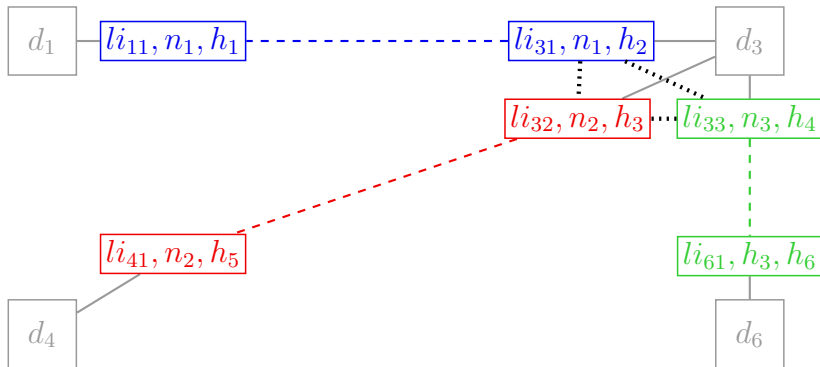
I^3 — set of network layer interfaces.

A^3, F^3, L^3 — relations of association, routing and network layer connections.



IP-subnetworks in the Model

Connected components of the graph $\widehat{G}^3 = \langle I^3, L^3 \rangle$

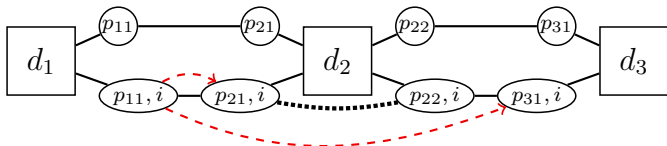


Network Topology Graph Building Procedure

1. Collect data from the network and initialize the graph.
2. Inference of the devices, data about which are missing from the network input data.
3. Build link layer connection edges of the graph and infer physical and network connections.

Reachability Sets of Link Layer Interfaces

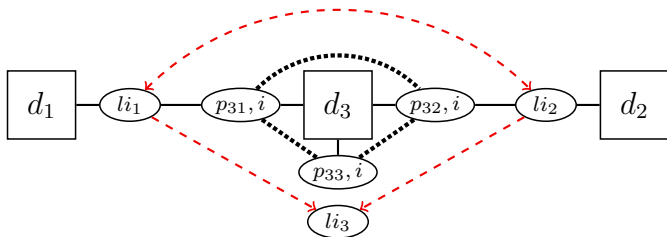
- ▶ We will say that li_2 is reachable from li_1 if there is a link layer path between them, in which the first and the last edges are not commutation edges.
- ▶ $RS_{li_1} \subset I^2$ — all link interfaces, that are reachable from li_1 .



$$RS_{(p_{11,i})} = \{(p_{21,i}), (p_{31,i})\}$$

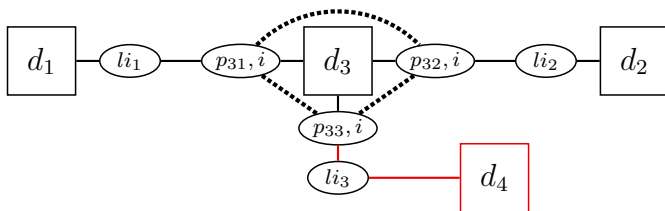
Evidence of the Presence of an Intermediate Device

If two reachable from each other interfaces have shared reachable interfaces, then those shared interfaces are not associated with the devices on the path between them.



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Evidence of the Link Layer Connectivity

If a link interface li_2 is the only reachable interface from a link interface li_1 , then li_1 and li_2 are connected on the link layer.



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Conclusion

- ▶ Generalized model of the network topology is required to combine different algorithms of the network state data processing.
- ▶ The graph model of basic layers of an Ethernet/IP based network was defined:
 - ▶ devices, ports, link and network interfaces, broadcast domains, IP-subnetworks, data communication paths;
 - ▶ criteria of links and nodes existence was stated and proved.