OpenFlow and SDN: Hype, Useful Tools or Panacea?

Ivan Pepelnjak (ip@ipSpace.net)
Chief Technology Advisor

NIL Data Communications

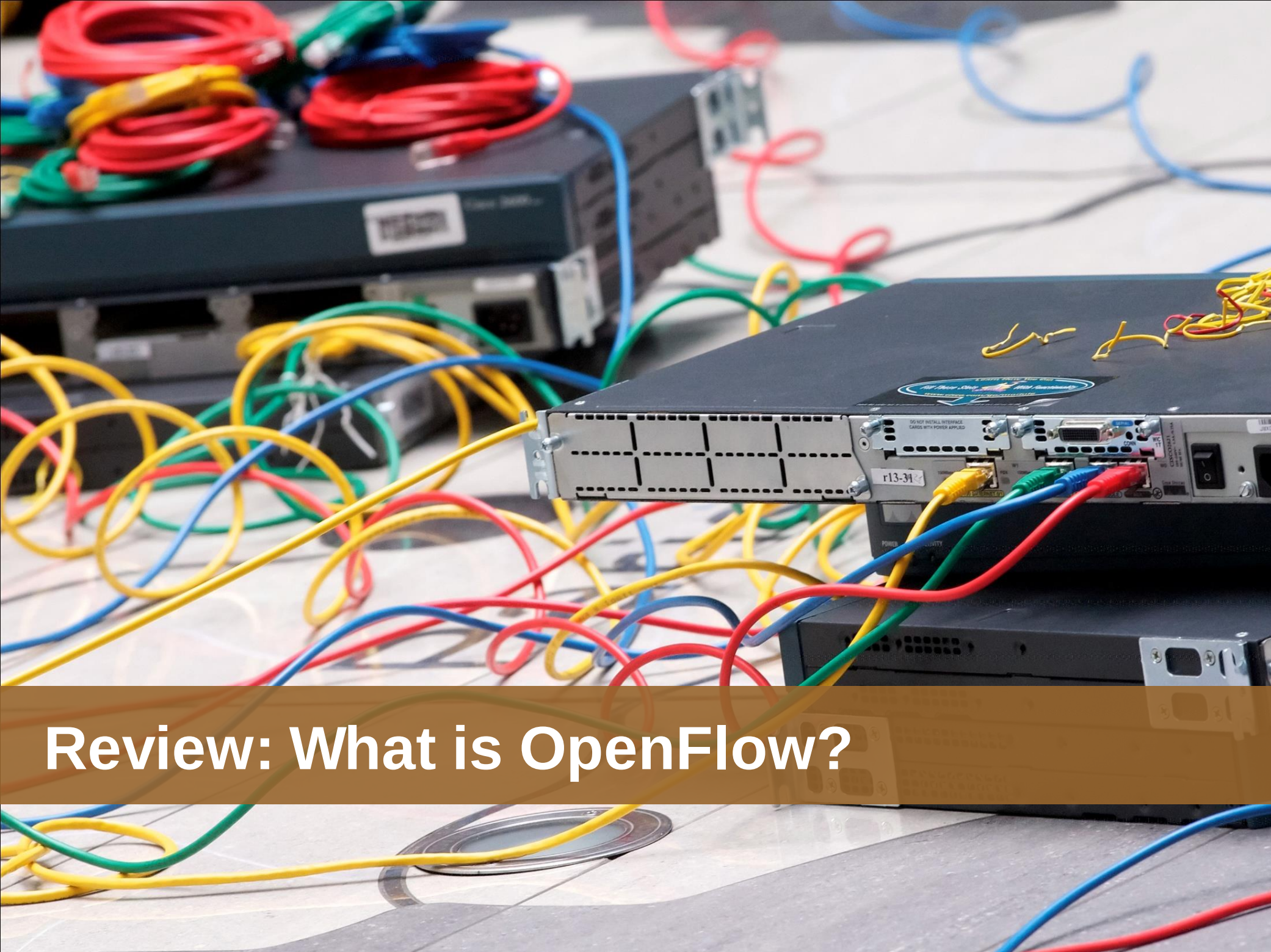
Who is Ivan Pepelnjak (@ioshints)

- Networking engineer since 1985
- Technical director, later Chief Technology Advisor @ NIL Data Communications
- Consultant, blogger (blog.ioshints.info), book and webinar author
- Currently teaching “Scalable Web Application Design” at University of Ljubljana

Focus:

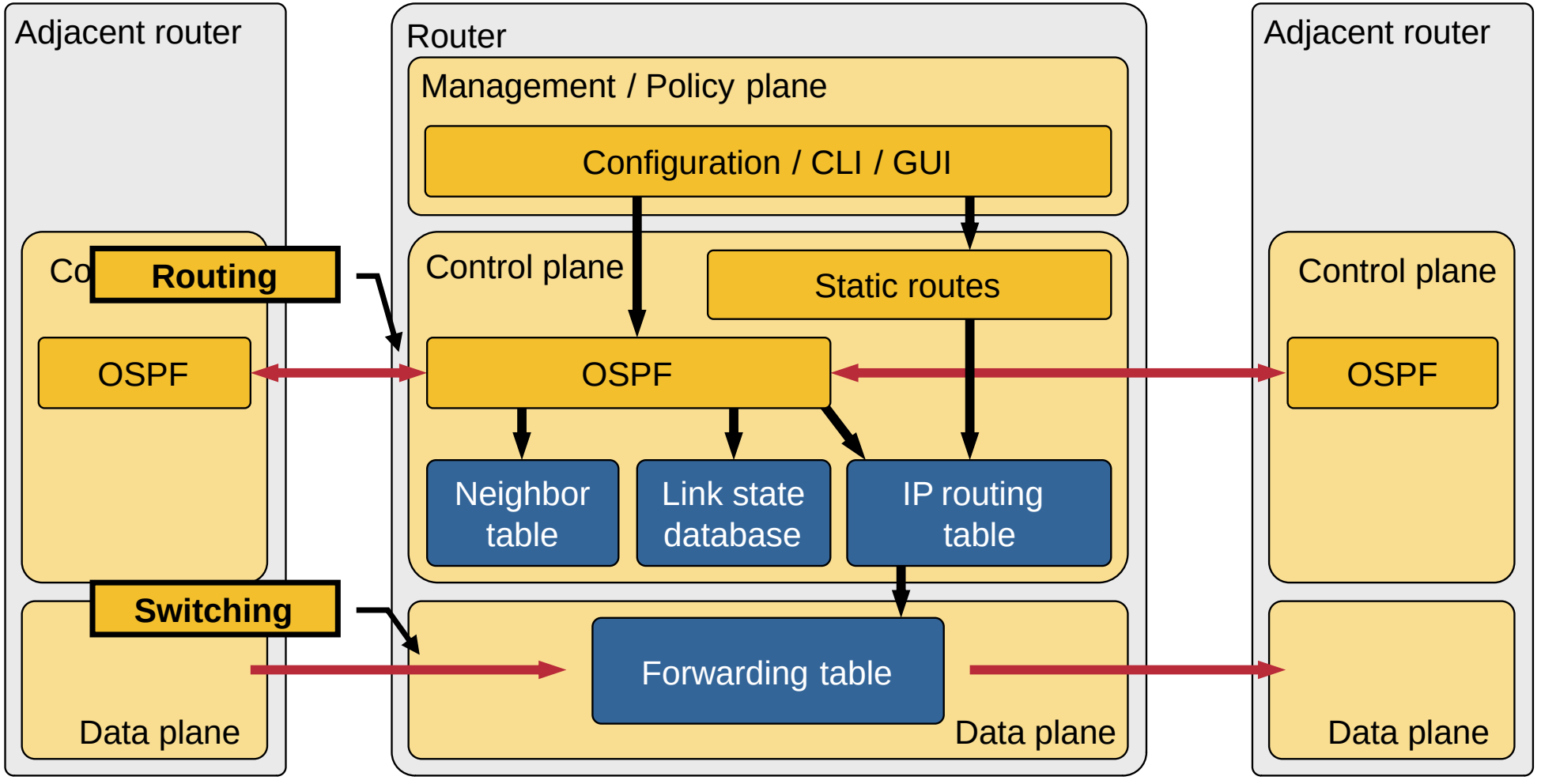
- Large-scale data centers and network virtualization
- Networking solutions for cloud computing
- Scalable application design
- Core IP routing/MPLS, IPv6, VPN

More @ ipSpace.net/About and ipSpace.net/Webinars

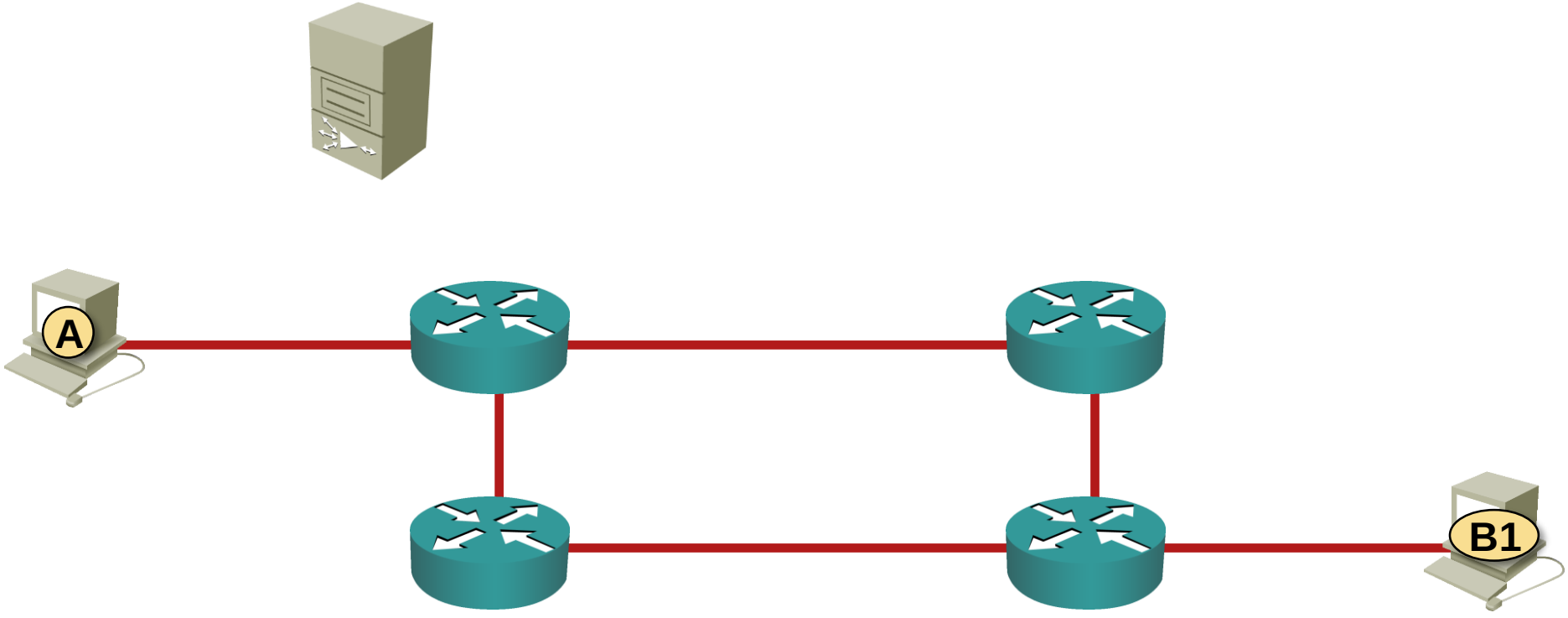


Review: What is OpenFlow?

Management, Control and Data Planes



OpenFlow = Control / Data Plane Separation



Basic principles:

- Control / Management plane in a dedicated *controller*
- Networking devices perform forwarding and maintenance functions
- IP / SSL connectivity between controller and OpenFlow switch
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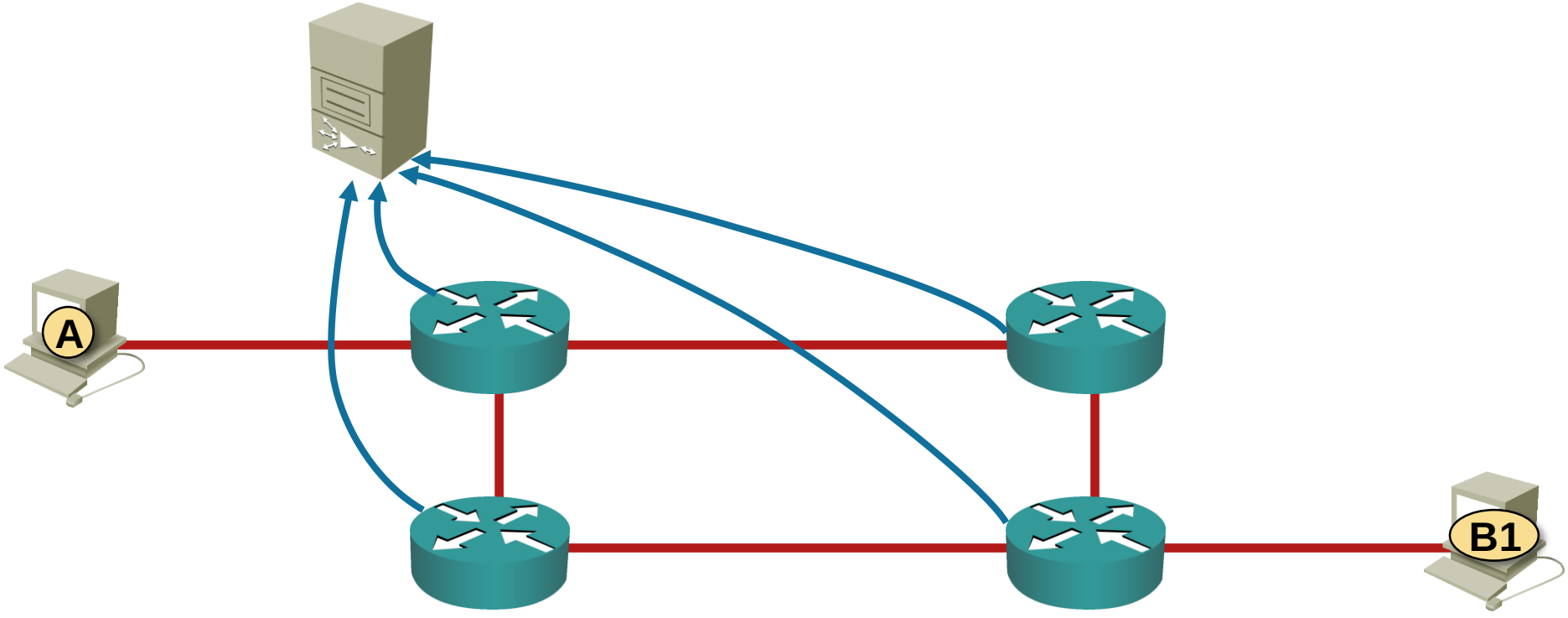

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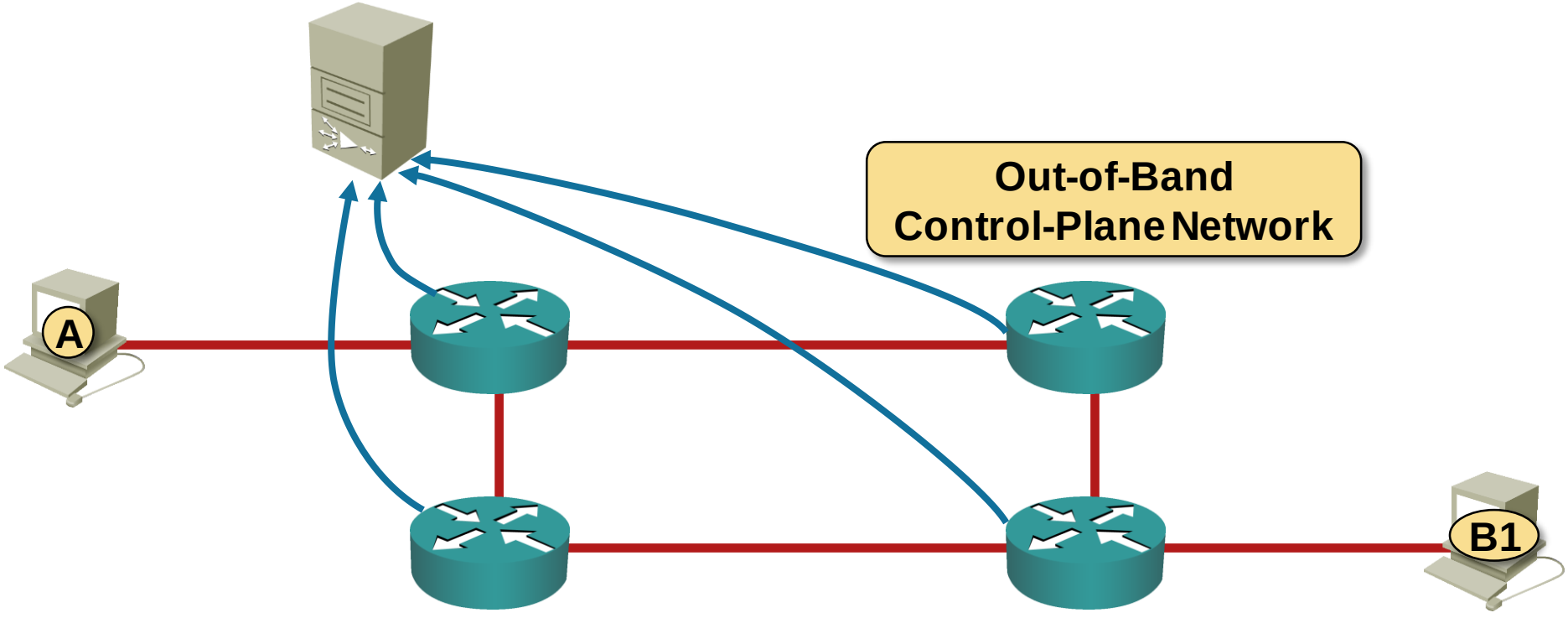

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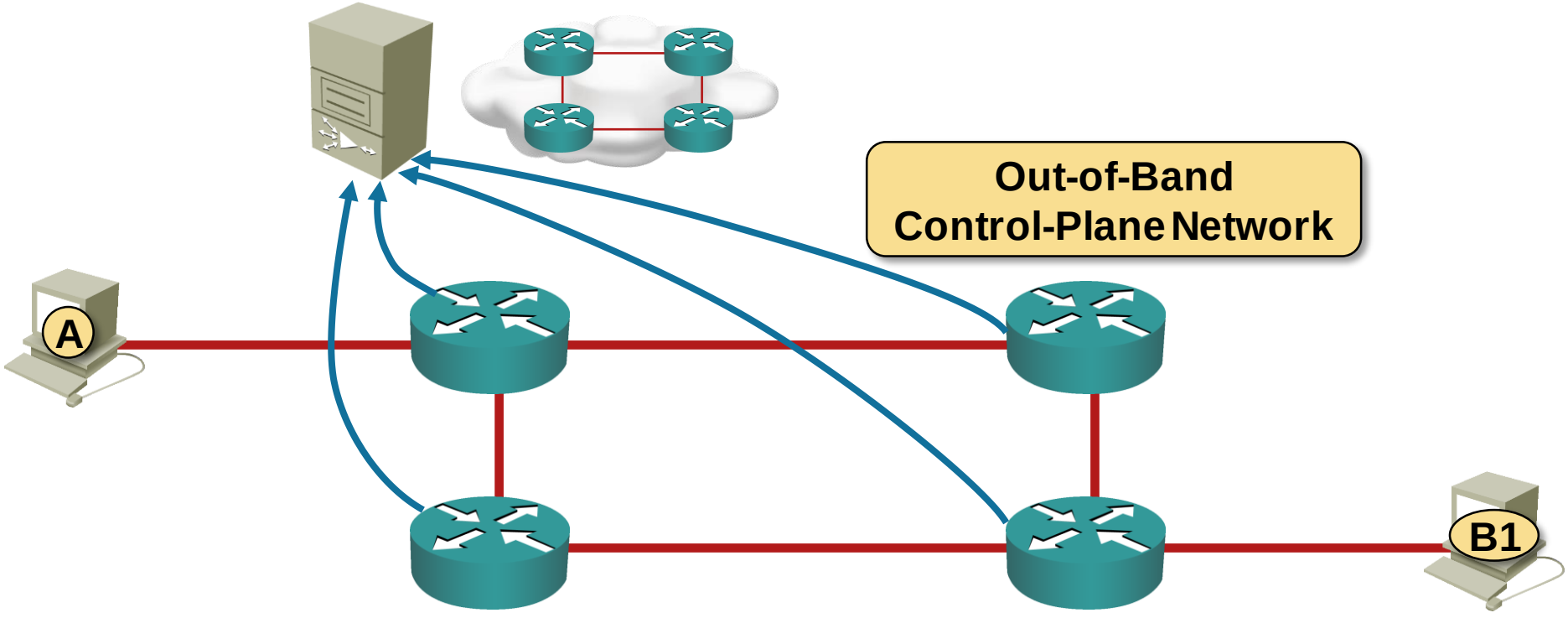

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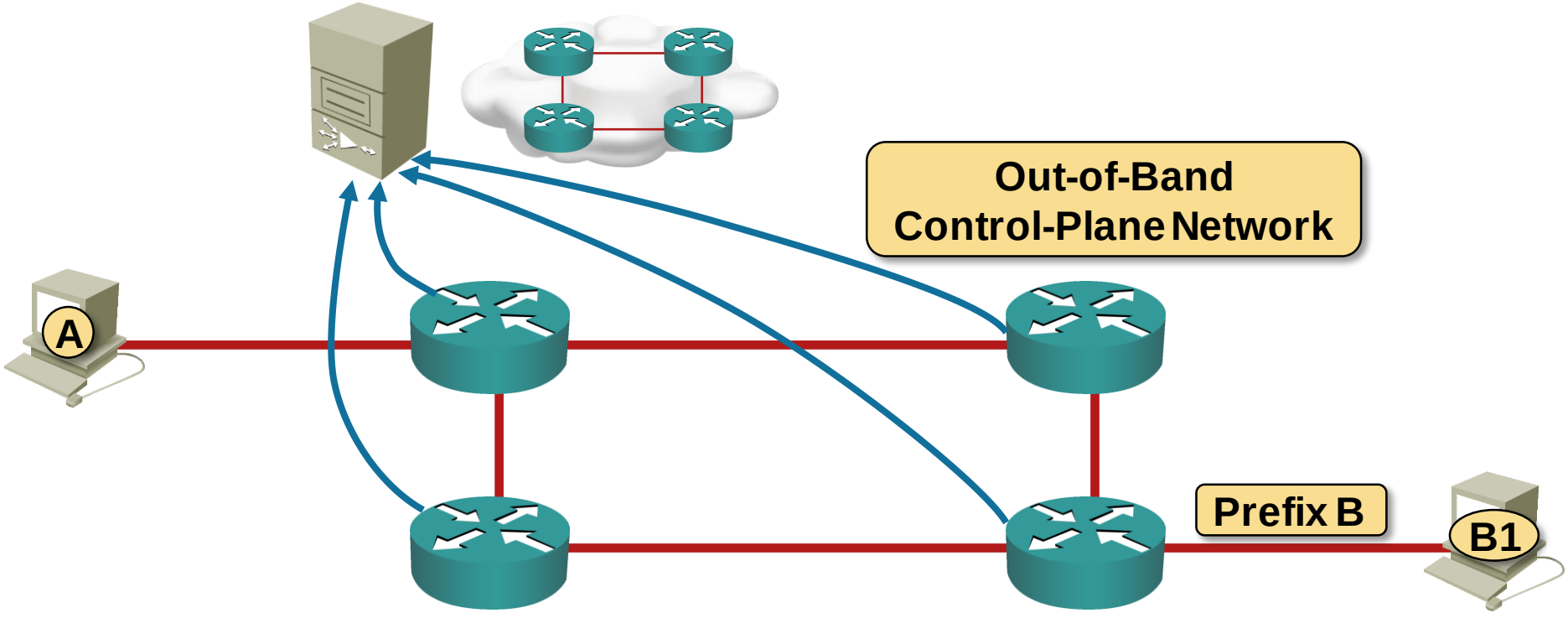

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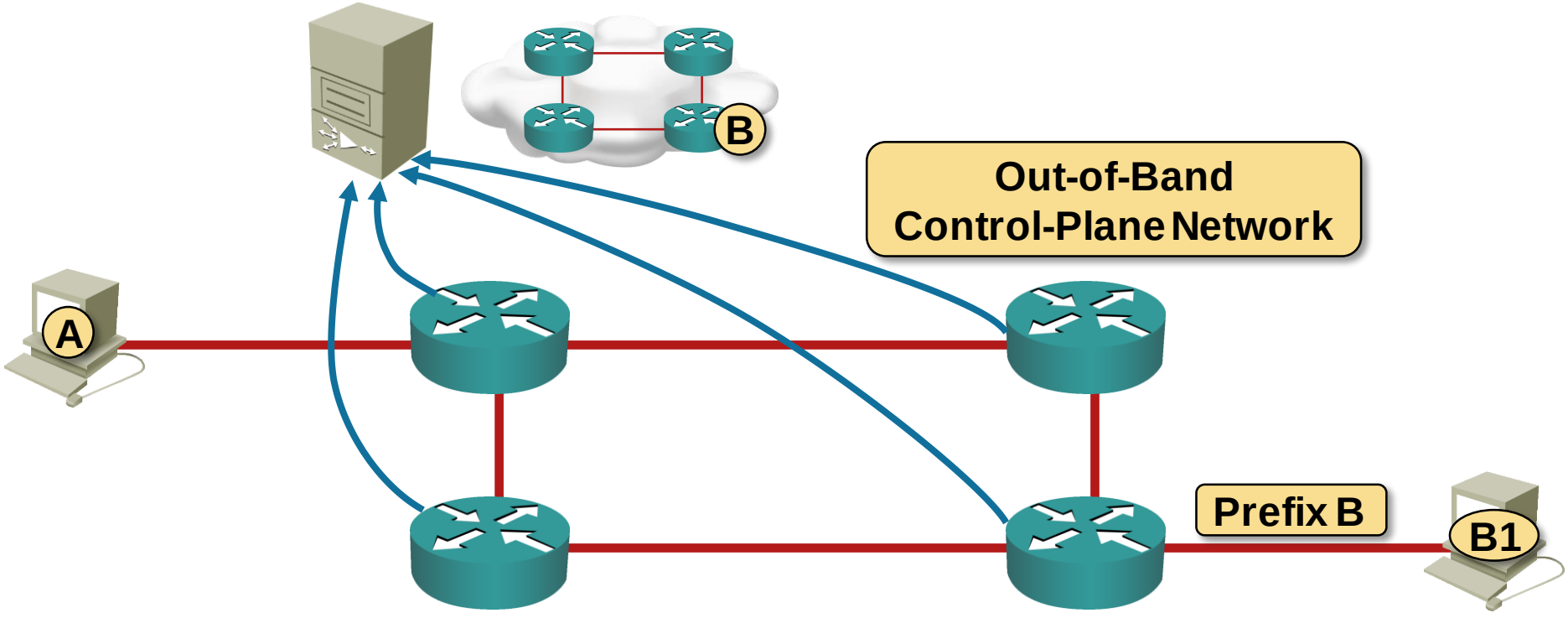

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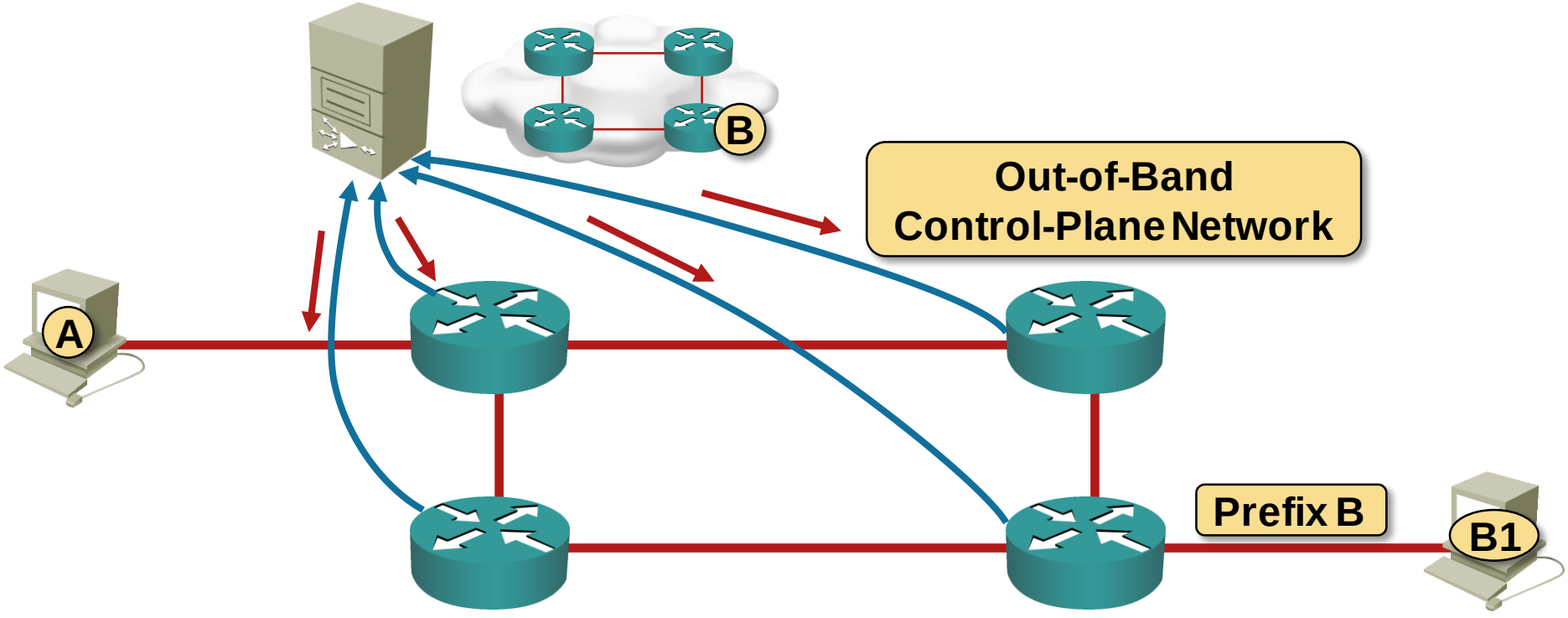

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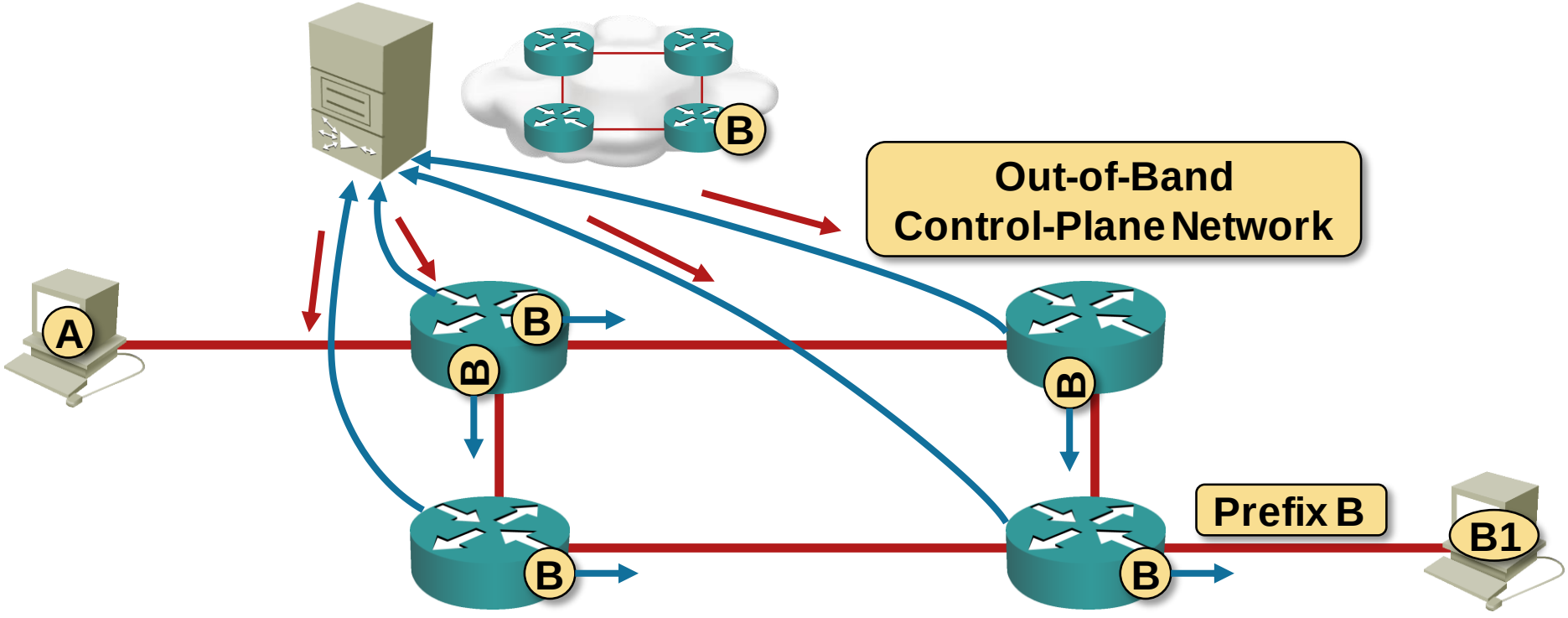

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Review: OpenFlow Protocol Details

Message types:

- Configuration
- Feature requests
- Flow/Port/Table modifications
- Statistics
- Barriers (~ transactions)
- Packet In/Out

Flow classifiers:

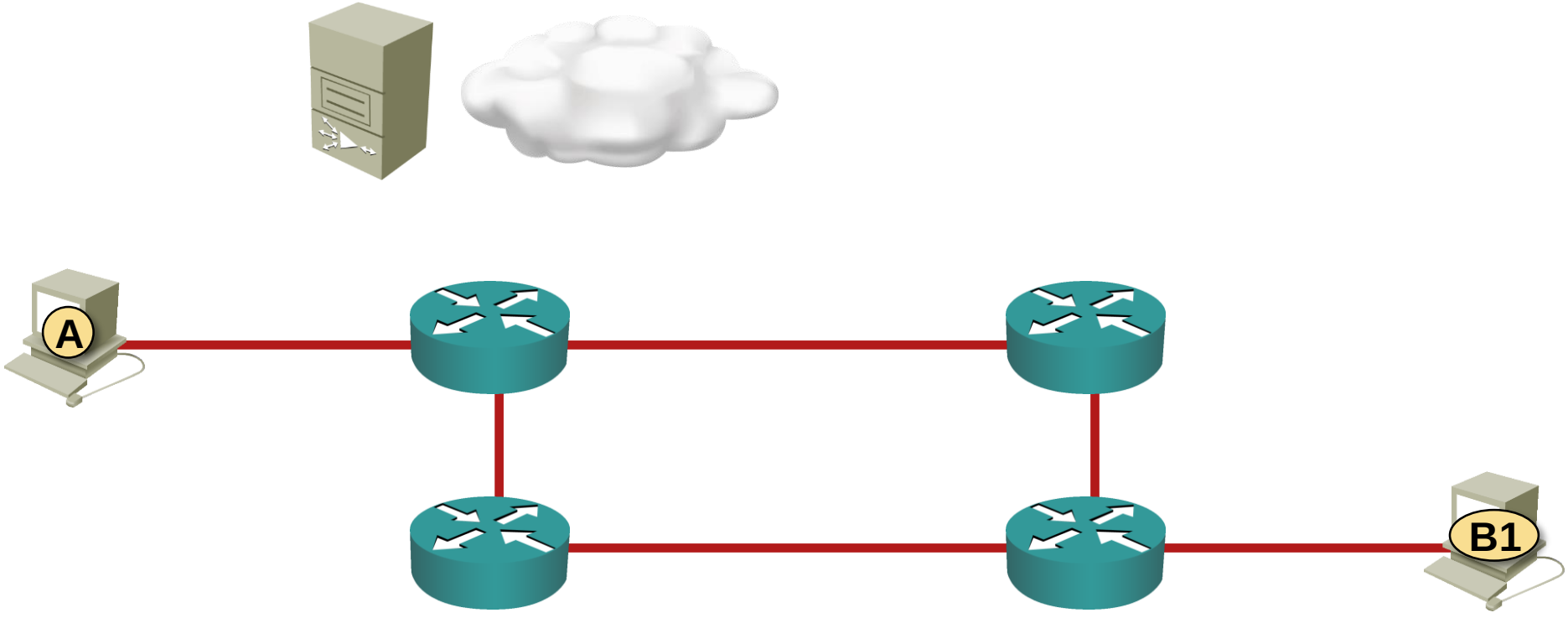
- Any combination of supported packet header fields
- IP and MAC address wildcards
- Other fields (OF 1.2, experimental)
- IPv6 extension headers (OF 1.3)

Flow actions:

- Header rewrites (ex: NAT/SLB)
- Push/pop VLAN/PBB/MPLS tags (OF 1.2)
- Output to a port
- Send to *normal processing*
- Send to controller

Hardware support usually limited to subset of OpenFlow 1.0 with extensions

Case Study: OpenFlow Topology Discovery



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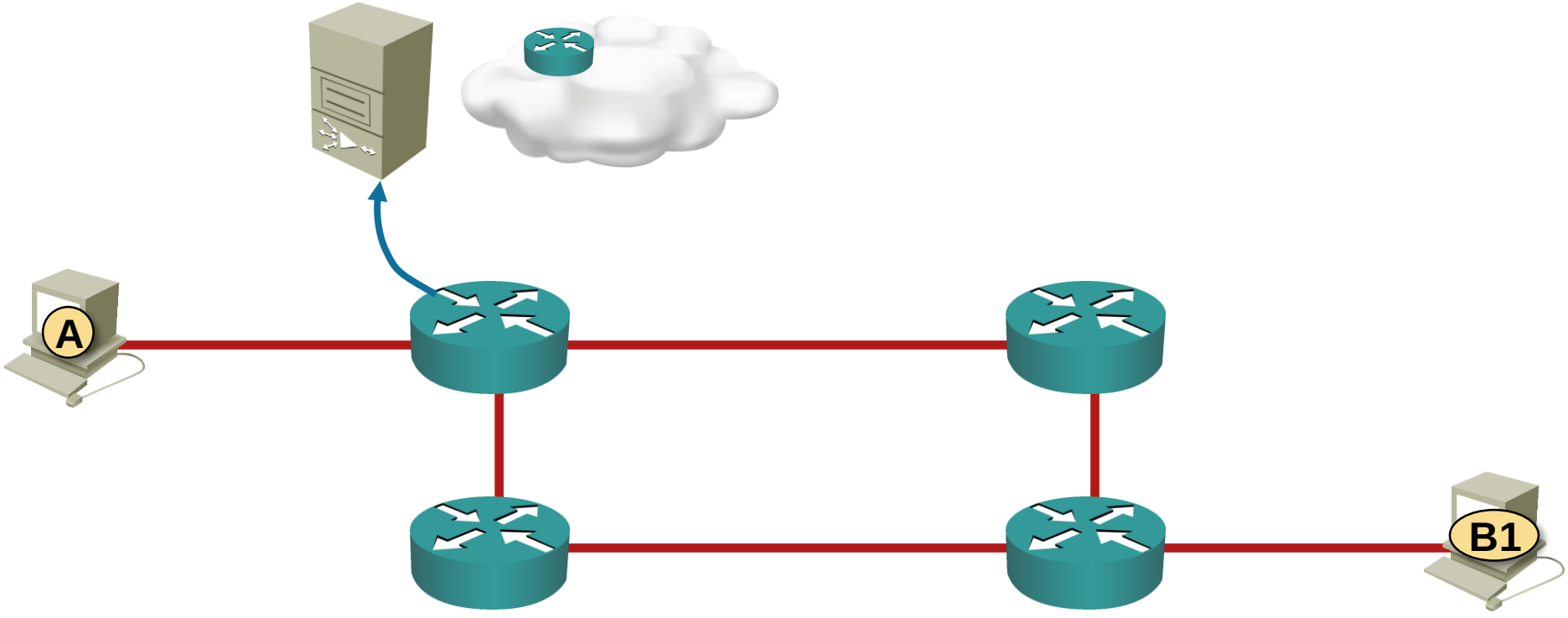

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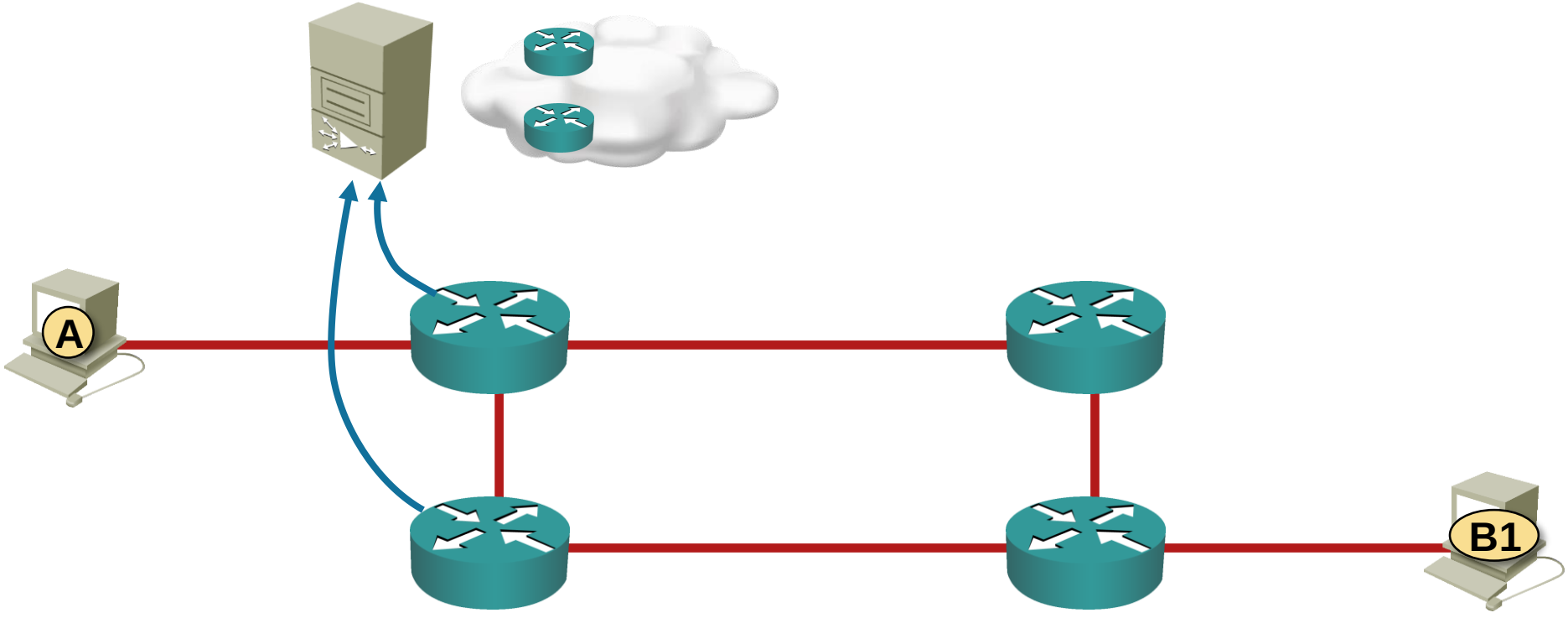

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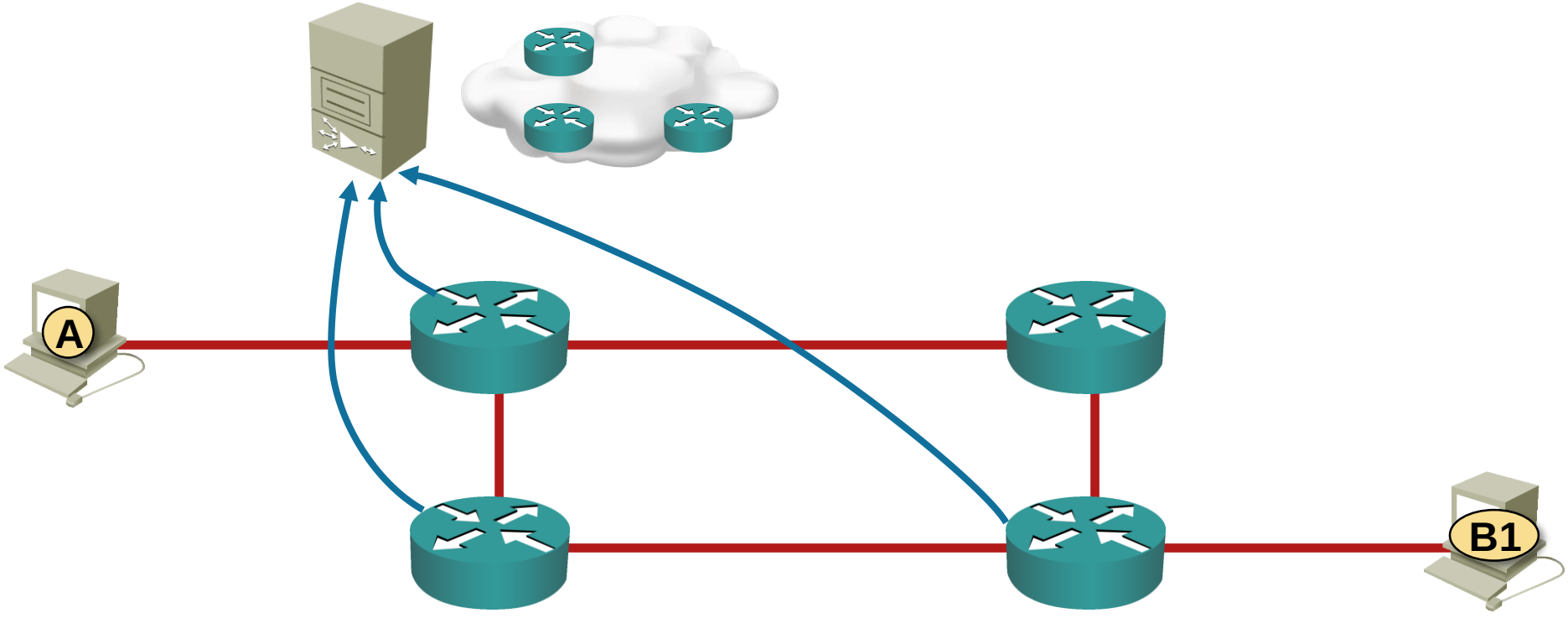

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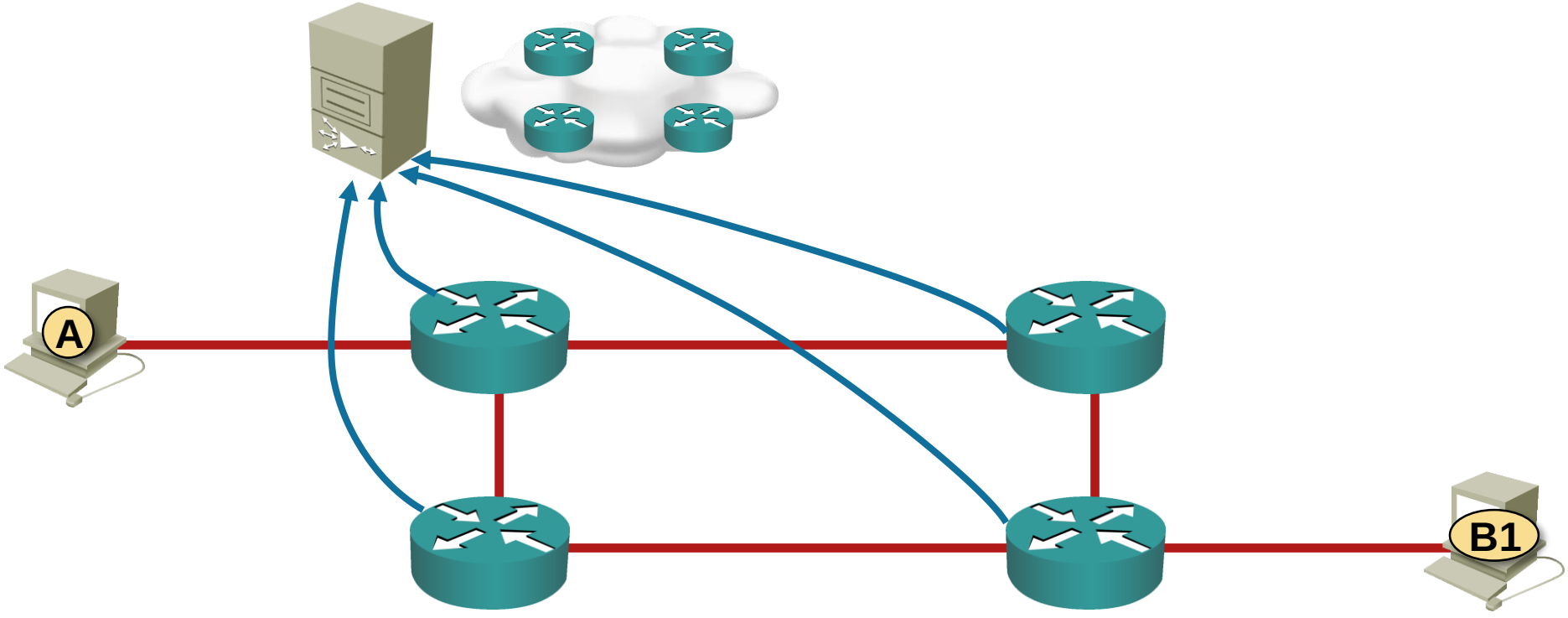

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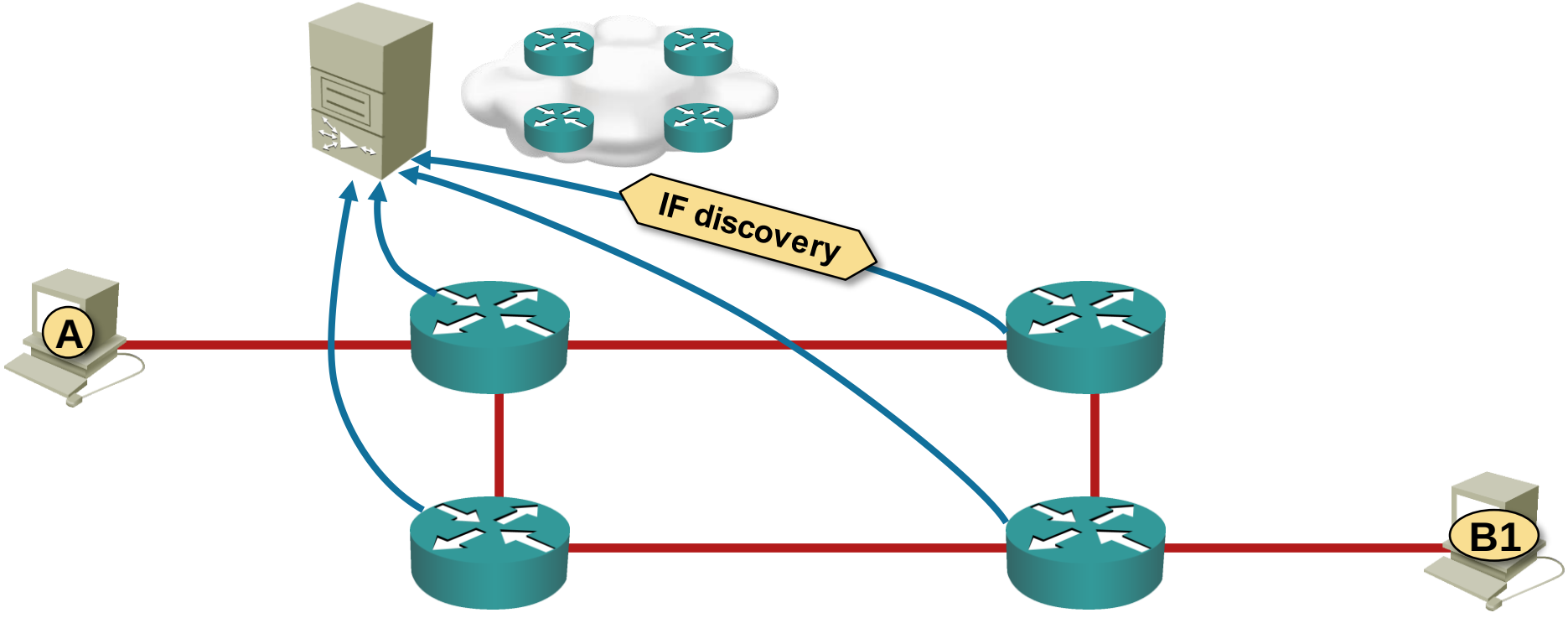

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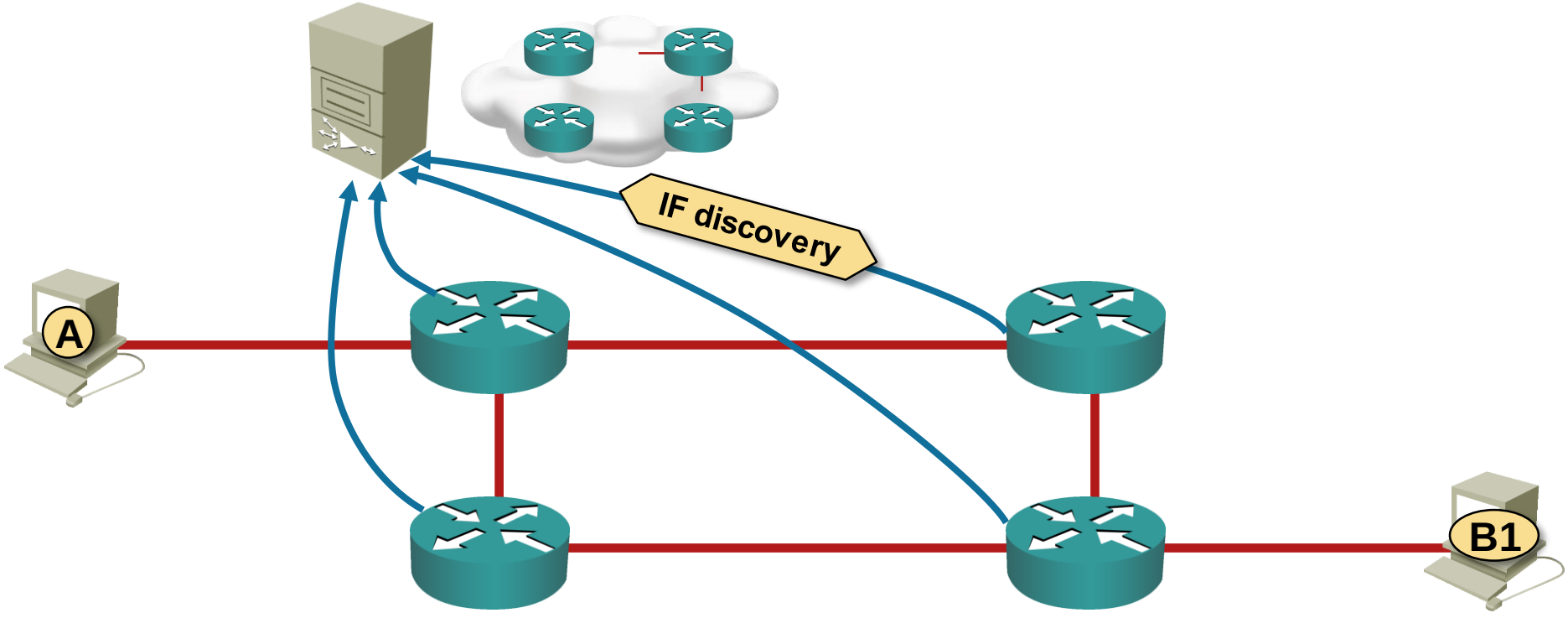

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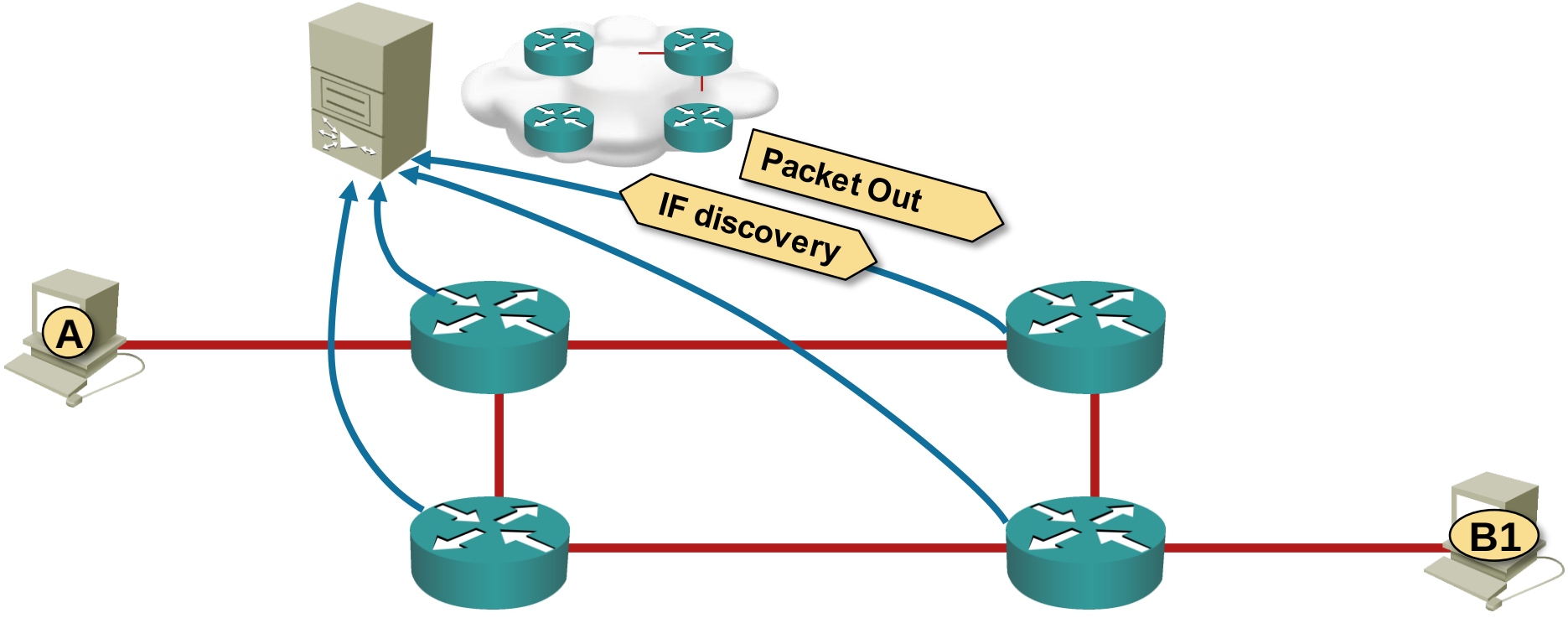

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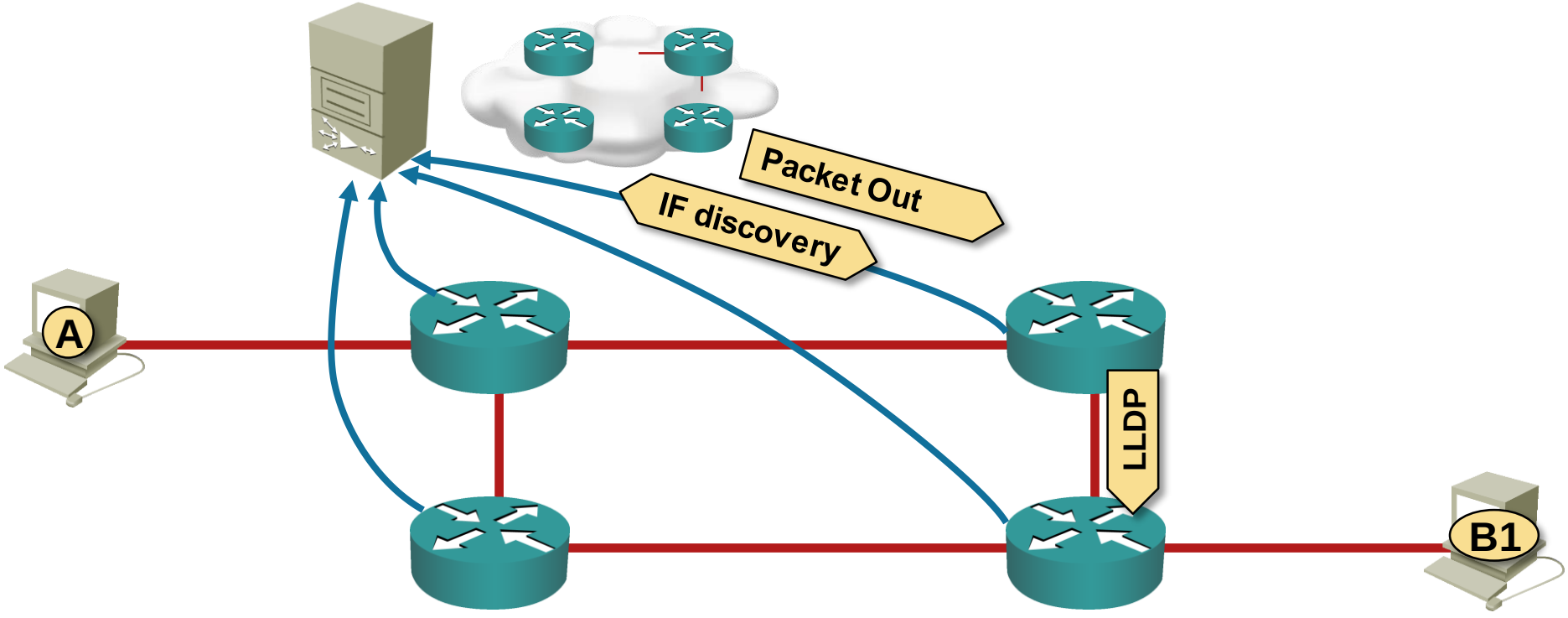

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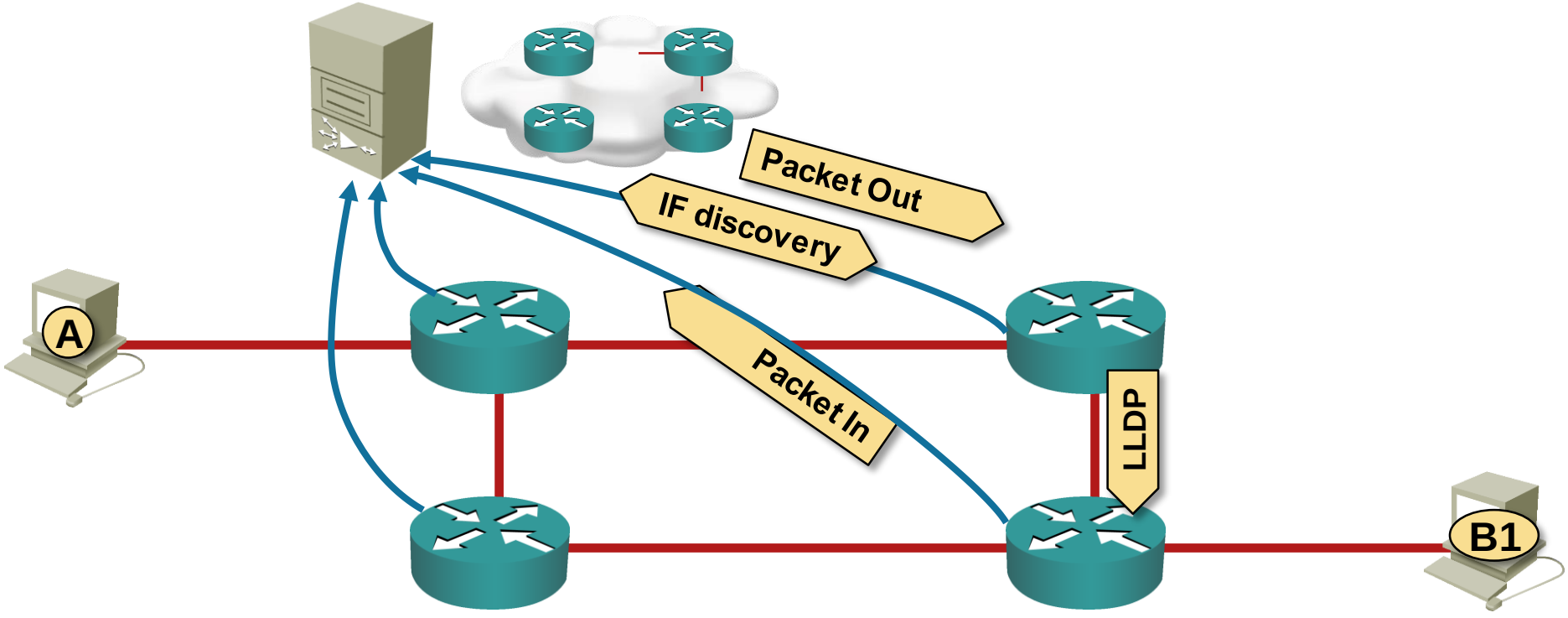

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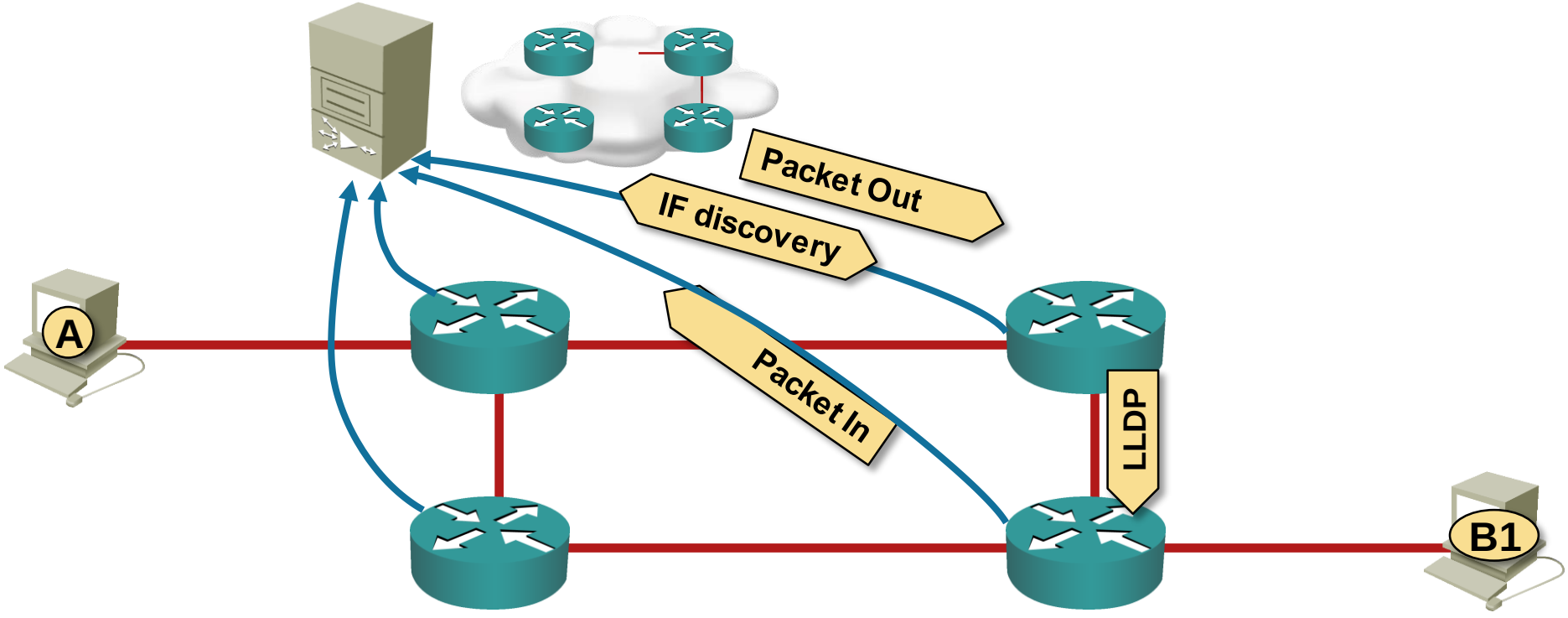

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It's a Déjà-Vu All Over Again (RFC 1925, sect 2.11)

Do you still remember ...

- Frame Relay and ATM networks
- SONET/SDH
- ForCES
- MPLS-TP

The problems are always the same:

- Forwarding state abstraction / scalability
- Distributed network resilience with centralized control plane
- Fast feedback loops
- Fast convergence (FRR, PIC)
- Linecard protocols (BFD, LACP, LLDP ...)

The important difference this time: customer pressure

Claim: OpenFlow will obsolete all networking protocols

Routing Protocol Drawbacks

- Loosely coupled
- Eventual consistency
- Destination-only
- Not load-aware
- Resistant to change and control

Does not make much sense. It's better to focus on new edge functionality

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Routing Protocols Benefits

- Reliable
- Proven
- Deterministic
- Self-Healing
- Autonomous
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An SDN/OpenFlow controller must

- Reinvent all the wheels (scalability, resilience, reliability, auto-discovery, fast convergence, fast control loops)
- Provide added value

Does not make much sense. It's better to focus on new edge functionality

OpenFlow Deployment Models

Native OpenFlow

- Works well at the edge (single set of uplinks)
- Too many complications at the core (OOB management, fast failure detection ...)

OpenFlow with vendor-specific extensions

- Link bundling
- Load balancing
- Linecard functionality (LLDP, LACP, BFD ...)
- IPv6, QoS ...

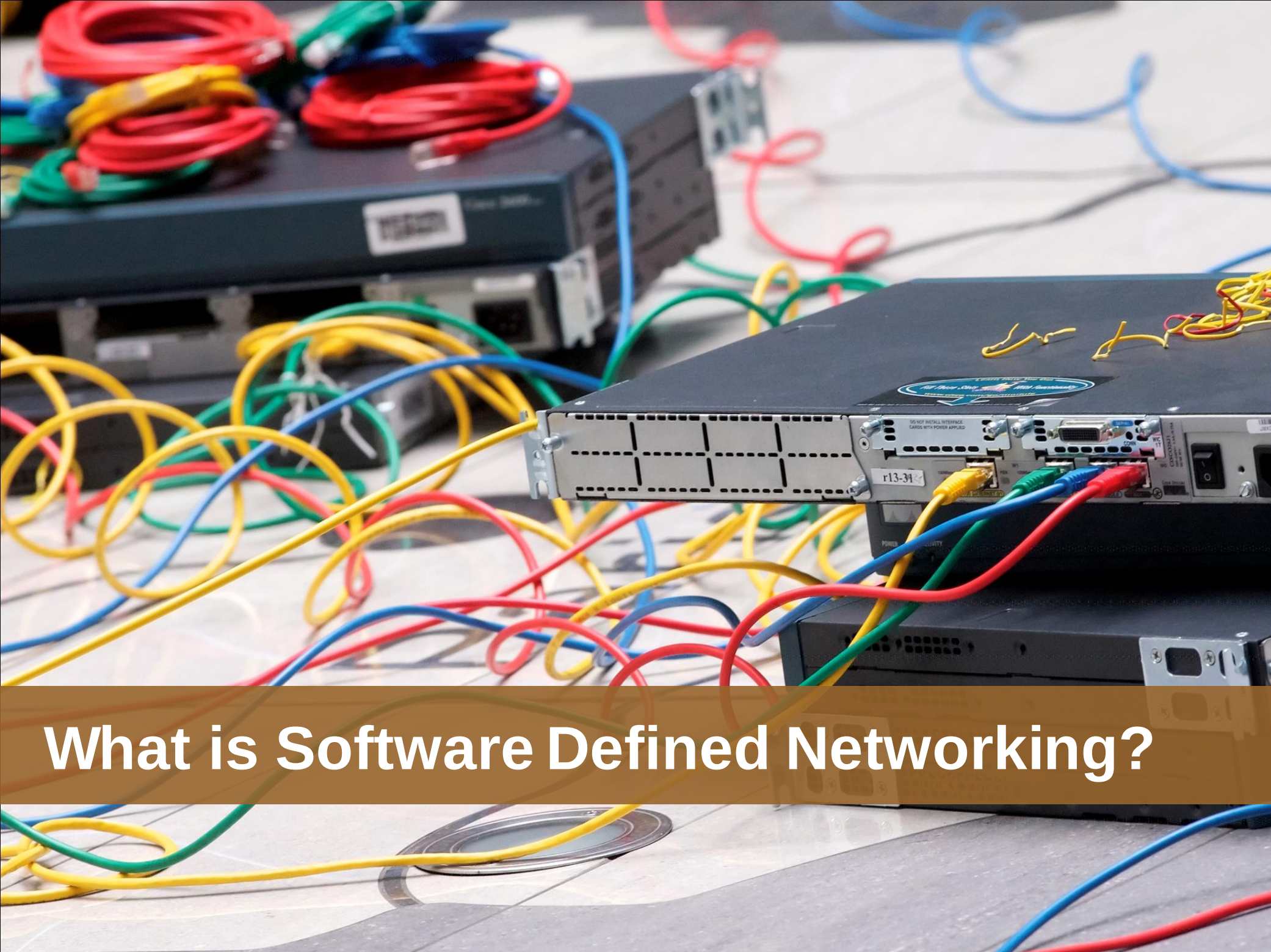
Ships in the night

- OpenFlow in parallel with traditional forwarding
- Some ports / VLANs dedicated to OpenFlow
- Fallback from OpenFlow to *normal*
- Solves OOB management and linecard functionality

Integrated

- OpenFlow classifiers/actions become part of regular packet processing
- OpenFlow provides *ephemeral state* configuration

More @ http://blog.ioshints.info/2011/11/openflow-deployment-models.html



What is Software Defined Networking?

What is SDN?

In the SDN architecture, the control and data planes are decoupled, network intelligence and state are logically centralized, and the underlying network infrastructure is abstracted from the applications.

Open Networking Foundation white paper

Let's call whatever we can ship today SDN

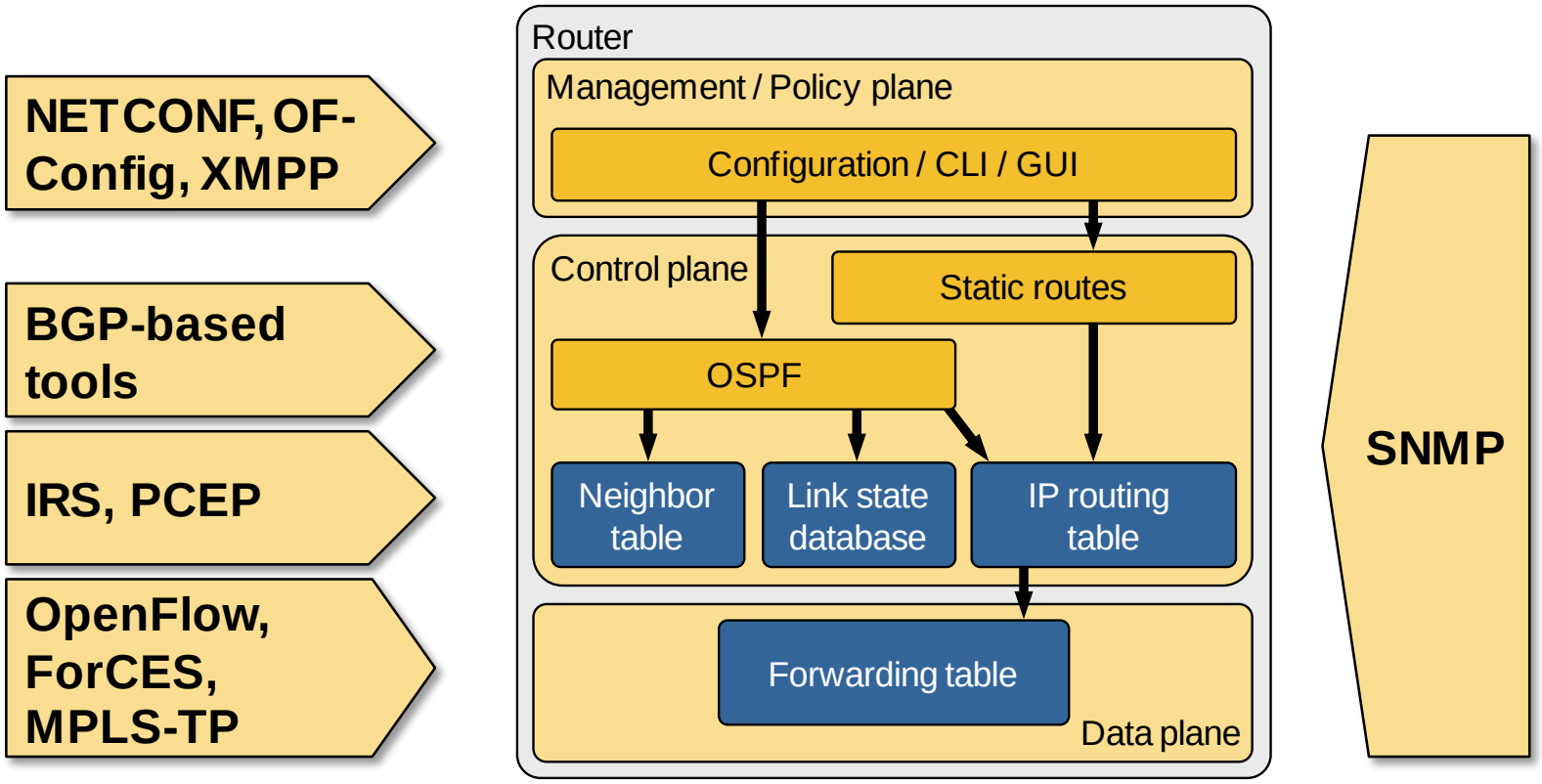
Vendor X

SDN is the magic buzzword that will bring us VC funding

Startup Y

Dear vendor, an API does not SDN make

OpenFlow Is Not the Only SDN Tool



- Vendor APIs: Cisco, Juniper
- Scripting: Cisco, Juniper, Arista, Dell, F5 ...

SDN Advantages / Perfect Use Cases

Solving hard problems that require centralized view or synchronization

Things we do well:

- Destination-only hop-by-hop L3 forwarding

Things we don't do so well:

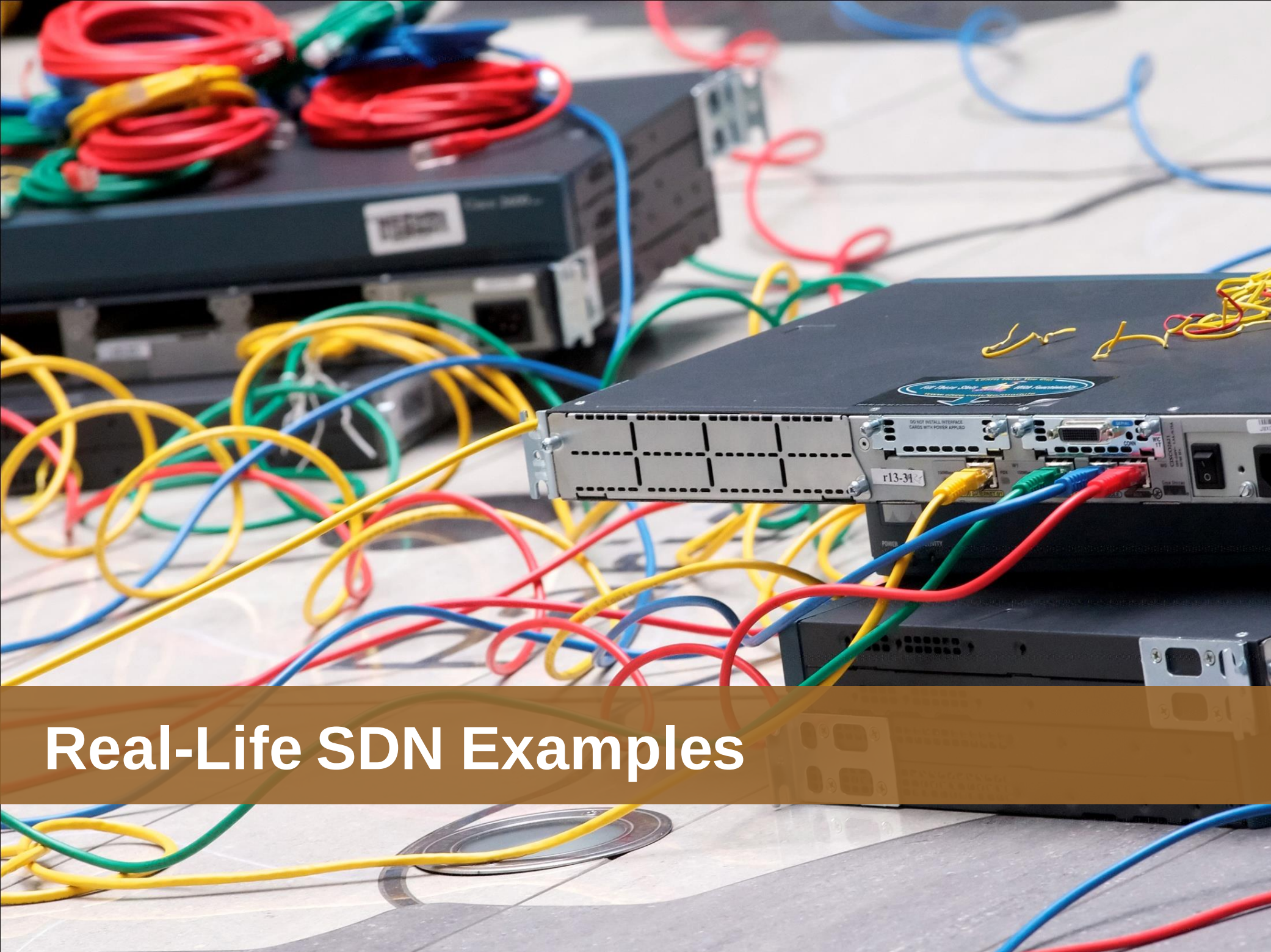
- Layer-2 forwarding (spanning tree limitations)
- Optimal traffic engineering (MPLS-TE) – the knapsack problem
- Routing of elephant flows

Things we don't do at all:

- Synchronized distributed policies (security, QoS ...)
- QoS- or load-based forwarding adaptations
- L3/L4-based or source+destination-based forwarding (policy-based routing)
- Insertion of security features in the forwarding path

More @ http://blog.ioshints.info/2011/11/openflow-enterprise-use-cases.html , http://networkheresy.wordpress.com/2011/11/17/is-openflowsdn-good-at-forwarding/

Best approach: combine SDN/OpenFlow with traditional mechanisms

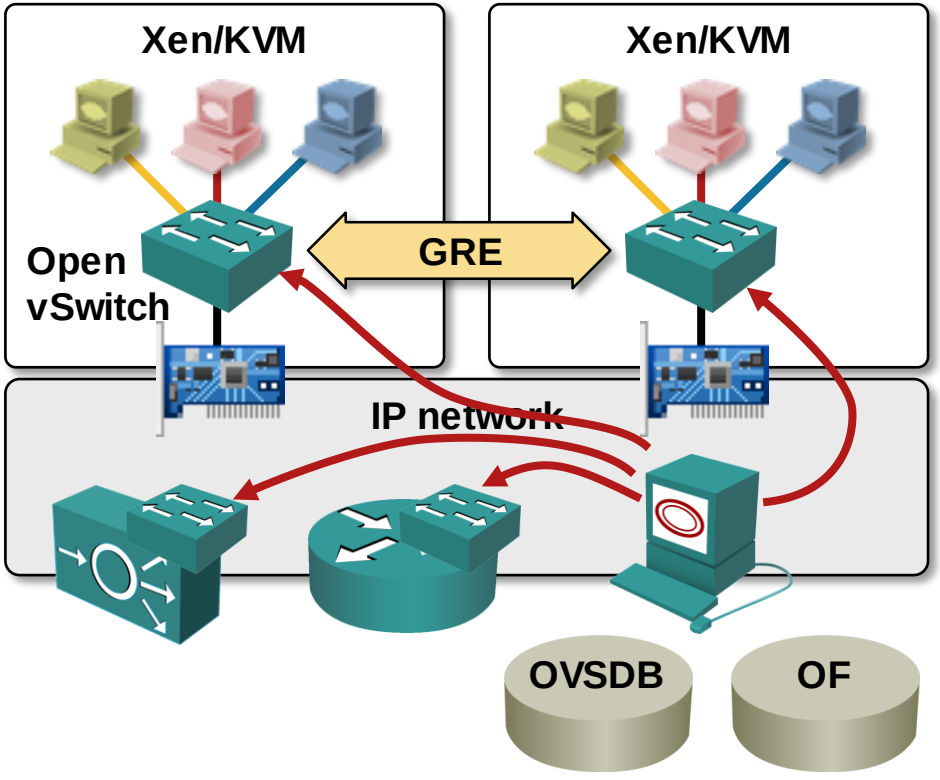


Real-Life SDN Examples

Virtual Networking w/ Central Controller: Nicira NVP

MAC-over-IP with control plane

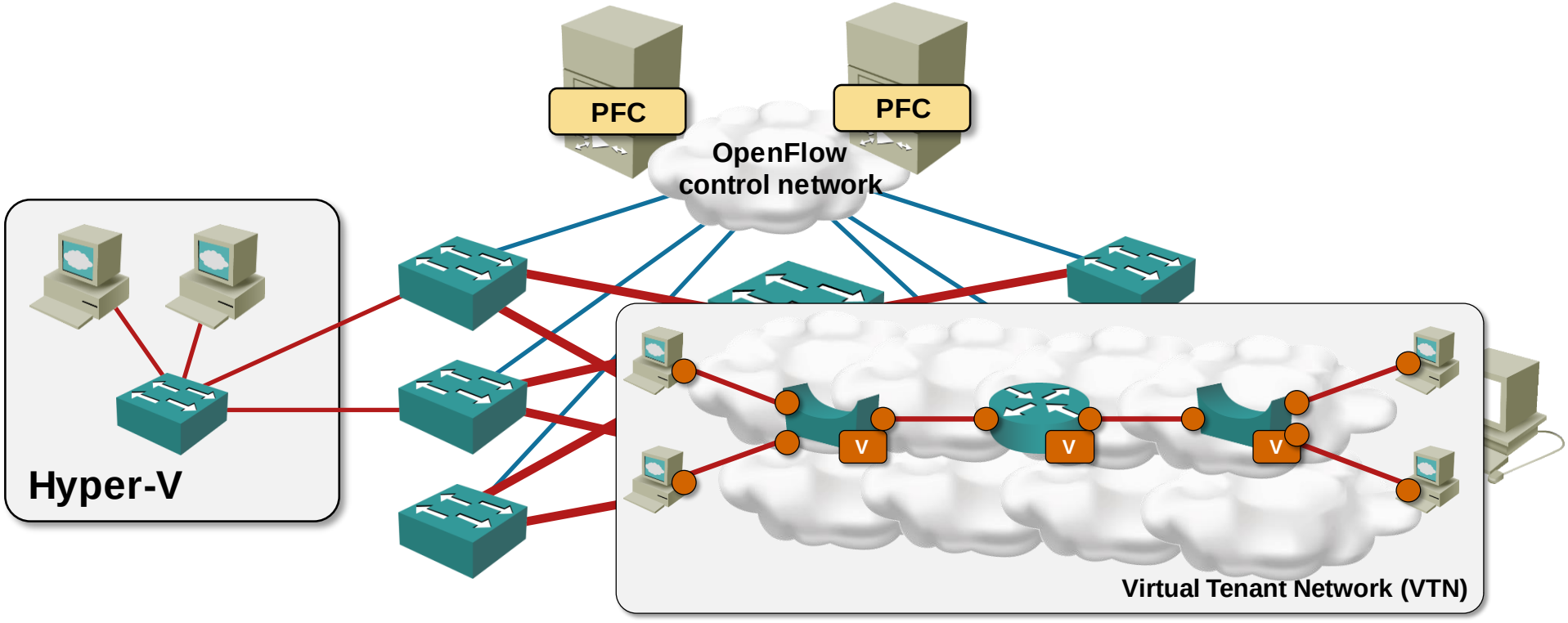
- OpenFlow-capable vSwitches (OVS)
- P2P GRE tunnels provisioned with OVSDB
- MAC-to-IP mapping downloaded to OVS with OpenFlow
- Third-party physical devices with OVS



Benefits

- OpenFlow-based scalable control plane
- No interaction with transport fabric
- No IP multicast in the core

NEC ProgrammableFlow: OpenFlow in Data Center



- Fabric of physical and hypervisor (Hyper-V) switches
- Single control, management and configuration entity
- Virtual bridges, routers, packet filters, traffic redirection and QoS
- Use case: mid-sized virtualized data centers

OpenFlow @ Google

Problem:

- Traffic engineering in inter-DC WAN backbone

Solution

- Custom data center edge switches
- Cluster of OpenFlow controllers in each data center
  ➔ data center edge switches behave like a single node
- BGP and IS-IS between OpenFlow controllers
  ➔ classic routing between data centers
- Centralized traffic engineering application
  ➔ path elements are downloaded into individual controllers

Equivalent to IS-IS + BGP + PCEP

Shipping OpenFlow Products

Switches – Commercial

- Brocade MLX/NetIron products
- Extreme BlackDiamond X8
- HP ProCurve
- IBM BNT G8264
- NEC ProgrammableFlow switches
- Juniper MX-Series (SDK)
- Cisco (roadmapped)
- Smaller vendors

Switches – Open Source

- Open vSwitch (Xen, KVM)
- NetFPGA reference implementation
- OpenWRT
- Mininet (emulation)

Controllers – Commercial

- NEC ProgrammableFlow Controller
- Nicira NVP
- Big Switch Networks (EFT?)
- IBM (shipping?)
- HP (announced)

Controllers – Open Source

- NOX (C++/Python)
- Beacon (Java)
- Floodlight (Java)
- Maestro (Java)
- RouteFlow (NOX, Quagga, ...)
- NodeFlow (JavaScript)
- Trema (Ruby)

More @ http://www.sdncentral.com/shipping-sdn-products/
http://www.sdncentral.com/comprehensive-list-of-open-source-sdn-projects/

Conclusions

- SDN is an interesting concept
- Centralized computation and management plane makes more sense than centralized control plane
- OpenFlow is just a low-level tool
- Initial use cases: large data centers @ portals or cloud providers (cost cutting or virtualized networking)
- Still a very immature technology, standards are rapidly changing
- Northbound controller API is missing (but badly needed) ➔ Creating controller vendor lock-in
- Already crossed the academic ➔ commercial gap

If you want to get involved, NOW is a good time

More Information

OpenFlow standards, tools and projects

- opennetworking.org
- openflow.org
- openflowhub.org

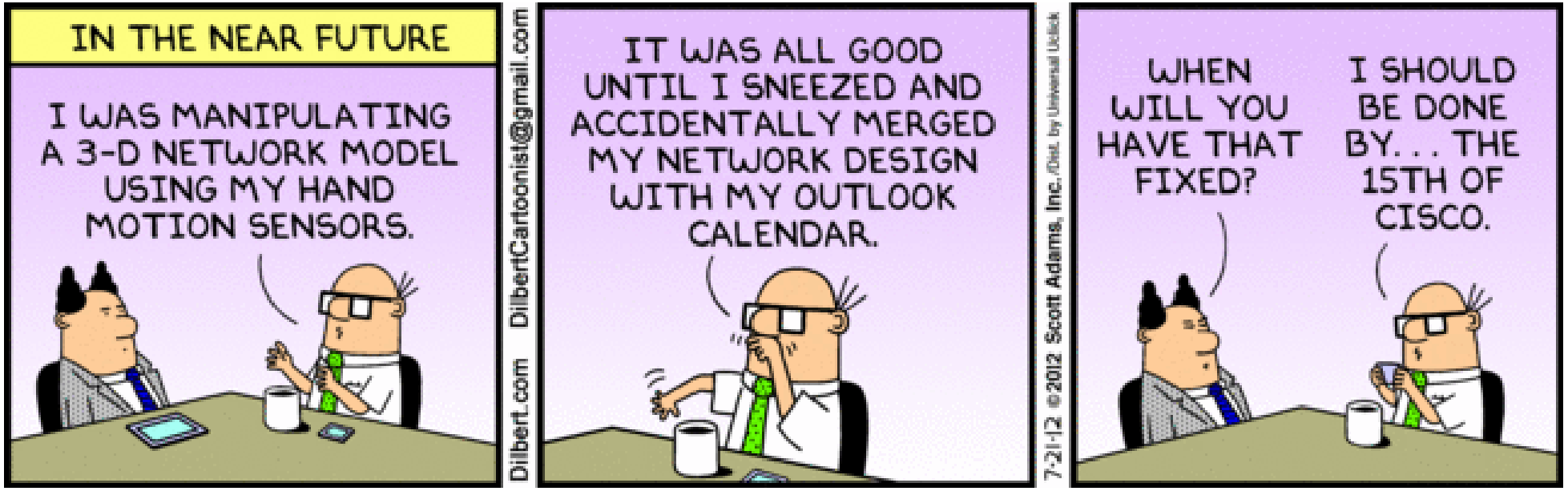
Web sites

- SDN Central (sdncentral.com)
- InCNTRE (Indiana University)

Blogs

- Networkstatic.net (Brent Salisbury, University of Kentucky)
- Networkheresy.com (Martin Casado, Nicira)
- Packet Pushers (packetpushers.net)
- Twilight in the Valley of the Nerds (Brad Casemore)
- blog.ioshints.info (yours truly)
- demo.ipSpace.net/get/OpenFlow (free OpenFlow webinar by Greg Ferro)

A Brief Look into the SDN Future



Source: http://dilbert.com/strips/comic/2012-07-21/

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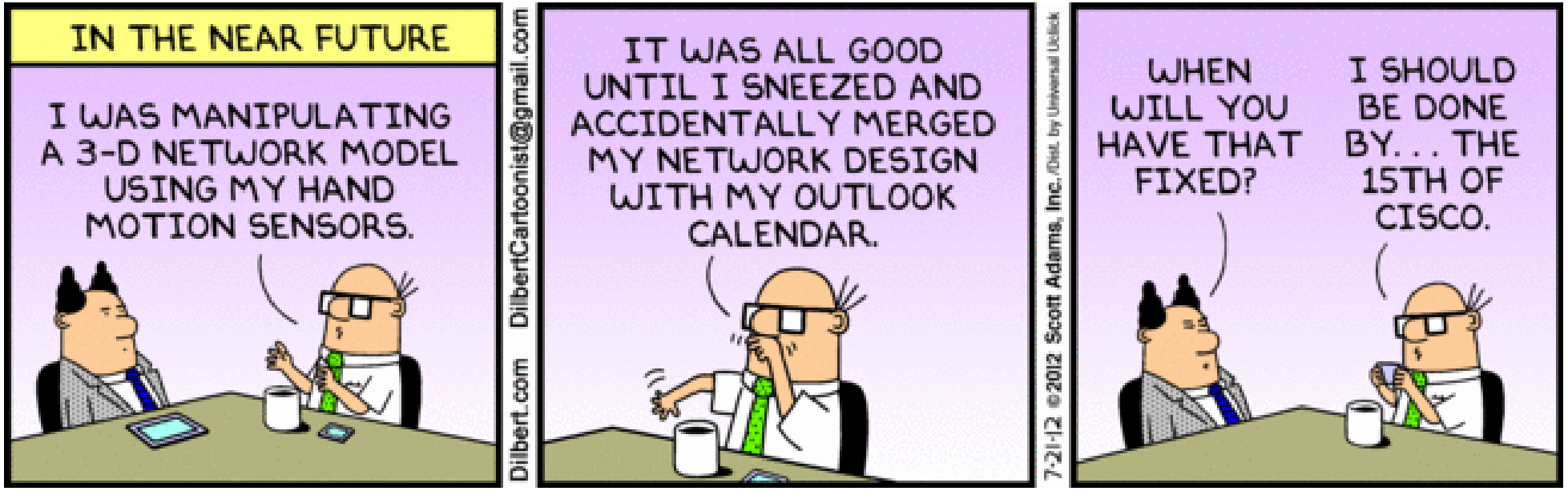

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Send questions to ip@ipSpace.net or @ioshints