Network Myths and Mysteries

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All opinions expressed herein

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- Though I’m sure…independently shared by lots of other people

Network Protocols

- A lot of what we all know…is false!

How networking tends to be taught

- Memorize these RFCs
- Nothing else ever existed
- Except possibly to make snide comments about “other teams”

Things are so confusing

- Comparing technology A vs B
  - Nobody knows both of them
  - Somebody mumbles some vague marketing thing, and everyone repeats it
  - Both A and B are moving targets

How I wish we'd compare

- Isolate conceptual pieces
- Ignore "which team"

Orthogonal ways networks can differ

- What information is in a packet
- Who computes the forwarding table
- Whether forwarding table is always complete, or created on demand when a flow starts
- Whether switch can choose among multiple next hops
- How to translate from layer 3 to layer 2 address
- …

What does a switch do?

- Forward based on:
  - Info in packet
    - Destination address
    - If need to keep things in order, other stuff in packet (e.g., TCP ports, flow ID, entropy field)
  - Forwarding table lookup
    - Destination: ➔ single port
    - Destination: ➔ {ports}
    - “Flow”: ➔ single port

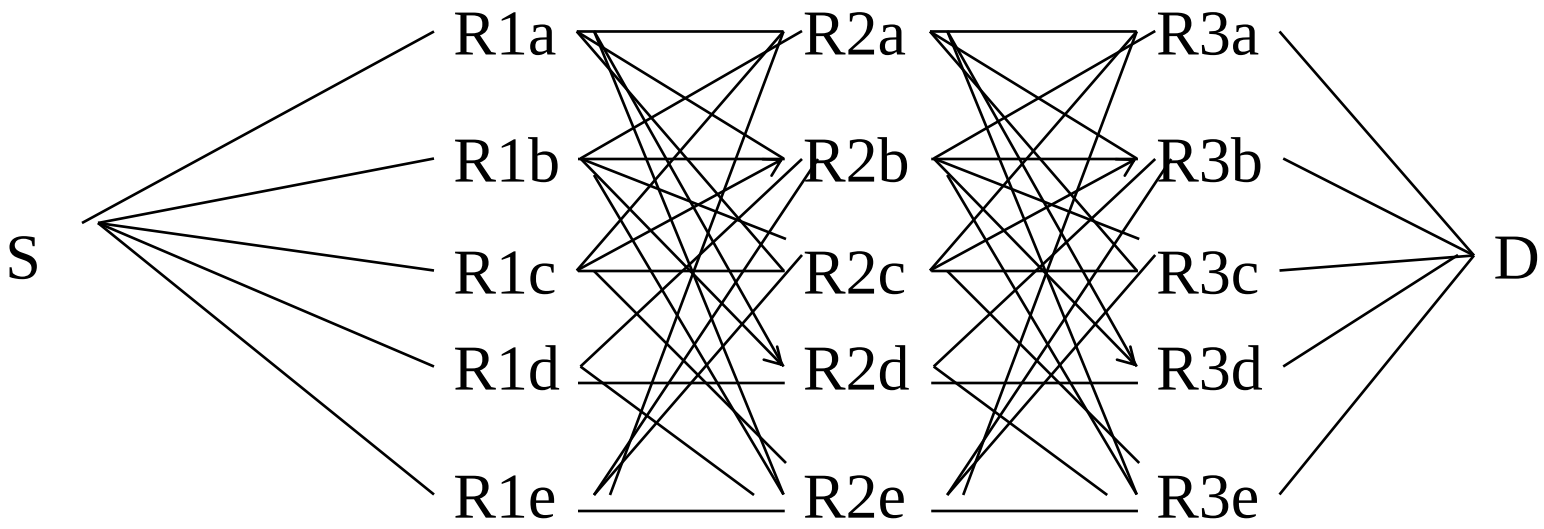
Different types of Destination Lookup

- Direct lookup: simple and fast. Only possible if small enough address that table is not too large
- Hash (like Ethernet)
- Longest Prefix match (like IP)

Thoughts

- Flow-based vs destination-based
  - Only way to make flow-based not totally explode the forwarding table is to create entry when flow starts (incur latency)
  - Switch in better position to load-split traffic than central fabric manager
  - If switch has to keep packets of a flow in order, switch can look at TCP ports, etc., or have “entropy” field in header
  - Switch can do new hash to adjust traffic

Exploiting parallel paths



Completely orthogonal concept

Where does forwarding table come from?

- Distributed algorithm
- Central fabric manager
- Neither concept new…and completely orthogonal to “data plane”
- Concept of separation of control plane from data plane not new…

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- I think distributed algorithm is superior, because it can react to topology changes more quickly

Where does forwarding table come from?

- Distributed algorithm
- Central fabric manager
- Neither concept new…and completely orthogonal to “data plane”
- Distributed algorithm isn’t what makes switches expensive

Also orthogonal: Fancy extra features

What kinds of features are in DC switches?

- Security features (firewalls, intrusion detection/protection, IPsec, SSL session termination)
- NAT (and other stateful features)
- Multipathing
- Traffic engineering/bandwidth guarantees
- Multiprotocol ports: layer 2 and layer 3; IPv4, IPv6
- IP multicast
- Dynamic VLAN registration
- …

When does forwarding table get filled in?

- Proactively
- When a flow starts

Proactively seems better

How do you manage a network?

- From a management console, which translates “ big” commands, such as “forward based on this metric” or “traffic engineer this path” into individual commands to switches

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- Protocols define parameters that are settable, readable, events that trigger alerts

Management commands to switches

- SNMP
- Netconf
- YANG
- OpenFlow

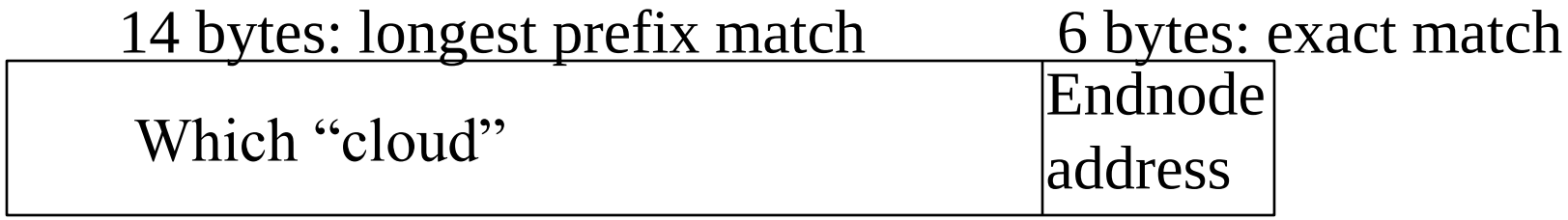
Now, sorting out a few existing things

- IP, Ethernet, TRILL, etc.

A bit of layer 3 history

- ISO's layer 3 (CLNP: ConnectionLess Network Protocol)
- 20 byte address
- Top 14 bytes an entire "cloud"
- Inside cloud
  - No configuration of switches
  - Flat address space (bottom 6 bytes)
  - Endnodes help by announcing to routers where they are
  - Endnodes can move around and keep address

CLNP addresses

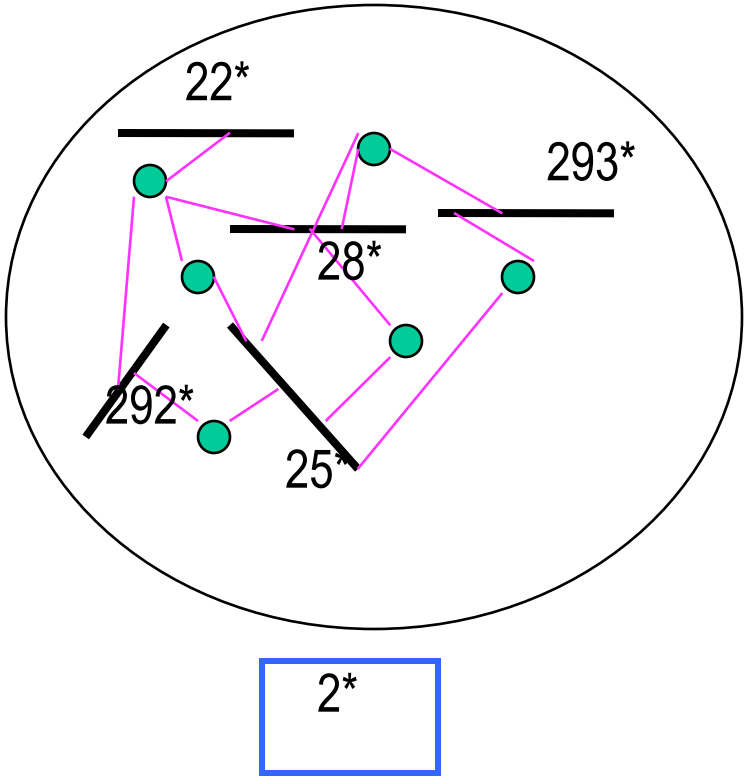


In contrast: IP

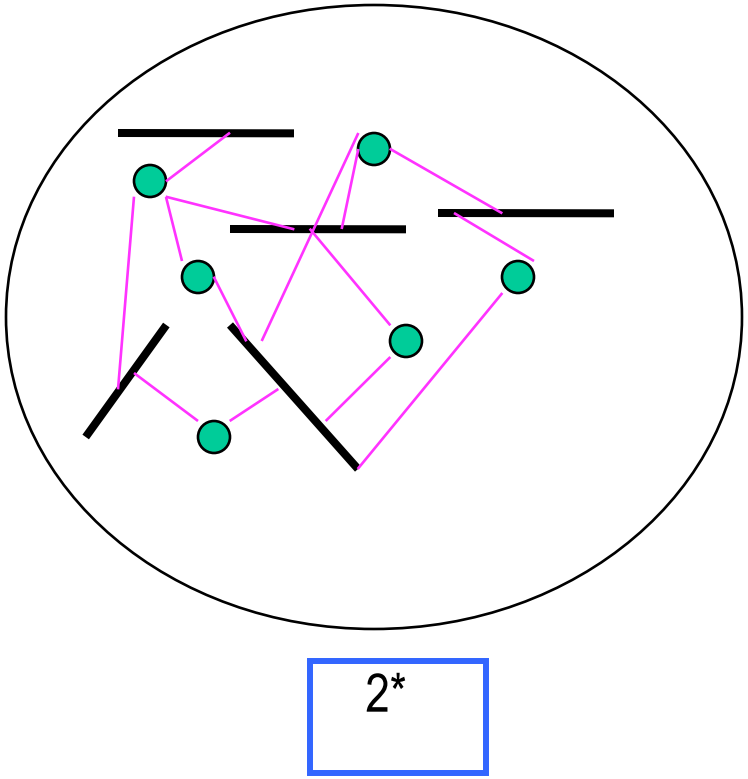
- Every link has its own prefix
- Routers need to be configured
- If node moves, address has to change

Hierarchy

One prefix per link (like IP)



One prefix per campus (like CLNP)



Advantages of CLNP over IP

- No configuration of routers inside a “cloud”
- Flat address within cloud so endnodes can move around within the cloud
- No need for ARP (since cloud address is carried within the layer 3 address)
- Other things…not enough time to go into

Worst decision ever

- 1992…Internet could have adopted CLNP
- Easier to move to a new layer 3 back then
  - Internet smaller
  - Not so mission critical
  - IP hadn't yet (out of necessity) invented DHCP, NAT, so CLNP gave understandable advantages
- CLNP still has advantages over IPv6 (e.g., large multilink routed bottom layer)

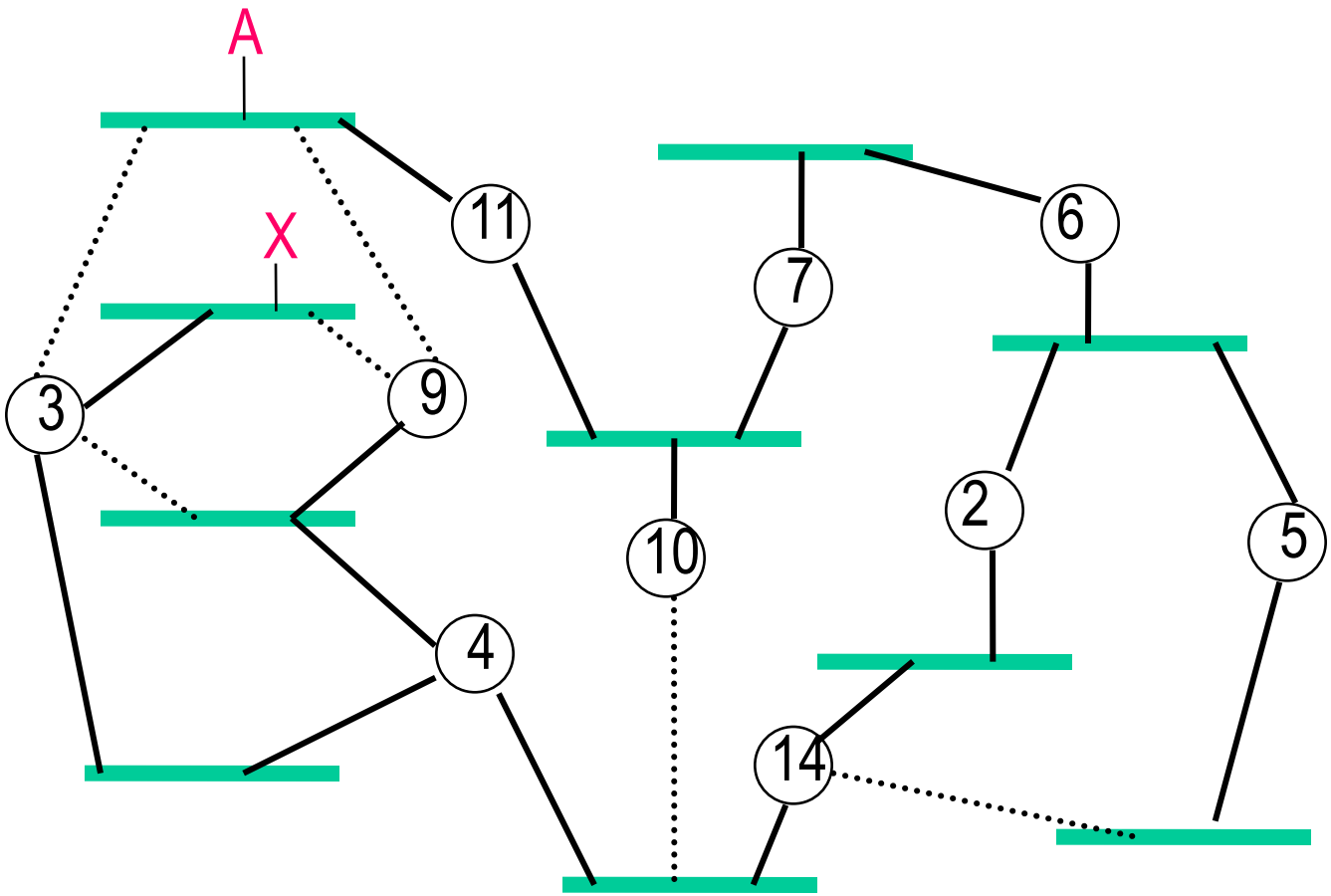
So that's why we are stuck with both Ethernet and IP

- Need "Ethernet" to create a flat cloud at bottom layer for IP
- Original Ethernet CSMA/CD
- But now based on spanning tree

Constraint in 1983 for designing spanning tree (“transparent”) bridge

- No change to Ethernet frame (including adding to length)
- No change to endnode behavior

Spanning Tree doesn't give optimal paths



Then…length restriction ended…

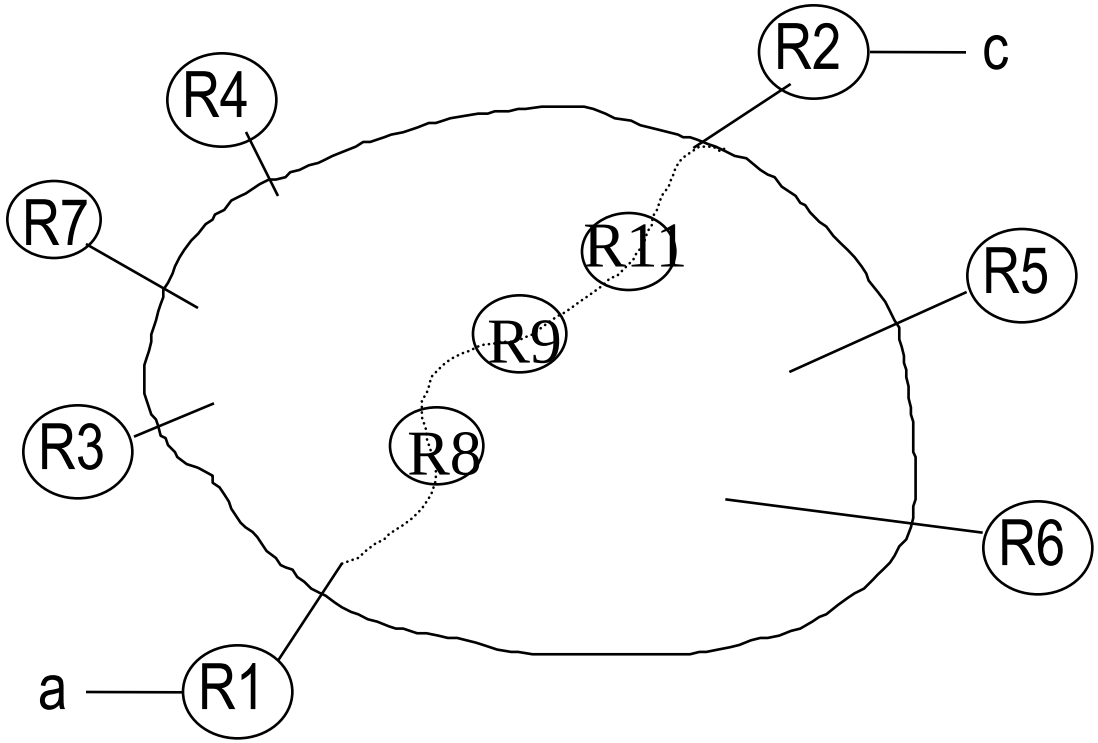
So…TRILL (TRansparent Interconnection of Lots of Links

- Allows clouds with flat address space, optimal routing, and no configuration of switches
- Evolutionary: Can replace any subset of spanning tree bridges with TRILL switches
- First published about 10 years ago
- Been an IETF working group for about 8 years, initial version standardized about 3 years ago

Basic TRILL concept

- TRILL switches find each other (perhaps with bridges in between)
- Calculate paths to other TRILL switches
- First TRILL switch tunnels to last TRILL switch

Basic TRILL concept

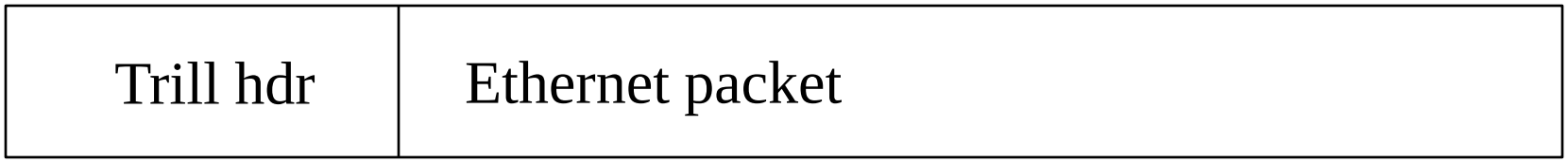


What's in TRILL header?

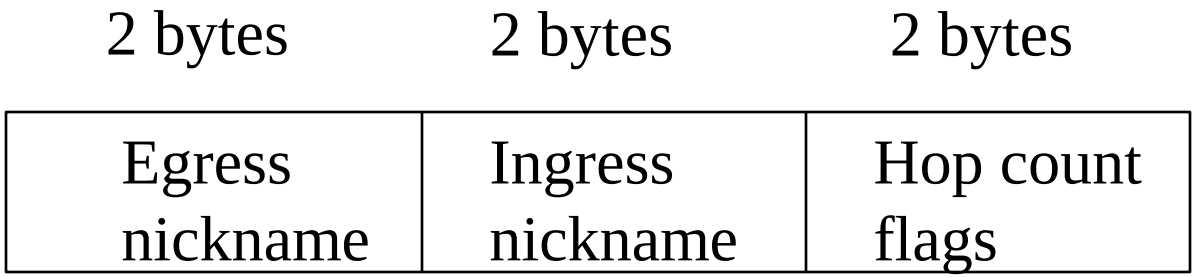
- TRILL switches autoconfigure a 2-byte "nickname"
- So header contains
  - Ingress TRILL switch (2 bytes)
  - Egress TRILL switch (2 bytes)
  - Hop count
  - Flags (e.g., unicast vs multicast)

TRILL-encapsulated Ethernet pkt

6 bytes



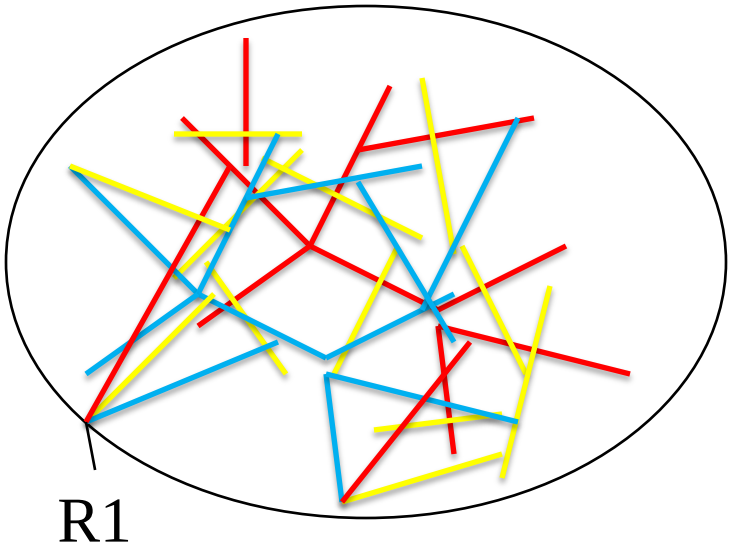
TRILL Header



Unicast vs multicast use of “egress” field in TRILL header

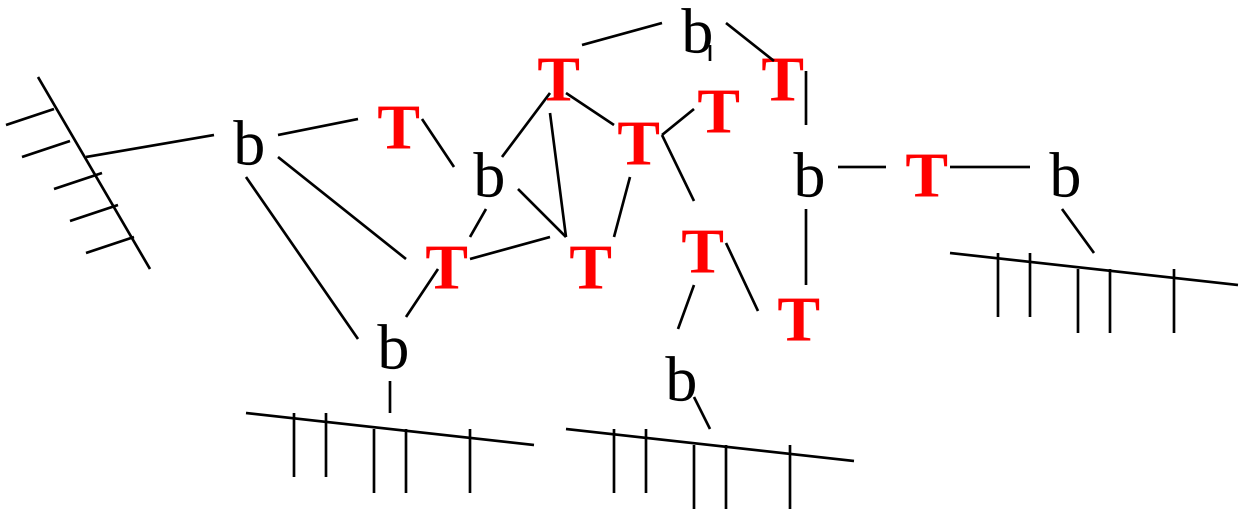
- Unicast: “egress” is last switch
- Multicast: “egress” is “which tree”

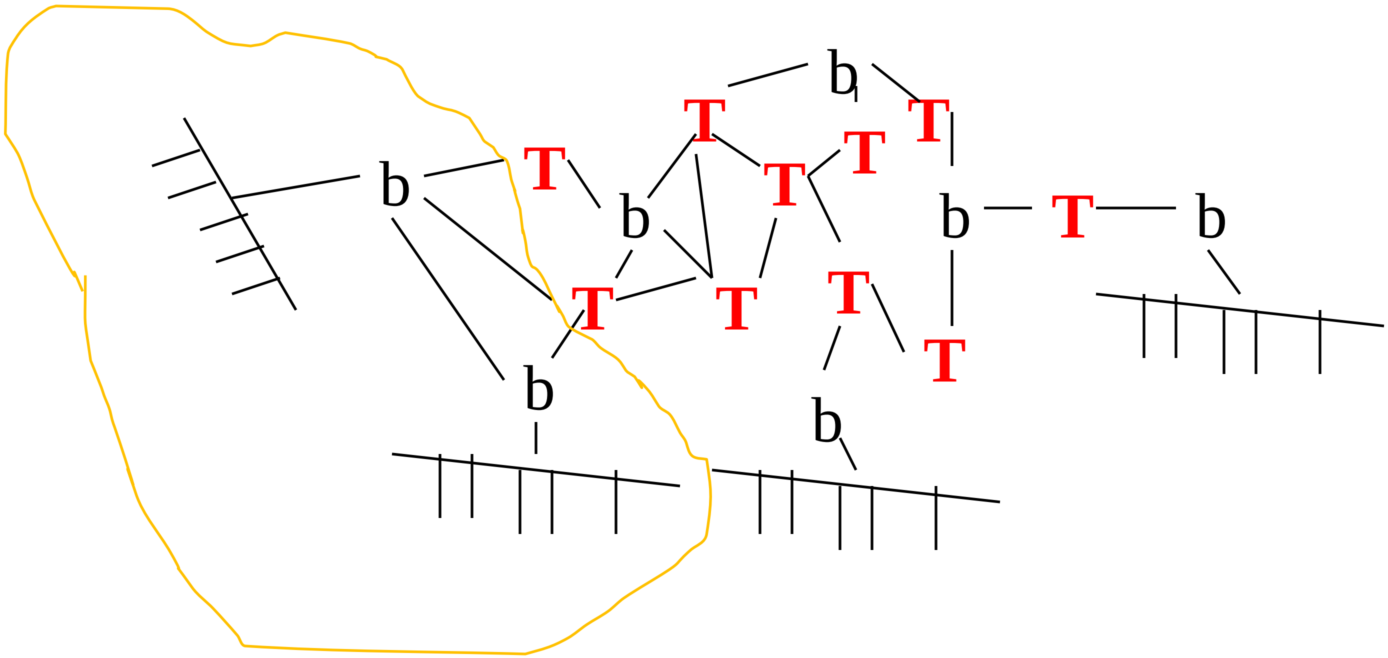
Multiple trees for multicast



R1 specifies which tree (yellow, red, or blue)

TRILL switches find each other, creating network of just TRILL switches

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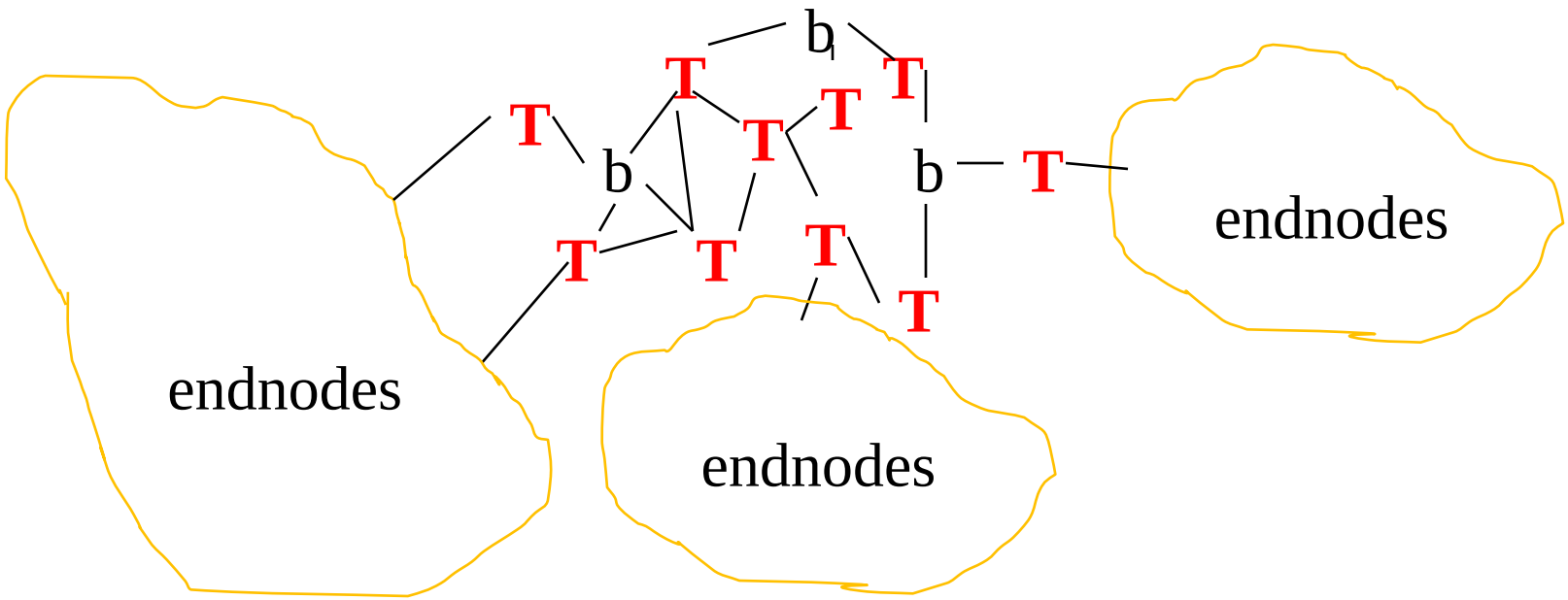
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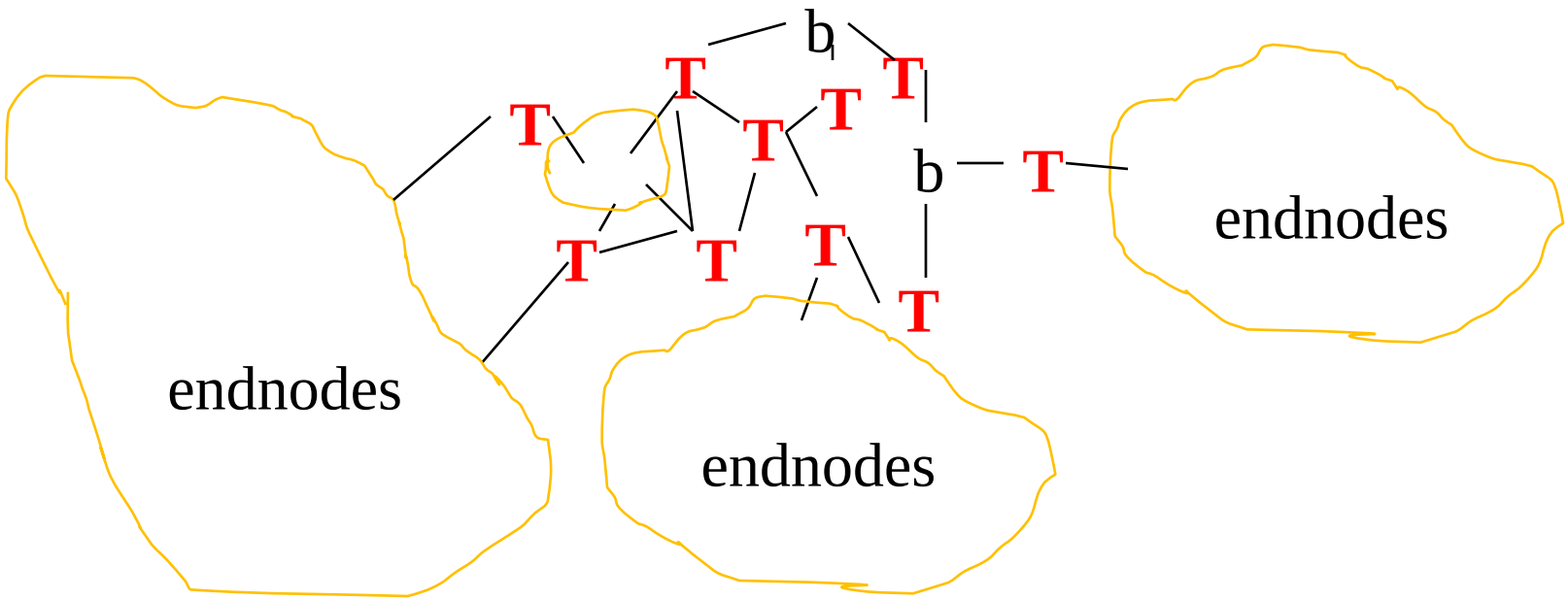
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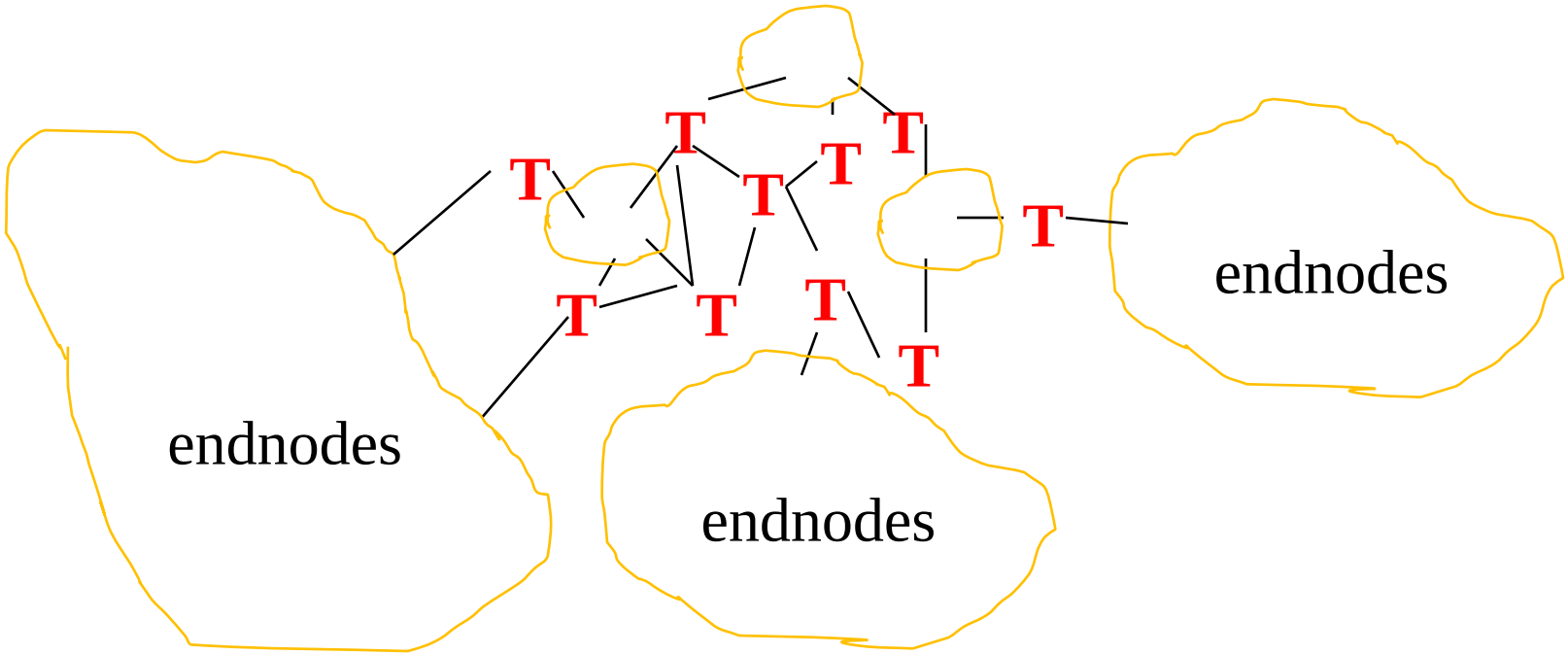
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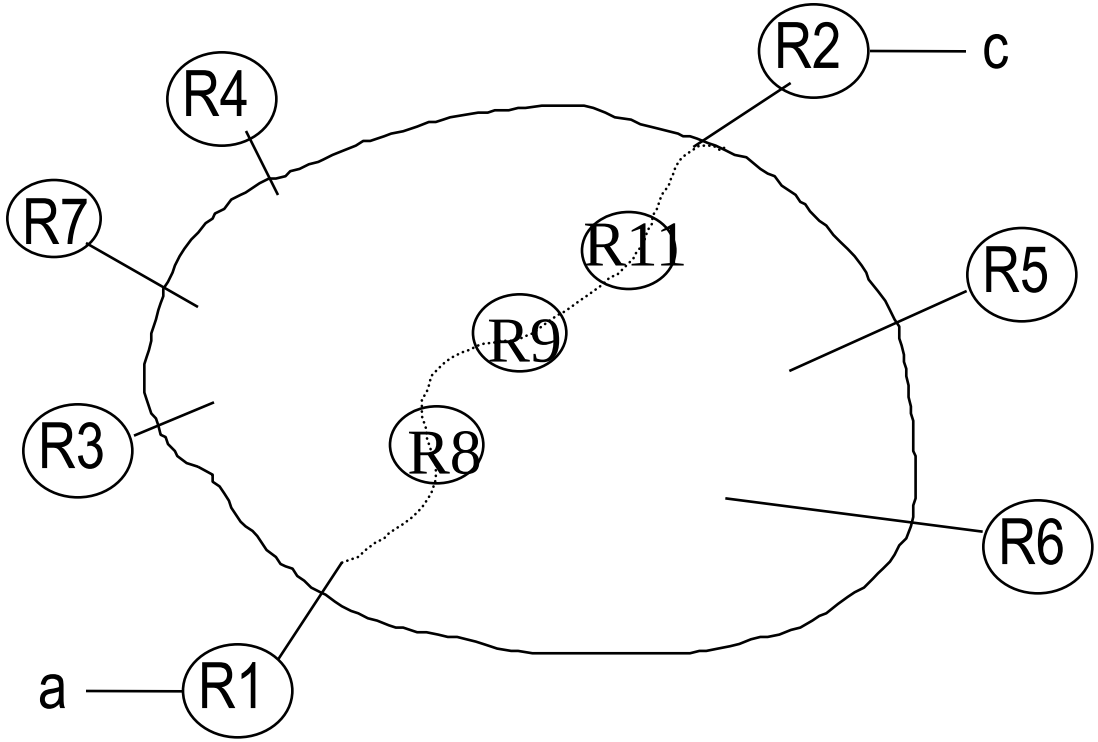
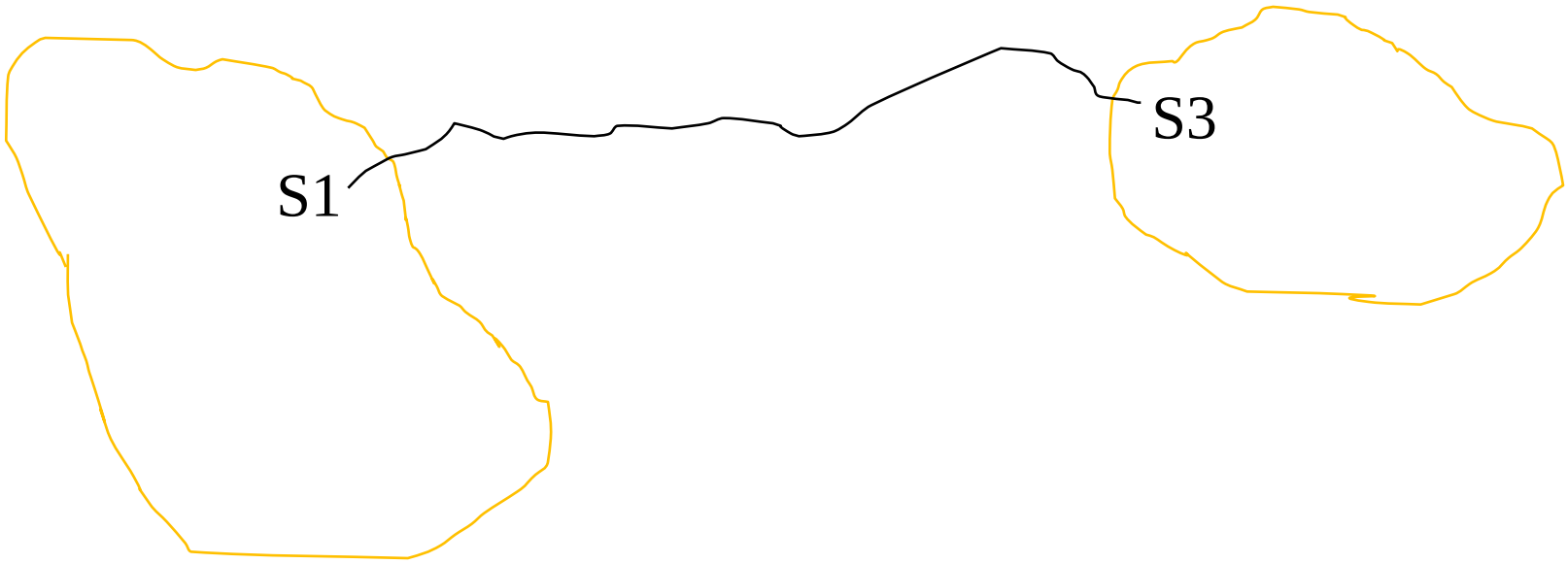
Reason for extra header

- Forwarding table in TRILL switches just size of # of TRILL switches (not # of endnodes)
- Layer 3-like header (hop count)
- Small, easy to look up, addresses (16 bits can be direct lookup rather than prefix match or hash)

Switches inside cloud don't need to know about endnodes



Gluing two clouds together



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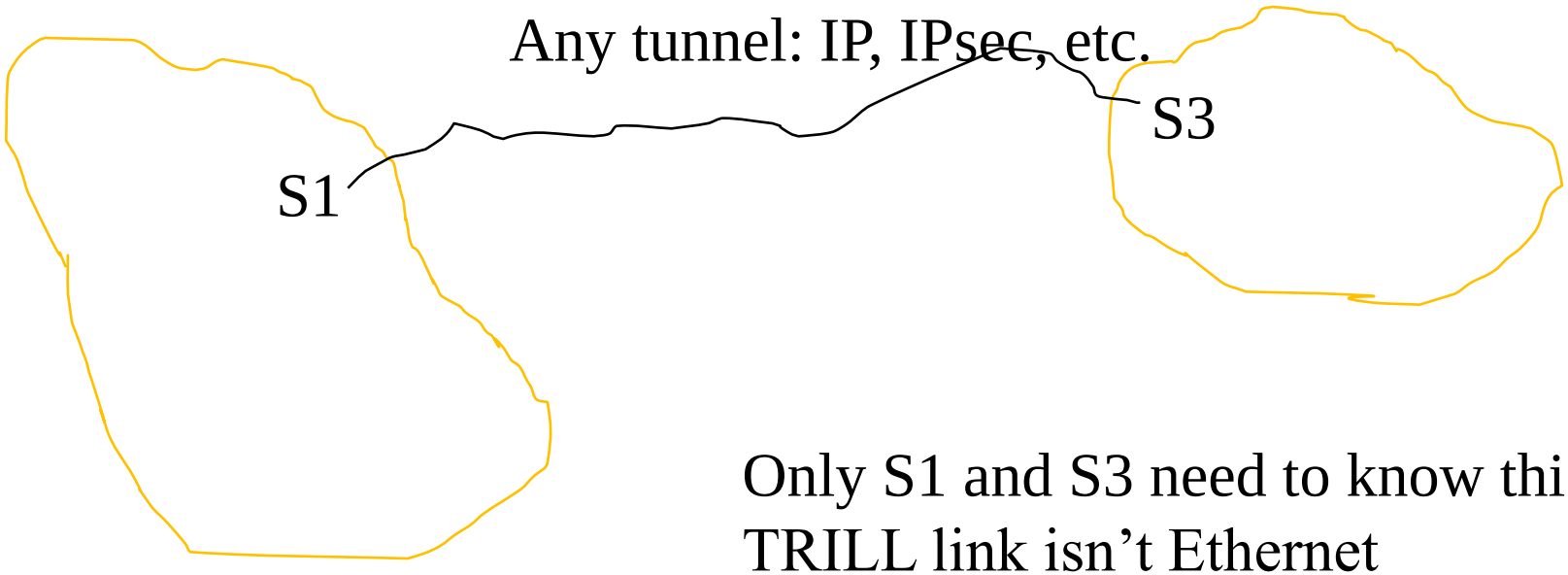

Only S1 and S3 need to know this TRILL link isn't Ethernet

Advantage of CLNP vs IP+TRILL

- No need for ARP: no “layer 2 address”. It’s all part of layer 3

Some advantages of IP+TRILL vs CLNP

- Easier forwarding lookup inside cloud (16 bit nicknames allows direct lookup)
- Smaller forwarding table in switches inside cloud (table size # of switches rather than endnodes)
- Ability to multipath multicast
- VLANs

How does R1 know R2 is “last switch”?

- Orthogonal concept to rest of TRILL
- R1 needs table of (destination MAC, egress switch)
- Various possibilities
  - Edge switch learns when decapsulating data, floods if destination unknown
  - Configuration of edge switches
  - Directory that R1 queries
  - Central fabric manager pushes table

Orthogonal concept

Who encapsulates/decapsulates?

- Could be
  - first switch
  - Or hypervisor
  - Or VM
  - Or application
- Having endnode do it saves work for switch, easier to eliminate stale entries

Recently, a bunch of similar things invented

- NVGRE, VXLAN, …

How to compare

- "Inner" packet based on flat address space
  - IP or Ethernet…
    - IP header bigger, addresses smaller, well-known how to get unique Ethernet addresses without configuring
- "Outer" header location dependent
  - TRILL header small, nickname; simple forwarding lookup

So review some of what I said

- Proactive forwarding table vs incur latency when “flow” starts
- Distributed algorithm vs central fabric manager
- Load split based on fabric manager placing “flows” vs switch choosing among a set of next hops
- TRILL evolutionary, efficient outer header, Ethernet for flat cloud, can glue distant clouds together by having TRILL link which is a tunnel over IP

Questions?