**Presentation at George Mason University**
**Communications and Networking Lab**
**March 12, 2008**

# Myths, Missteps, and Folklore in Network Protocols

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## Why this talk?

- Learn from mistakes
- Understand oddities in today’s protocols
- Counteract “religion” aspect
  - Mark Twain*: “It’s not what you don’t know that’ll get you. It’s what you do know that ain’t true*”
- Be provocative. Start lively discussion
- Pet peeve: teach networking as a science, not like a trade school

## Myths

- Technology that is most successful is the best technically
- Everything in standards makes sense
- If a conference or journal accepts paper A and rejects paper B, that means paper B is not as good as paper A

## Example

- Sometimes you need to know the history in order to understand something

## Topic 1: Bridges, Routers, and Switches, Oh My!

- Myths
  - bridges were designed before routers, because they are/were simpler
  - switches are a technology newer than bridges that make bridges obsolete

## A bit of background

- ISO’s OSI Reference Model, network layers:
  - 1: physical
  - 2: neighbor-to-neighbor
  - 3: talk across multi-hop path
  - 4: end-to-end

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  - 2: neighbor-to-neighbor
  - 3: talk across multi-hop path
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  - 5 and above: boring
- layer 1 relay: repeater
- layer 2 relay: bridge
- layer 3 relay: router

## OK: so what is layer 2?

- If I ran the world
  - no such thing as layer 2 relay
- My discovery of true definition of “a layer 2 protocol”

## OK: so what is layer 2?

- If I ran the world
  - no such thing as layer 2 relay
- My discovery of true definition of “a layer 2 protocol”
  - anything designed by a committee whose charter is to design a layer 2 protocol

## So, where did bridges come from?

## In the beginning...

- There were routers
- I was DECnet routing architect
- Layer 3 requires endnode cooperation
  - put an envelope on the data, with source, destination, hop count, etc
  - Do additional things (e.g., ARP in IP)
  - Have an address that reflects topology

## Then along came the EtherNET

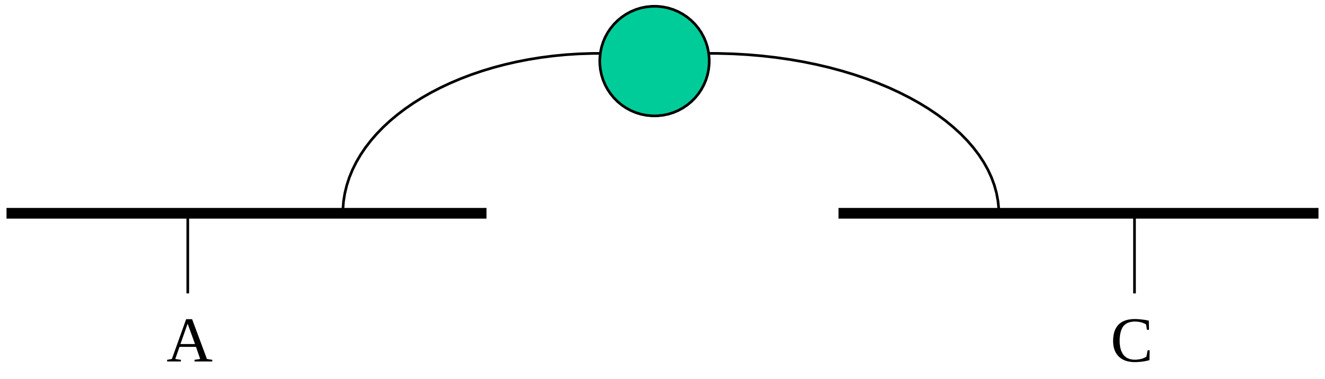
- Fine technology
- But it’s not a network! It’s a link in a network
- Ethernet is multiaccess, so requires envelope with source and destination
- But it’s not a layer 3 protocol, e.g.,
  - addresses have no structure
  - no hop count
  - technology doesn’t scale

## Confusion

- People designed things to work directly on Ethernet. Left out layer 3
- Press got excited about “Which will win? DECnet or Ethernet?”
- Explaining was hopeless

# Problem Statement

*Need something that will sit between two Ethernets, and let a station on one Ethernet talk to another*



## Basic bridge idea

- Listen promiscuously
- Learn location of source
- forward based on learned location of destination

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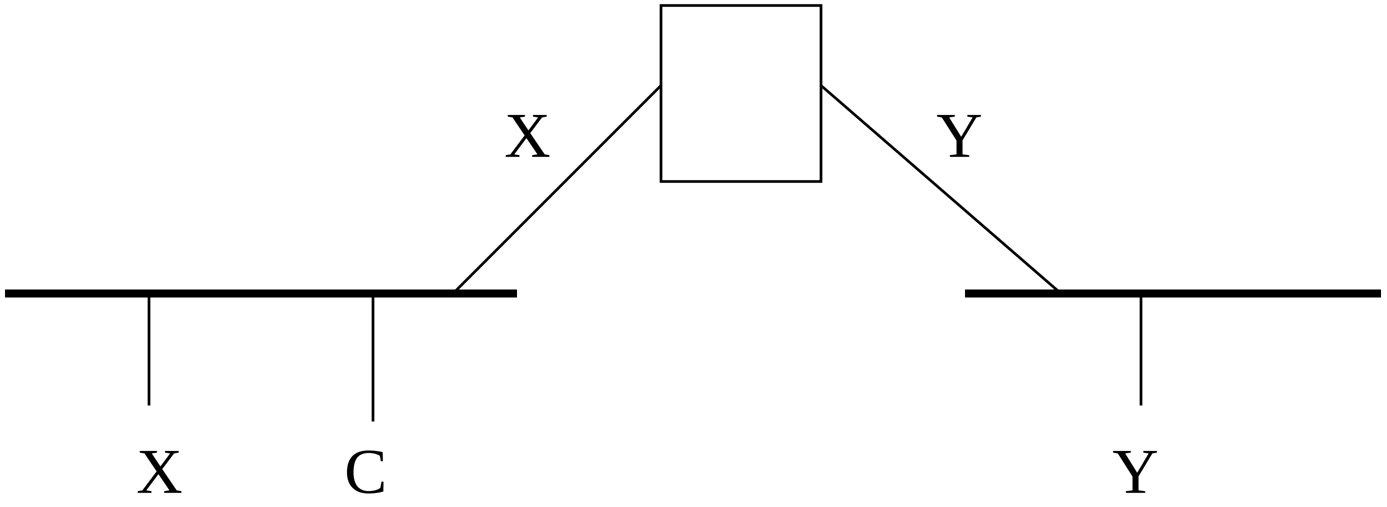
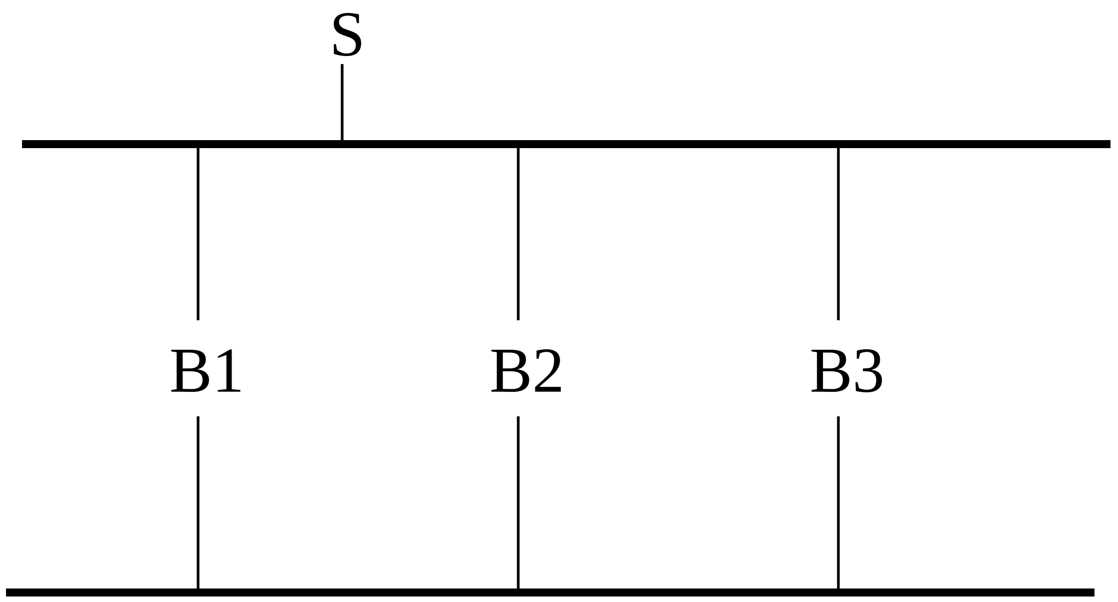


## Need loop-free topology

- Can’t learn location of source if it’s in multiple directions
- loops are a disaster (no hop count, exponential proliferation)

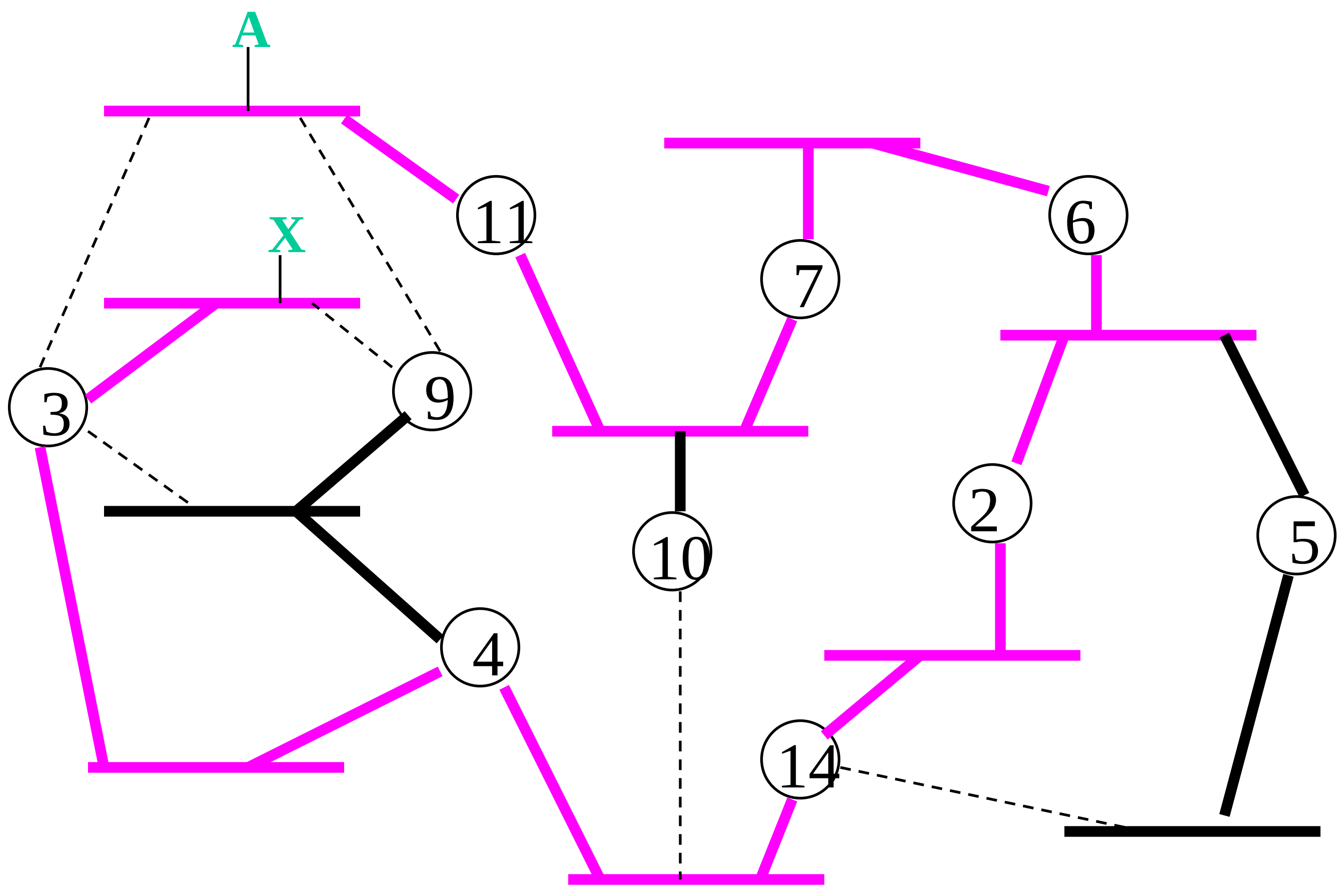
# Bridge loops



## Need spanning tree algorithm

- Finds loop-free spanning subset of current topology

# A talks to X



## Problems

- But suboptimal routing
  - Can’t have pairwise optimal with spanning tree
  - Concentrates traffic
- Also, temporary loops scary
  - conservative about turning on loops (I was REAL scared of temporary loops)
- And inherently fragile
  - Lost messages turn ***on*** links

## Algorhyme

*I think that I shall never see*
*A graph more lovely than a tree.*

*A tree whose crucial property*
*Is loop-free connectivity*

*A tree which must be sure to span,*
*So packets can reach every LAN.*

*First the Root must be selected.*
*By ID it is elected.*

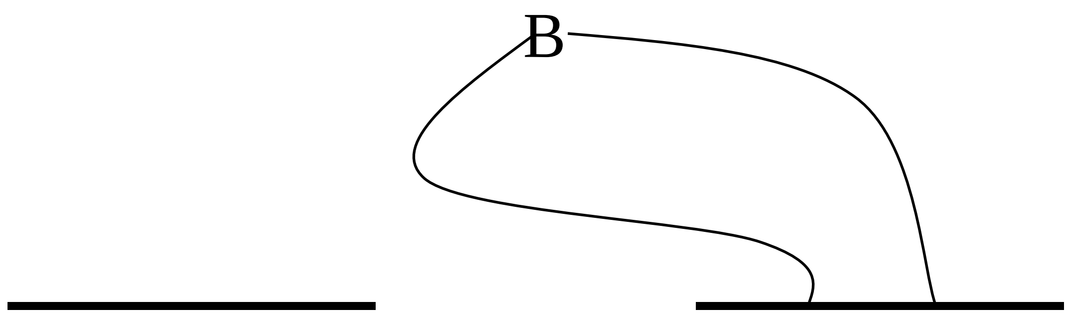
*Least-cost paths from Root are traced.*
*In the tree these paths are placed.*

*A mesh is made by folks like me.*
*Then bridges find a spanning tree.*

## Bridges without Spanning Tree?

- Implementers wanted bridges as simple as possible. “Don’t allow loops”
- Felt a little bad about forcing them to do STP
- … Until, first customer site

# First customer site

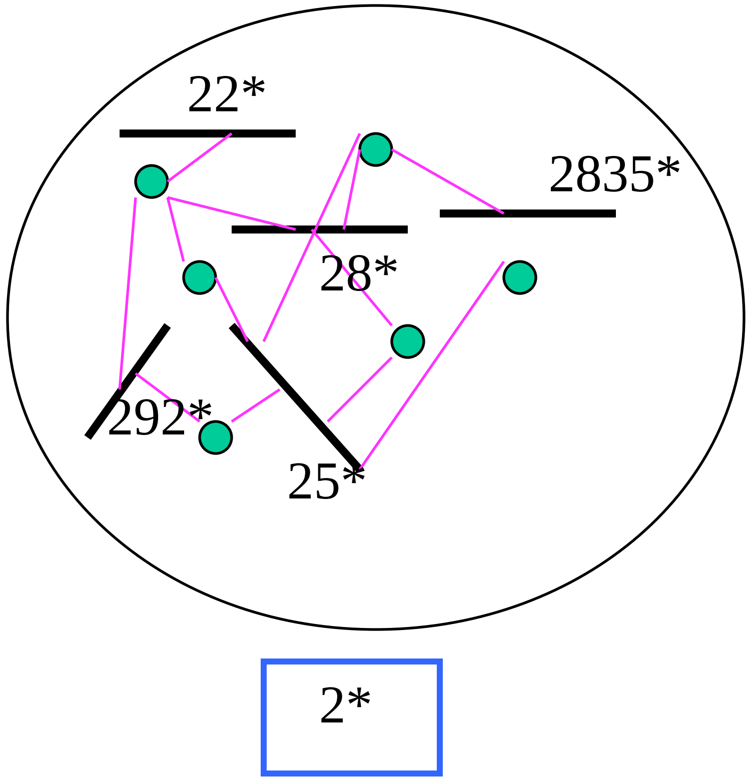


## Bridge success

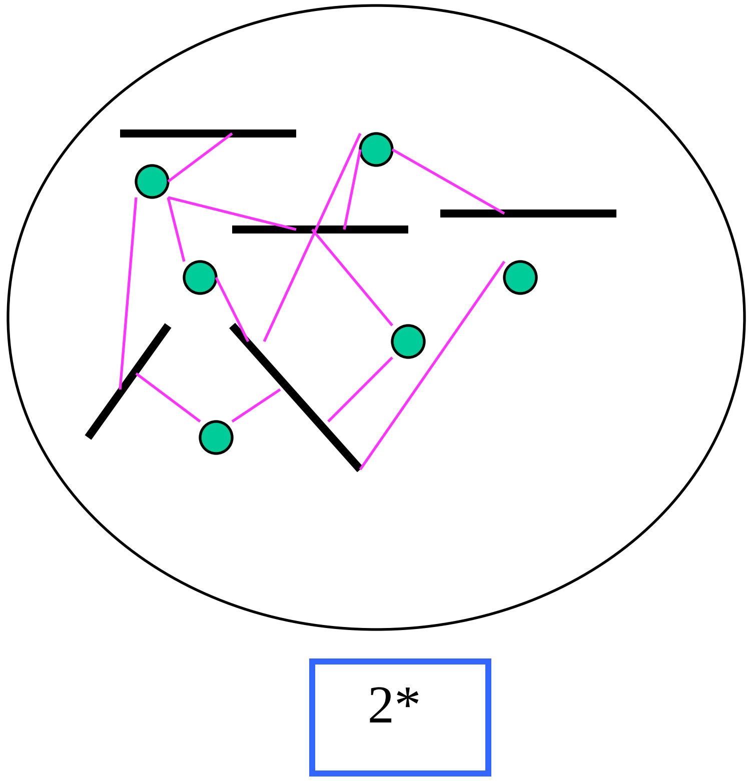
- Simple, fast, reliable, plug-and-play
- Routers have gotten better. Will bridges go away?
- No for subtle reason: IP needs address per link.
- Layer 3 doesn’t have to work that way
  - CLNP and DECnet
  - Bottom level of routing is a whole cloud with the same prefix
  - Routing is to endnodes inside the cloud

# Hierarchy

One prefix per link



One prefix per campus



## Advantages of lots of links in a prefix

- Zero configuration of routers inside campus
- Nodes can move within campus and keep address
- Address space doesn’t need to be chopped up

## Plug for TRILL working group in IETF

- TRILL= TRansparent Interconnection of Lots of Links
- Use layer 3 routing, and encapsulate with a civilized header
- But still look like a bridge from the outside

## RBridges/TRILL

- Compatible with today’s bridges and routers
- Like routers, terminate bridges’ spanning tree
- Like bridges, glue LANs together to create one IP subnet (or for other protocols, a broadcast domain)
- Like routers, optimal paths, fast convergence, no meltdowns
- Like bridges, plug-and-play

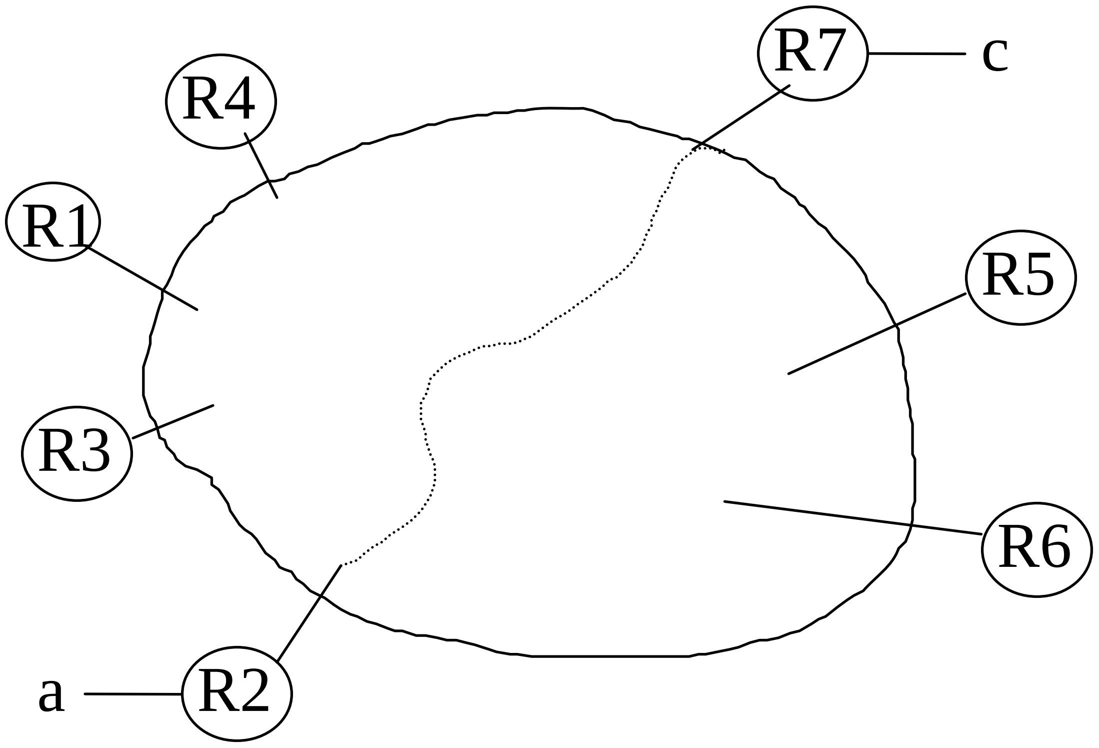
## RBridging layer 2

- Link state protocol among Rbridges (so know how to route to other Rbridges)
- Like bridges, learn location of endnodes from receiving data traffic
- But since traffic on optimal paths, need to distinguish originating traffic from transit
- So encapsulate packet

## “Layer 2” routing

- Think of it just like routers
  - At each hop, add a layer 2 header to get to the next hop RBridge
  - The “destination” is the egress RBridge
- First RBridge
  - Looks up destination endnode, finds egress RB
  - Adds shim header, forwards to egress RB
- Egress RBridge decapsulates

# Rbridging



# Encapsulation Header

| | | |
|---|---|---|
| S=Xmitting Rbridge<br>D=Rcving Rbridge<br>pt="transit" | hop count<br>In/out RBridge | original pkt (including L2 hdr) |

Outer header: new p-t: otherwise, ordinary Ethernet hdr

Shim: hop count, ingress and egress RBridge

**To make shim shorter, dynamically acquire 2-byte RBridge nicknames**

## Flooded traffic

- Some traffic needs to be sent to all links
  - Unknown destinations
  - Multicast traffic
- Could use a single spanning tree
  - Spanning tree computed from link state database (not separate spanning tree protocol)
- But we decided on per-ingress trees..And actually a bit more flexible than that

## Other subtleties

- VLANs
- Shared VLAN learning
- IP multicast
- ARP/ND optimization

# Algorhyme v2

*I hope that we shall one day see*
*A graph more lovely than a tree.*

*A graph to boost efficiency*
*While still configuration-free.*

*A network where RBridges can*
*Route packets to their target LAN.*

*The paths they find, to our elation,*
*Are least cost paths to destination.*

*With packet hop counts we now see,*
*The network need not be loop-free.*

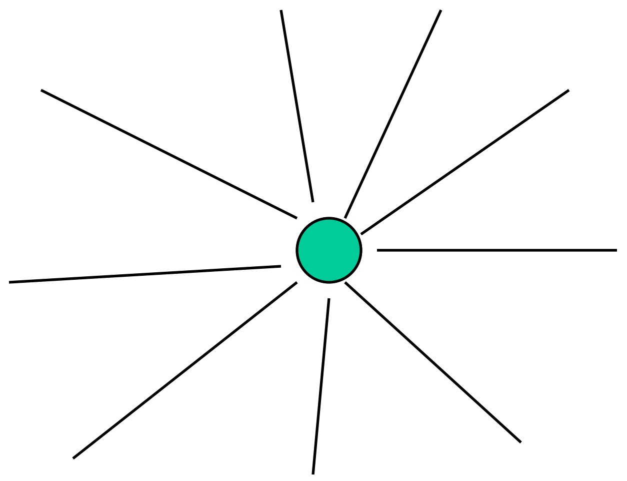
*RBridges work effectively.*
*Without a common spanning tree.*

*Ray Perlner*

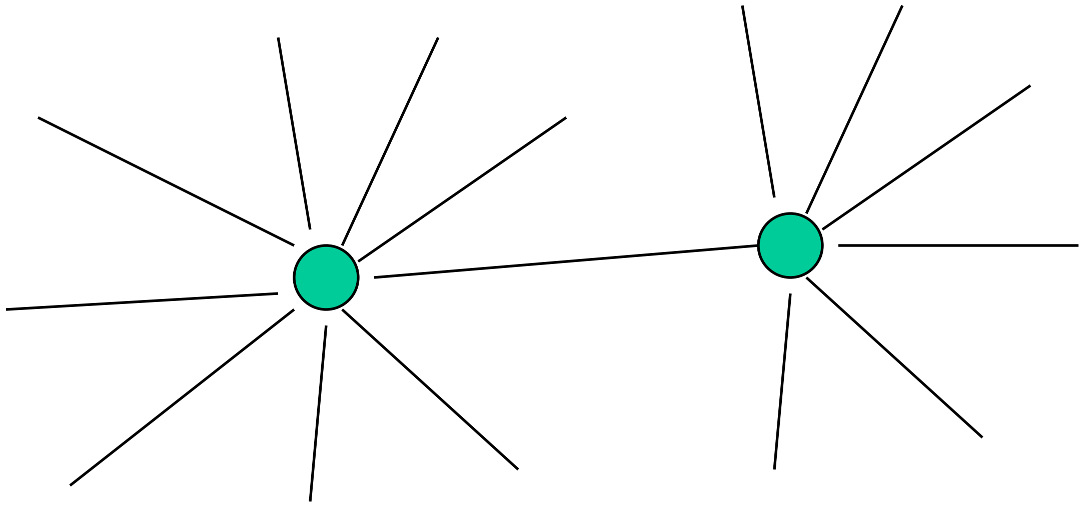
## What are switches?

- Myth: Ethernet is wildly successful
- Reality: Ethernet (CSMA/CD) doesn’t exist anymore!
- Panel: bus (Ethernet) vs ring (vs star)

# Stars



## Plug star into another star



## Stars

- Start with multi-port repeater
- Then notice that hub can be smarter. Store and forward, learn location of sources.
- Then notice can cascade them.
- Should run spanning tree.
- We’ve reinvented the bridge!
- “Switched Ethernet”: pt-to-pt links with bridges!
- Ports don’t need to be the same speed!

## New topic: What’s with IPv6?

- Why should it have taken over a decade to design?
- What’s really new?
- IAB, in 1992, realized IP addresses were too small, and said we should replace IP with CLNP, ISO’s “Connectionless Network Protocol”
- CLNP is like IP, with 20 byte addresses
- At the time, CLNP fully implemented, mature standard, enthusiasm in Europe

## IPv6 reality

- Much harder to change Internet to bigger addresses now than in 1992
  - Internet much larger
  - More “mission-critical”
- Less incentive now
  - delay necessitated inventions like DHCP, NAT

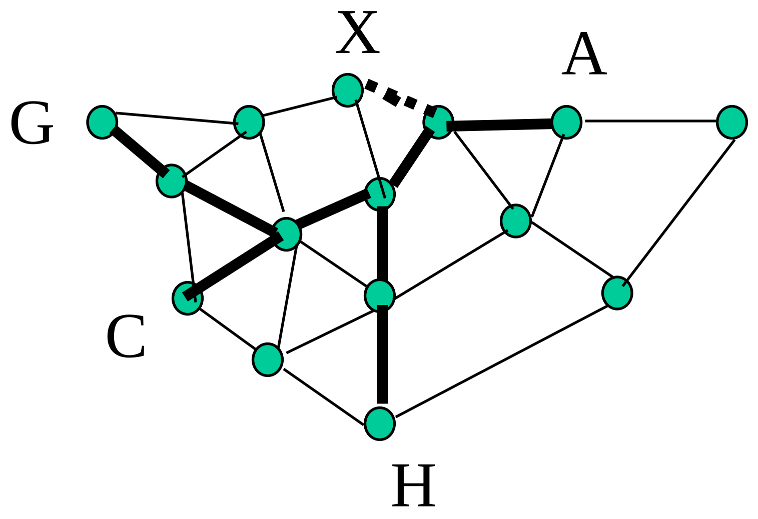
## IPv6 myths

- It’s not a replacement of IP. It’s just a “new version” of IP
- Security is built into IPv6. It’s just an add-on to IPv4

## New Topic: Bad “Framework”

# Multicast

- Ethernet: falls out of technology
- ATM: create VC. “Add member”



# IP Multicast

- Idea: make it look “just like Ethernet”
  - – globally unique multicast addresses
    - IP address 32 bits, top 4 bits=1110
  - – anyone can request to listen. anyone can send without being a member
- So, start out with unchangeable “model”
  - – signalling protocol to inform local rtr to send G

# Problem: Can’t be implemented

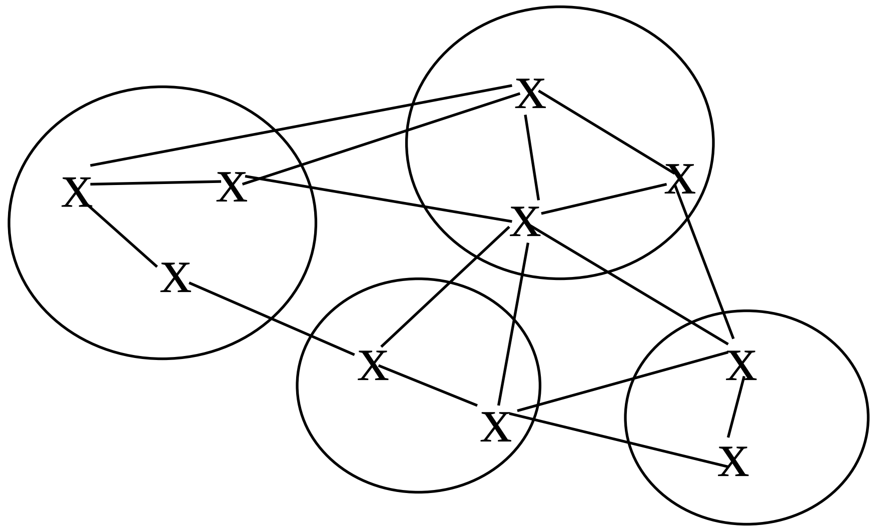
- various attempts:
  - – flood and prune
    - send all data everywhere, in case someone in Albania wants to listen
    - if not interested, send “prune”
    - keep track of all (S,G) pairs nbr NOT interested in
  - – MOSPF
    - routers keep track of all listeners for all groups

# IP Multicast attempts

- Tree building like with ATM
  - send join towards Root
  - create tree
- Problems:
  - who is Root for G?
    - unscalable intradomain protocol to select a Root-candidate for G
  - how to administer addresses

# IP Multicast

- So, came up with unscalable complex intradomain
- Then MSDP to piece domains together



## How IP Multicast should look

- Two types
  - finding something (low bandwidth, can’t set up tree). Just flood with RPF
  - conference call, etc. Find host H. Build tree to H. Have address of group be (H,G), where G only has to be unique to H

## New topic: simple things people screw up

- Parameters. Need to set in running net!
  - better if plug and play
  - hopefully not there because committee couldn't decide on a value
  - Sometimes parameters must be compatible:
    - hello timer vs dead timer
  - IS-IS strategy: tell nbr
  - OSPF: refuse to talk unless equal!
  - Spanning tree: use root bridge's values

## Forward compatibility

- TLV encoding: so can define new fields, and have old implementations skip them
  - L must be consistent
  - BOOTP “vendor specific” field

## Version number

- What’s the difference between a new protocol and a new version of a protocol?

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- What’s the difference between a new protocol and a new version of a protocol?
- For instance, is IPv6 a new version of IP, whereas CLNP would have been “replacing it”?

## What’s a “different” protocol

- Reasonable definition: If has a different Ethertype
- New version: share the same Ethertype
- If you ever make the format incompatible, change the version number
- Which means you can’t just specify what you set the field to, but that you should drop something with an unrecognized version number
- Some fancy things you could do (major|minor; bit for “I could support a higher version)

## Version numbers, reserved fields

- Lots of protocols don’t say what to do
- So difficult to do new version
- SSL
  - version 3 totally redid packet format
  - moved version number field!
  - So have to send version 2 (0.2) msg with 3 (3.0) in version number field
  - version 2 nodes happy to accept version 768!

## Version numbers, reserved fields

- Lots of protocols don’t say what to do
- So difficult to do new version
- IPv4
  - Just says “set the field to 4”
  - So you can’t send an IPv6 packet to an IPv4 node
  - So IPv6 is a new protocol, not a new version of IPv4

## So you’d assume they’ve learned their lesson for IPv6

- No…the spec says “fill in this field as 6”

# SSL

- Version 3 completely changed the format from version 2

## SSL

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- And even moved the version field!

## SSL

- Version 3 completely changed the format from version 2
- And even moved the version field!
- How can this work?
  - Have to send first packet in v2 format, specifying version number as 3
  - Ironically, field is 2 bytes: version 2=(0,2)
  - Version 3=(3,0)
  - So version 2 node sees version 768, doesn’t even blink!

## Summary

- We need to have protocol designers humble enough to learn from previous protocols
- We need to learn from more than RFCs (which don’t give rationale, just operation)
- If things aren’t simple they won’t work
- Know what problem you’re trying to solve before you try to solve it!