lecture 02: review of “how the Internet works”

5590: software defined networking

anduo wang, Temple University

TTLMAN 402, R 17:30-20:00

some materials in this slide are based on lectures by

Jennifer Rexford https://www.cs.princeton.edu/courses/archive/fall13/cos597E/


THE GOOD


THE BAD


THE UGLY

why review

SDN interacts with "legacy" networks

- unmodified end-host computers
- hybrid deployment of SDN
- connecting to non-SDN domains

SDN is a reaction to legacy networks

- retain the "good"
- improve on the "bad" and the "ugly"

outline

brief review

- defining characteristics

"the good, the bad and the ugly" by examples

- traffic engineering in IP networks
- Ethernet
- VLAN usage in campus networks

defining characteristics

- packet switching
- layering

packet switching

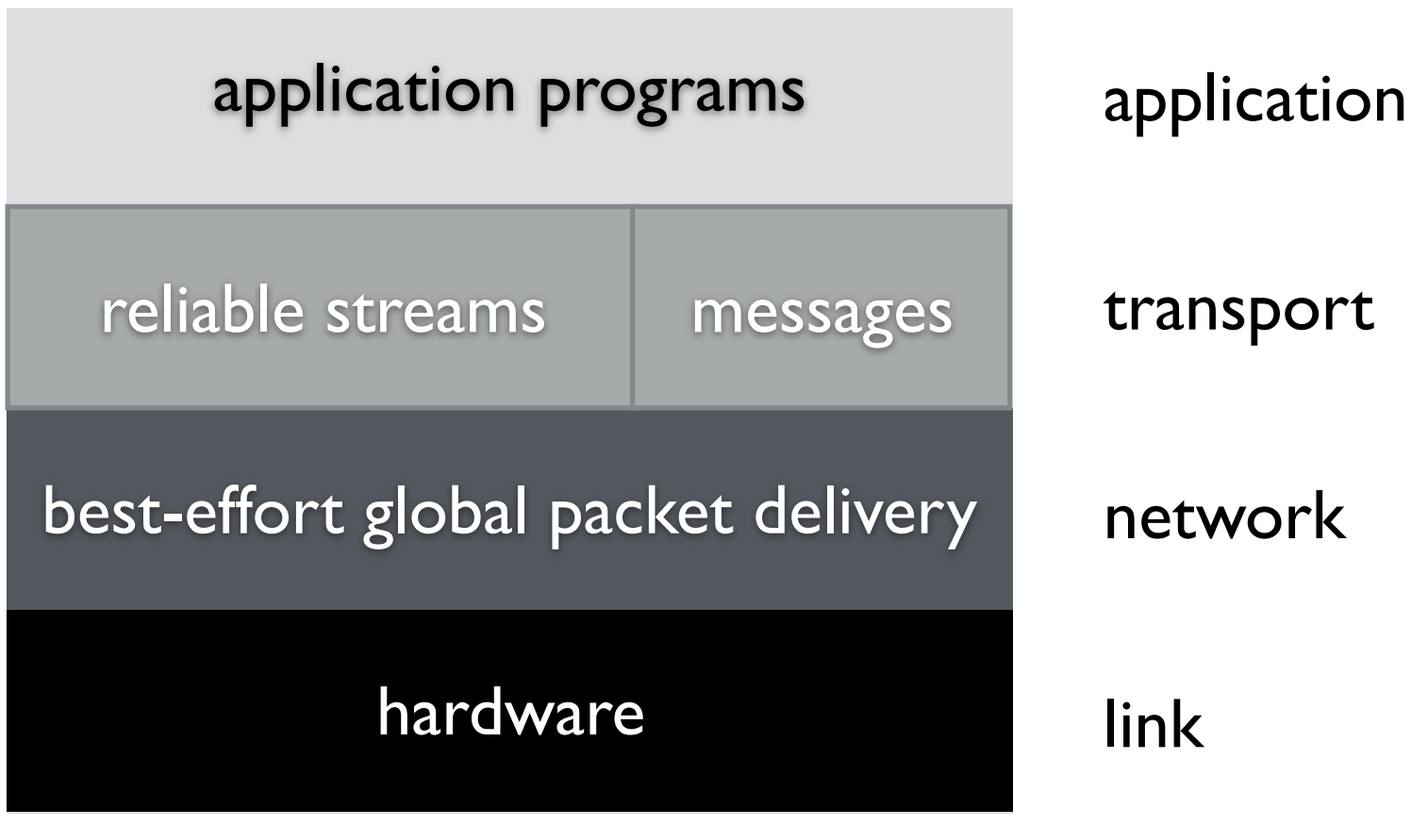
the simple and transparent core network

- the datagram, connectionless service
  - carries data without knowing what data it is
- effective for multiplexed utilization of shared interconnected networks
- open to new applications, hardwares, and new protocols

intelligence at the edges

- end hosts can run arbitrary applications

protocol layering for modularity



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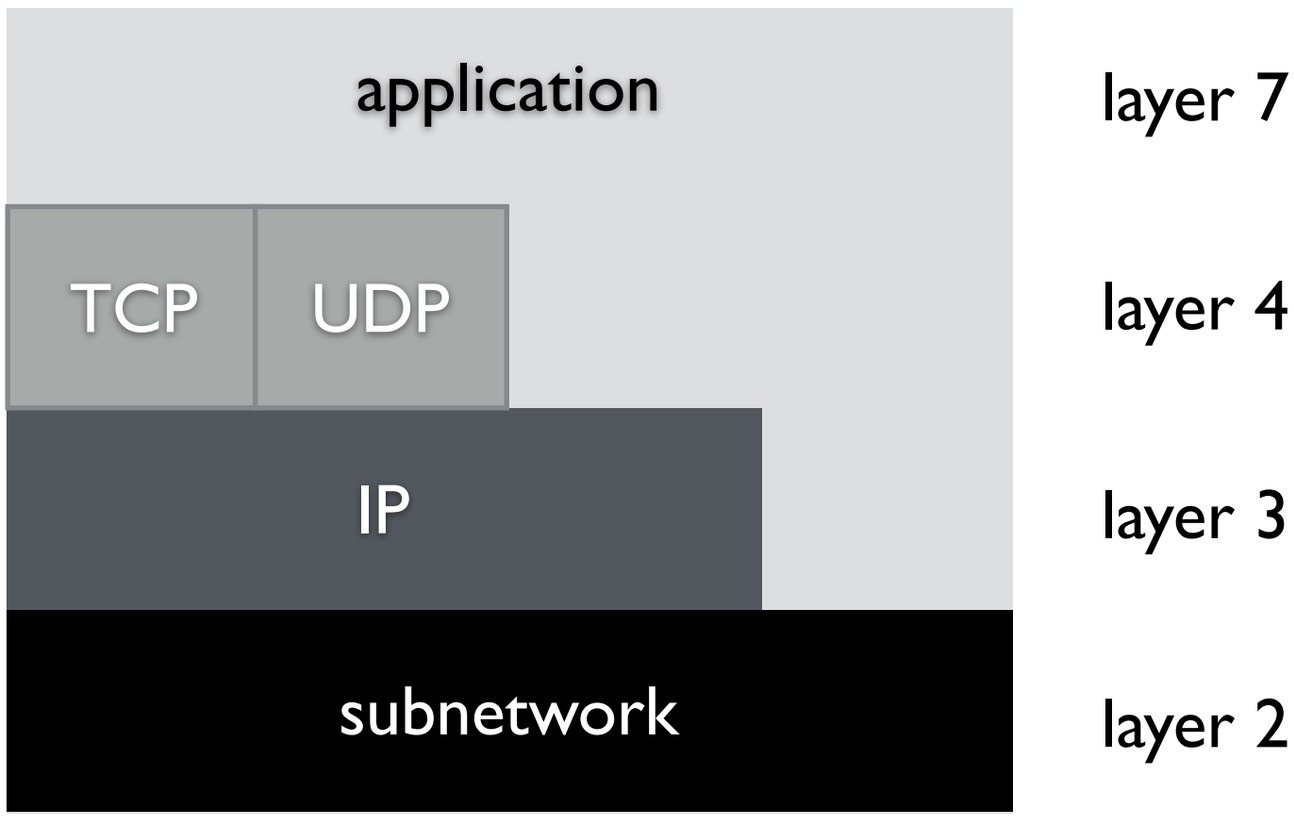

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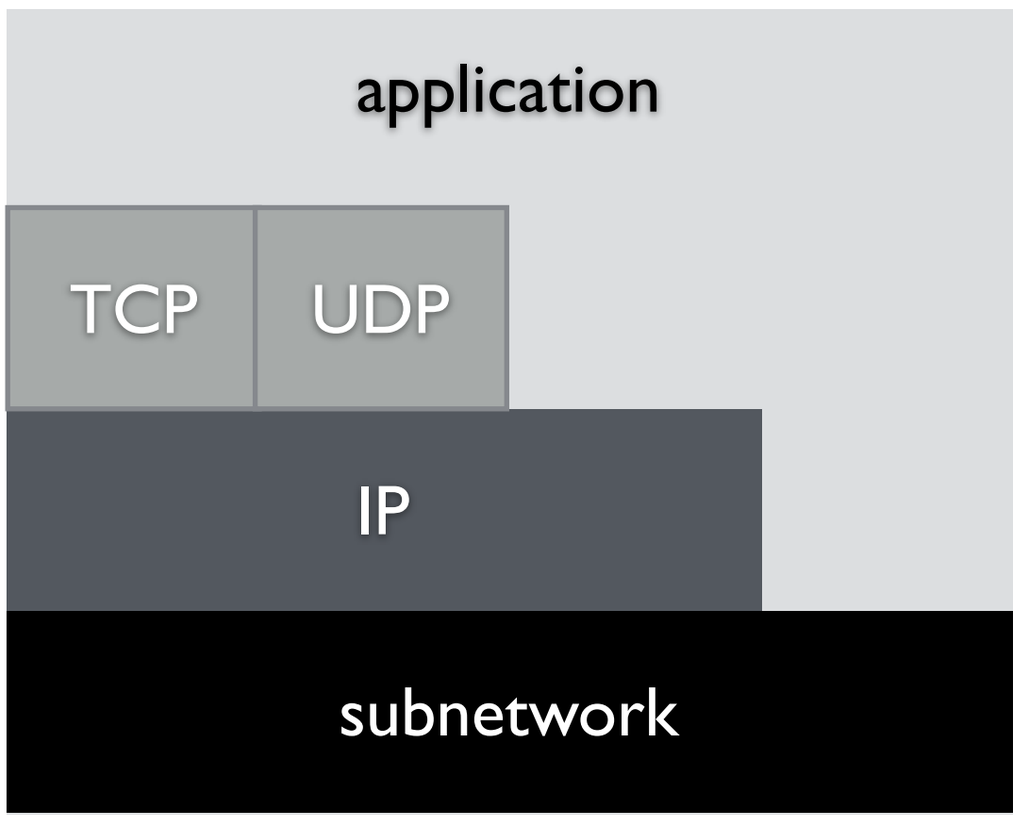
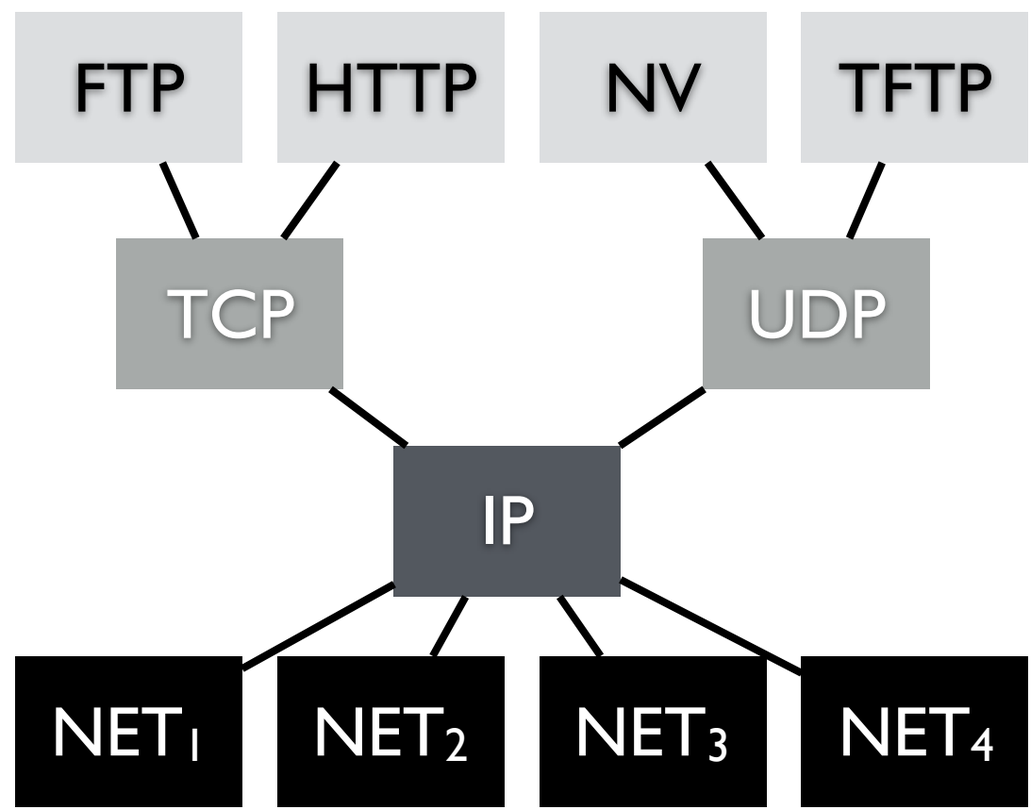
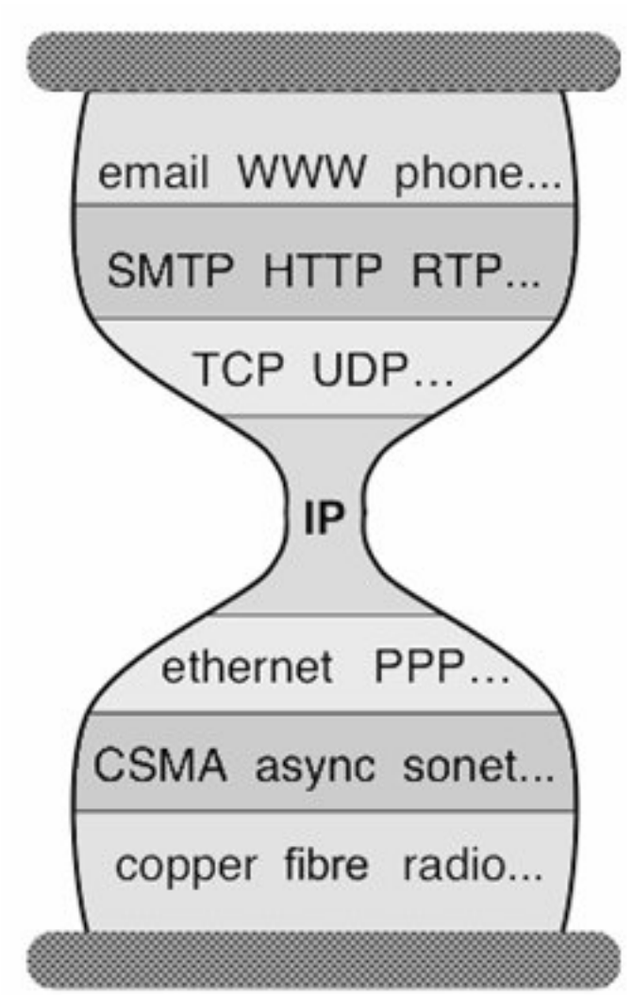
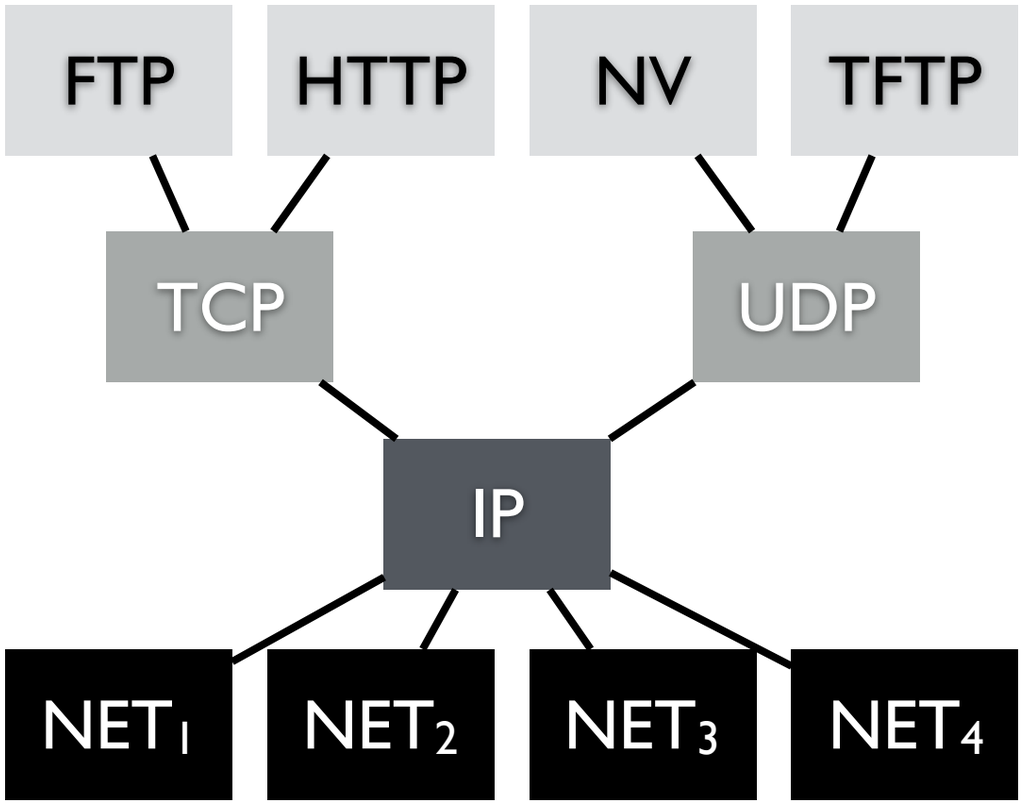




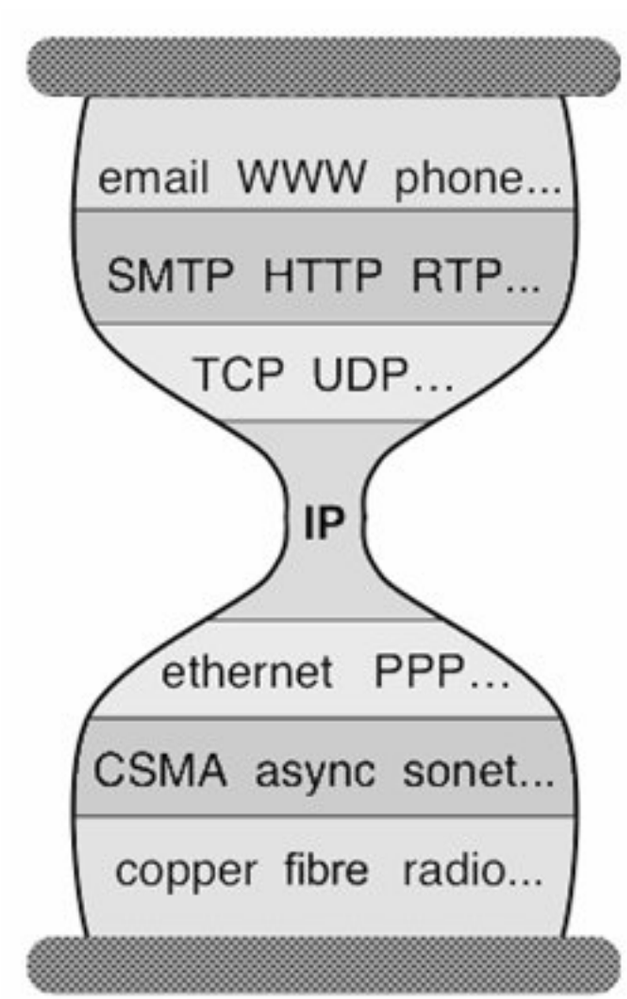
protocol layering for modularity

the hourglass





packet switching + layering



tension

- high-level network-wide objectives understood by the edges
- low-level network management of the core

the Internet is increasingly complex and notoriously hard to operate

outline

brief review

- significant ideas

"the good, the bad and the ugly" by examples

- traffic engineering in IP networks
- Ethernet
- VLAN usage in campus networks

traffic engineering with traditional IP routing protocols

traffic engineering

IP network manages itself

- end hosts running TCP adapt their sending rates to network congestion
- but, a particular link might be congested despite the presence of under-utilized links

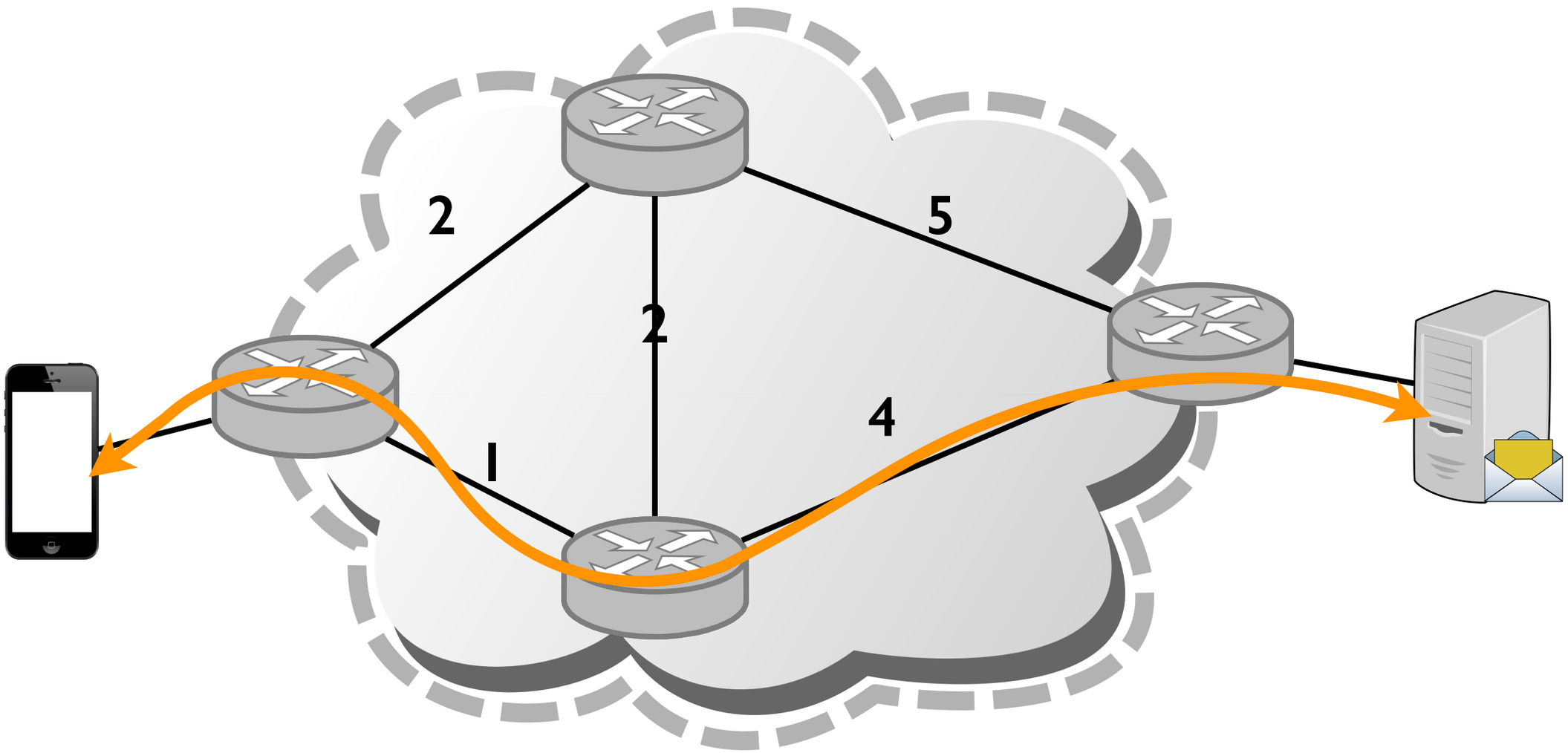
TCP/IP does not adapt the routing of traffic to the prevailing demand

- *a network-wide objective: improving user performance and making more efficient use of network resources*
- this task: traffic engineering

intradomain routing

shortest path routing

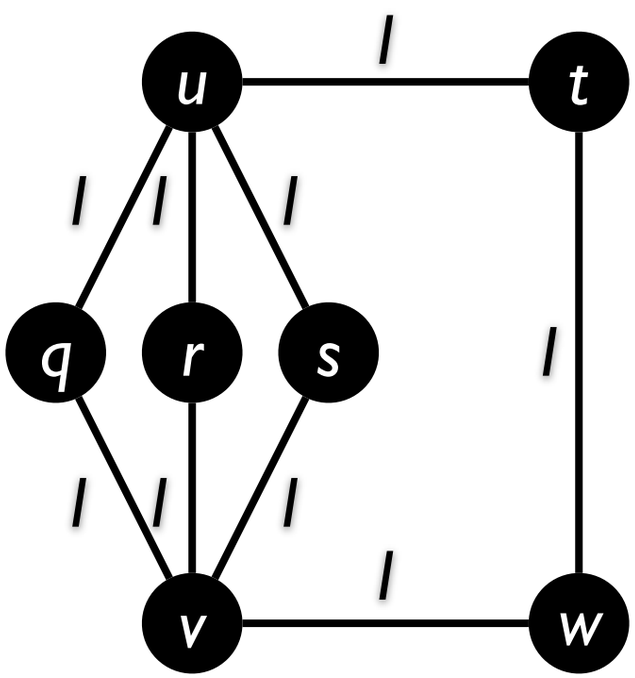
- route traffic through the shortest path within an Autonomous system based on OSPF weights



intradomain traffic engineering

routing the same demand with differing weights

- demand: *q,r,s,w* each has one unit of traffic to send to *t*



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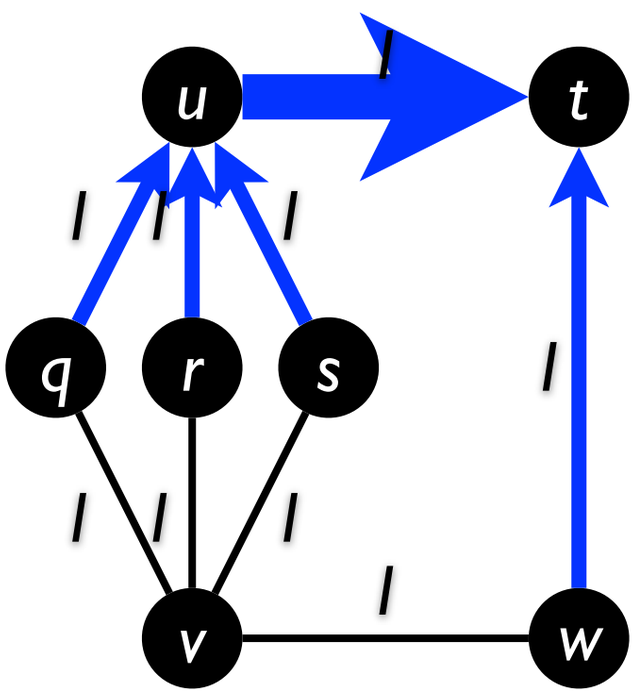
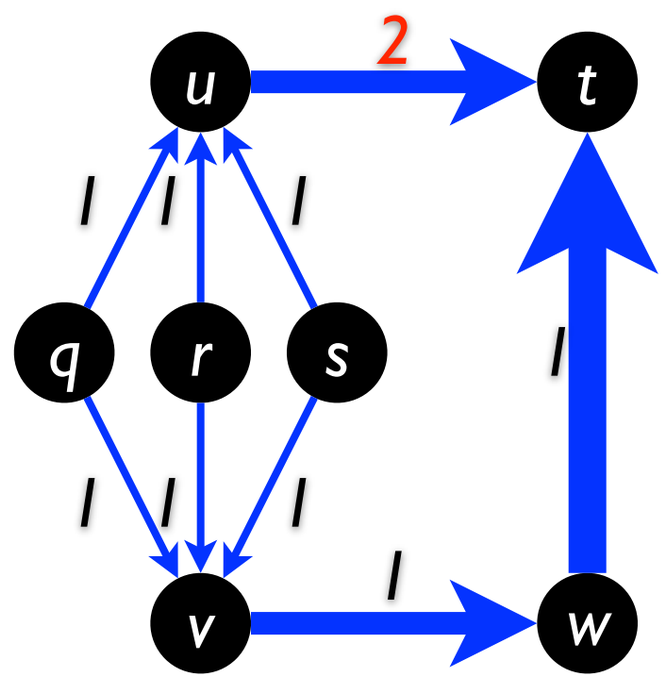
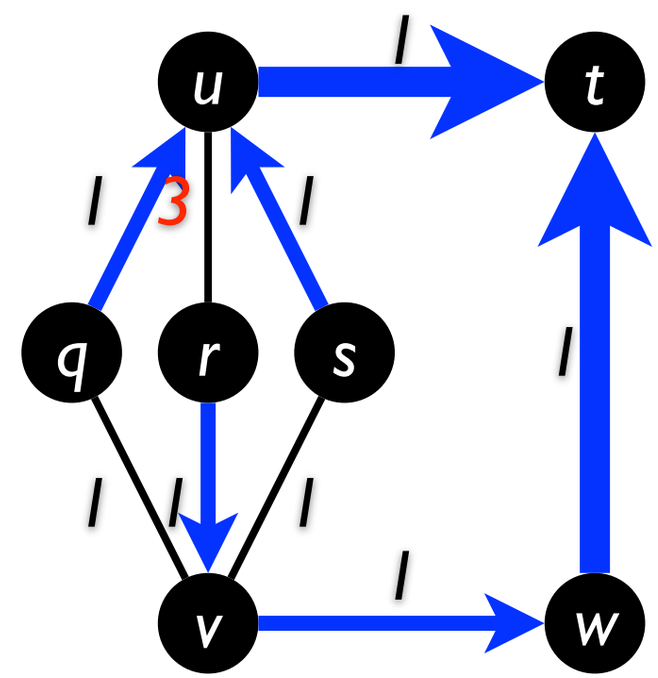


initial unit weights



local change of
the congested link

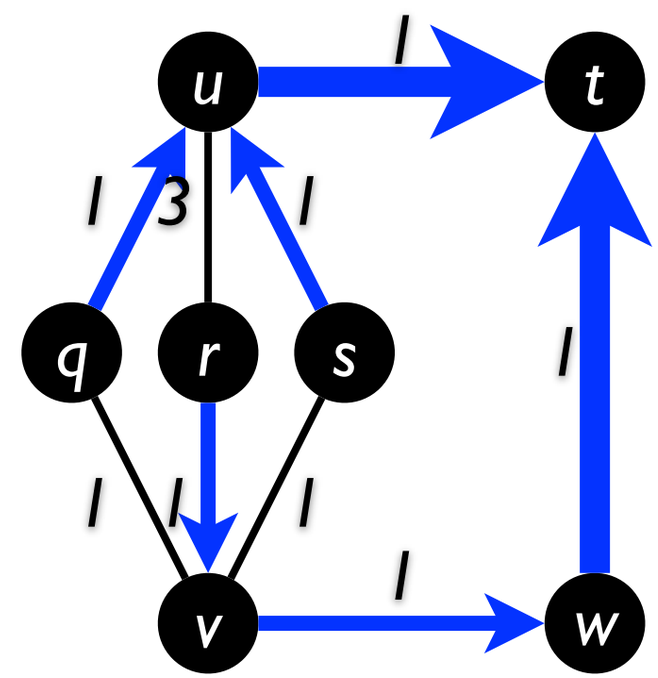


global optimization
of link weights

intradomain traffic engineering

globally optimized link weights

- alleviate congestion
- attractive alternative to buying additional bandwidth



traffic engineering framework

routing model

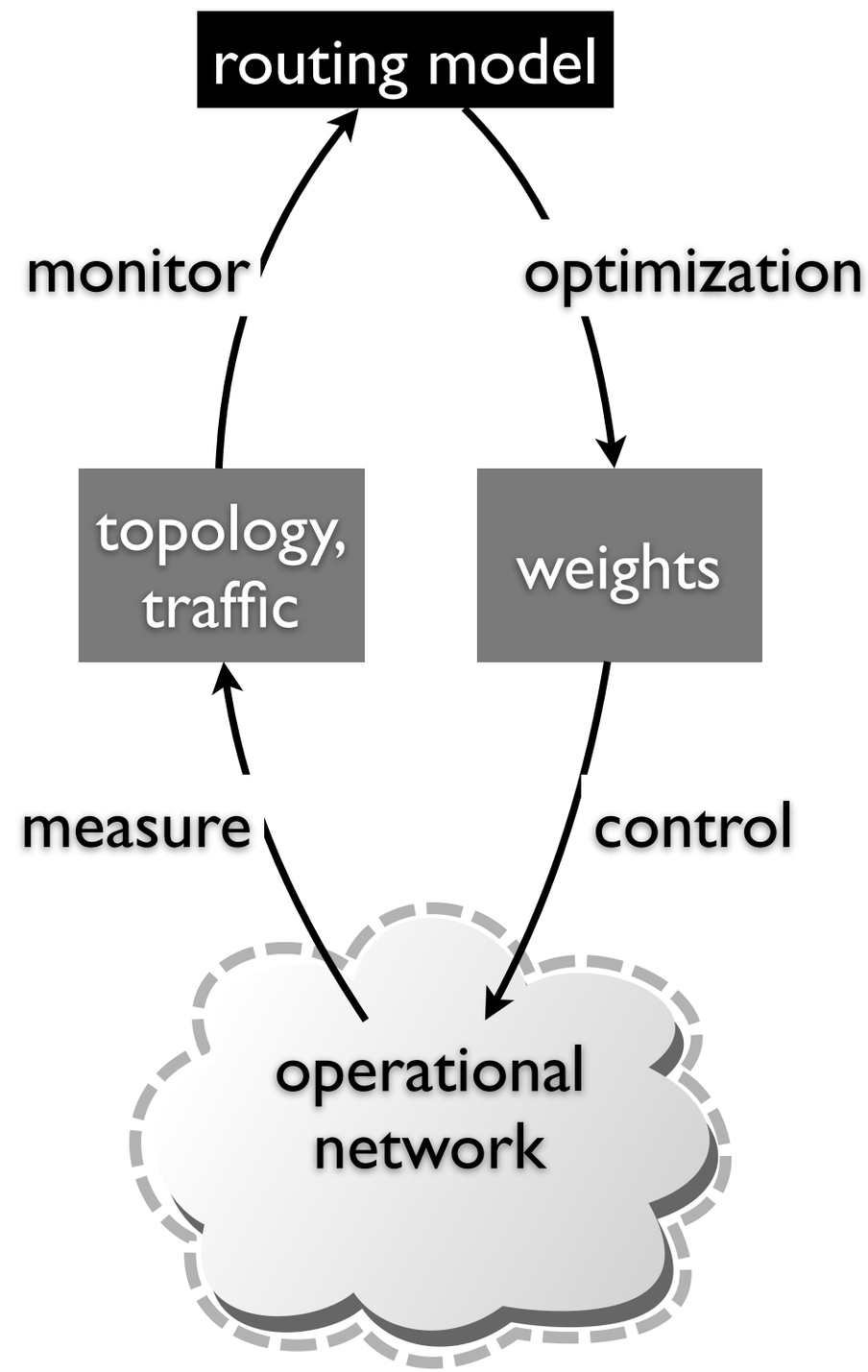
- path selection (shortest path) based on IGP weights

measurement

- lively and accurate view of the network — topology, traffic demand

reconfiguring weights

- optimize a network-wide objective
  - e.g., minimize the max-utilization
  - e.g., keep max-utilization under 60%



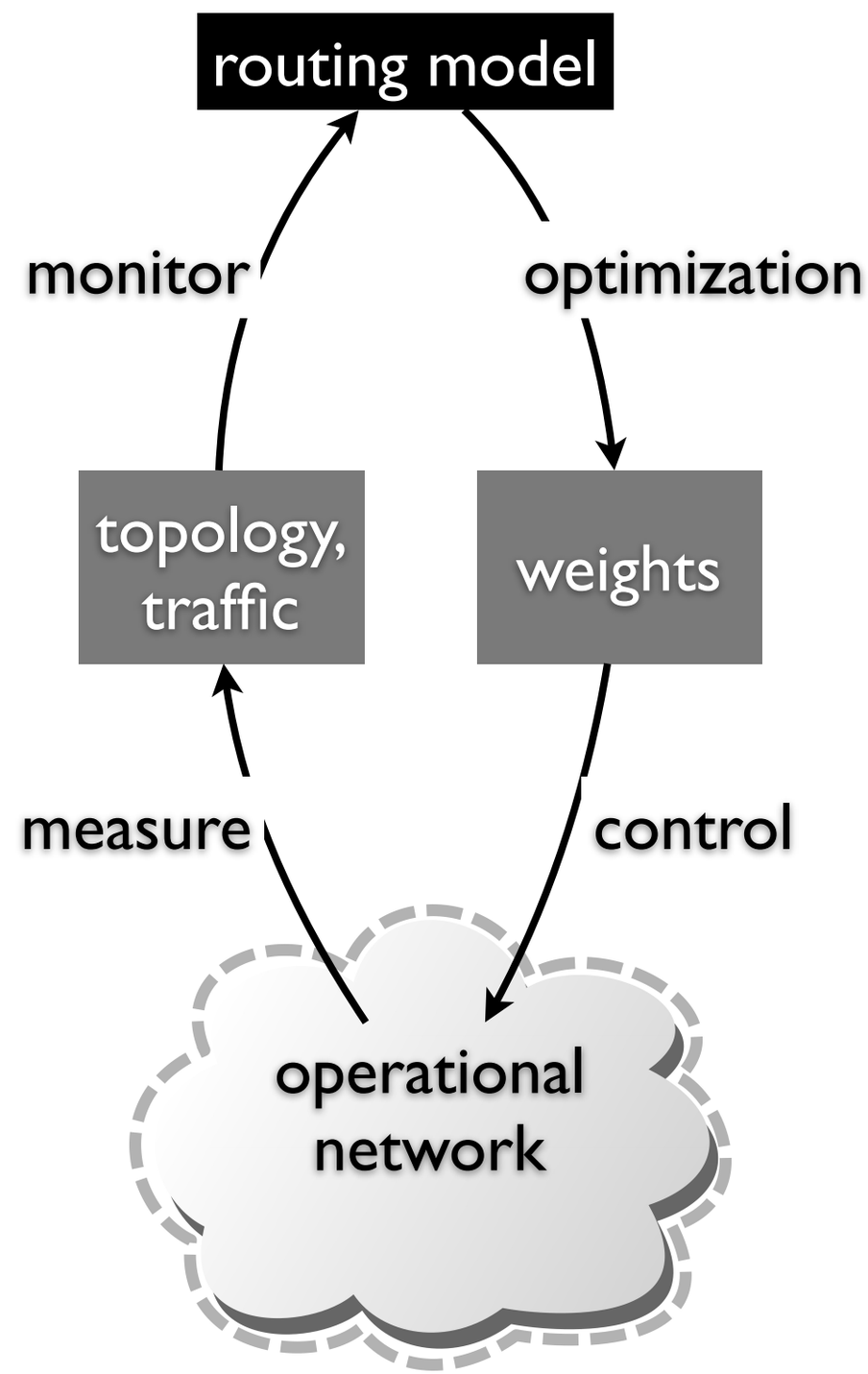
traffic engineering framework

centralized control

- stable
- lower overhead
- diverse performance objective

link weights express the routing configuration

- compatibility
- concise
- default weights and backup routes



performance

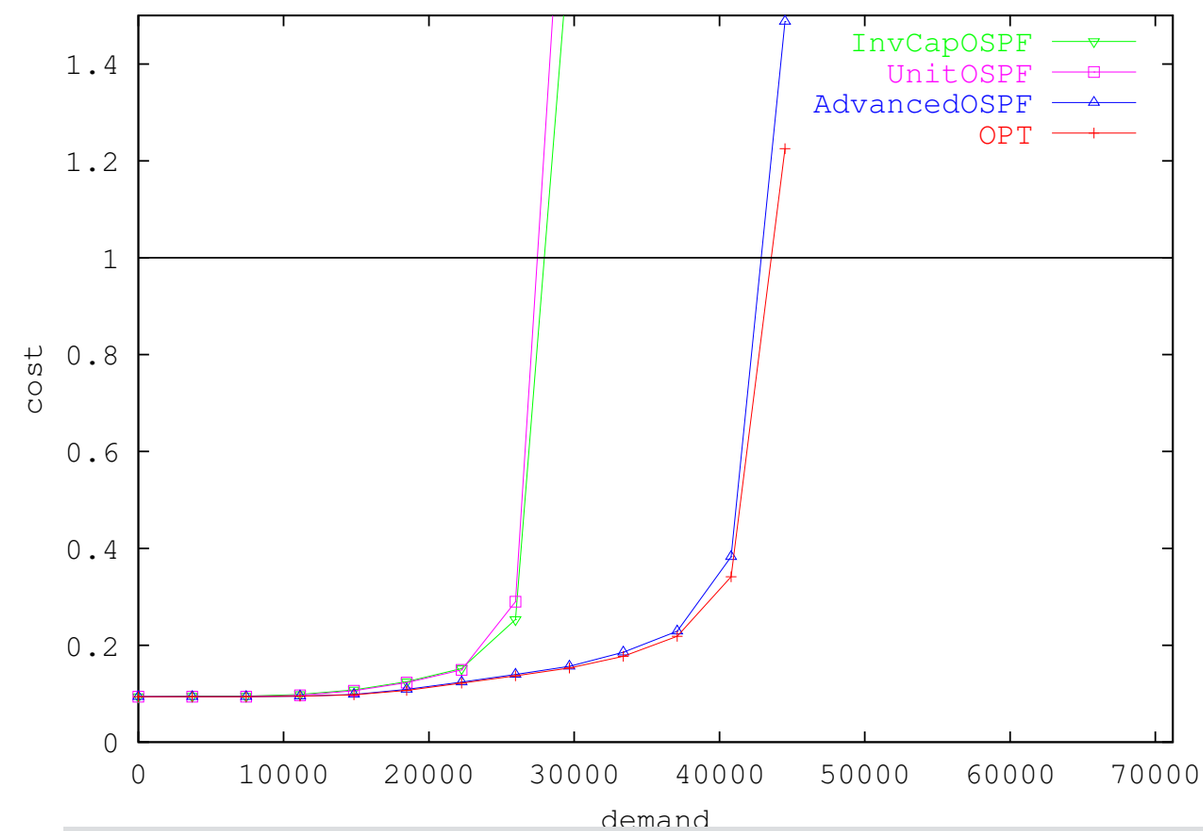
objective: link cost

- cost of using a link increases with utilization, explosive growth as utilization exceeds 100%

global optimization close to optimal

- can handle 70% more demands than Cisco or unit weights

OPT: can direct traffic along ay paths in any proportions
InvCapOSPF: (Cisco) set link weight inversely proportional to its capacity
UnitOSPF: set all weights to 1
AdvancedOSPF: global optimization



results on an AT&T backbone with a projected traffic matrix

discussion

centralized control

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- lower overhead
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the good

- centralized control, shared with SDN
- can express diverse network-wide objective

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the good

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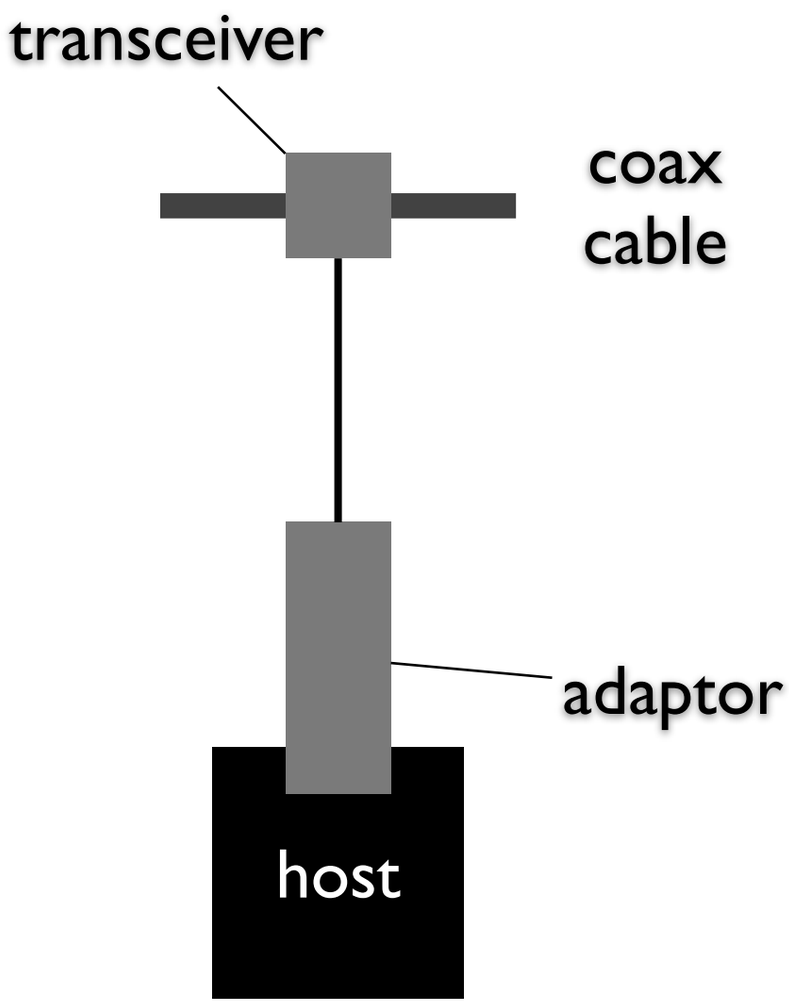
the bad and the ugly?

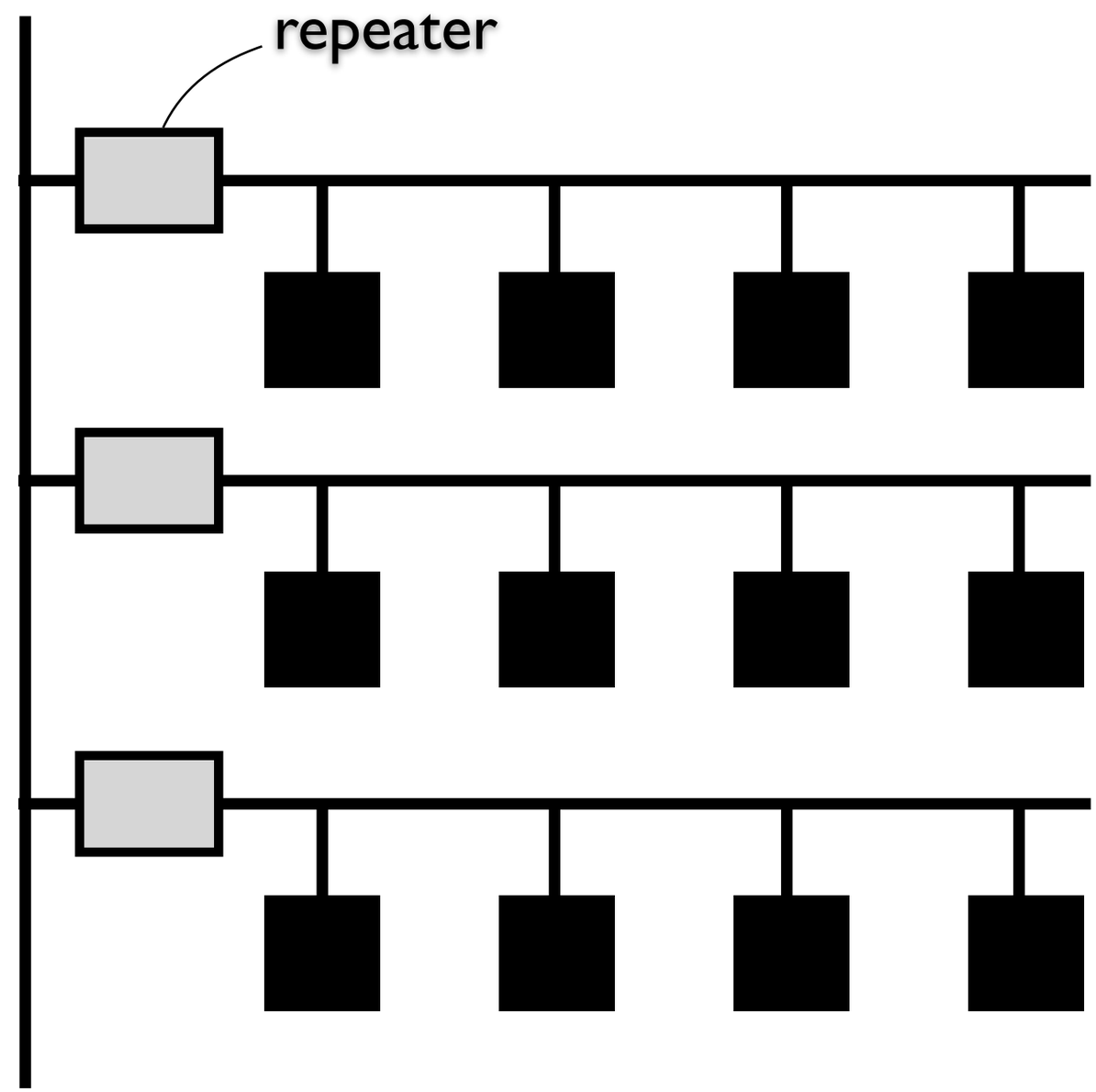
- inflexible: limited expressiveness
- indirect: link weights do not embed any semantics of higher-level network-wide goals

Ethernet

Ethernet

a local area network (LAN)





Ethernet

broadcasting communication

- message placed on the Ethernet is broadcast over

media access control (MAC) algorithm

- 1-persistent
  - adaptor with a frame to send transmits with probability 1 whenever busy line goes idle
- exponential backoff
  - upon detection of collision, adaptor stops transmission, waits a certain amount of time (and doubles before trying again)

Ethernet — “the” LAN technology

“zero” configuration

- extremely simple to configure and maintain: no switch, no routing, no configuration tables

inexpensive

- cable is cheap
- only cost: the adaptor

switched Ethernet …

discussion

distributed control

- coordination of access is distributed among contending senders
  - colliding senders: random retransmission intervals
- switching is distributed among the recipients

no central controller

- eliminate the reliability problem

zero configuration

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SDN abandons distributed control for simplicity

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reliability, a challenge for SDN

zero configuration

a goal shared with SDN

discussion

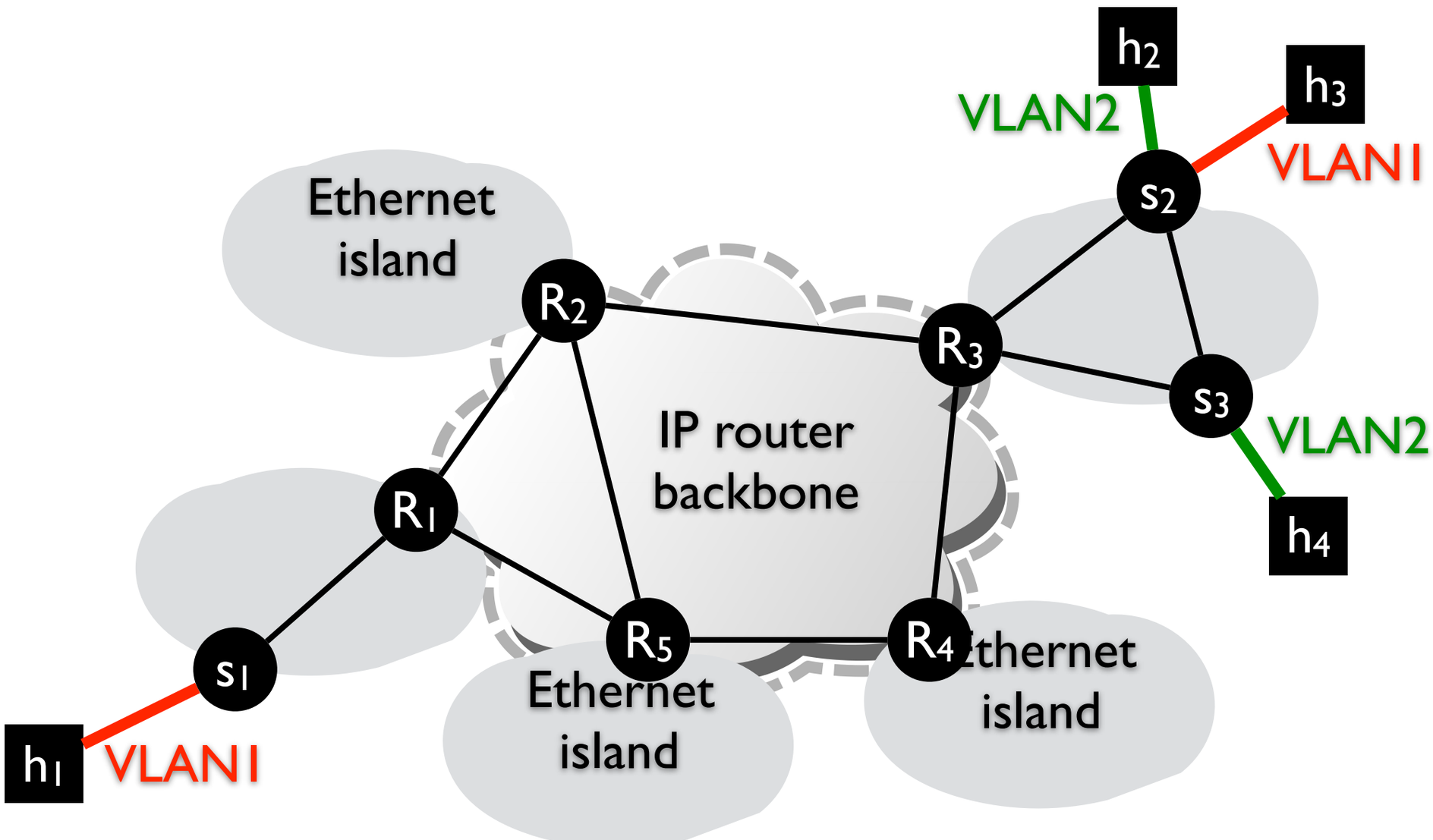
Ethernet is a real gem

- despite limitations — scalability, best effort delivery
- a rare combination of distributed control and simplicity
- arbitration of conflicting transmission demands is both distributed and statistical

VLAN for campus networks

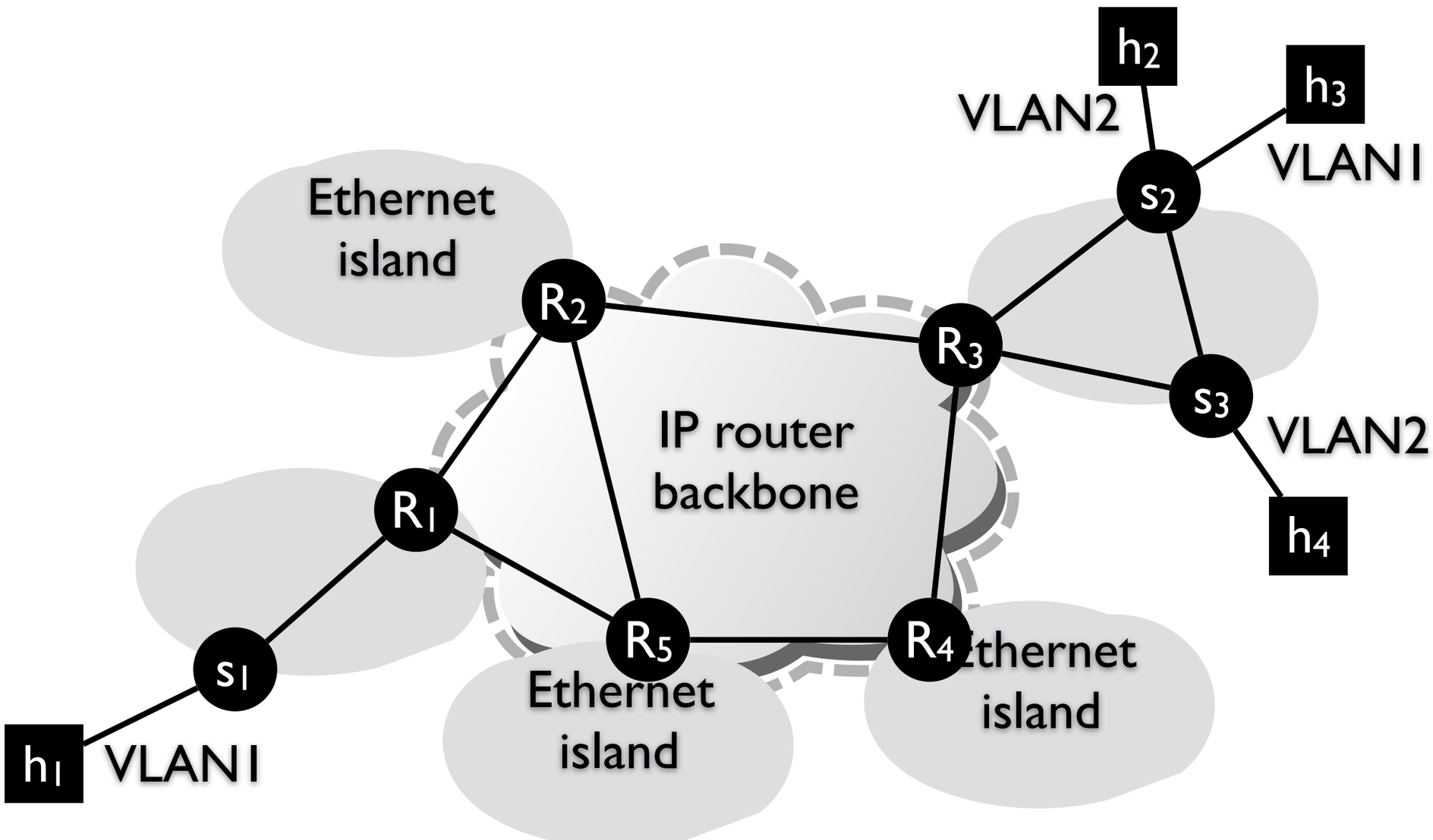
VLAN

connect hosts in the same broadcast domain, independent of their physical location



communication within a VLAN

h2 and h4 communicate over the spanning tree in VLAN2



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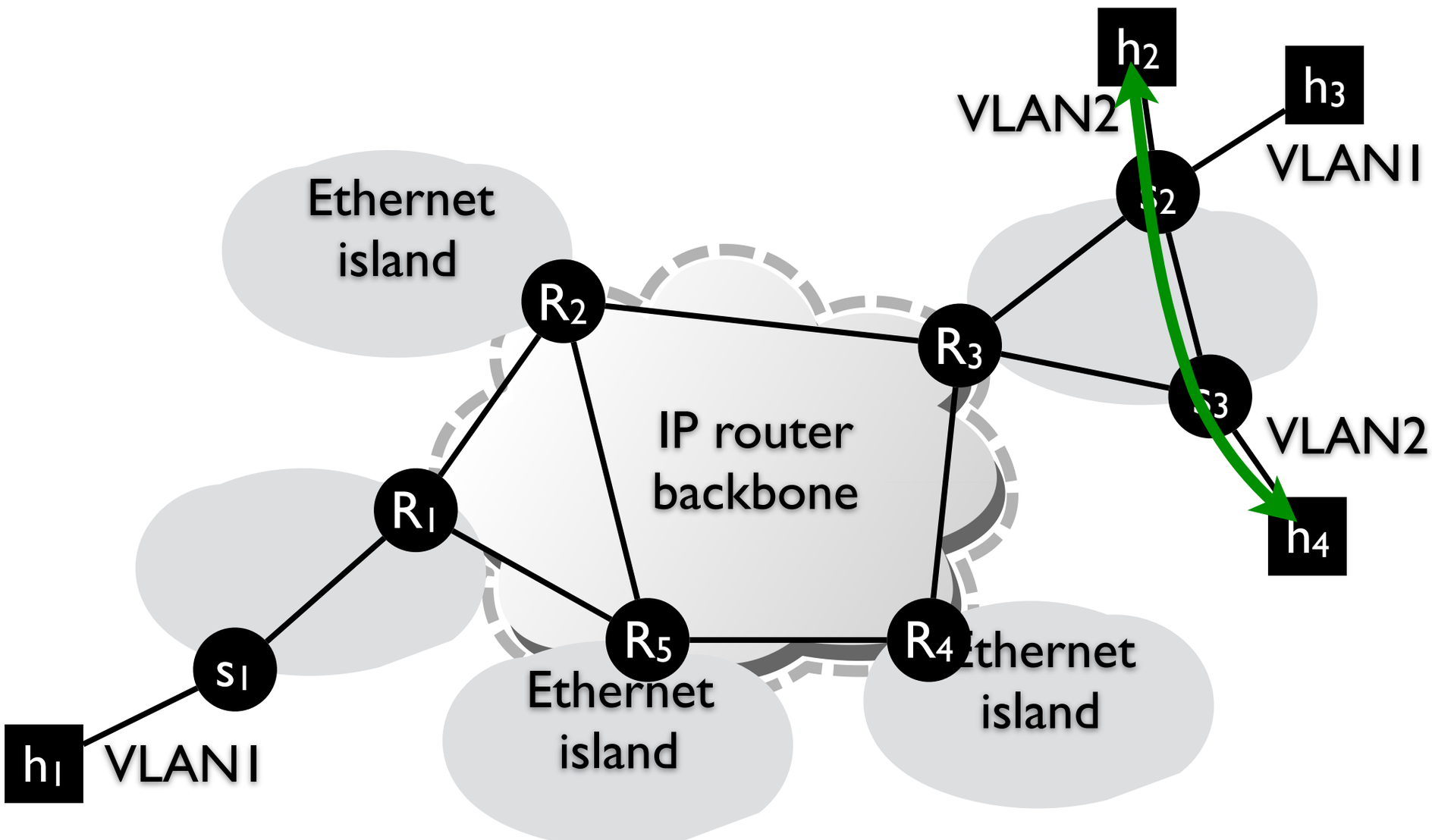
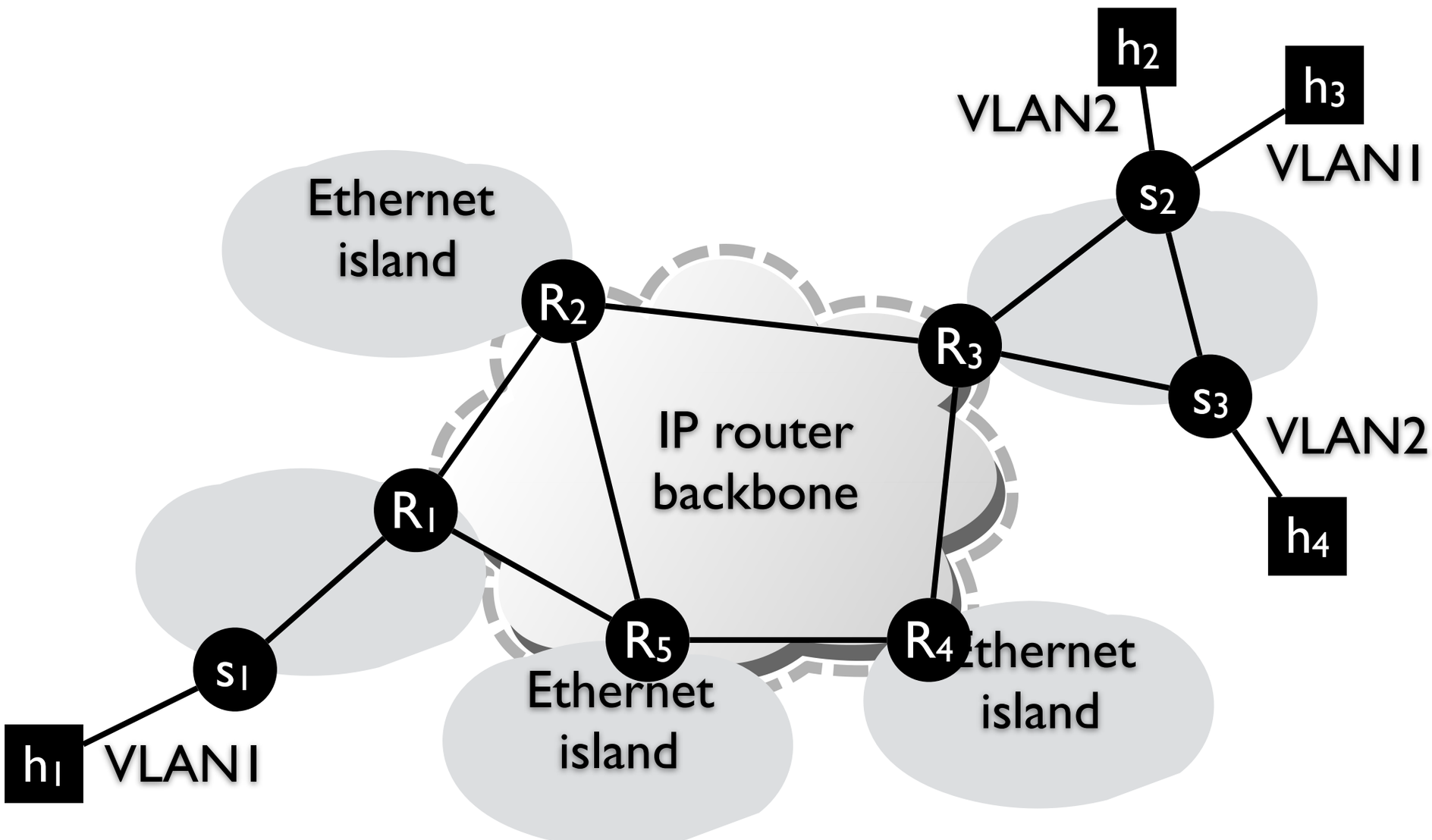


communication between VLANs

- each VLAN has a IP prefix
- IP routers forward packets based on these prefixes



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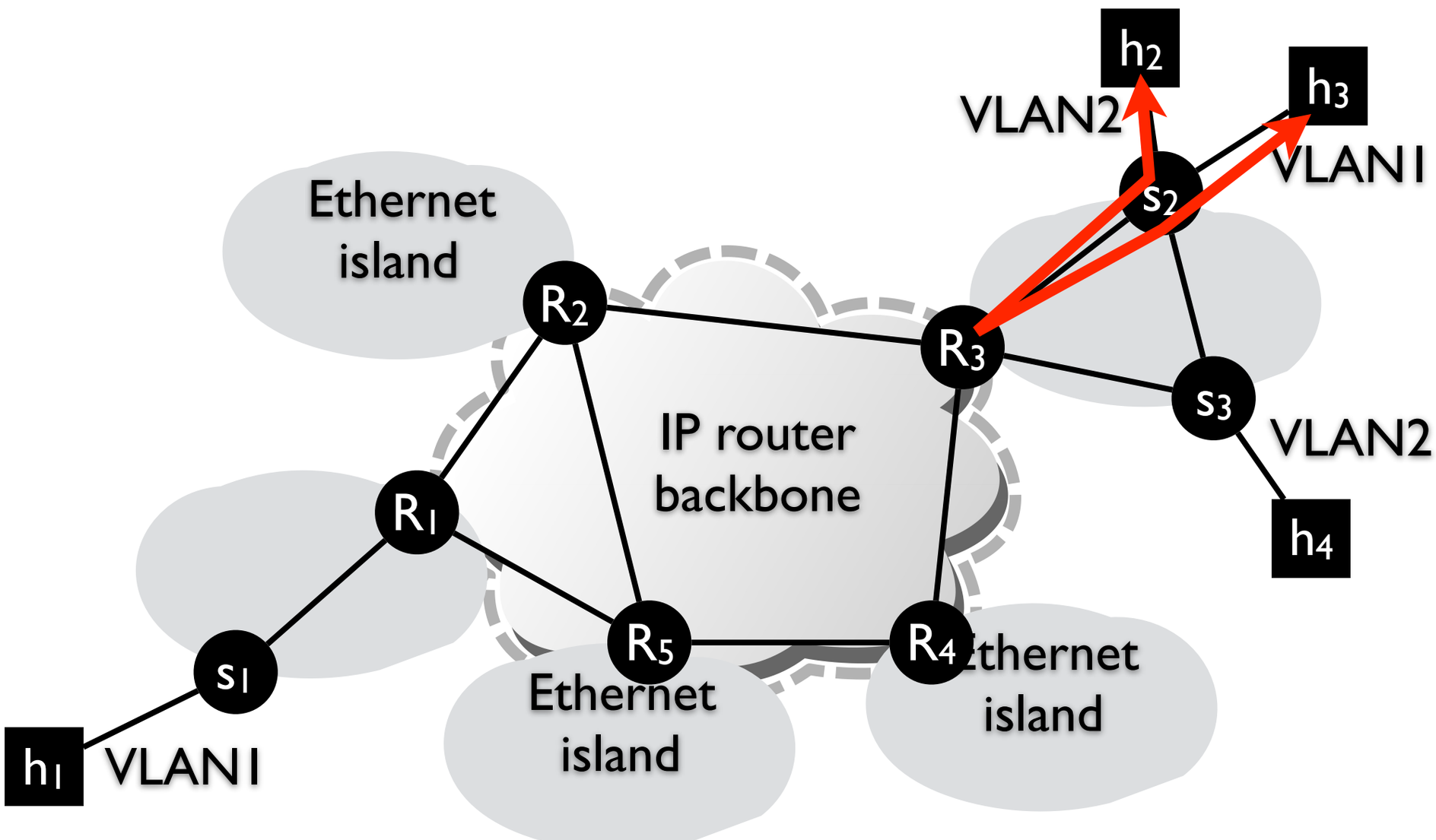

VLAN usage in campus networks

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VLAN widely used for various policy objectives

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- enabling host mobility

problem: inexpressiveness

problem: inexpressiveness

built-in protocol limitation

- number of VLANs < 4096 (12-bit header field)
  - multiple *isolated* group in the same VLAN
  - *isolated* VLANs share VLAN ID
- number of hosts per VLAN (flooding, spanning tree)
  - artificially divide large group into multiple VLANs

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unfit for traffic grouping

- VLAN naturally groups end hosts
  - unexpected security bleach: student plugs into a hub in a faculty office
  - restricted policy: a faculty on faculty VLAN cannot participate in admin

problem: complex configuration

problem: complex configuration

tight coupling between VLANs and IP

- wasting IP addresses, complex IP assignment

problem: complex configuration

tight coupling between VLANs and IP

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spanning tree computation

- explicitly configure switches to form spanning tree
  - determining which links participate in which VLAN is difficult
  - trunk links become inconsistent after network evolves
  - over-loading root bridge: same switch selected as the root in multiple VLANs

discussion: the bad and the ugly?

VLAN mechanism

- indirect and inflexible
  - VLAN creates broadcast domain for end-hosts
  - built-in protocol limitation
- low-level realization
  - explicit access port, trunk port

diverse high-level policy

- scoping traffic
- access control
- delegate management

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SDN mechanisms

- **direct, flexible**
- **high-level abstraction**

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SDN mechanisms

- **direct, flexible**
- **high-level abstraction**

the diverse high-level policy is a goal shared with SDN

to do

submit reviews by 5pm, September 8

- 4D and Ethane papers

next time

- centralized control
- database defined networking