Find Your Group / Table

Last name	First name	Group
Aasbø	Felix Leon Johnsen	6B
Ackerman	Maan	1A
Ådlandsvik	Jonathan Ward	6A
Alhajeed	Suha	2A
Bække	Frida Nordnes	3A
Bang-Olsen	Andreas Isegran	8A
Berwari	Kurdin Bekes	2A
Bjørkum	Hans Skirstad	8B
Borch	Christian Uteng	5A
Bratsvedal	Adam Paalsrud	6B
Cincovic	Leon	1A
Dalbye	Karin Ingrid Marie	4A
Flatberg	Odin	9B
Gerhardsen	Trym Silsand	8B
Gulljord	Kaisa	5A
Håkonsen	Sondre Songedal	8A
Hansen	Frida Andrea	6A
Hauksson	Daniel Örn	8B
Heggem	Ingrid Grov	7A

Last name	First name	Group
Hegre	Torjus Meyer	1A
Helgesen	Sander	9B
Henriksen	Daniel	2A
Iden	Erika	8A
Jægersborg-Iversen	Olav	3B
Johansen	Justine Sønsteli	9A
Korterud	Jacob Weldingh	7A
Lervik	Liv Barstad	1B
Lutnæs	Tørres	5B
Makhtari	Mohand	9A
Melsnes	Maria Olsen	2B
Migliorini	Mika Gabriel Holst	5B
Mosfjell	Jonathan	1B
Muruganandan	Anarththan Achshathan	3A
Myrland	Viktor	4B
Nguyen	Christoffer Hoang	3B
Ommundsen	Kristoffer Sørli	9A
Opdøl	Oskar	1B

Last name	First name	Group
Paheerathan	Rithaann	4B
Pettersen	Henrik	4A
Rian	Tobias	7A
Robstad	William	7B
Rosvoldaunet	Annika Olaussen	7B
Sævareid	Olav Onstad	7B
Salte	Sigrid	4B
Skjerve	Eskil Andreas Kjønstad	3A
Sonerud	Mina Kibsgård	5B
Torp	Sindre André Svendsrud	2B
Trælandshei	Jørgen	6A
Udnæs	Andrea Charlotte Ribe	6B
Valle	Ole Gustav	9B
Vikingstad	Viktor Westerberg	4A
Vist	Sigrid	3B
Walderhaug-Johnsen	Adrian	2B
Willoch	Caroline	8B
Wittner	Herman	5A

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TTM4175 – Week 37

Networking III

Routing and DNS

Goals

Recognize the role of routing in networking

Use ip route for managing routes

Retrieve basic DNS information

Deploy simple network services

Recap of Preparation Material

Readings

Routing and DNS

Web servers

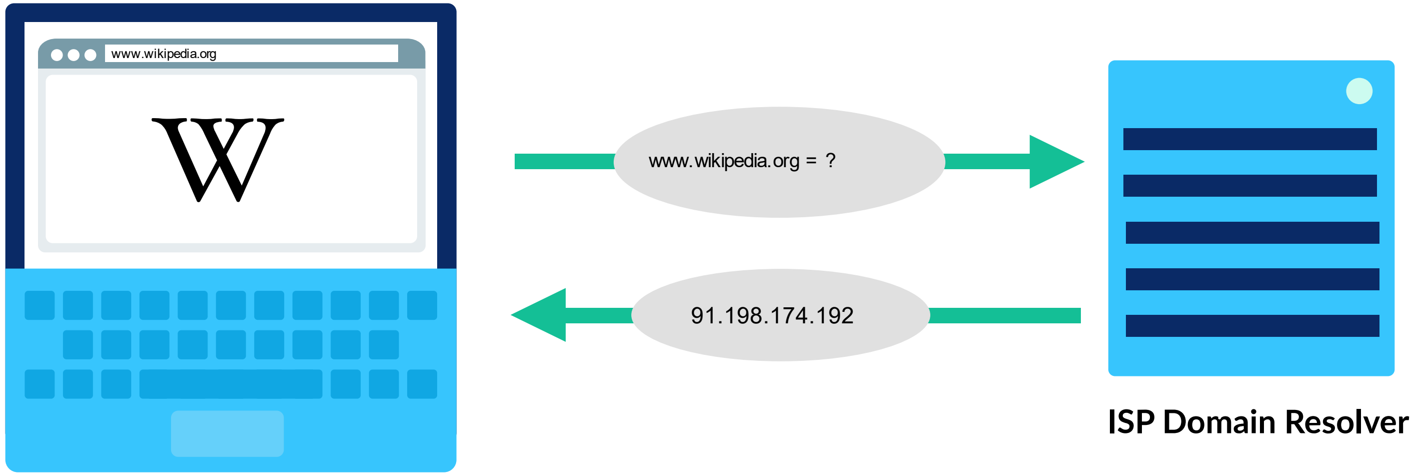
Videos

Routing and DNS

Docker compose (optional)

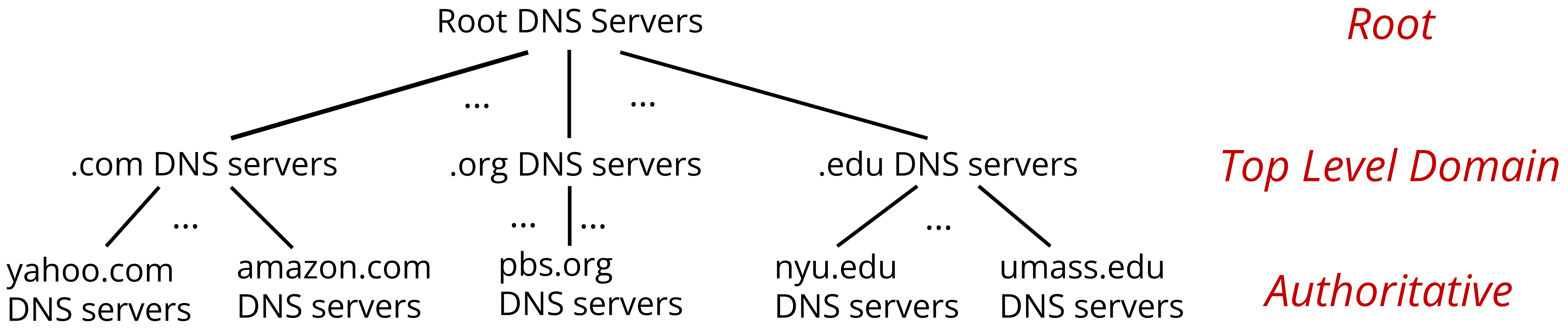
Domain Name System (DNS)

- Maps between easier-to-remember names and IPs
- **Distributed** database with trillions of daily requests
  - Performance, scalability, and security challenges!



Graphic credit: https://www.khanacademy.org/computing/computers-and-internet/xcae6f4a7ff015e7d:the-internet/xcae6f4a7ff015e7d:web-protocols/a/domain-name-system-dns

DNS - A Distributed, Hierarchical Database



Client wants IP address for www.amazon.com; 1st approximation

- Client queries root server to find .com DNS server
- Client queries .com DNS server to get amazon.com DNS server
- Client queries amazon.com DNS server to get IP address for www.amazon.com

Local DNS Name Servers

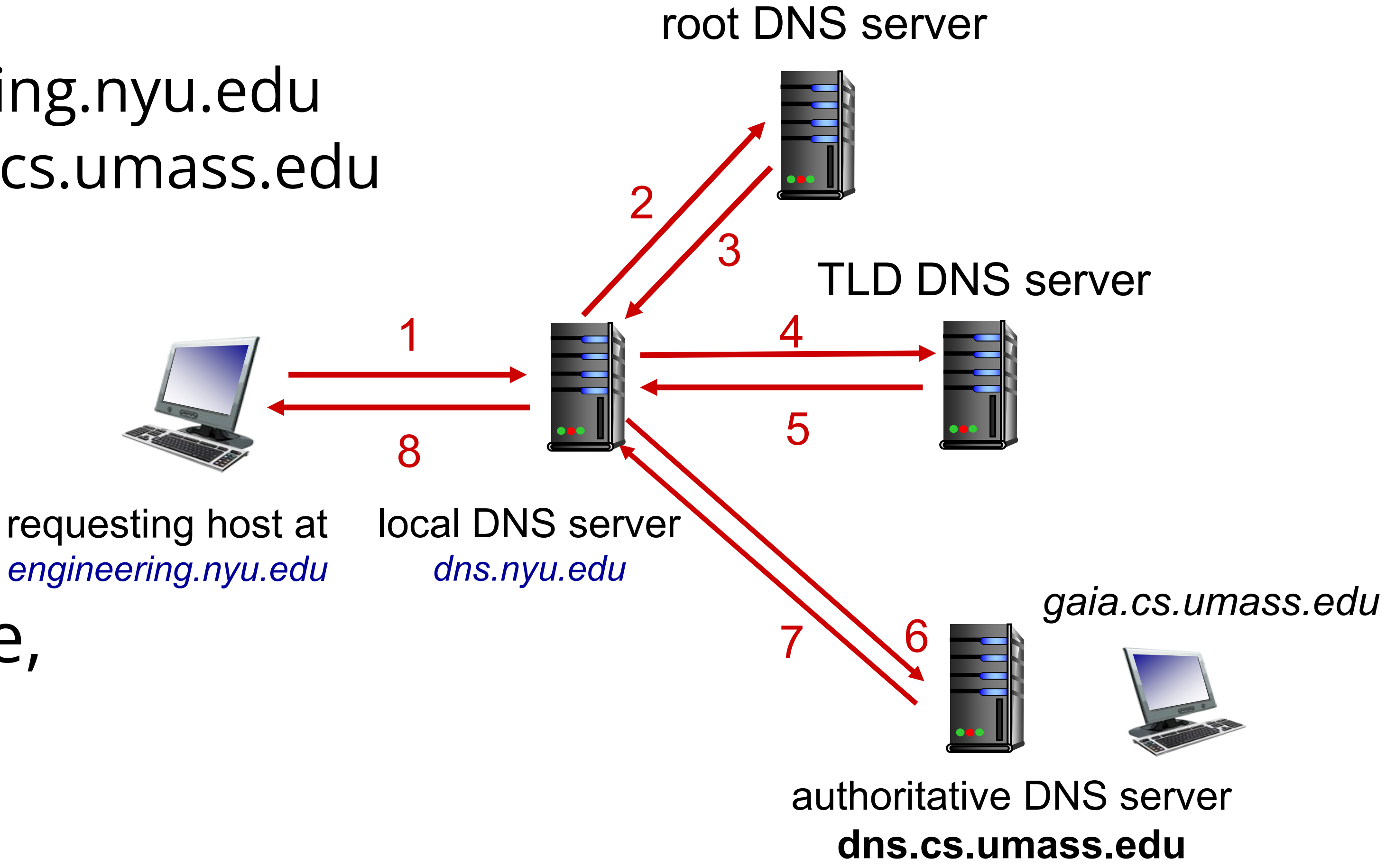
- When host makes DNS query, it is sent to its *local* DNS server
  - Local DNS server returns reply, answering
    - From its local cache of recent name-to-address translation pairs (possibly out of date!)
    - Forwarding request into DNS hierarchy for resolution
  - Each ISP has local DNS name server; to find yours
    - MacOS: `scutil --dns`
    - Windows: `ipconfig /all`
- Local DNS server doesn't strictly belong to hierarchy

DNS Name Resolution – Iterated Query

Example: host at engineering.nyu.edu wants IP address for gaia.cs.umass.edu

Iterated query

- Contacted server replies with name of server to contact
- "I don't know this name, but ask this server"



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Caching DNS Information

- Once (any) name server learns mapping, it *caches* mapping, and i*mmediately* returns a cached mapping in response to a query
  - Caching improves response time
  - Cache entries timeout (disappear) after some time (TTL)
  - TLD servers typically cached in local name servers
- Cached entries may be *out-of-date*
  - If named host changes IP address, may not be known Internet-wide until all TTLs expire!
  - *Best-effort name-to-address translation!*

IP and DNS – Useful Tools

- Checking your own IP address
  - Private: `ifconfig / ip / ipconfig`
  - Public: https://www.showmyip.com/

- Resolving IP address of a remote target
  - Operating system tools: `nslookup / dig / host`
  - Online tools: https://www.nslookup.io/
    - More options: reverse lookups (IP address → domain), lookups from different geographical locations (under “Local DNS”)

IP and DNS – Exercise

Go to

www.menti.com

Enter the code

1342 3859

Find your private IP address and compare with your team members. Do you notice a pattern?

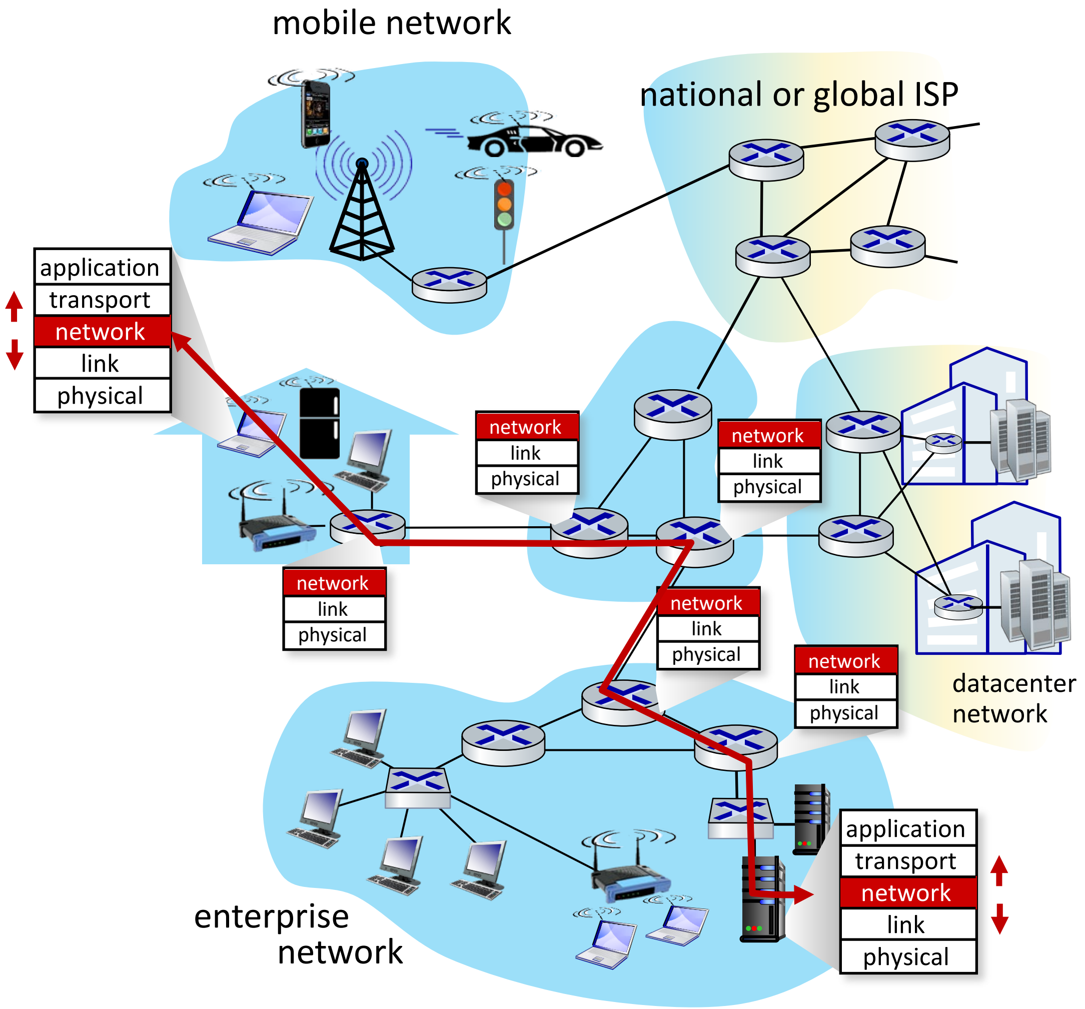
Find your public IP address and do the same

When using your local DNS tools, which name server is used? Who owns it?

Try different DNS servers at nslookup.io – do you notice something when comparing the results for large services like netflix.com?

Network-Layer Services and Protocols

- Transport segment from sending to receiving host
  - Sender: encapsulates segments into datagrams, passes to link layer
  - Receiver: delivers segments to transport layer protocol
- Network layer protocols in *every Internet device*: hosts, routers
- Routers
  - Examine header fields in all IP datagrams passing through it
  - Move datagrams from input ports to output ports to transfer datagrams along end-end path



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Two Key Network-Layer Functions

Network-layer functions

- *Forwarding:* move packets from a router's input link to appropriate router output link
- *Routing:* determine route taken by packets from source to destination
  - *Routing algorithms*

Analogy: taking a trip

- *Forwarding:* process of getting through single interchange
- *Routing:* process of planning trip from source to destination

Forwarding

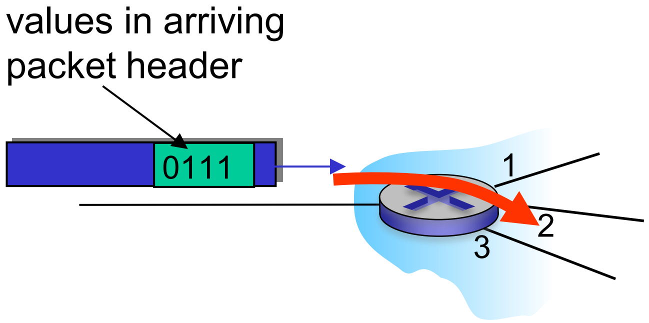
Routing

Slide adapted from "*Computer Networking: A Top Down Approach 8e*". ©

Network Layer – Data and Control Plane

Data plane

- *Local*, per-router function
- Determines how datagram arriving on router input port is forwarded to router output port



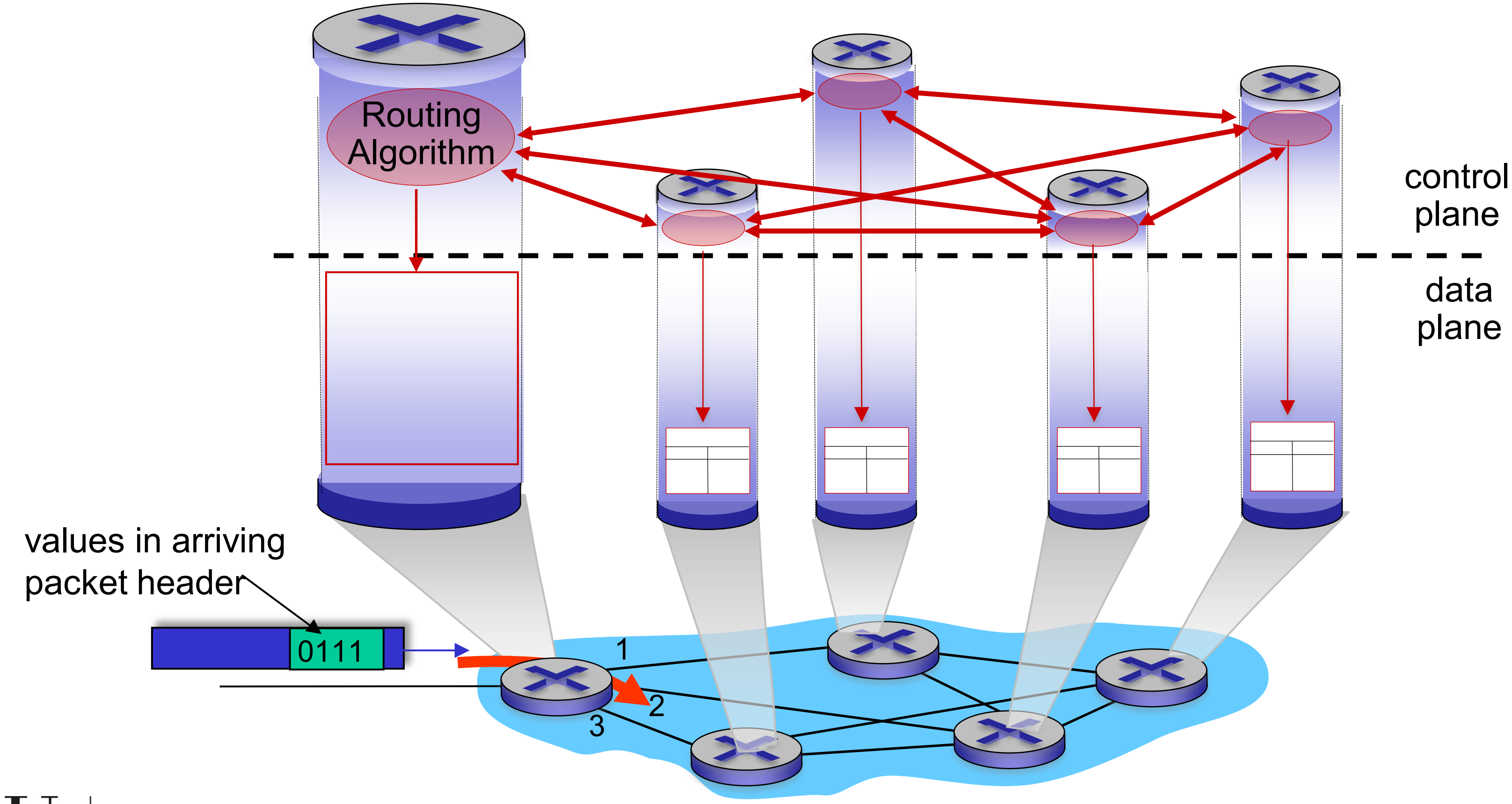
Control plane

- *Network-wide* logic
- Determines how datagram is routed among routers along end-end path from source host to destination host

Slide adapted from "*Computer Networking: A Top Down Approach 8e*".

Per-Router Control Plane

Individual routing algorithm components *in each router* interact in the control plane



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IP Prefixes, Subnet Masks, Headers

IP Prefixes

- Example: 10.240.1.0/24
  - Network address with prefix length 24
    - First 24 bits specify network address
    - 00001010 . 11110000 . 00000001 . 00000000

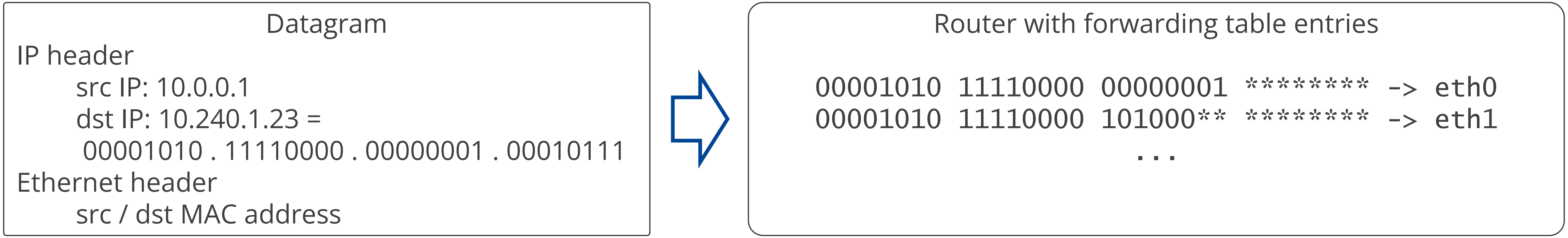
      Prefix
  - Allows routers to determine **interface towards next hop** on the way to a packet’s destination in an **aggregated** way
    - Longest prefix match: compare destination IP of packet against **all** entries, return the one with the **longest, most specific** match
    - No need to create forwarding table entries for each IP address

Subnet Masks

- 32-bit number used to extract network part from IP address
- /24 mask = 11111111 . 11111111 . 11111111 . 00000000 = 255.255.255.0
- Applying mask to any address from 10.240.1.0/24 yields network
  - 10.240.1.23 → 00001010.11110000.00000001.00010111
  - Bit-wise AND 11111111.11111111.11111111.00000000
  - 10.240.1.0 ← 00001010.11110000.00000001.00000000
- Used by hosts to determine reachability of destinations
  - Same subnet → reachable locally → send directly via layer 2
  - Other subnet → send to gateway (typically a router)

IP Prefixes, Subnet Masks, Headers

- Prefix: substring of specific length
  - Example: 00001010 11110000 00000001
  - Used by routers to perform longest prefix matching (most specific)



Datagram

IP header

src IP: 10.0.0.1

dst IP: 10.240.1.23 =

00001010 . 11110000 . 00000001 . 00010111

Ethernet header

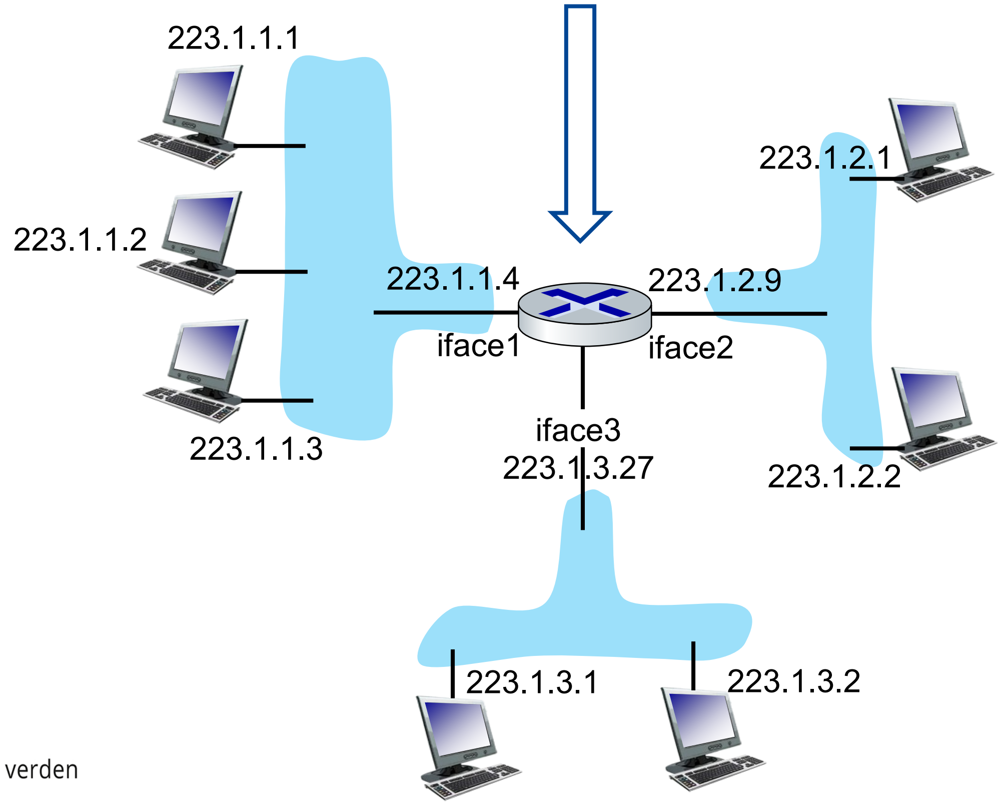
src / dst MAC address

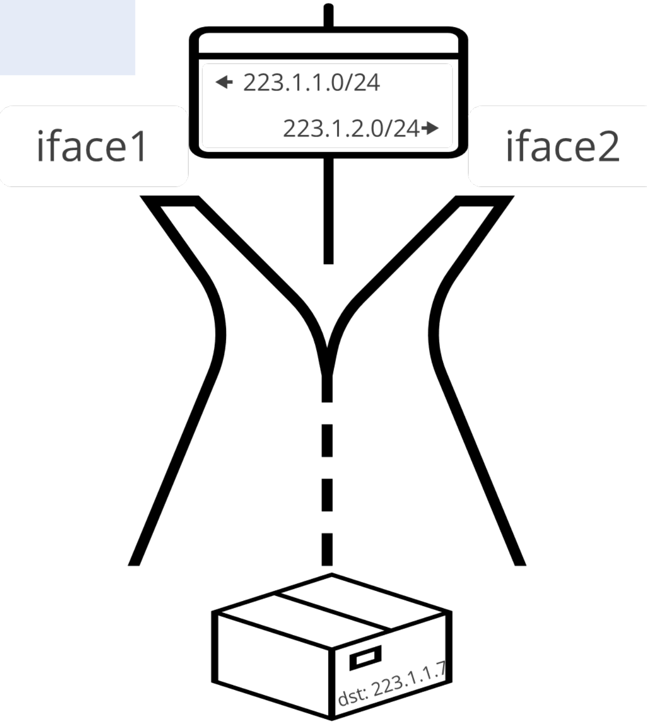
Router with forwarding table entries

```
00001010 11110000 00000001 ******** -> eth0
00001010 11110000 101000** ******** -> eth1
                 ...
```

Router Configuration – Examples

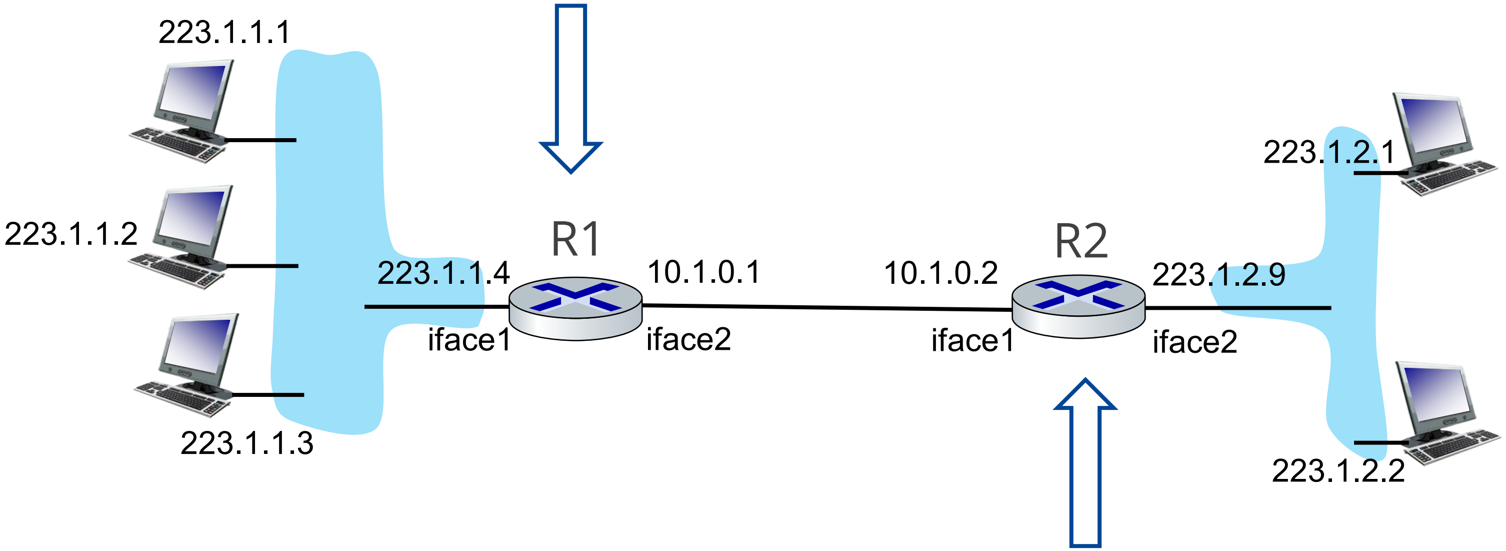
Prefix	Next-hop IP	Interface
223.1.1.0/24	- (directly conn.)	1
223.1.2.0/24	- (directly conn.)	2
223.1.3.0/24	- (directly conn.)	3





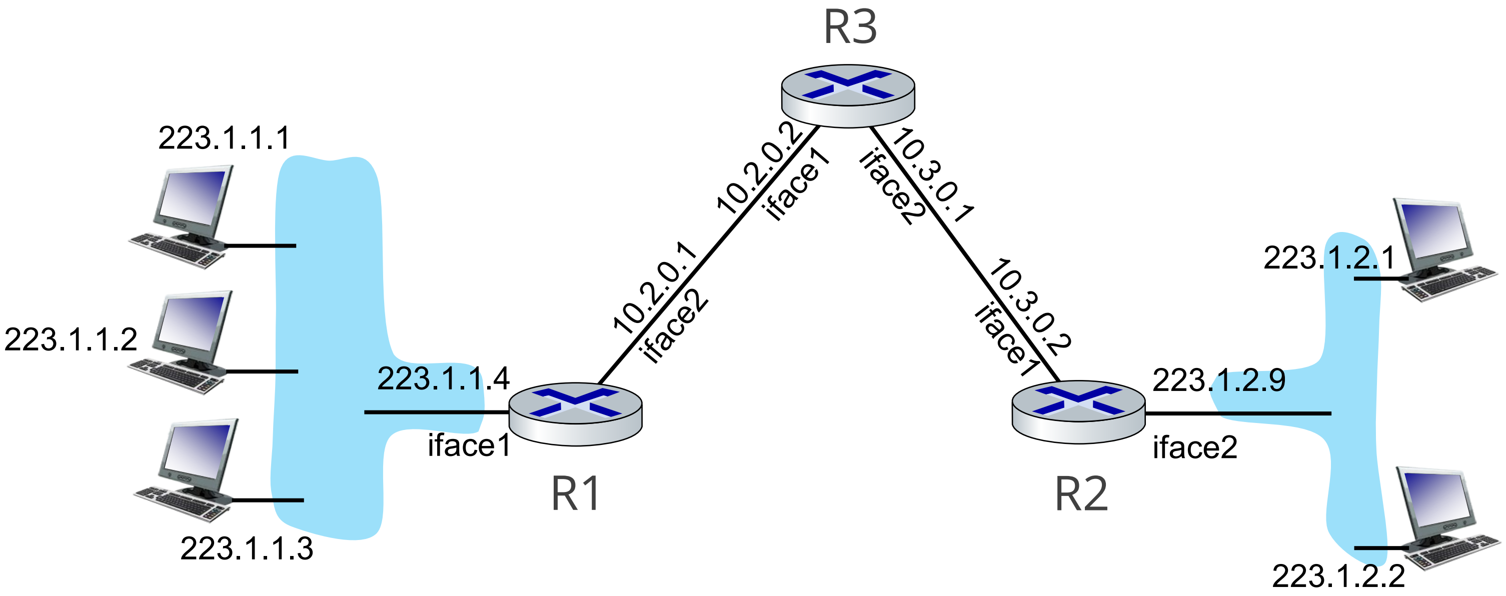
Router Configuration – Examples

Prefix	Next-hop IP	Interface
223.1.1.0/24	- (directly conn.)	1
10.1.0.0/30	- (directly conn.)	2
223.1.2.0/24	10.1.0.2	2



Prefix	Next-hop IP	Interface
223.1.2.0/24	- (directly conn.)	2
10.1.0.0/30	- (directly conn.)	1
223.1.1.0/24	10.1.0.1	1

Router Configuration – Exercise



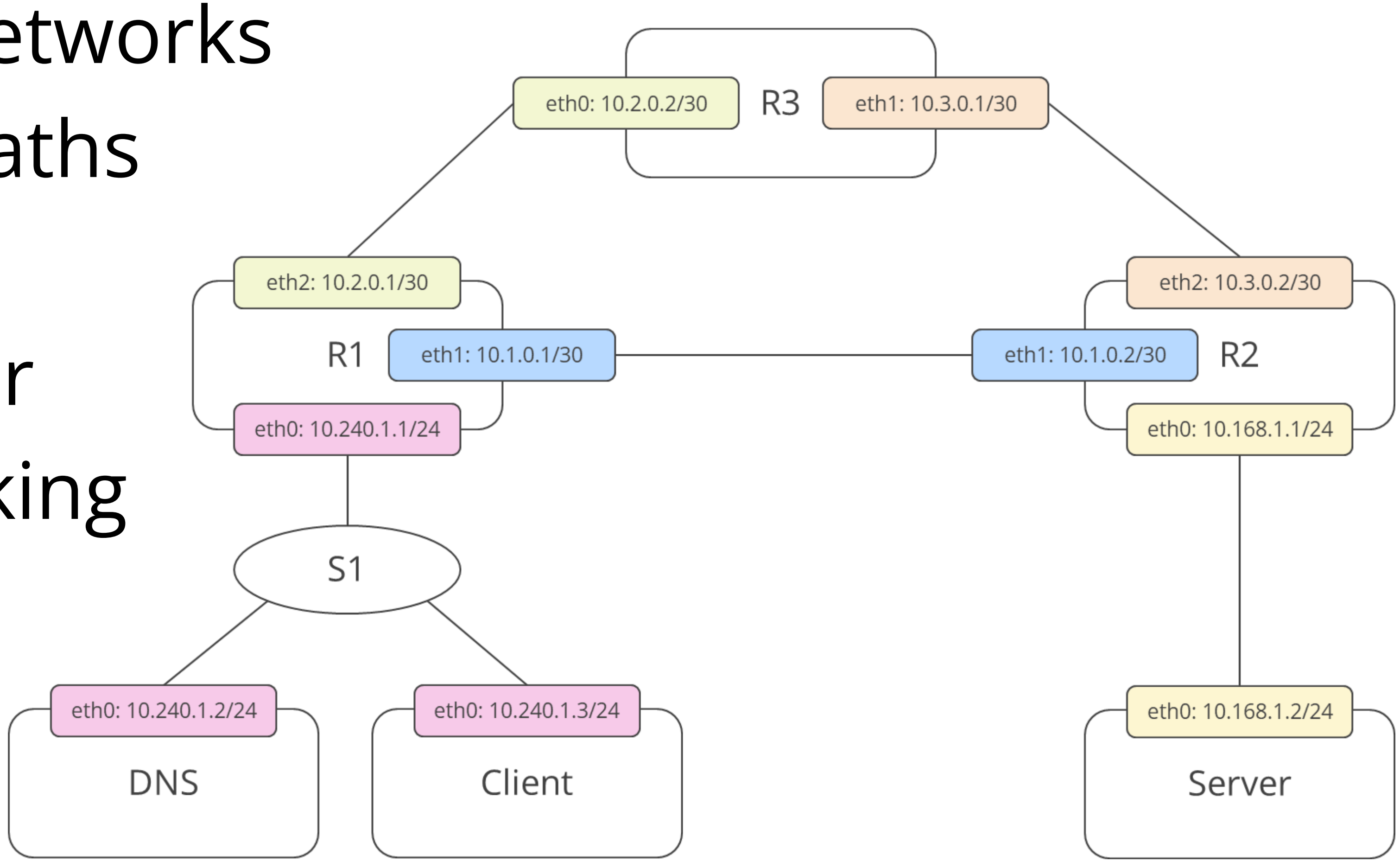
- R1

Prefix	Next-hop IP	Int.
223.1.1.0/24	-	1
10.2.0.0/30	-	2
223.1.2.0/24	10.2.0.2	2
10.3.0.0/30	10.2.0.2	2

➔ Configure R2 and R3 to allow host-host connectivity

Lab Program Today

- Navigate complex networks
- Determine packet paths
- Adjust routing
- Modify DNS behavior
- Consolidate networking knowledge


eth0: 10.2.0.2/30
R3
eth1: 10.3.0.1/30
eth2: 10.2.0.1/30
R1
eth1: 10.1.0.1/30
eth0: 10.240.1.1/24
eth2: 10.3.0.2/30
eth1: 10.1.0.2/30
R2
eth0: 10.168.1.1/24
S1
eth0: 10.240.1.2/24
DNS
eth0: 10.240.1.3/24
Client
eth0: 10.168.1.2/24
Server