

Introduction to Caching



COS 316: Principles of Computer System Design

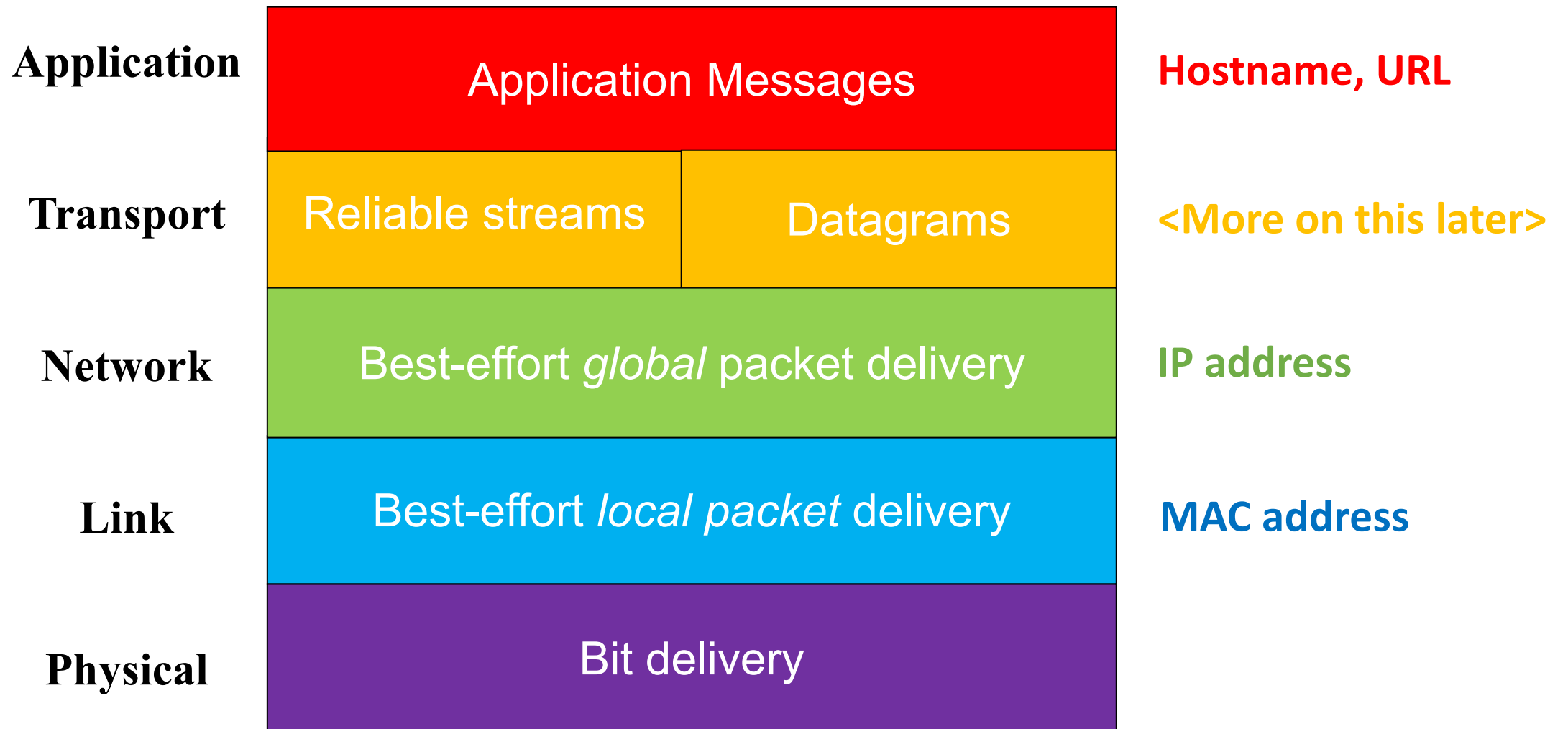
Lecture 7

Amit Levy & Ravi Netravali

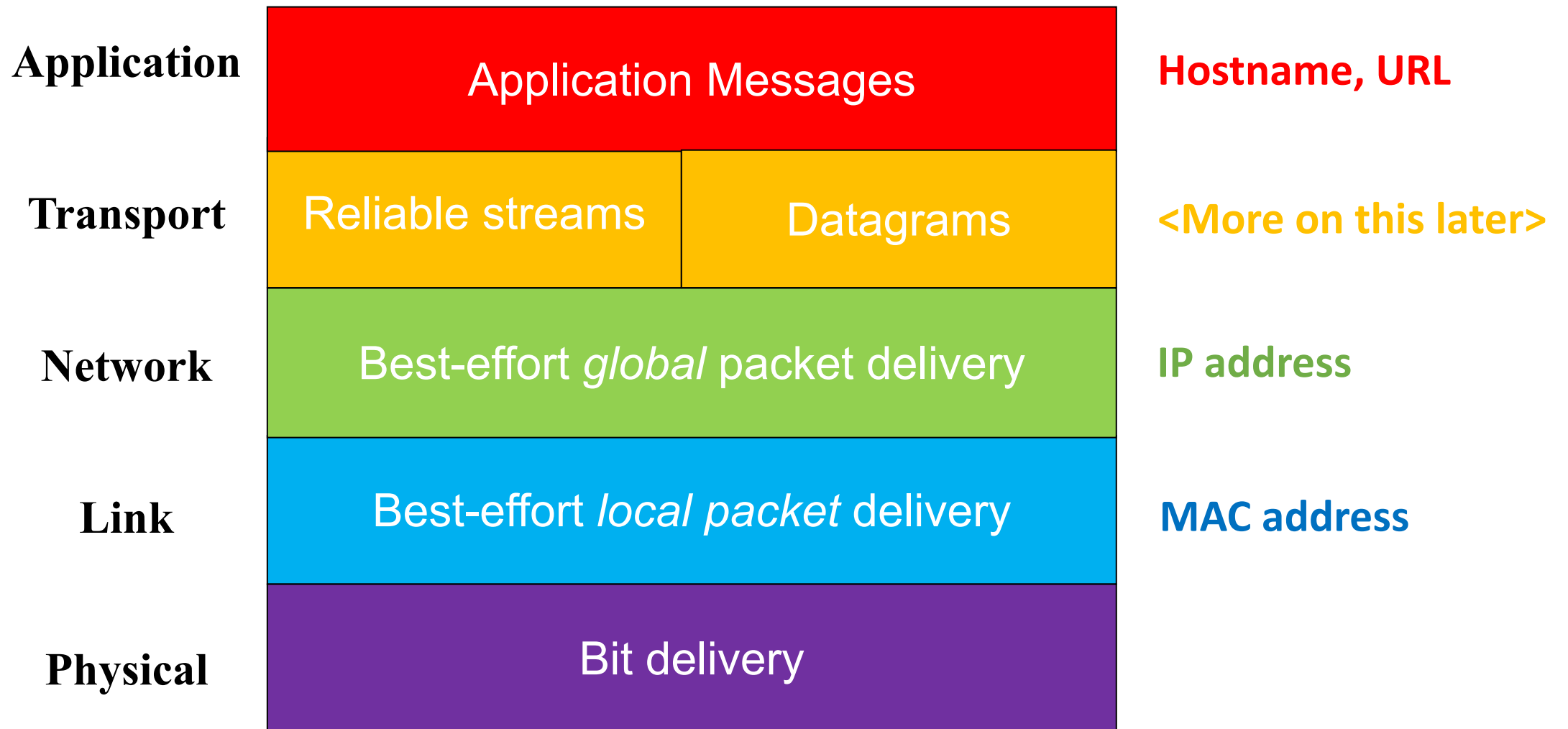
Network Naming

Type of Name	Example
Uniform Resource Locator	<code>http://www.cs.princeton.edu/~ravi/index.html</code>
Hostname	<code>www.cs.princeton.edu</code>
Internet Protocol (IP) Address	<code>128.112.136.61</code>
Media Access Control (MAC) Address	<code>00:15:C5:49:04:A9</code>

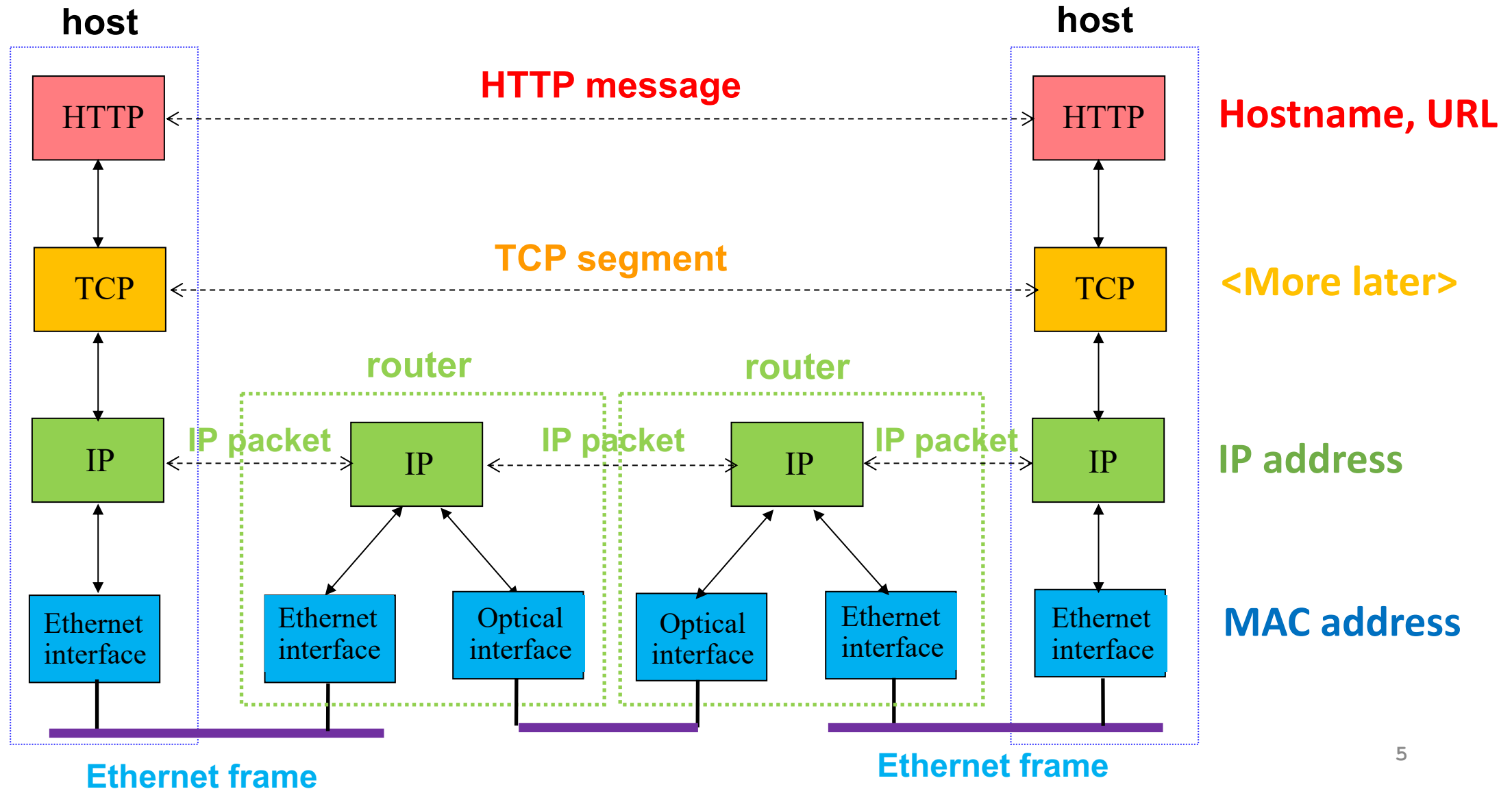
Internet Protocol Stack



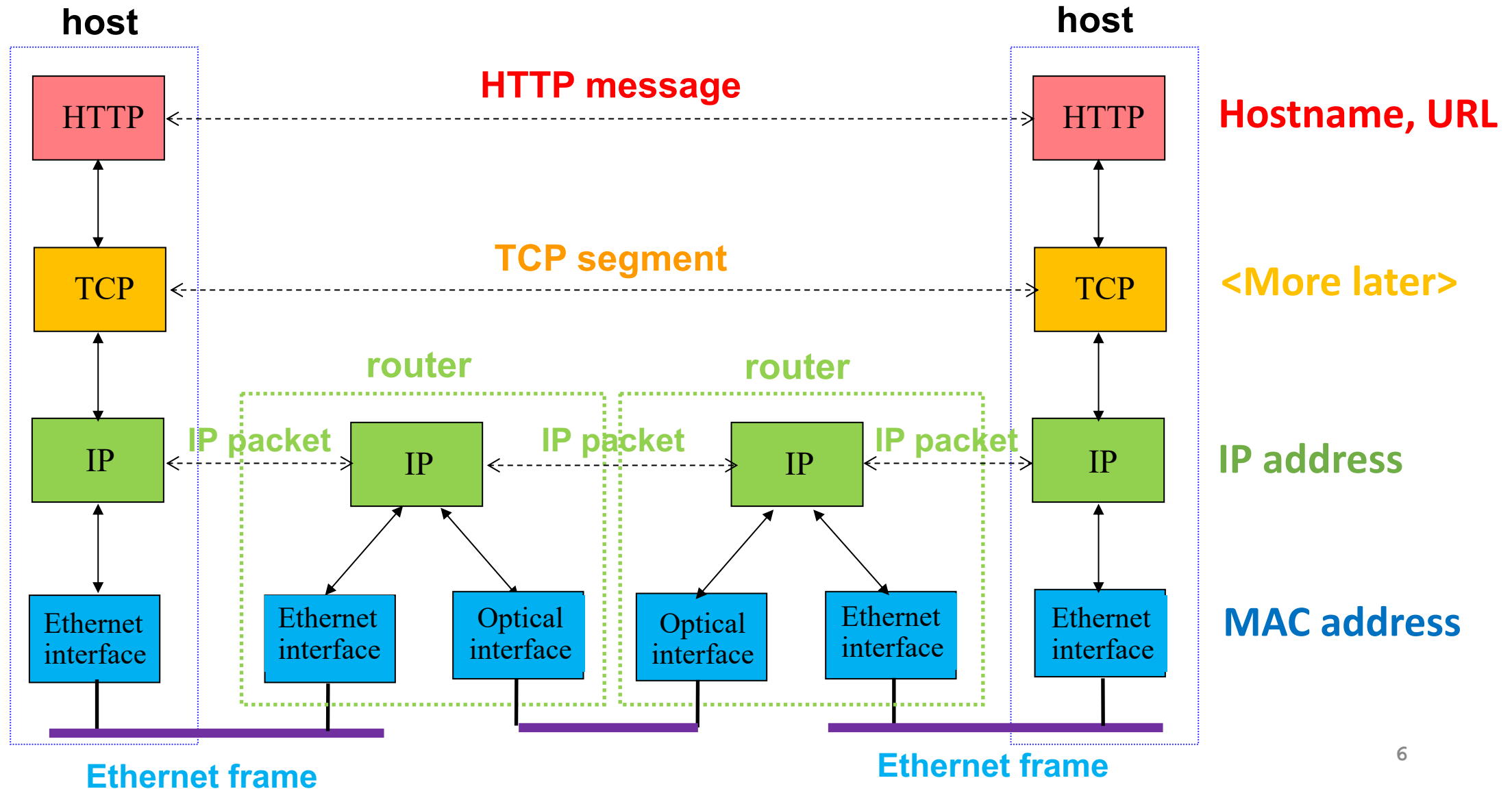
Internet Protocol Stack



Internet Protocol Stack

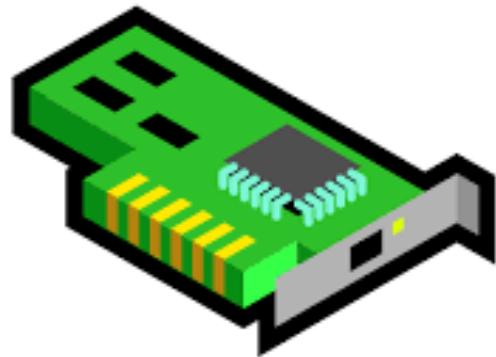


Internet Protocol Stack



MAC Layer Names for Local Packet Delivery

- *What are we naming?*
- Network interfaces
 - Ethernet interface
 - WiFi interface
 - ...



Values:

Names:

Allocation:

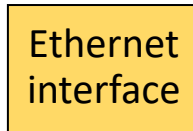
Lookup:

MAC Layer Names for Local Packet Delivery

- *Who will use the names?*

Values: Network Interfaces

- Network adaptors
 - This packet is for you.
 - Is this packet for me?



Names:

- *Goals for name?*
 - Fast and easy for adaptors to check

Allocation:

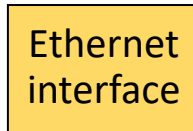
Lookup:

MAC Layer Names for Local Packet Delivery

- *Who will use the names?*

Values: Network Interfaces

- Network adaptors
 - This packet is for you.
 - Is this packet for me?



Names:

- *Goals for name?*
 - Fast and easy for adaptors to check
 - Globally unique

Allocation:

- MAC addresses are 48-bit addresses
 - 00:15:C5:49:04:A9

Lookup:

MAC Layer Names for Local Packet Delivery

- *Globally unique names?*
- Ask central authority for every name? **X**
- Random allocation? **X**
- Two-level allocation? **✓**
 - Central authority allocates blocks to vendors
 - Vendors assigns address for its blocks
 - **00:15:C5:49:04:A9**
Dell

Values: Network Interfaces

Names: 48-bit address

Allocation:

Lookup:

MAC Layer Names for Local Packet Delivery

- *Globally unique names?*
- Ask central authority for every name? **X**
- Random allocation? **X**
- Two-level allocation? **✓**
 - Central authority allocates blocks to vendors
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 - **00:15:C5:49:04:A9**
Dell

Values: Network Interfaces

Names: 48-bit address

Allocation:

Lookup:

MAC Layer Names for Local Packet Delivery

- Lookup
 - Flood packet to all hosts in the network
 - (Optionally) learn what direction to go

Values: Network Interfaces

Names: 48-bit address

Allocation: Vendor from their assigned blocks

Lookup: Local flooding

Network Layer Names for Global Packet Delivery

- *What are we naming?*

Values:

- Hosts

- My laptop
- Zoom server
- Your laptop
- ...

Names:

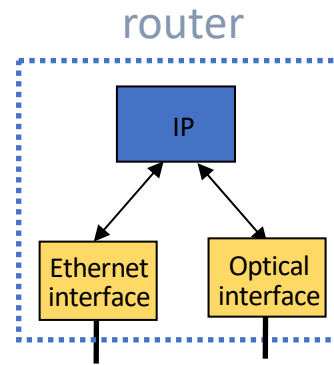
Allocation:

Lookup:



Network Layer Names for Global Packet Delivery

- *Who will use the names?*
- Routers
 - Where is this packet headed?



Values: Hosts

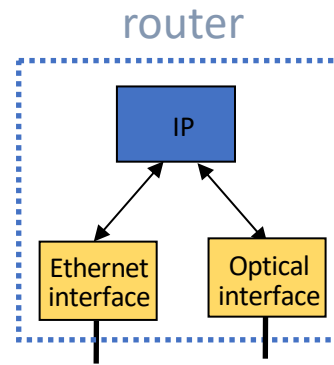
Names:

Allocation:

Lookup:

Network Layer Names for Global Packet Delivery

- *Who will use the names?*
- Routers
 - Where is this packet headed?
- *Goals for name?*
 - Fast and easy for routers to process
 - Globally unique
 - Location-based: enable routing packets to destination
- IP addresses are 32 or 128 bit addresses
 - 128.112.7.156



Values: Hosts

Names:

Allocation:

Lookup:

Network Layer Names for Global Packet Delivery

- *Globally unique and location-based names?*

Values: Hosts

- Multi-level allocation? ✓

Names: 32 bit address

- ICANN assigns large blocks to
- Regional Internet registries assign sub-blocks to
- Internet Service Providers assign addresses to
- Hosts

Allocation:

- ISPs serve a group of nearby hosts
- ISPs can route to hosts in their sub-blocks

Lookup:

Network Layer Names for Global Packet Delivery

- *How to map 128.112.7.156 to host?*
- Network Routing!
 - Can't get all the way there right away, so figure out next hop: use routing table
 - Routing protocols map destination to next-hop IP address (fill in routing table)
 - BGP, OSPF, RIP, ...
 - ARP maps next-hop IP address to MAC address

Values: Hosts

Names: 32 bit address

Allocation: Multi-level,
location-based

Lookup:

Network Layer Names for Global Packet Delivery

- ARP: Address Resolution Protocol briefly

Values: Hosts

- Broadcast Request: Who has 128.112.7.156?

Names: 32 bit address

- Broadcast Response: 00:15:C5:49:04:A9 has 128.112.7.156

Allocation: Multi-level, location-based

- Hosts cache responses, lookup in local table

Lookup: Routing table for next-hop IP; ARP next-hop IP -> MAC address

Host Names for Applications {Websites}

- *What are we naming?*
- Hosts
 - CS department webserver
 - COS316 webserver
 - ...

Values:

Names:

Allocation:

Lookup:

Host Names for Applications {Websites}

- *Who will use the names?*
- People
- *Goals for name?*
 - Memorable
 - Reflect organizational hierarchical
 - e.g., educational?, princeton?
- Hostnames are variable length, hierarchical strings
 - `www.cs.princeton.edu` vs `cos316.princeton.edu`

Values: Hosts

Names:

Allocation:

Lookup:

Host Names for Applications {Websites}

- *Globally unique and organizational-hierarchy-based names?*
- Multi-level allocation? ✓
 - IANA assigns top-level domains
 - .com, .edu, ...
 - Registries assigns second-level domains
 - princeton.edu
 - Organizations assign subdomains
 - cs.princeton.edu OR cos316.princeton.edu
 - And so on...
 - www.cs.princeton.edu

Values: Hosts

Names: hierarchical
variable-length strings

Allocation:

Lookup:

Host Names for Applications {Websites}

- *How to map cos316.princeton.edu to host?*

Values: Hosts

- Map to IP address, give to networking layer
 - Domain Name System (DNS) maps a hostname to an IP address

Names: hierarchical variable-length strings

Allocation: Multi-level, organization based

Lookup: DNS maps hostname to IP

Host Names for Applications {Websites}

- *How to map cos316.princeton.edu to host?*

Values: Hosts

- Map to IP address, give to networking layer
 - Domain Name System (DNS) maps a hostname to an IP address

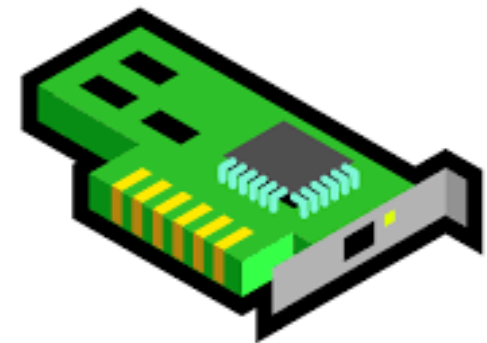
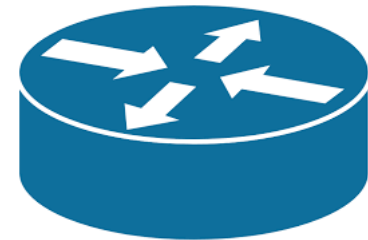
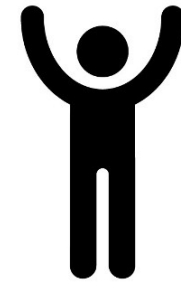
Names: hierarchical variable-length strings

Allocation: Multi-level, organization based

Lookup: DNS maps hostname to IP

Different Layers, Different Names

- **Host name** (e.g., `www.cs.princeton.edu`)
 - Mnemonic, variable-length, appreciated *by humans*
 - Hierarchical, based on organizations
- **IP address** (e.g., `128.112.136.61`)
 - Numerical 32-bit address appreciated *by routers*
 - Hierarchical, based on organizations and location
- **MAC address** (e.g., `00:15:C5:49:04:A9`)
 - Numerical 48-bit address appreciated *by adapters*
 - Hierarchical, based on vendors, unrelated to location



Hierarchical Allocation Processes

- **Host name:** `www.cs.princeton.edu`
 - **Domain:** registries for each top-level domain (e.g., .edu)
 - **Host name:** local administrator assigns to each host
- **IP addresses:** `128.112.136.61`
 - **Prefixes:** ICANN, regional Internet registries, and ISPs
 - **Hosts:** static configuration, or dynamic using DHCP
- **MAC addresses:** `00:15:C5:49:04:A9`
 - **Blocks:** assigned to equipment vendors by the IEEE
 - **Adapters:** assigned by the vendor from its block

Different Layers, Different Lookup Protocols

- Host name -> IP address via Domain Name System (DNS)
- Destination IP address to next-hop address via routing table (populated by network routing protocols)
- Next-hop IP address to MAC address via ARP
- MAC address to network interface via local flooding (or learning)

Network Naming Conclusion

- Network names identify remote endpoints
- Different layers, different names
 - *Who will use the name?*
- Multi-level hierarchical allocation
 - Goals: Unique v , reflect organizations v , location-based?
- Different layers, different lookup protocols
 - We covered ARP, COS 461 covers them all 😊
- More on network **layers** in a few weeks