

CSCI 491-01

Topics: Internet Programming

Fall 2008

Network Layer

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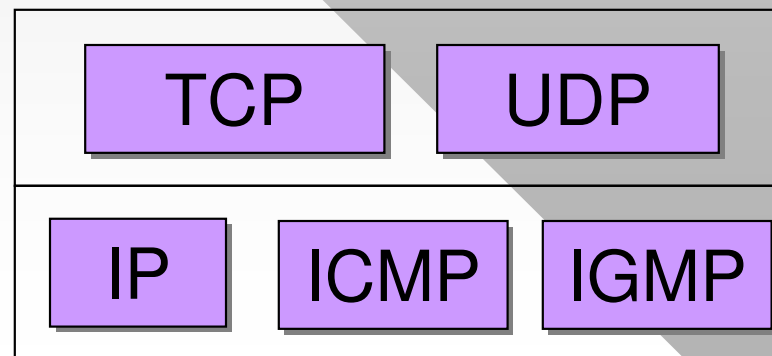
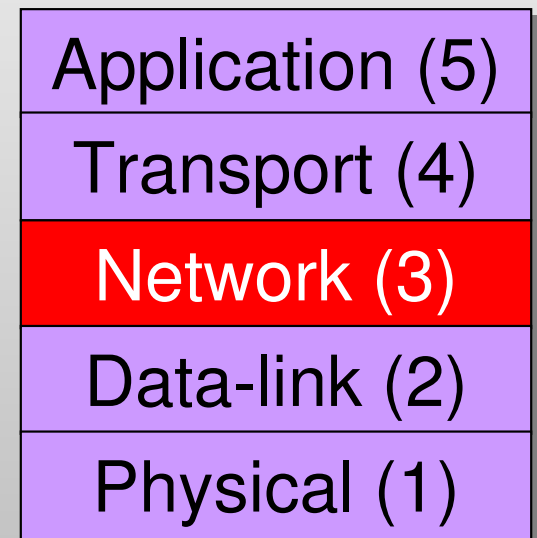
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Chapter 4: Network Layer

Chapter goals:

- Understand principles behind network layer services:
 - Routing (path selection)
 - Dealing with scale
 - How a router works
 - Advanced topics: IPv6, multicasting
- Big picture:



transport

network

Chapter 4: Roadmap

4.1 Introduction

4.2 Virtual circuit and datagram networks

4.3 What's inside a router

4.4 IP: Internet Protocol

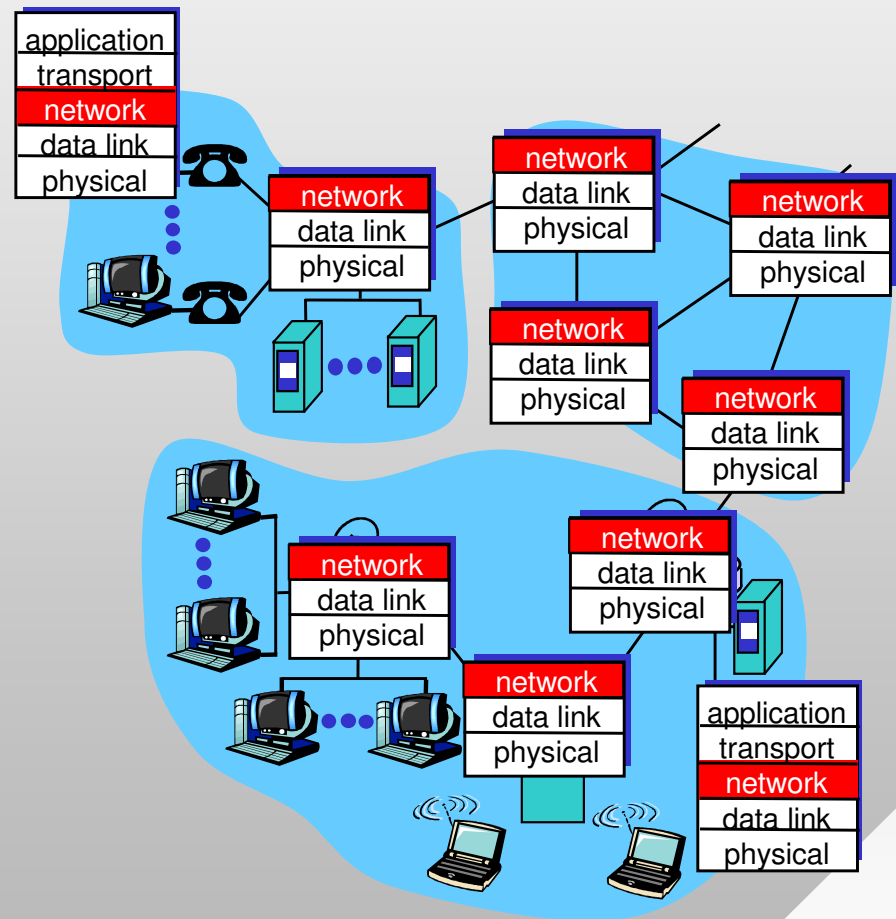
4.5 Routing algorithms

4.6 Routing in the Internet


4.7 Broadcast and multicast routing

Network Layer = IP Layer

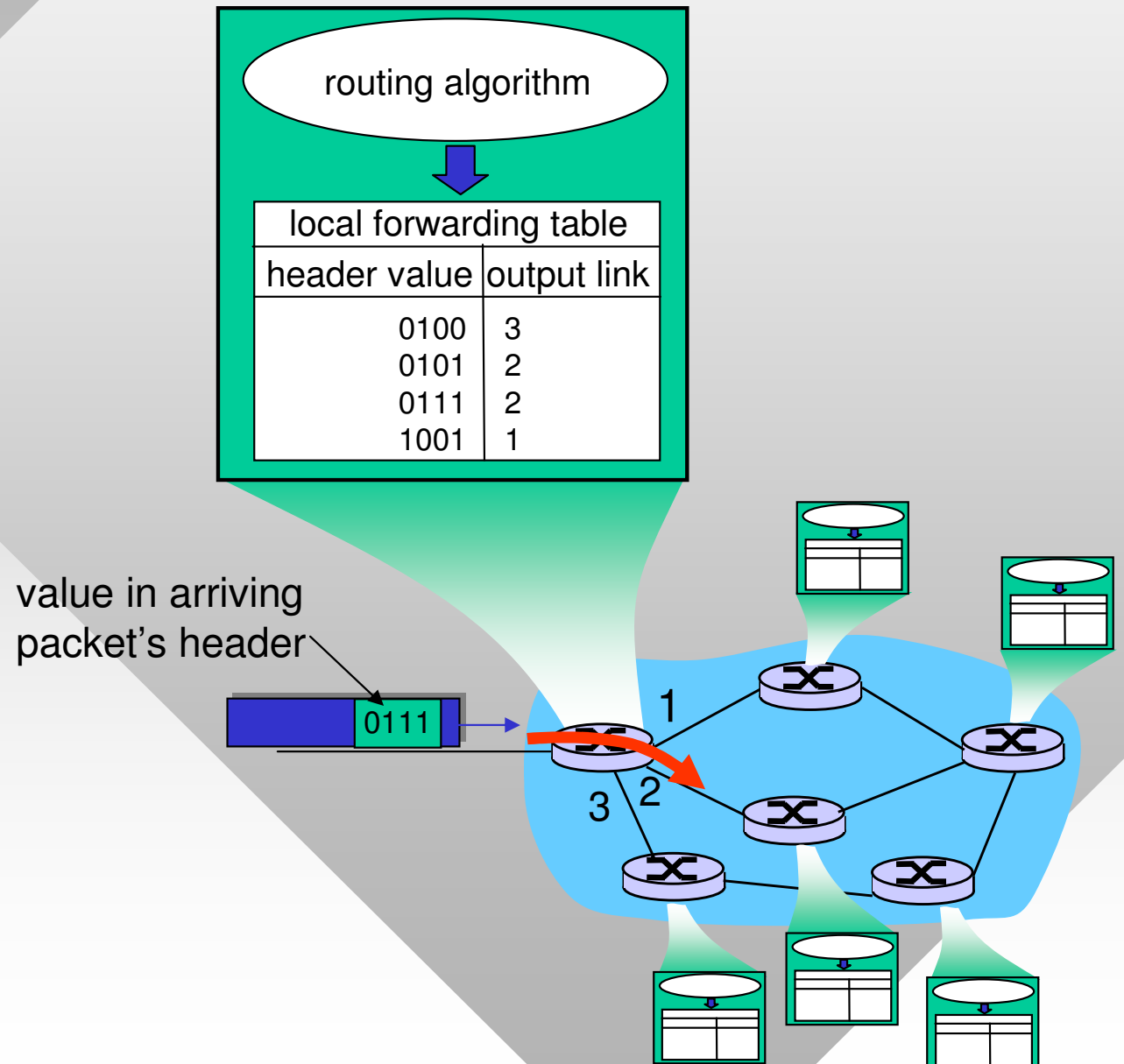
- Transports segments from sending to receiving host
- On the sending side, encapsulates segments into datagrams
- On the receiving side, delivers segments to transport layer
- Network layer protocols in *every* host and router
- Router examines header fields in all IP datagrams passing through it



Key Network-Layer Functions

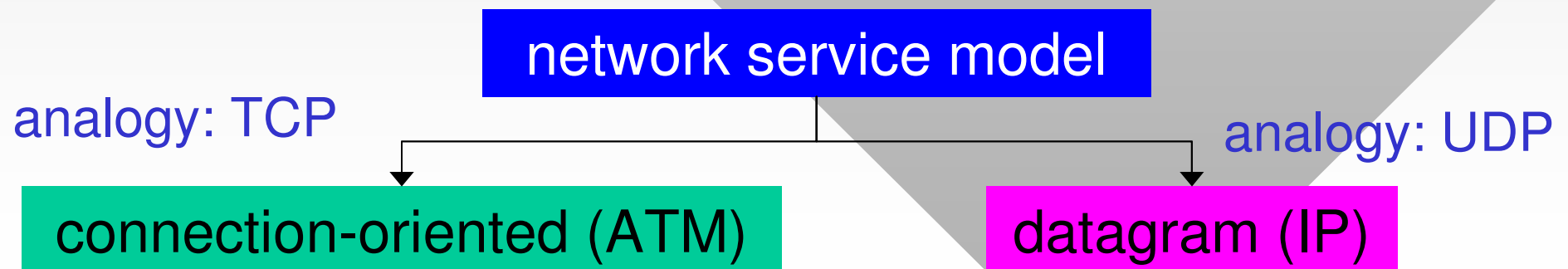
- *Routing*: determine route taken by packets from source to dest
 - Build a minimum-cost table at each router
 - Table has next-hop neighbor for each possible destination
 - **Goal**: achieve minimum-cost path (e.g., in terms of hops, ISPs, or based on peering agreements)
 - *Forwarding*: move packets from a router's input port to appropriate router output **port**
 - Table lookup
 - Port-to-port transfer
 - **Goal**: efficiency
- physical interface inside router (not a TCP/UDP port!)
- 

Interplay Between Routing and Forwarding



Connection Setup (ATM)

- **Connection setup** is a third important function in certain network architectures:
 - e.g., ATM (Asynchronous Transfer Mode)
- Before datagrams flow in such networks, two hosts and intervening routers establish a virtual circuit (VC)
 - Routers get involved to set up a path
- Network and transport layer connection service:
 - **Network:** between two hosts
 - **Transport:** between two processes



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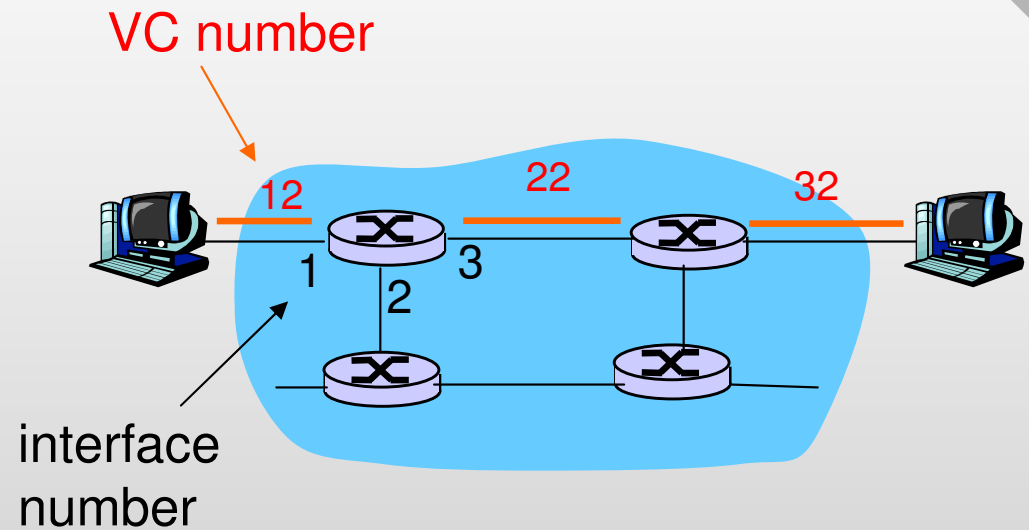
4.7 Broadcast and multicast routing

Virtual Circuits

- VCs may create a path that behaves much like a telephone circuit (no congestion, low delay, no loss)
- Call setup for each connection *before* data can flow
 - Similar to TCP's handshake, but involves routers
- Each packet carries VC identifier (tag)
- *Every* router on source-dest path maintains “state” for each passing connection
 - Mapping from tags to next-hop router
- Fraction of router resources (bandwidth, buffers) are allocated to each VC

Forwarding Table

Forwarding table in northwest router:

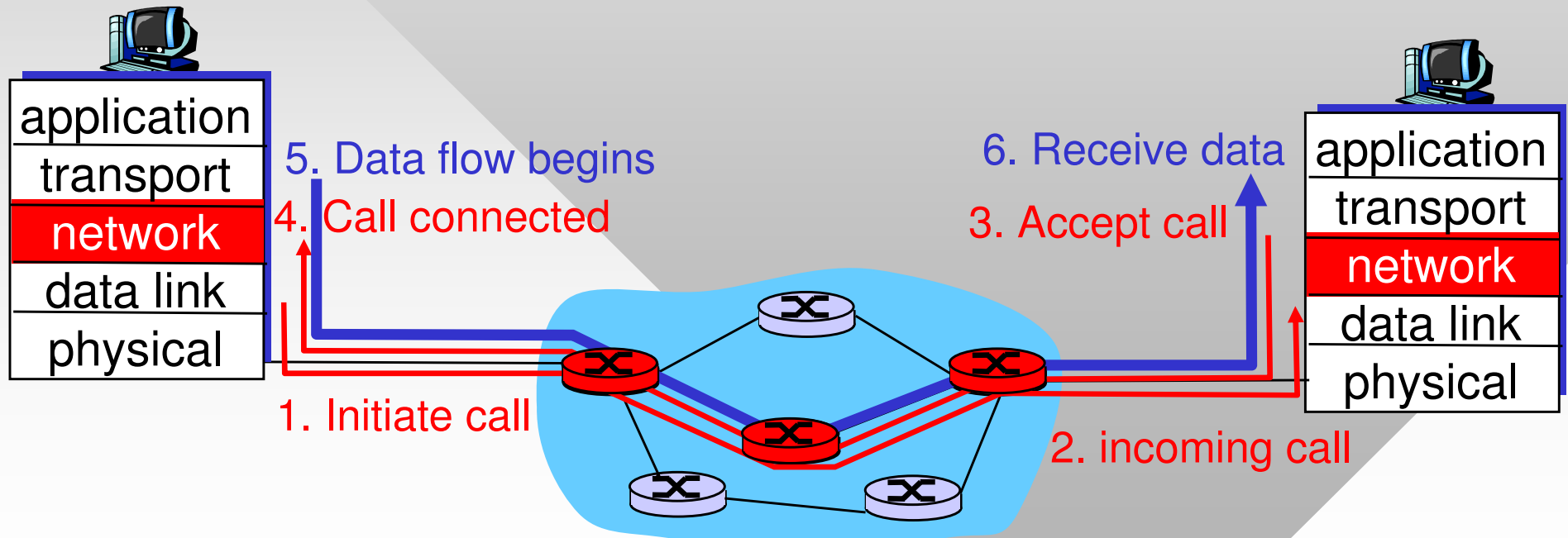


Incoming interface	Incoming VC #	Outgoing interface	Outgoing VC #
1	12	3	22
2	63	1	18
3	7	2	17
1	97	3	87
...

Routers maintain connection state information!

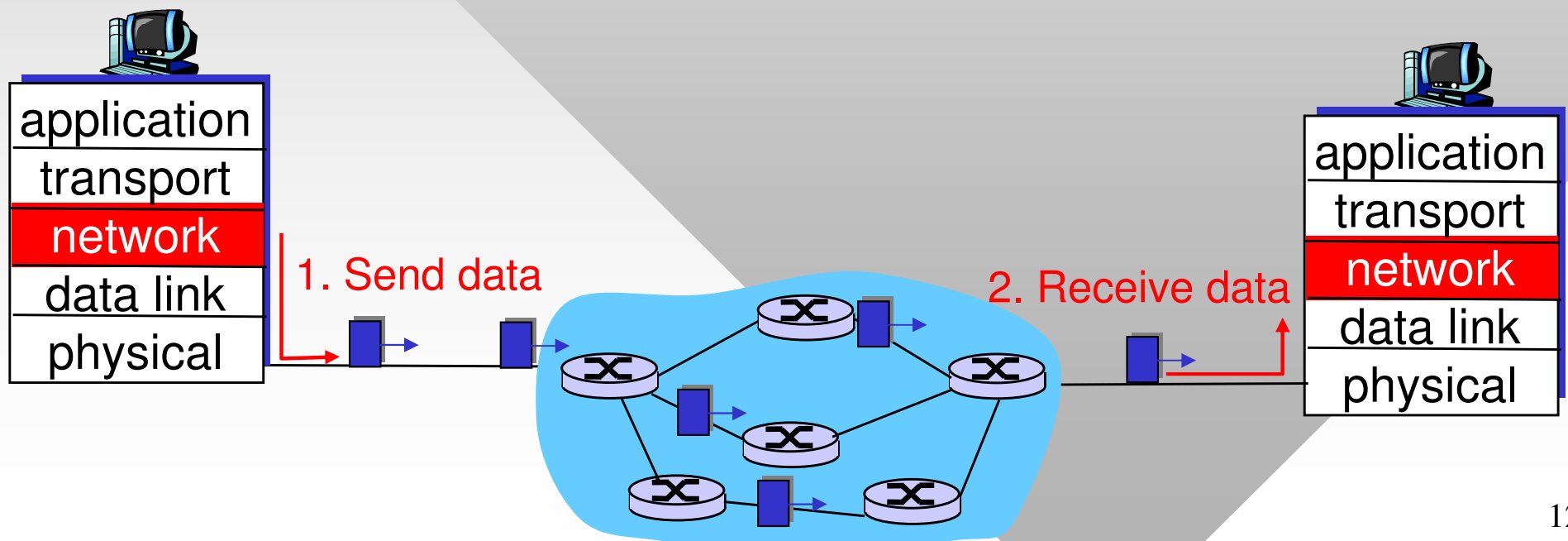
Virtual Circuits: Signaling Protocols

- Used to setup, maintain, teardown VC
- Used in ATM, frame-relay, etc.
- **Not used in today's Internet**



Datagram Networks (1960s)

- No call setup at network layer
- Routers: no state about end-to-end connections
 - No network-level concept of “connection”
- Packets forwarded using **destination host address**
 - Packets between the same source-dest pair may take different paths (**multi-path routing**)



Datagram Forwarding Table

4 billion
possible entries

Destination Address Range (32 bit)

Link Interface

11001000 00010111 00010000 00000000
through
11001000 00010111 00010111 11111111

0

11001000 00010111 00011000 00000000
through
11001000 00010111 00011000 11111111

1

11001000 00010111 00011000 00000000
through
11001000 00010111 00011111 11111111

2

otherwise

3