Computer Networks I

3rd stage
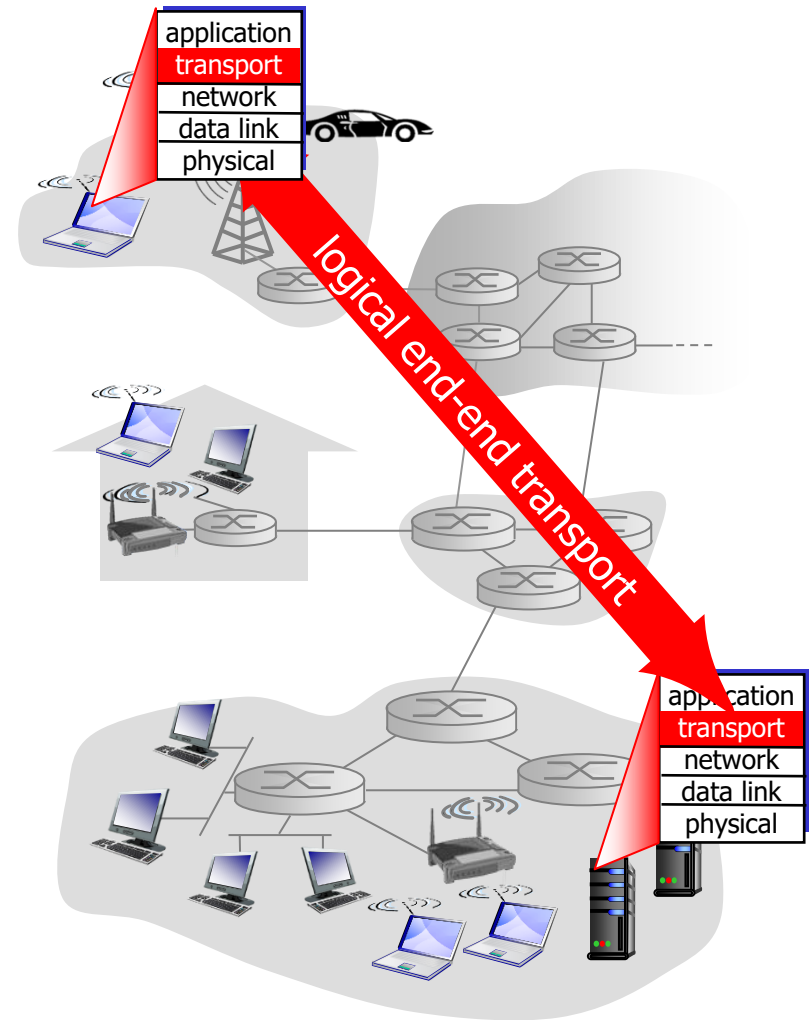
Lecture No. 5
Transport Layer

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Transport services and protocols

- ❖ provide *logical communication* between app processes running on different hosts
- ❖ transport protocols run in end systems
  - send side: breaks app messages into *segments*, passes to network layer
  - rcv side: reassembles segments into messages, passes to app layer
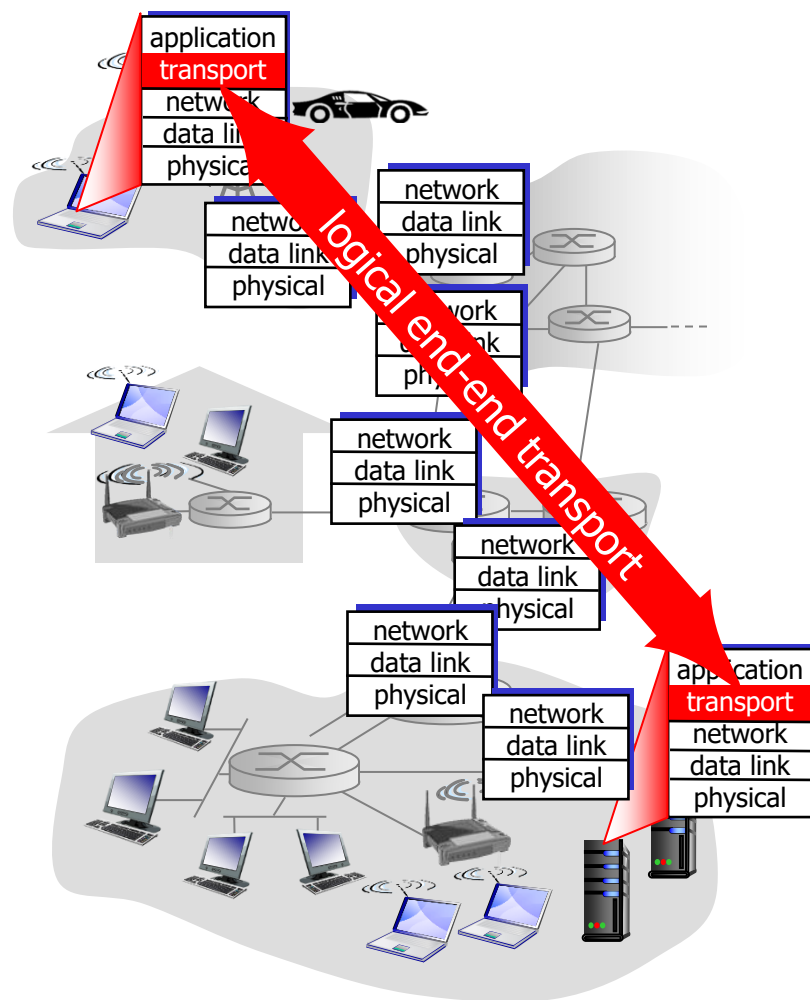- ❖ more than one transport protocol available to apps
  - Internet: TCP and UDP

application
transport
network
data link
physical

logical end-end transport

application
transport
network
data link
physical

Transport vs. network layer

* *network layer:* logical communication between hosts
* *transport layer:* logical communication between processes
  * relies on, enhances, network layer services

Internet transport-layer protocols

- ❖ reliable, in-order delivery (TCP)
  - congestion control
  - flow control
  - connection setup
- ❖ unreliable, unordered delivery: UDP
  - no-frills extension of "best-effort" IP
- ❖ services not available:
  - delay guarantees
 - bandwidth guarantees

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logical end-end transport

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UDP: User Datagram Protocol [RFC 768]

- ❖ "no frills," "bare bones" Internet transport protocol
- ❖ "best effort" service, UDP segments may be:
  - lost
  - delivered out-of-order to app
- ❖ *connectionless:*
  - no handshaking between UDP sender, receiver
  - each UDP segment handled independently of others

- ❖ UDP use:
  - streaming multimedia apps (loss tolerant, rate sensitive)
  - DNS
  - SNMP
- ❖ reliable transfer over UDP:
  - add reliability at application layer
  - application-specific error recovery!

Principles of reliable data transfer

❖ **important in application, transport, link layers**
  ▪ top-10 list of important networking topics!
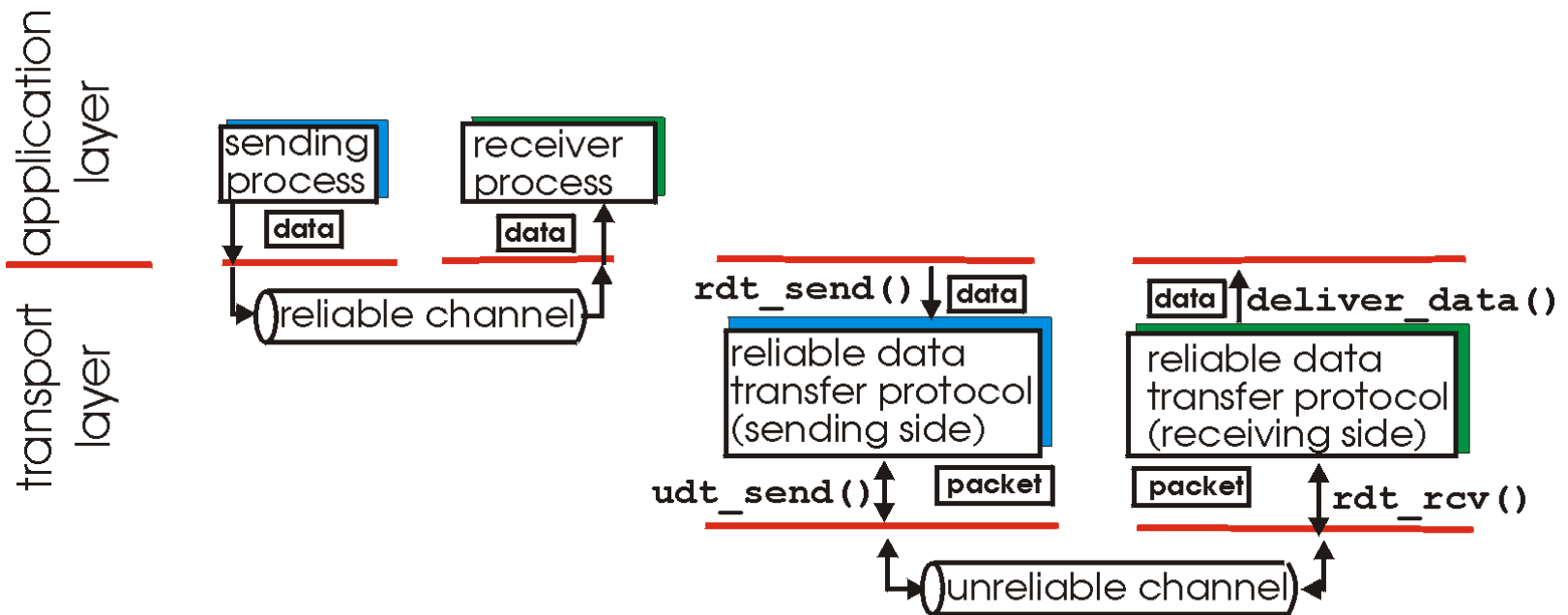
(a) provided service
(b) service implementation

❖ **characteristics of unreliable channel will determine complexity of reliable data transfer protocol (rdt)**
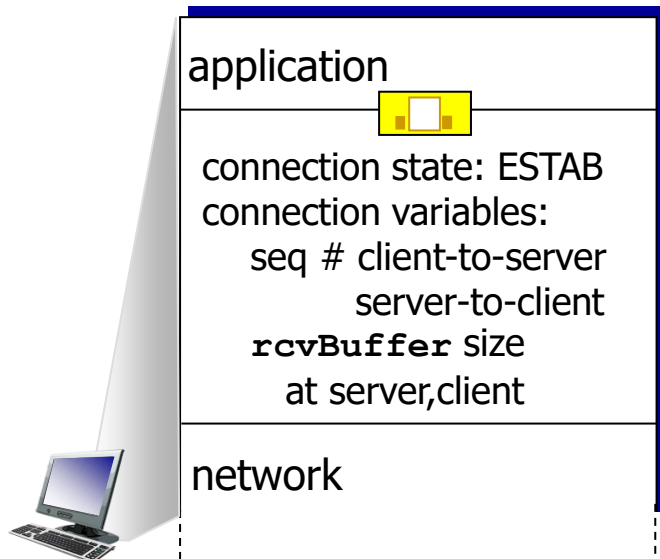
TCP: Overview RFCs: 793,1122,1323, 2018, 2581

- ❖ point-to-point:
  - one sender, one receiver
- ❖ reliable, in-order *byte steam:*
  - no "message boundaries"
- ❖ pipelined:
  - TCP congestion and flow control set window size

- ❖ full duplex data:
  - bi-directional data flow in same connection
  - MSS: maximum segment size
- ❖ connection-oriented:
  - handshaking (exchange of control msgs) inits sender, receiver state before data exchange
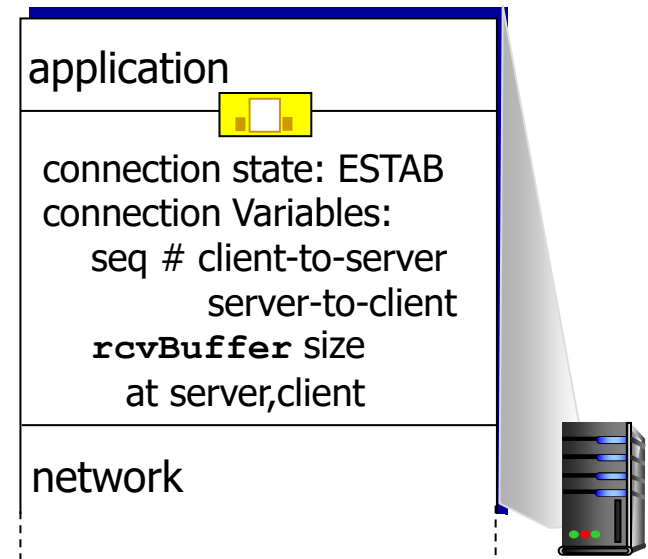- ❖ flow controlled:
  - sender will not overwhelm receiver

Connection Management

before exchanging data, sender/receiver "handshake":

❖ agree to establish connection (each knowing the other willing to establish connection)

❖ agree on connection parameters

application	
connection state: ESTAB	
connection variables:	
seq # client-to-server	
server-to-client	
rcvBuffer size	
at server,client	
network	

```
Socket clientSocket =
   newSocket("hostname","port
   number");
```

application	
connection state: ESTAB	
connection Variables:	
seq # client-to-server	
server-to-client	
rcvBuffer size	
at server,client	
network	

```
Socket connectionSocket =
   welcomeSocket.accept();
```

TCP: closing a connection

❖ client, server each close their side of connection
  ▪ send TCP segment with FIN bit = 1
❖ respond to received FIN with ACK
  ▪ on receiving FIN, ACK can be combined with own FIN
❖ simultaneous FIN exchanges can be handled

Principles of congestion control

congestion:

- ❖ informally: "too many sources sending too much data too fast for *network* to handle"
- ❖ different from flow control!
- ❖ manifestations:
  - ▪ lost packets (buffer overflow at routers)
  - ▪ long delays (queueing in router buffers)
- ❖ a top-10 problem!

Thank you for listening

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