Transport: Demultiplexing

Lecture 11

http://www.cs.rutgers.edu/~sn624/352-F24

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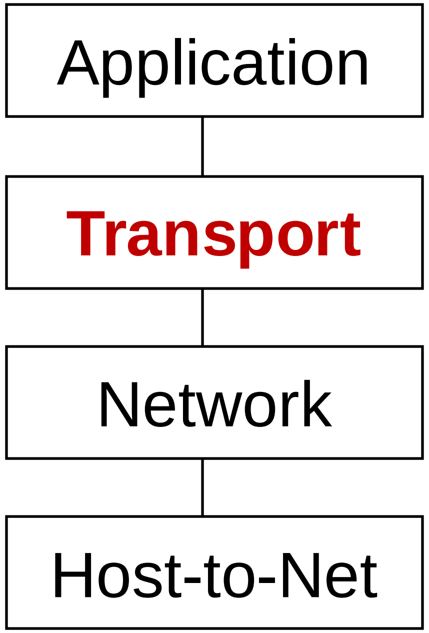
Transport

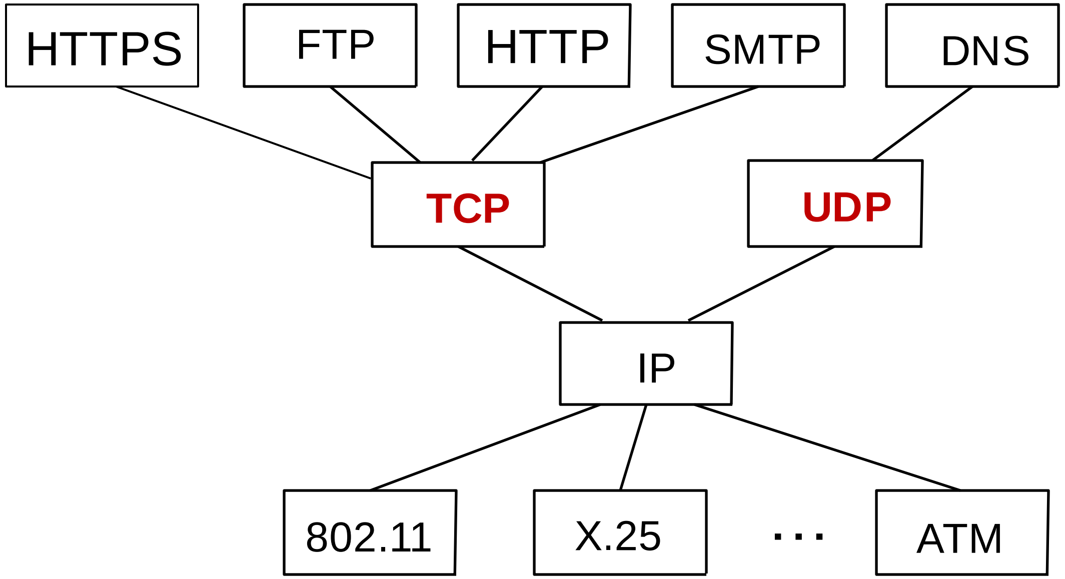


Application

Transport

Network

Host-to-Net



HTTPS FTP HTTP SMTP DNS

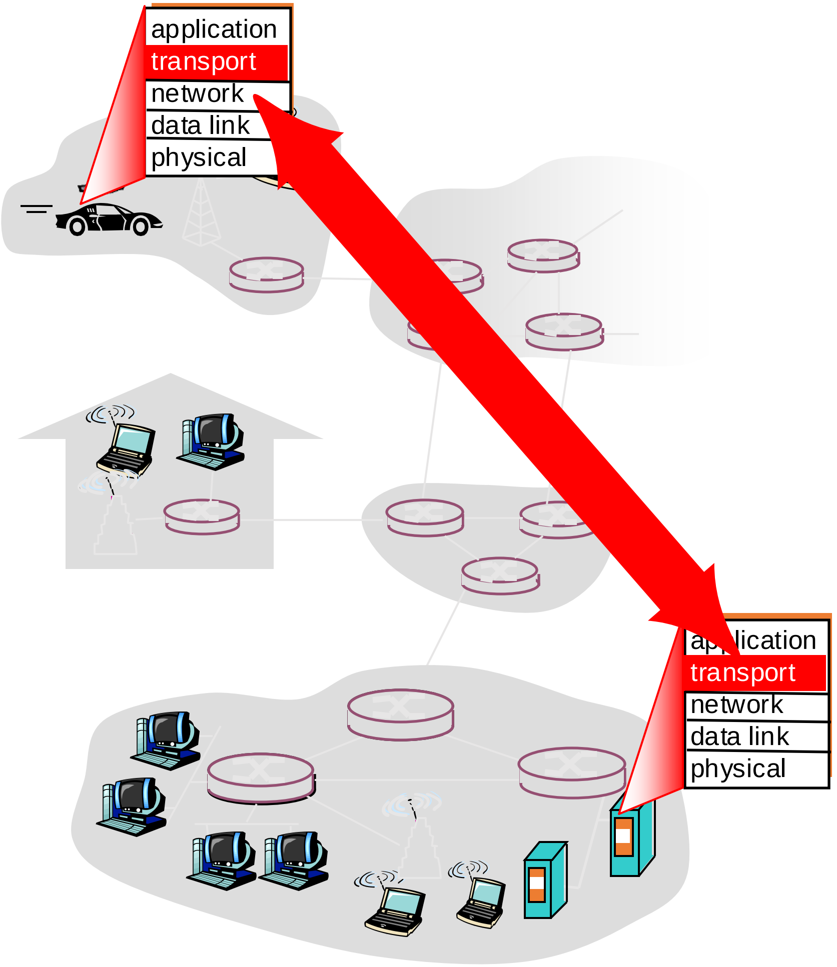
TCP **UDP**

IP

802.11 X.25 … ATM

Transport services and protocols

- Provide a communication abstraction between application processes
- Transport protocols run @ endpoints
  - send side: transport breaks app messages into segments, passes to network layer
  - recv side: reassembles segments into messages, passes to app layer
- Multiple transport protocols available to apps
  - Very popular in the Internet: TCP and UDP



Transport vs. network layer

- Transport layer: communication abstraction between processes. Delivers packets to the process.

- Network layer: abstraction to communicate between endpoints. Network layer provides best effort packet delivery to a remote endpoint.

Household analogy:

3 kids sending letters to 3 kids

- endpoints = houses
- processes = kids
- app messages = letters in envelopes
- transport protocol = Alice and Bob who de/mux to in-house siblings
- network-layer protocol = postal service

Alice

Bob

Identifying a single conversation

- Application connections are identified by 4-tuple:

- Source IP address
- Source port
- Destination IP address
- Destination port

Demultiplexing

(Not always 4-tuple)

- In this analogy,

- Source address: the address of the first house
- Source port: name of a kid in the first house
- Destination address: the address of the second house
- Destination port: name of a kid in the second house

Two popular transports

Transmission Control Protocol (TCP)

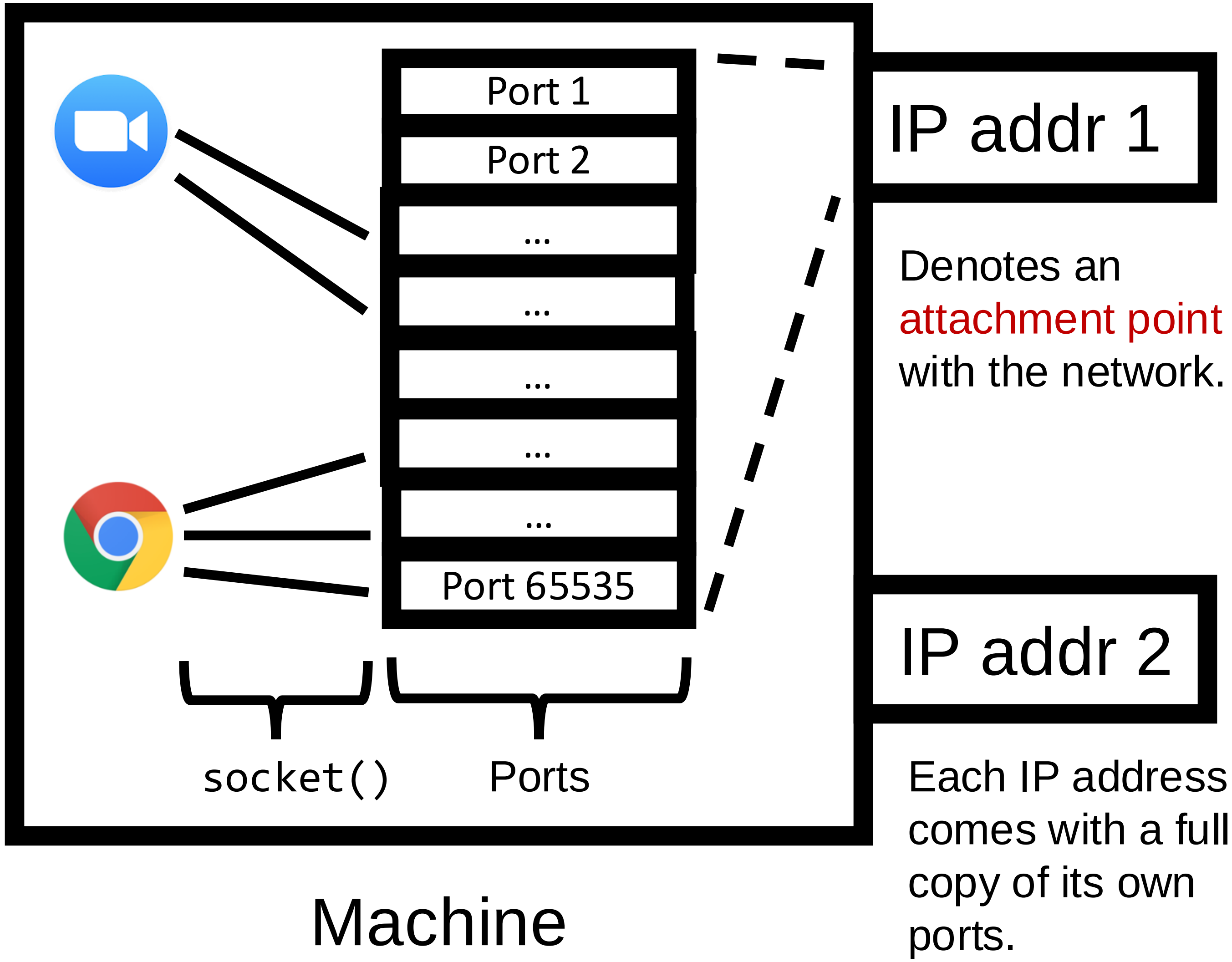
- Connection-based: the application remembers the other process talking to it.
- Suitable for longer-term, contextual data transfers, like HTTP, e-mail, etc.
- Guarantees: reliability, ordering, congestion control

User Datagram Protocol (UDP)

- Connectionless: app doesn’t remember the last process or source that talked to it.
- Suitable for single req/resp flows, like DNS.
- Guarantees: basic error detection

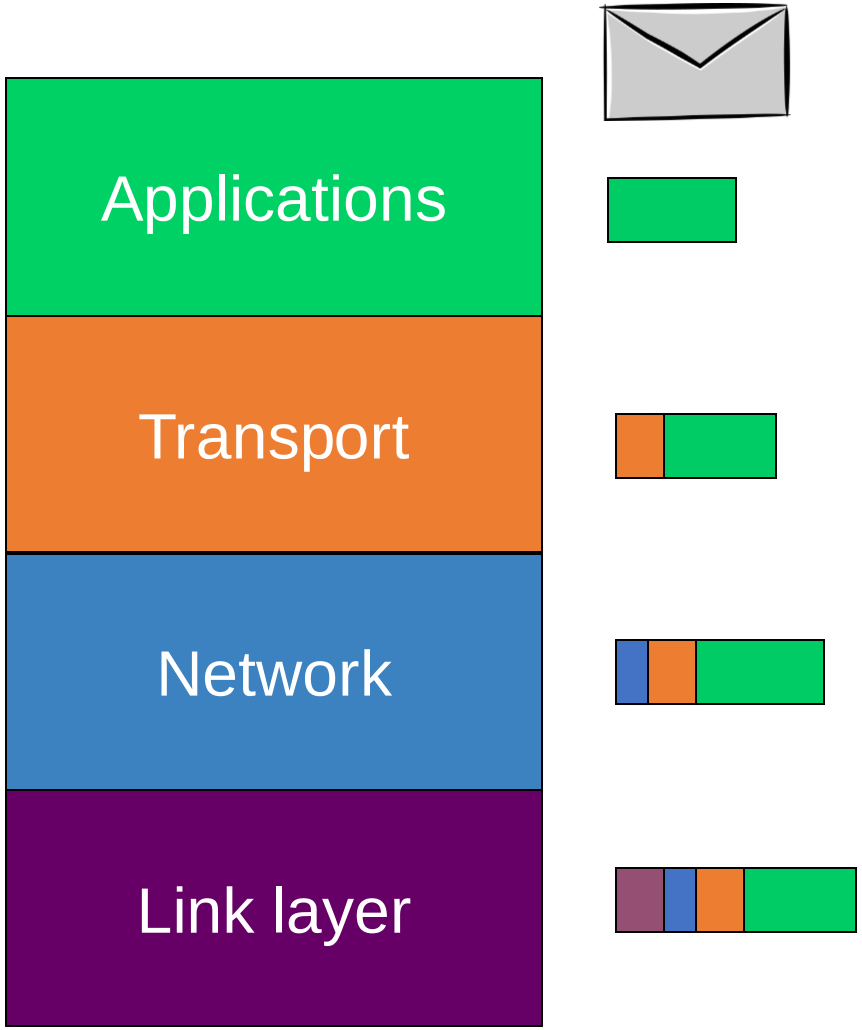
Demultiplexing Packets

Demultiplexing

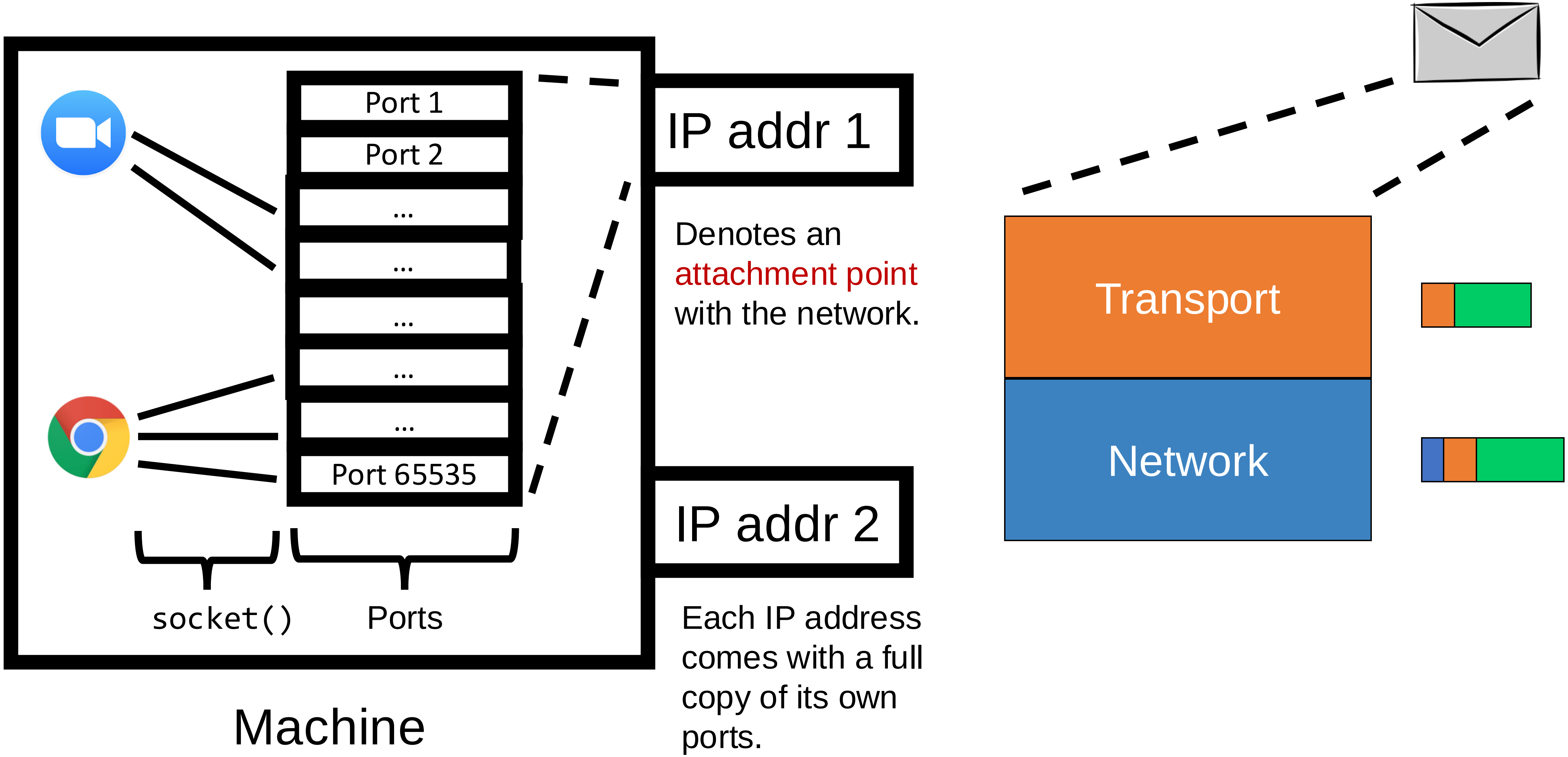


Denotes an attachment point with the network.

Each IP address comes with a full copy of its own ports.



Demultiplexing



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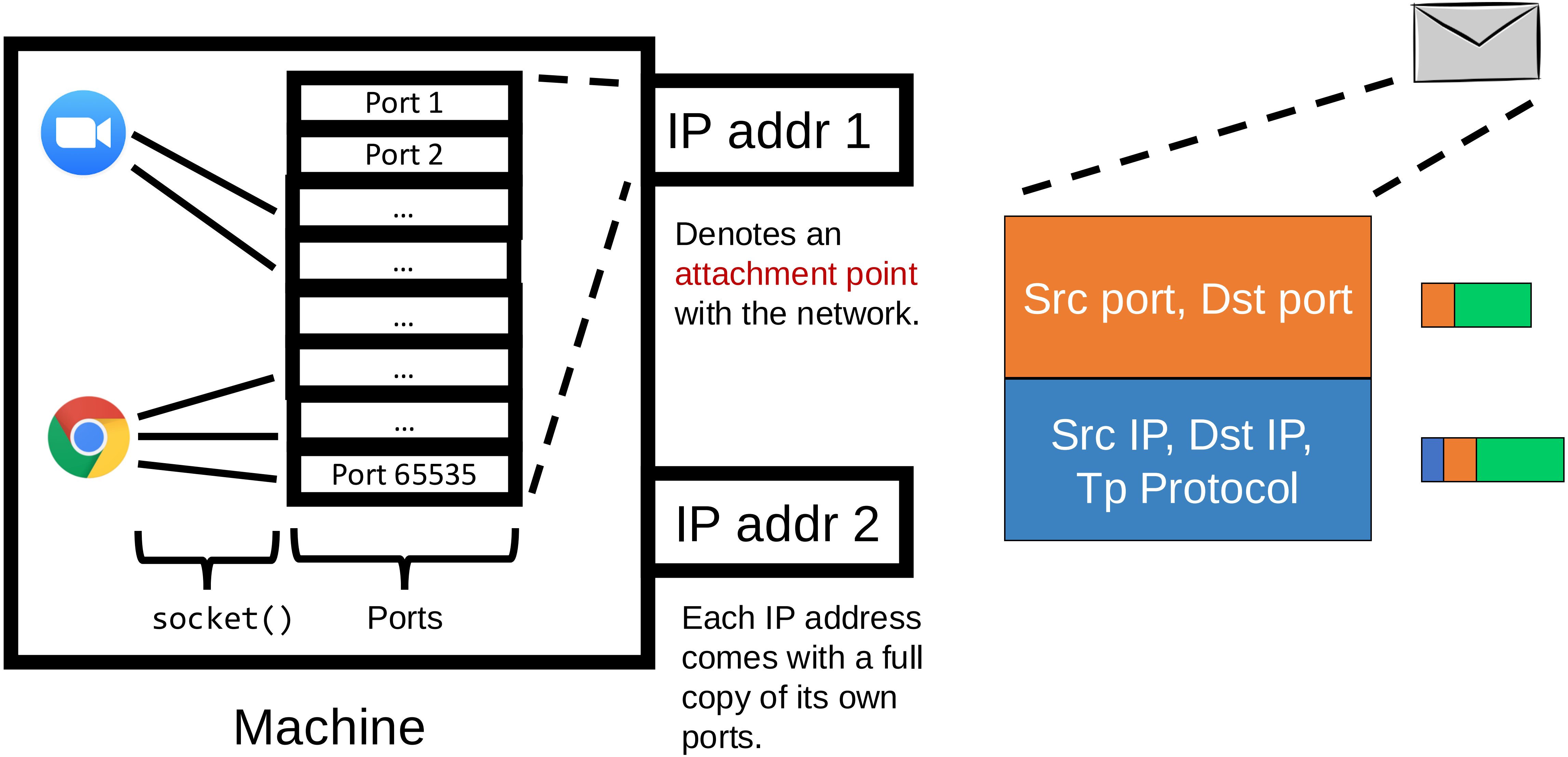


Port 1

Port 2

...

...

...

...

...

Port 65535

socket()

Ports

Machine

IP addr 1

Denotes an attachment point with the network.

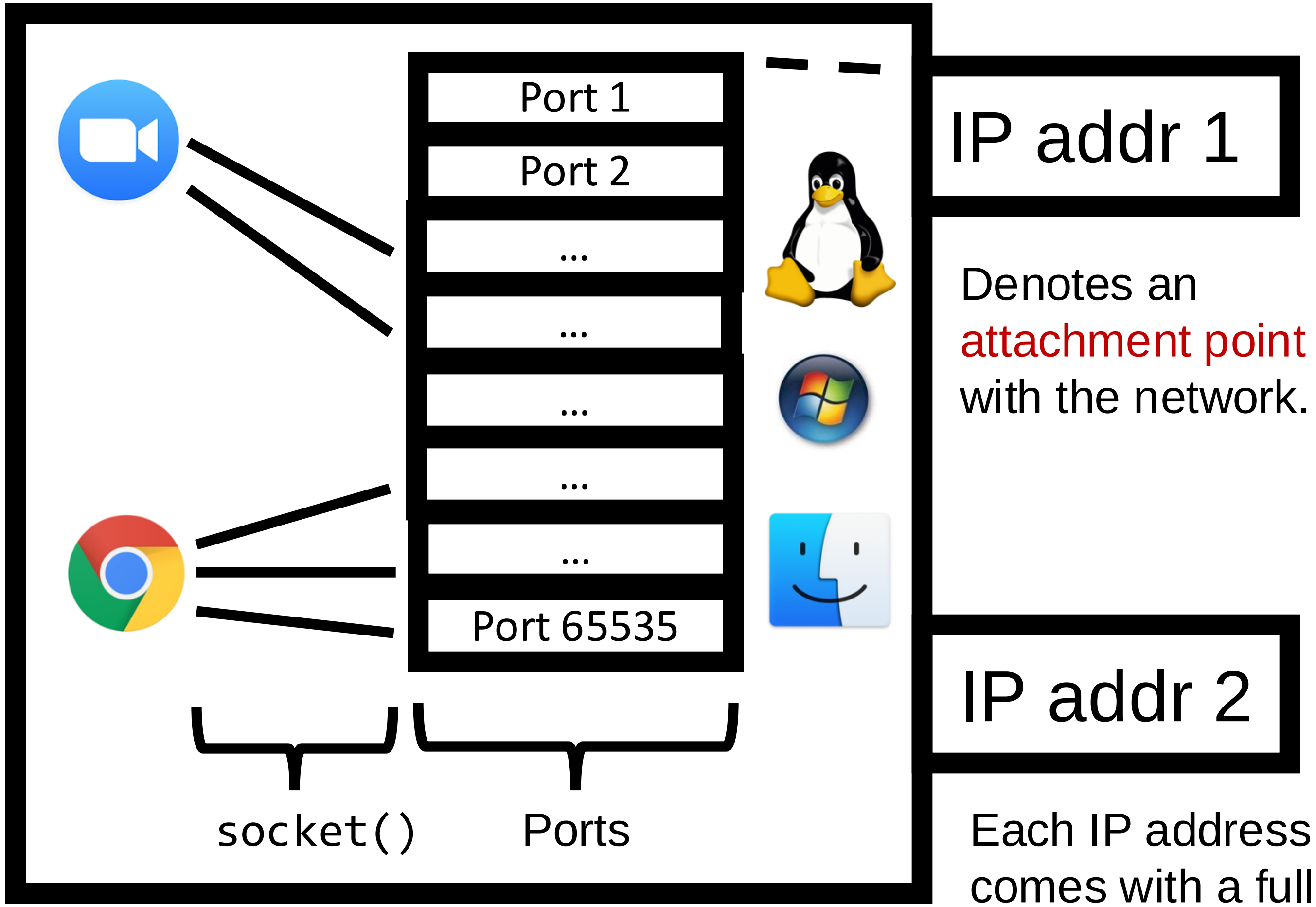
IP addr 2

Each IP address comes with a full copy of its own ports.

Src port, Dst port

Src IP, Dst IP, Tp Protocol

Demultiplexing



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socket()

Ports

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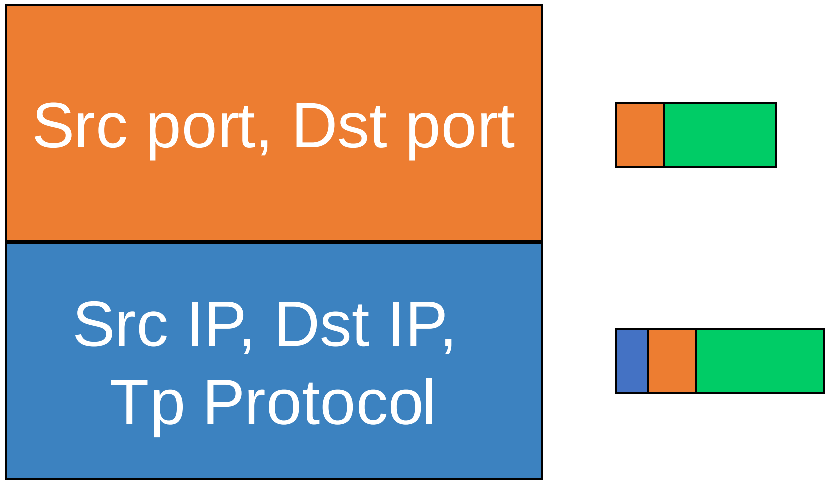
Machine

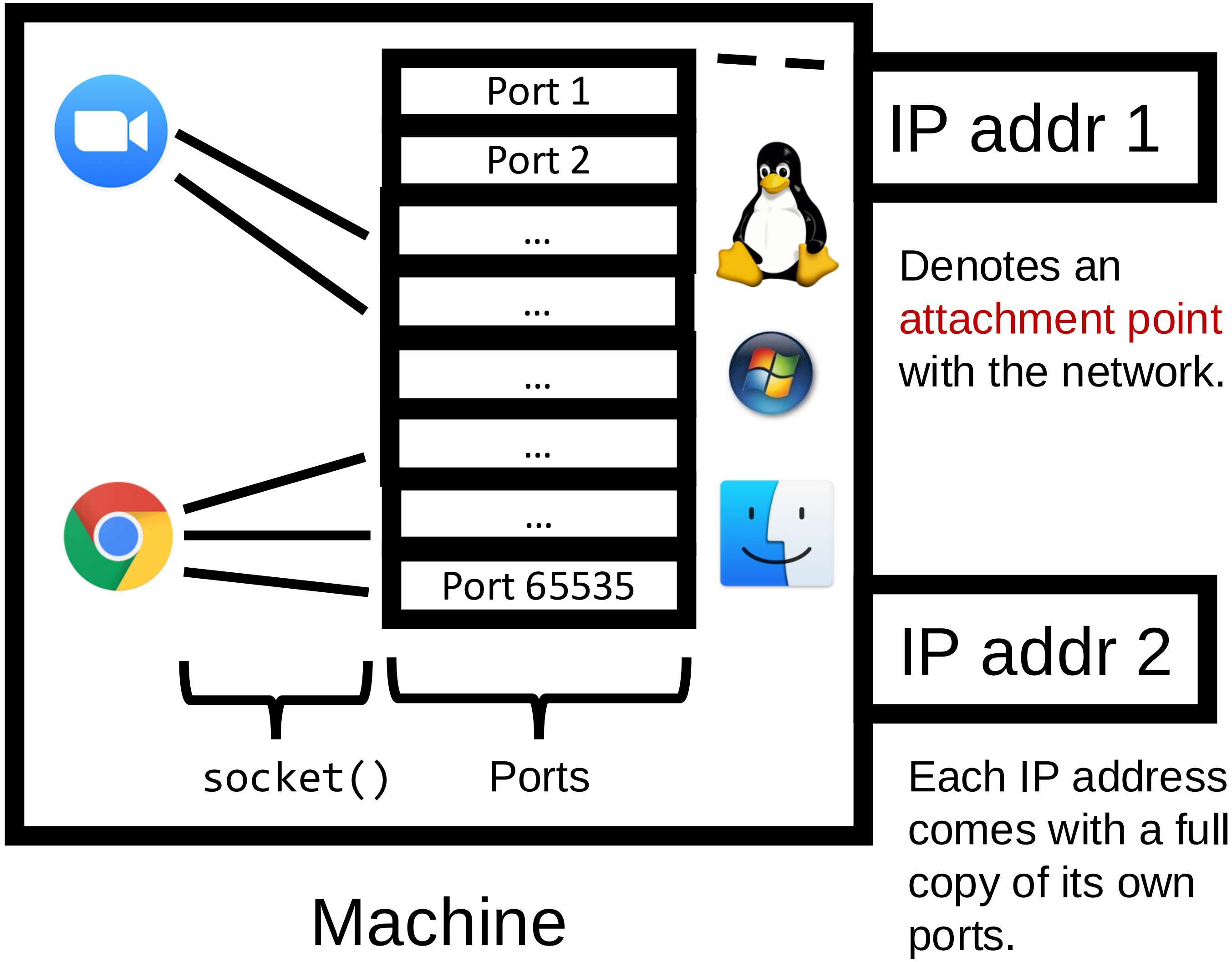
Connection lookup: The operating system does a lookup using these data to determine the right socket and app.



Src port, Dst port

Src IP, Dst IP, Tp Protocol

Demultiplexing



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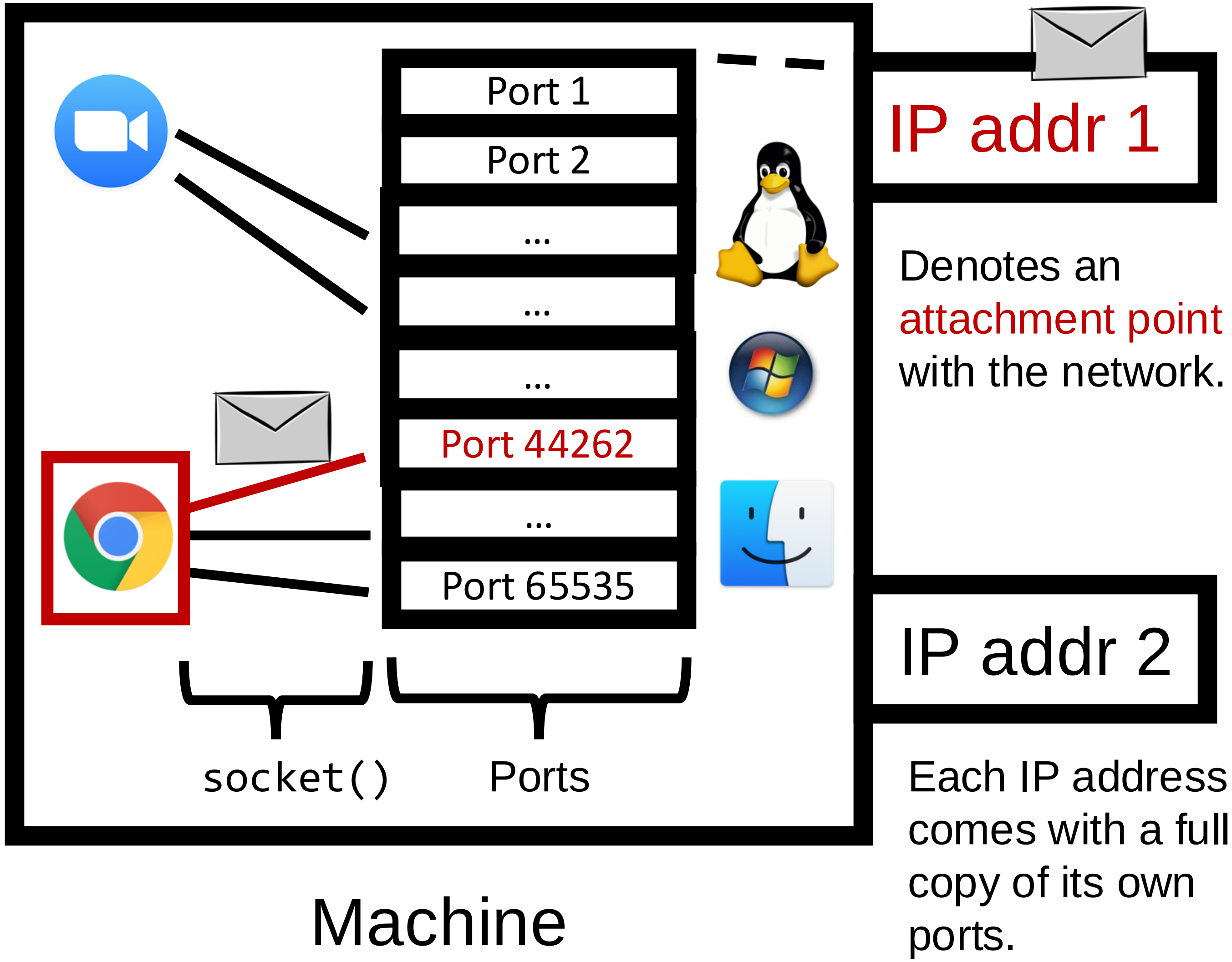
TCP sockets:
(src IP, dst IP, src port, dst port)
➔
Socket ID

Demultiplexing



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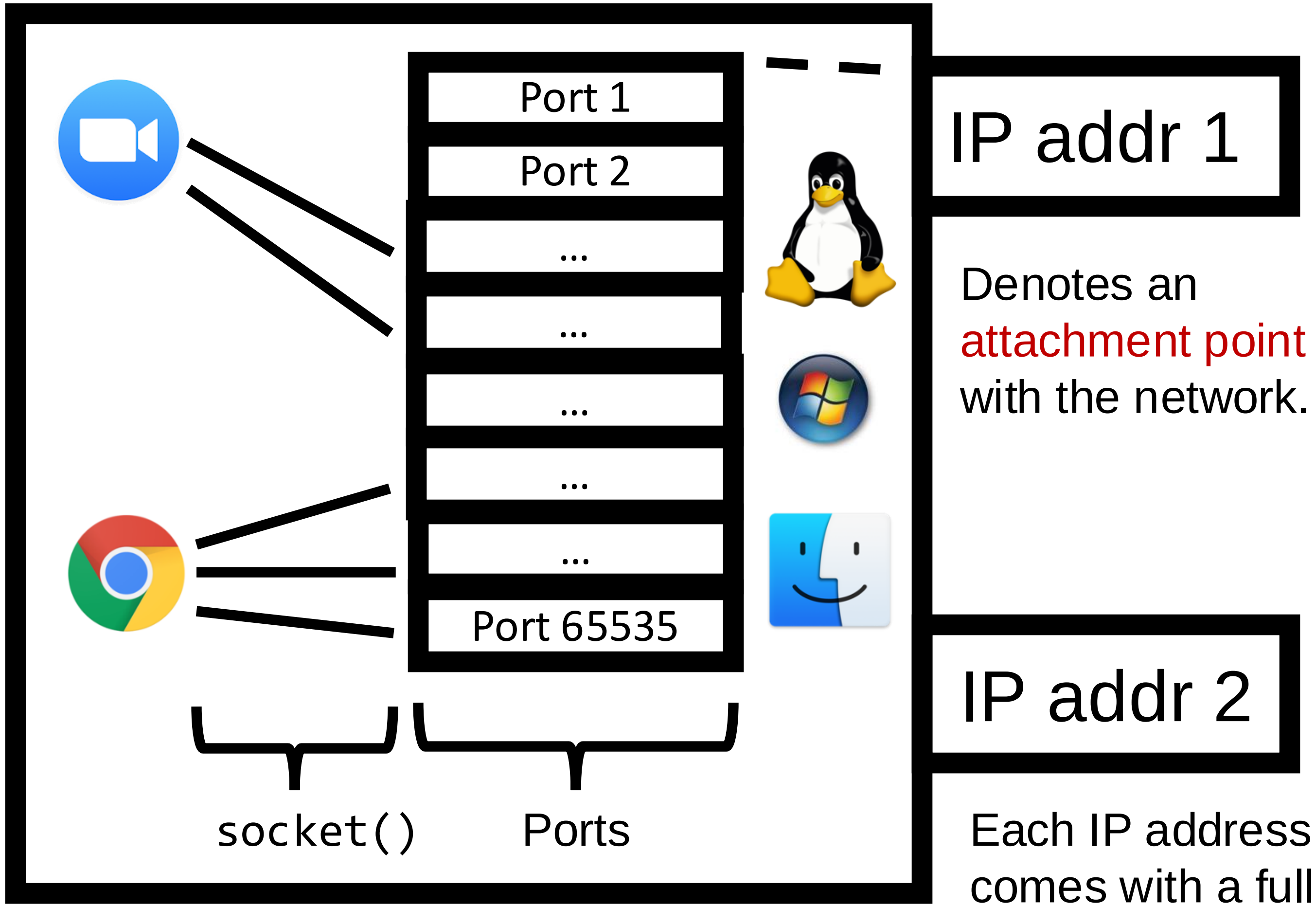
(Our familiar 4-tuple)

Demultiplexing



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Connection lookup: The operating system does a lookup using these data to determine the right socket and app.

TCP sockets:

(src IP, dst IP, src port, dst port)

➔

Socket ID

(Our familiar 4-tuple)

UDP sockets:

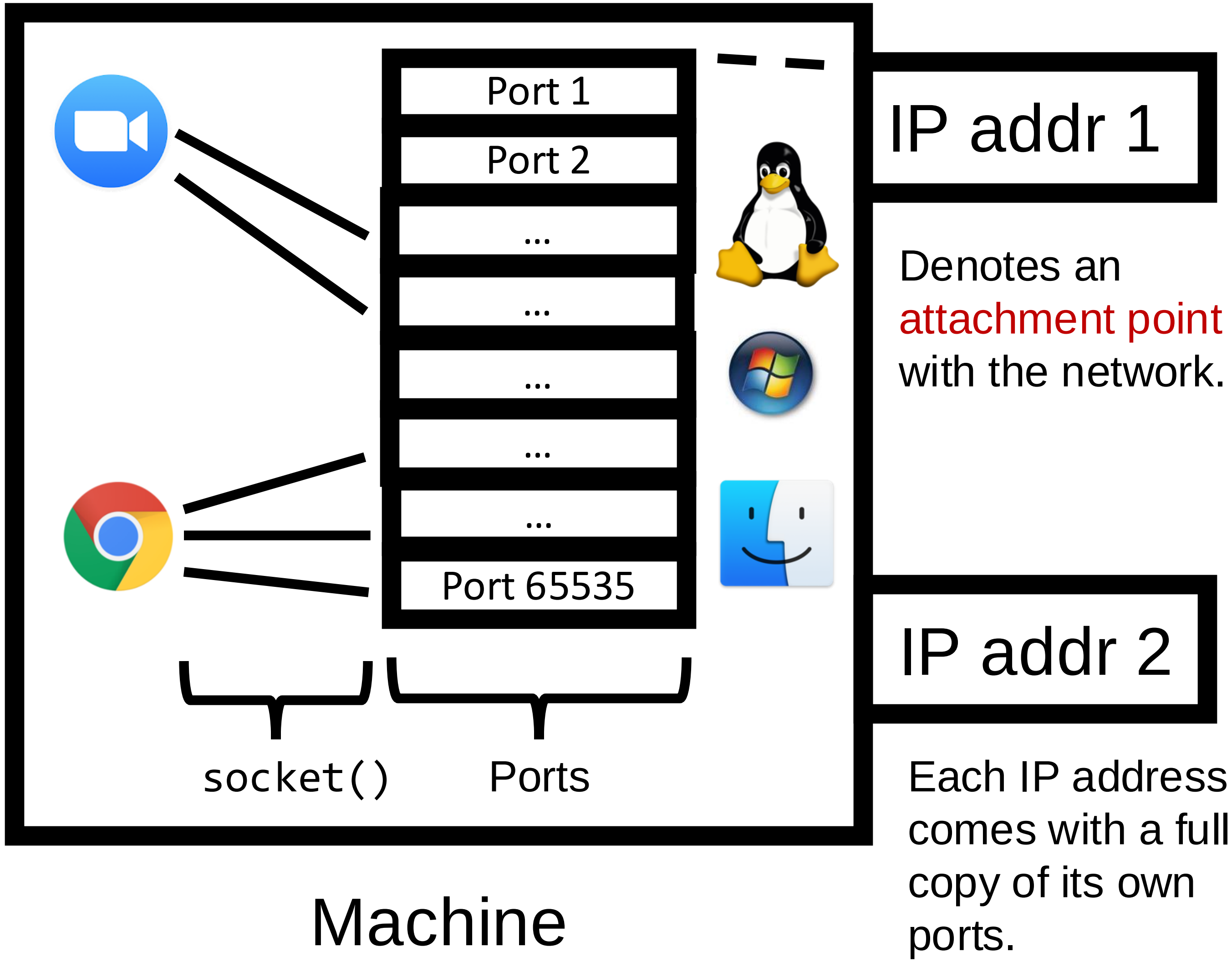
(dst IP, dst port)

➔

Socket ID

Connectionless: the socket is shared across all sources!

Demultiplexing



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Each IP address comes with a full copy of its own ports.

Connection lookup: The operating system does a lookup using these data to determine the right socket and app.

TCP sockets** More cases!
(src IP, dst IP, src port, dst port)
➔
Socket ID

(Our familiar 4-tuple)

UDP sockets:
(dst IP, dst port)
➔
Socket ID

Connectionless: the socket is shared across all sources!

TCP sockets of different types

Listening (bound but unconnected)

```
# On server side
ss = socket(AF_INET, SOCK_STREAM)
ss.bind(serv_ip, serv_port)
ss.listen() # no accept() yet
```

Connected (Established)

```
# On server side
csockid, addr = ss.accept()

# On client side
cs.connect(serv_ip, serv_port)
```

(src IP, dst IP, src port, dst port)

➔

Socket (`csockid NOT ss`)

TCP sockets of different types

Listening (bound but unconnected)

```
# On server side
ss = socket(AF_INET, SOCK_STREAM)
ss.bind(serv_ip, serv_port)
ss.listen() # no accept() yet
```

(dst IP, dst port)

→

Socket (ss)

Enables new connections to be demultiplexed correctly

Connected (Established)

```
# On server side
csockid, addr = ss.accept()

# On client side
cs.connect(serv_ip, serv_port)
```

accept() creates a new socket with the 4-tuple (established) mapping

(src IP, dst IP, src port, dst port)

→

Socket (csockid NOT ss)

Enables existing connections to be demultiplexed correctly

TCP demultiplexing

- When a TCP packet comes in, the operating system:

- Looks up table of established connections using 4-tuple
  - If success, send to corresponding (established) socket

- If fail (no table entry), look up table of listening connections using just (dst IP, dst port)
  - If success, send to corresponding (listening) socket
  - Add an entry for established connection in the established table (next packet from the established connection will demultiplex correctly)

- If lookup failed in the listening table (no table entry), send error to client
  - Connection refused

UDP demultiplexing

- When a UDP packet comes in, the operating system:

- Looks up table of listening UDP sockets using (dst IP, dst port)
  - If success, send packet to corresponding socket
  - There are no established UDP sockets; they're all "unconnected"

- If fail (no table entry), send error to client
  - Port unreachable