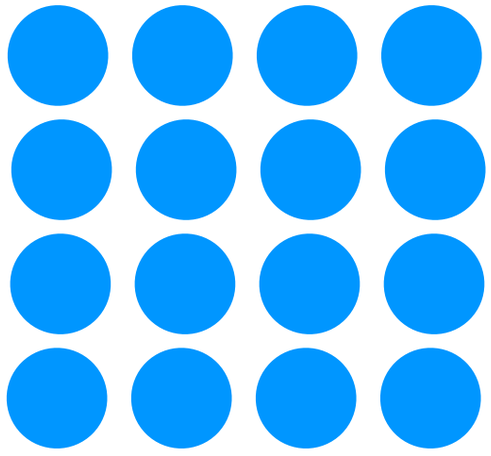
Lecture 1:

Introduction

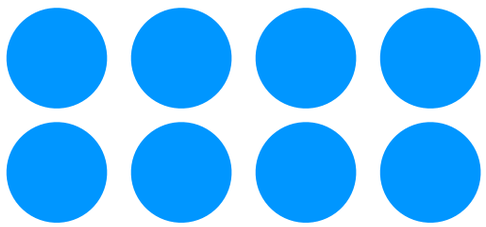
Katerina Argyraki, EPFL

- Tesla Model 3 controller
- your washing machine
- heart pacemaker



Google servers

- end-system
- laptop
- smartphone



World of warcraft servers

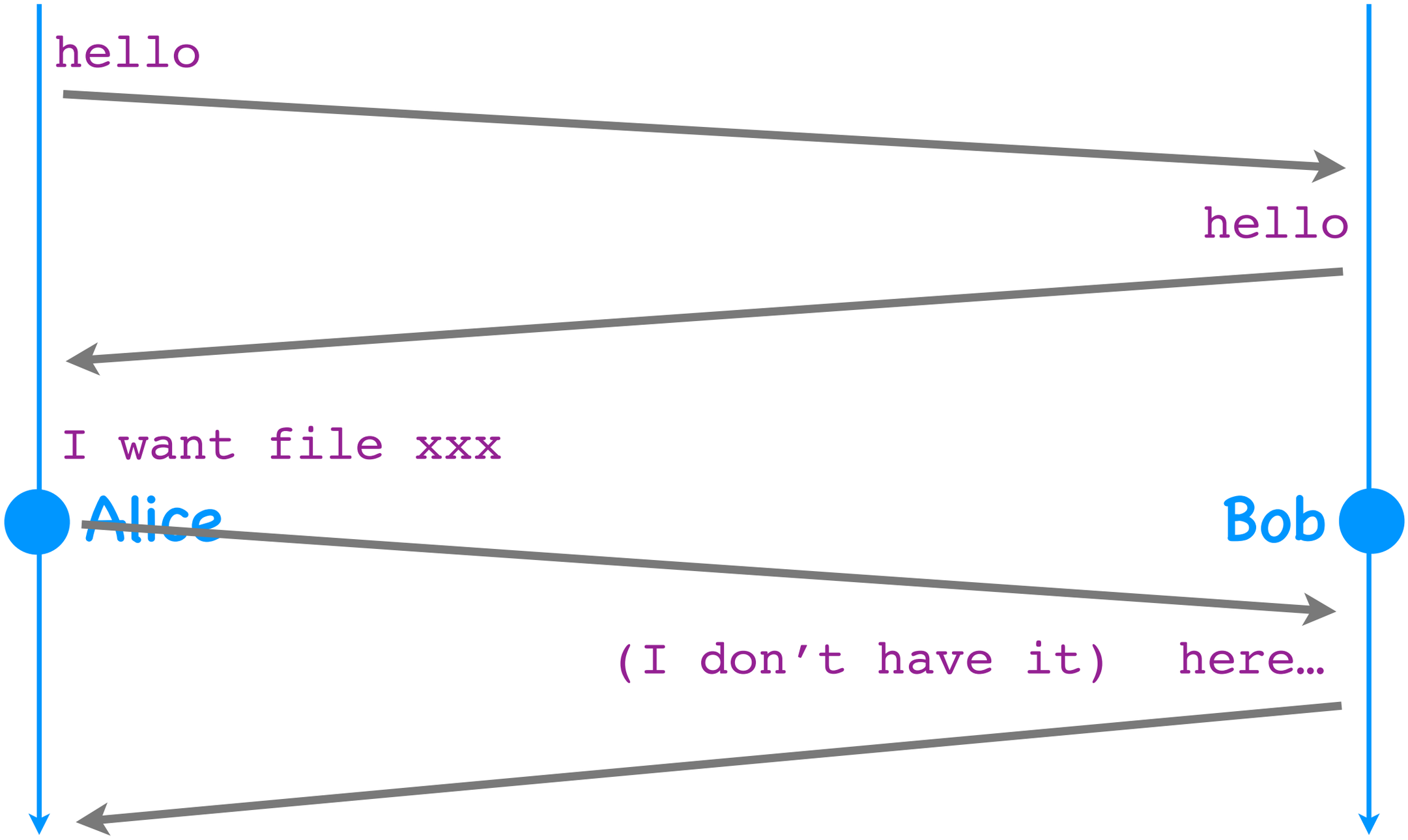
```
while (...) {
    message = ...;
    send ( message, ... );
}
```

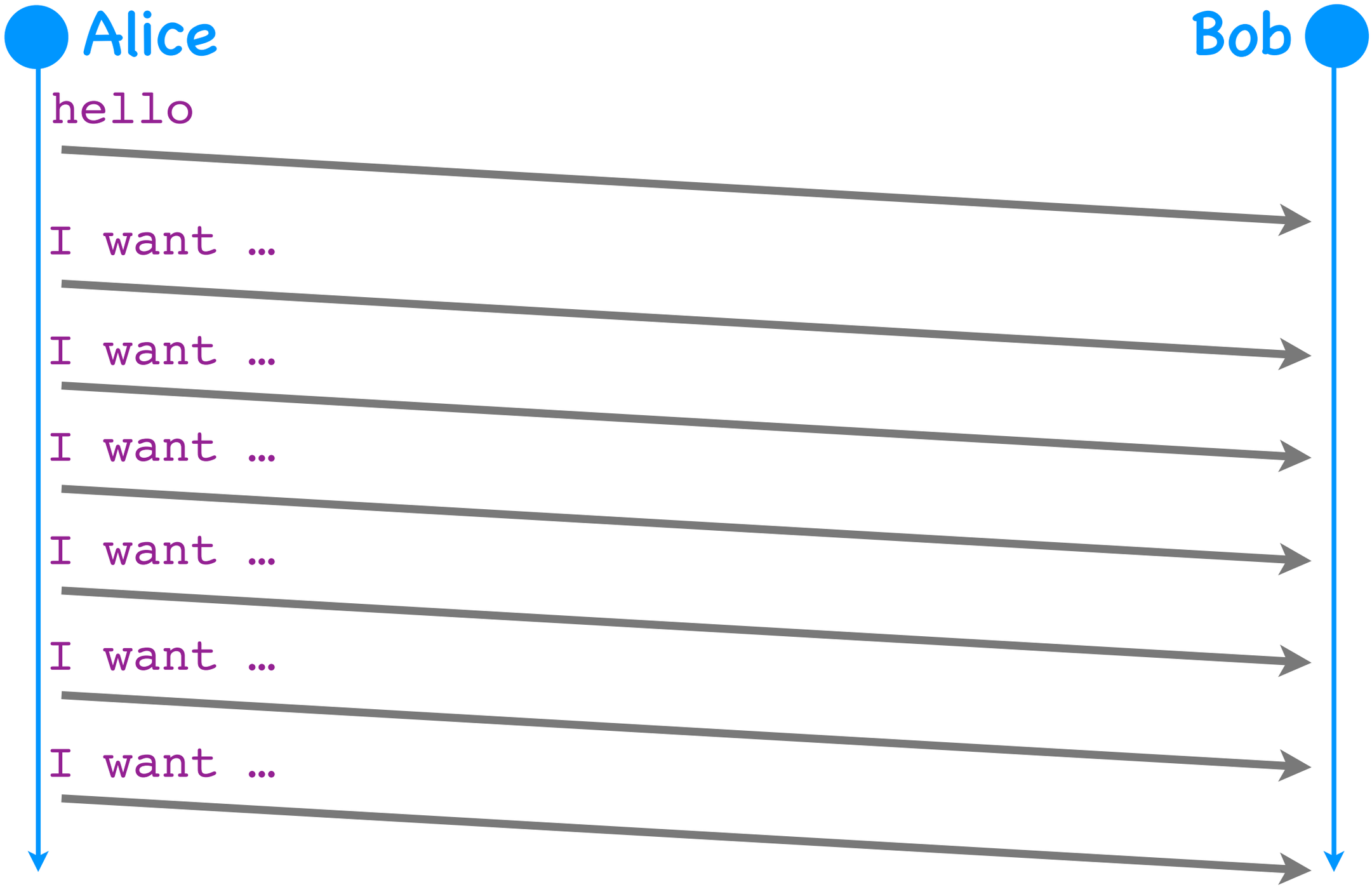
```
while (...) {
    message = receive ( ... );
}
```

Alice

Bob

Application Programming Interface


hello
hello
I want file xxx
Alice
Bob
(I don’t have it)
here…

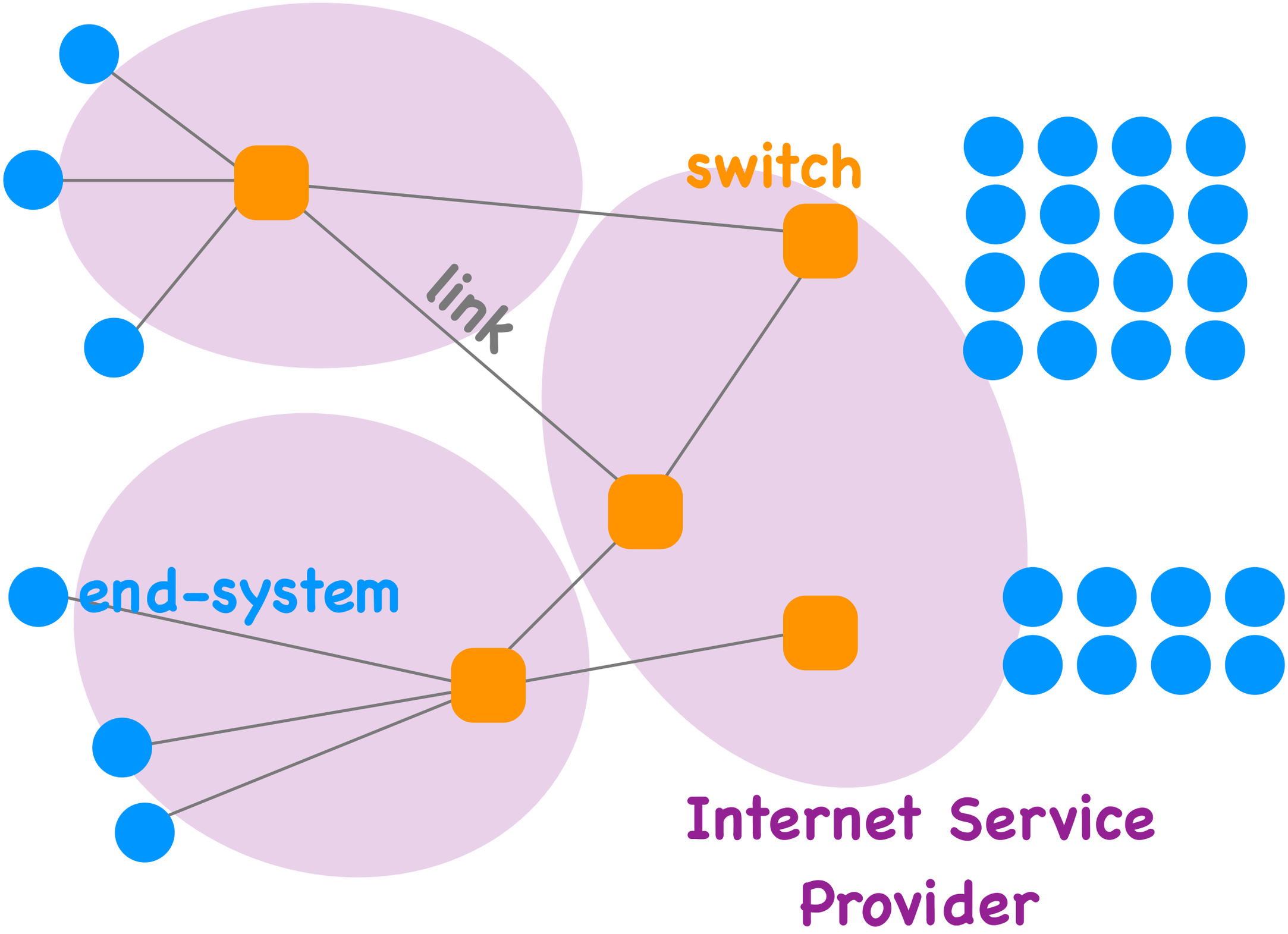

Alice
Bob
hello
I want …
I want …
I want …
I want …
I want …
I want …

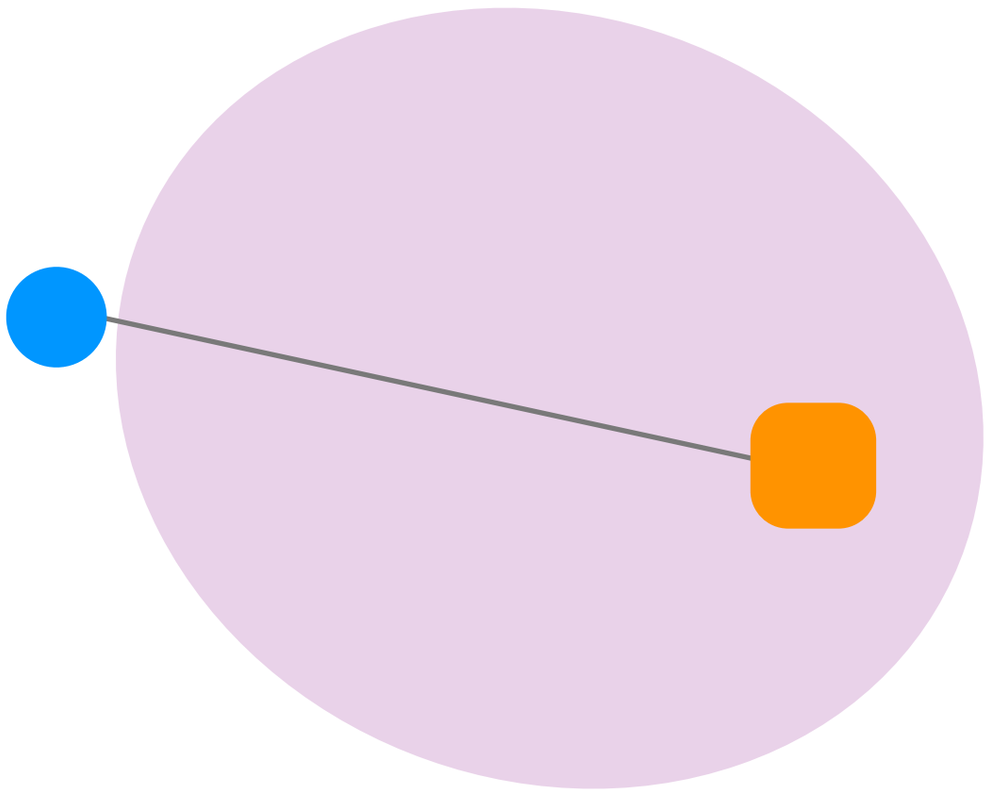
Questions

- What's **underneath**?
- Who **owns** what?
- How does it **work**?
- How does one **evaluate** it?
- How do end-systems **share** it?

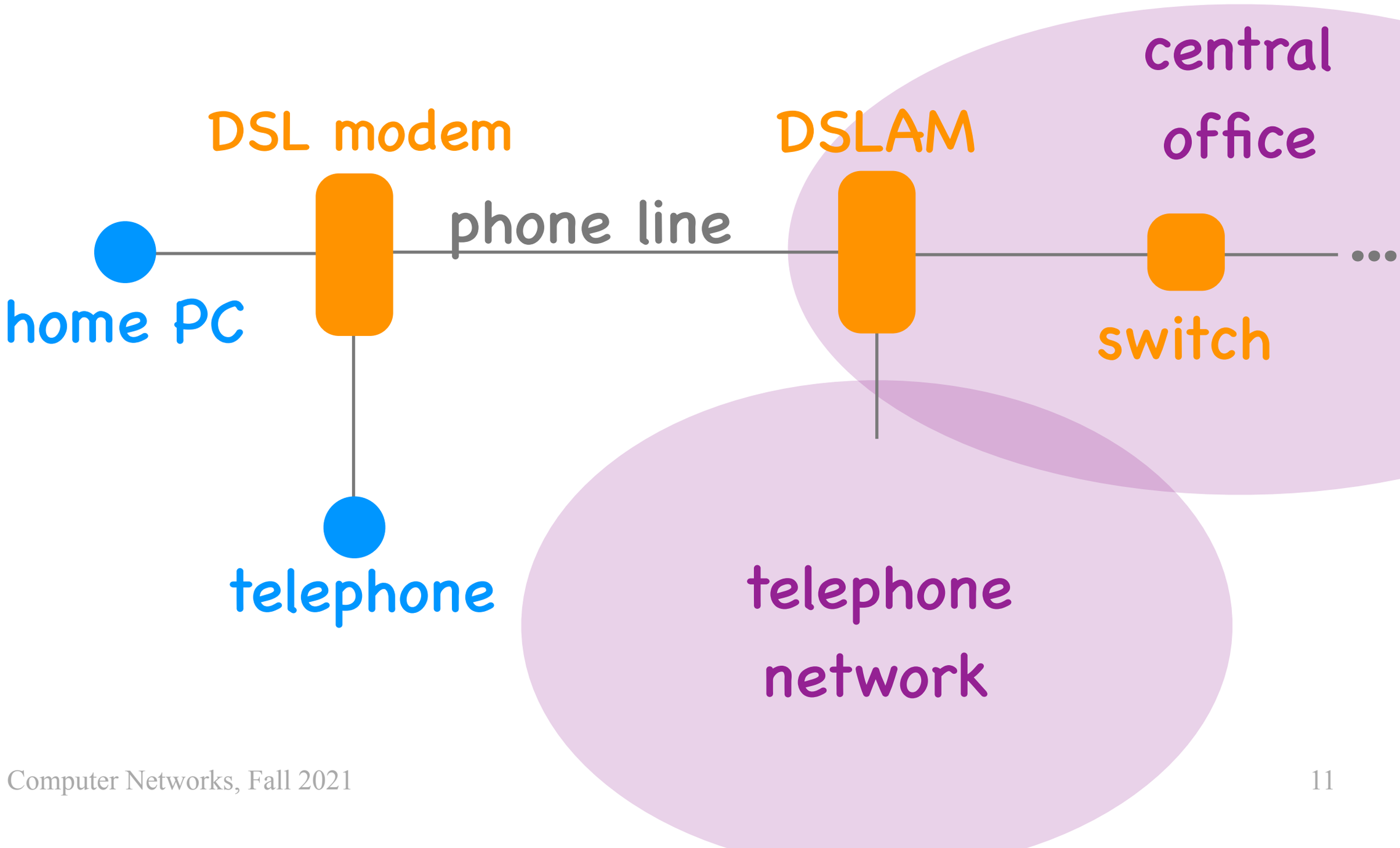
Questions

- What's underneath?
- Who owns what?
- How does it work?
- How does one evaluate it?
- How do end-systems share it?


switch
link
end-system
Internet Service Provider



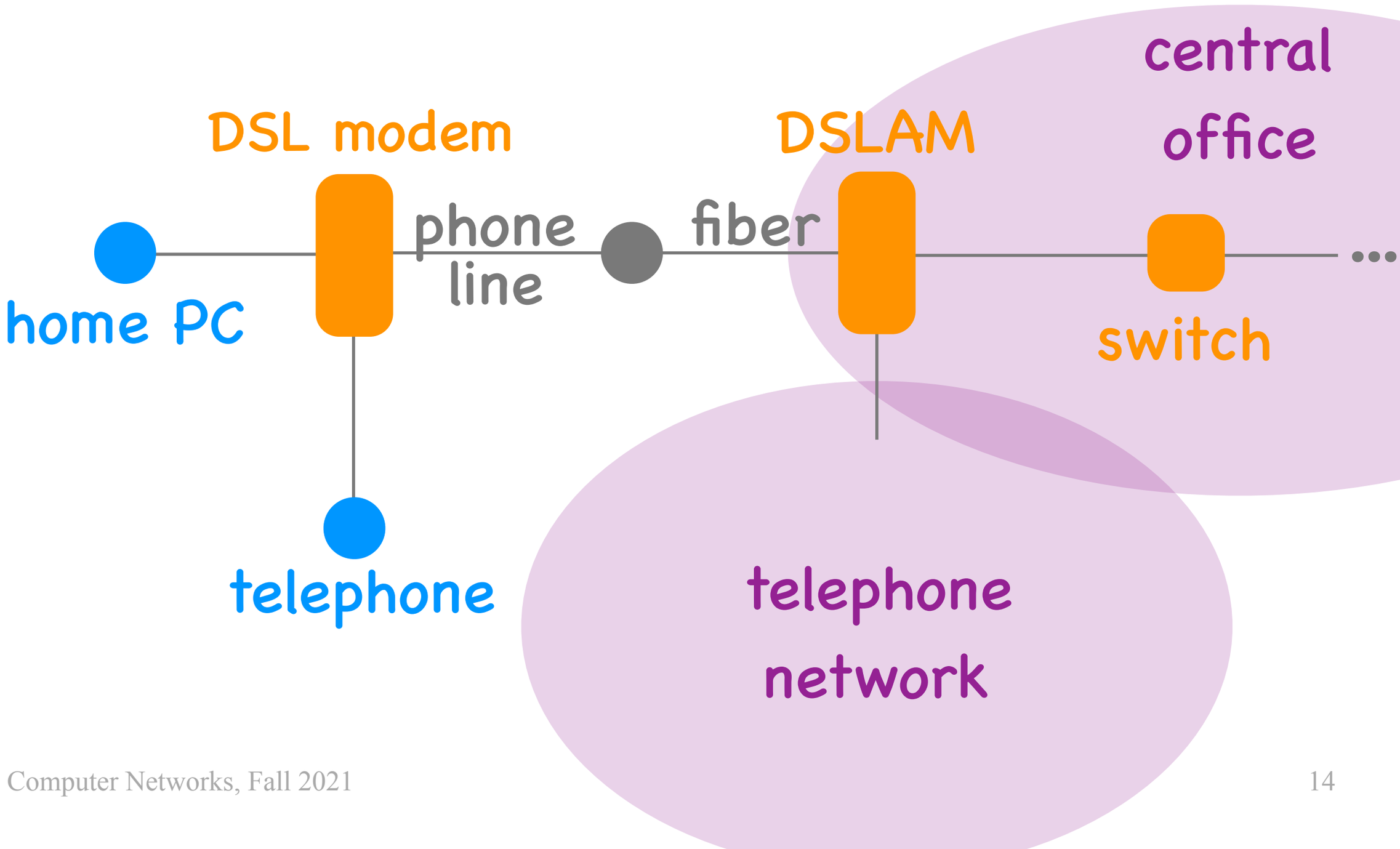
home PC
switch

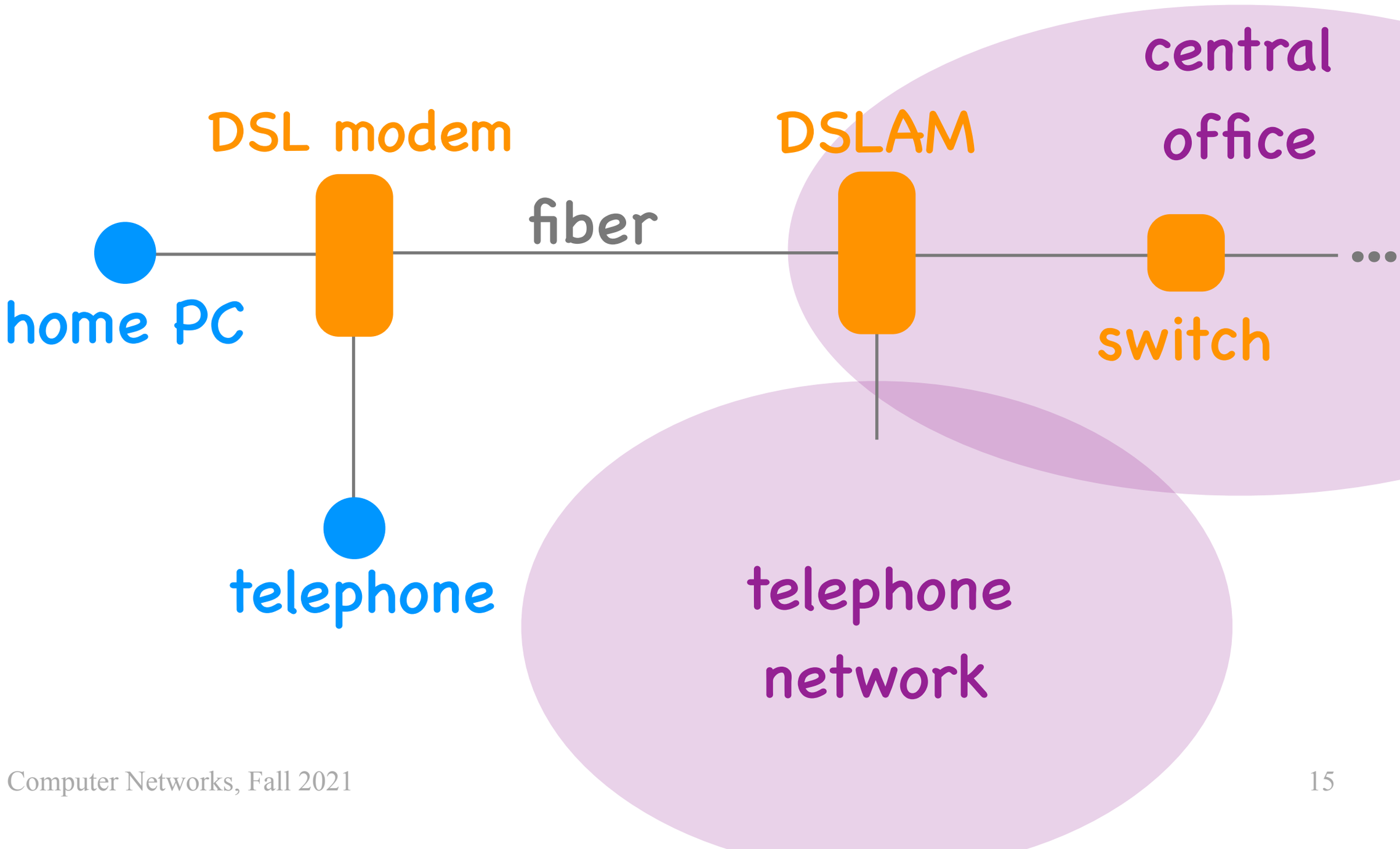

DSL modem
DSLAM
central office
phone line
...
home PC
switch
telephone
telephone network

Digital Subscriber Line (DSL)

- DSL modem + phone line (copper)
- 3 channels (downstream data, upstream data, voice)
- typically 10s to 100+ Mbps
  - most allocated to the downstream data channel

Why phone lines?

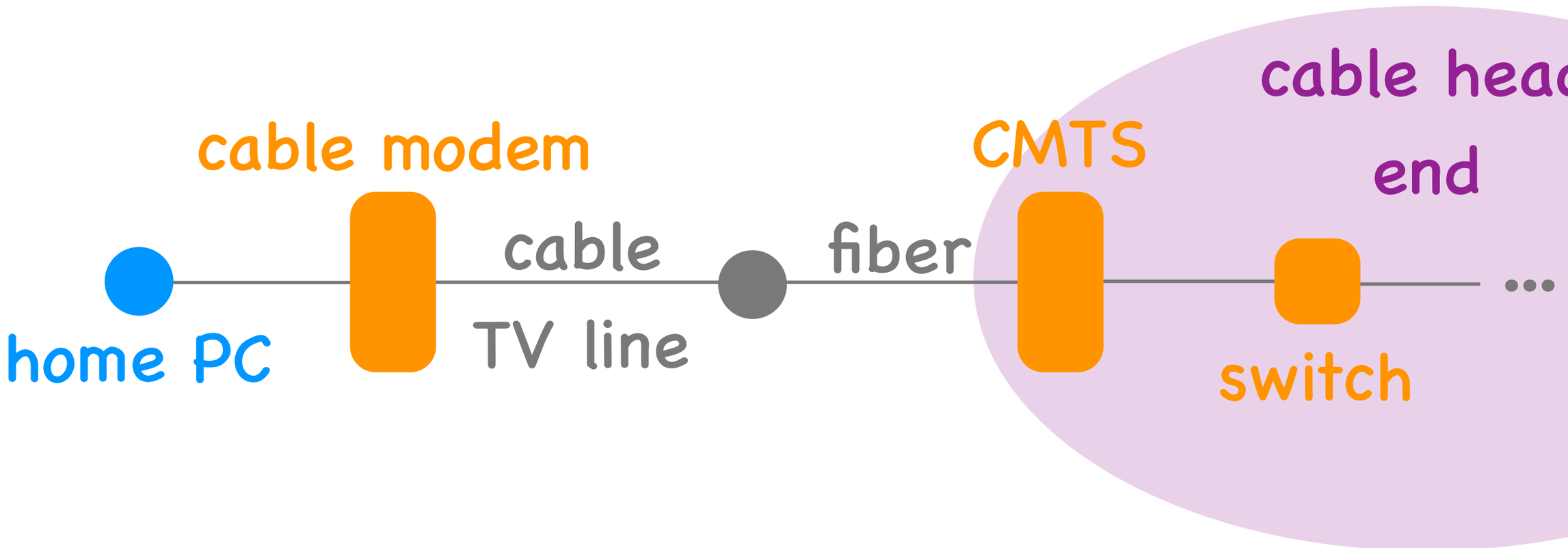

DSL modem
DSLAM
central office
phone line
fiber
home PC
switch
...
telephone
telephone network

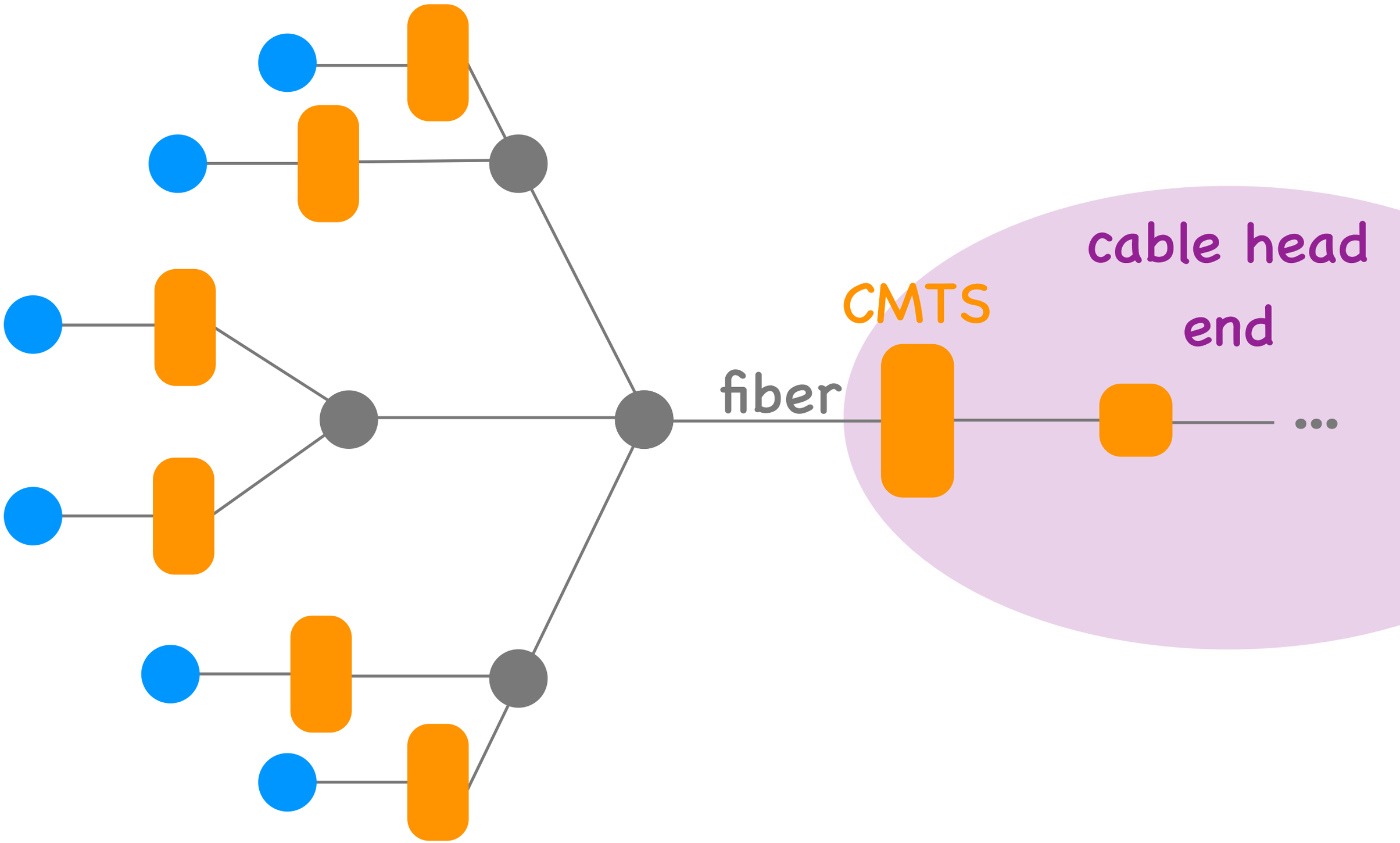

DSL modem
DSLAM
central office
fiber
home PC
switch
telephone
telephone network

Fiber to the Home

- ...or to the Building/Curb/Street
- modem + fiber (+ copper phone line)
- up to 1 Gbps per direction
  (as deployed in Switzerland)

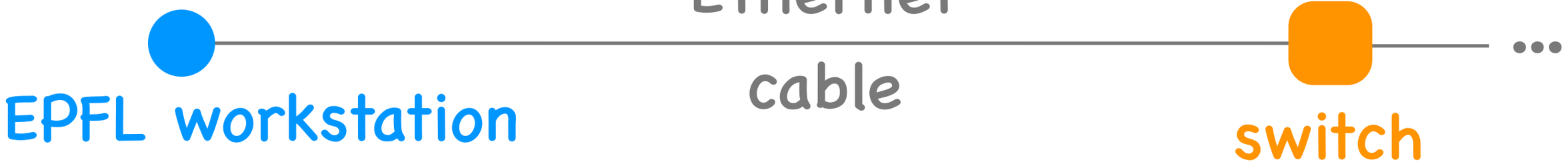
home PC
switch

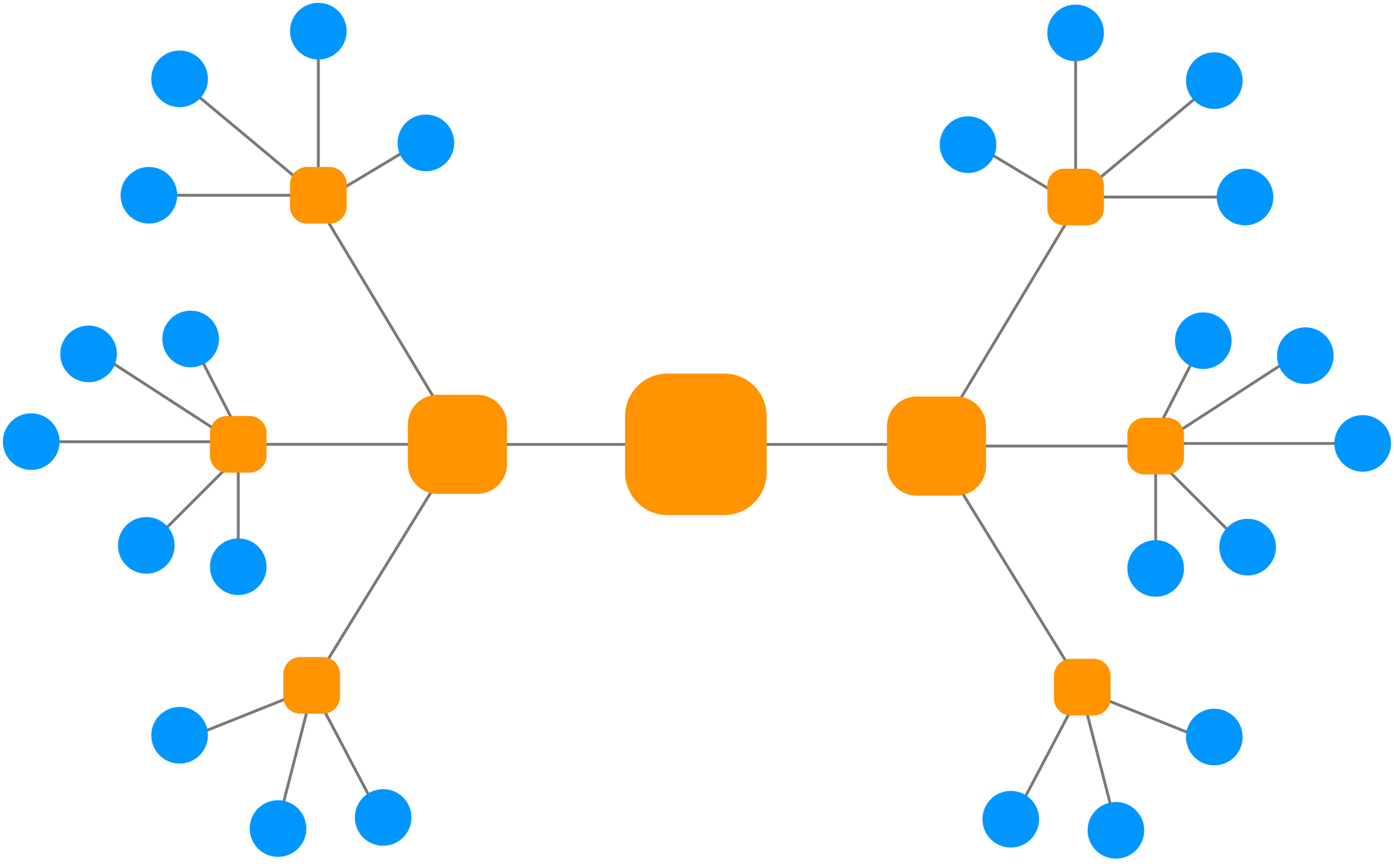

cable modem
CMTS
cable head end
cable
fiber
home PC
TV line
switch
...


cable head end
CMTS
fiber
...

Cable

- Cable modem + cable line (copper, fiber)
- 2 channels (downstream, upstream)
  - typically 100s of Mbps
    - most allocated to the downstream channel
  - shared broadcast medium


Ethernet
cable
EPFL workstation
switch

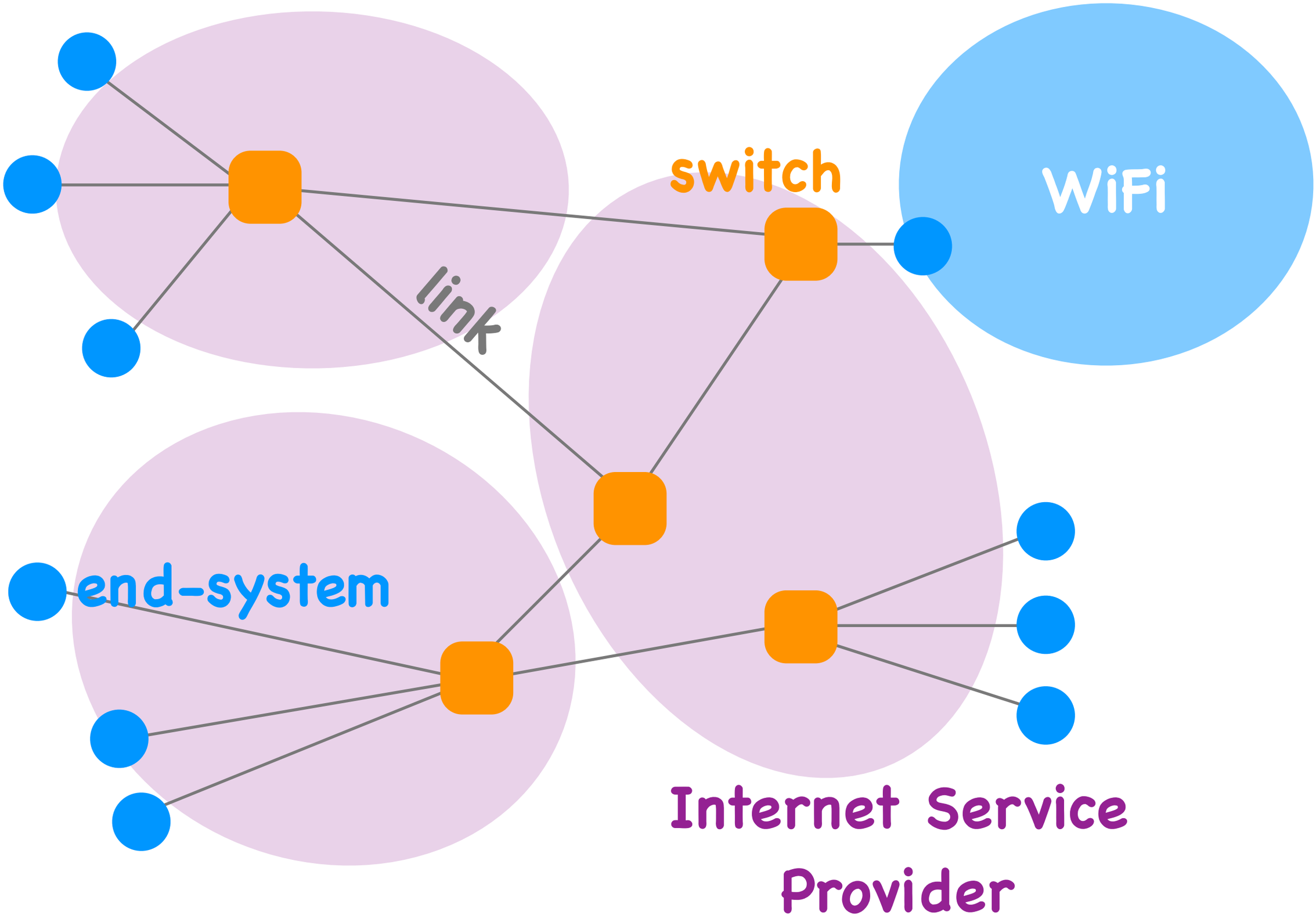


Ethernet

- Ethernet switches and cables (copper)
- 2 channels (downstream + upstream)
- 1 Gbps, 10 Gbps, 40 Gbps in each direction

& more

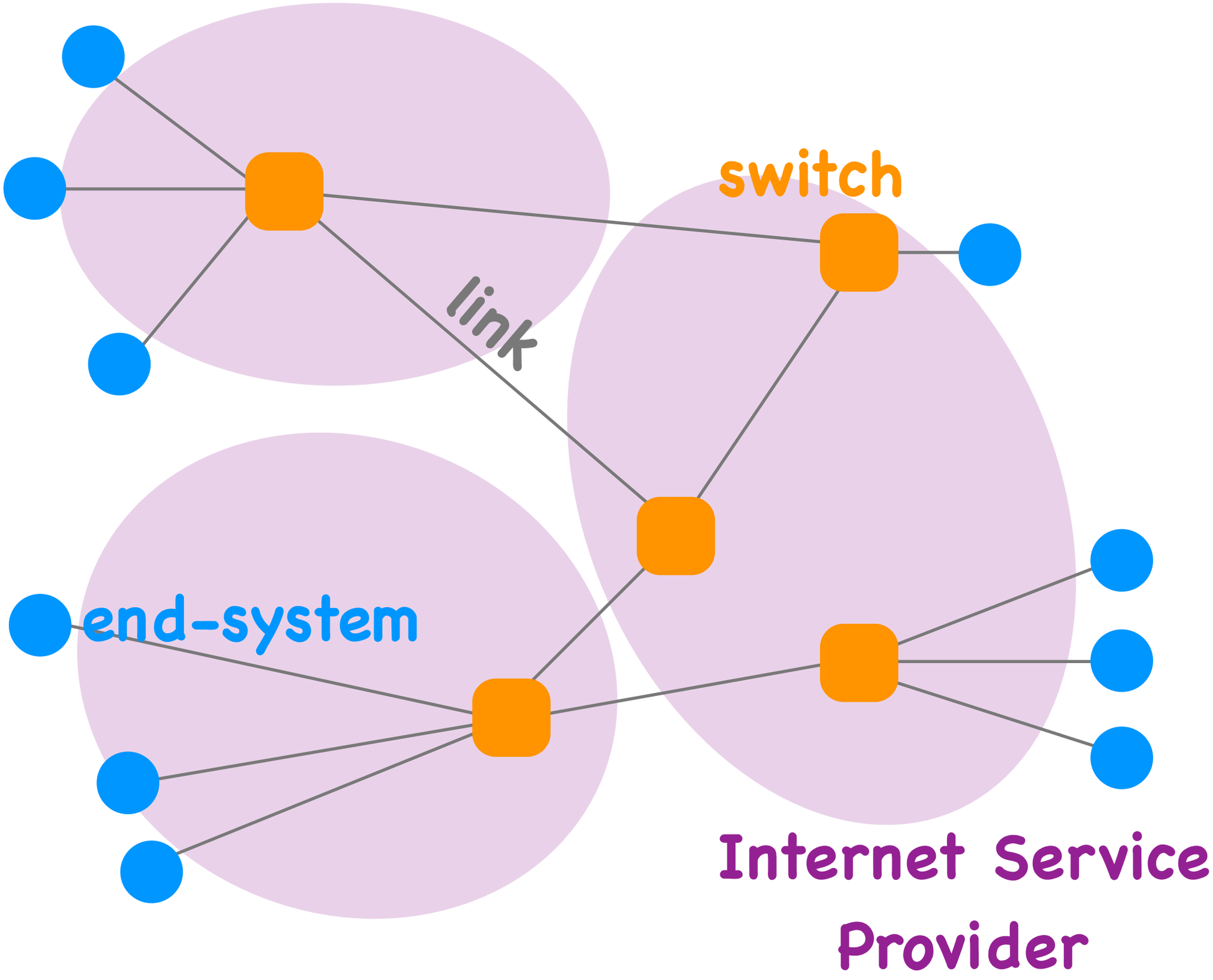
- Cellular (smart phones)
- Satellite (remote areas)
- ...


switch
WiFi
link
end-system
Internet Service Provider

What physical infrastructure is already available?

Questions

- What's underneath?
- Who **owns** what?
- How does it work?
- How do we evaluate it?
- How do we share it?


switch
link
end-system
Internet Service Provider

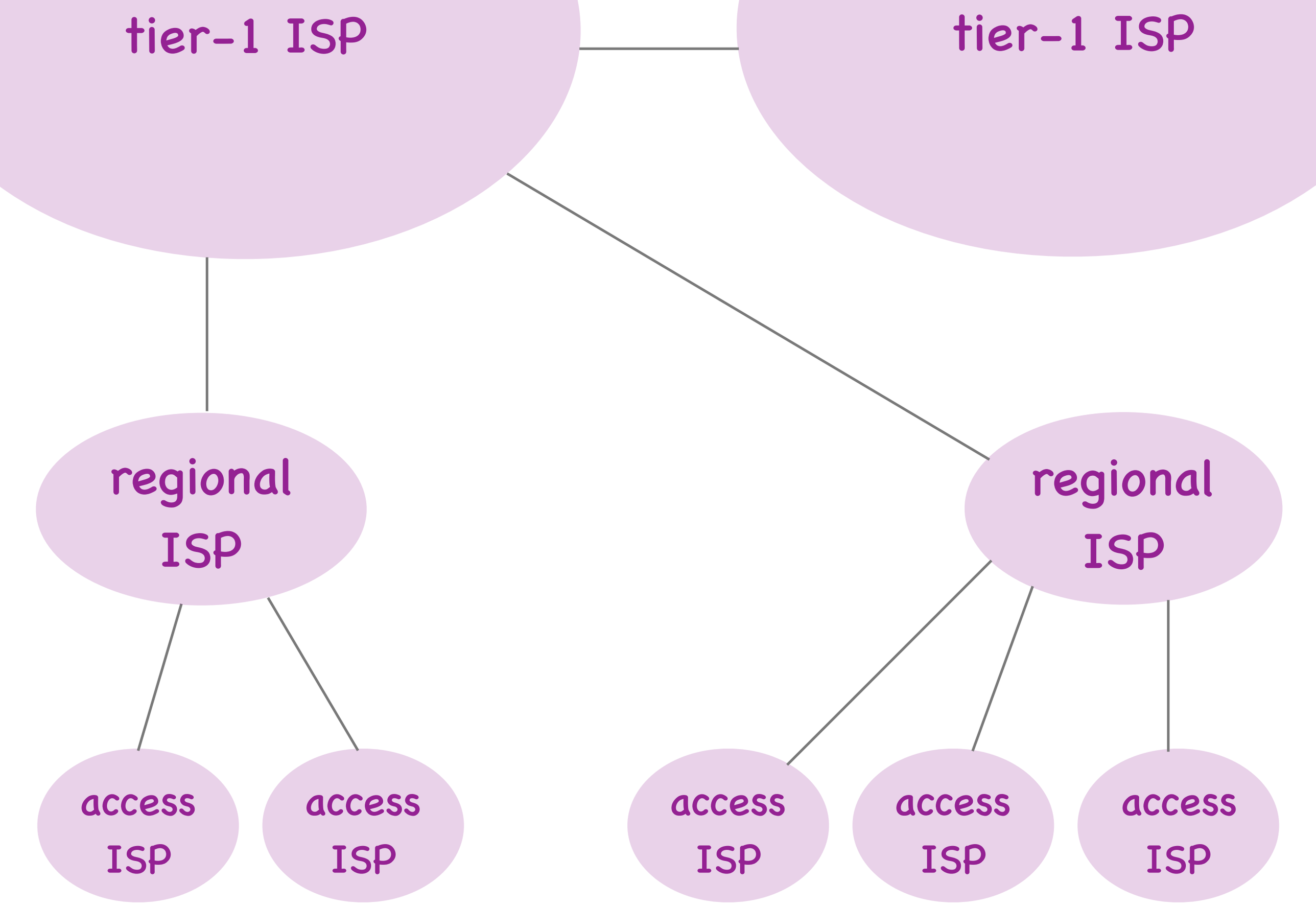
Internet Service Provider

access ISP
access ISP

global ISP

access ISP

access ISP


tier-1 ISP
tier-1 ISP
regional ISP
regional ISP
access ISP
access ISP
access ISP
access ISP
access ISP

Zurich

Boston

Lausanne

Bern

St Sulpice

Renens

peering

provider

customer

customer

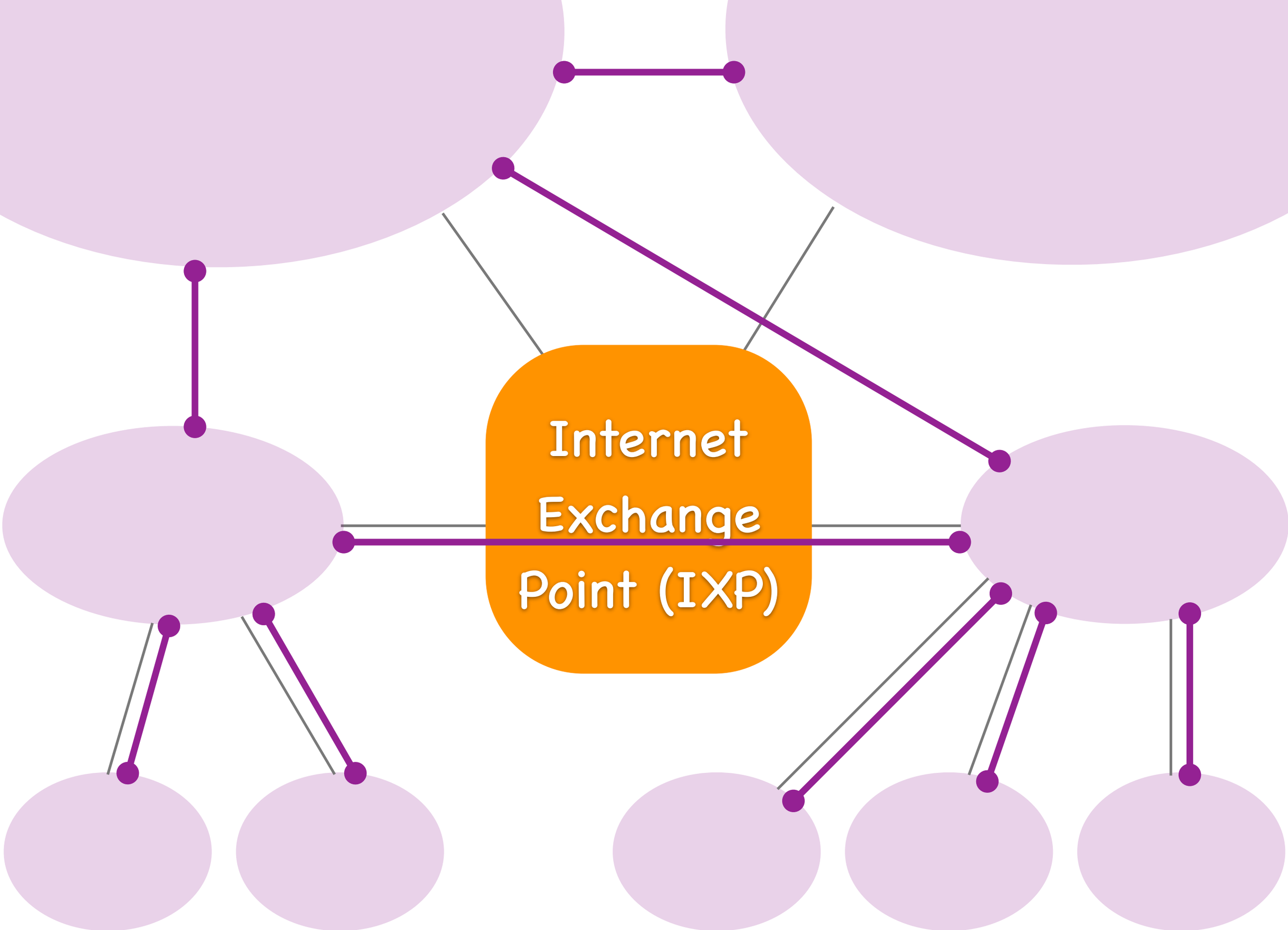
peering

provider

provider

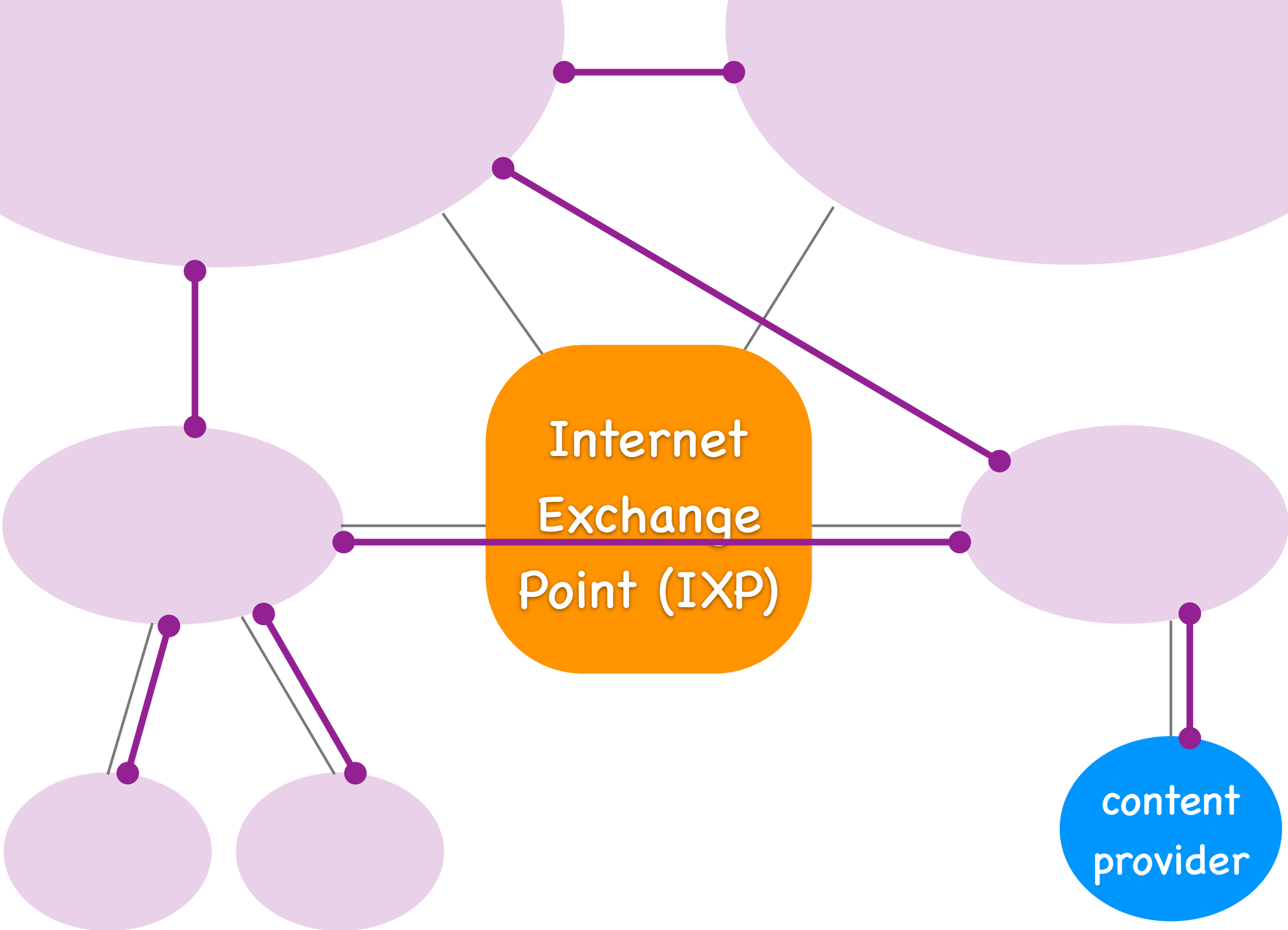
customers

customers


Internet
Exchange
Point (IXP)

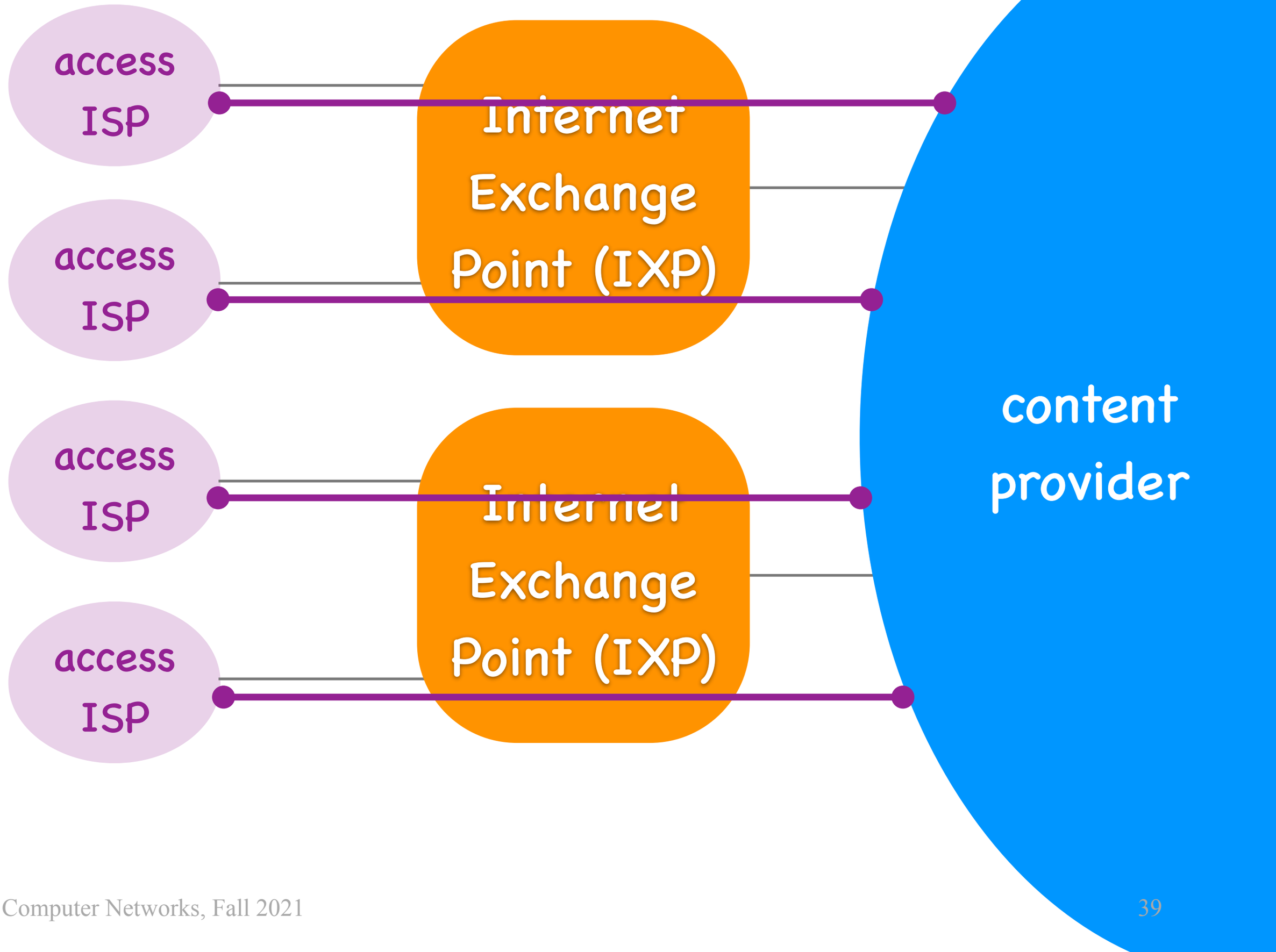
Internet Exchange Point (IXP)

content provider


Internet Exchange Point (IXP)
content provider

Internet Exchange Point (IXP)

content provider


access ISP
access ISP
access ISP
Internet Exchange Point (IXP)
Internet Exchange Point (IXP)
content provider

Internet Exchange Point (IXP)

content provider

What modularity?

What hierarchy?

Questions

- What's underneath?
- Who owns what?
- How does it work?
- How do we evaluate it?
- How do we share it?

Layers

- Layer = a part of a system with well-defined interfaces to other parts

- Two layers interact only through the interface between them

- One layer interacts only with layer above and layer below

Alice

mailbox

local post office

mail bag

central post office

Bob

mailbox

local post office

mail bag

central post office

Alice's program

Bob's program

Alice's OS

Bob's OS

Internet

DSL

Cable

Ethernet

WiFi

Cellular

Optical

copper

fiber

wireless

application	web	BitTorrent	email	DNS		
transport	TCP	UDP				
network	IP					
link	DSL	Cable	Ethernet	WiFi	Cellular	Optical
physical	copper	fiber	wireless			

application

web

BitTorrent

DNS

transport

TCP

UDP

network

IP

link

Ethernet

physical

application	
transport	moves data between end-systems
network	moves data across the Internet
link	moves data across a link
physical	moves data across a physical medium

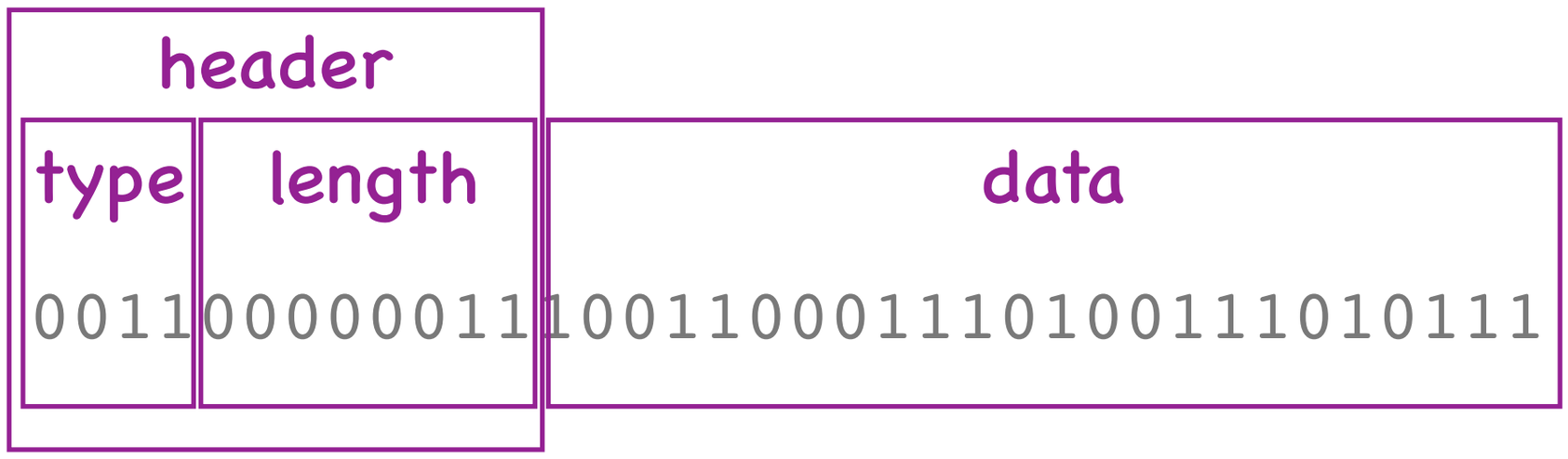
```
while (...) {
    message = ...;
    send ( message, ... );
}
```

```
while (...) {
    message = receive ( ... );
}
```

Alice

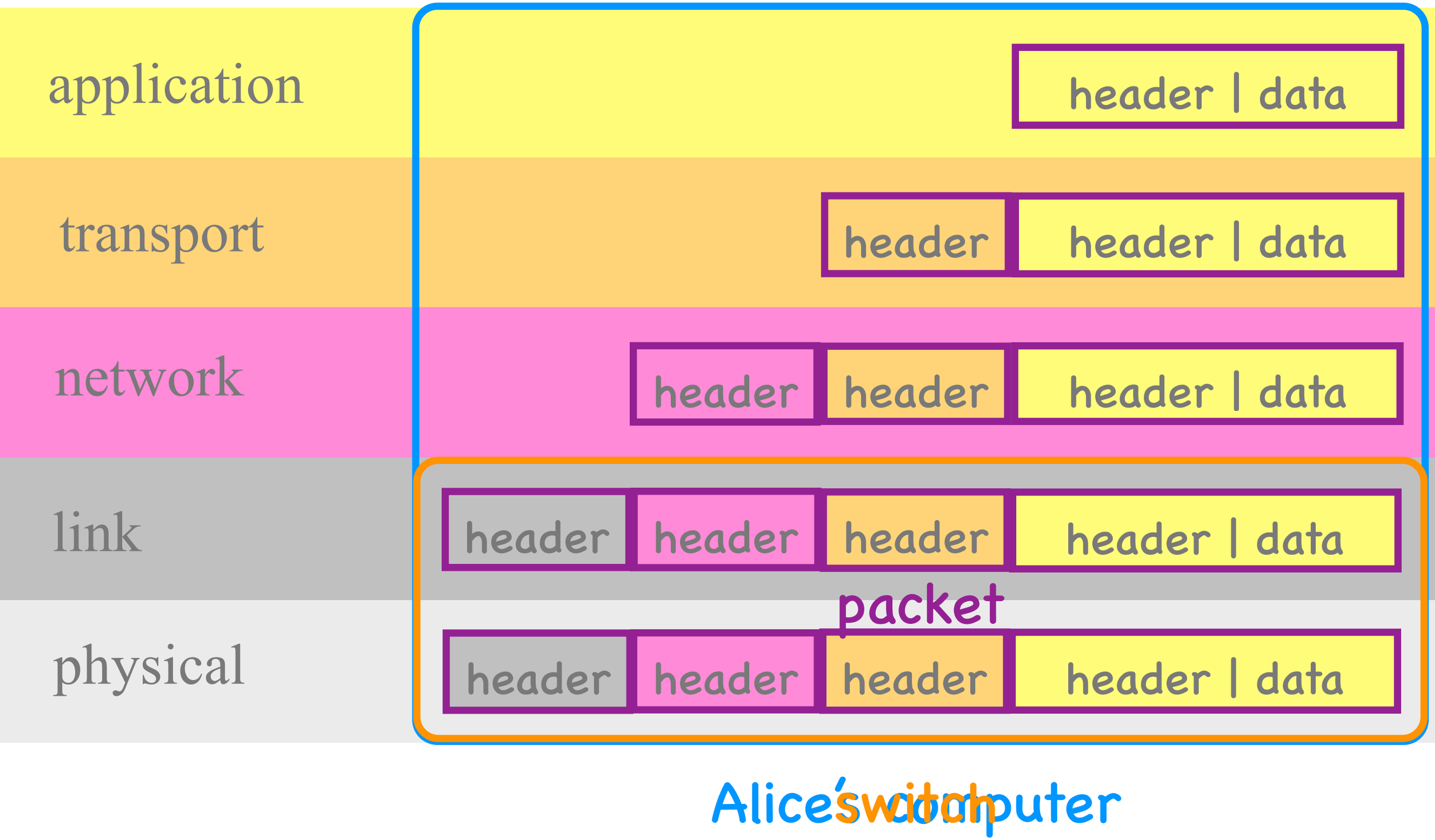
Bob

```
while (...) {
    message = ...;
    send ( message, ... );
}
```



Message format:

agreement on what each bit means


application
transport
network
link
physical
header | data
header
header | data
header
header
header | data
header
header
header
header | data
packet
header
header
header
header | data
Alice's computer
switch

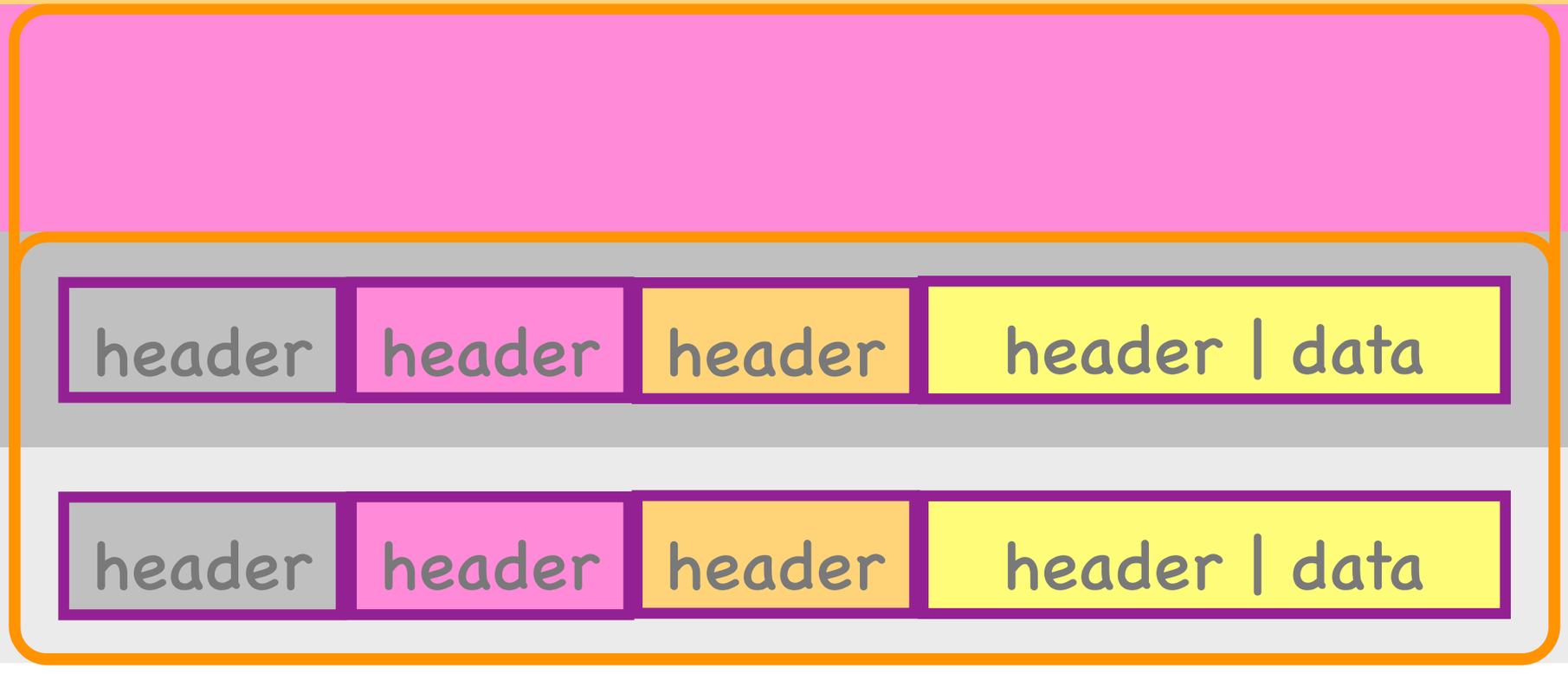
application

transport

network

link

physical



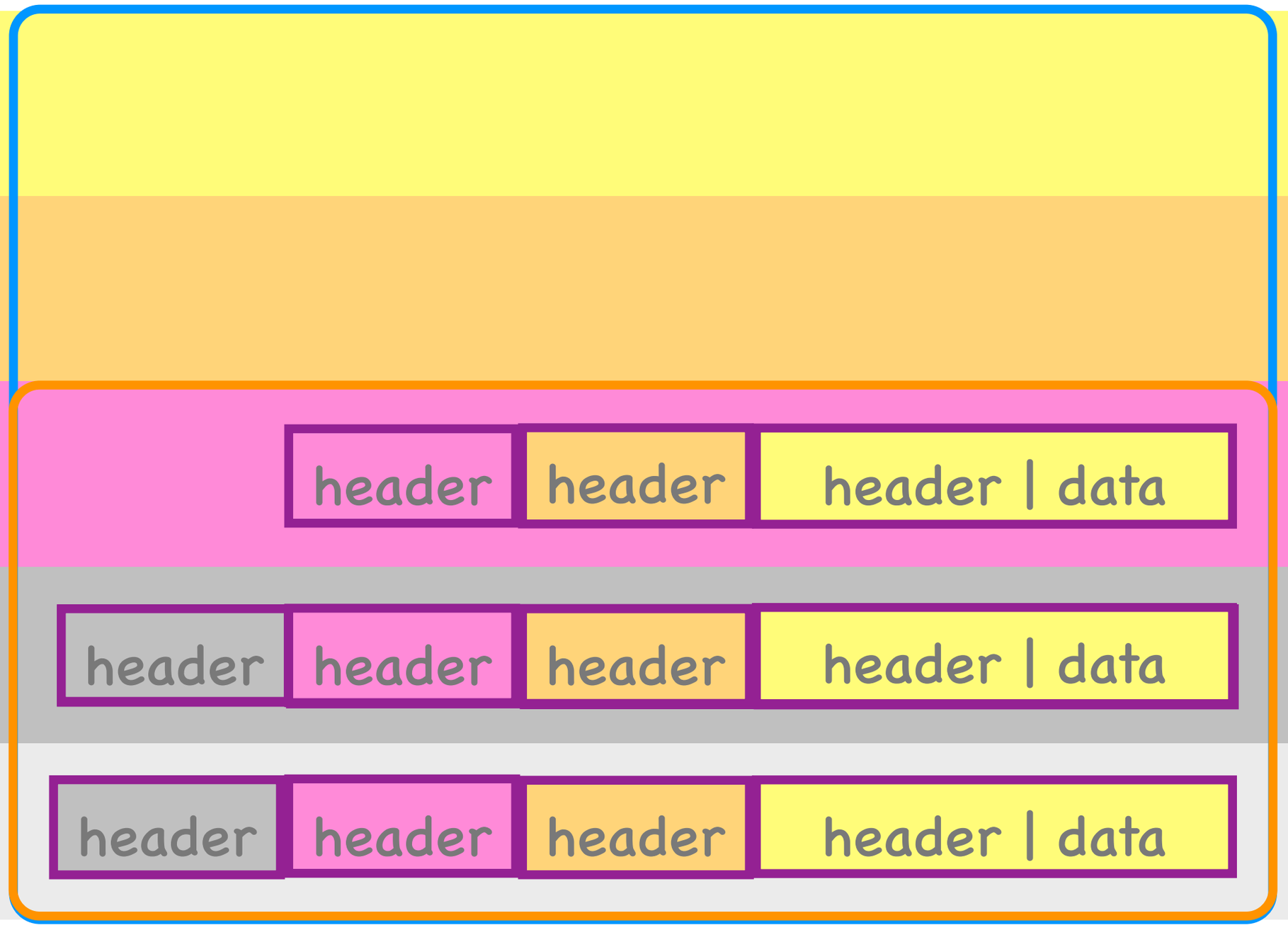
application

transport

network

link

physical



application

transport

network

link

physical

header | data

header | header | data

header | header | header | data

header | header | header | header | data

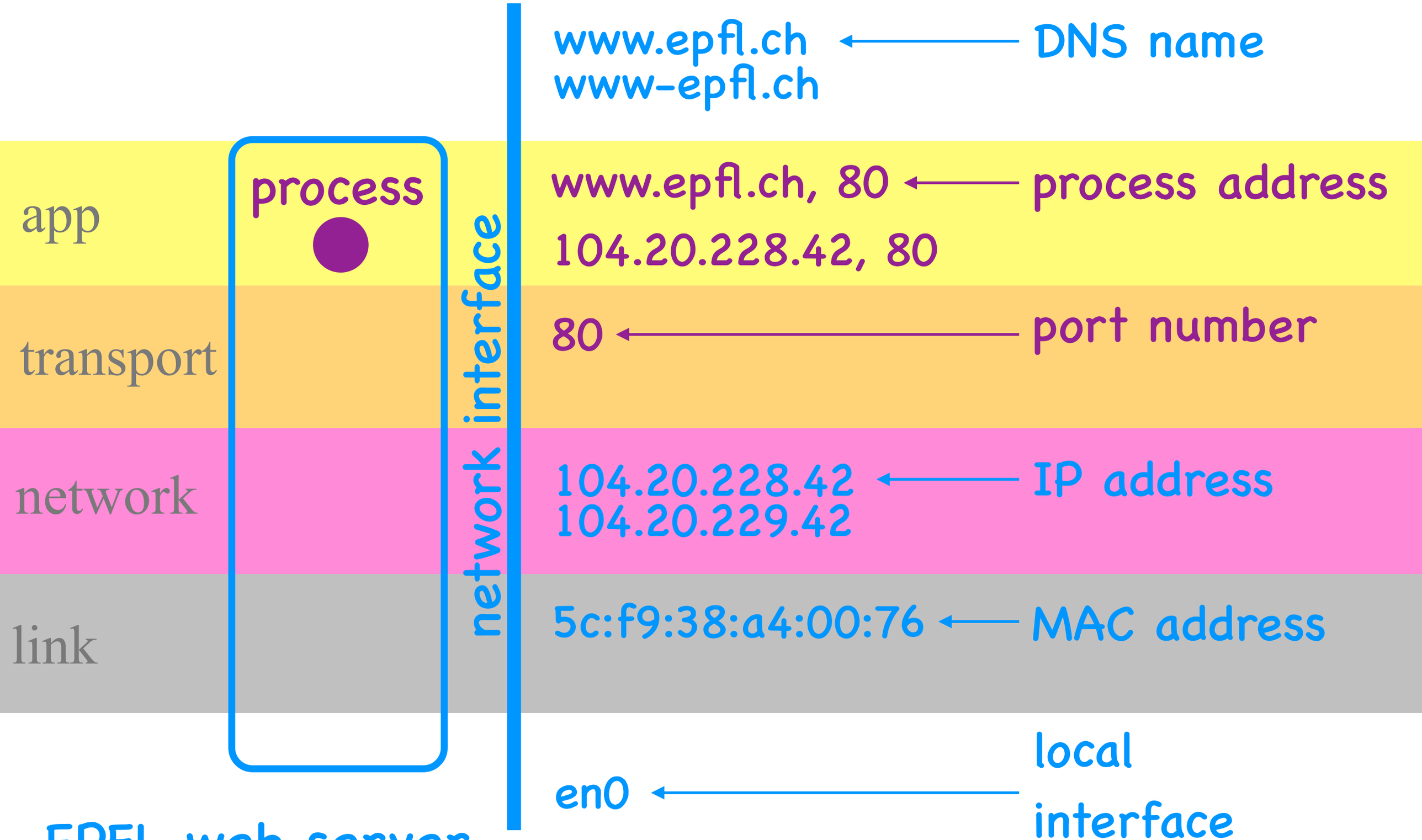
Bob's computer

Layers

- Each layer touches only
  the header of the same layer

- May add a new header
  = encapsulation

- May remove the header
  = decapsulation


www.epfl.ch
www-epfl.ch
DNS name
app
process
www.epfl.ch, 80
process address
104.20.228.42, 80
transport
80
port number
network
104.20.228.42
104.20.229.42
IP address
link
5c:f9:38:a4:00:76
MAC address
network interface
en0
local
interface
name
EPFL web server

Names (Identifiers)

- For network interfaces:
  DNS names, IP addresses,
  MAC addresses, local names
- For processes:
  network-interface name
  + port number

Translate DNS names to IP addresses:

```
> host www.epfl.ch

  www.epfl.ch is an alias for
  www.epfl.ch.cdn.cloudflare.net

  www.epfl.ch.cdn.cloudflare.net
  has address 104.20.229.42

  www.epfl.ch.cdn.cloudflare.net
  has address 104.20.228.42
```

DNS names

IP addresses

Find out the MAC and IP address
of the network interface(s) on your computer:

```
> ifconfig

   en0:
   ether 5c:f9:38:a4:00:76
   inet 128.168.178.27
```

MAC address

IP address

Check whom you are communicating with:

port numbers

```
> netstat

   Local Address                 Foreign Address

   goldfish.fritz.b.60242        ewa.epfl.ch.https
   goldfish.fritz.b.59740        108.177.119.188.5228
```

DNS names

IP address

Discover packet switches between your computer and a remote one:

```
> traceroute www.epfl.ch

  1 fritz.box (192.168.178.1) …
  2 10.136.43.239 (10.136.43.239) …
  3 as13335.swissix.ch (91.206.52.192) …
```

DNS names

IP addresses

Look inside network packets:

source + dst MAC addresses

source + dst IP addresses

source + dst port numbers

application stuff

Why layers?

What layers to define?

Course rythme

- Friday: material becomes available
  - slides in Keynote and PDF
  - lab + homework problems
  - on Moodle

- Friday, 15h00-17h00: lecture
  - SG1138 + online on Zoom

Course rythme

- Tuesday, 12h00-14h00: office hours
  - focus on homework
  - online on Zoom
- Wednesday, 15h00-17h00: lab/hw session
  - INF2/INF3 + online on Discord
  - on your own computer or EPFL infrastructure

Quizzes

- Voluntary, count only if you do well
- 10min, every other week
- Cover the 2 previous lectures
- Online on Moodle

Midterm

- Voluntary, counts only if you do well
- Exact format TBD
- Covers all lectures, homework, and labs prior to midterm date
- Online on Moodle + Discord

Final

- Mandatory, counts always
- 2 hours, closed-book, date + room TBD
- Covers all lectures, homework, and labs
- During winter exam session

Grade

- quiz grade =
  average of 3 best quizzes

- exam grade =
  max { final, 0.7final + 0.3mid }

- overall course grade =
  max { exam, 0.9exam + 0.1quiz }

On Moodle

- Lecture slides & pre-recorded videos
- Lab & homework problems, solutions
- Announcements (News forum)
- Q&A (Discussion forum)
- Course logistics (e.g., where to login to do the labs remotely)

Communication

- Discord space
  - informal, fast, knowledge sharing
- Moodle discussion forum
  - for longer interactions, still fast
- com208-staff@groupes.epfl.ch
  - for questions you don't want to share

Welcome aboard!