IT -305
Data Communication

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Guest Faculty

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Overview

What is a Network made of?

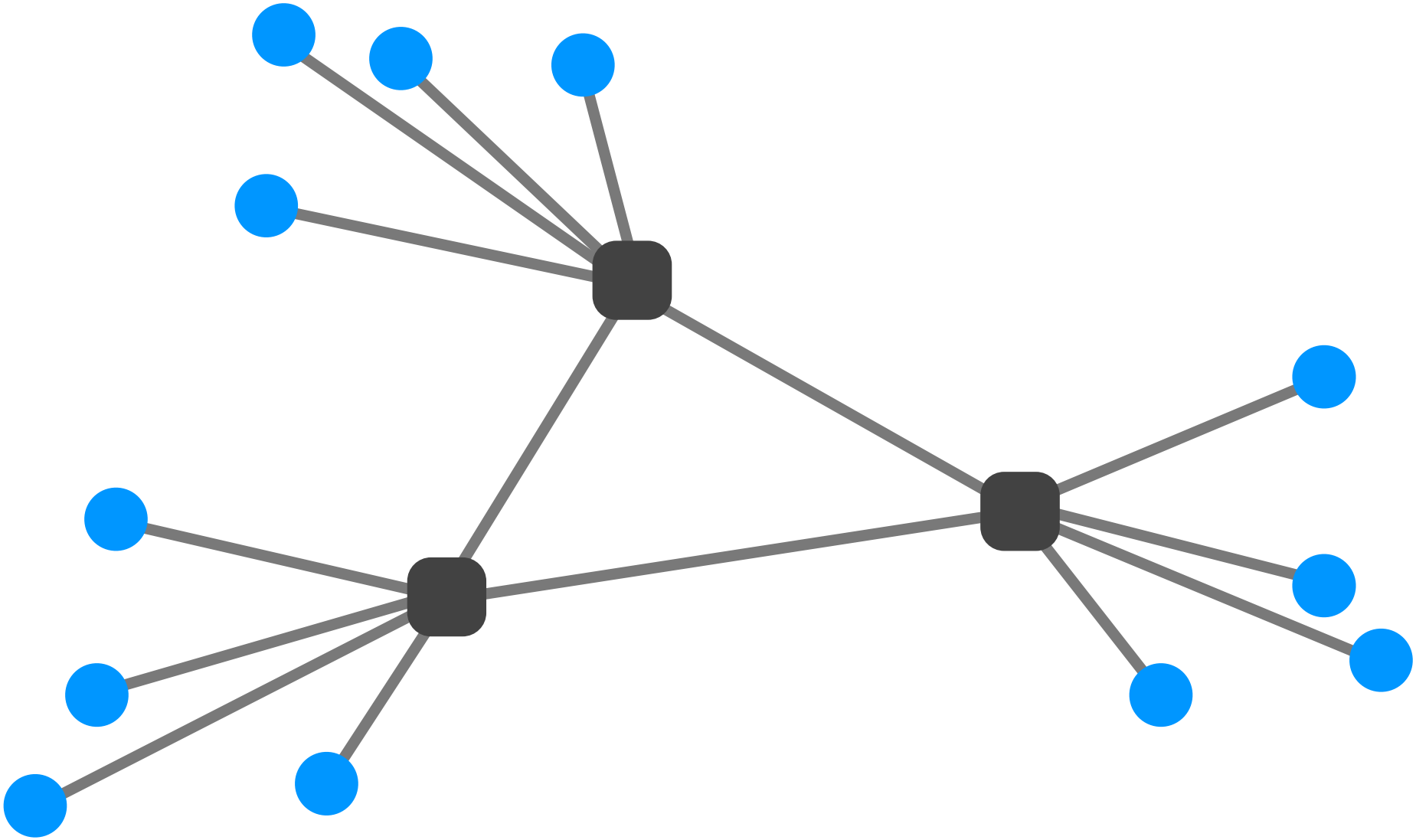
How is it shared?

How is it organized?

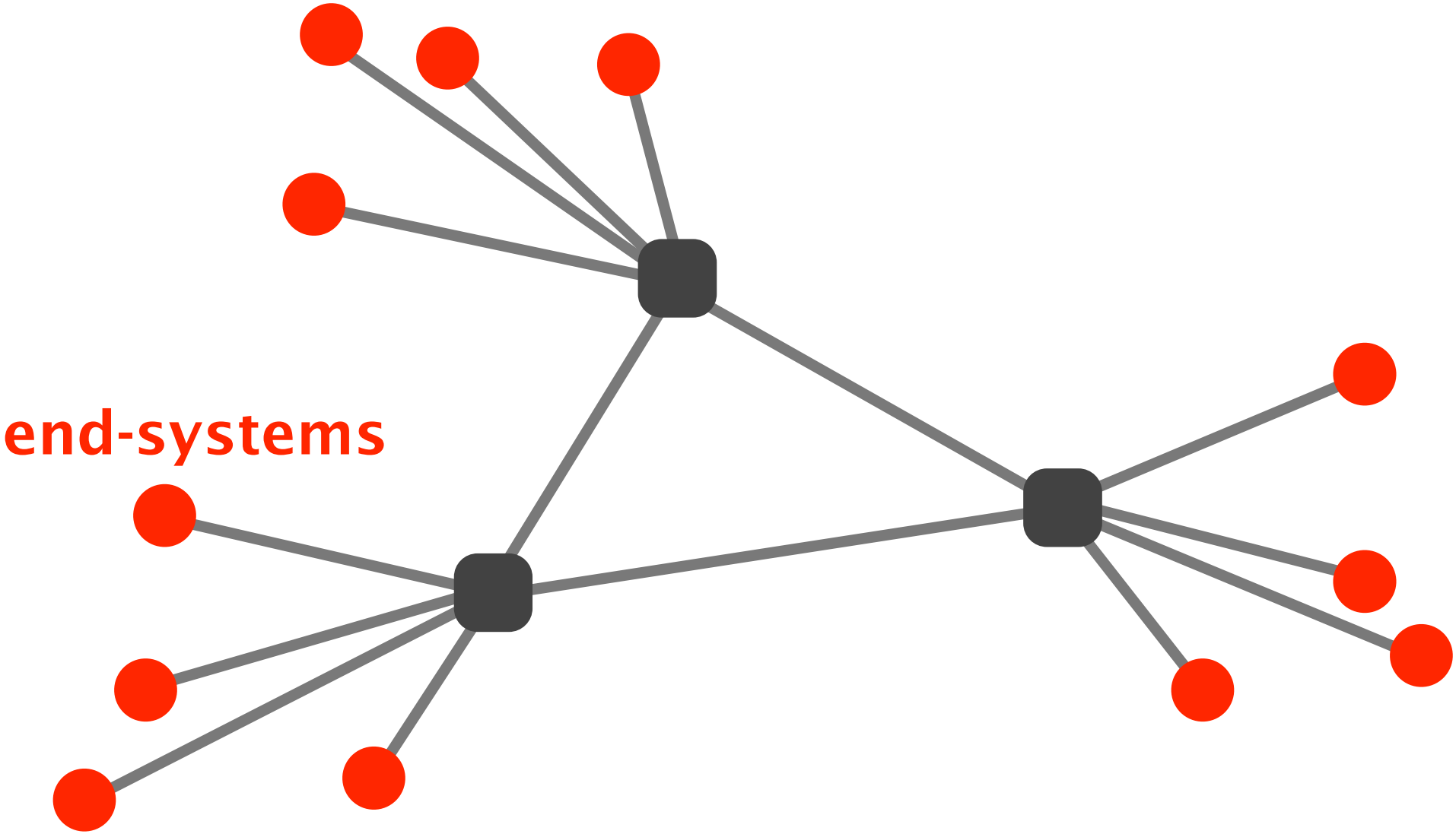
How does communication happen?

How do we characterize it?

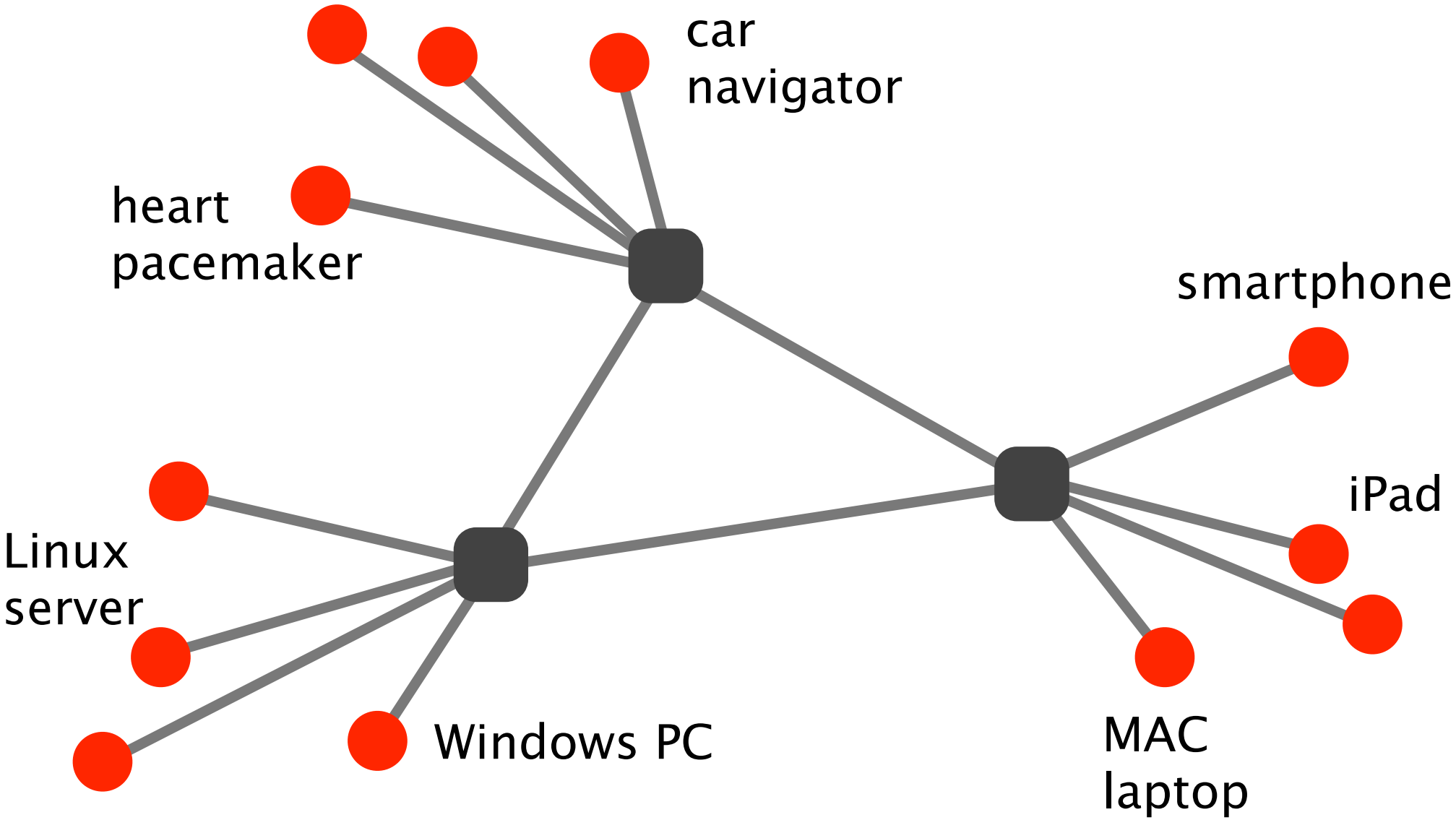
Networks are composed of three basic components



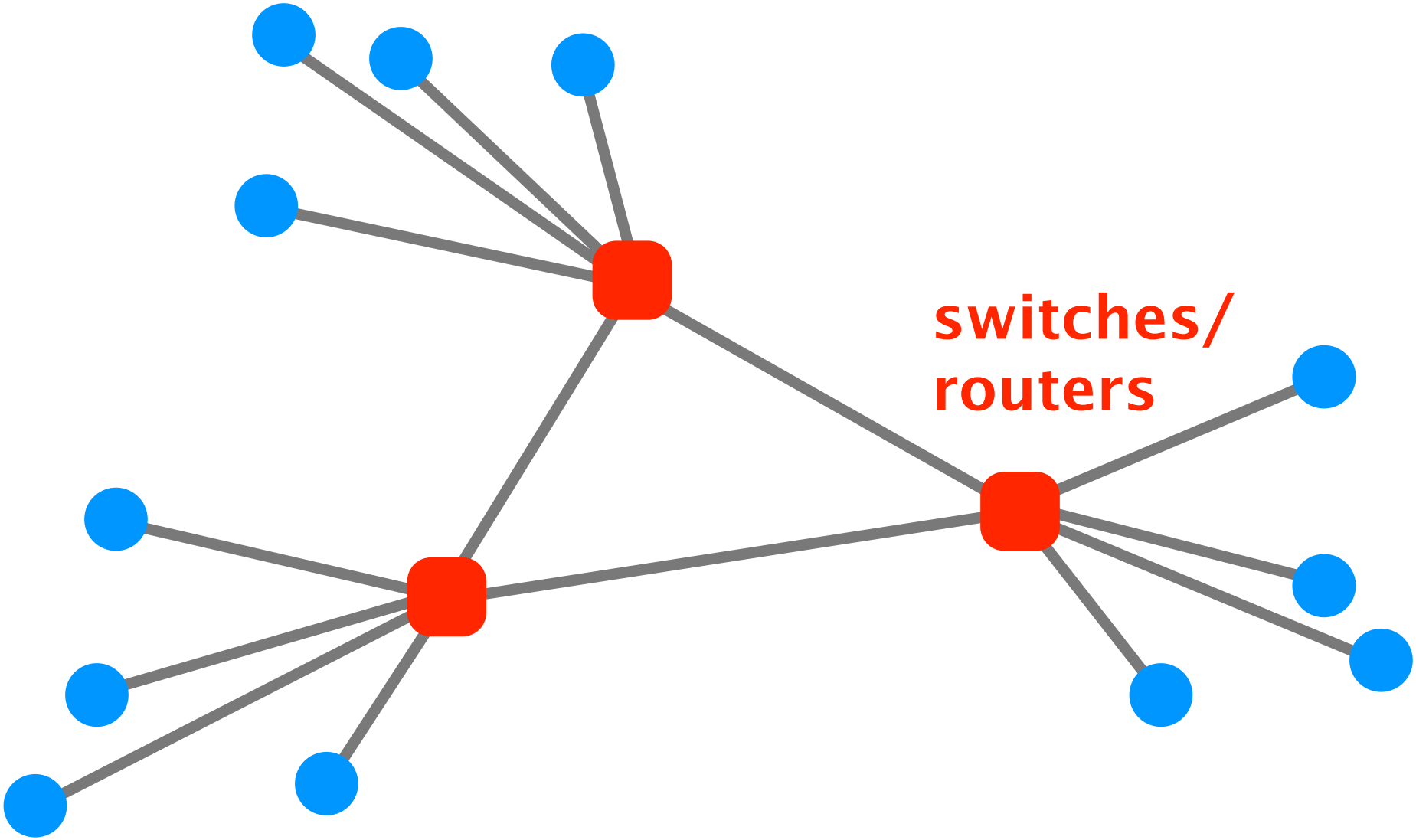
End-systems send & receive data



End-systems come in a wide-variety



Switches & routers forward data to the destination



Routers/switches vary in size and usage

Home router

~20 cm

0,5 kg

1 Gbps

Internet core router

>200cm

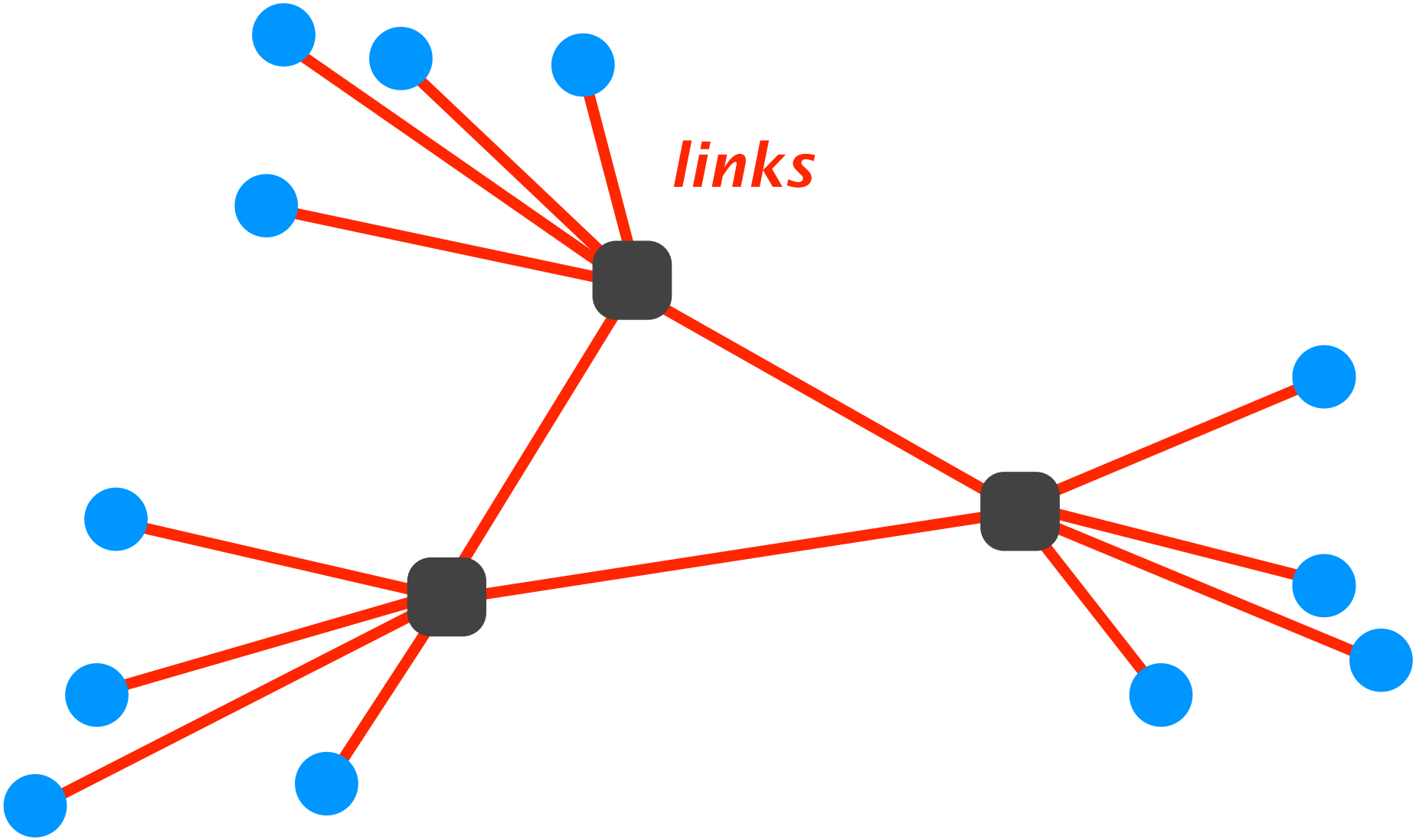
700kg

>12 Tbps

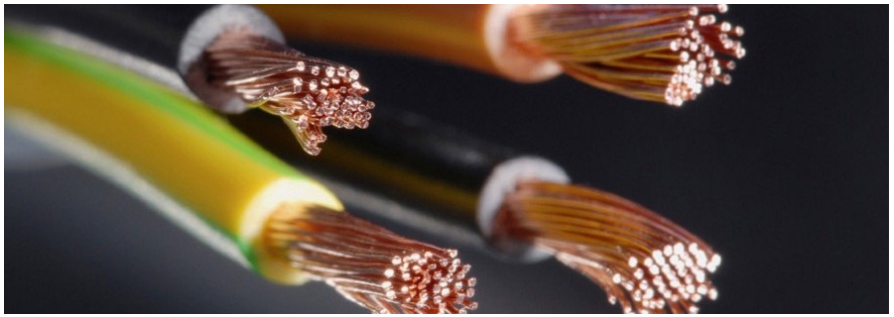
(>920 Tbps in multi-chassis*)

*https://www.cisco.com/c/en/us/products/collateral/routers/carrier-routing-system/data_sheet_c78-726136.html

Links connect end-systems to switches
and switches to each other

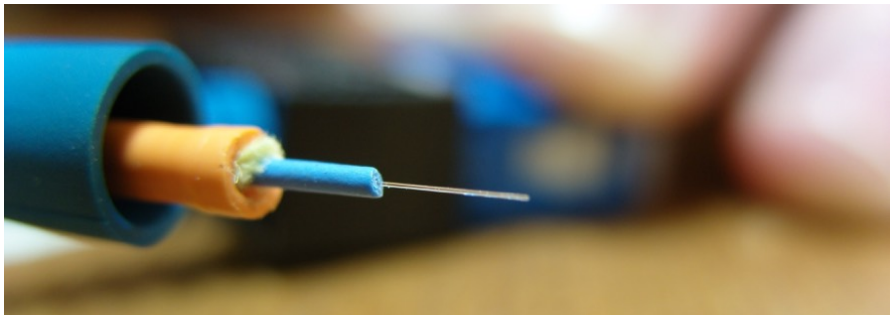


Links, too, vary in size and usage



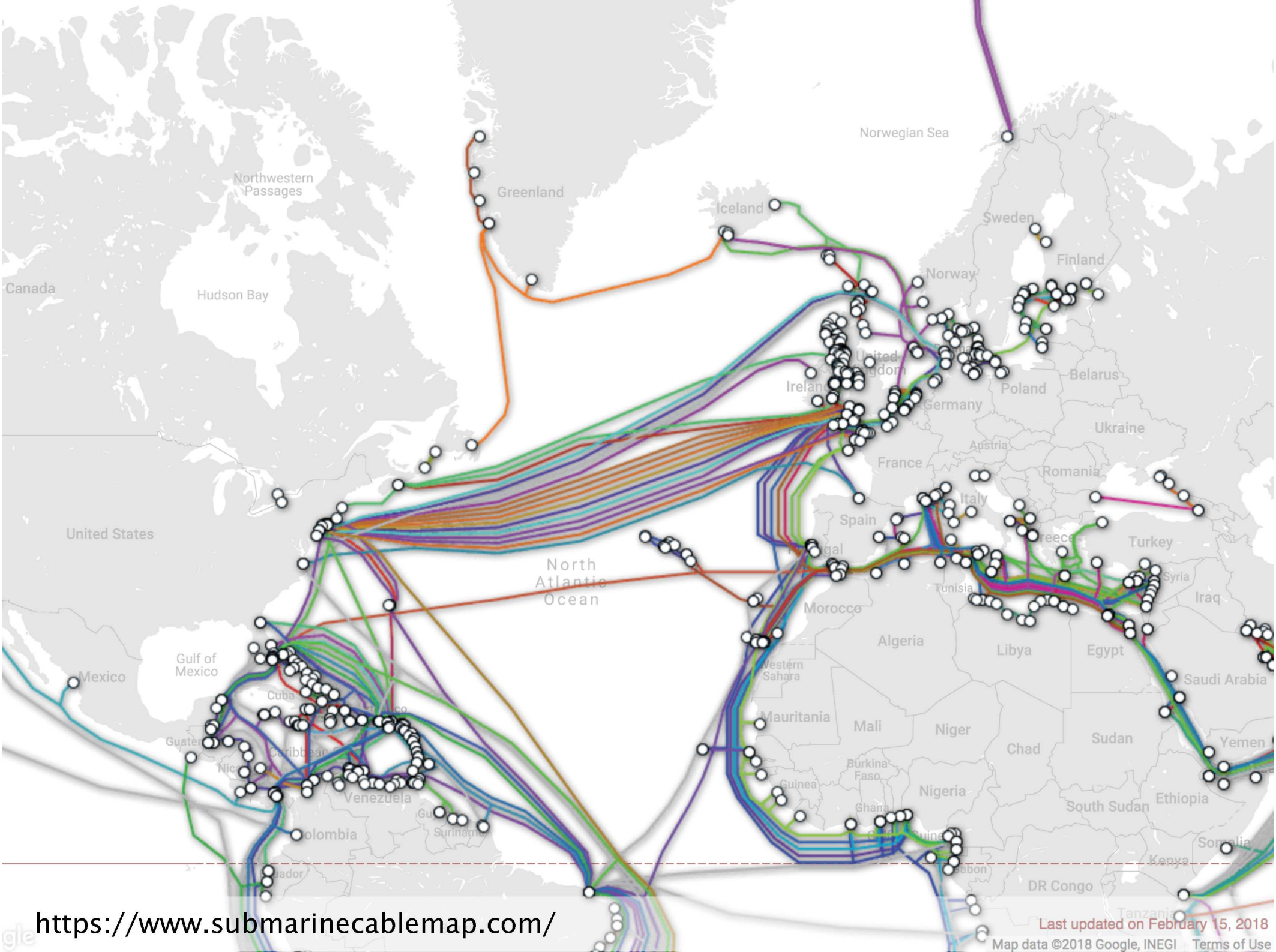
Copper

ADSL, RJ-45,…



Optical fibers

Wireless link


Norwegian Sea
Northwestern Passages
Greenland
Iceland
Sweden
Finland
Canada
Hudson Bay
Norway
United Kingdom
Ireland
Belarus
Poland
Germany
Ukraine
Austria
France
Romania
Italy
Spain
Turkey
United States
North Atlantic Ocean
Tunisia
Syria
Iraq
Morocco
Algeria
Libya
Egypt
Gulf of Mexico
Mexico
Western Sahara
Saudi Arabia
Cuba
Mauritania
Mali
Niger
Chad
Sudan
Yemen
Burkina Faso
Guinea
Nigeria
Ethiopia
Venezuela
Ghana
South Sudan
Colombia
Suriname
Kenya
Gabon
DR Congo
https://www.submarinecablemap.com/
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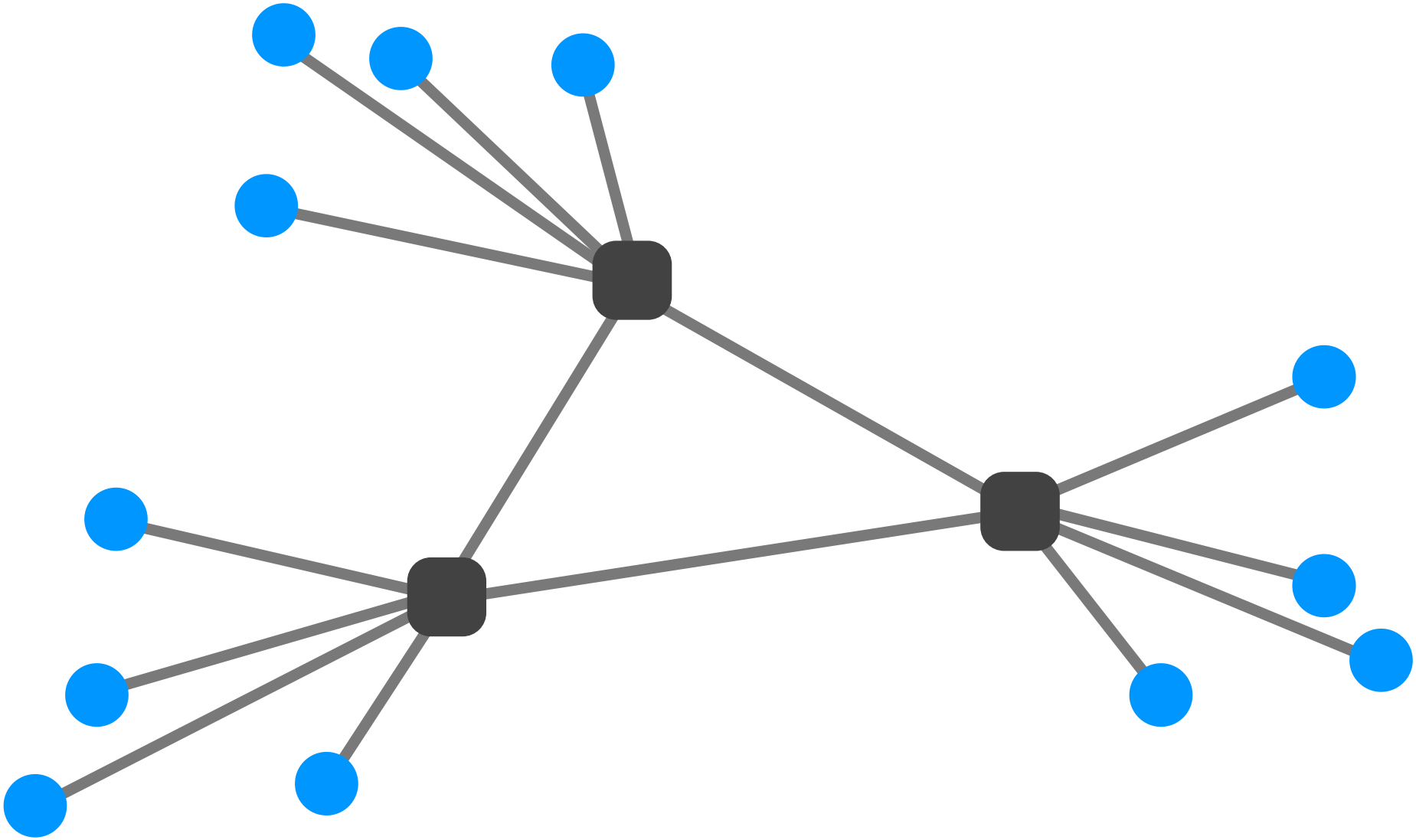
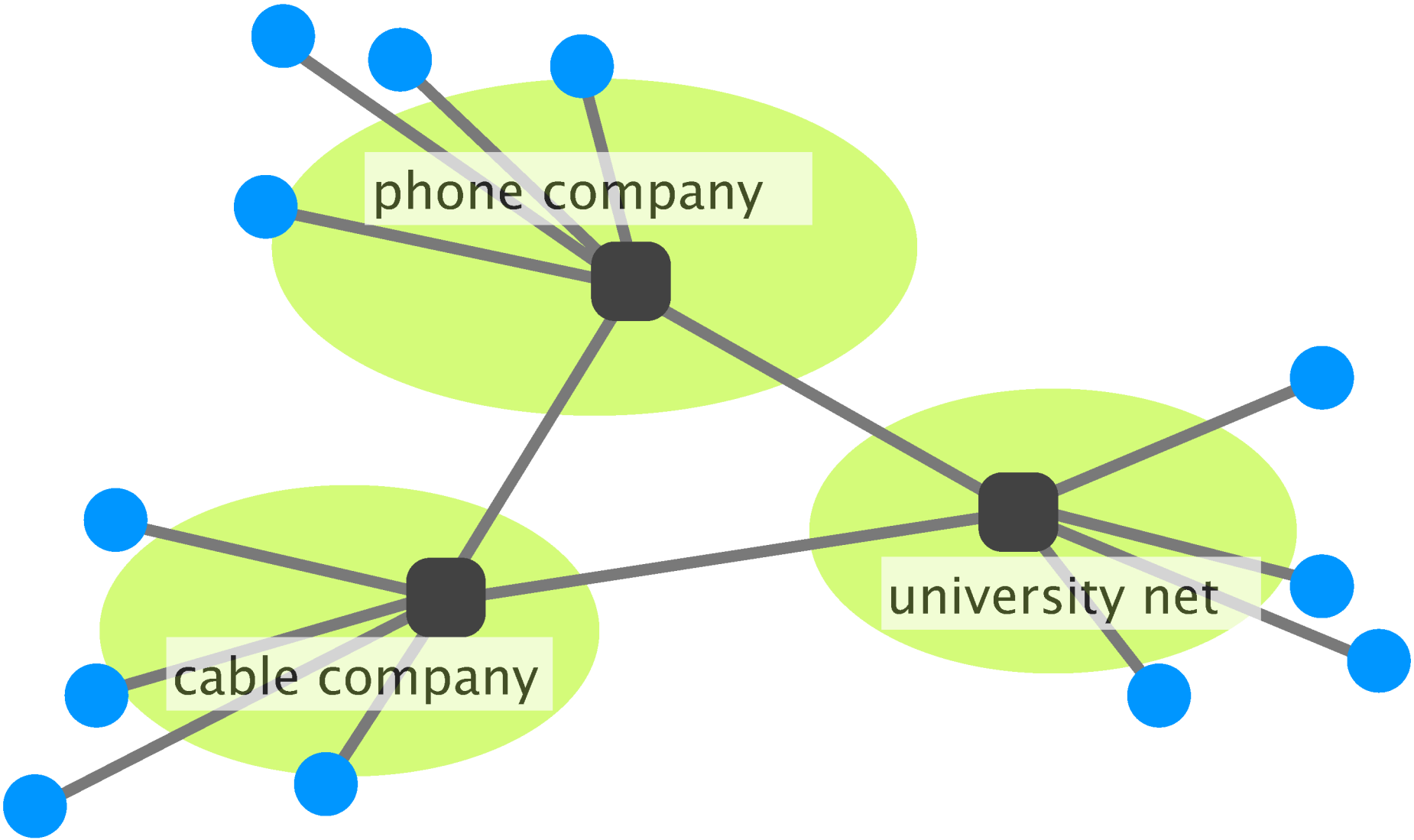
The *Inter*net is a network of networks



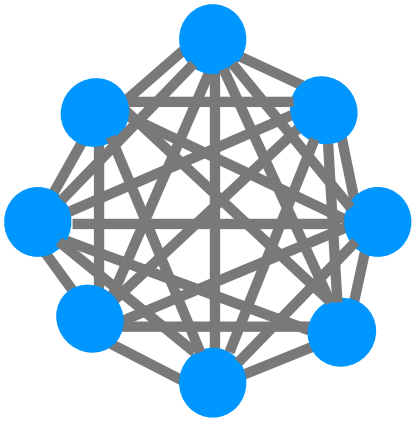
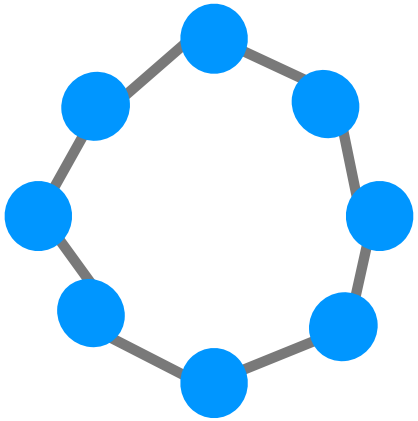
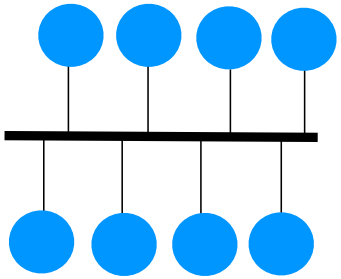
Internet Service Providers



There exists a huge amount of access technologies

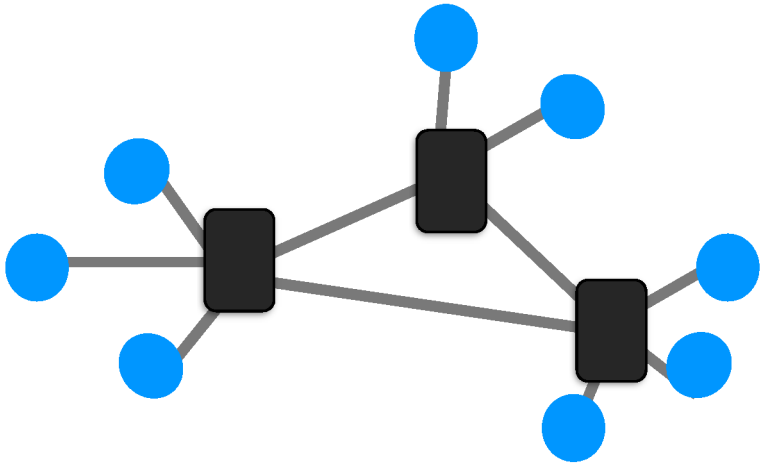
Ethernet	most common, symmetric
DSL	over phone lines, asymmetric
CATV	via cable TV, shared
Cellular	smart phones
Satellite	remote areas
FTTH	household
Fibers	Internet backbone
Infiniband	High performance computing

Compare these three designs in terms of sharing, resiliency, and per-node capacity

design	full-mesh	chain	bus
			
advantages			
disadvantages			

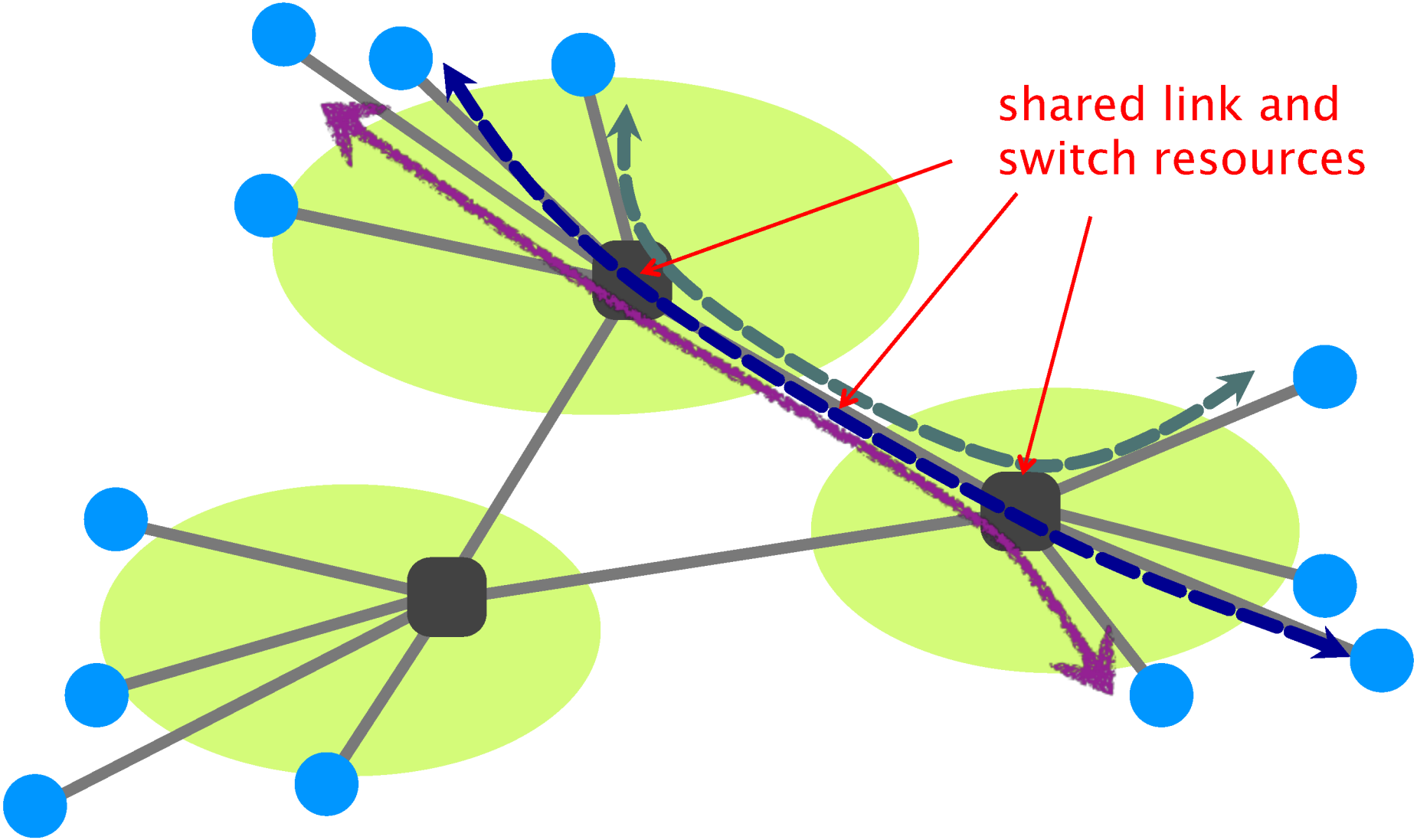
Switched networks provide reasonable and flexible compromise

design	switched



advantages	sharing and per-node capacity can be adapted to fit the network needs
disadvantages	require smart devices to perform: forwarding, routing, resource allocation

Links and switches are shared between flows



There exist two approaches to sharing:

reservation and on-demand

	Reservation	On-demand
principle	reserve the bandwidth you need in advance	send data when you need

Both are examples of statistical multiplexing

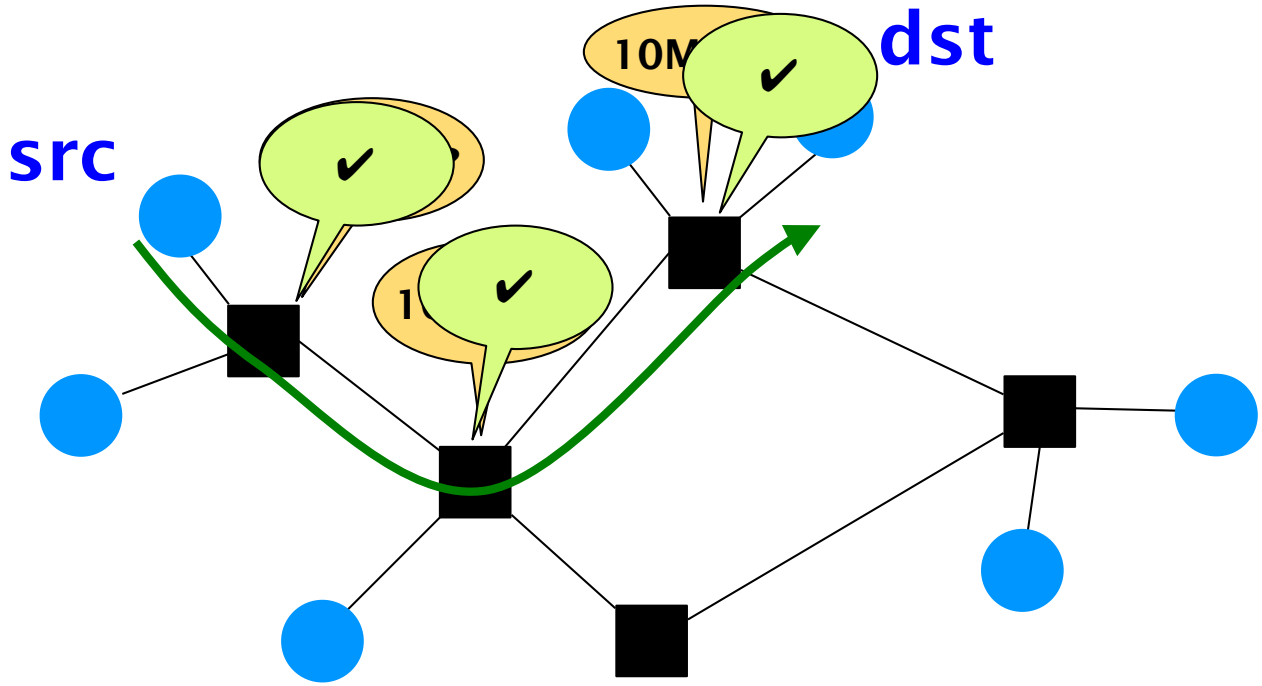
	Reservation	On-demand
multiplexing	at the flow-level	at the packet-level

The two approaches are implemented using circuit-switching or packet-switching, respectively

	Reservation	On-demand
implem.	circuit-switching	packet-switching

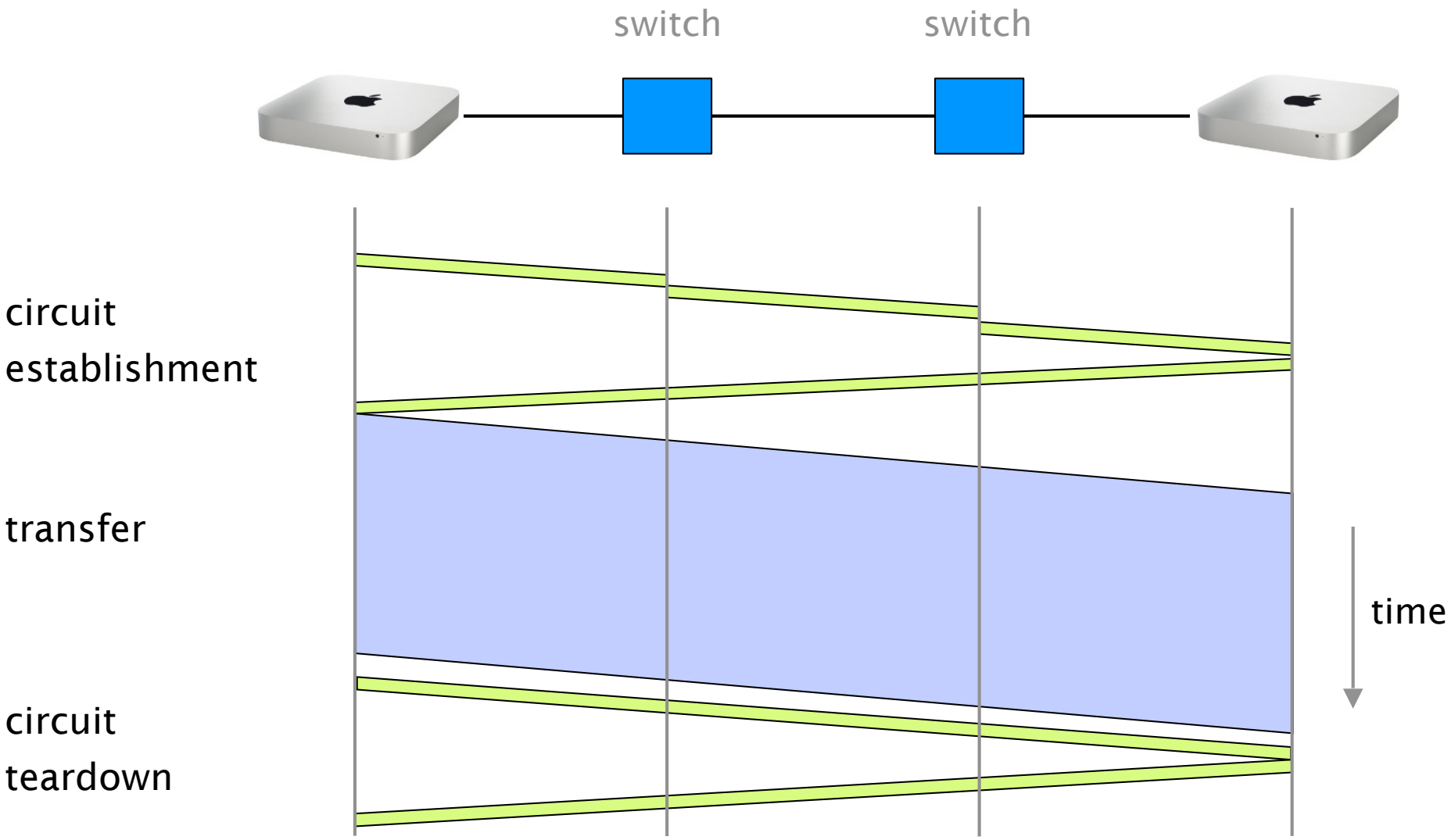
	Reservation	On-demand
implem.	circuit-switching	packet-switching

Circuit switching relies on
the Resource Reservation Protocol



(1) src sends a reservation request for 10Mbps to dst
(2) switches “establish a circuit”
(3) src starts sending data
(4) src sends a “teardown circuit” message

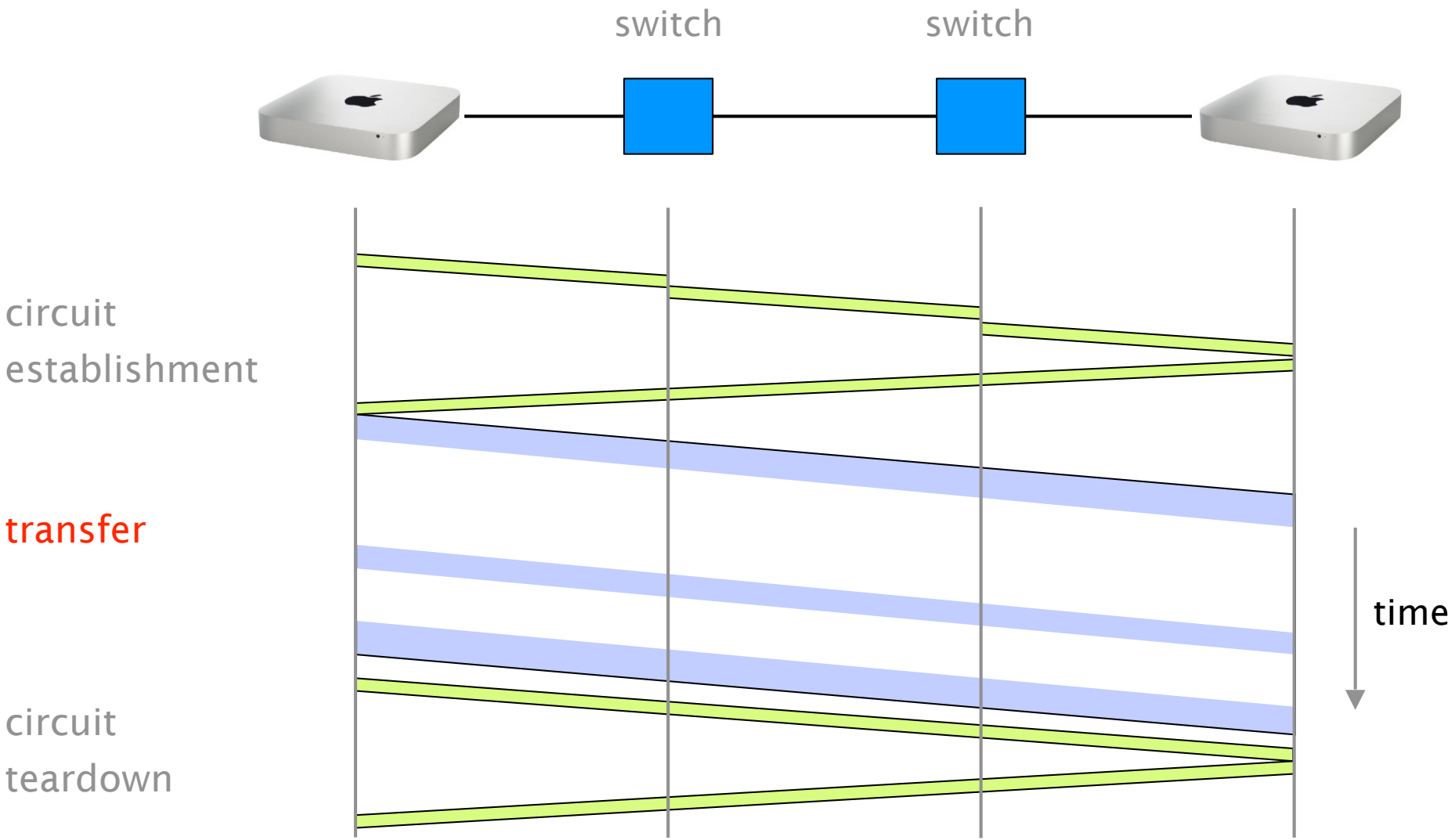
Let's walk through example of data transfer using circuit switching



The efficiency of the transfer depends on how utilized the circuit is once established

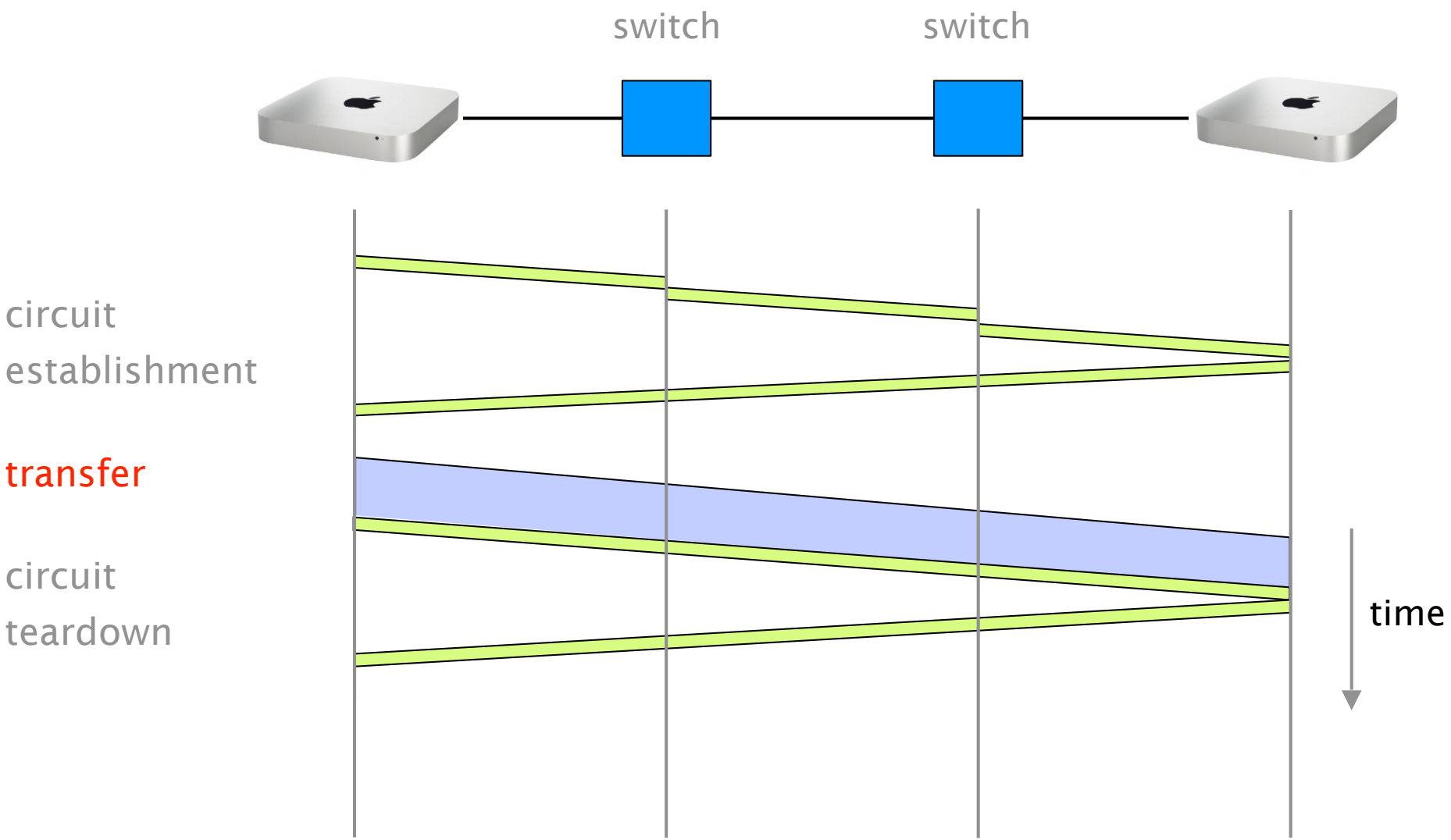
This is an example of poor efficiency.

The circuit is mostly idle due to traffic bursts

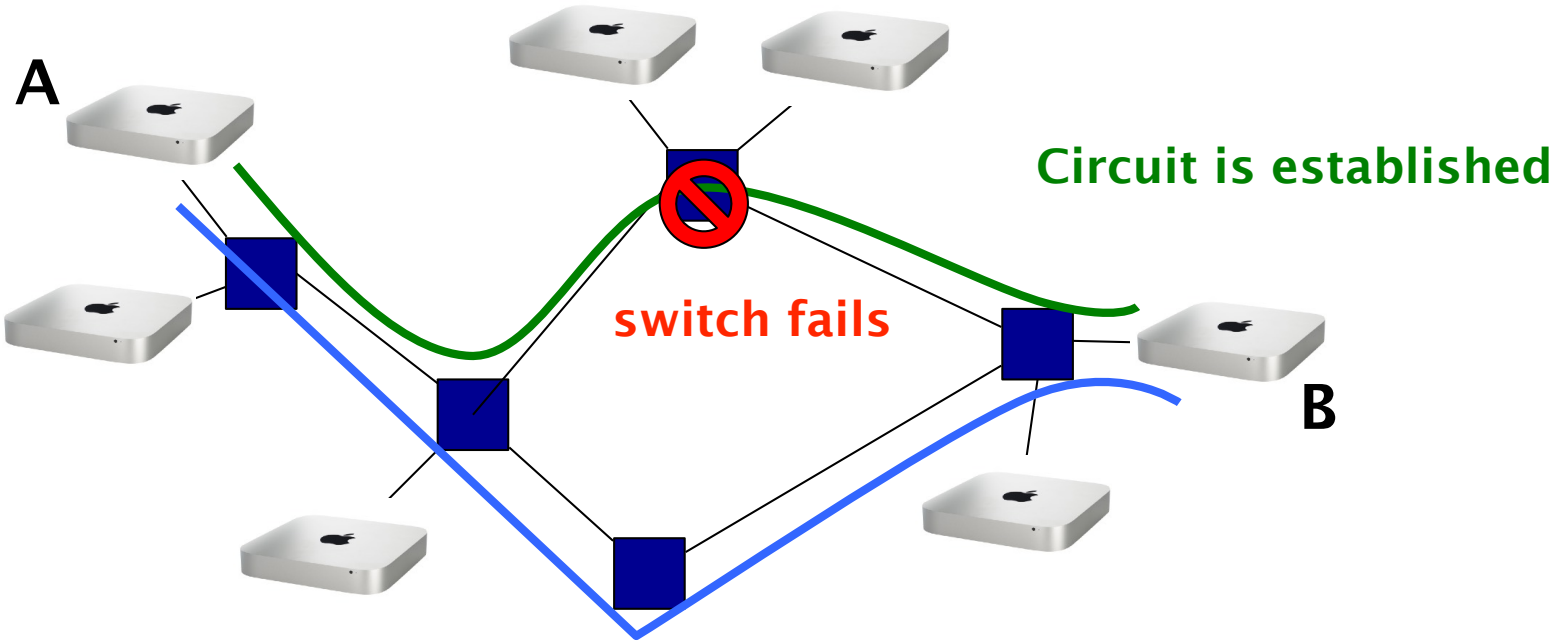


This is another example of poor efficiency.

The circuit is used for a short amount of time



Another problem of circuit switching is that it doesn't route around trouble



Pros and cons of circuit switching

advantages	disadvantages
predictable performance	inefficient if traffic is bursty or short
simple & fast switching once circuit established	complex circuit setup/teardown which adds delays to transfer
	requires new circuit upon failure

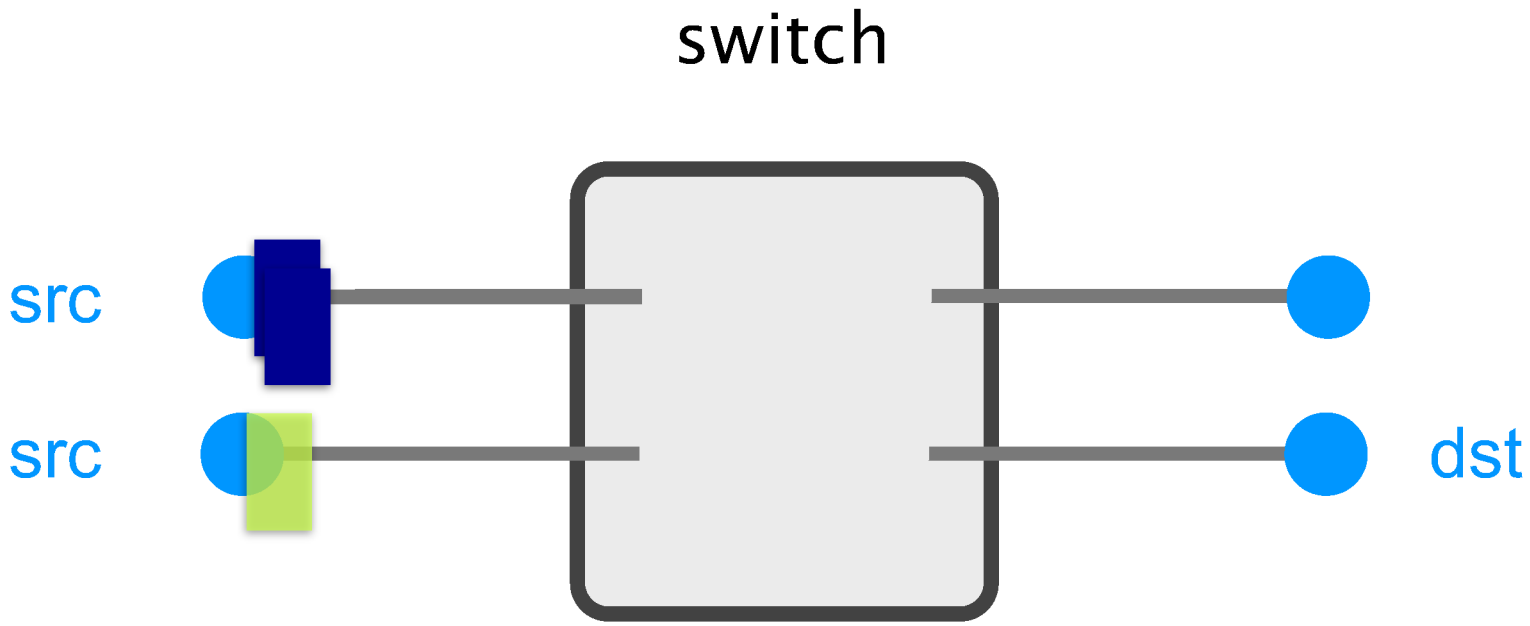
What about packet switching?

circuit-switching

packet-switching

In packet switching,

data transfer is done using independent packets



Each packet contains a destination (dst)

Since packets are sent without global coordination, they can “clash” with each other

To absorb transient overload,
packet switching relies on buffers

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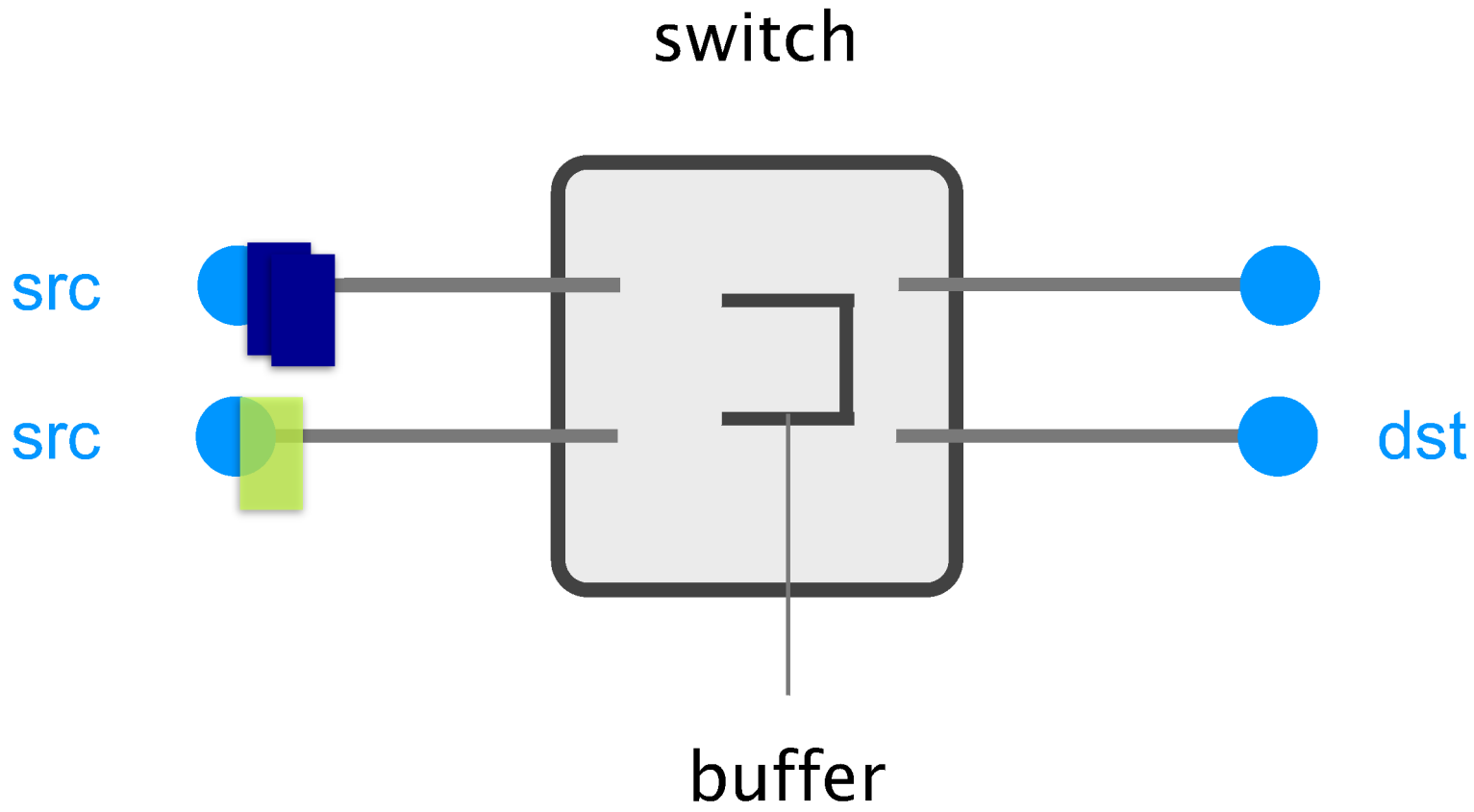
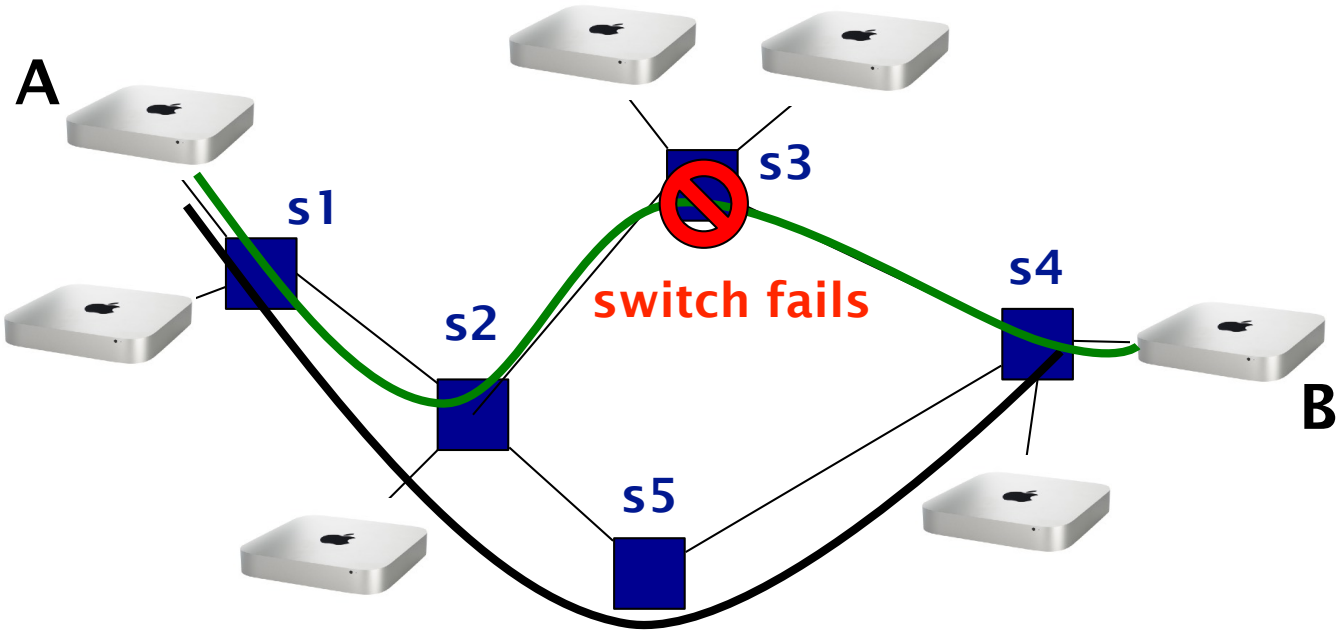
packet switching relies on buffers



Packet switching routes around trouble

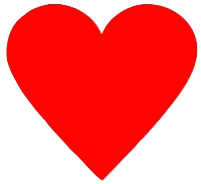


route recomputed
on the fly by s2

Pros and cons of packet switching

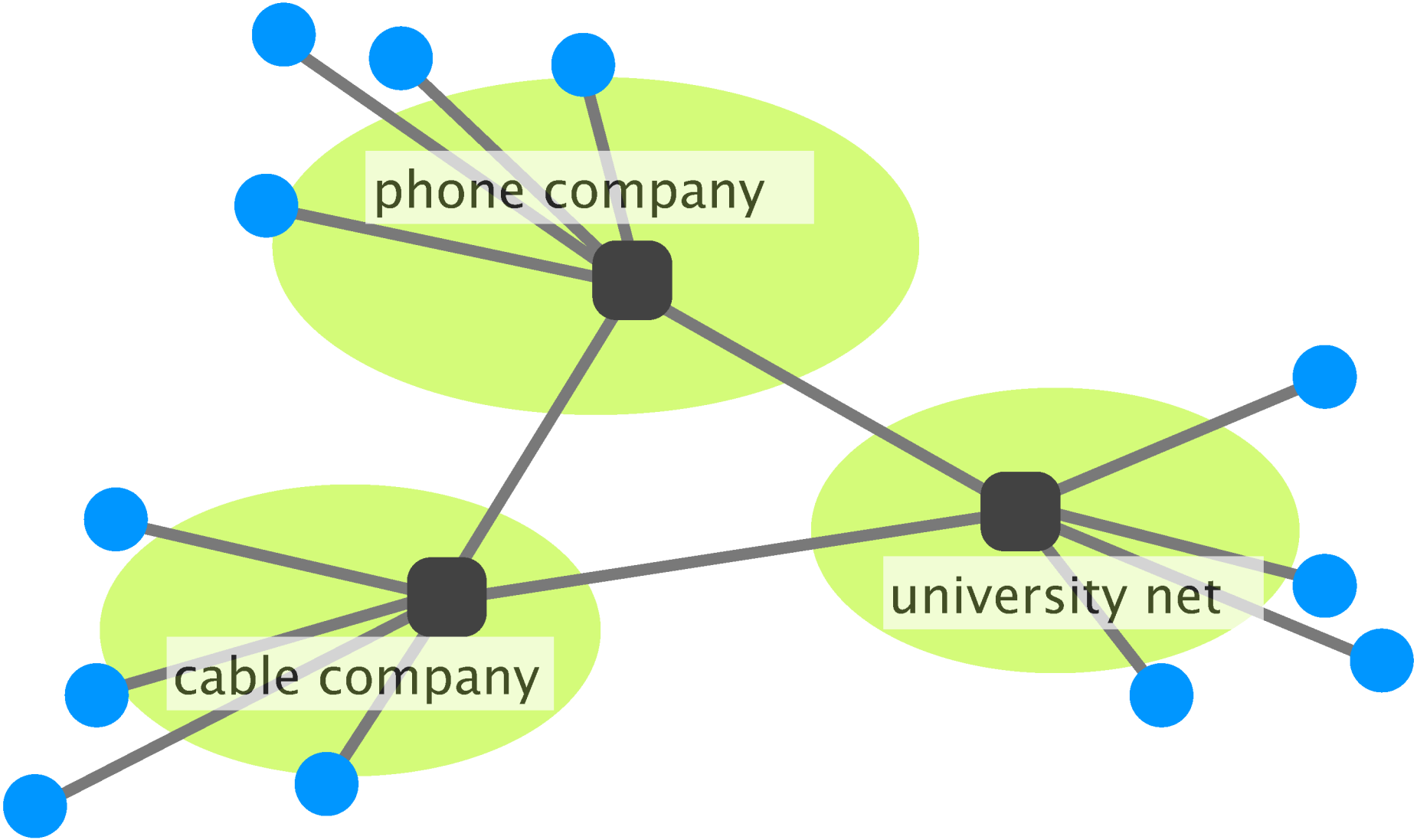
advantages	disadvantages
efficient use of resources	unpredictable performance
simpler to implement	requires buffer management and congestion control
route around trouble	

Packet switching beats circuit switching
with respect to *resiliency* and *efficiency*

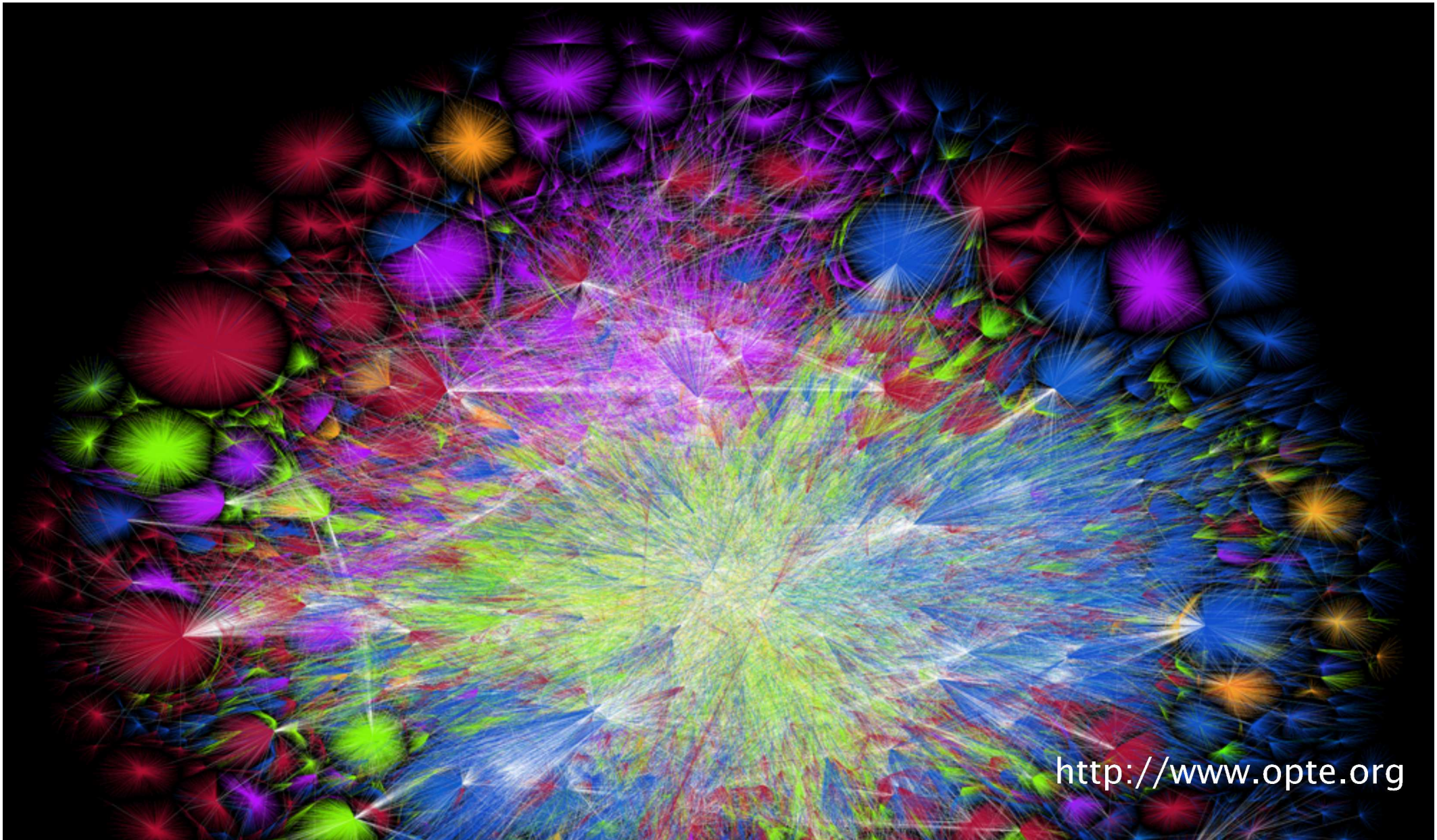
Internet  packets

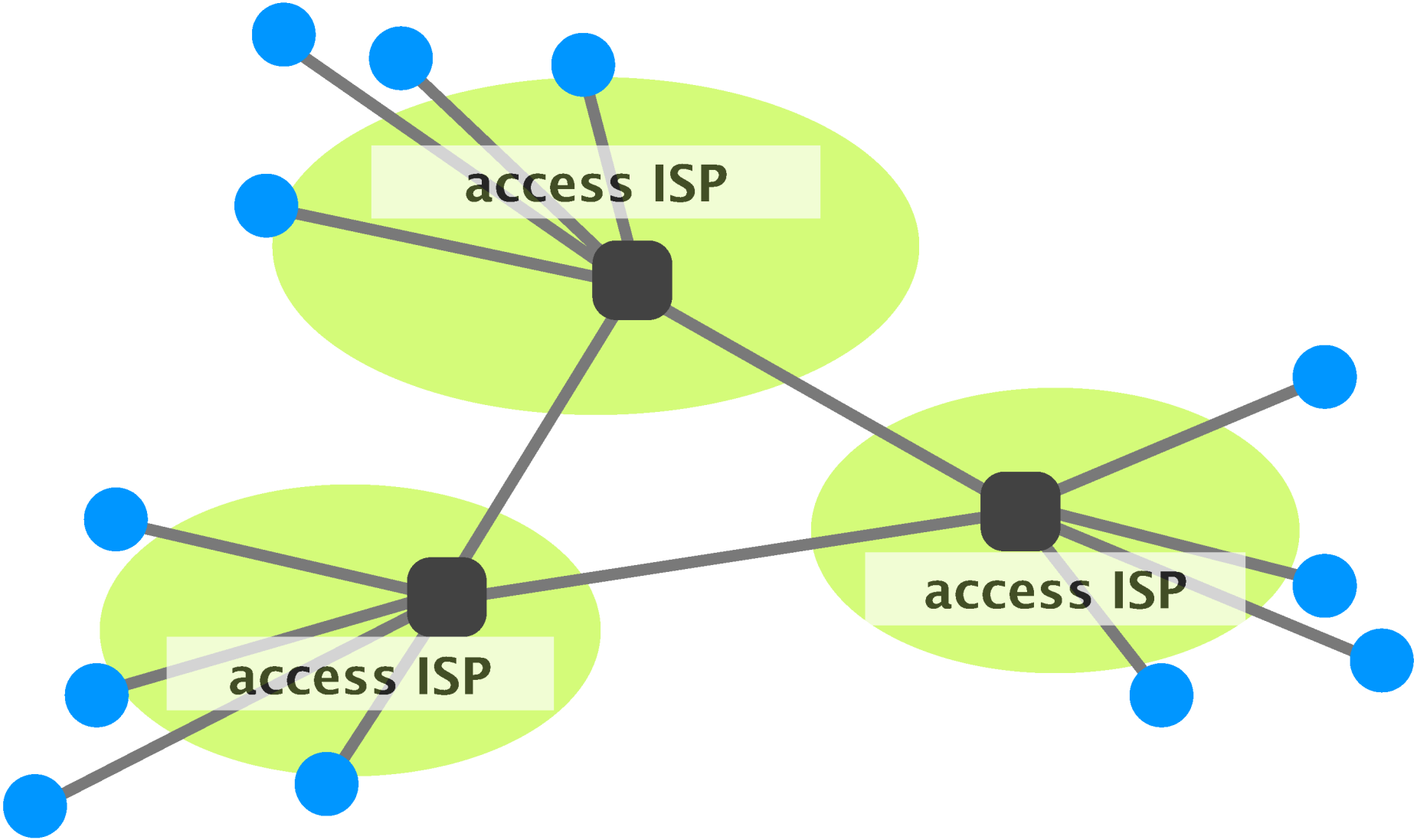
Packet switching will be our focus for the rest of the course

So far, this is our vision of the Internet…



The real Internet is a “tad” more complex




access ISP
access ISP
access ISP