CPSC 433/533
Computer Networks

Spring 2021

Anurag Khandelwal

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for student in raised_hands:
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- Feel free to stop me any number of times!

Today's Agenda

- Introductions
- What is (this course on) networking about?
- Class policies, Administrivia and Roadmap

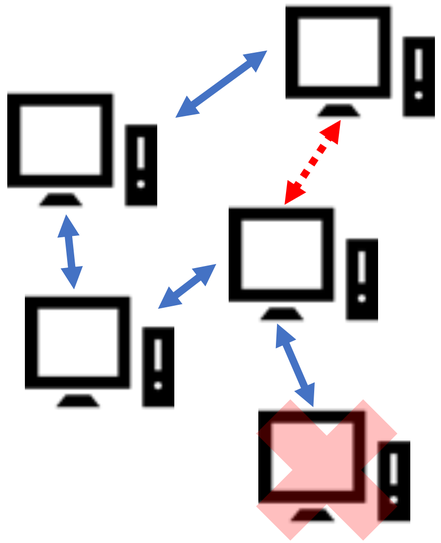
Introduction

Who Am I?

- **Assistant Professor, started Spring 2020**
  - PhD in Computer Science from UC Berkeley (Systems & Networking)
  - **Thesis:** Enabling Queries on Compressed Data
  - **Office:** AKW 205

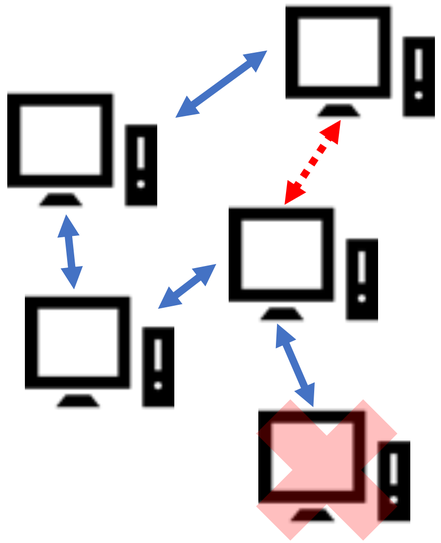
My Research

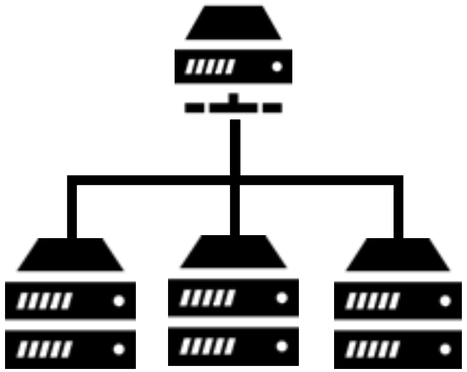
My Research

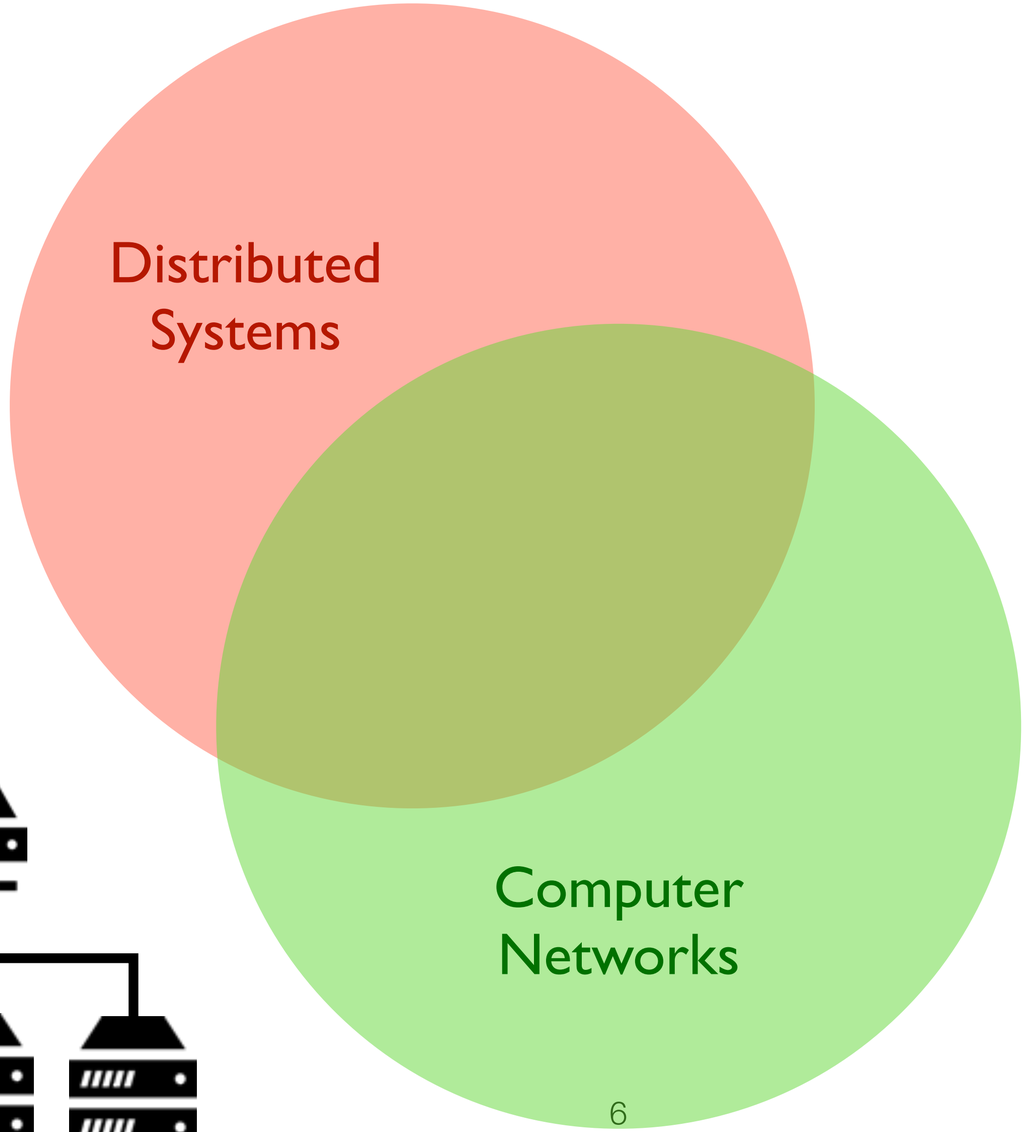


Distributed
Systems

My Research







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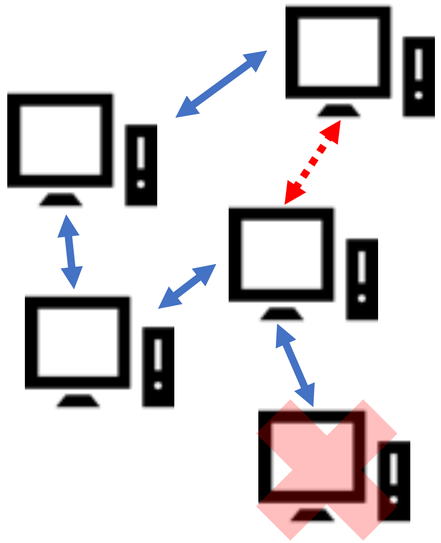
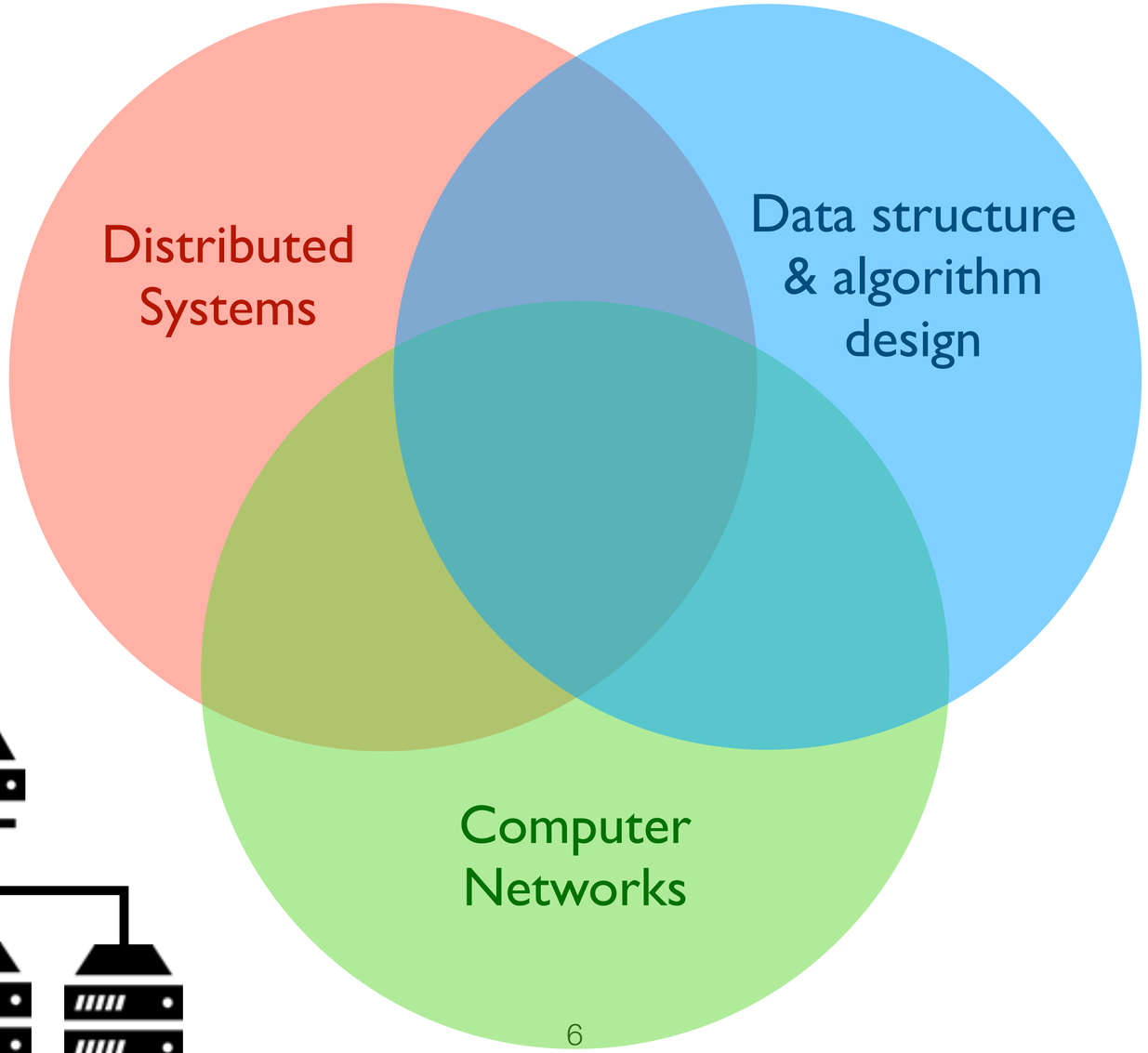
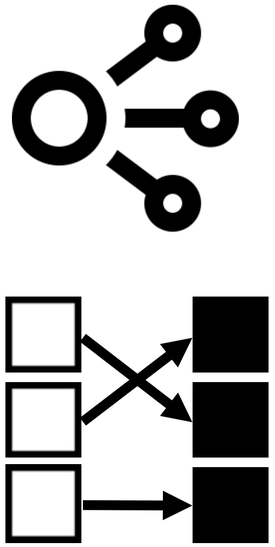
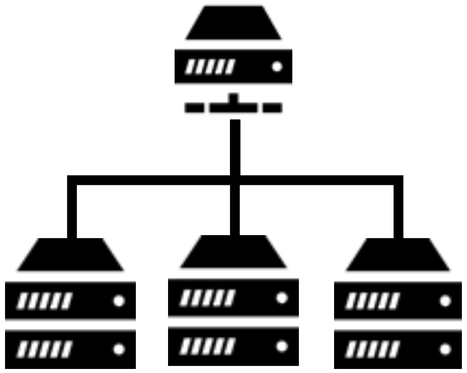



Distributed Systems
Data structure & algorithm design
Computer Networks





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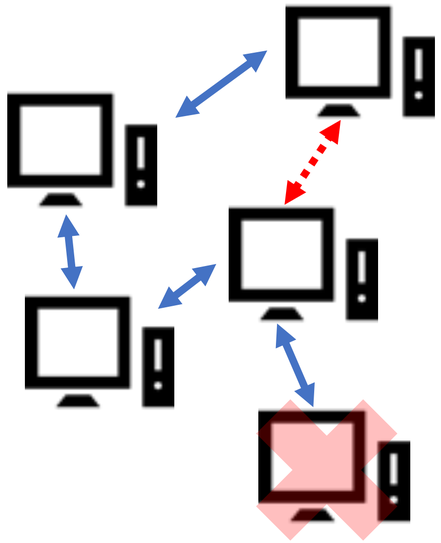

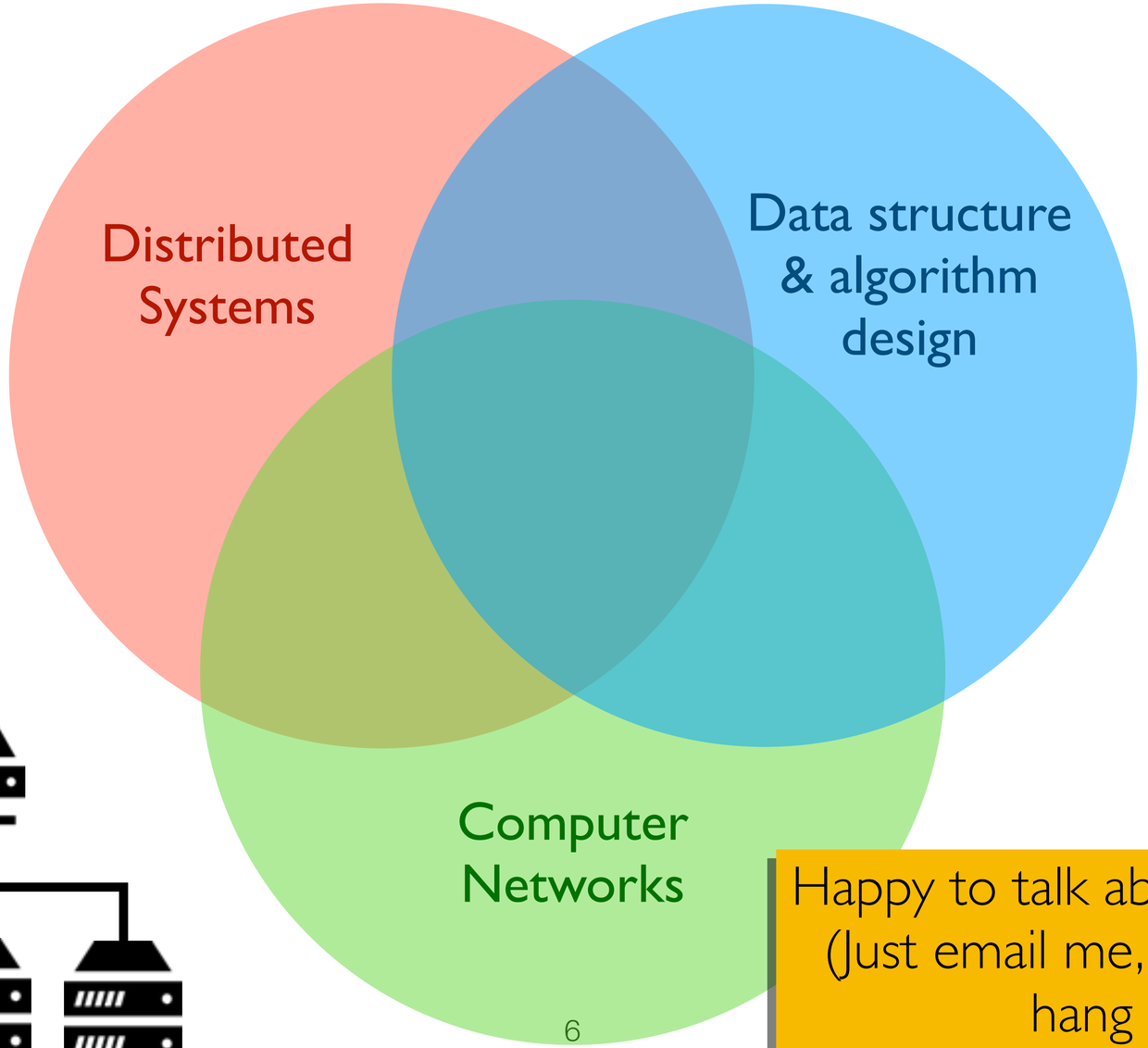

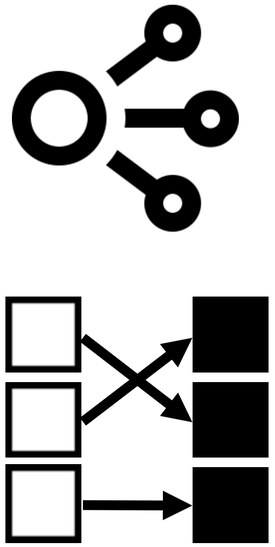

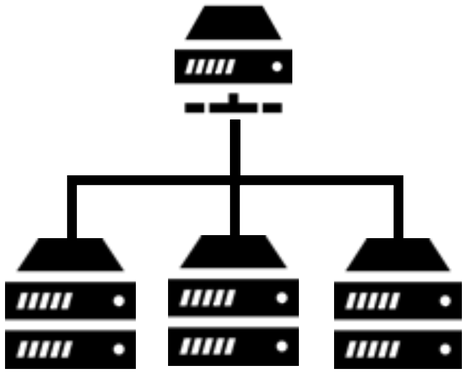

Happy to talk about my research anytime! (Just email me, we can set up a time to hang out on Zoom)

Non-research Interests

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- I want you to understand not just the **what** and **how**, but the **why**
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My Teaching Style

- I want you to understand not just the **what** and **how**, but the **why**
  - ***Why*** was some protocol designed in a certain way?
- Make it a point to ask yourself (and me) ***why??***
  - May not always get answer right away, but I will make it a point that you do
  - Ask me as many times as you have to if you are not satisfied

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- If no one asks questions, I will assume you understand
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- **My goal:** I really want you to learn
  - You may not end up pursuing a career in networking, but you will learn fundamental principles that you will use
  - If something helps you learn better, let me know; if some thing ***isn't*** helping you learn, let me know!

So how do we know about you?

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- Not feasible to go through all 40+ students :-)
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- So how do we get to know more about you?
  - **Participation** in and outside class! (There are points for participation!)
  - Ask questions, drop in on office hours, be active on online discussions

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What is networking about?

A Computer Network

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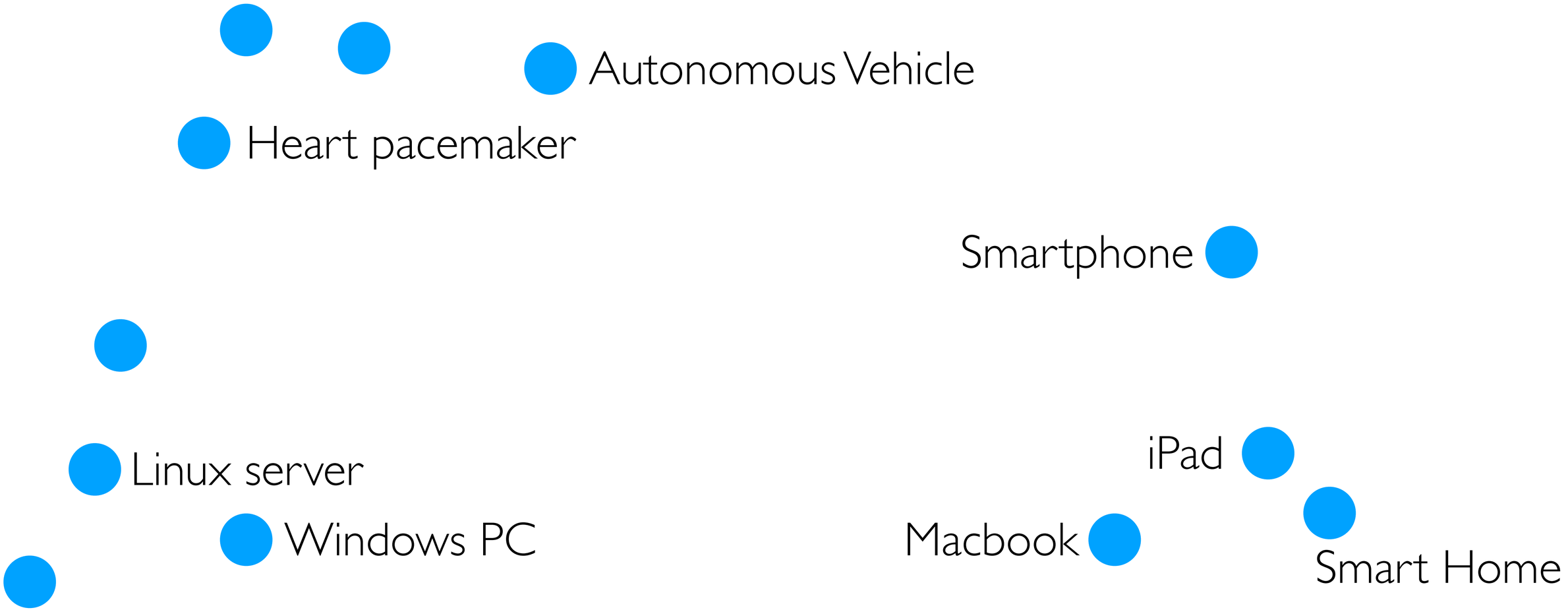
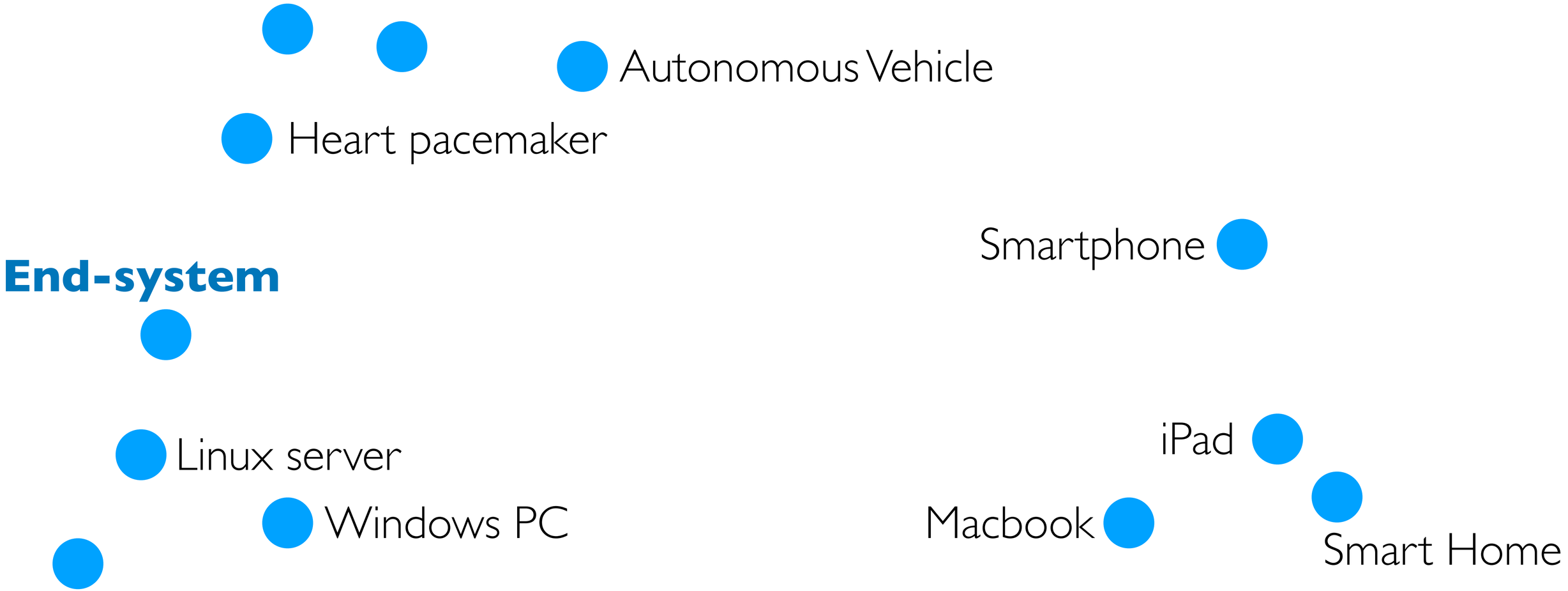
  - **The what:** a set of connected elements
  - **The how:** protocols
  - **The why:** to communicate data
- **This course:** mainly about the ***Internet***
  - What, how and why?

The What


Autonomous Vehicle
Heart pacemaker
Smartphone
Linux server
Windows PC
iPad
Macbook
Smart Home

The What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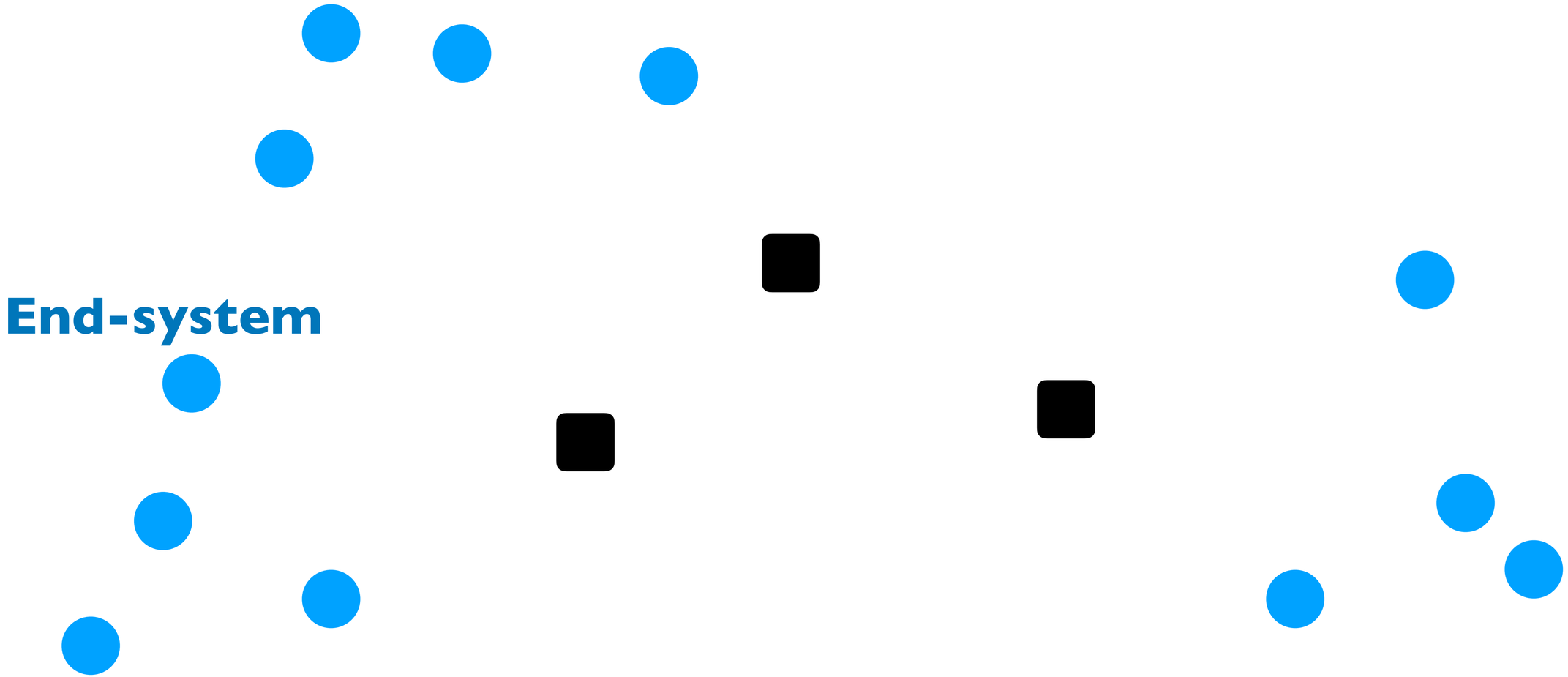

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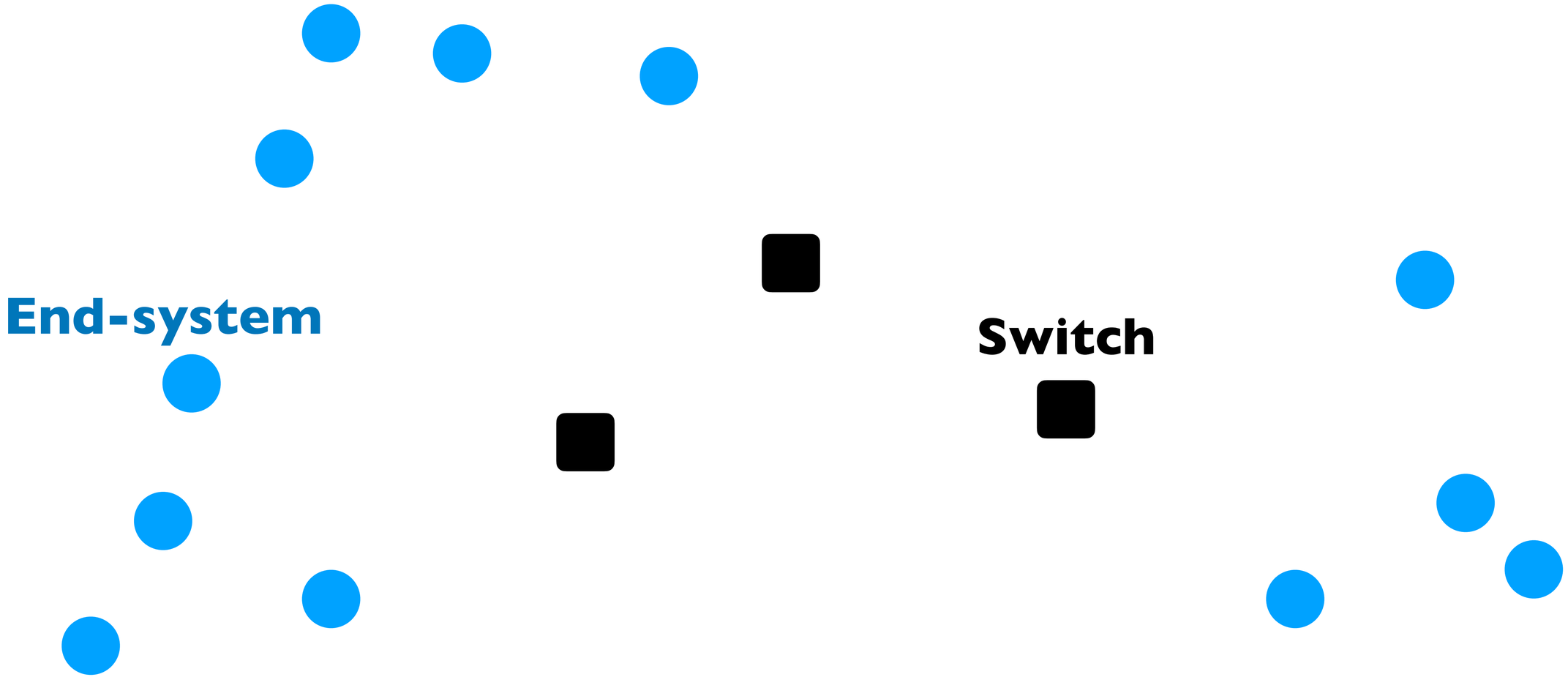

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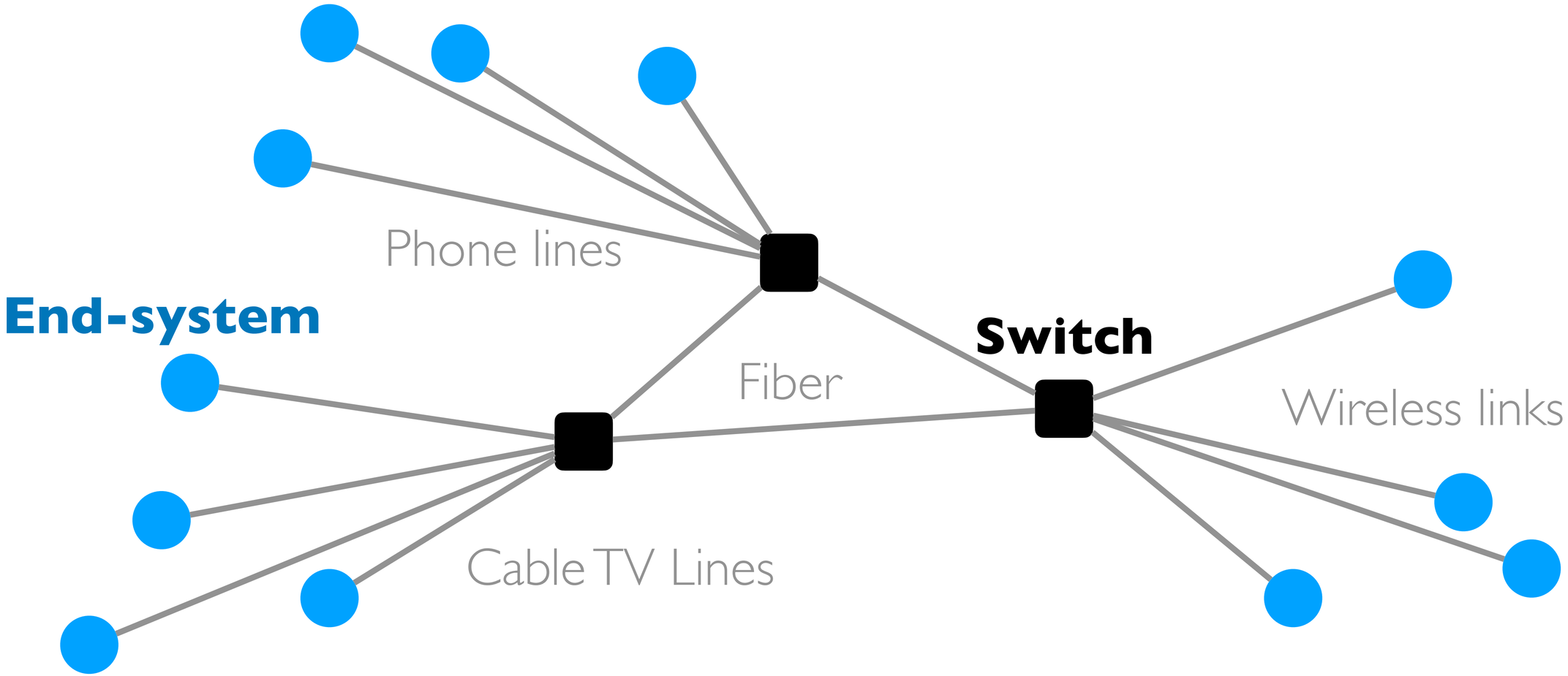
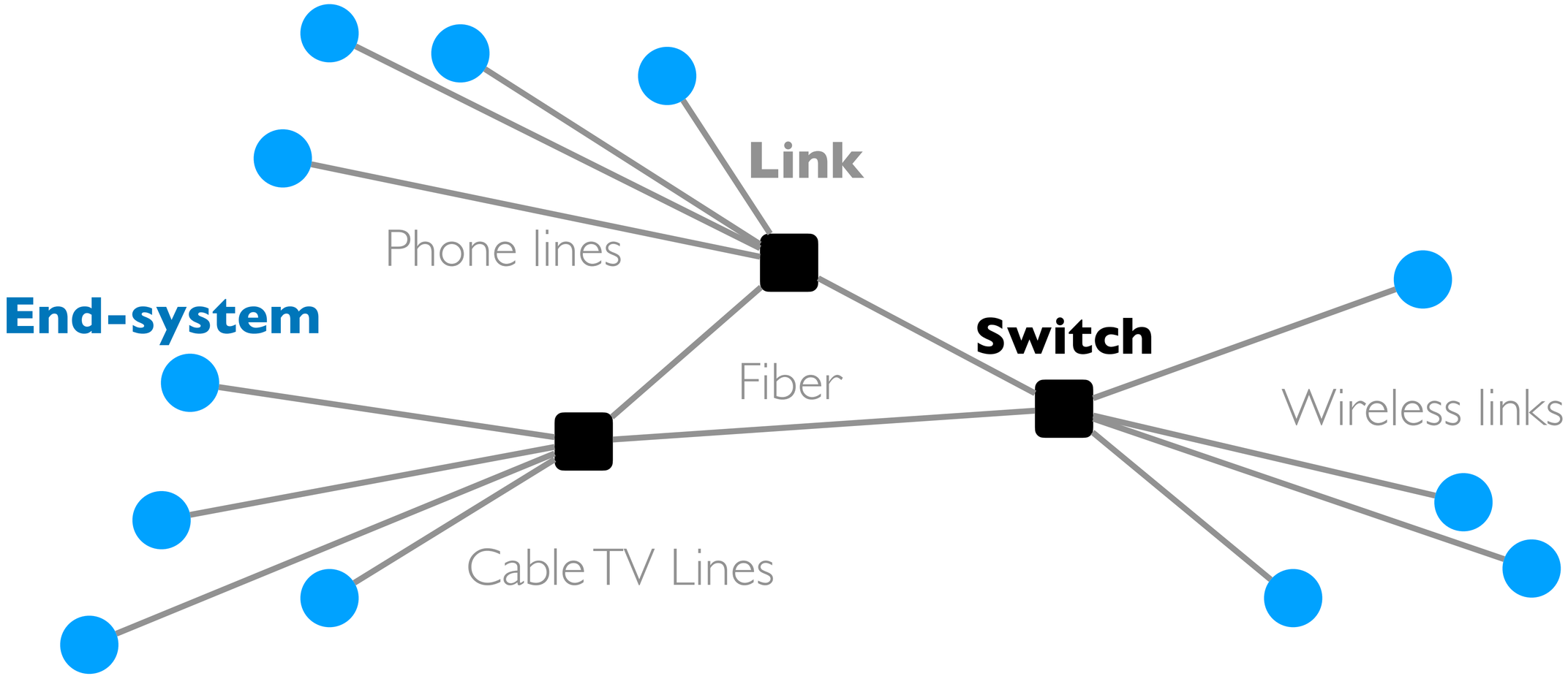

Phone lines
End-system
Switch
Fiber
Wireless links
Cable TV Lines

The What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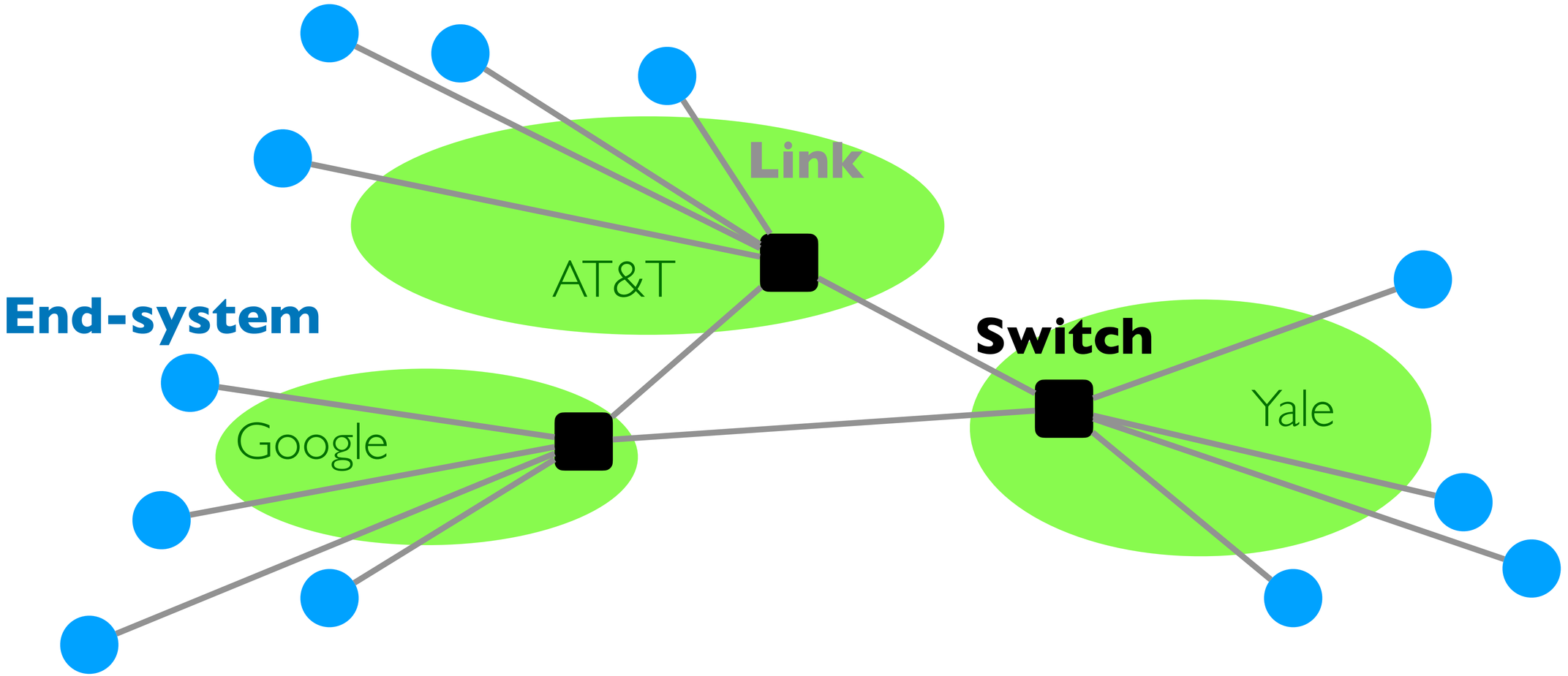

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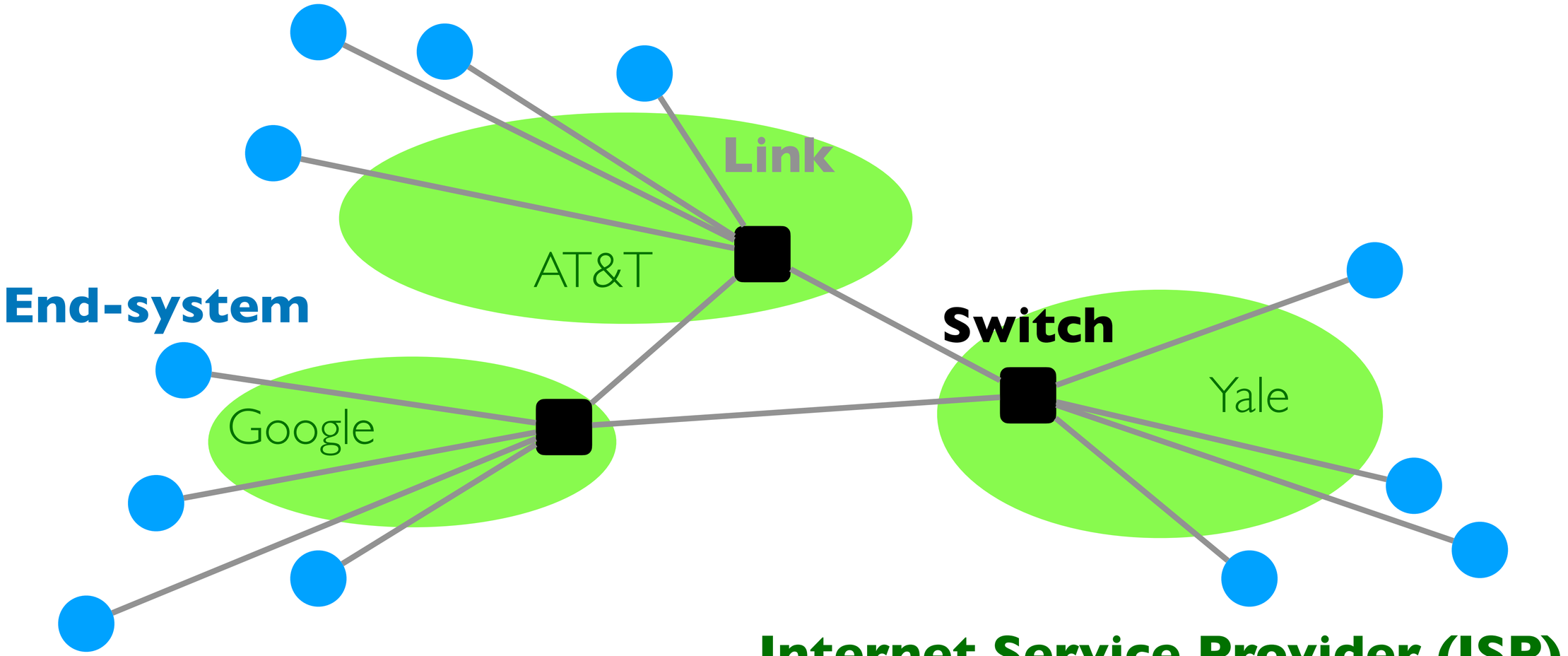
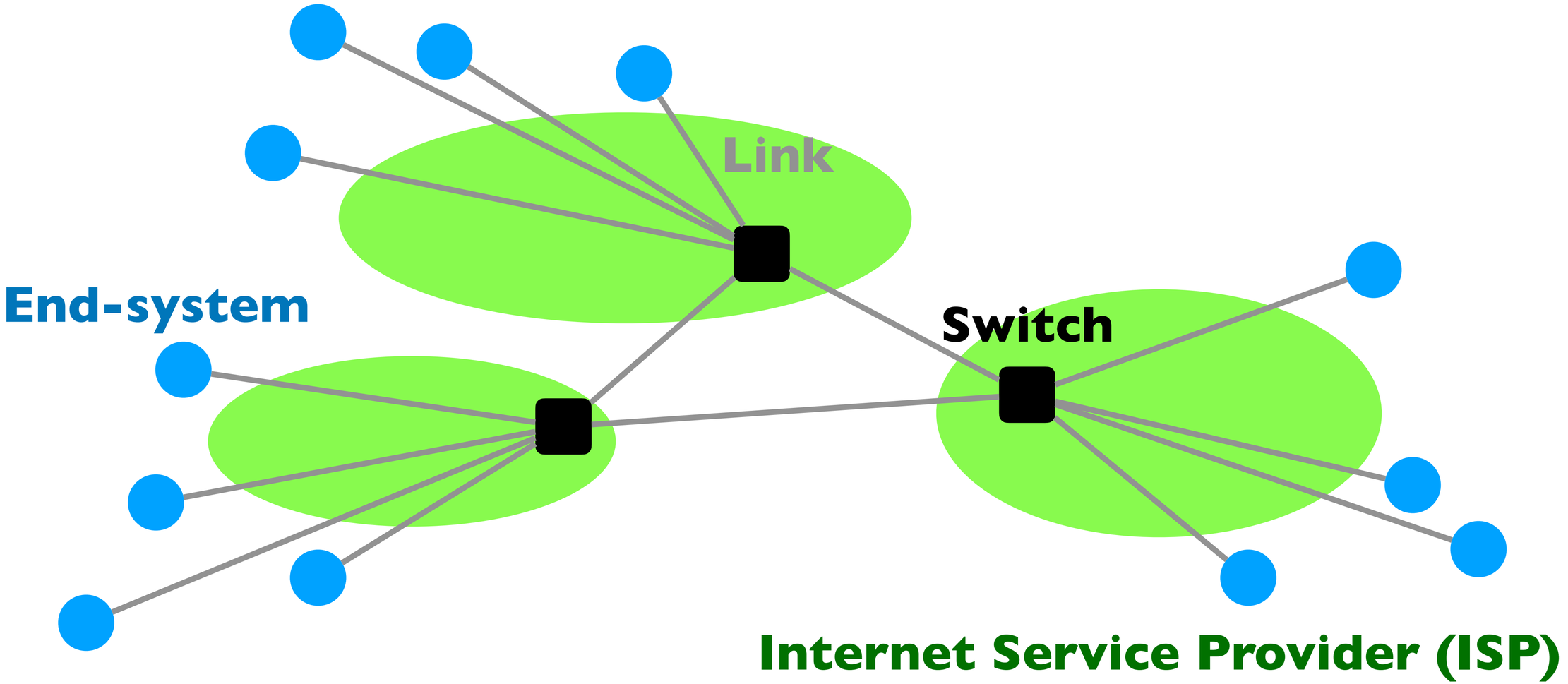

Link
AT&T
End-system
Switch
Google
Yale
Internet Service Provider (ISP)

The How



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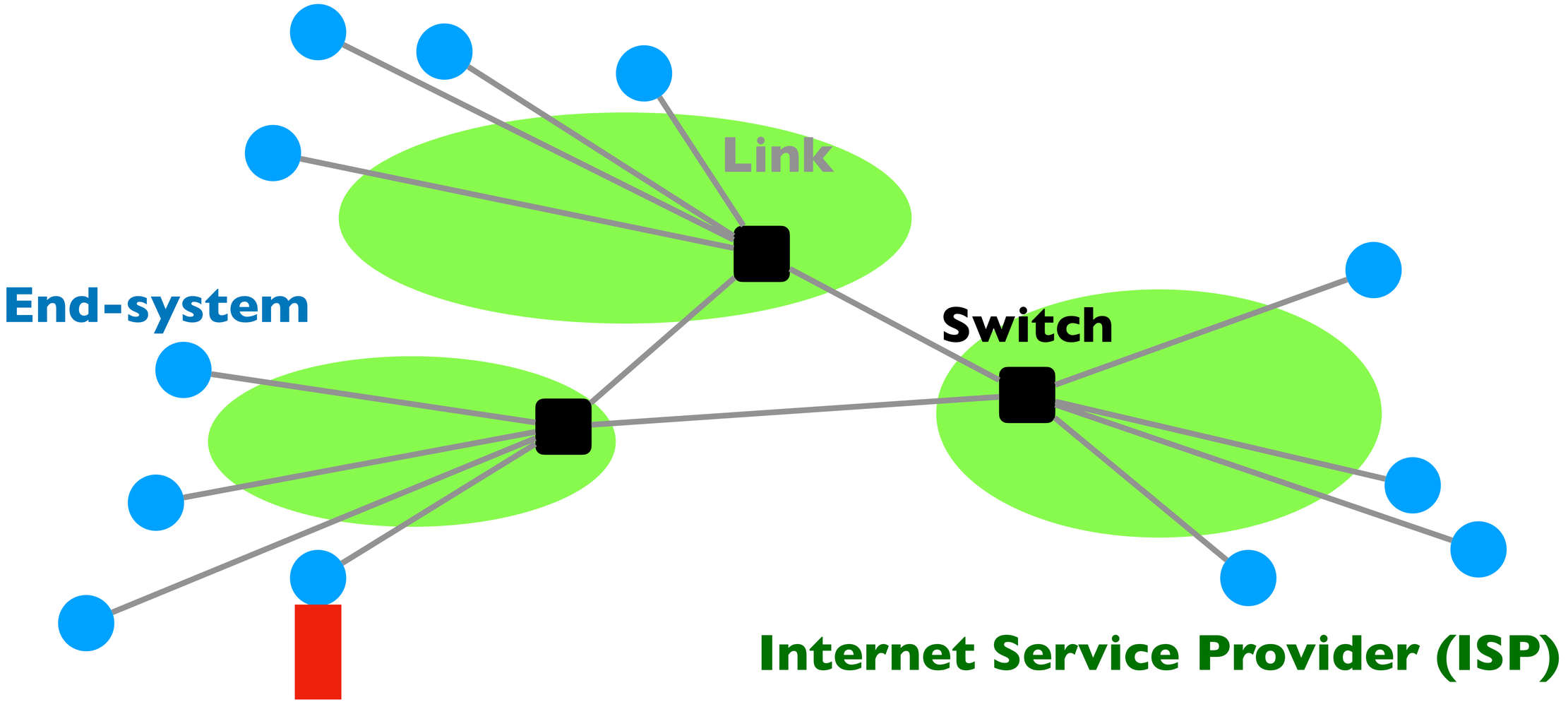

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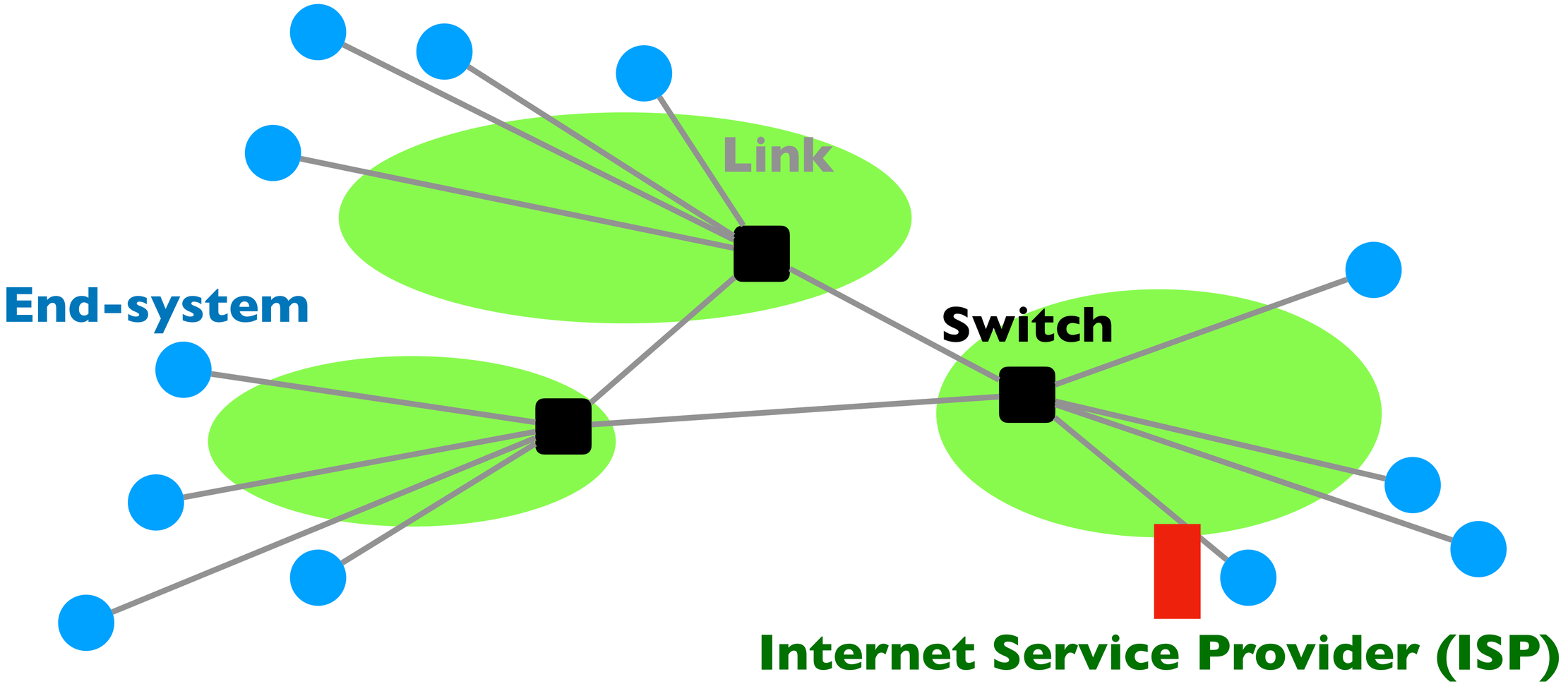

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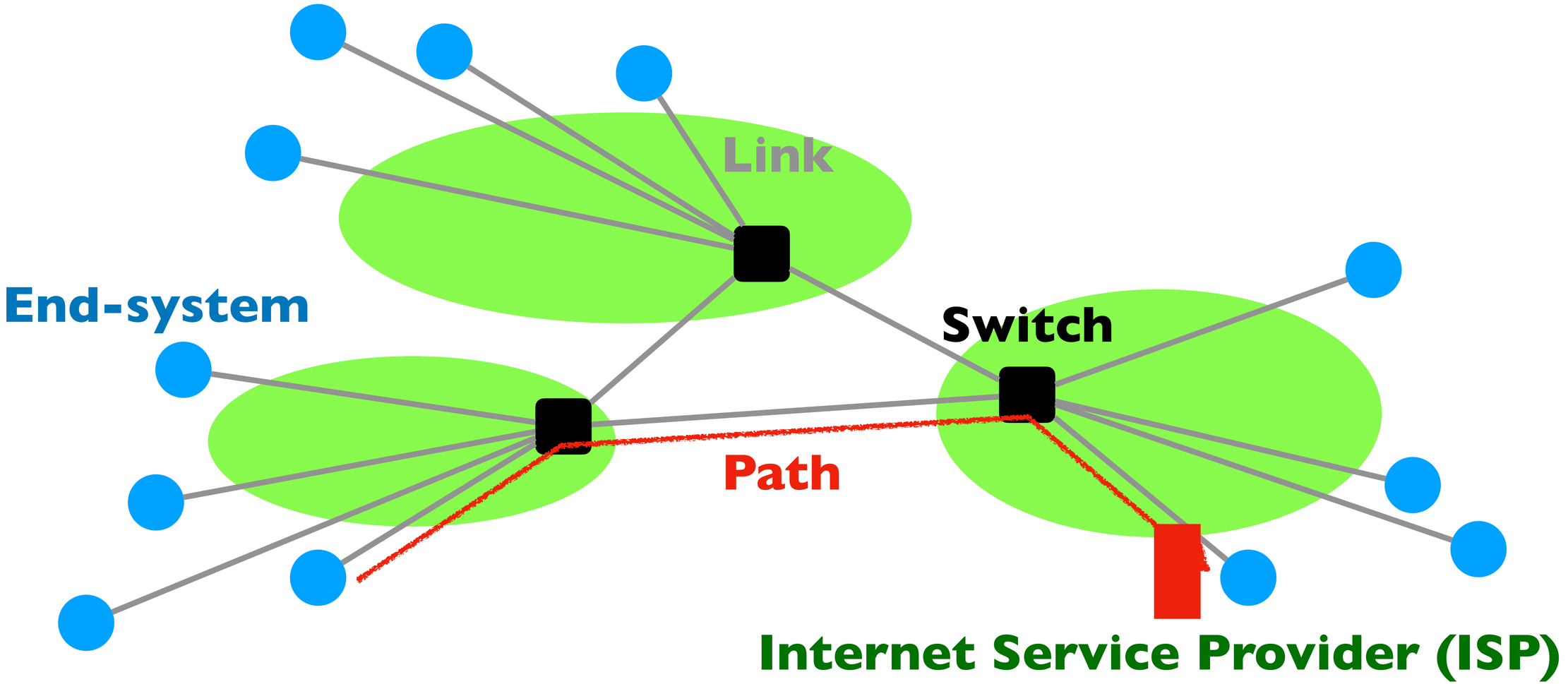
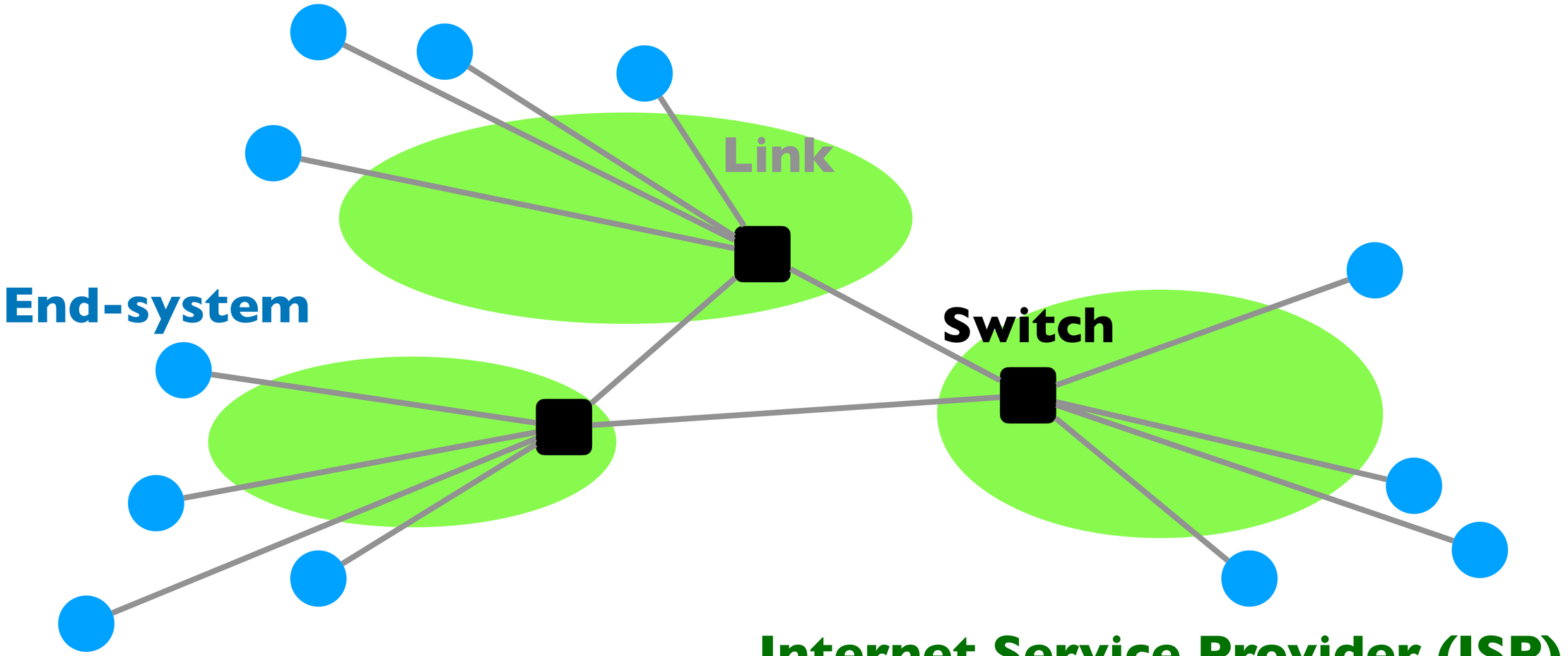


The Why



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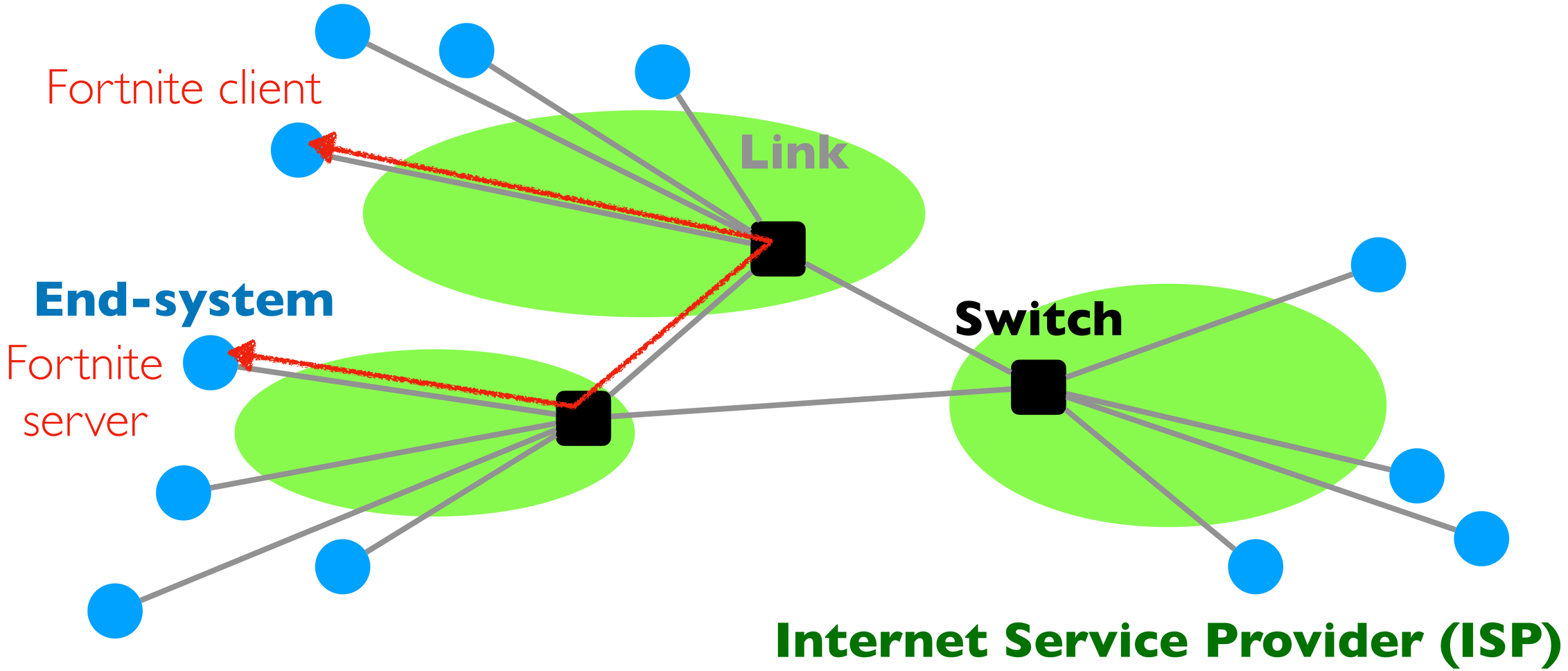
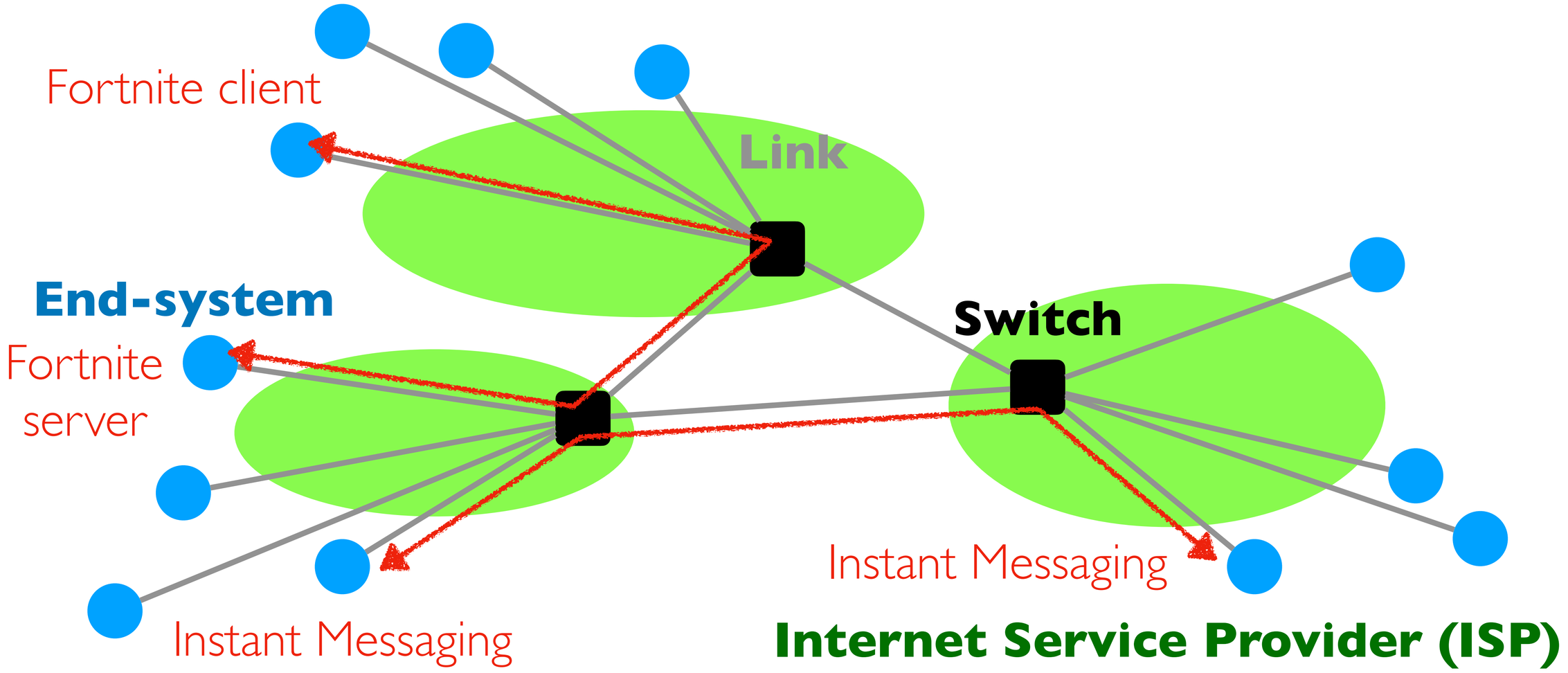

Fortnite client
Link
End-system
Fortnite
server
Switch
Internet Service Provider (ISP)

The Why


Fortnite client
Link
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Instant Messaging
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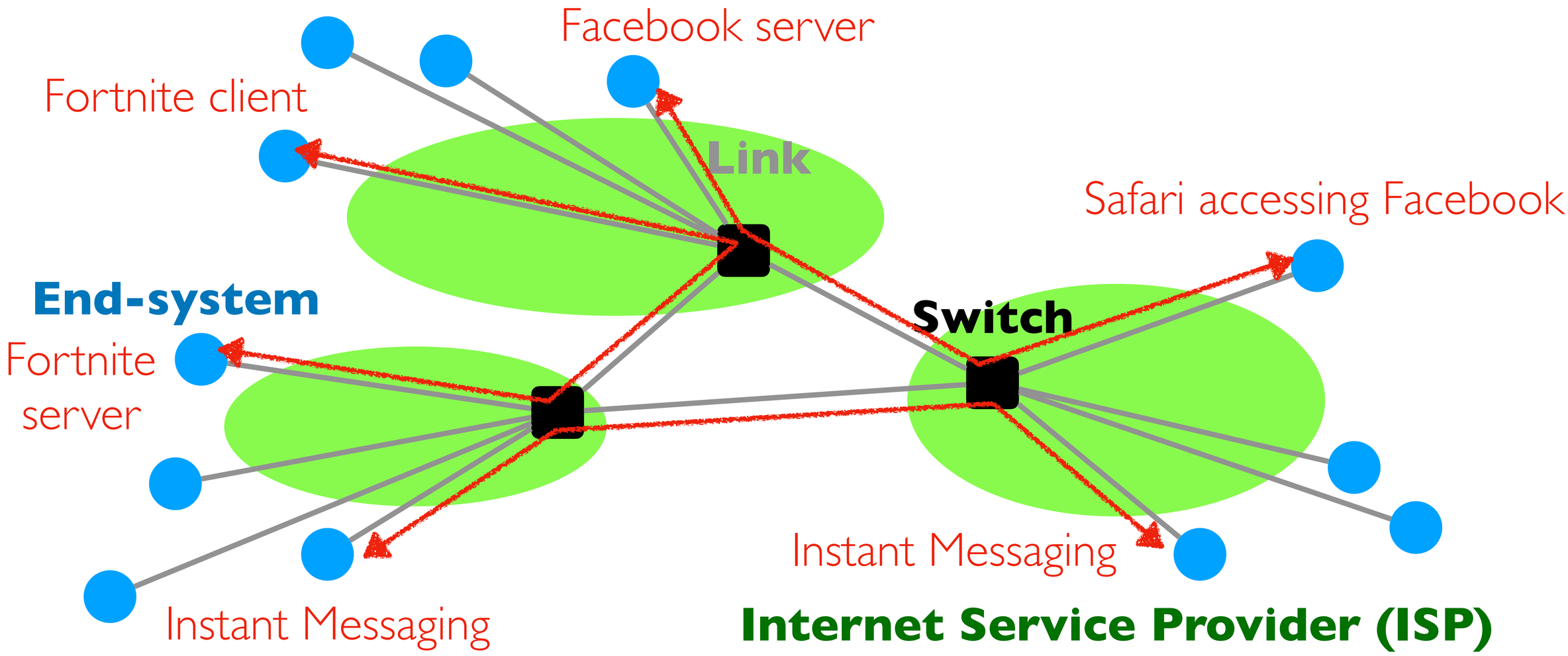
The Why


Facebook server
Fortnite client
Link
Safari accessing Facebook
End-system
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Fortnite
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Questions?

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'What's with all the TLAs???' - Everyone

'So you're saying you can't fix our internet even with your fancy PhD?' - My parents

A few defining characteristics of the Internet…

Network vs. “The Internet”

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- There are many different kinds of network technologies (switches and links)
  - Ethernet, optical, WiFi access points, DSL modems, Infiniband switches, …

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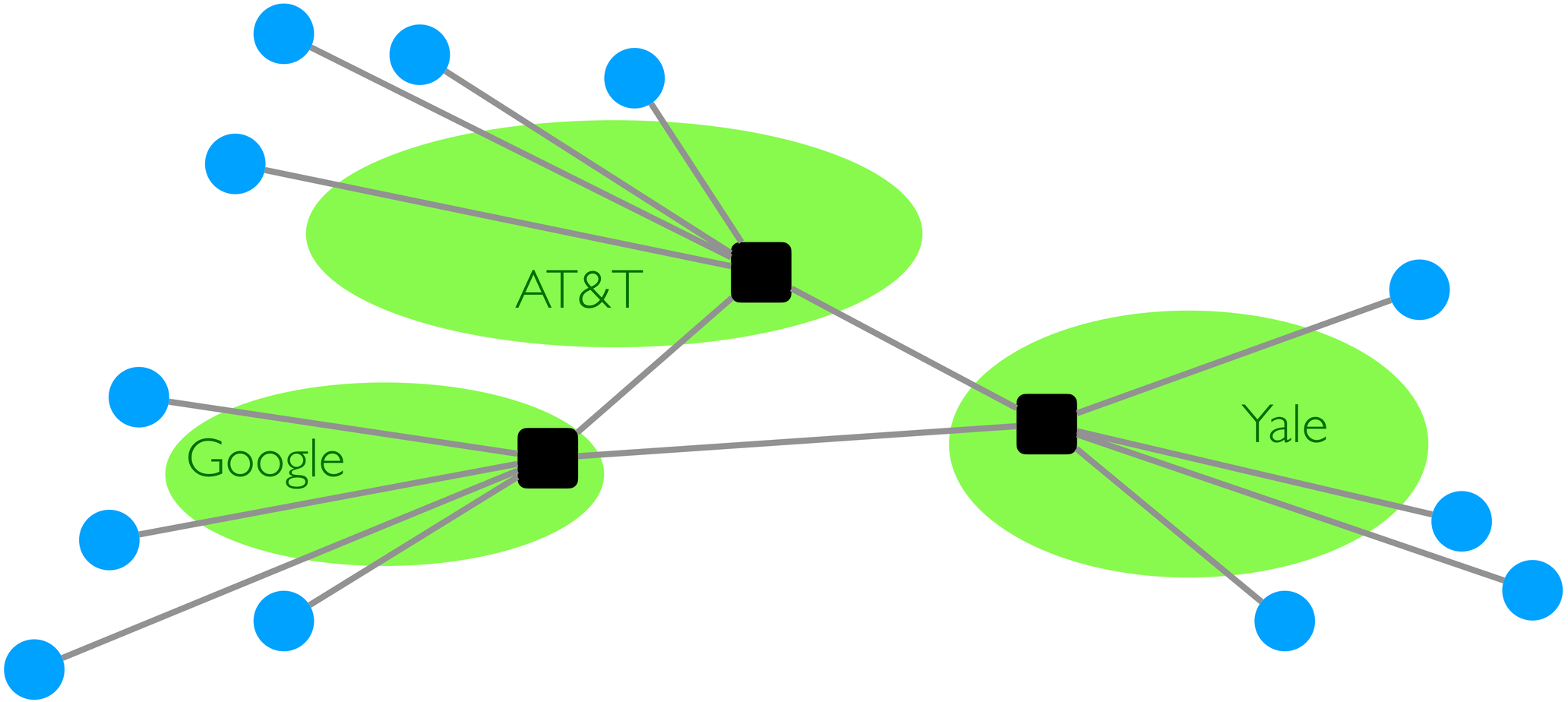
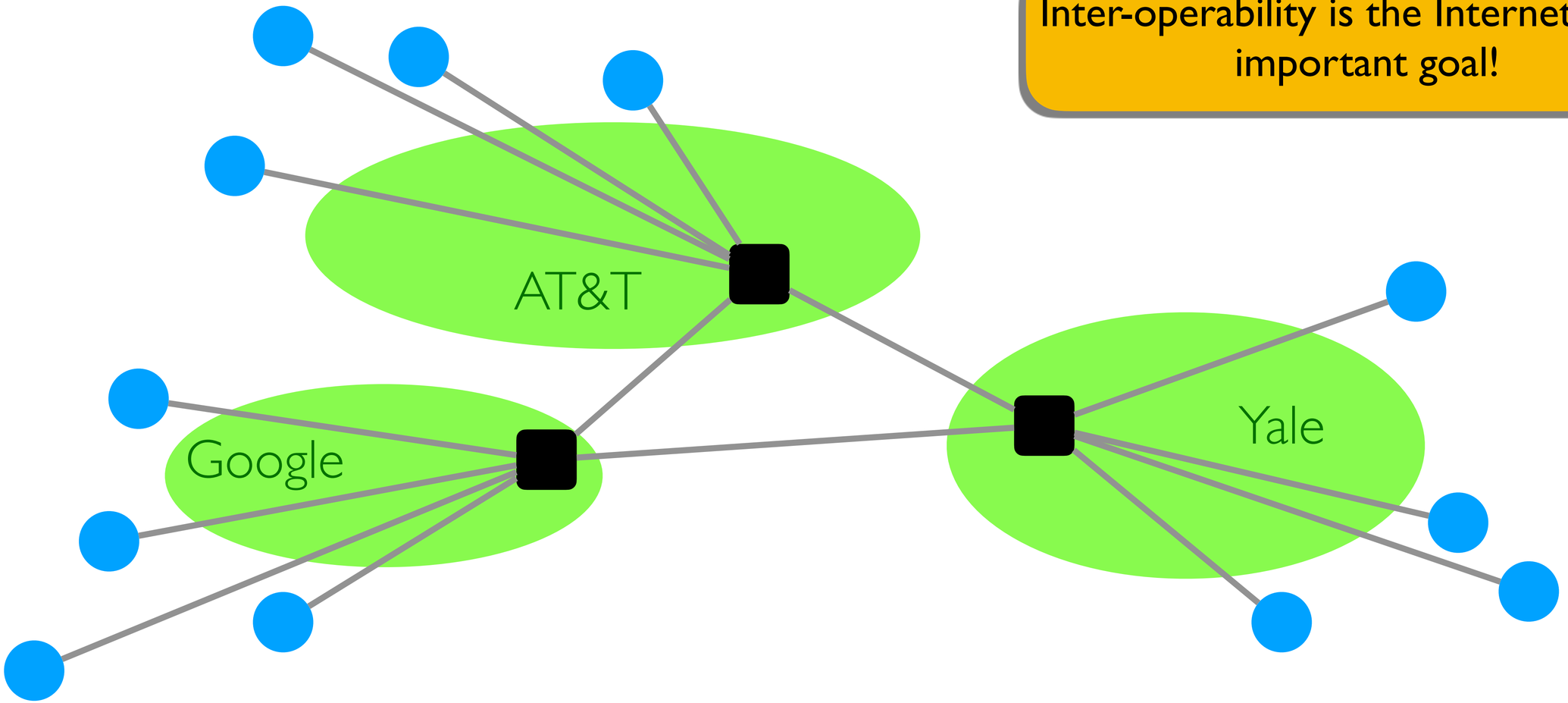
- Instead, the Internet ties different networks together
  - The Internet

A Federated System



A Federated System

Inter-operability is the Internet's most important goal!



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- But must ***cooperate*** to serve customers
  - Get as much data across ASAP to keep customers happy
- Leads to a constant tussle between business and technical factors!
  - **Efficiency** + **incentives, economics & real-world trust** determine physical topology and efficient path selection

A Federated System

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  - Get as much data across ASAP to keep customers happy
- Leads to a constant tussle between business and technical factors!
  - **Efficiency** + **incentives, economics & real-world trust** determine physical topology and efficient path selection
- And complicates innovation!
  - Upgrading the internet is not an option!
  - How do you differentiate your infrastructure when interoperability relies on supporting a common protocol?

Tremendous Scale

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- **4.66 billion** users (59% of world population)
- **1.24 trillion** unique webpages
- **306 billion** emails sent per day
- **3.8 billion** smartphone users
- **2.7 billion** Facebook users
- **500 hours** of video uploaded to Youtube every minute
- **6000 tweets** per second
- **70000 Google queries** per second
- Switches that move **300 terabits per second (10^{14})**
- Links that carry **100 gigabits per second**

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- **Applications:** Skype, live video, gaming, remote medicine
- **Users:** the governing, the governed, operators, selfish, malicious, naive, savvy, embarrassed, paranoid…

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  - < 100 computers, a handful of sites in the US
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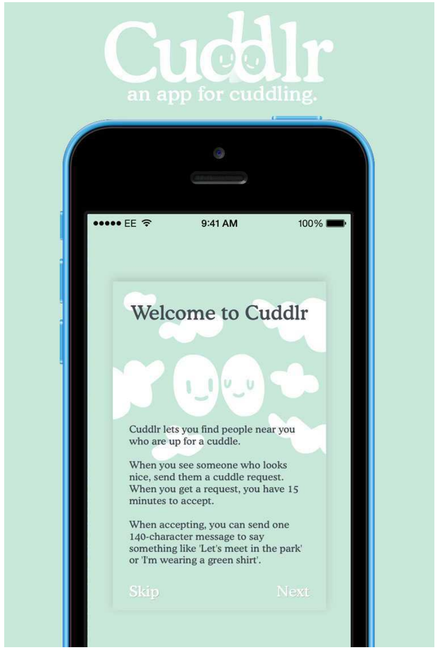

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  - Software, modem, wireless access point, firewall, links, network interface cards, switches, …
  - Including **human** operators!

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- To send a message, **all** components along the path must function correctly!
  - Software, modem, wireless access point, firewall, links, network interface cards, switches, …
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- Consider 50 components that work correctly **99% of the time**
  - **39.5%** chance communication will fail!

An Engineered System

An Engineered System

- Constrained by limits of available technology
  - Link bandwidths
  - Switch port counts
  - Bit error rates
  - *Cost*
  - …

Questions?

Taking Stock: The Internet Is…

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- A federated system
- Of enormous scale
- Dynamic range
- Diversity
- Constantly evolving
- Failure prone
- Constrained by what's practical to engineer

So, what do we need?

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- We still don't really know…
  - No consensus on what constitutes the "correct" or "best" network design
  - No consensus on "top 10 problems"
  - No consensus on the right prioritization of goals
- But before you flee…

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Principles now routinely adopted in modern systems (e.g., Cloud)

What we *do* know

- The early internet pioneers came up with a solution that was successful beyond all imagining!
- Several enduring **architectural principles and practices emerged from their work**
- But its just one design
- And numerous cracks have emerged over time
  - Want to diagnose problems but federation hides inner workings
  - Want to block unwanted traffic but network doesn't authenticate
  - Can't optimize for different applications or customers
  - Upgrading protocols is deeply painful

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- Several enduring **architectural principles and practices emerged from their work**
- But its just one design
- And numerous cracks have emerged over time
- As have new requirements
  - *Mobility, reliability, data centers, sensors, …*

And we're still debating the big questions…

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- **Decentralization** — SDN: Centralize?
- **Packets** — Optical: Circuits?
- **Statistical Multiplexing** — Reservations?
- **Best-effort service** — Quality of Service?
- **The "end-to-end" principle** — Edge computing?
- **"Layered" decomposition**
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Backing up a level

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- The Internet offers us a lesson on how to reason through the design of a complex system through the design of a complex system
  - *What are the goals and constraints?*
  - *What's the right prioritization of goals?*
  - *How do we decompose a problem?*
  - *Who does what? How?*
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- In short: a lesson in how to **architect** a system

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- How the internet works
- Why it works the way it does
- How to reason through a complicated (networking/system) design problem

Questions?

Today's Agenda

- Introductions
- What is (this course on) networking about?
- Class policies, Administrivia and Roadmap

Class Workload

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- **Two projects**

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- **Three homeworks**

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- **Graduate readings for CPSC 533 (next slide…)**

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- **Three homeworks**
- **Graduate readings for CPSC 533 (next slide…)**
- **Exams:**
  - **Midterm: March 30th (During class time)**
  - **Final (aka Midterm#2): May 6th (During class time)**

Graduate Readings (CPSC 533)

- **Only** required for those enrolled in CPSC 533
  - Others encouraged to read!
- Submit a paper critique for at least **10** out of **25** papers (any 10 will do!)
  - **5 before midterm, 5 before finals**
  - See Canvas for format and resources on how to read & critique a paper!
  - Submit critique via **google form** link provided on Canvas
- **CPSC 433 students — Do not submit**

Grading

	CPSC 433	CPSC 533
2x Projects	2 x 15%	2 x 15%
3x Homeworks	3 x 5%	3 x 5%
Paper critiques	0%	10%
Midterm	25%	20%
Final (=Midterm#2)	25%	20%
Class Participation	5%	5%

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- **Important new(er) topics [Lectures 21-26]**
  - Management, security, datacenters

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  - Distance vector routing implementation on a Python simulator

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  - Distance vector routing implementation on a Python simulator
- **Project 2: Reliable transport**
  - A toy reliable transport design in Python

Textbook

- **J. Kurose & K. Ross, "Computer Networking: A Top-Down Approach" [K&R]**
  - Either 6th or 7th edition will do
- **You will not be tested on materials we did not cover in lectures**
  - But you *will need to* read through the linked 'Readings' in K&R for exams & homeworks

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- My office hours are **4-5pm ET** on **Tuesdays,** but you can always email me to set up a time to chat!

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- **Help me remember your name! (If you participate, I will remember!)**

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  - Do whatever you must to make this happen — I will;
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- You ***must laugh at my jokes***

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  - All of the administrivia along with a tentative syllabus is posted there
  - Get participatin'

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