oueees-202306 topic 01: Latency and laws of physics Centralized Communication Multiplexing

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Lecture notes and reporting

- https://github.com/jj1bdx/oueees-202306-public/
- Check out the README.md file and the issues!
- Keyword at the end of the talk
- URL for submitting the report at the end of the talk

Latency and laws of physics

Speed of light in vacuum c

299 792 458 [m/s]

This is a definition, *not* a measured value

Refractive indices of materials

- v: speed of light in a material
- Refractive index $n = c/v$, always $n \geq 1$!
- Air: 1.000279 for λ=0.50 μm [1] -> 299709 km/s
- Water: 1.3330 for λ=589.3 nm [1] -> 224901 km/s
- Silica glass (optic fiber): 1.45 [2] -> 206753 km/s

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[1] 「光学的性質」、理科年表2022、丸善、ISBN: 978-4-621-30648-2, pp. 477-479

[2] https://apniphysics.com/classroom/optical-fiber-refractive-index/

Distance latency and timing

- Osaka to Tokyo: ~400km = ~1.3ms (in vacuum/air)
- Tokyo, Japan to San Francisco, CA, USA: ~8300km ~= 28ms (in vacuum/air), 41ms (in silica glass)
- Japan <-> USA in optic fiber, round trip: ~100ms or more
- *Synchronization is hard*
- A question: can you play a network real-time game in the global scale, e.g., between Tokyo, New York, and Paris?

Light traveling time and distance

wiring and wavelength matter

- ~300km in 1ms aka 1kHz
- ~300m in 1μs aka 1MHz
- ~30cm in 1ns aka 1GHz
- ~3mm in 1ps aka 1THz

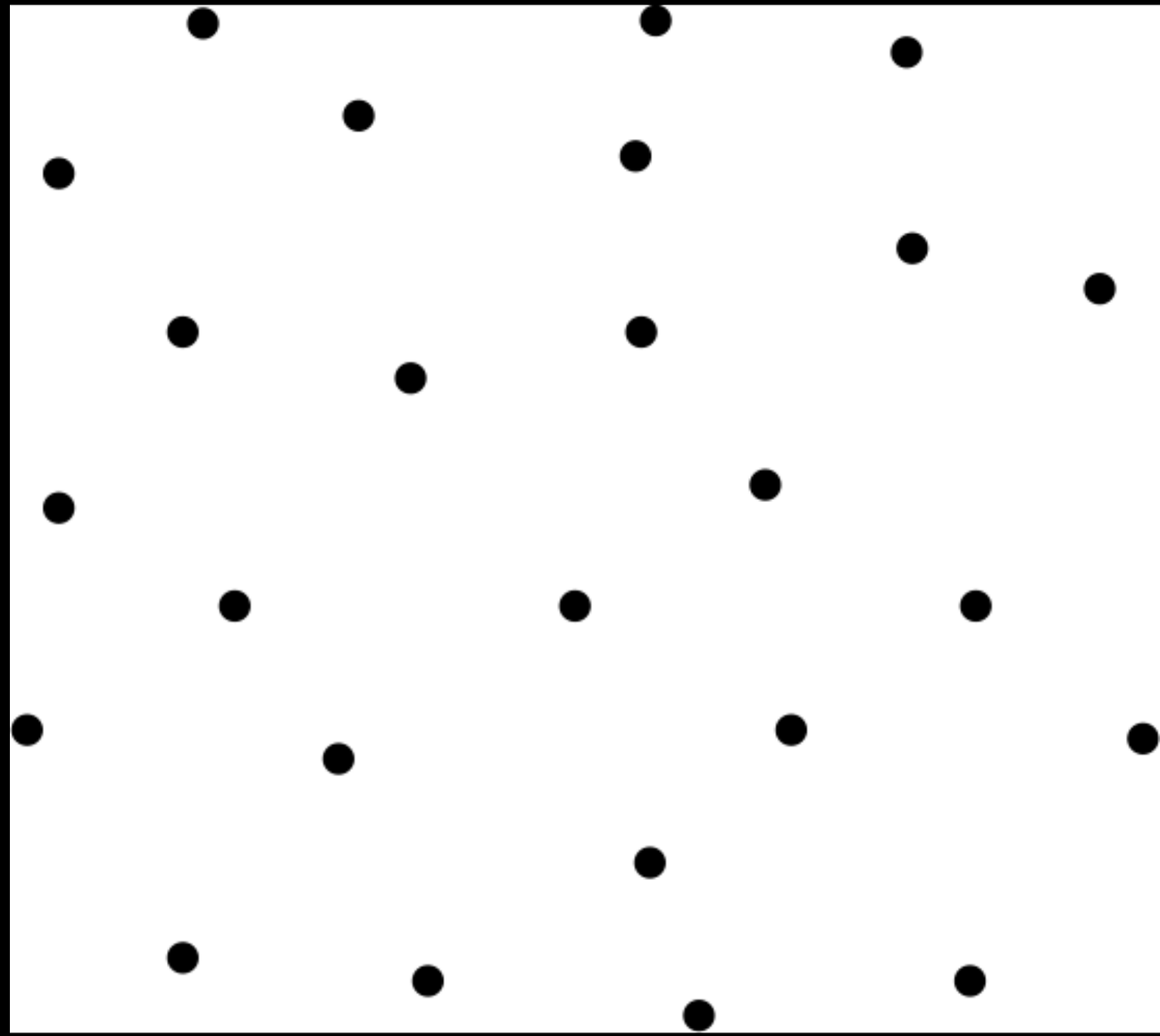
Centralized communication

Communication: sharing a medium

- Sharing a physical link between two or multiple parties
- *The physical layer*
- A medium could be: electric wires, optic fibers, radio airwaves, sound, flying birds like pigeons

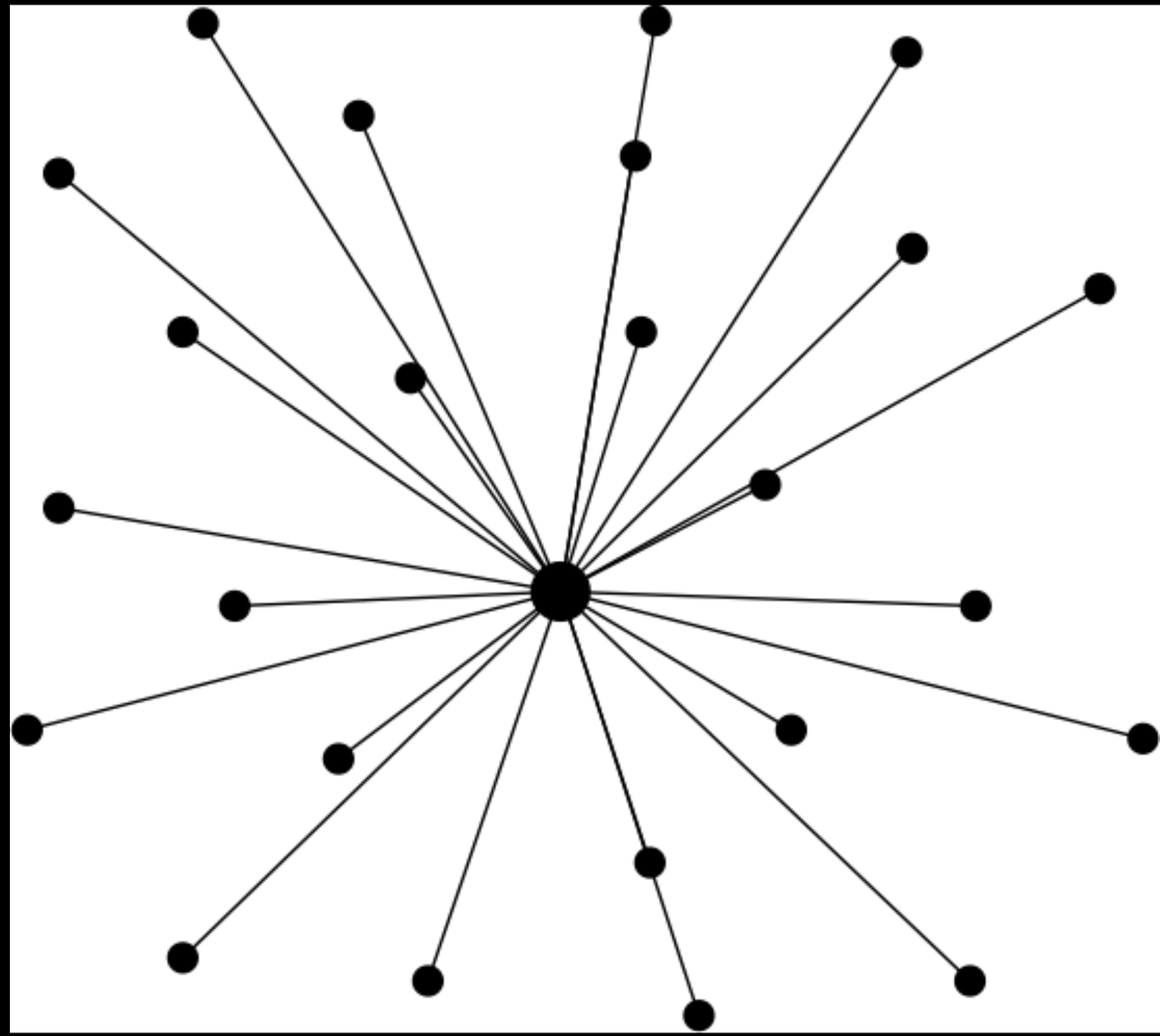
Connecting unconnected nodes

There are many ways to connect the dots in this picture



Simplest way: star/ centralized connection

- Centralized connection was the easiest way to connect the nodes
- Very much susceptible to network link failures
- Links should stay connected during the connection



The old Stockholm telephone tower in 1890

Fallen telephone lines by frost at Jönköping, Sweden, 1929

Tekniska museet in Stockholm

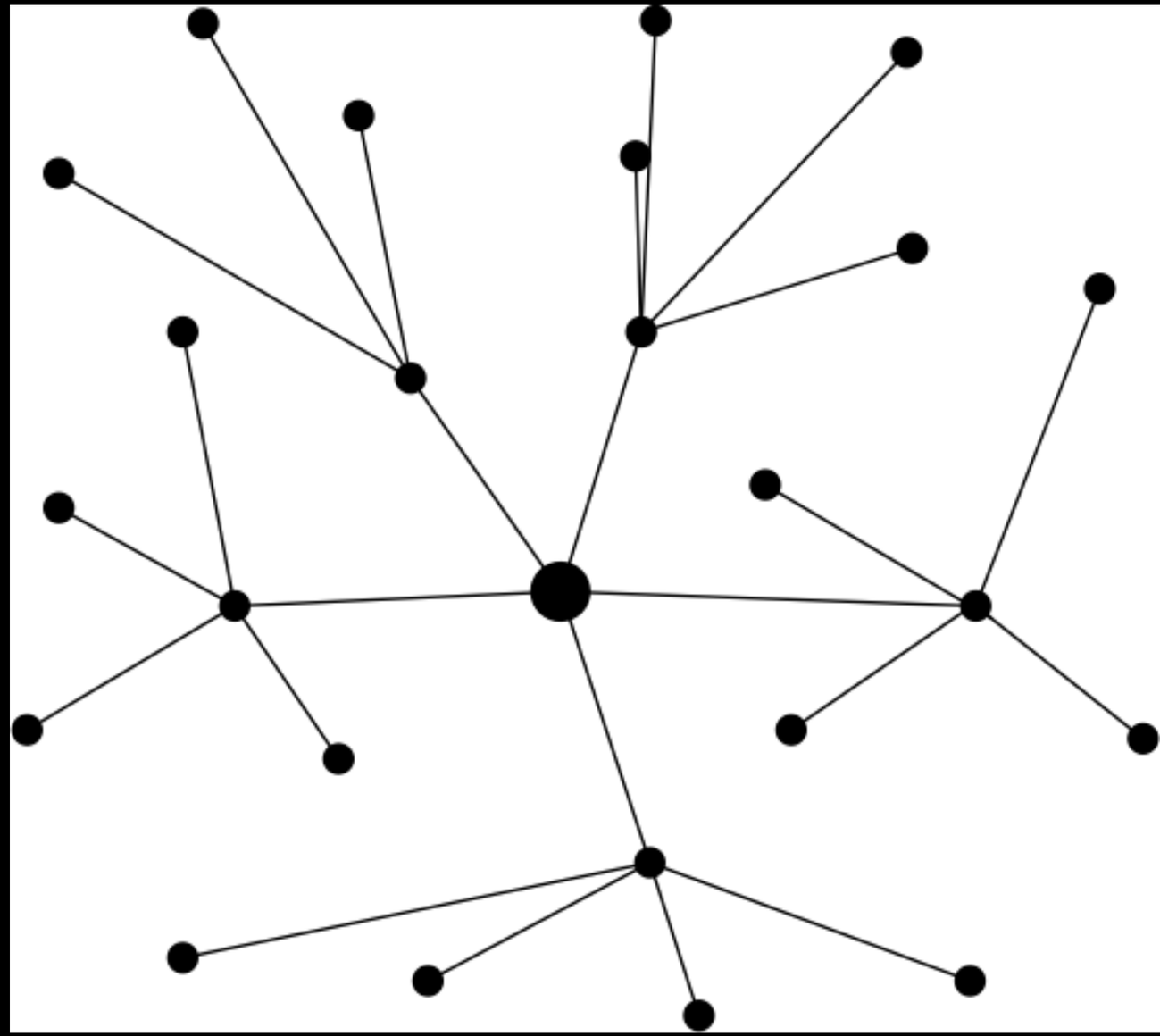
(June 2018)

Multiplexing

Multiplexing: sharing the same link by multiple nodes and communication devices

Multiplexing enables decentralization

- Some links carry shared traffics for many different nodes



How to multiplex different types of information, and put them together for sharing a same medium?

Signal characteristics used for multiplexing

- Space division (multiple lines or multiple beam-formed antennas)
- Time division
- Frequency/wavelength division
- Polarization division
- Code division (multiple codes of very small cross-correlation)

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