

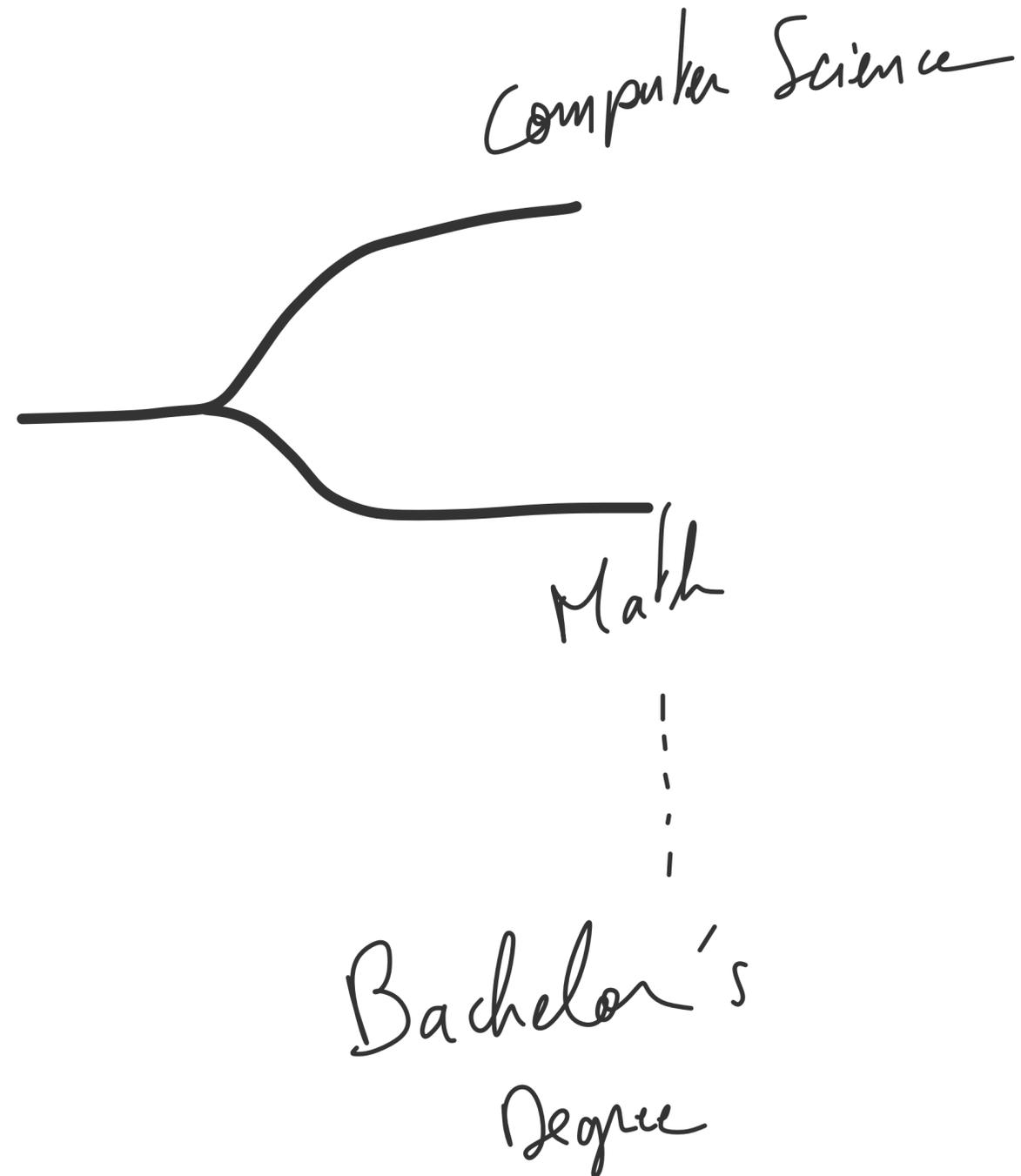
Some Examples of distributed systems and algorithms

Quentin Bramas

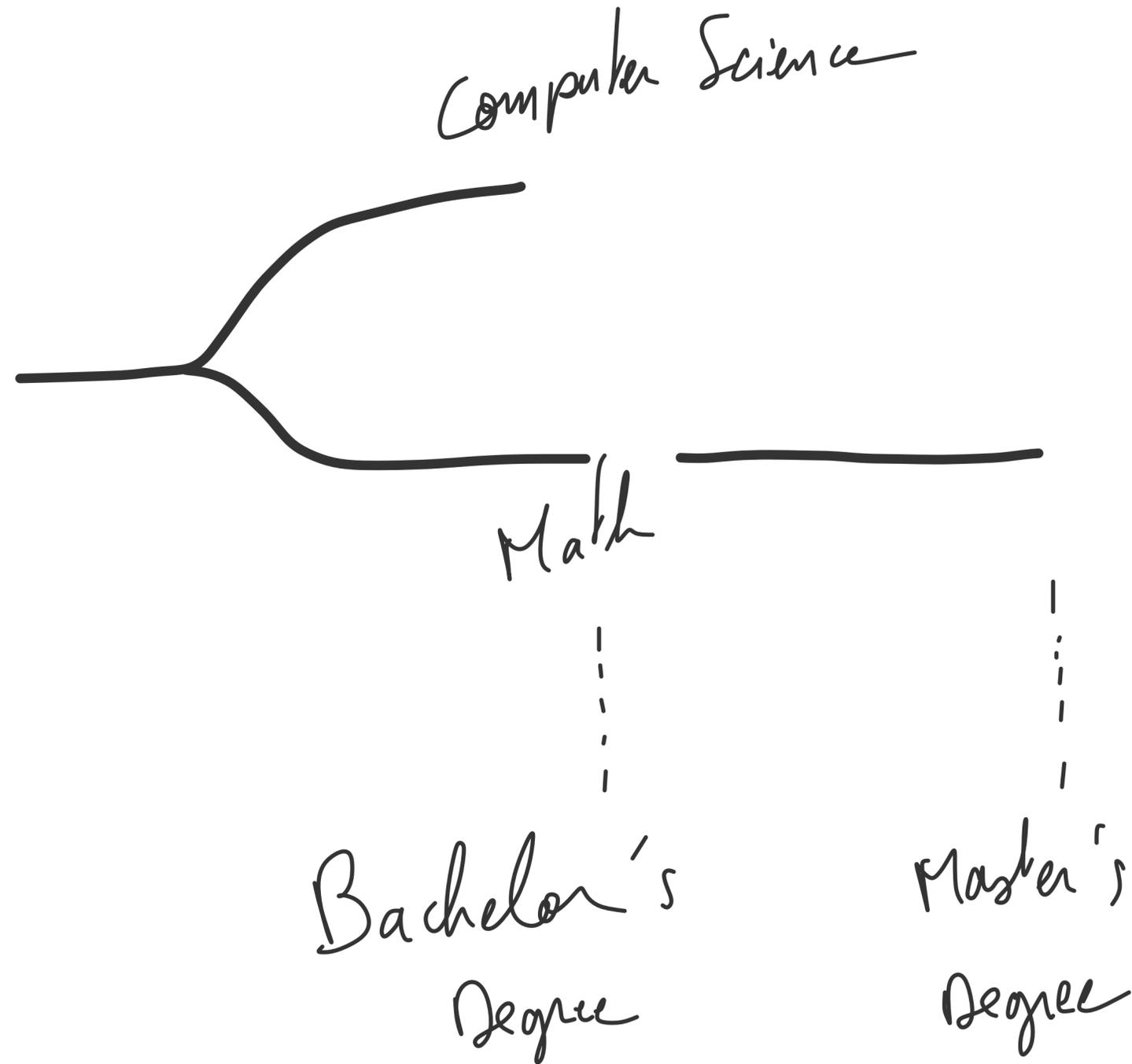
January, 17, 2025



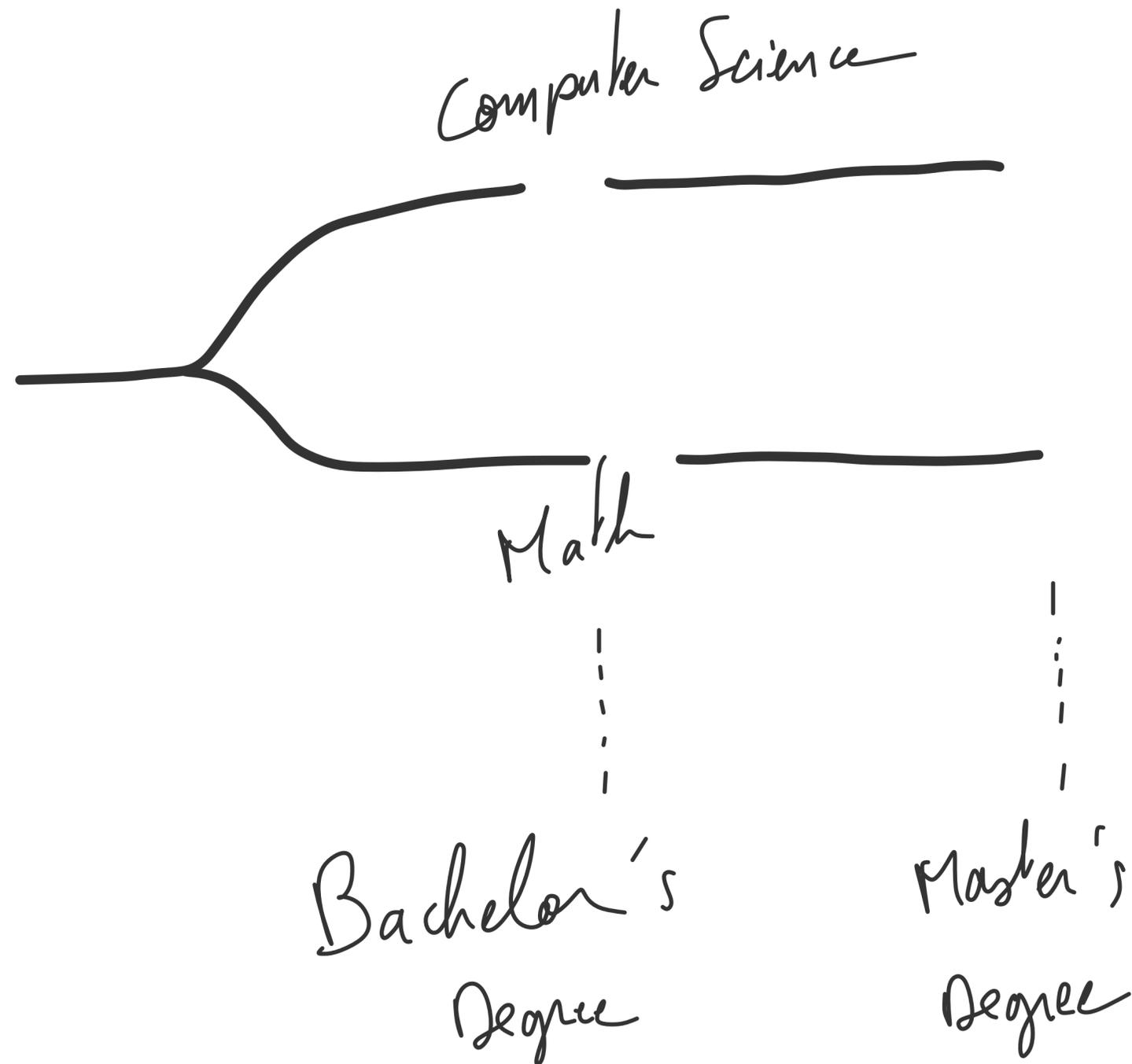
My Background



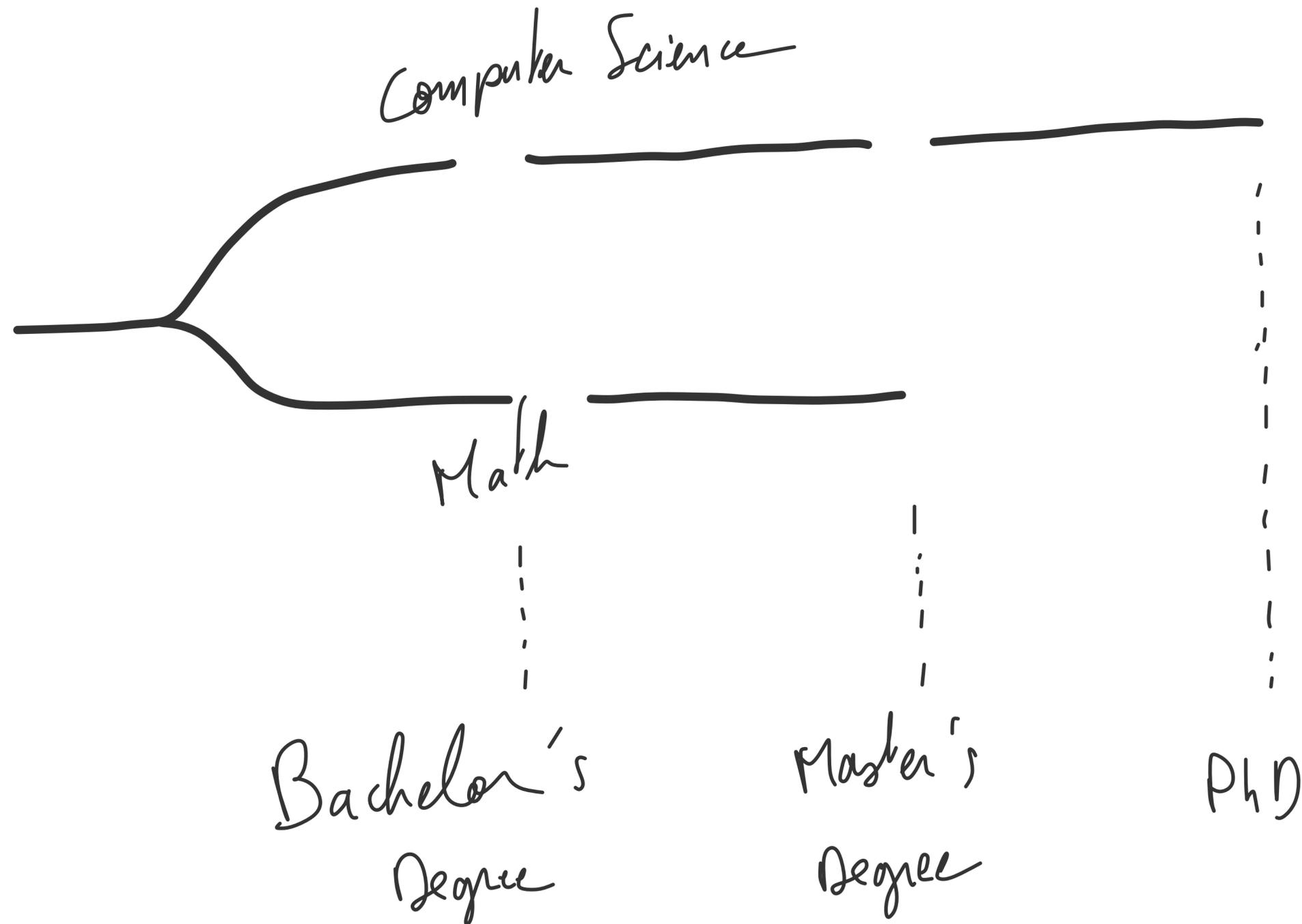
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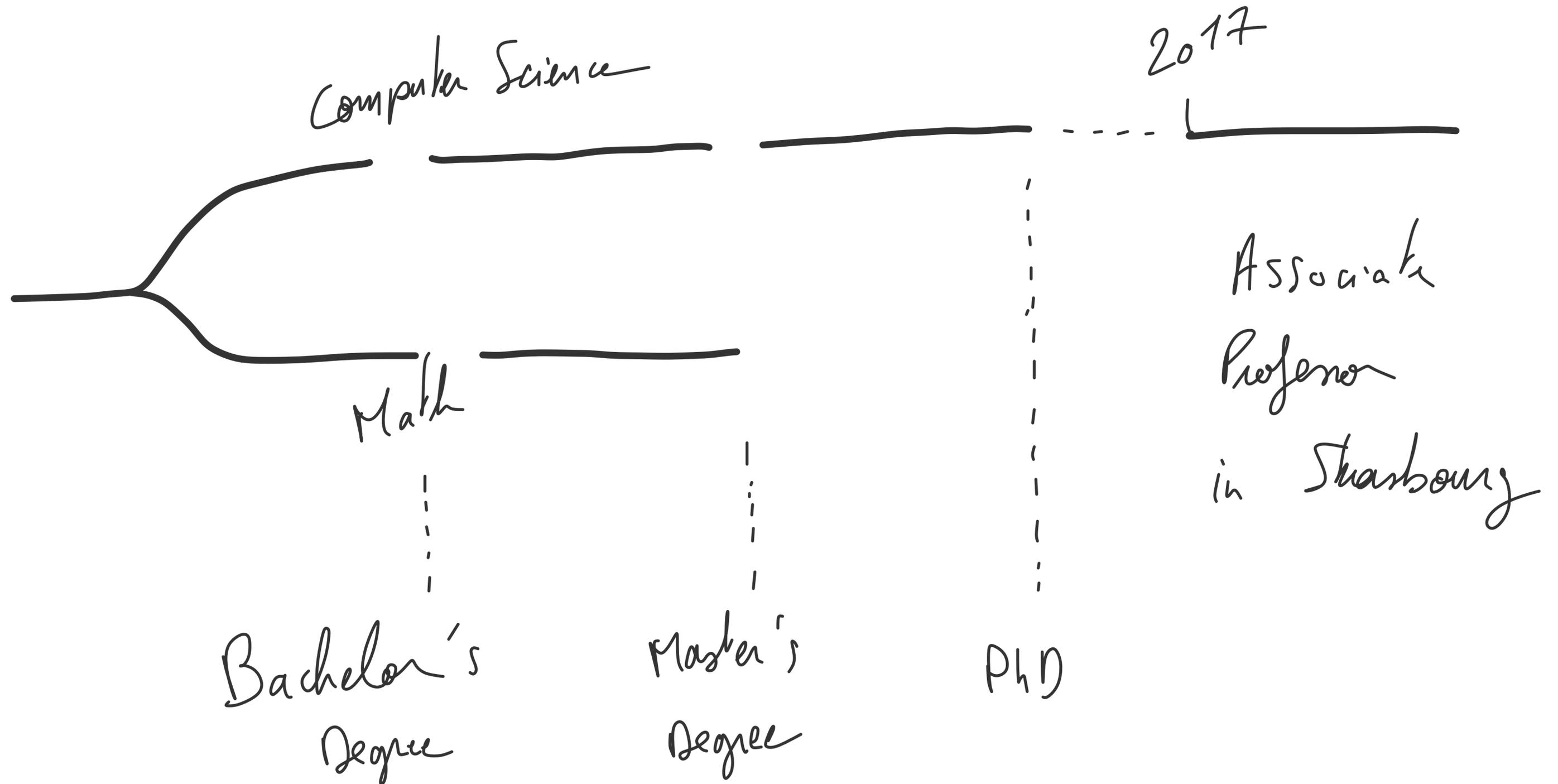
My Background



My Background



My Background



Plan

- What is computer science?
- What is distributed computing?
- Some examples of distributed systems

What is computer science?

What is computer science?

- Science of information
- Algorithms

Informatics

- The real name of computer science
- The study of representing and transforming information

Algorithms

- A way to transform states



Programming

- Using a language to represent and execute an algorithm on a computer

Complexity / Computability

- Analysing algorithm performance / existence

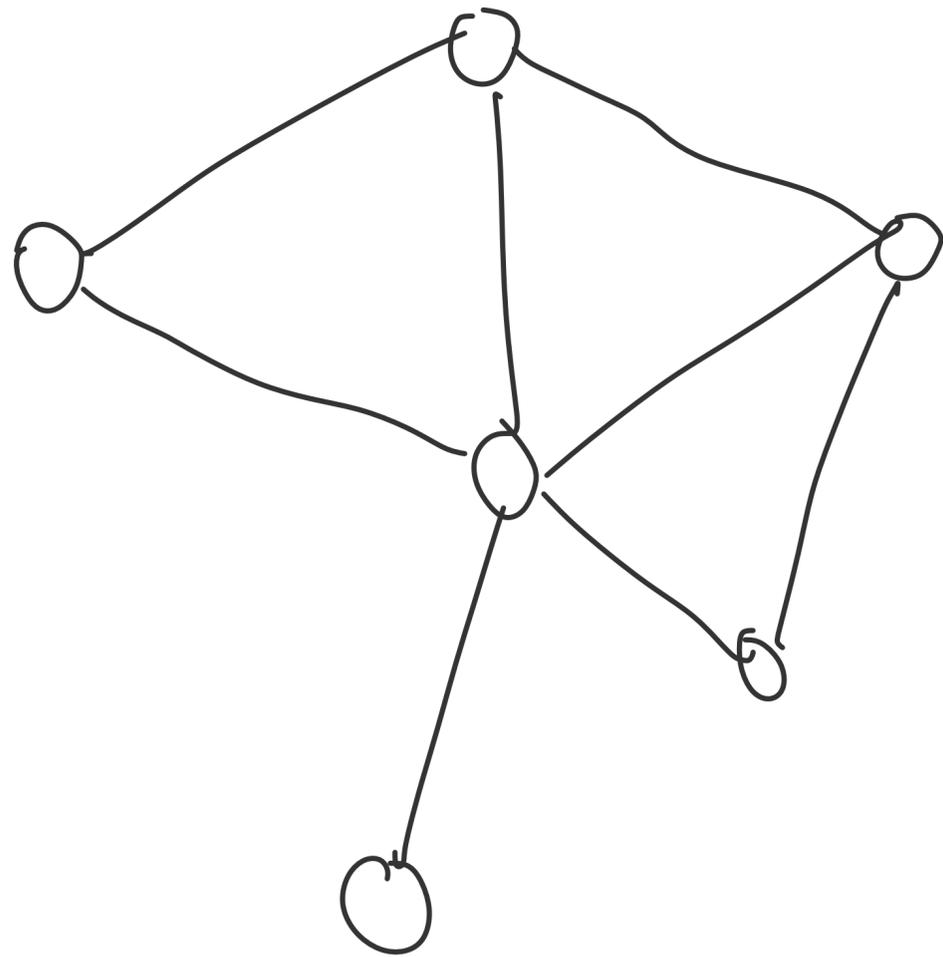
How to test primality efficiently?

* Given a set S of integers, is there a partition $S_1 \cup S_2$ such that $\text{sum}(S_1) = \text{sum}(S_2)$?

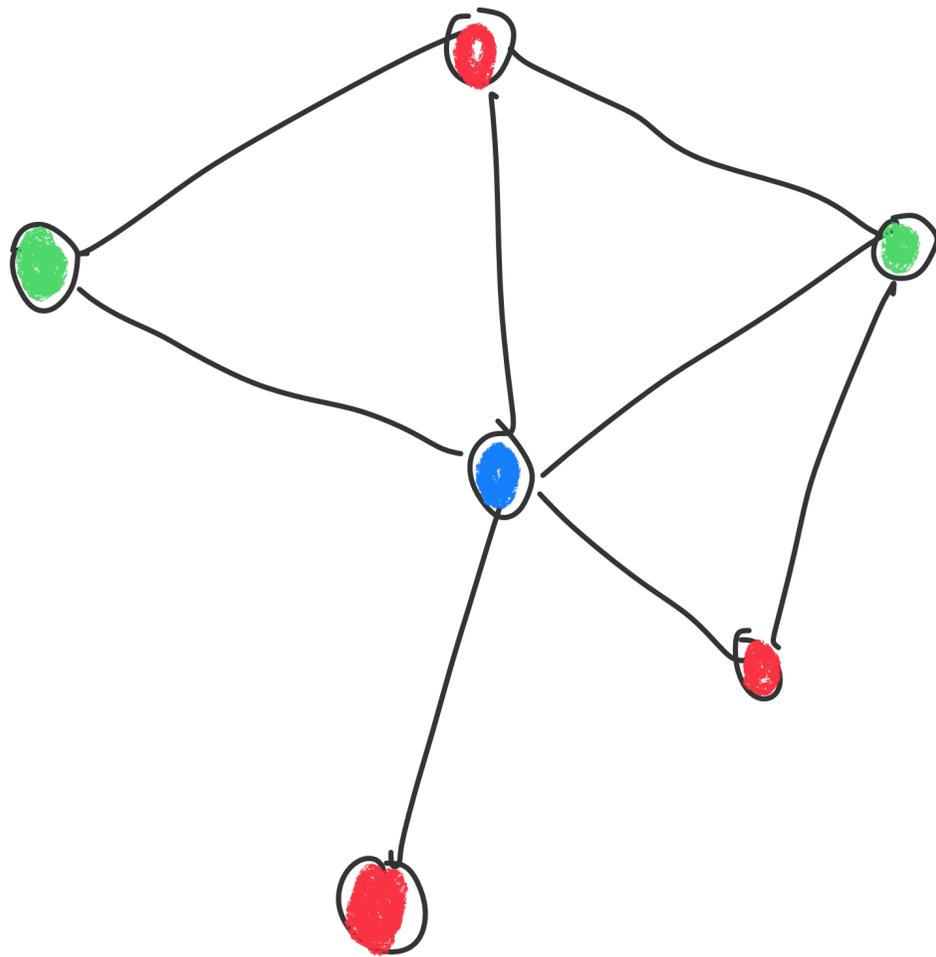
Is there a polynomial algorithm?

Graph Algorithms

- A graph is structure to represent a set of entities and their interactions
 - The goal is to associate a state to each node satisfying some properties
 - coloring, distance, ...

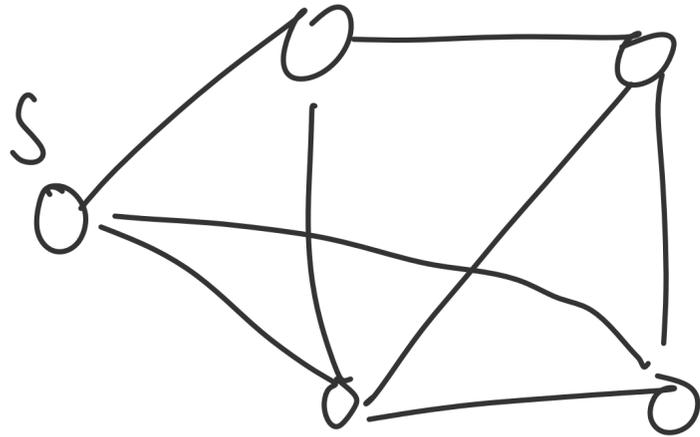


How many colors?



How many colours?

Dijkstra's Algorithm



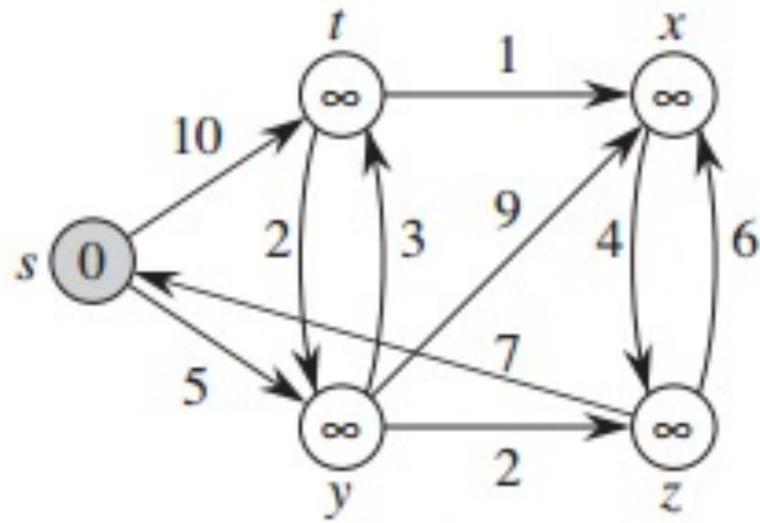
$PQ \leftarrow \{s\}$

while $PQ \neq \emptyset$

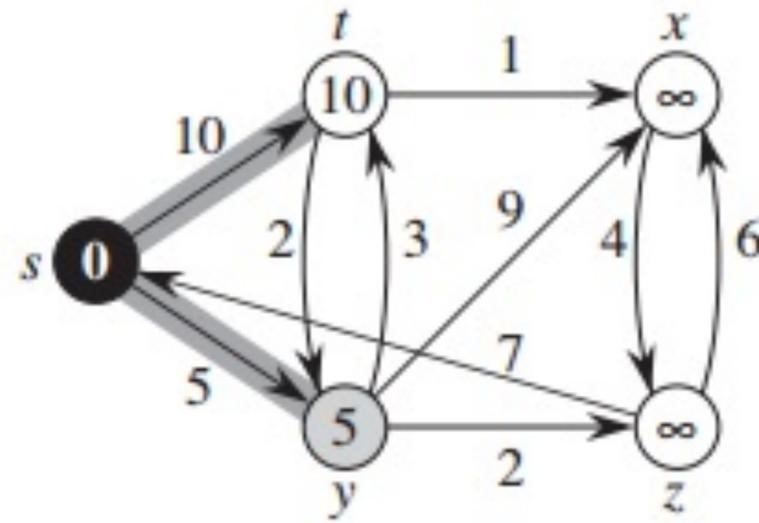
$u \leftarrow \text{extract_min}(PQ)$

$\text{extend}(u)$

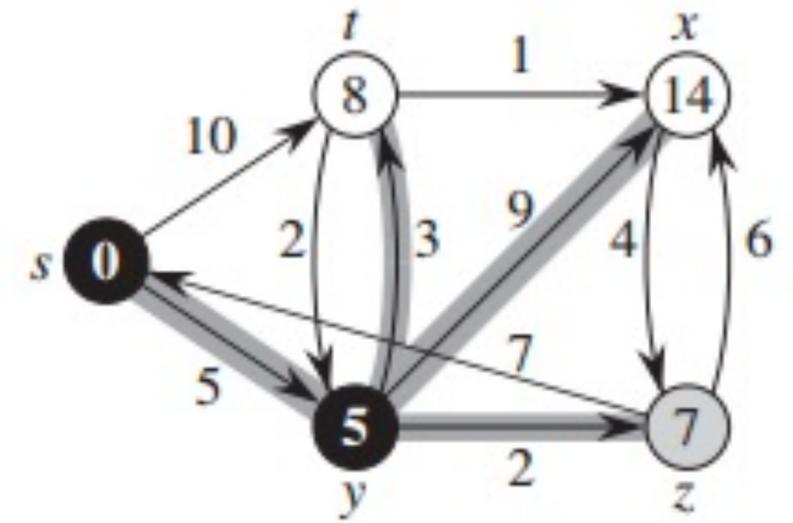
Dijkstra's Algorithm



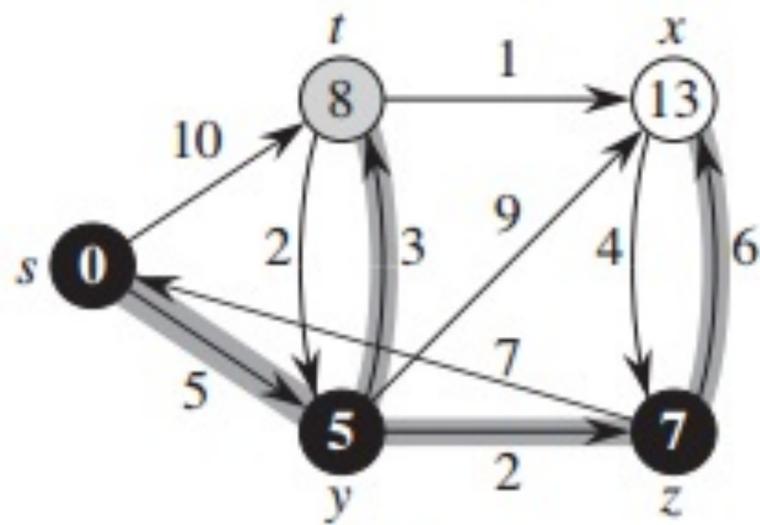
(a)



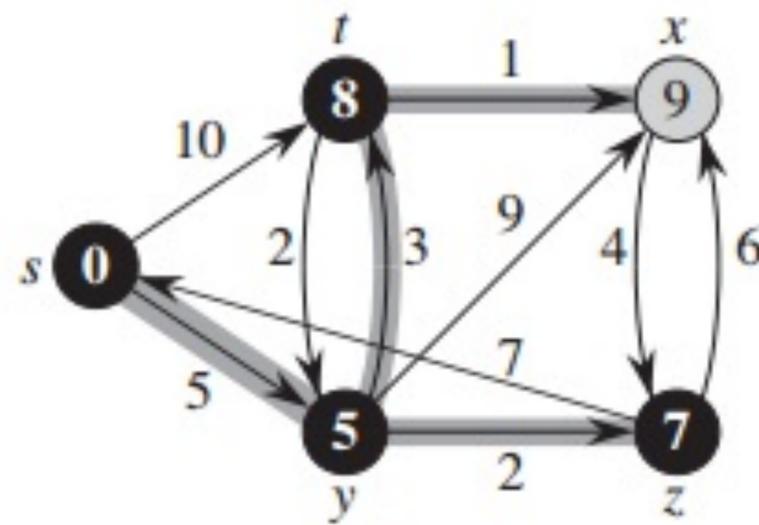
(b)



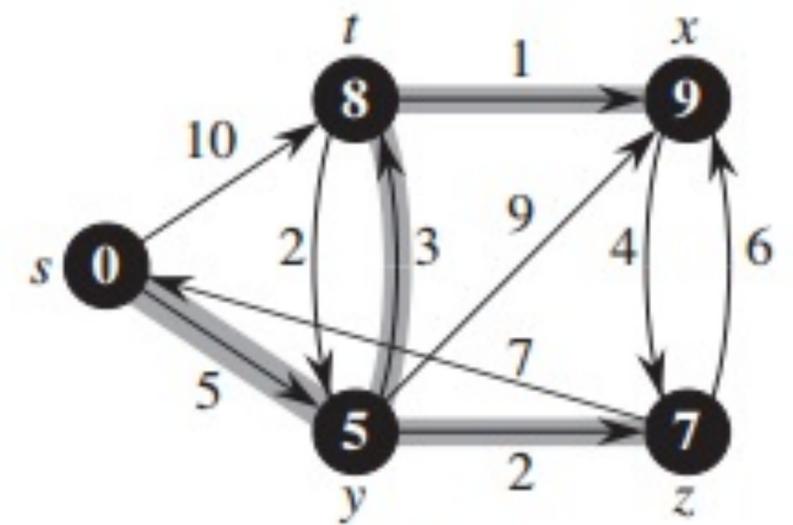
(c)



(d)

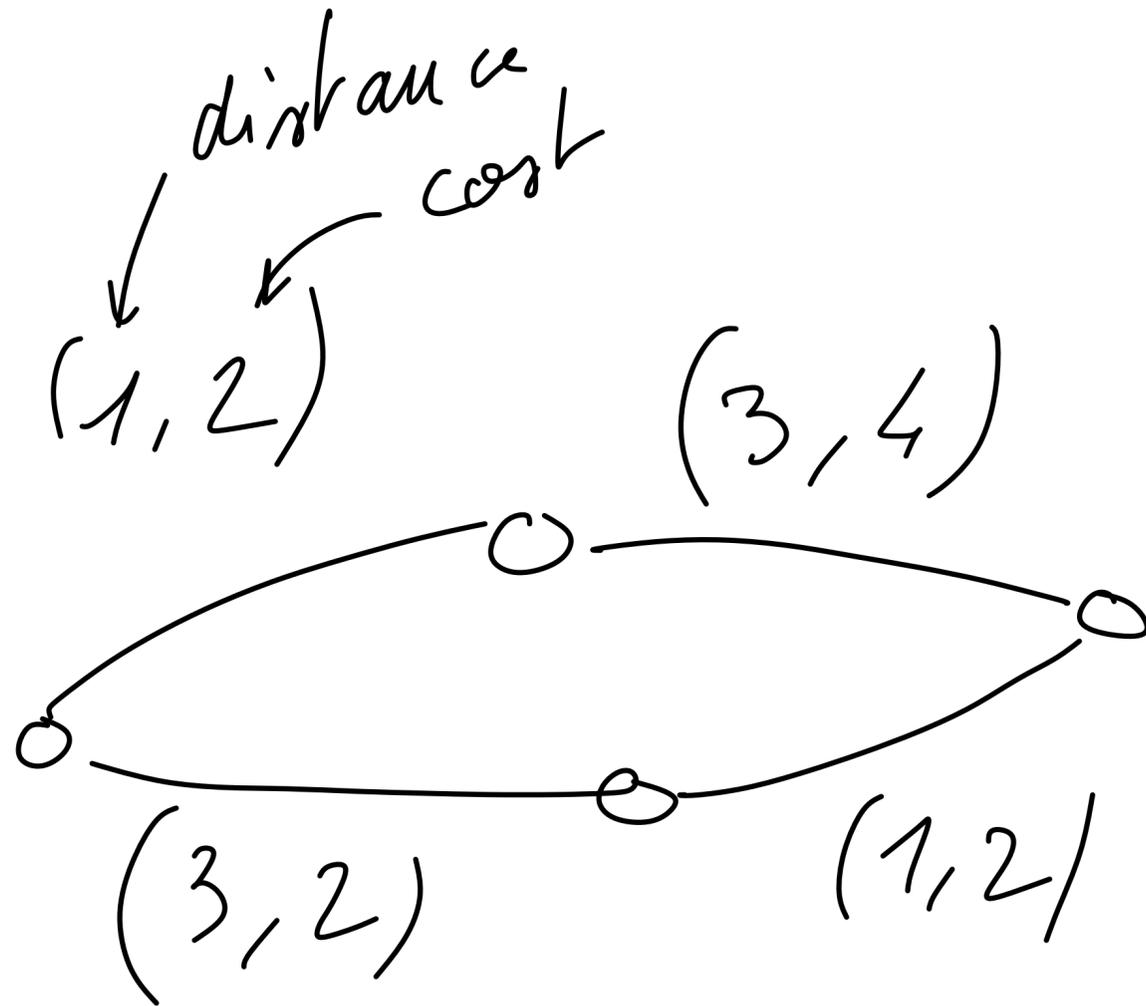


(e)



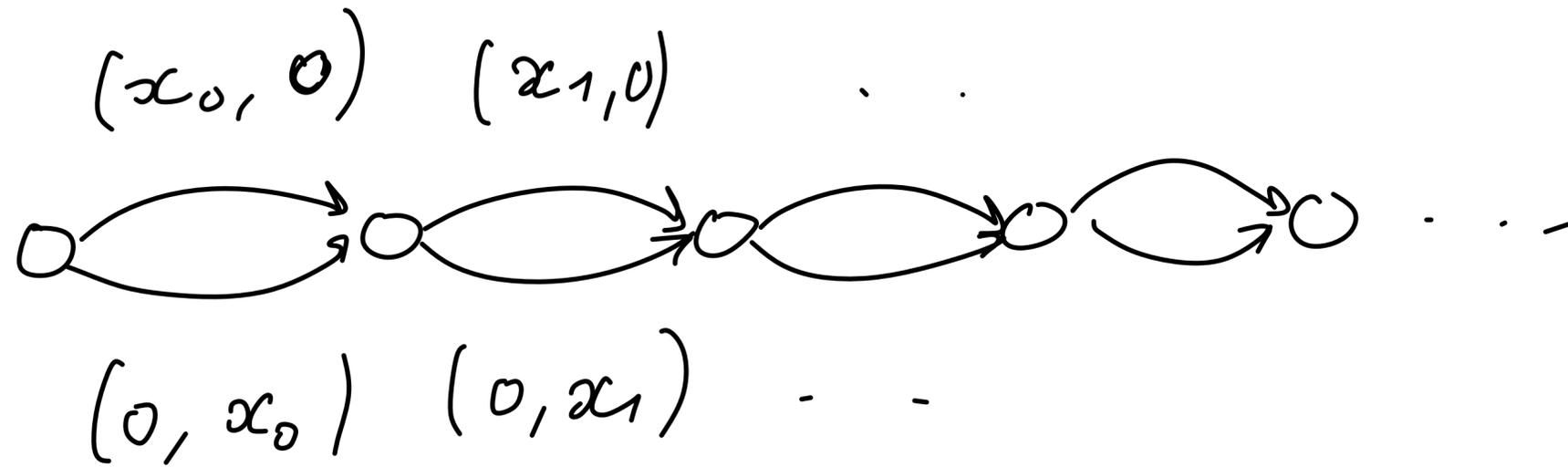
(f)

Multi-metric paths

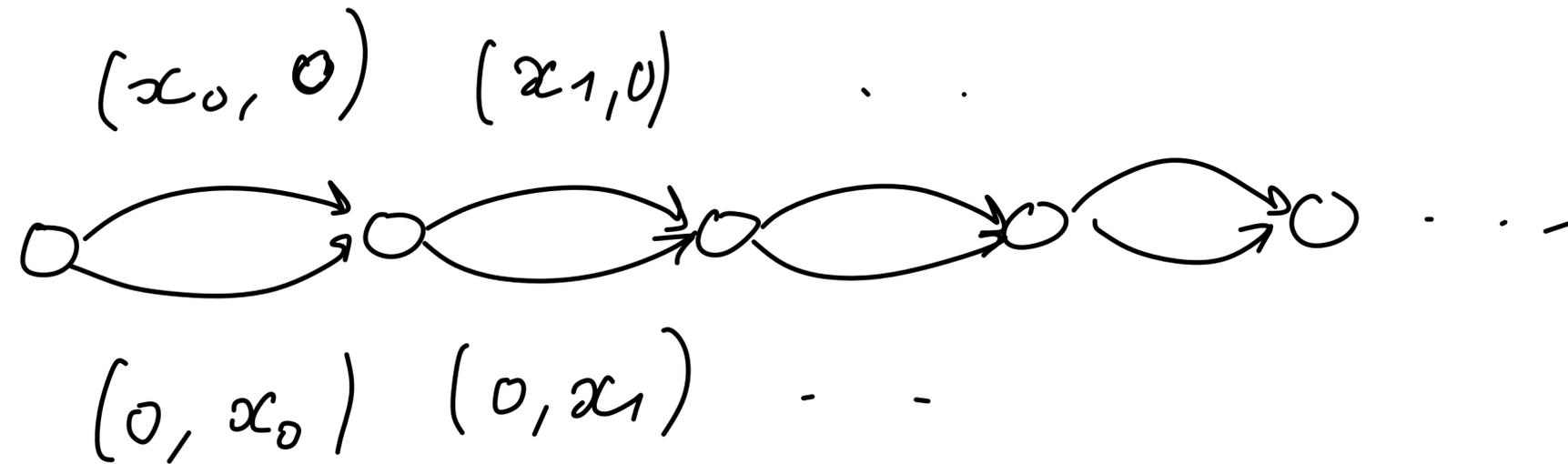


→ Minimize distance
→ Bounded cost

Multi-metric paths



Multi-metric paths



The path defines a partition of $\{x_0, x_1, \dots\}$

What is distributed computing

What is distributed computing

- What happens when you have several computers?
- The **computation** is distributed and the **information** is distributed!
- Where does it occurs?
- More or less efficient?

What is distributed computing

- What happens when you have several computers?
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If you have two computers



If you have two cores in your CPU



What is distributed computing

"A distributed system is one in which the failure of a computer you didn't even know existed can render your own computer unusable"

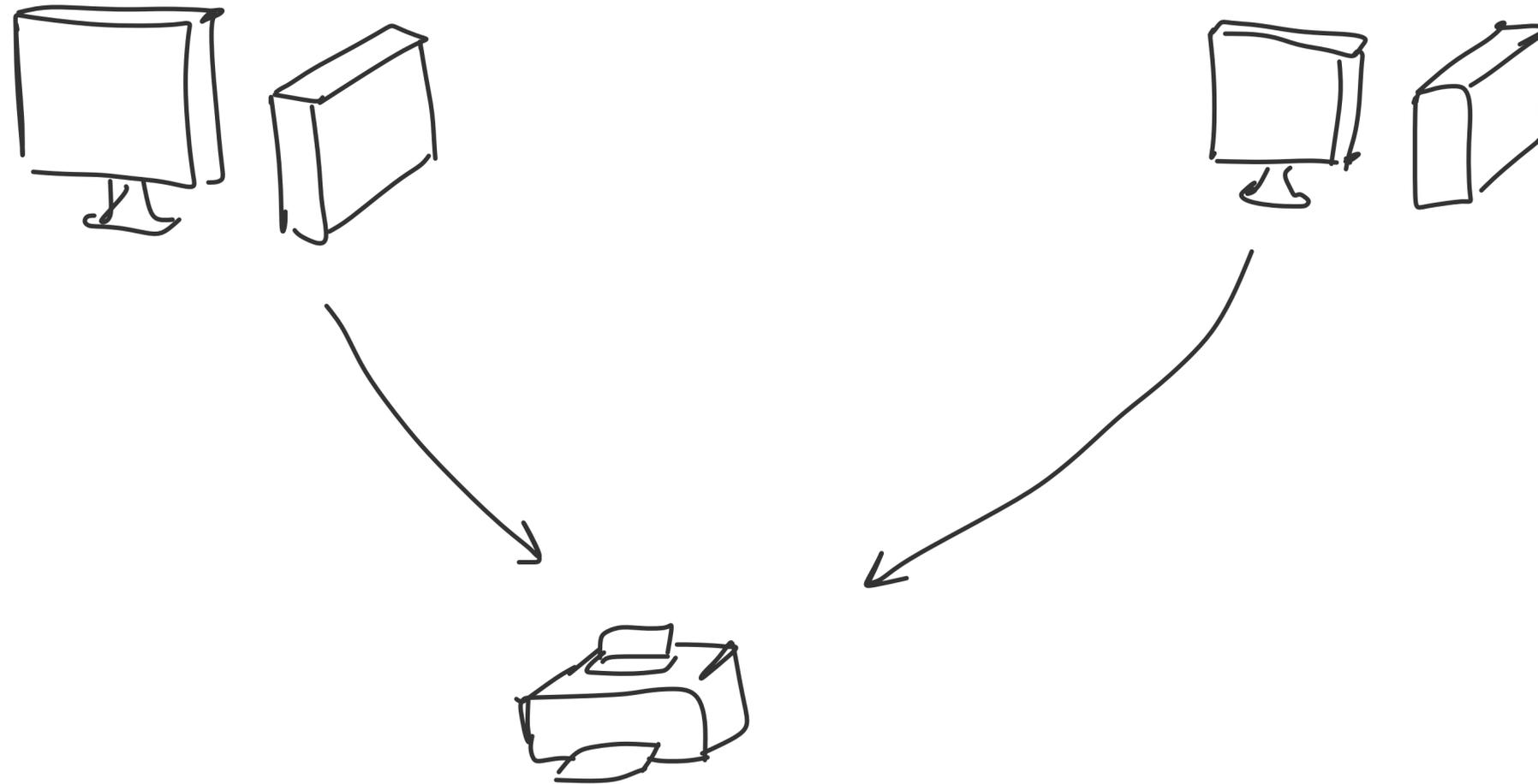
Leslie Lamport - A.M. Turing Award Laureate

Examples of distributed system

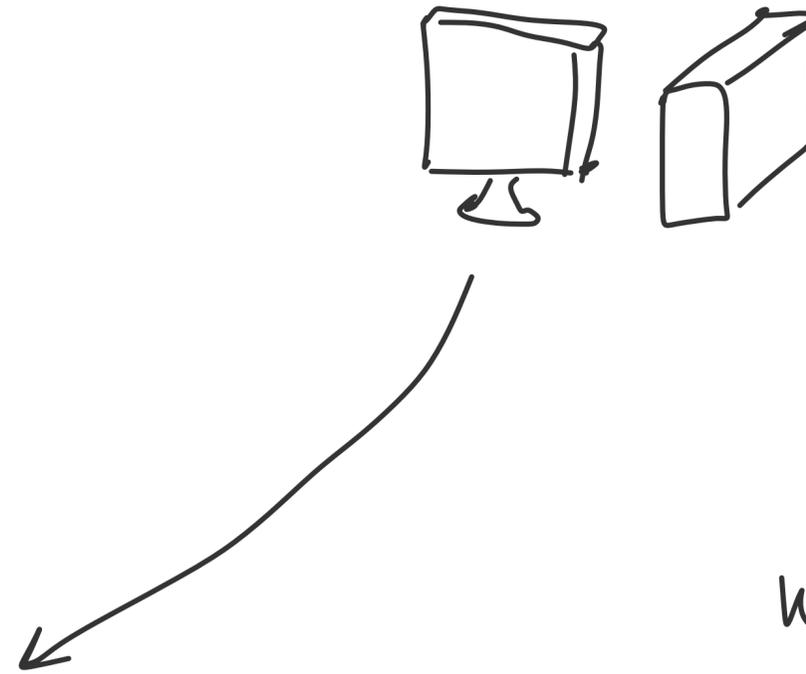
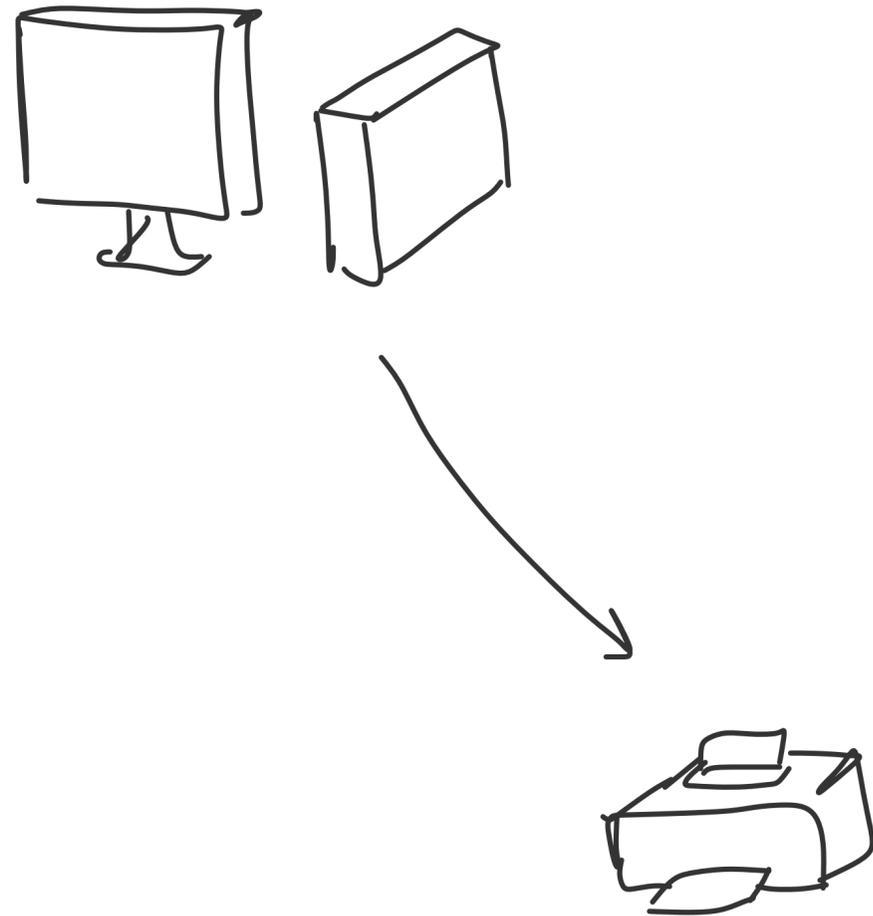
Examples of distributed system

- Accessing a printer
- Dijkstra algorithm tolerating arbitrary initial configuration
- Routing on the internet
- Chat applications
- Lying entities

Accessing a printer

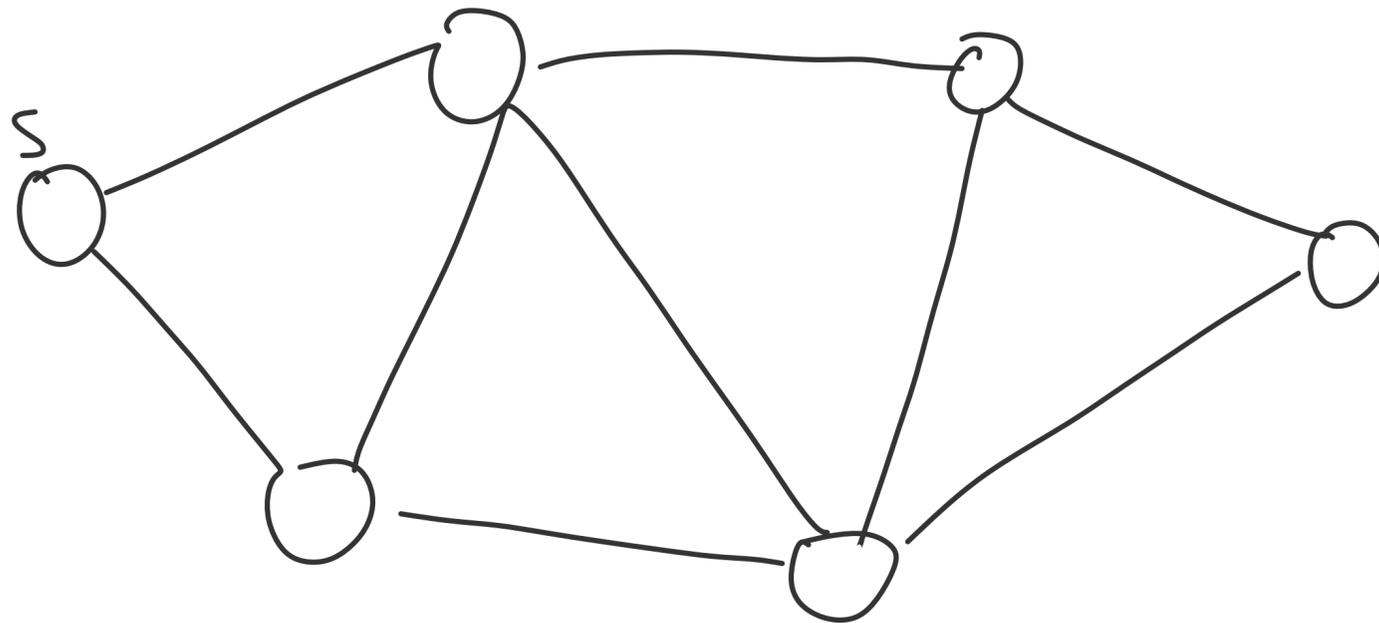


Accessing a printer

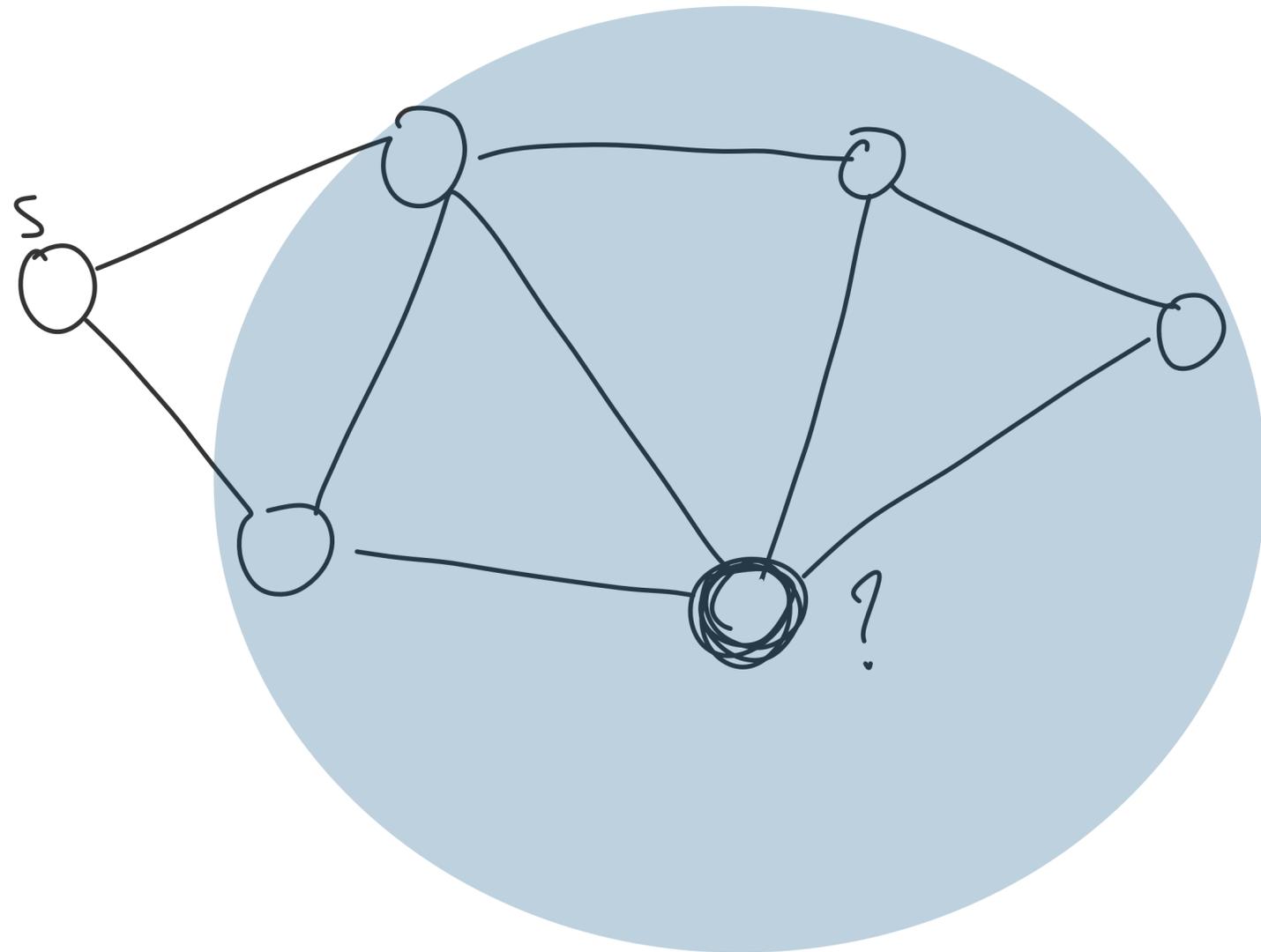


One at a time!
"critical section"

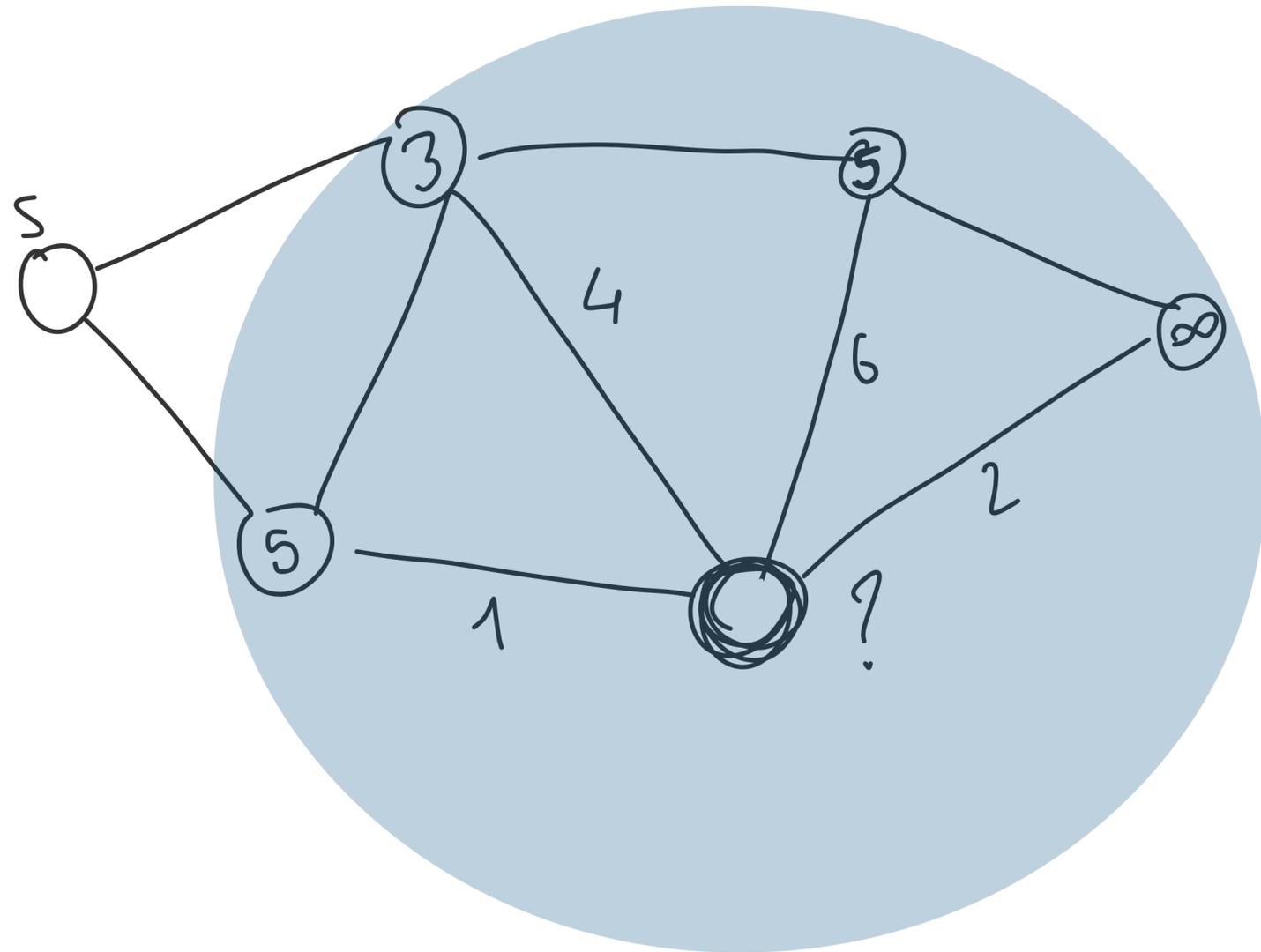
Distributed Dijkstra



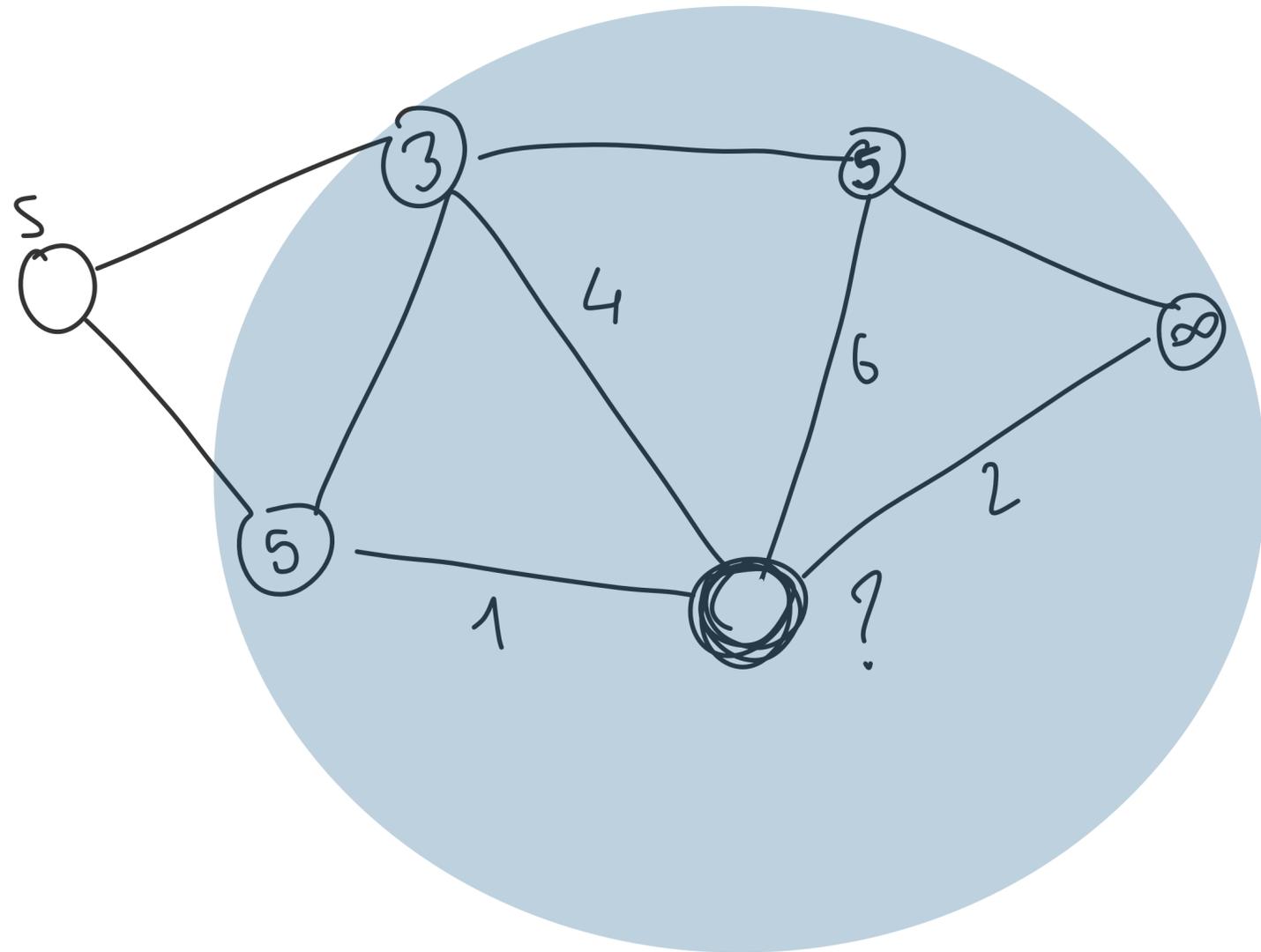
Distributed Dijkstra



Distributed Dijkstra

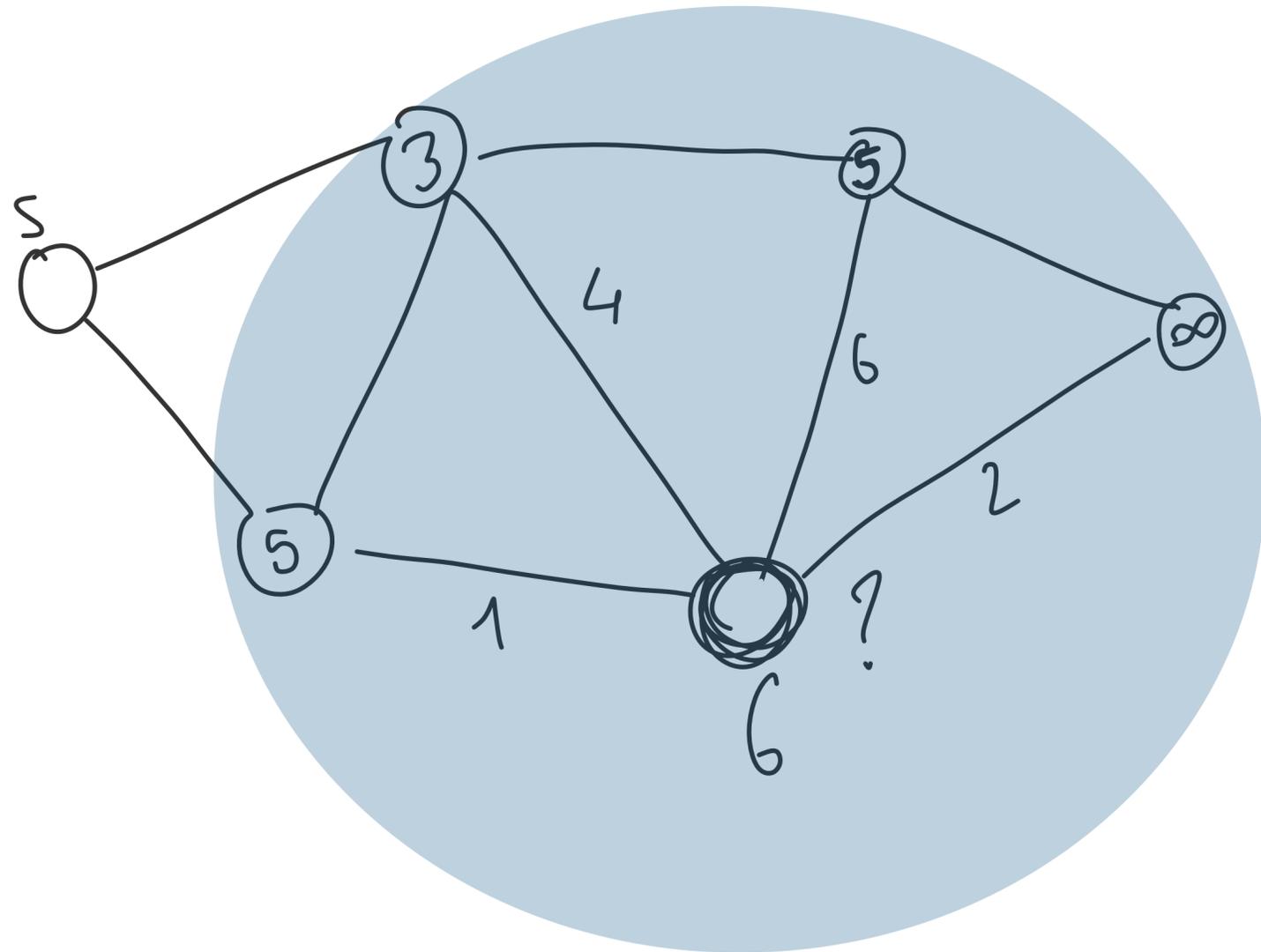


Distributed Dijkstra



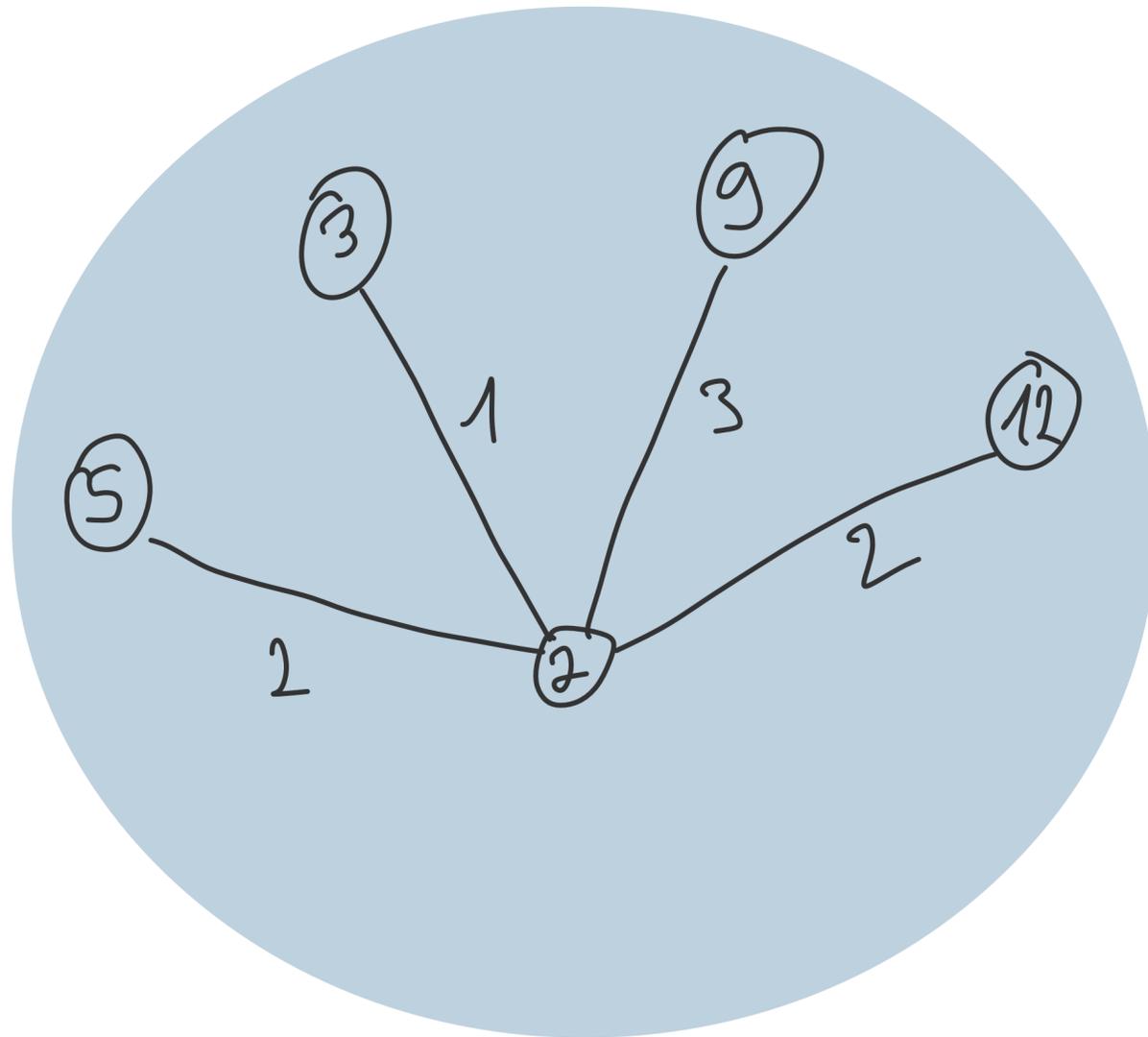
$$\begin{aligned} 3 + 4 &= 7 \\ 5 + 1 &= 6 \\ 5 + 6 &= 11 \\ \infty + 2 &= \infty \end{aligned}$$

Distributed Dijkstra

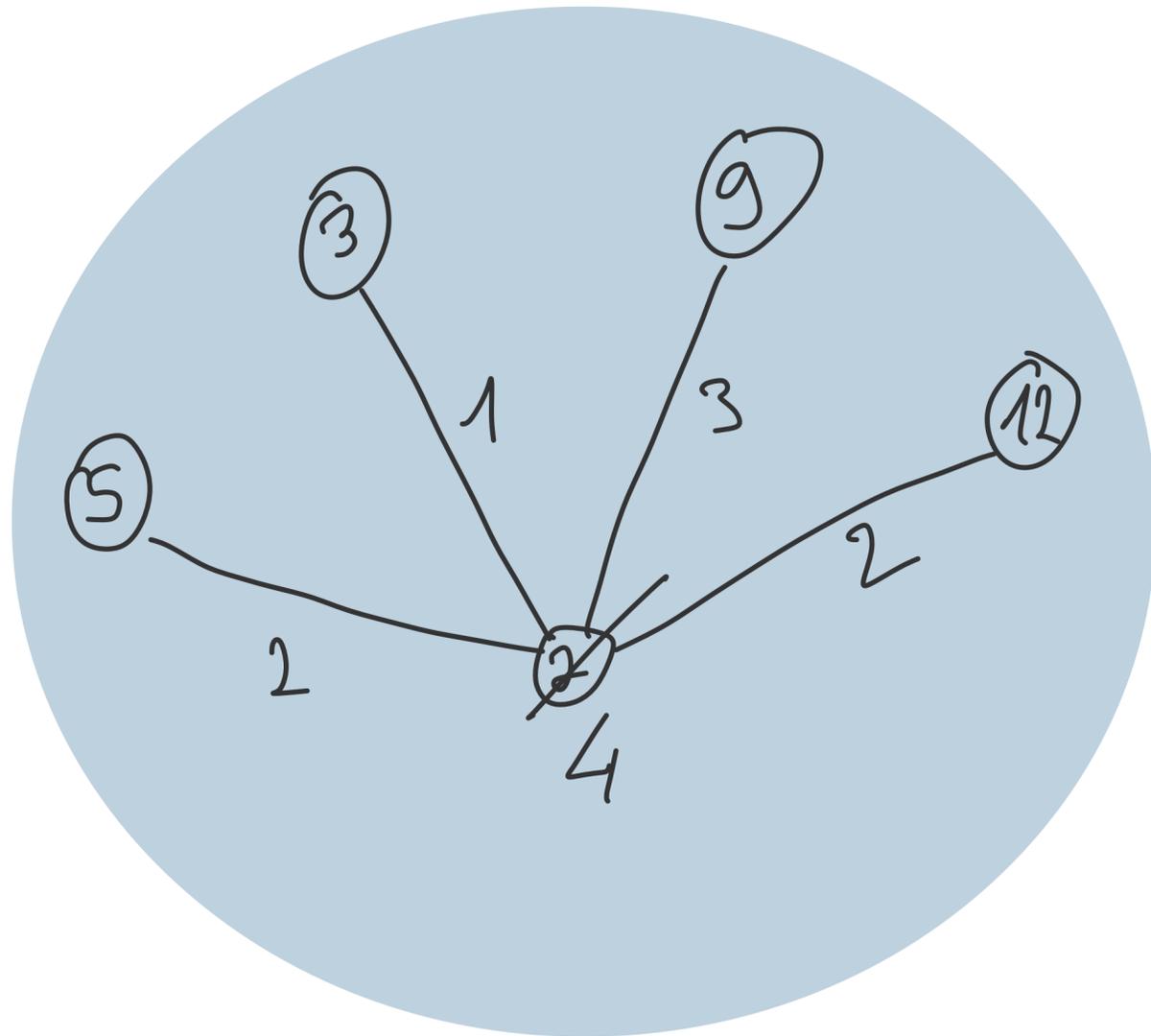


$$3 + 4 = 7$$
$$\boxed{5 + 1 = 6}$$
$$5 + 6 = 11$$
$$\infty + 2 = \infty$$

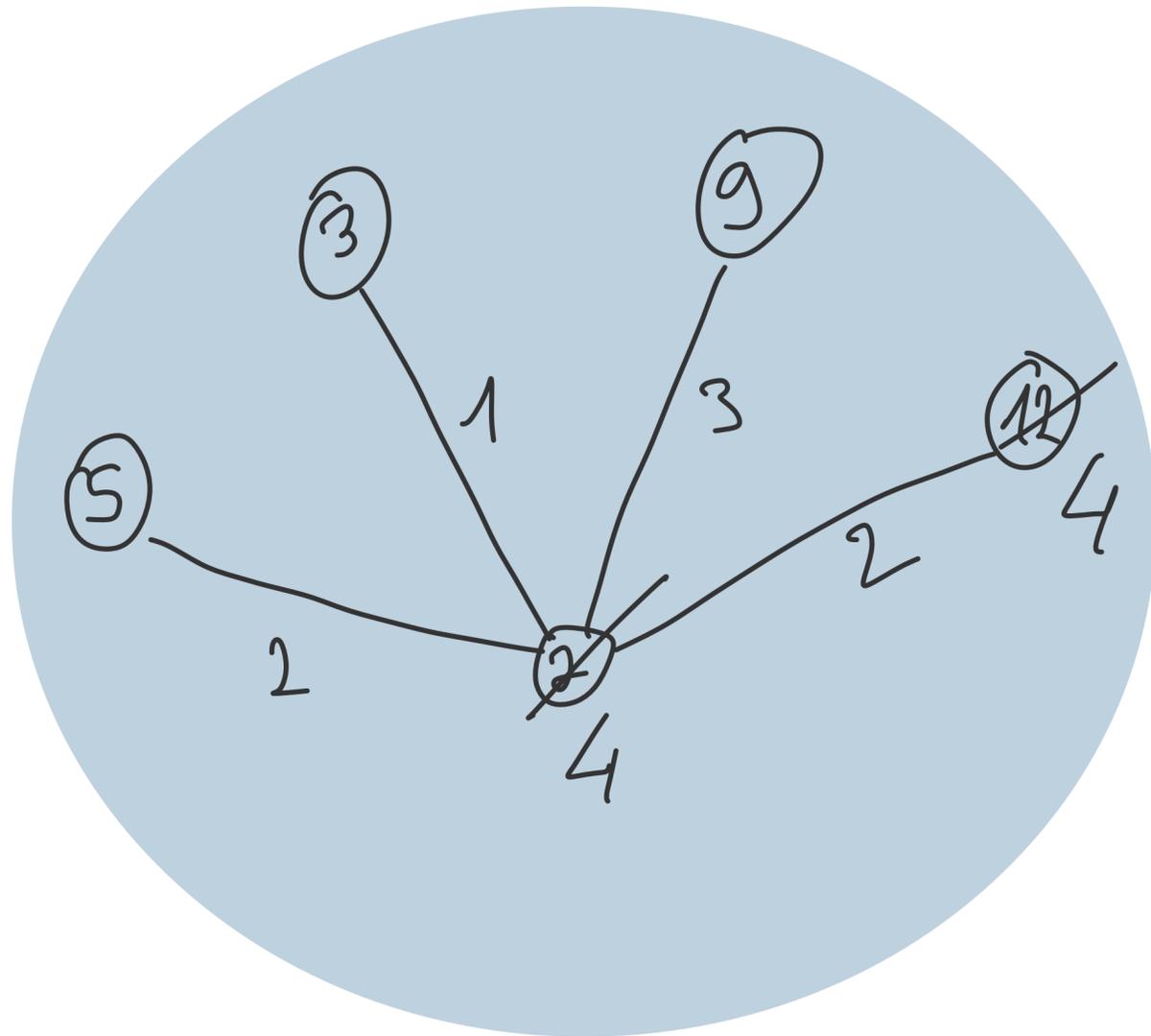
Distributed Dijkstra



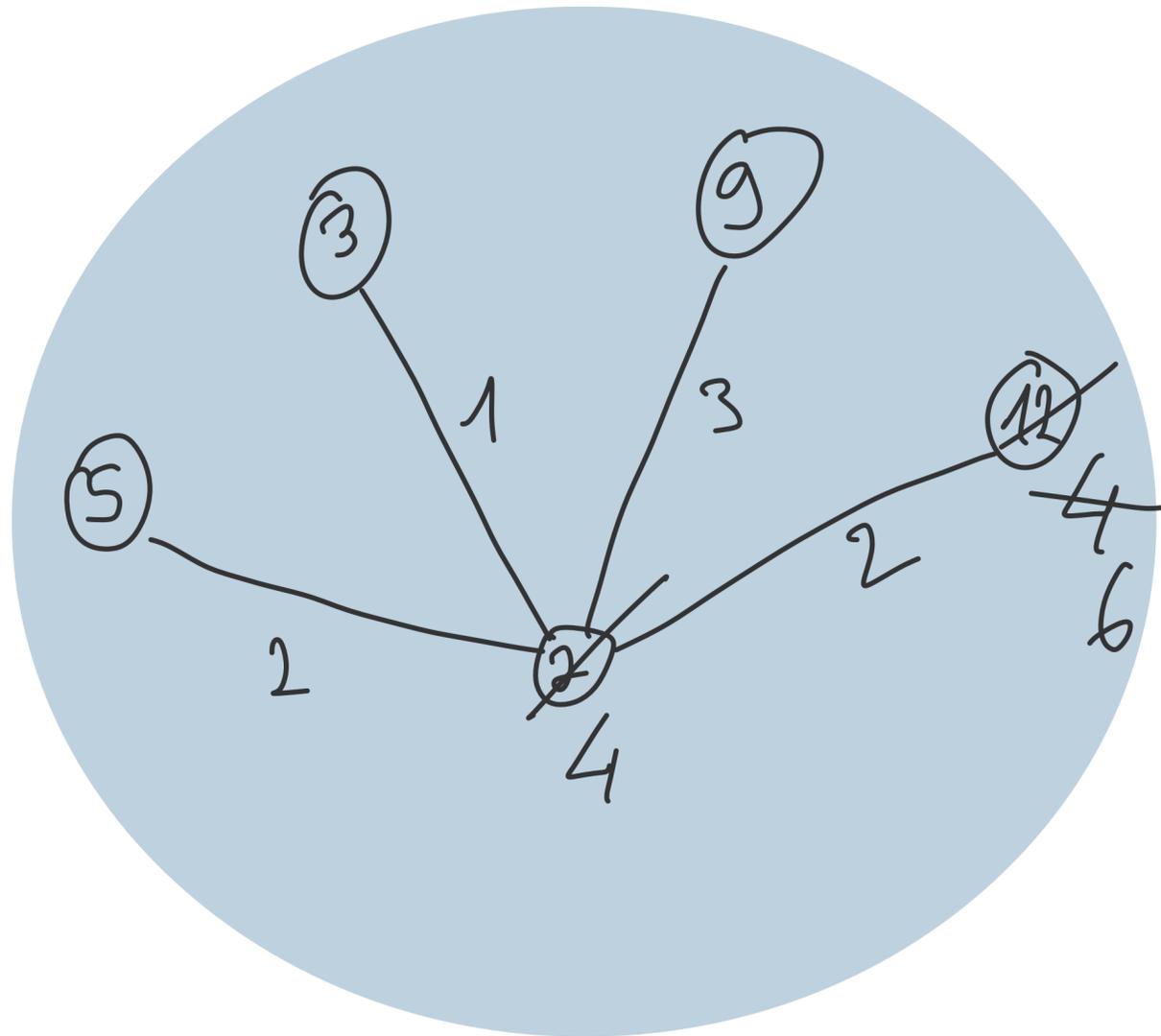
Distributed Dijkstra



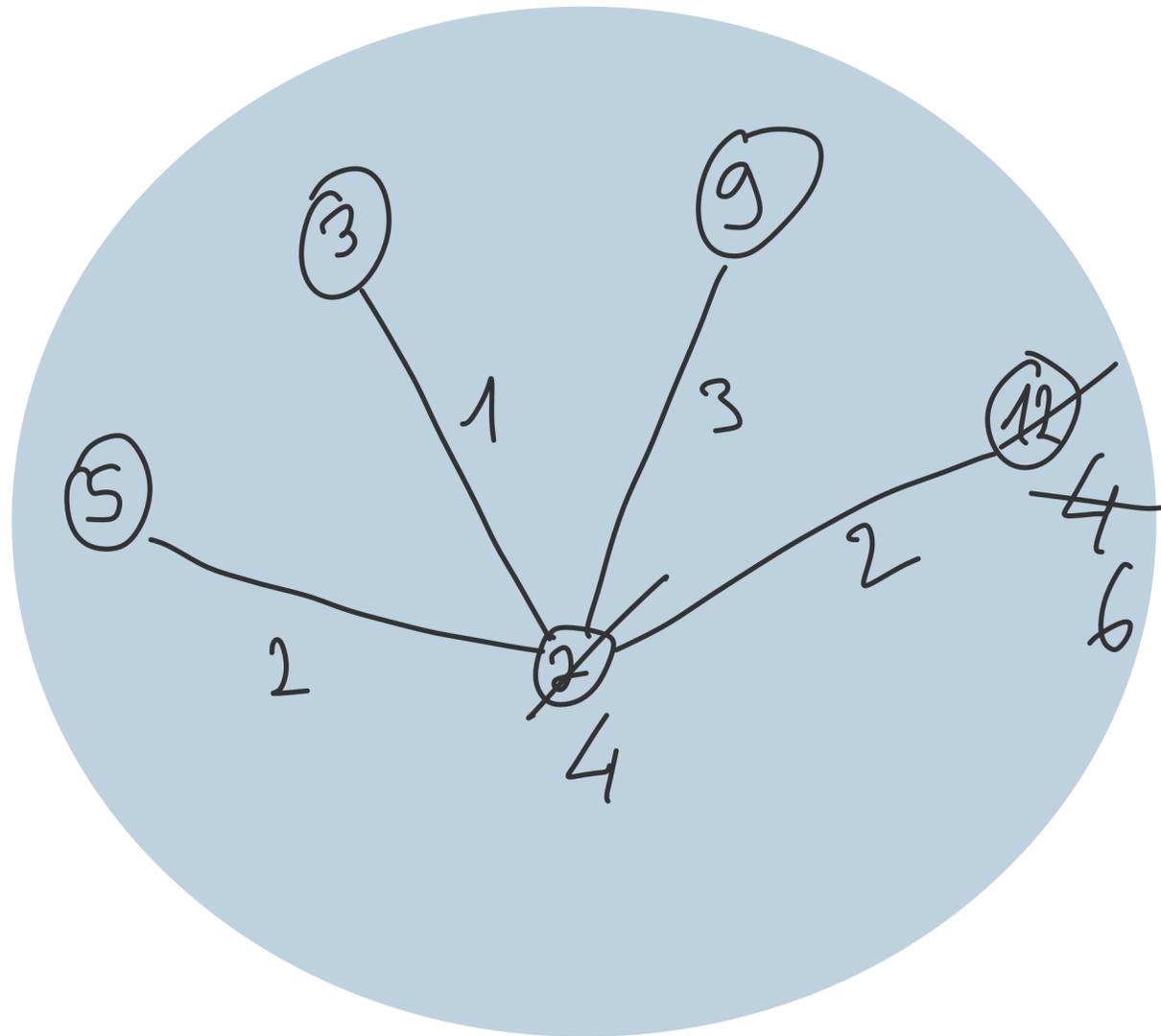
Distributed Dijkstra



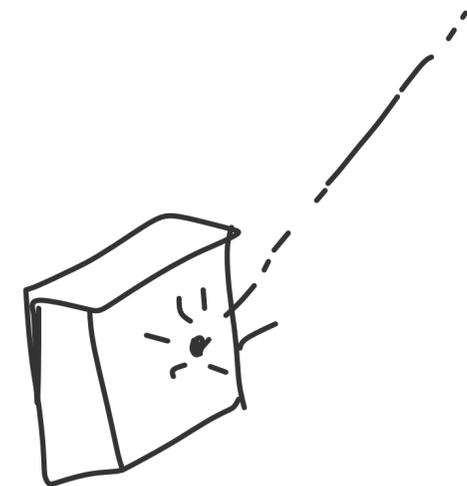
Distributed Dijkstra



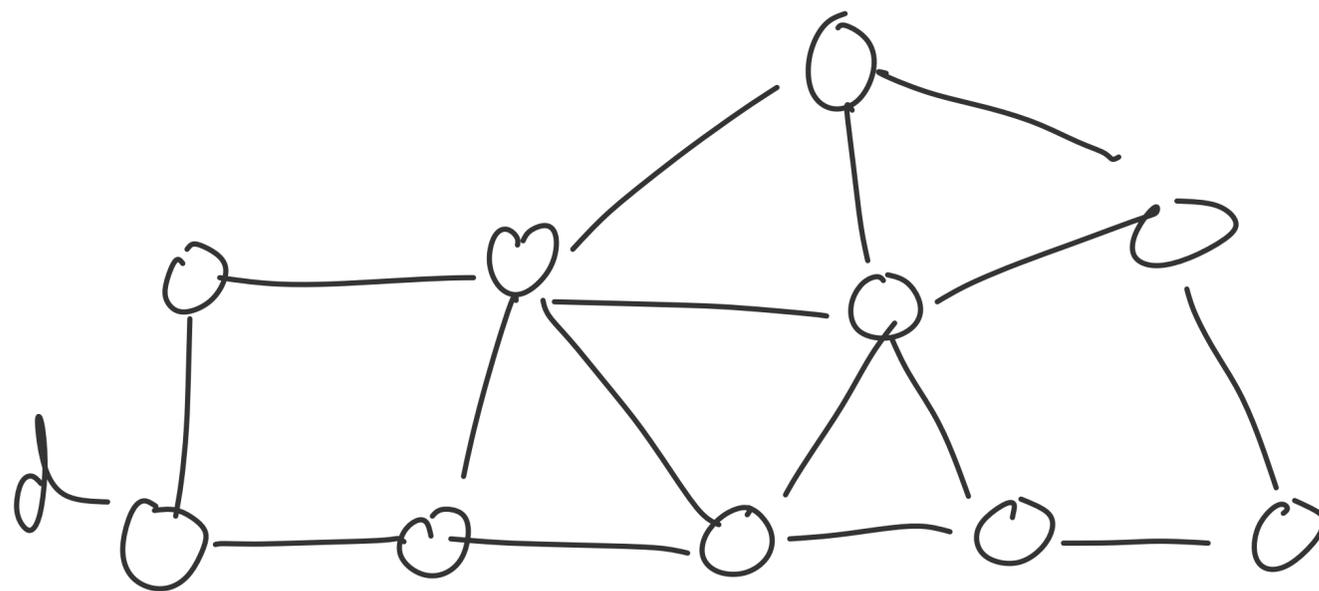
Distributed Dijkstra



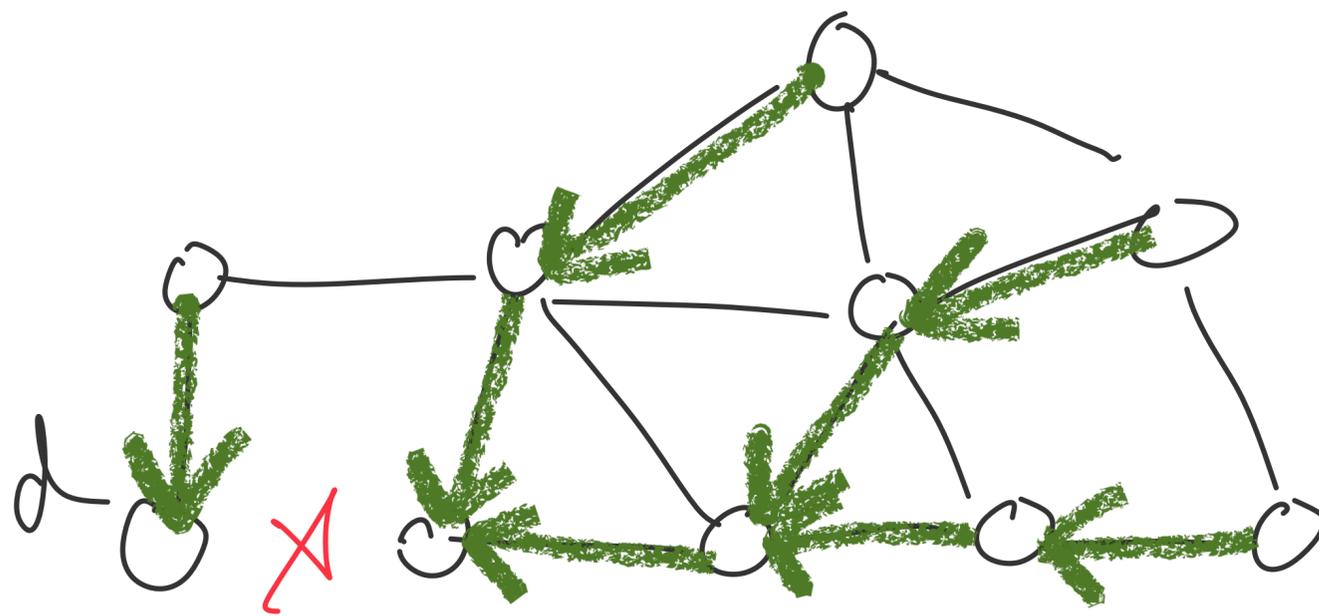
We can tolerate
transient faults



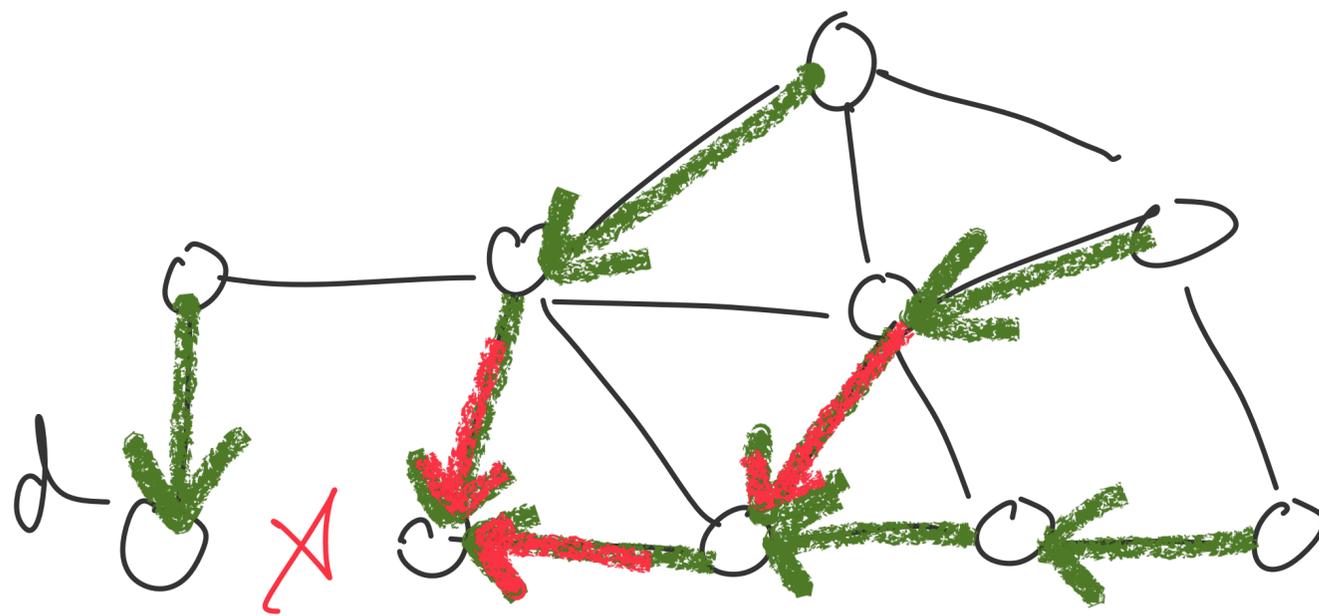
Routing packets in a Network



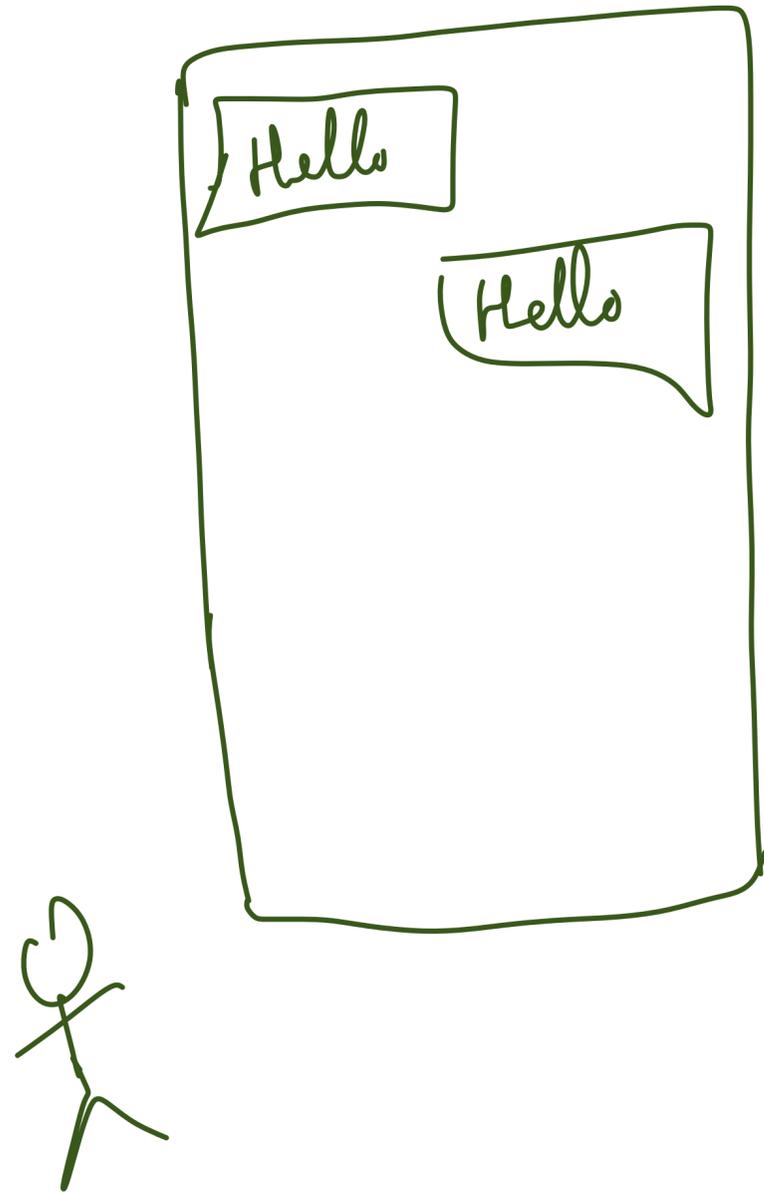
Routing packets in a Network



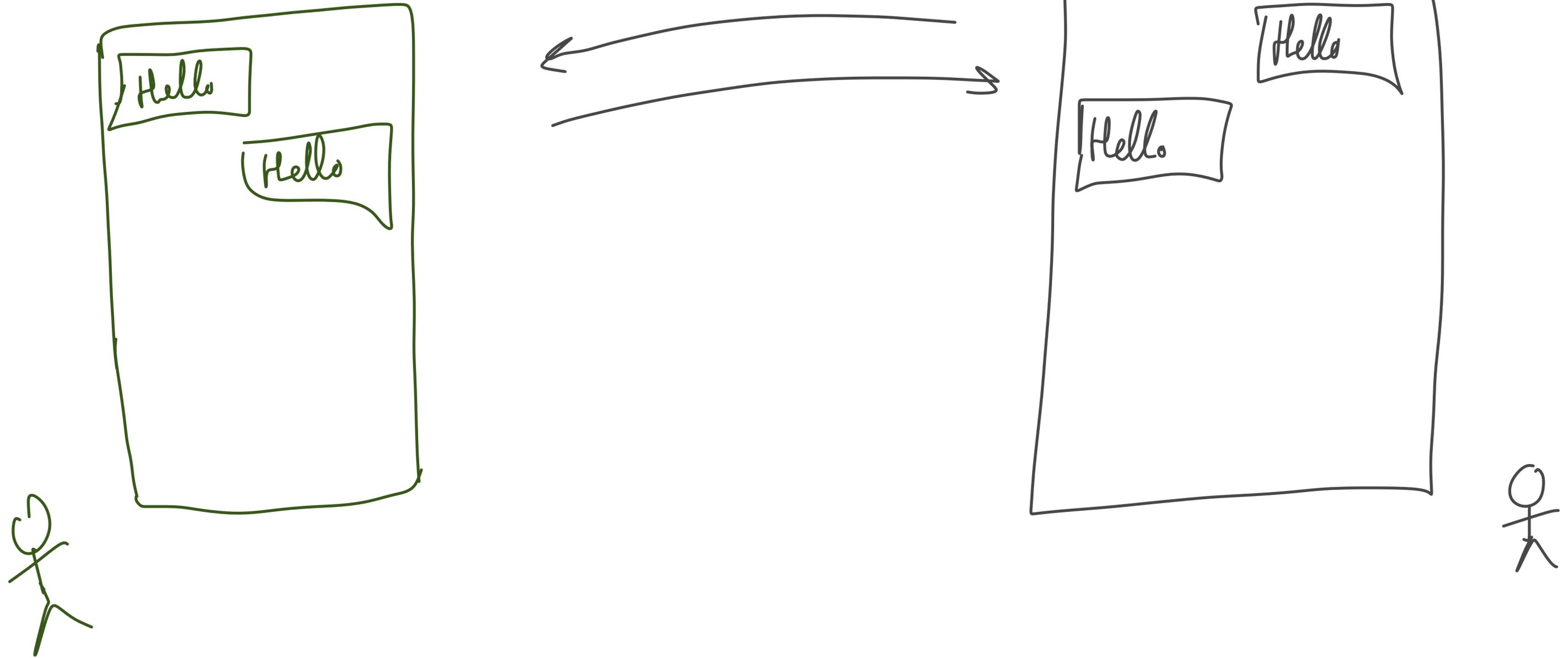
Routing packets in a Network



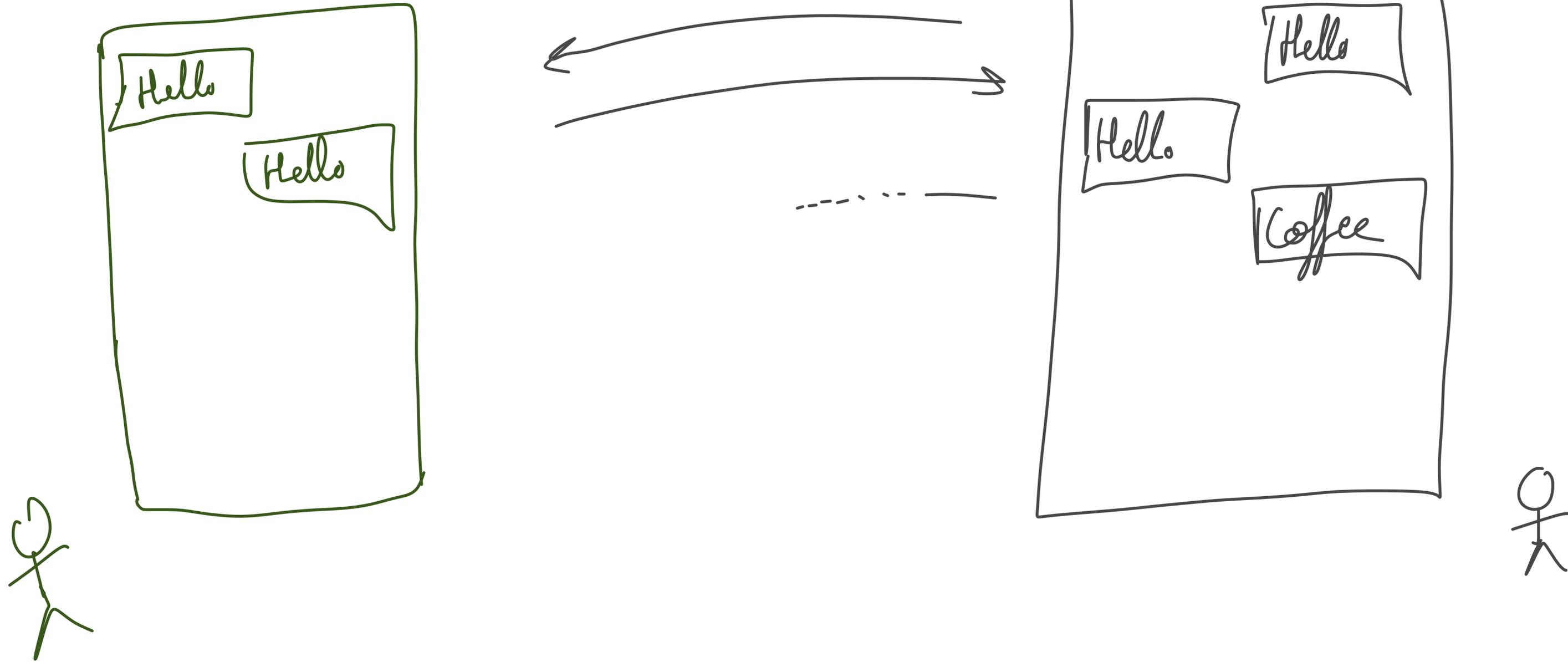
Chat Applications



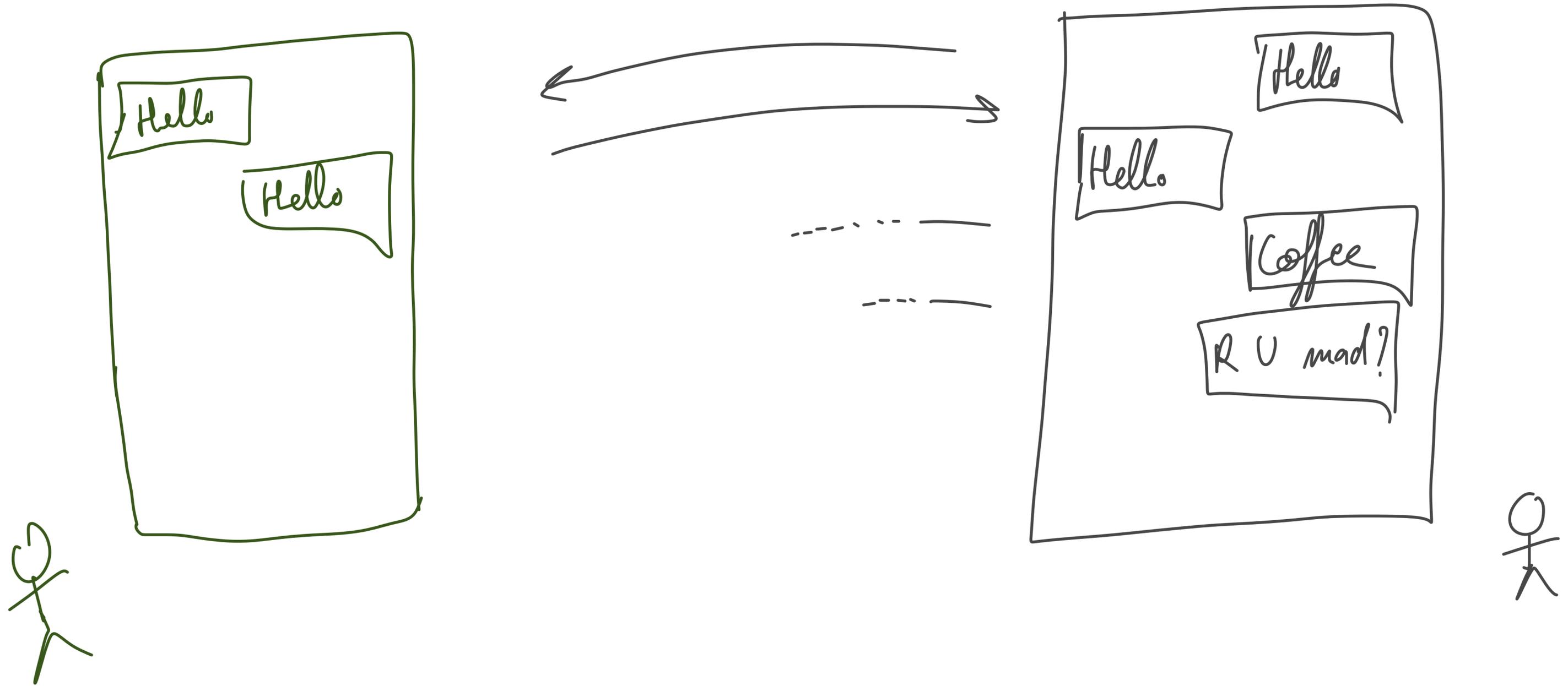
Chat Applications



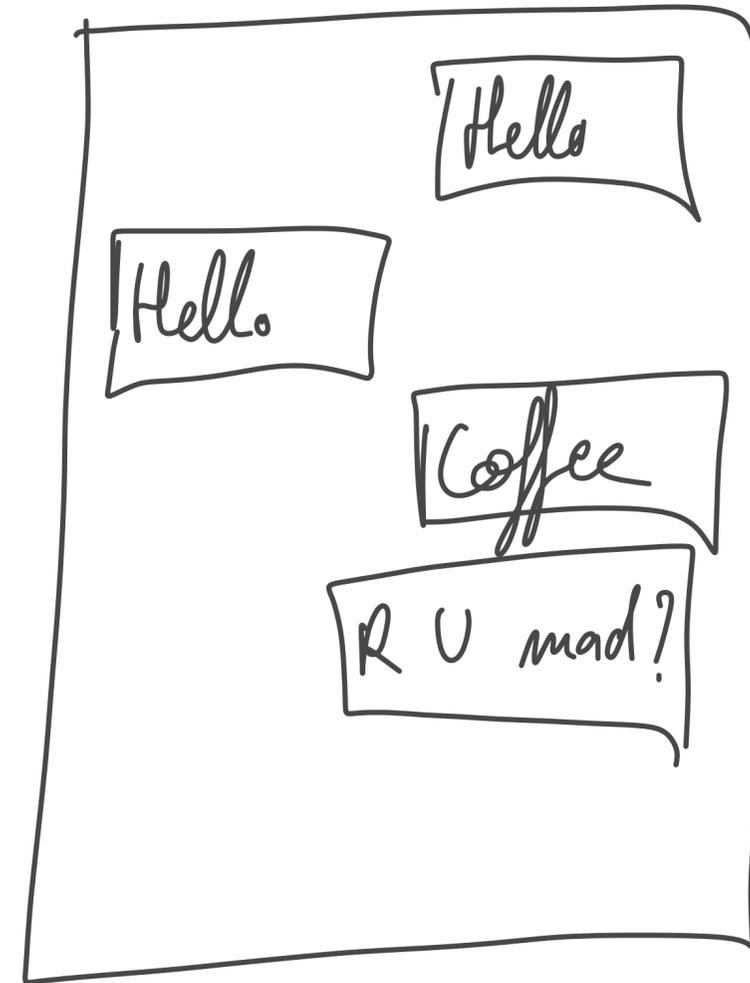
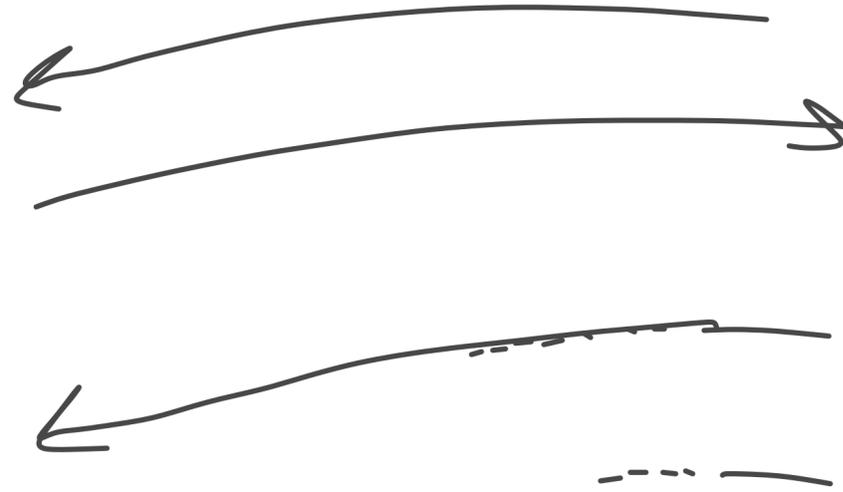
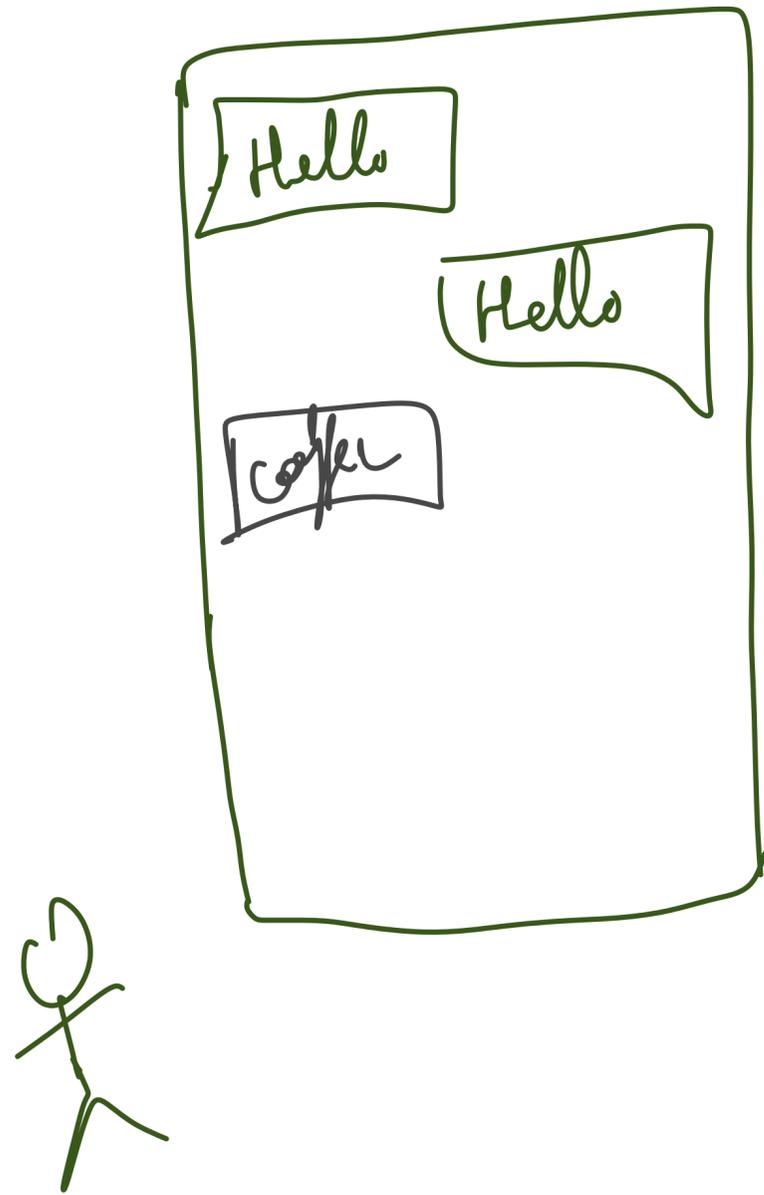
Chat Applications



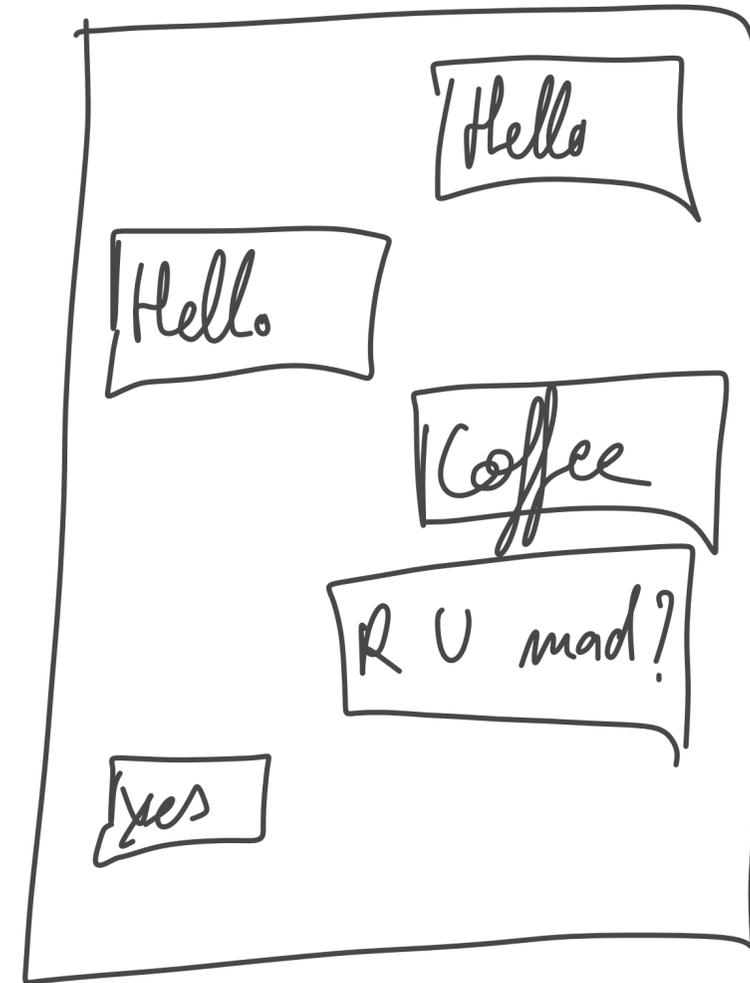
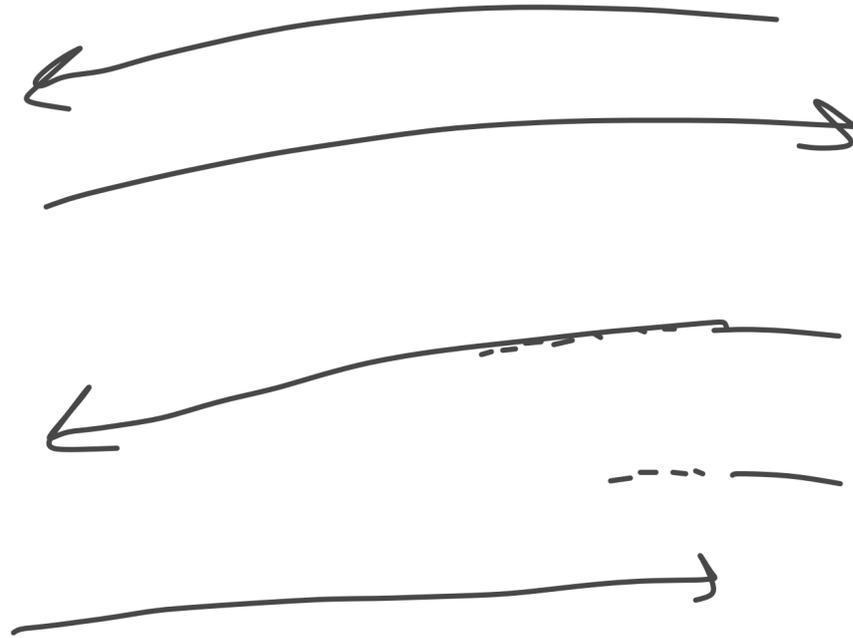
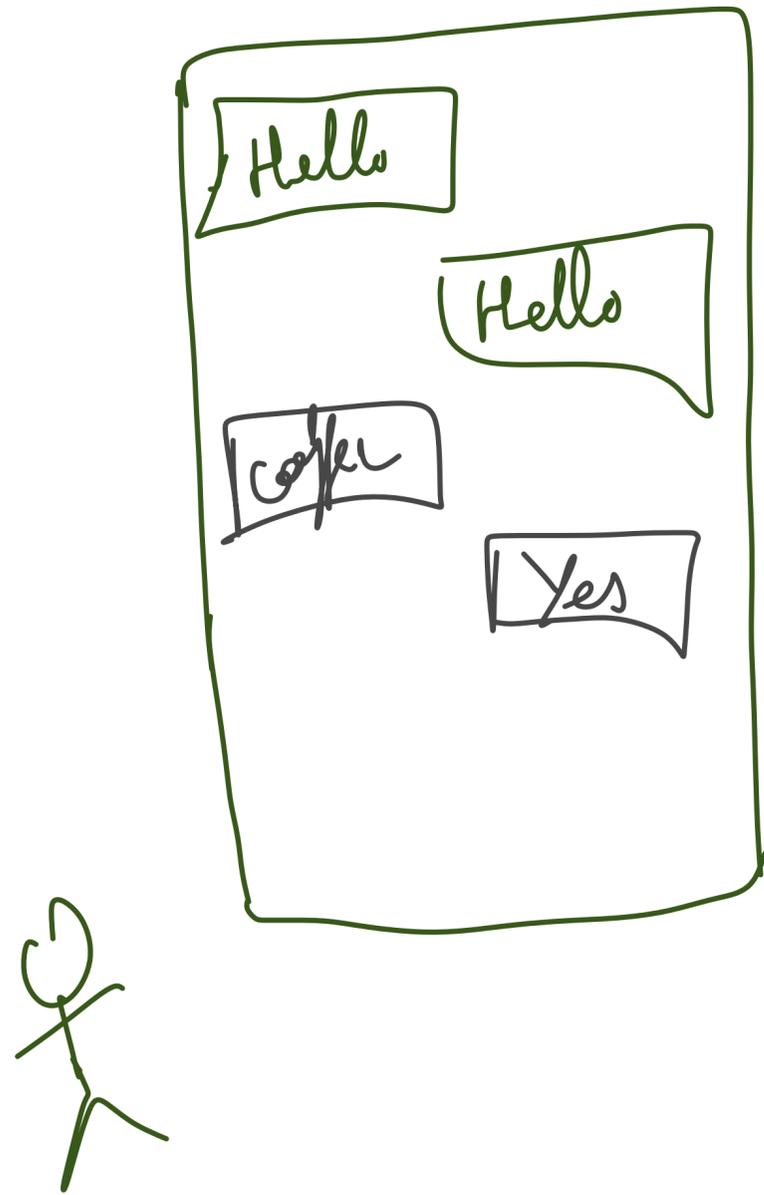
Chat Applications



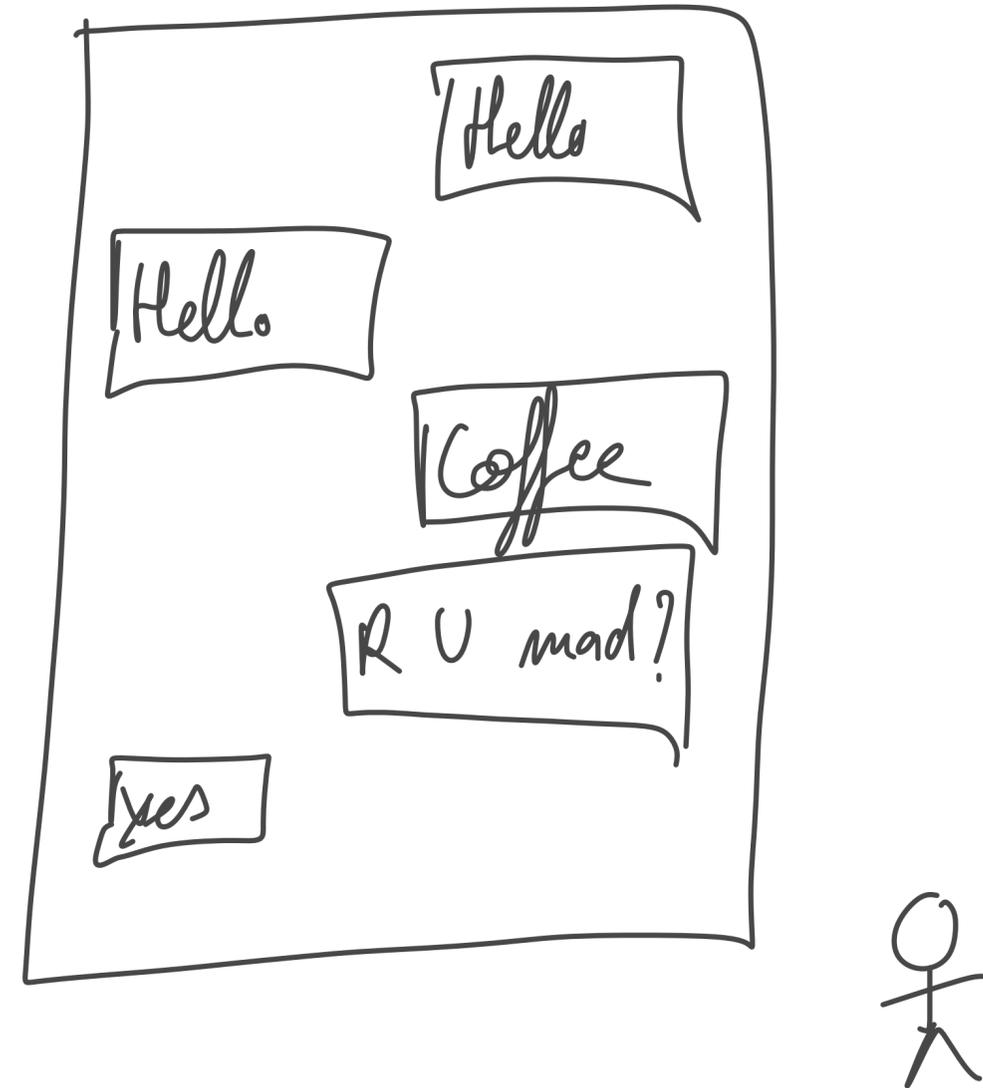
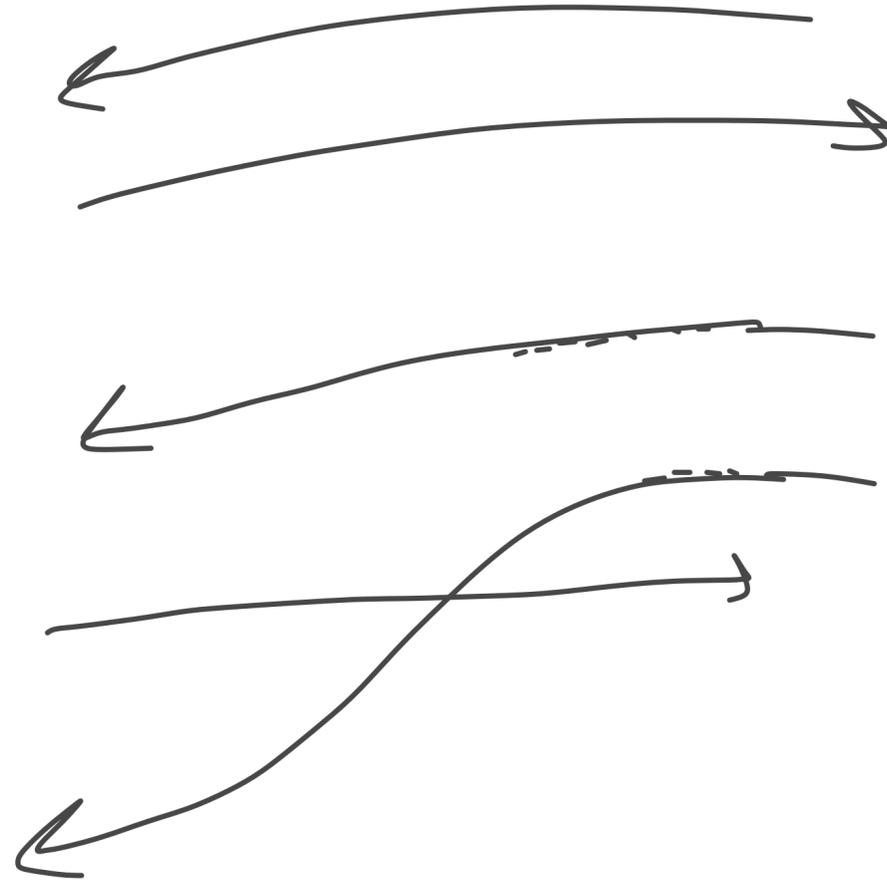
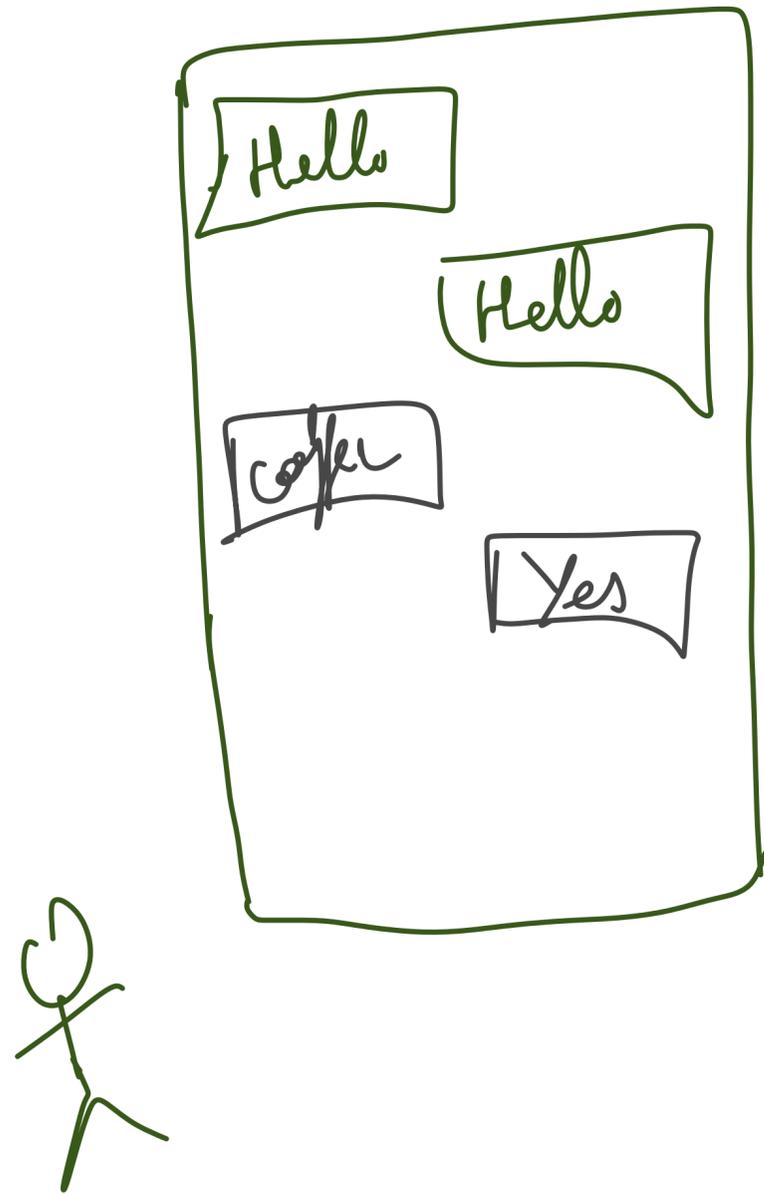
Chat Applications



Chat Applications



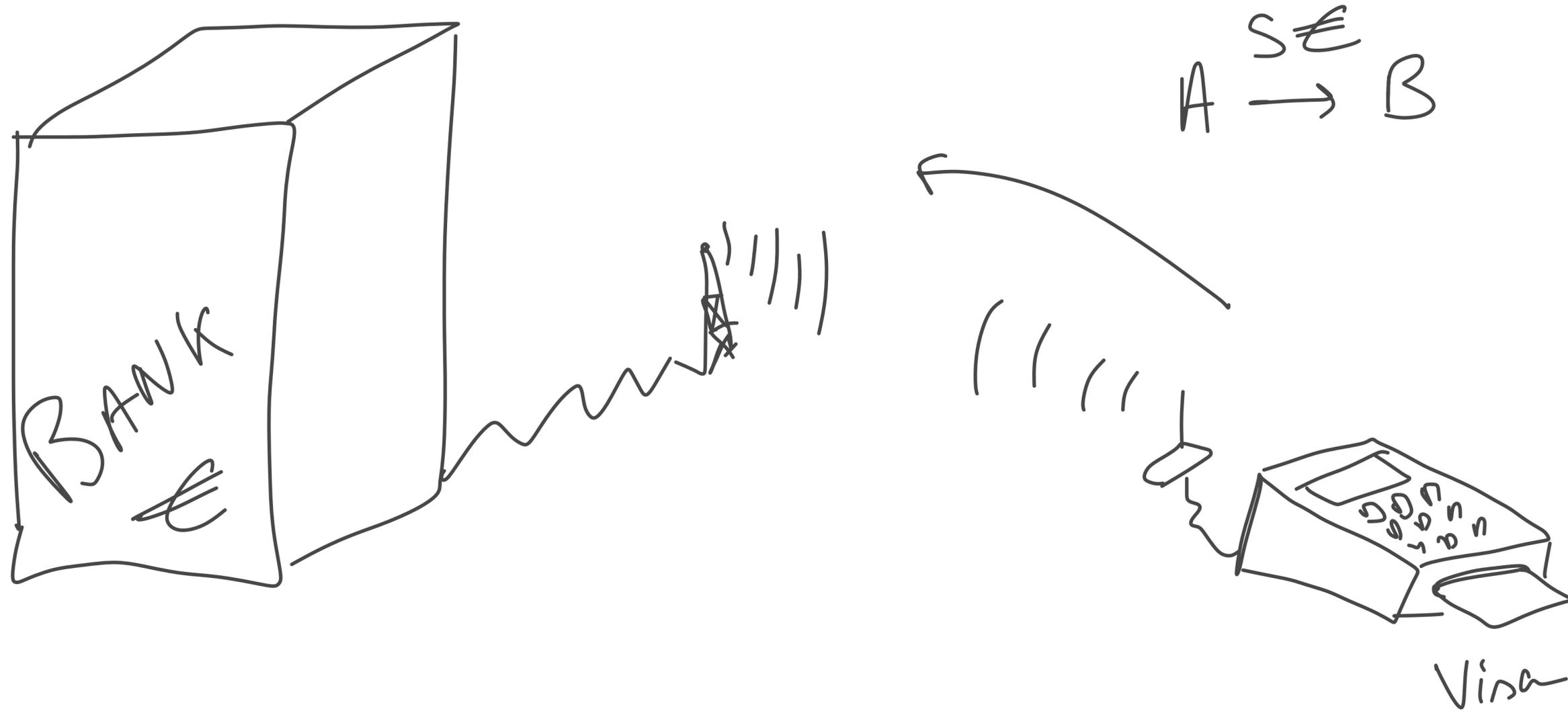
Chat Applications



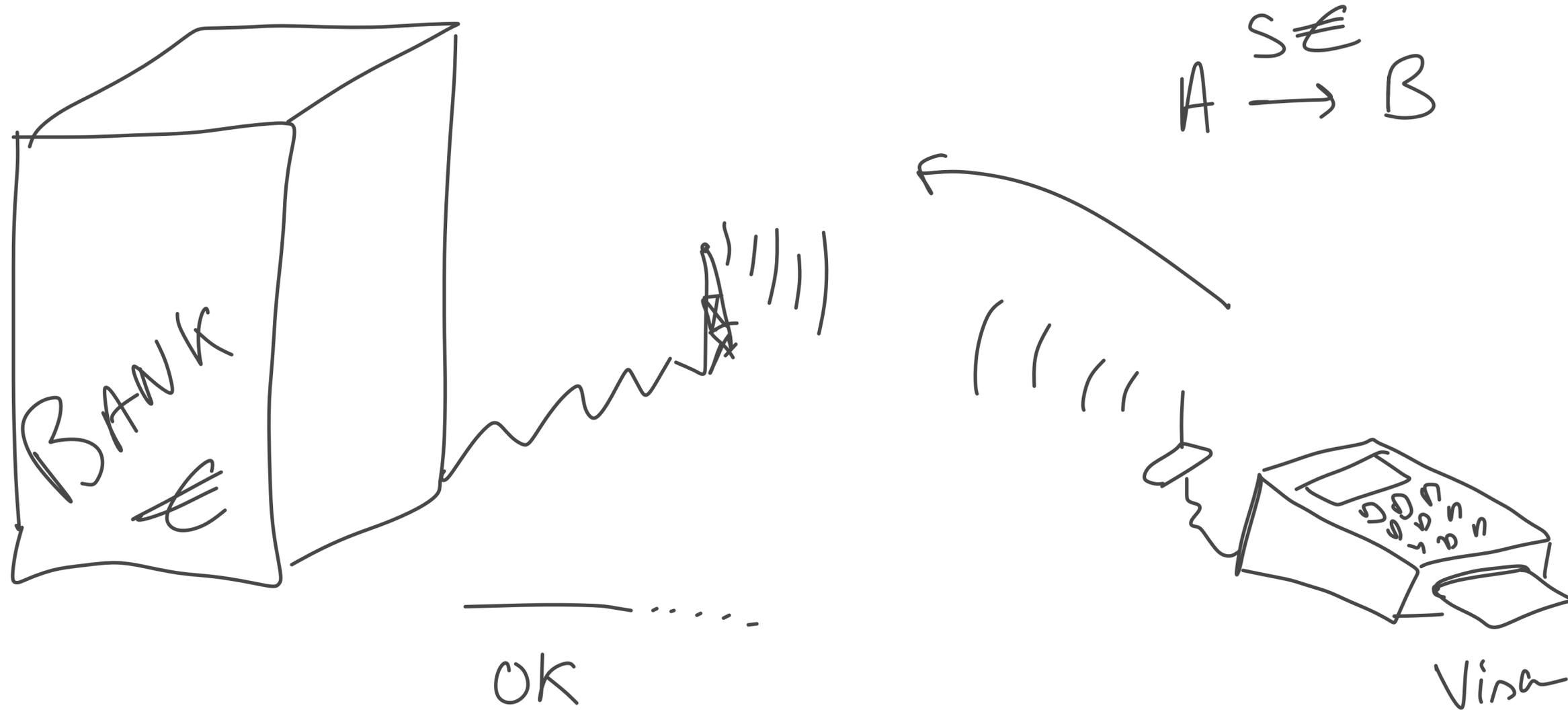
Agreement



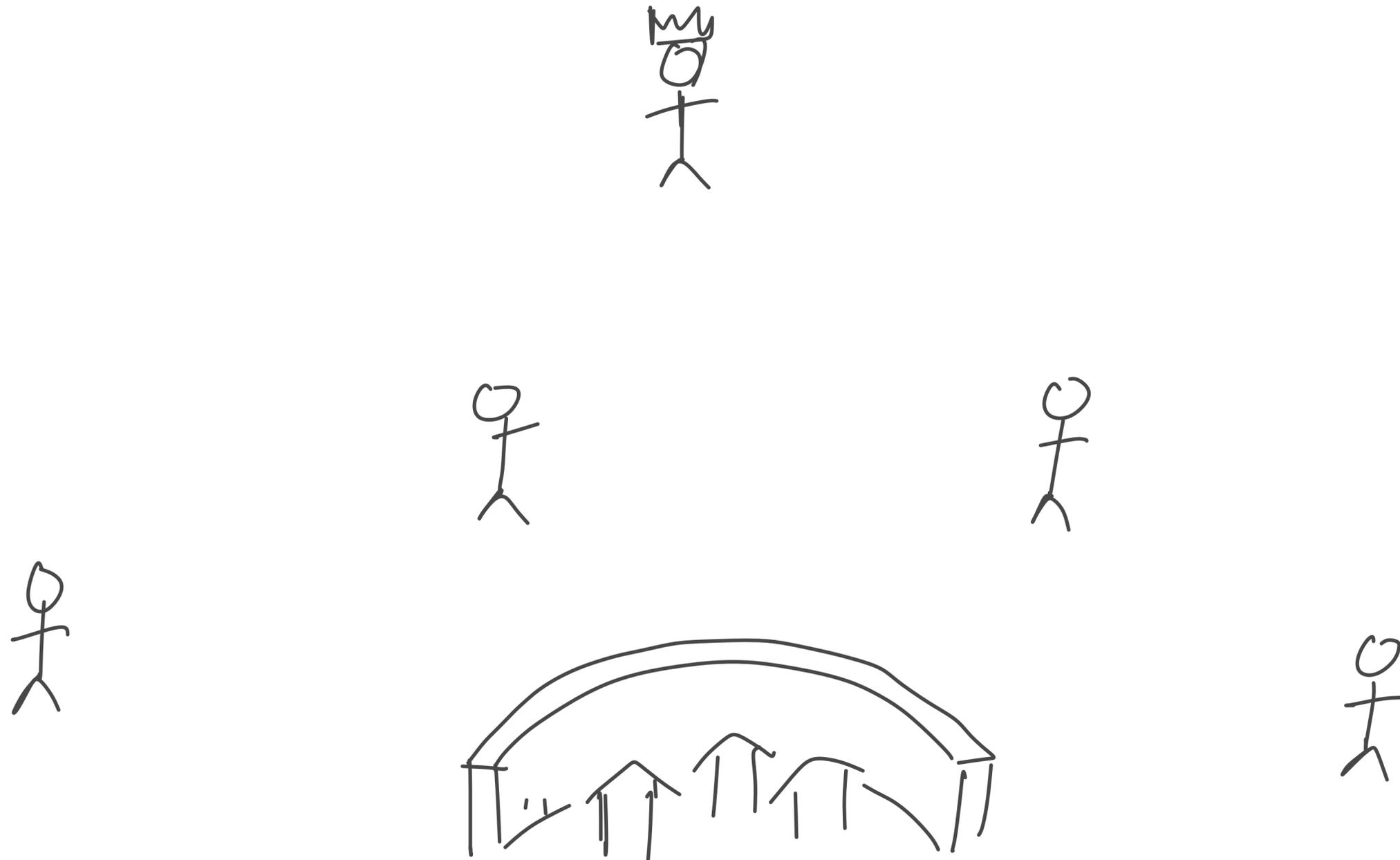
Agreement



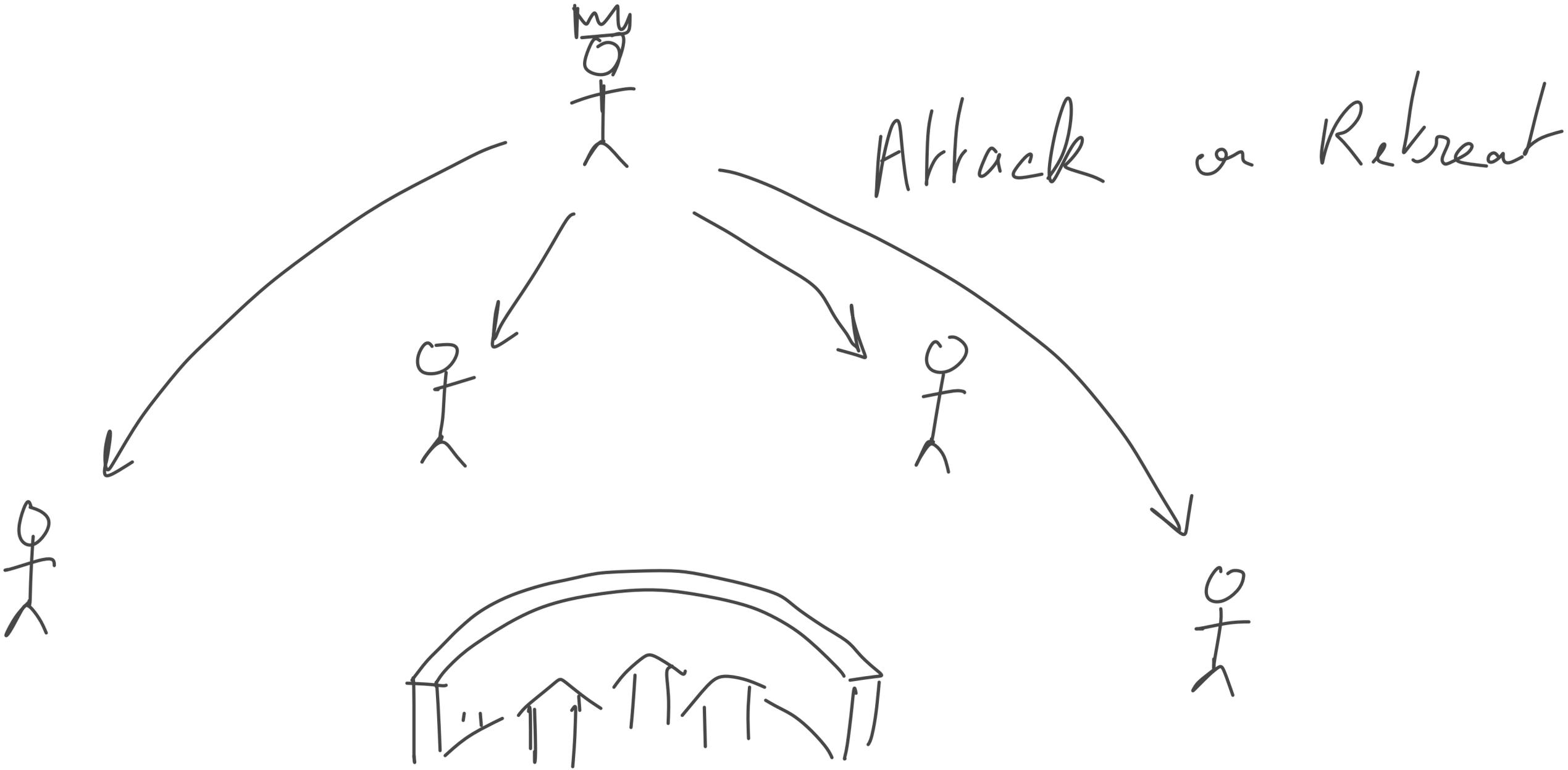
Agreement



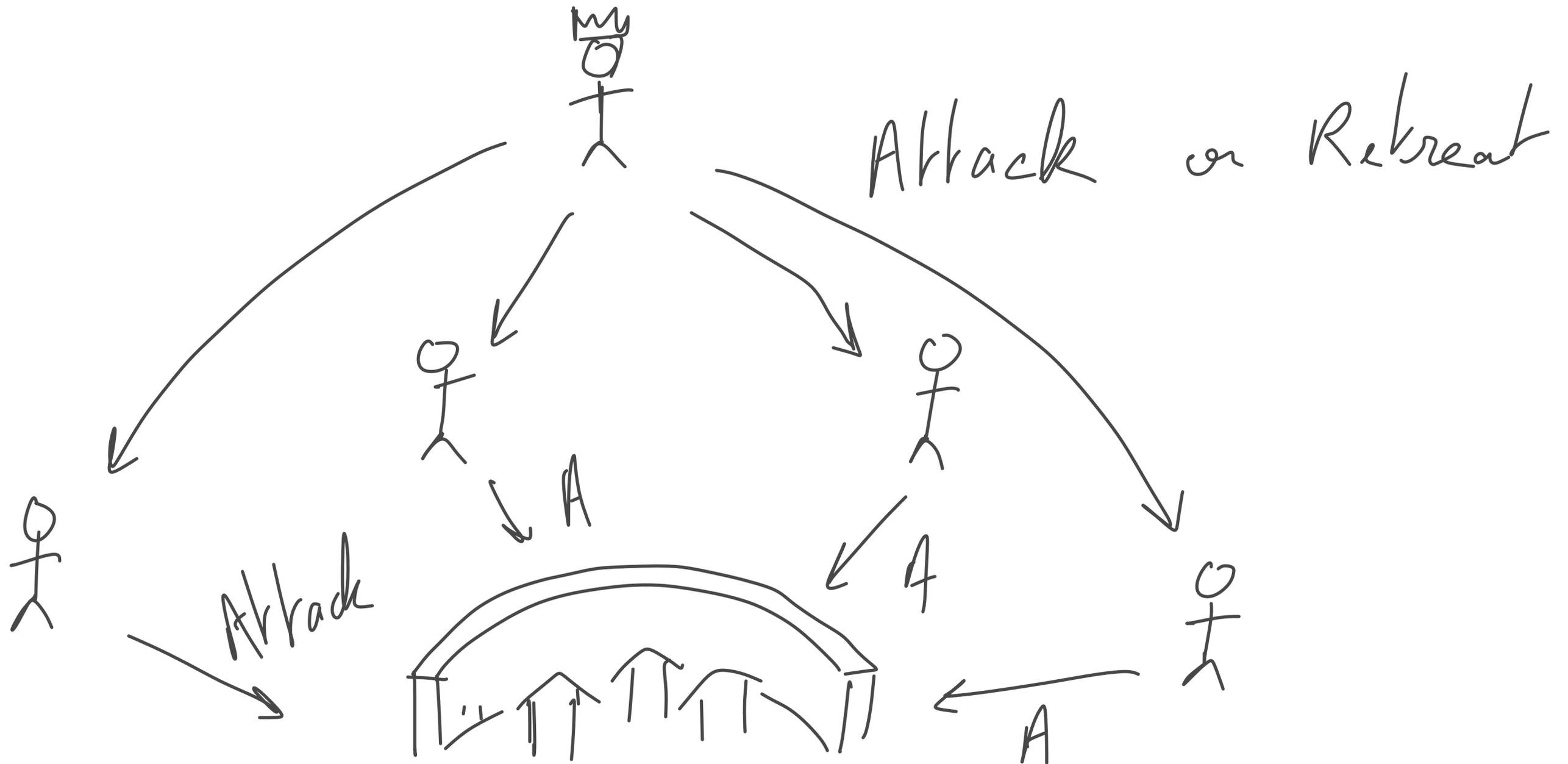
Byzantin general



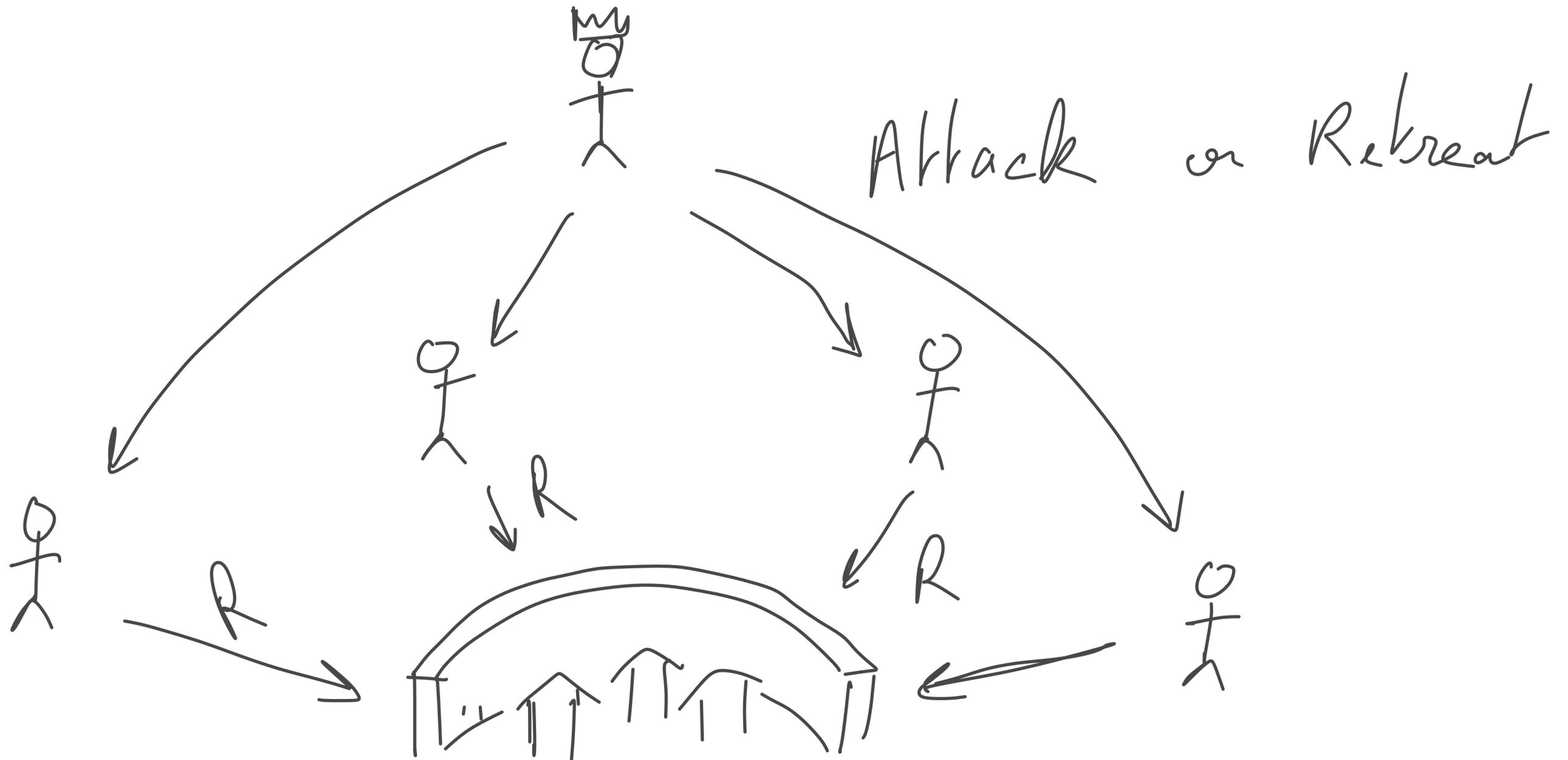
Byzantin general



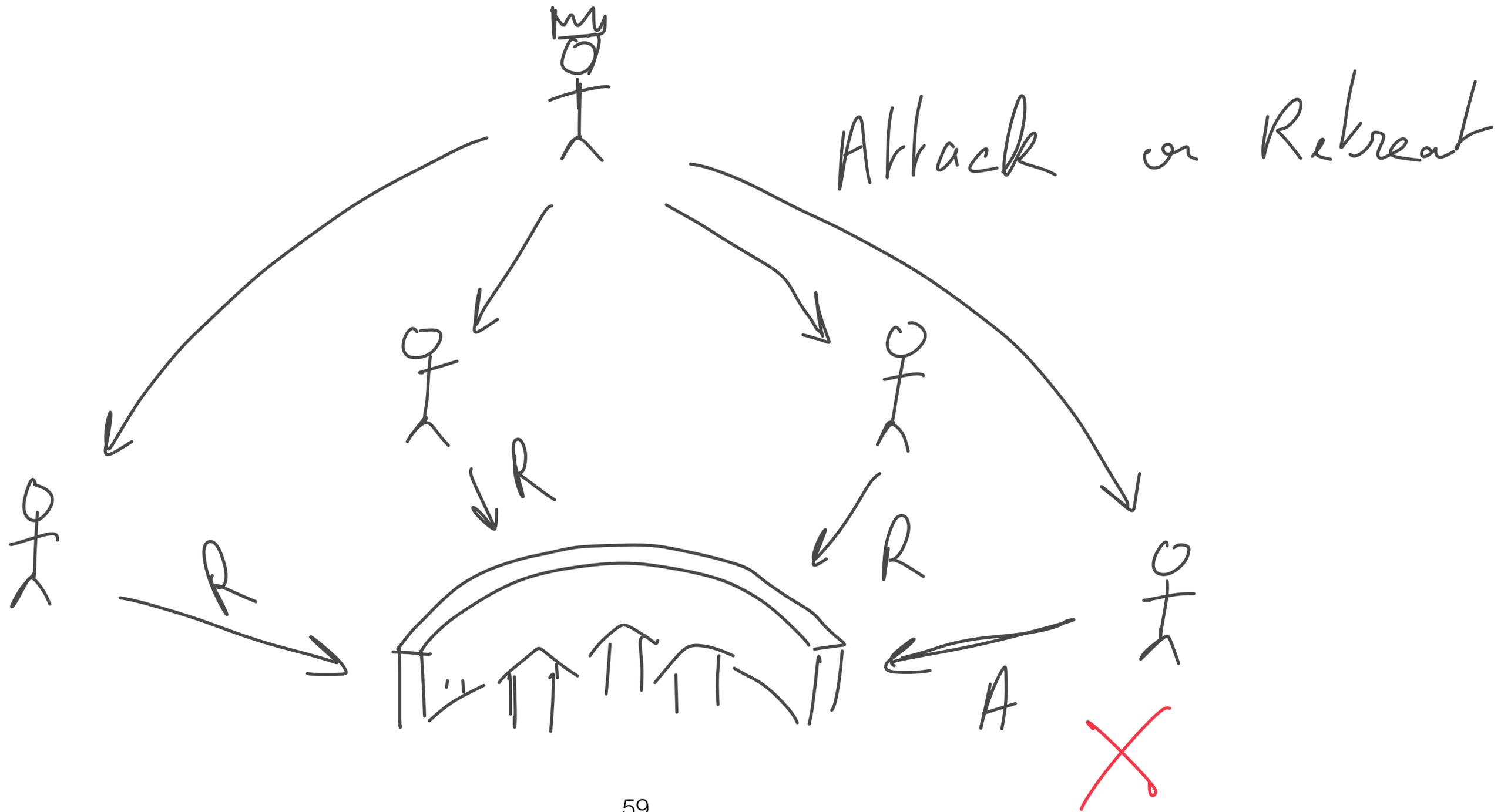
Byzantin general



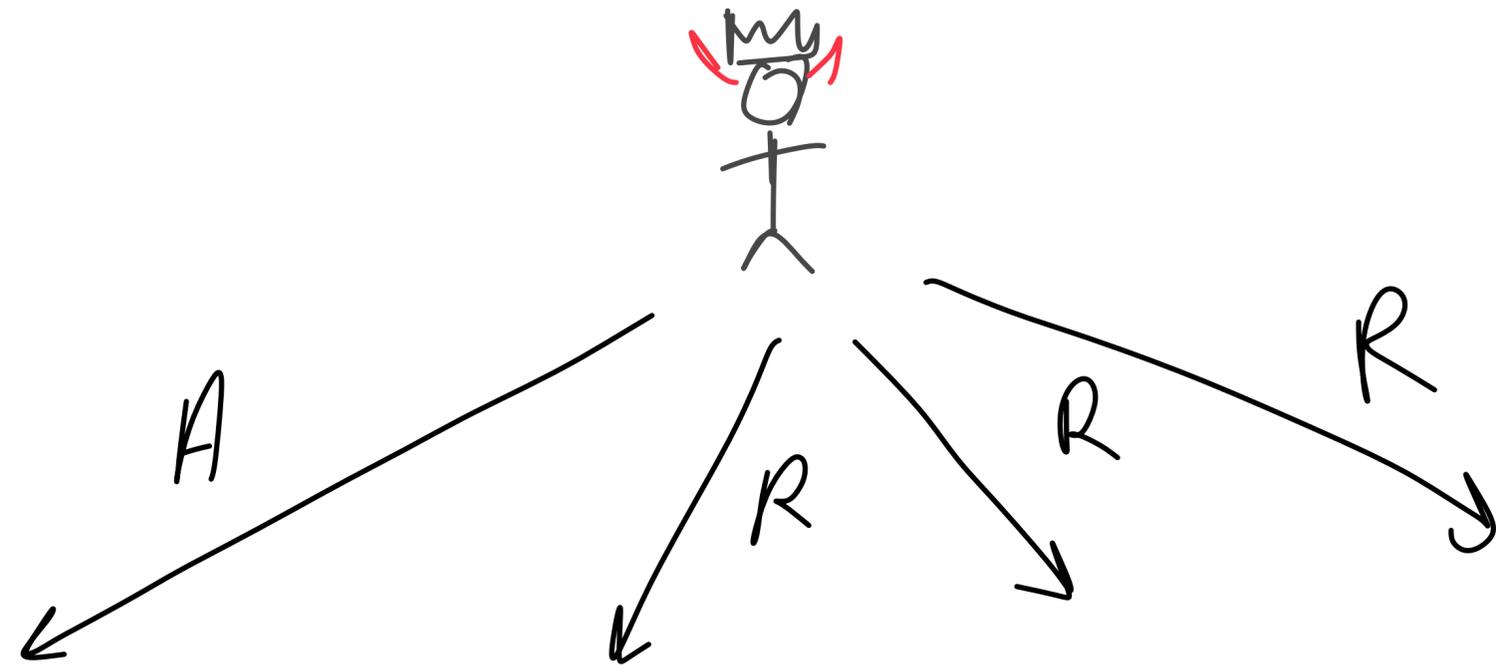
Byzantin general



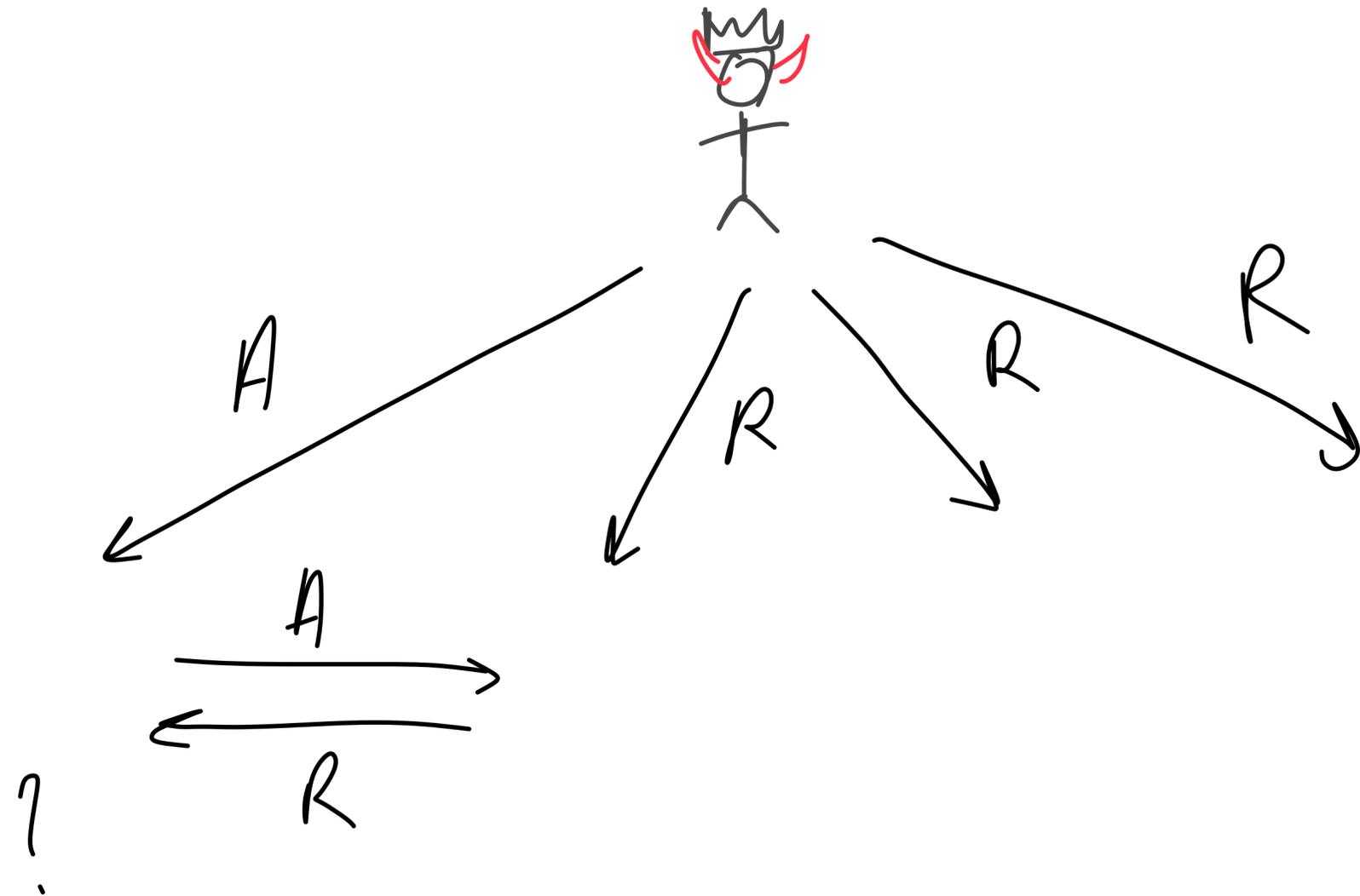
Byzantin general



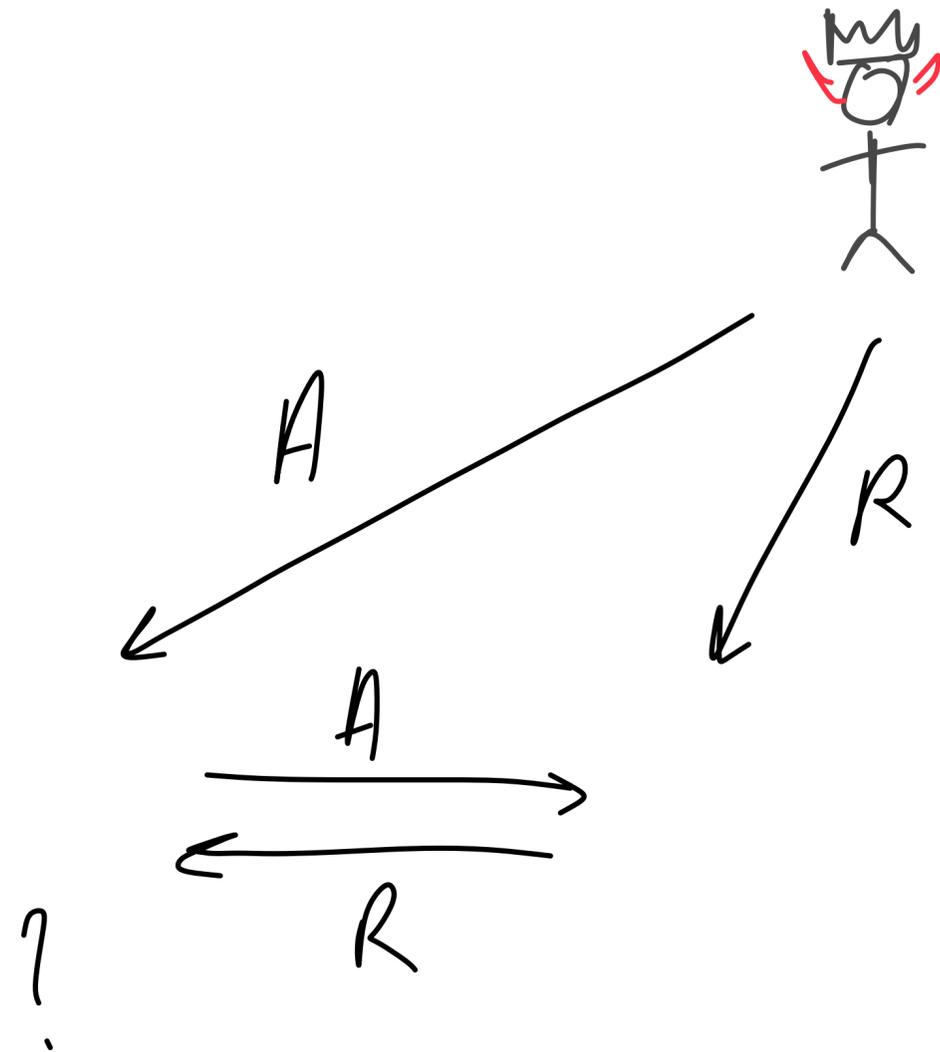
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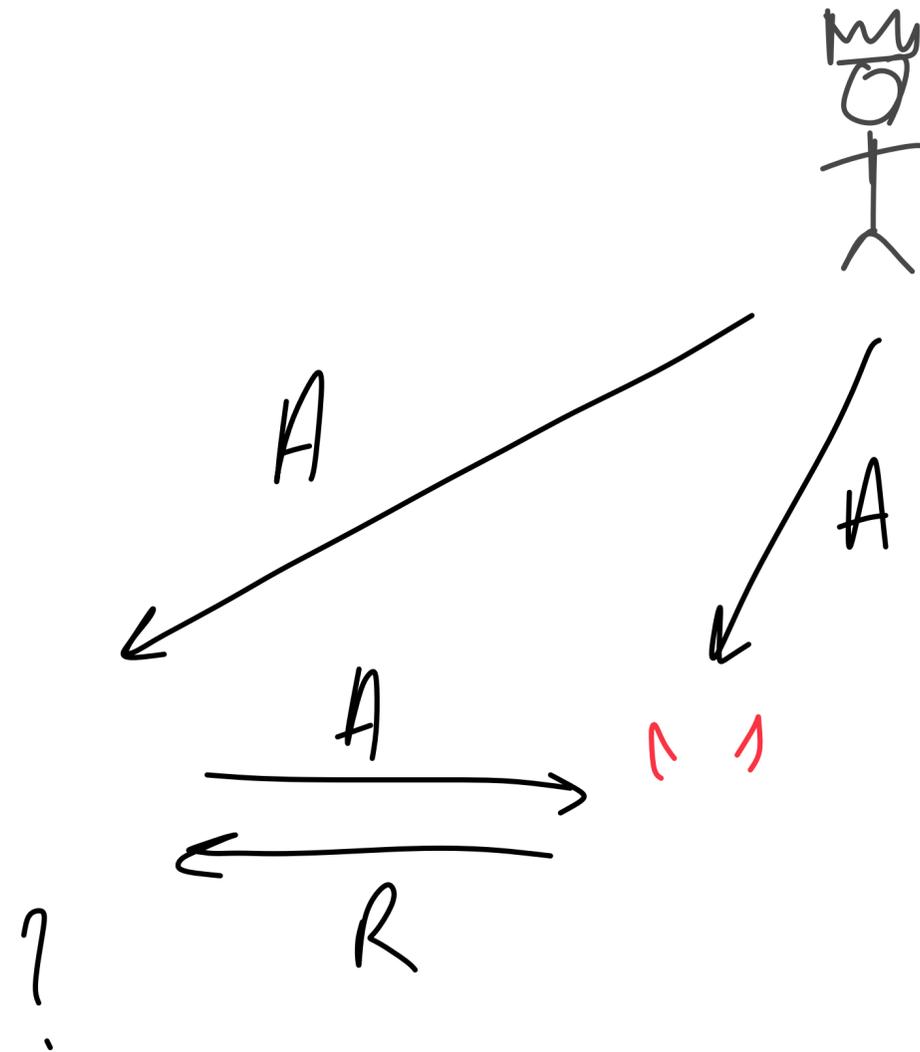
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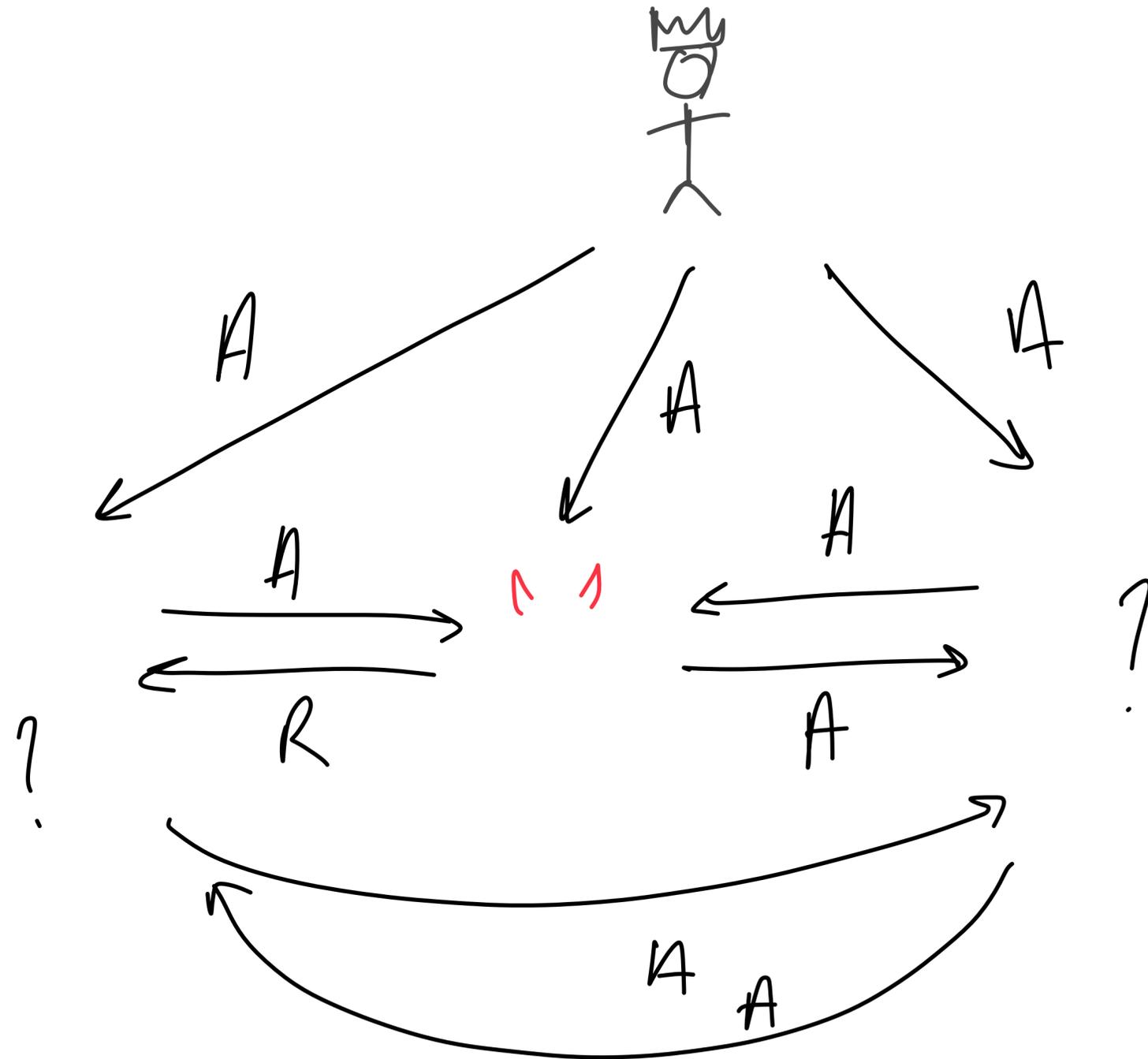
Byzantin general



Byzantin general



Byzantin general



Conclusion

- Computer science: many theoretical problems, interesting for students with a mathematical background
- Distributed system problems appear everywhere