

Distributed Algorithms 2025

5

CONGEST model:
Bandwidth limitations

LOCAL model

=

port-numbering model
+ unique identifiers

Nodes have distinct labels from $\{1, 2, \dots, \text{poly}(n)\}$

CONGEST model
=
LOCAL model
+ bandwidth limitation

Messages at most $O(\log n)$ bits

LOCAL · unbounded messages

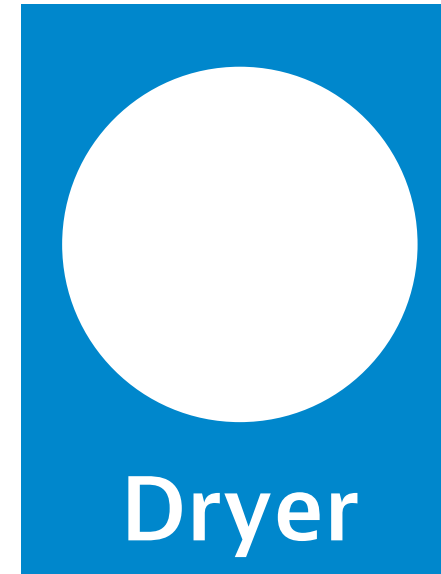
- everything trivial to solve in $O(\text{diameter})$ rounds: gather full input and solve locally

CONGEST · bounded messages

- gathering everything is way too expensive
- $O(\text{diameter})$ and $O(n)$ is nontrivial

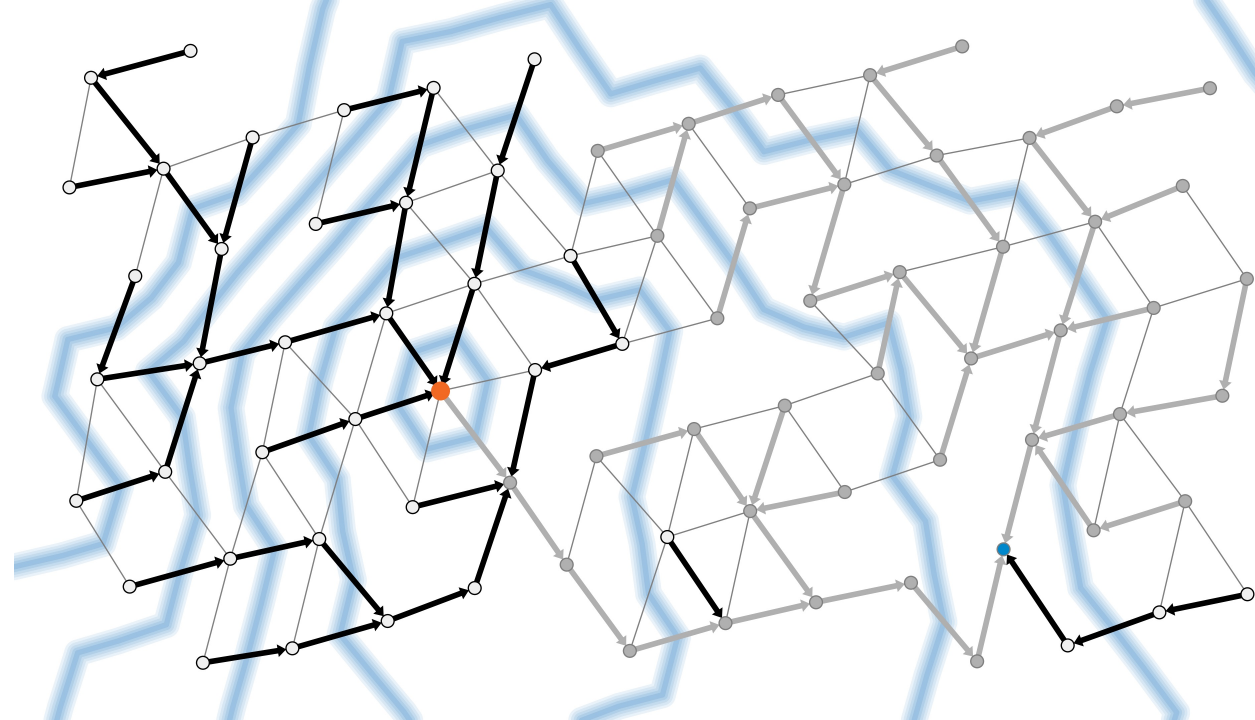
Designing efficient algorithms in CONGEST model

Pipelining



Pipelining

- Multiple operations in progress *simultaneously*
- Using *different resources*
- In APSP algorithm:
 - multiple waves
 - using different communication links



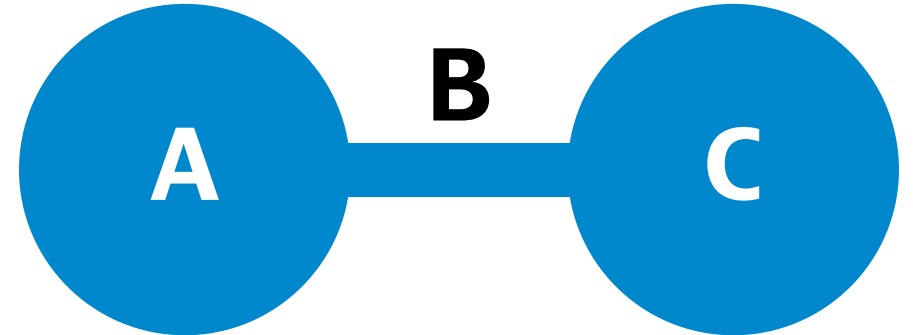
Pipelining

- *Does not reduce the total number of messages*
 - only removes idle periods between messages
- If all communication links are already sending useful data every round, no room for pipelining

**What kind of
problems cannot
be solved fast in
CONGEST model?**

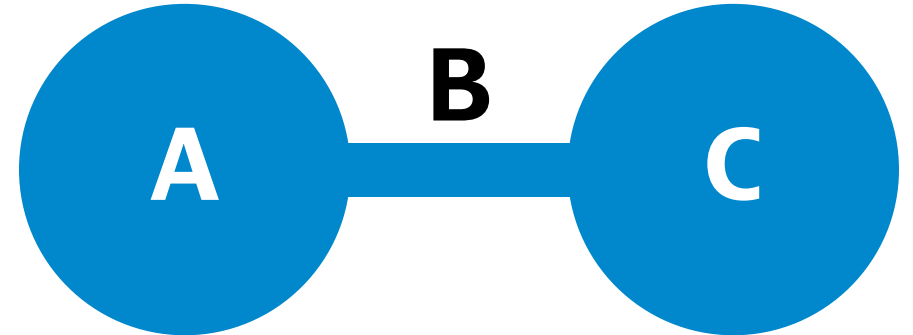
Typical hard problems

- **A:** complicated, lots of information
- **B: bottleneck**
 - can only send small number of bits per round from A to C
- **C:** need to know A



Proving hardness

- Counting argument
- *Many* possible inputs in A
- *Few* possible messages across bottleneck B



Proving hardness

- Counting argument
- *Many* possible inputs in A
- *Few* possible messages across bottleneck B
- Contradiction:
 - *different* inputs in A
 - *same* messages across B
 - *same* output in C

