CONGEST model: Bandwidth limitations
LOCAL model = port-numbering model + unique identifiers

Nodes have distinct labels from \{1, 2, \ldots, \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

Washing machine

Dryer
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

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• Contradiction:
  • different inputs in A
  • same messages across B
  • same output in C