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

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

• 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