

Distributed Algorithms 2025

12 Conclusions

Recap:

**Key ideas from
previous weeks**

Models of computing

- **PN**
- **LOCAL** — unique identifiers
- **CONGEST** — bandwidth constraints
- Deterministic and **randomized** algorithms

Canonical problems

- **Vertex coloring**
 - coloring = schedule
 - coloring breaks symmetry
- Used to solve many other problems
- Used to show that other problems are hard
- Demonstrates different algorithm design ideas and lower-bound techniques

Algorithm ideas

- **Conflict avoidance & coordination**
- Process nodes by color classes
- Send proposals one by one
- Random subset of nodes is active
- Pipelining
- Algebraic techniques

Lower bound proofs

- Covering maps — PN model
- Local neighborhoods — any model
- Round elimination
- Simulation arguments
- **Reductions**

Key lessons learned

New kinds of challenges

- **Unknown systems**
 - algorithms that work in any network
- **Partial information**
 - making decisions based on local information
- **Parallelism**
 - many nodes act simultaneously

**What else
is there?**

Networks vs. big data

- **Models for computer networks**

- PN, LOCAL, CONGEST

- **Models for big data systems**

- congested clique
- BSP (bulk-synchronous parallel)
- MPC (massively parallel computation)
- k -machine model

Asynchrony & failures

- **Asynchronous networks**
 - no failures → can use synchronizers
- **Tolerating failures**
 - crash faults, Byzantine faults ...
- **Recovery from failures**
 - self-stabilization

And a lot more...

- **Different kinds of models**

- shared memory — message passing
- physical models (e.g. radio networks, *quantum*)
- mobile agents (e.g. robot navigation, exploration)
- security and privacy

- **Different kinds of questions**

- solving — proving — verifying — fixing
- #rounds — #messages — #bits

Our current research

- Is quantum-LOCAL any stronger than LOCAL?
- Locality in different settings:
 - online algorithms
 - dynamic algorithms
 - probability distributions
 - volume vs. distance
- Massively parallel matrix multiplication

What next?

Exercises this week

- **Exercises 12.1–12.4:** small research project
 - *what are possible distributed complexities?*
 - LOCAL model
 - locally verifiable problems
 - cycles
- **Exercise 12.5:** an example of an open research question

Exam next week

- Setup and rules exactly like the first exam
- Allowed: one A4-sized 2-sided **cheat sheet**
 - no other material or equipment
- Focus: proving impossibility results

Course feedback

- **1 extra point** for everyone who provides feedback in the official Aalto course feedback system (in MyCourses)

After this course

- Ask us if you are interested in doing more:
 - thesis topics
 - research projects
 - summer jobs
 - doctoral studies ...