Aalto University

Distributed Algorithms 2025

1

Warm-up

Algorithms for networks

How can individual nodes in a large computer network work together towards a common goal?

Learning objectives

- Understand models of distributed computing
- Design and analyze efficient distributed algorithms
- Prove impossibility results
- Use standard graph-theoretic concepts

Practiced in exercises

Tested in exams

Zero to research-level

- No prior knowledge on distributed systems expected
- We will reach topics close to current research by the end of the course

Good start for a Master’s thesis or PhD studies

This is a theory course

- **100% mathematics**
  - definitions
  - theorems
  - proofs …
- **0% practice**
  - programming
  - hardware
  - protocols …

Expected: basic knowledge of university-level mathematics

Example: what is a mathematical proof

Preparation

- You should have already done this:
  - register in **Sisu**
  - read instructions in **MyCourses**
  - join our **Zulip workspace**
  - watch two **pre-recorded videos**
  - solve this week's **quiz**

This week: extra time to solve the quiz until midnight tomorrow!

Our weekly routine

- **Mon:** videos, quiz, lecture (10:15pm)
- **Wed:** 1 exercise (midnight)
- **Thu:** exercise session (10:15am)
- **Fri:** 2 exercises (midnight)

Workload:
10–11 h/week

Quiz

- One quiz per week, in **MyCourses**
- Solve before the lecture
- Automatically graded
  - 2 points for correct answer
  - 0.5-point penalty per wrong answer

Exercises

- 5+ exercises per week, in the **textbook**
- Solve 1 by ***Wednesday***, 2 more by ***Friday***
- Submit your answers in **MyCourses**
- ***The answers need to be complete***
  - full details, complete proofs
  - e.g. why does your algorithm work correctly?
  - ask if unclear!

Challenging exercises

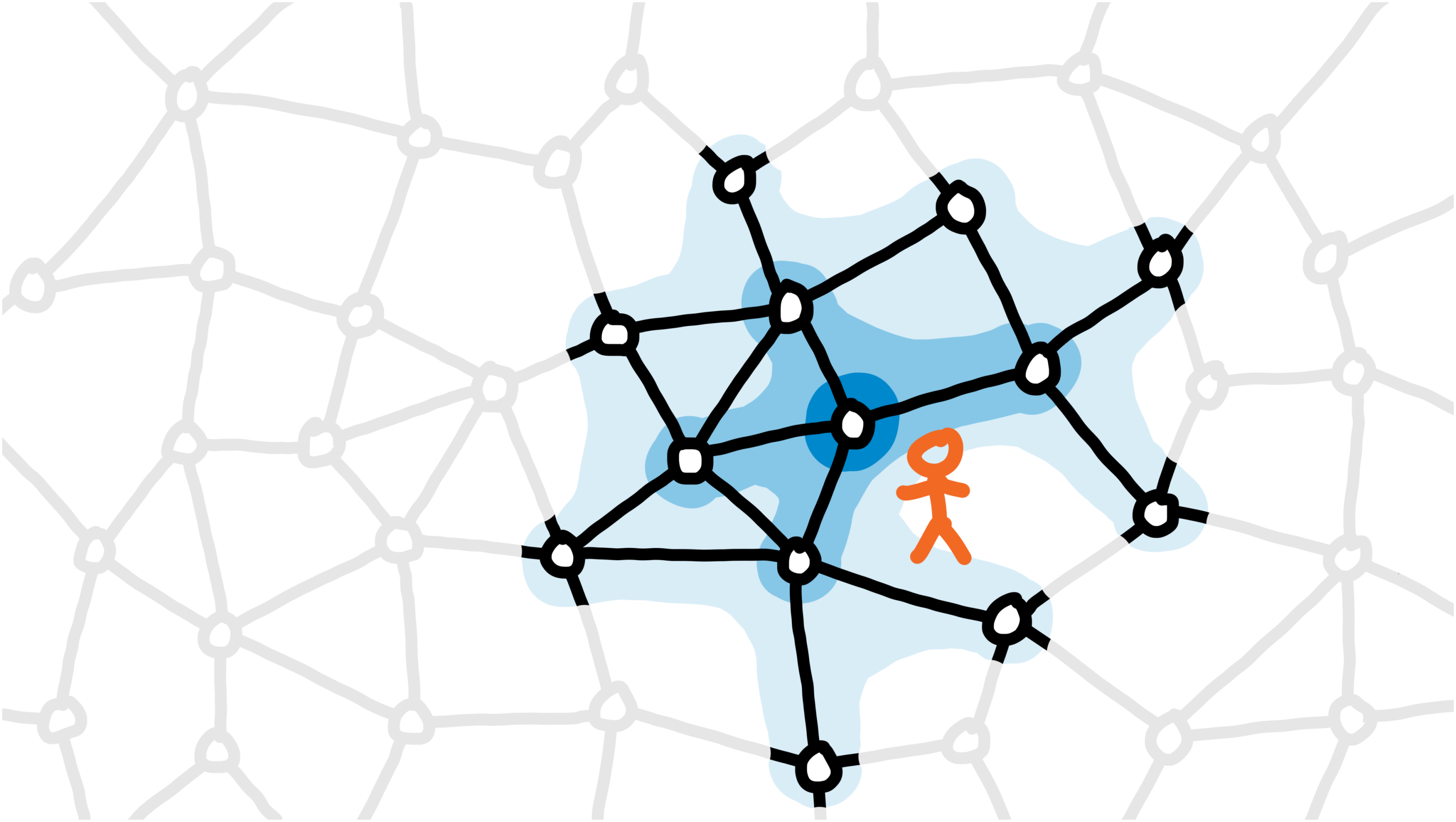
- In the textbook, marked with a star ★
- Solve ***at any point*** during the course
- ***Again, the answers need to be complete***

Grading

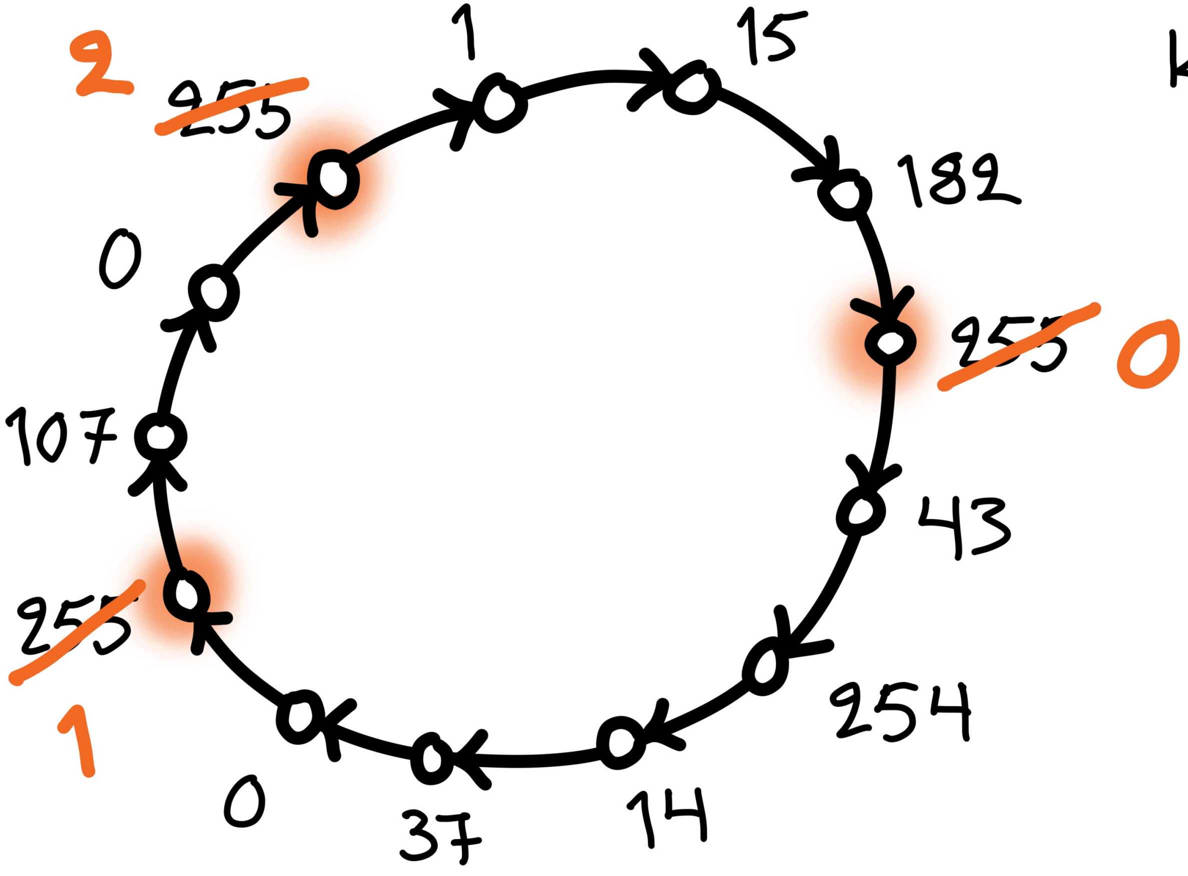
- **To pass the course:**
  - you need to pass both ***exams***
- **For a good grade:**
  - you need to ***solve exercises***
  - quiz + exercises = max 96 points in total
  - 80 points = grade 5/5

This week's content...

Video 1a: introduction



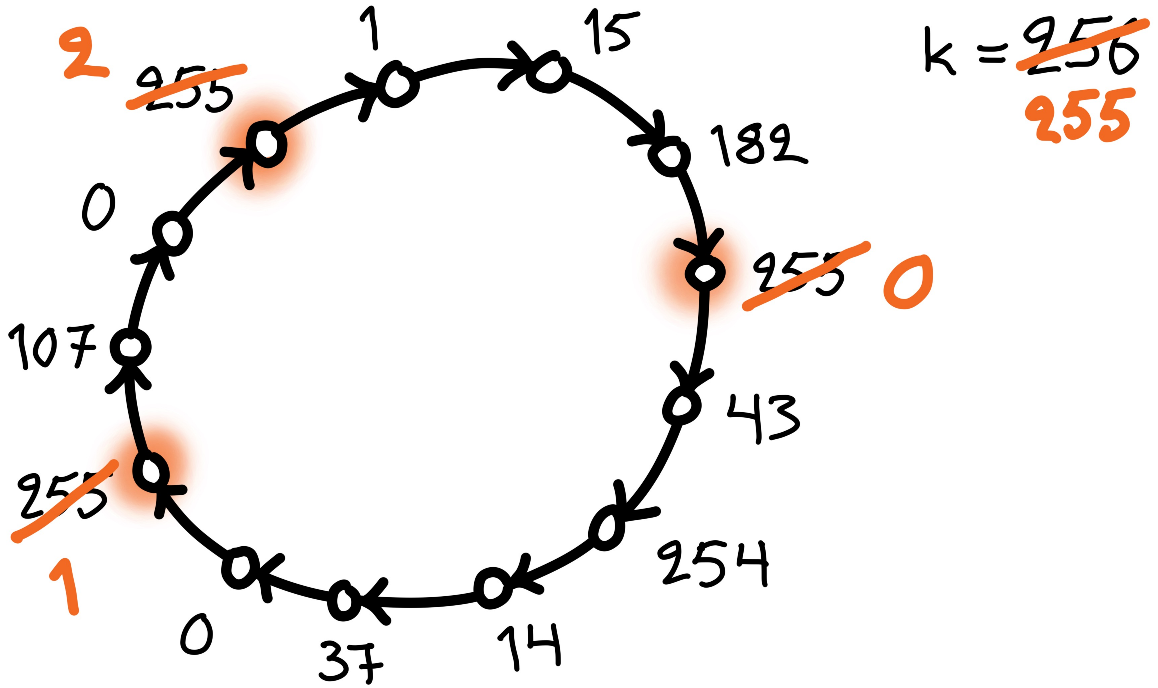
Video 1b: coloring



k = ~~256~~ 255

Slow color reduction

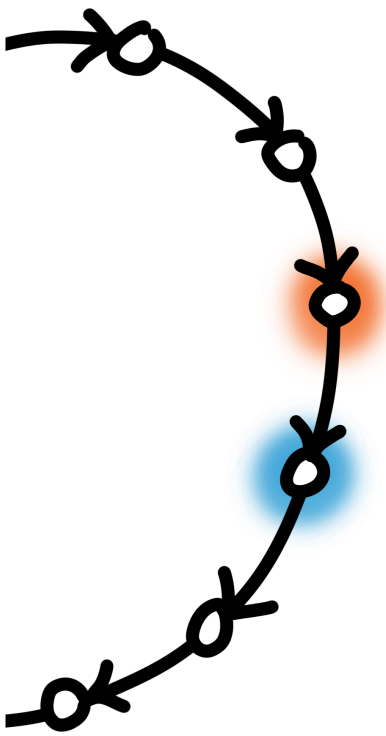
- Algorithm idea:
  - all nodes with the **largest color** are active
  - active nodes pick the ***smallest color that is not used by their neighbors***



Puzzle 1

- Consider a simpler algorithm idea:
    - ***all nodes*** pick the smallest color that is not used by their neighbors
- **What would go wrong?**
    - *construct an example in which this algorithm fails!*

Video 1b: coloring fast



$$\underset{0\text{-}7}{2},\ \underset{0\text{-}1}{0}$$

$$(2, 0) = \underbrace{010}_{3\text{ bits}}\underbrace{0}_{1\text{ bit}}$$

~~123~~ = 01111011

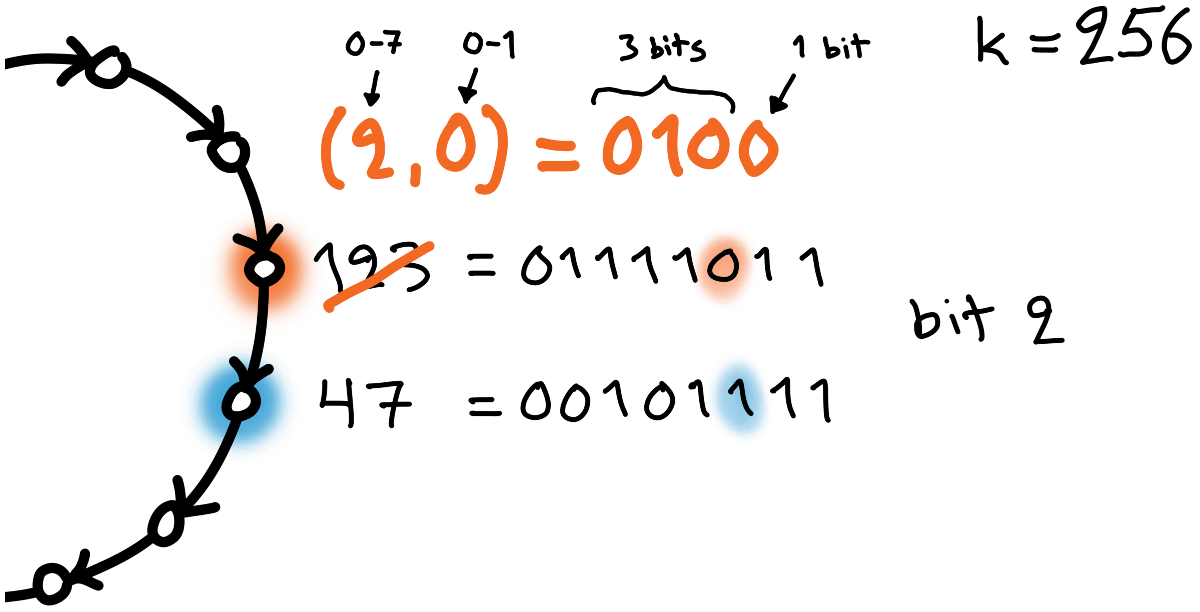
47 = 00101111

k = 256

bit 2

Fast color reduction

- Algorithm idea:
  - find the first bit that differs in successor
  - index ***i***, bit value ***b***
  - new color is (***i***, ***b***)



Puzzle 2

- Algorithm idea:
  - find the first bit that differs in successor
  - index ***i***, bit value ***b***
  - new color is (***i***, ***b***)
- **What would go wrong if the new color was just *b*?**
  - *construct an example in which it fails!*

Puzzle 3

- Algorithm idea:
  - find the first bit that differs in successor
  - index ***i***, bit value ***b***
  - new color is (***i***, ***b***)
- **What would go wrong if the new color was just *i*?**
  - *construct an example in which it fails!*

Puzzle 4

- Algorithm idea:
  - find the first bit that differs in successor
  - index ***i***, bit value ***b***
  - new color is (***i***, ***b***)
- **Why does the algorithm work correctly?**
  - *why is my new color always different from the new colors of my successor and my predecessor?*

Coming next

- **Week 2:** graph theory
- **Weeks 3–6:** models of distributed computing
  - examples of efficient distributed algorithms
- **Weeks 7–11:** proving impossibility results
- **Week 12:** conclusions, recap