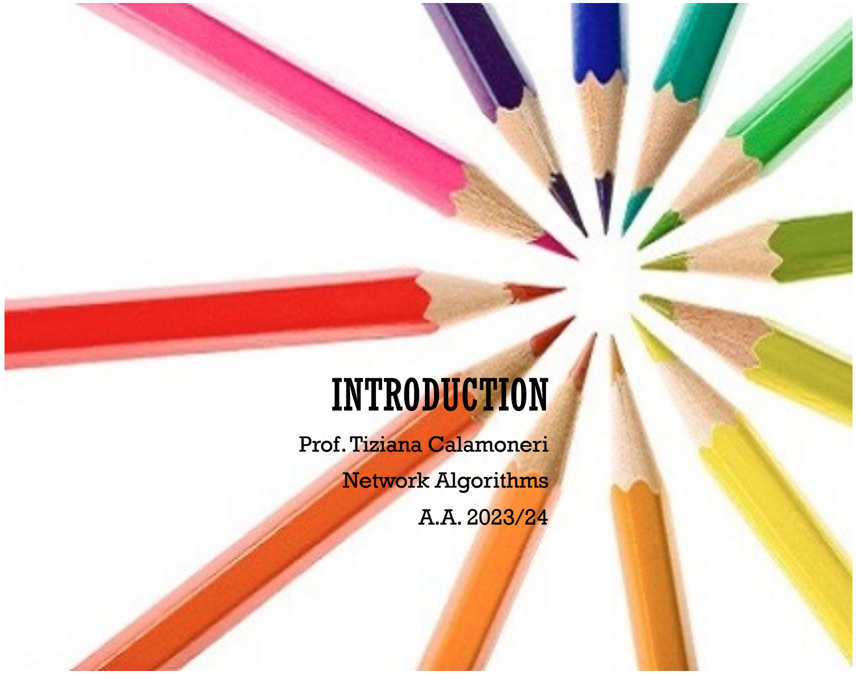
NETWORK ALGORITHMS WELCOME!!

A.A. 2023/24



INTRODUCTION

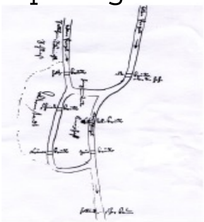
Prof. Tiziana Calamoneri

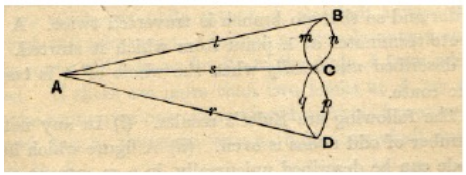
Network Algorithms

A.A. 2023/24

THE STARTING POINT (1)

- It is usual to position the birthdate of the modern *graph theory* in 1736, when Euler formulated his Königsberg bridge problem.
- Euler solved this problem proving, in a constructive fashion, a characterization of Eulerian graphs. This is considered the first graph algorithm solving a "real life" problem.

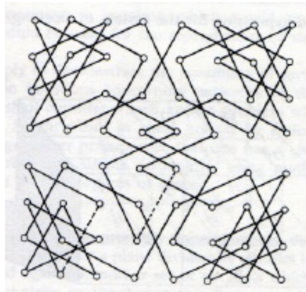




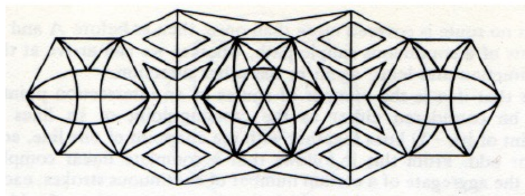
THE STARTING POINT (2)

Since then, graph algorithms have been used to solve many problems in several applicative fields:

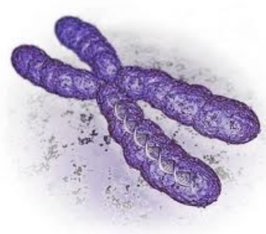
- games and puzzles:



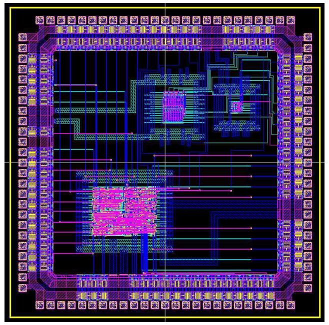
- topology:



- biology:

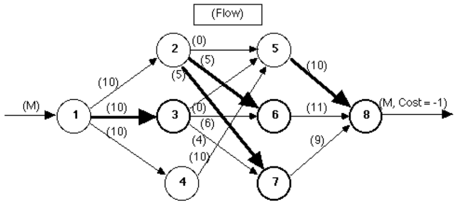


THE STARTING POINT (3)



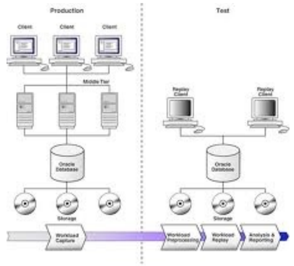
Specifically, in computer science:

- Electronic engineering:
- Operative research:



THE STARTING POINT (4)

- Artificial intelligence:
- Data bases:



- Communication:

THE STARTING POINT (5)

- Networks:

This course will be focused on:

- Cable networks
- Wireless networks
  - Fixed
  - Mobile (sensor)

THE STARTING POINT (6)

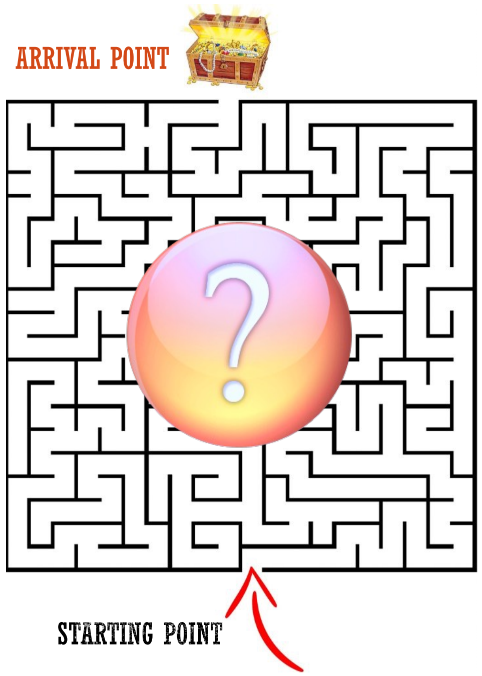
- All over the world, courses of Network Algorithms are thought.
- Almost all of them have a theoretical approach:

(in the last years)

- Princeton Univ. (Robert Tarjan) http://www.cs.princeton.edu/courses/archive/spr11/cos423/
- Stanford Univ. (Balaji Prabhakar) http://web.stanford.edu/class/ee384m/
- Cornell Univ. (David Easley & Eva Tardos) https://courses.cit.cornell.edu/cs2850_2016fa/
- Universiteit Utrecht (Hans Bodlaender) http://www.cs.uu.nl/docs/vakken/na/
- Tel Aviv Univ.(Noga Alon & Amos Fiat) http://tau-algorithms.wikidot.com/course-schedule
- Uni Freiburg (Fabian Kuhn) http://ac.informatik.uni-freiburg.de/teaching/ss_16/network-algorithms.php
- ...

THE ARRIVAL POINT

- Aim: to convince you that graph algorithms are not old-fashioned, though dated; instead, they are useful instruments to solve important and living problems.
- We will see a number of advanced techniques for efficient algorithm design to solve problems from networks and graphs. In many network applications, graphs are used as a natural model. In other applications, the graph model may be less obvious, but appears to be anyway very useful.
- We will study how network problems are transformed exploiting a graph model; moreover, we will look into algorithmic problems and their solutions on networks and graphs.



WHICH ROUTE? (1)

Several topics will be dealt with, all in the (more or less) same way:

- Definition of the network problem
- Model as (classical) graph problem
- Known solutions for the graph problem
- Other possible approaches based on the properties of the considered networks

Some classical topics

Some research topics (suitable for theses and new results)

WHICH ROUTE? (2)

- The first topics will be more classical, and they will exploit some things you studied in the past, in order to start in an "easy" way; then the topics will become less and less standard…
- Why (my) research topics? three reasons:
  - Passion for these topics
  - International context
  - Chance to approach research topics in the algorithm field and produce new and interesting results (e.g. during your master thesis period…)

WHICH ROUTE? (3)

Topics surely dealt with in this course (1):

- Cable networks:
  - The routing problem
    i.e.
    The minimum cost path problem
  - The interconnection topology layout problem
    i.e.
    The orthogonal grid drawing
  - The problem of minimizing boolean circuits
    i.e.
    The minimum set cover problem
  - The problem of infecting a network with a worm
    i.e.
    The minimum vertex cover problem

WHICH ROUTE? (4)

Topics surely dealt with in this course (2):

- Wireless ad hoc networks:
  - The frequency assignment problem
    i.e.
    A vertex coloring problem
  - The minimum energy broadcast problem
    i.e.
    The minimum spanning tree problem
  - The data mule scheduling problem
    i.e.
    The travelling salesman problem

WHICH ROUTE? (5)

Topics surely dealt with in this course (3):

- Mobile sensor networks:
  - The centralized deployment problem
    i.e.
    The minimum cost perfect matching problem on bipartite graphs
  - The self-deployment problem
    i.e.
    The Voronoi diagram construction problem
  - The Data collection problem
    i.e.
    The connected dominating set problem
  - Monitoring by UAVs
    i.e.
    The multiple TSP with constraints (more or less)

WHICH ROUTE? (6)

Topics surely dealt with in this course (4):

- Some topics suitable for a master thesis…

WHICH ROUTE? (7)

Books:

- Many topics of the course deal with recent research, so:

  few books and many papers
- In the web page of the course

  http://twiki.di.uniroma1.it/twiki/view/Algoreti/WebHome1011

  list of papers to be read.
- Attending lessons is particularly important!

  Even because...

EXAM PROCEDURE

- Only oral exam
- Possibility of a mid term exam (on a flexible first part)
- One (short!) lesson will be held by each student
- This has a twofold aim: on the one hand it gets close students to research; on the other hand it is a good exercise to learn to extract the main ideas from a paper.
- This lesson will exonerate students by a part of the oral exam and is compulsory (mod the # of attendees).

RELATION WITH OTHER COURSES

No previous exams are required to attend this course, nevertheless A DEEP FAMILIARITY WITH ALGORITHMS AND DATA STRUCTURES IS NECESSARY.

AT THE END OF THIS COURSE...

I would be happy to have your comments, especially about possible improvements.

Namely:

- What to deep in,
- What to skip,
- What to add,
- Any other suggestion...

WHICH OTHER COURSES TO ATTEND? (1)

Starting from the 2023/2024 academic year, the teaching proposal is organised in such a way that all lectures can be chosen and taken in both the first and second year; each class is associated only with a semester in which the courses are delivered.

WHICH OTHER COURSES TO ATTEND? (2)

The courses are divided into four groups, which are given the names of

- Ada Lovelace
- Charles Babbage
- Joan Clarks
- Alan Turing

first semester (Ada Lovelace, Charles Babbage)

second semester (Joan Clarks, Alan Turing)

Lectures in each group are organised in a timetable without overlapping.

WHICH OTHER COURSES TO ATTEND? (3)

A. Lovelace & C. Babbage
first semester

J. Clarks & A. Turing
second semester

To attend other classes without any overlapping timetable, it is sufficient to participate in the lectures in the same group during each semester (choose between A. Lovelace and C. Babbage in the first semester and between J. Clarks and A. Turing in the second semester)

The lectures relating to the courses in the remaining groups can be attended during the second year.

WHICH OTHER COURSES TO ATTEND? (4)

Why this organization?

When courses where divided into first and second year, most of the students attended (and passed the exams) of as many courses as possible during the first year, to have more time for the master thesis in the second year.

In this way, they missed many interesting courses at the second year!

We hope that, in this way, you have more choice!

WHICH OTHER COURSES TO ATTEND? (5)

A. Lovelace & C. Babbage
first semester

This course is in the Ada Lovelace Group with:

- Autonomous Networking
- Biometric Systems
- Blockchain and Distributed Ledger Technology
- Computational Complexity
- Computer Network Performance
- Cryptography
- Distributed Systems
- Security in Software Applications