# NETWORK ALGORITHMS WELCOME!!

A.A. 2021/22

Blended Teaching

## INTRODUCTION

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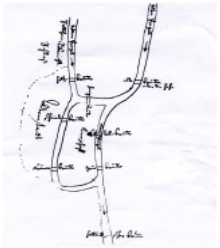
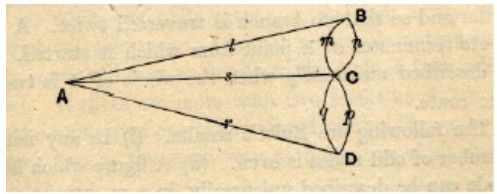
Network Algorithms

A.A. 2021/22

## THE STARTING POINT (1)

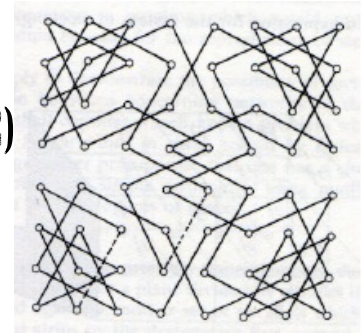
- It is usual to position the birthdate of the modern *graph theory* in 1736, when Euler formulated his Königsberg bridge problem.
- Euler solved this problem proving, in a constructive fashion, a characterization of Eulerian graphs. This is considered the first graph algorithm solving a "real life"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





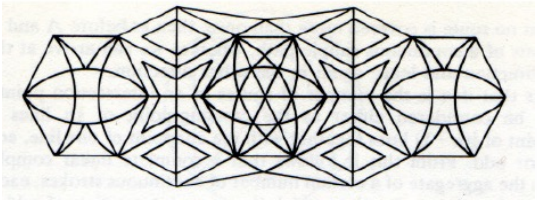



## THE STARTING POINT (2)

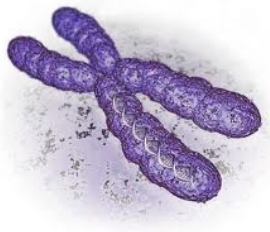


Since then, graph algorithms have been used to solve many problems in several applicative fields:

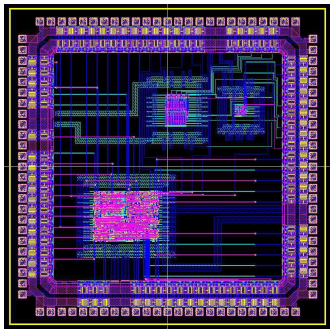
- games and puzzles:
- topology:



- biology:



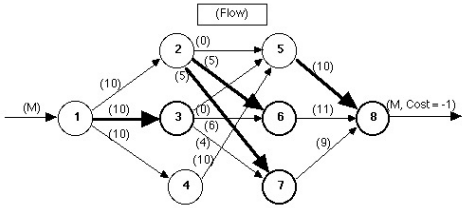
# THE STARTING POINT (3)



Specifically, in computer science:

- Electronic engineering:

- Operative research:

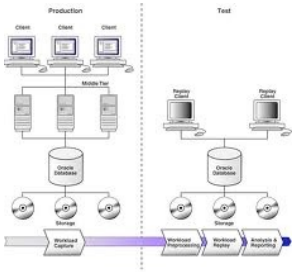





# THE STARTING POINT (4)

- 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

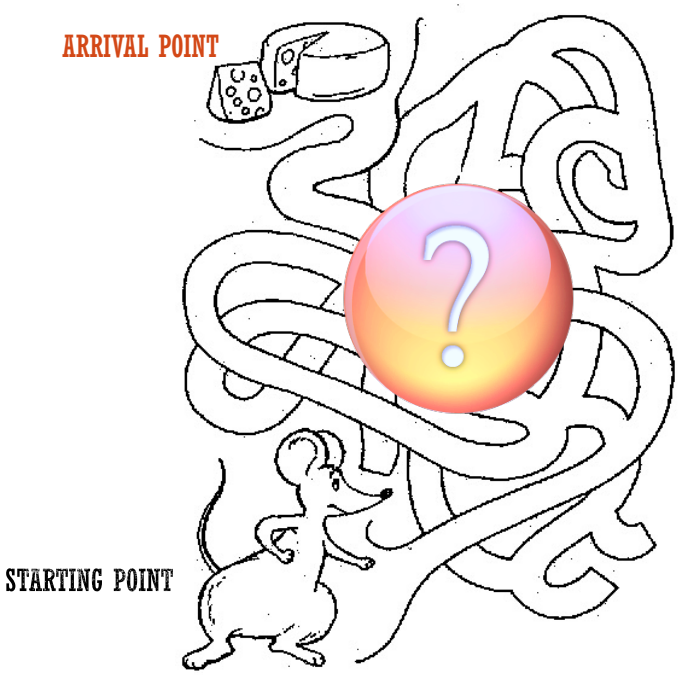
- Aim:

  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
  - 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

- This course is a second year one…
- 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…