Graph Theory in High School Education

Week of Doctoral Students
3. 6. 2011

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Outline

- Introduction
  - Aim of our research
  - Previous results
  - Reminder of graph theory
- Graph theory on high schools
  - Why?
  - Example: Topological sorting
  - Education targets
  - Further topics
- Summary

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Computer science

- How do we process information?
  - Obtain, create, transform, transmit, store...
  - Describe, measure, secure...
- How can a machine do it instead?
  - How can we describe what to do?
  - How can we compare algorithms?
  - Are there limitations?
- What *is* information?

Aim of our research

What about teaching computer science on high schools?

Computer science: situation

- CS has no direct support in curricula
- However, with a closer look...
  - Basic algorithmics
  - Key competences
  - Possible extensions
- Enough abroad experience available
  - Content
  - Methods
  - (Organisation)

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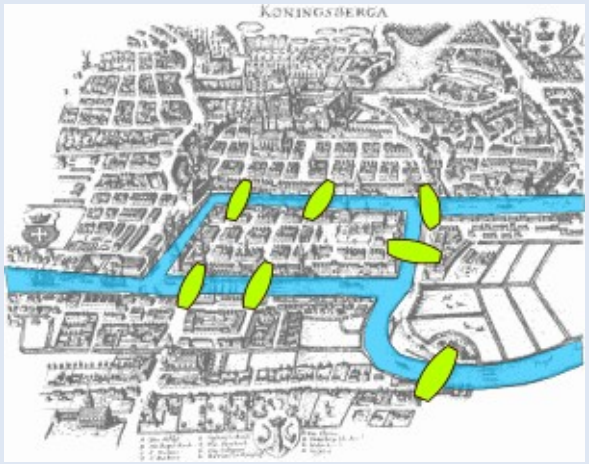
A specific example

Graph theory:

A visual approach to relations between objects.

(with some serious Maths behind)



Topics to study

- Terms:
  - Graph, vertice, edge, orientation, degree, score...
  - Cycle, path, colors, components, …
  - Complete g., tree, ...
- Representation, both ways
- Processing
  - Traversing, searching
  - Topological sorting
- Applications

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Graph theory: situation

- Not a part of high school education
  - Historical reasons?
  - Though used intuitively (chemistry, spatial objects, mind mapping...)
  - No idea of a unifying theory
- Breeze of change
  - Fraus text-books by prof. Hejný

Why should we teach graphs?

- Wide practical use
- New structure to work with (reasoning, algorithms)
  - Seemingly: different way of thinking
    (numbers and operations gone, logic stays)
  - Intuitive?
- Easy basics, though enough advanced material
  - Planarity
  - Isomorphism
- Insight into an algorithm causes more efficient future approaches

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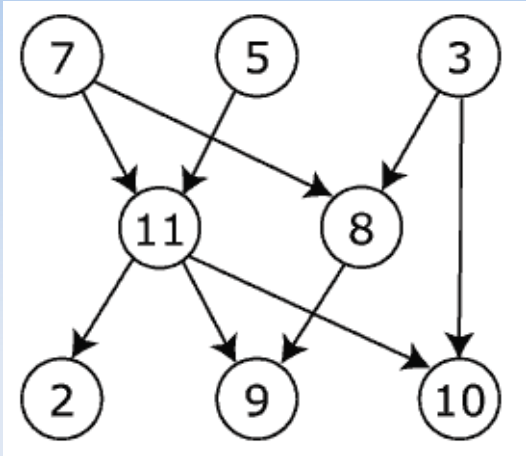
Topological sorting

- What?
- Why?
- How?



- Input:

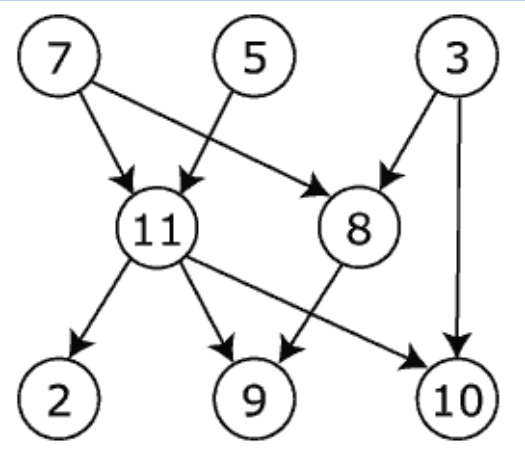
  (2, 11), (9, 8), (11, 5), (9,11), (8, 3), (10, 3), (11, 7), (10, 11)

- Output (e. g.):

  3, 7, 5, 11, 2, 8, 10, 9

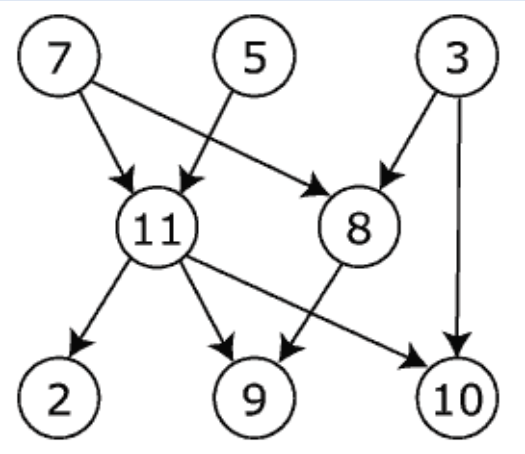
Topological sorting: solution

- Brute force
- Find independent tasks...
  - How exactly?
  - How to get prepared for it?
- Depth first search



Topological sorting: solution

- 2: 1, 3: 0, 5: 0, 7: 0, 8: 2, 9: 2, 10: 2, 11: 2
  - Choose 3
- 2: 1, 3: 0, 5: 0, 7: 0, 8: 1, 9: 2, 10: 1, 11: 2
  - Choose 7
- 2: 1, 3: 0, 5: 0, 7: 0, 8: 0, 9: 2, 10: 1, 11: 1
  - Choose 5
- (...)



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Teaching graphs: Targets

- Recognize appropriate situations to apply graphs
  - Read relations
  - Denote relations
  - Further processing
- Use terminology correctly
- Use the advantage of drawing, rely on reasoning
- Traverse systematically (e. g. searching)

TS: Ideas to experience

- Graphs are not maps only
- Many ways to achieve the same goal
  - Both the algorithm and its subject.
  - Different efficiency.
- Work in phases
  - Preprocess data
- Greedy approach (no turning back) may work well
  - Least wrong move?
  - Rather guarantee of correnctness
  - That is decomposition!

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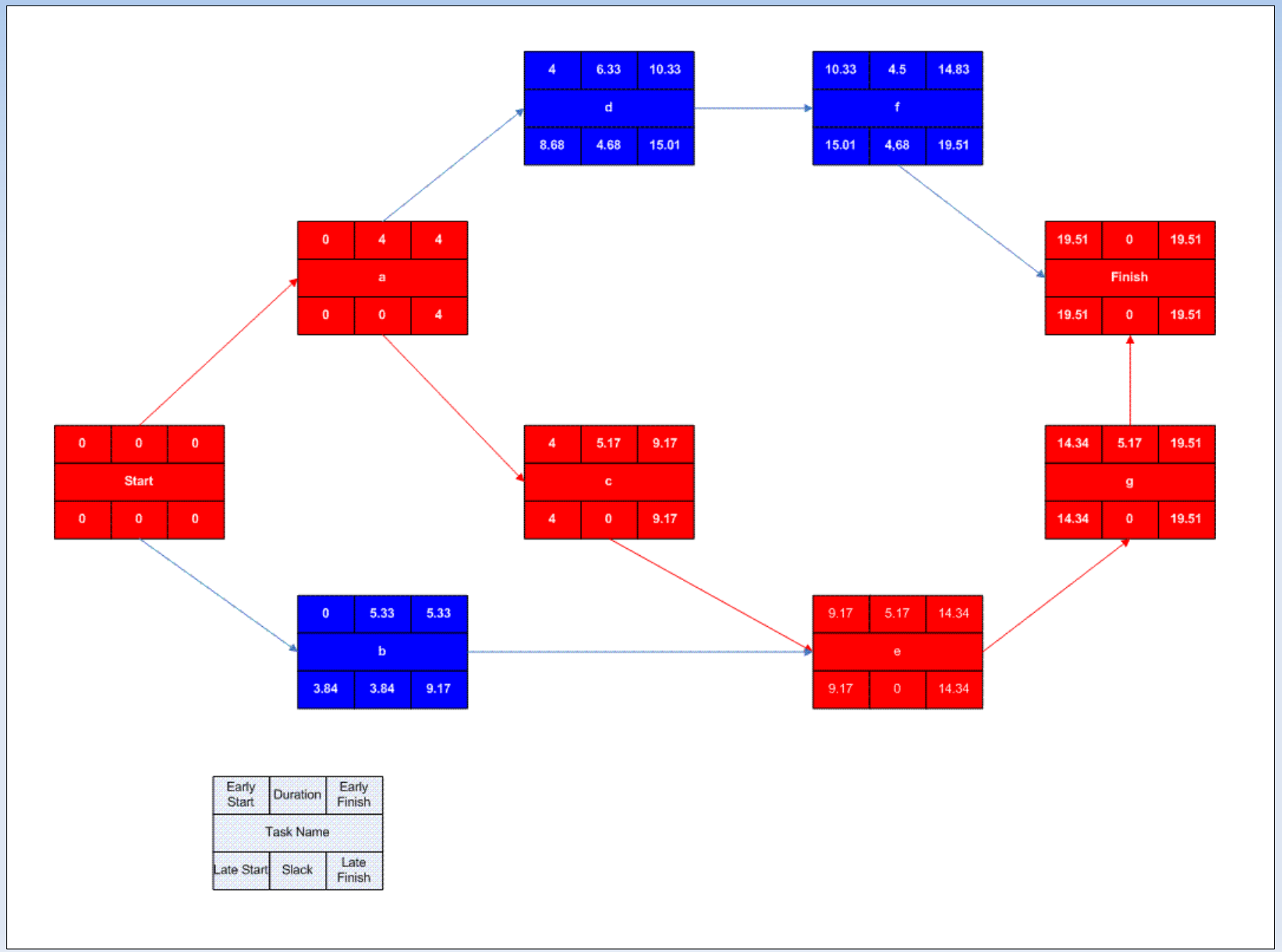
Further topics

- Planning, scheduling, project management
  - Network diagrammes
  - PERT, Critical Path Method
  - Hierarchical tasks, WBS
- Lattice and Hasse diagrams
  - Riddles

Advanced use



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Graphs on HS: Summary

- Widely used, yet not taught explicitly
- Provide a tool to work with relations
- Basics are easy to master
- Topological sorting:
  - Understandable
  - Powerful in applications
  - Opens for advanced topics (and applications)

Thank you for your attention.