5LIG0:
Applied combinatorial algorithms

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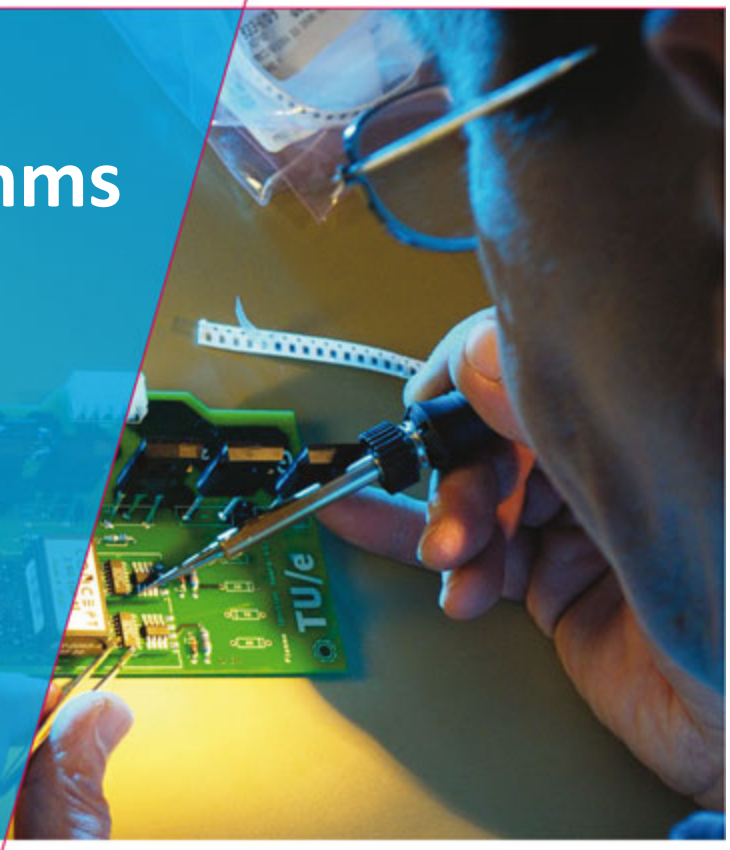
~~Flux 04.135~~ **working from home :-)**

Department of Electrical Engineering



Technische Universiteit
Eindhoven
University of Technology

Where innovation starts

Course admin

Lecturer

Dr. Mitra Nasri (m.nasri@tue.nl)

(and Prof. Twan Basten for the lecture on NP-Completeness)

Teaching assistant

S. Dehnavi

Reference

Sanjit Dasgupta, C.H. Papadimitriou and U.V. Vazirani "Algorithms".

Materials, updates, and announcements

Canvas and the course "Team" on MS Teams

- Join team: EE_5LIG0 (2020-2021)
- Team code: -----

Logistics

- **No activity (lecture, assignment, etc.) on campus**
- **The course is fully online (all activities, including the exam, are online)**
- **The course follows a "blended education" style**
  - You watch pre-recorded lectures
  - Then you attend the **live session** that is about solving new exercises on the topic
- **All live sessions will be recorded**
- **To communicate with the lecturer and the TA, we will use MS Teams.**

How to join the course team on MS Teams

- Open your MS Teams app (login with your TU/e credentials)
- Go to “Teams”
- Join team: EE_5LIG0 (2020-2021) using the option “**Join a team with a code**”
- Enter the team’s code: **----**

Course's Team EE_5LIG0 (2020-2021)

- **Channels:**
  - **A discussion channel for each assignments**
    - You can ask your questions about each assignment here from the **TA**. He will do his best to answer your question as soon as possible.
    - When needed, **TA** will create a private channel to discuss with you individually
  - **A discussion channel for any question related to the lectures**
  - **Links to the "Live sessions"**
  - **General**
  - **Off topic**

Live exercise sessions

- **Live sessions are mostly on Mondays**
  - They start at the time slot of the course
  - A few live sessions are on Wednesdays
  - Follow the schedule on Canvas

- Links to the live sessions will be provided on the course's "Team" on MS Teams
  - Find the link in channel "**Live sessions**"

- **Live sessions include:**
  - **Q&A**: where you can ask your questions about the lecture contents or exercises
  - **Solving and practicing new problems** with techniques taught in (self-study) pre-recorded lectures

Self study

- **A self study includes**
  - **Short recorded videos** that explain the topic and solve examples
    - For each video, there will also be a PDF file (without voice or video) on the module (on Canvas)
  - **Self assessments** (ungraded exercises)
  - **Quiz** (graded exercise)

- **You must go through all activities of each Module on Canvas**

- **You must watch all videos before attending the live session on that topic**

- **All materials will be provided on Canvas**

Assessment

- **Assignments**
  - Assignments are mini-projects that allow you to get involved with problems similar to those found in industry
  - Each assignment has a set of deliverables (report + code)
  - Assignments are individual and can be done in any programming language that you are comfortable with.

- **Quizzes**
  - There are 4 quizzes
  - You have 2 tries on each quiz.
  - your last try will be considered for grading.

- **Oral exam**
  - The oral exam is about the course contents, assignments, and quizzes

- **You can get <u>bonus points</u> for activities during the live sessions**

Assessment

- **Assignment 1**
  - Graph analysis (40%)
  - Deadline: 6 Dec. 2020
- **Assignment 2**
  - ILP (15%)
  - Deadline: 6 Jan. 2021
- **Assignment 3**
  - NP-Completeness (20%)
  - Deadline: 6 Jan. 2021

You must get at least 50% of the points of each component, and your final grade must be 6 or higher to pass the course.

- **Quiz 1: Divide and conquer + complexity**
  - Deadline: 17 Nov. 2020
- **Quiz 2: Graph analysis**
  - Deadline: 22 Nov. 2020
- **Quiz 3: Dynamic programming and greedy algorithms**
  - Deadline: 29 Nov. 2020
- **Quiz 4: ILP and NP-Completeness**
  - Deadline: 15 Dec. 2020
- Quizzes (all together) are 25% of the grade

Learning objectives and topics

At the end of the course, you should be able to **understand**, **apply**, and **evaluate** algorithmic solutions for various problems in embedded and/or cyber-physical systems.

Topics covered

- **Big-O notation and complexity**
- **Divide-and-conquer algorithms**
- **Graph analysis**
- **Greedy algorithms and minimum-spanning tree algorithms**
- **Dynamic programming**
- **Linear and integer-linear programming, and network flow**
- **NP-completeness**
- **[tentative] Coping with NP-completeness**

How to evaluate and compare algorithms

Design efficient algorithms to solve optimization problems

Use automatic tools to solve optimization problems

Learn about and cope with problems that are inherently "hard" to solve

Schedule

- **Official time slots:**
  - Mondays 13:30 to 15:30 and Wednesdays 8:45 to 10:30

	Topic	Quizzes	book
Nov. 9, Mon	**Live lecture: introduction and complexity**		ch 0
Nov. 11, Wed	**Study at home: divide & conquer + graph analysis**	Quiz 1 (divide&conquer)	ch 2, 3, 4
	Assignment1: (Volvo) Graph analysis and greedy algorithms		
Nov. 16, Mon	**Live exercise and Q&A: graph analysis + divide& conquer**	Quiz 2 (graph analysis)	ch 3 & 4
Nov. 17, Tue	**Study at home: dynamic programming and greedy alg.**	Quiz 1: deadline	ch 5
Nov. 18, Wed	No lecture (contact hours with the TA)		
Nov. 22, Sun		Quiz 2: deadline	
Nov. 23, Mon	**Live exercise and Q&A: DP and greedy algorithms**	Quiz 3 (DP and greedy)	ch 5
Nov. 24, Tue	**Study at home: linear programming and ILP**		ch 7
Nov. 25, Wed	No lecture (contact hours with the TA)		
	Assignment 2: ILP		
Nov. 29, Sun		Quiz 3: deadline	
Nov. 30, Mon	**Live exercise and Q&A: linear programming, ILP**		ch 7
Dec. 2, Wed	No lecture (contact hours with the TA)		
Dec. 6, Sun	Assignment 1: final deadline		

Schedule (cont.)

- **Official time slots:**
  - Mondays 13:30 to 15:30 and Wednesdays 8:45 to 10:30

	Topic	Quizzes	book
Dec. 7, Mon	No lecture (contact hours with the TA)		
Dec. 9, Wed	**Live lecture: NP-Completeness (Prof. Twan Basten)**	Quiz 4 (ILP & NP-comp.)	ch 8
	Assignment 3: NP-Completeness		
Dec. 14, Mon	**[to be confirmed] Study at home: coping with NP-completeness**		ch 9
Dec. 15, Tue		Quiz 4: deadline	
Dec. 16, Wed	**Q&A for all topics**		
	<< Happy holidays >>		
Jan. 4, Mon	No lecture (contact hours with the TA)		
Jan. 6, Wed	No lecture (contact hours with the TA)		
Jan. 6, Wed	Assignment 2 and 3: deadline		
Jan. 11, Mon	**Oral exam on the assignments and quizzes**		
Jan. 13, Wed	**Oral exam on the assignments and quizzes**		

Can you finish the course earlier than scheduled?

- **Yes!**

- I am trying to upload the **lectures**, **quizzes**, and **assignments** much earlier than the dates mentioned in the schedule on canvas.
  - The only lecture that cannot be uploaded earlier is the one on NP-Completeness (which will be given by Prof. Twan Basten on Dec. 9th during a live session).

- You can submit the quizzes and assignments even before their live sessions. It helps you manage your time the way you want.

Bonus points

- Each student can gather up to **100 bonus points**.

- **100 bonus points will be equal to 1 extra point on your final grade**
  - Example: if your grade from the oral exam is 8.5 and you have 85 bonus points, then you will have 8.5 + 0.85 = 9.35 and hence your final grade will be 9.5 (9.35 will be automatically rounded up to 9.5).

- Each question in a yellow box has **5 bonus points**.

A yellow question-box
will look like this

- By preparing yourself before a live session, you can increase your chance to get a very high grade from the course :-)

Any question?

Just to break the ice:

What is the name of the second teacher of **Naruto** in **Naruto anime**?

Kakashi Hatake

Anime: Naruto
https://www.nicepng.com/ourpic/u2q8i1u2w7y3i1a9_naruto-uzumaki-sasuke-uchiha-sakura-haruno-kakashi-naruto/

Now a bit about me (the lecturer)

- **I moved from TU Delft to TU/e in February 2020**

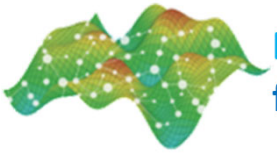
More than 8 years of research experience on

Designing and **analyzing** **real-time** **embedded systems**

Response-time analysis using graph-based solutions

ROS
Robot Operating System

Time-predictable ROS



Design-space exploration for real-time systems

Scheduling in embedded systems with very limited resources

Security in real-time systems

- **I have various master thesis topics.**
- **They require solutions that are very similar to what you learn in this course!**

- Find more about me here:
  http://www.es.ele.tue.nl/~m.nasri/

Real-time systems

Q1. What is a real-time system?

Q2. What is the difference between "**real-time**" and "**real time**" systems?

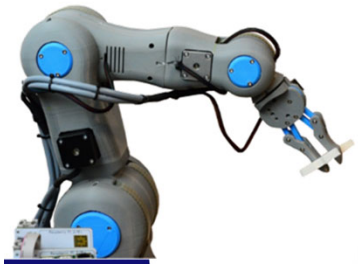
What is a real-time system?

Real-time systems are those whose **correctness** depends not only on the correctness of logical results (e.g., decisions), but also on the time at which the results are produced.

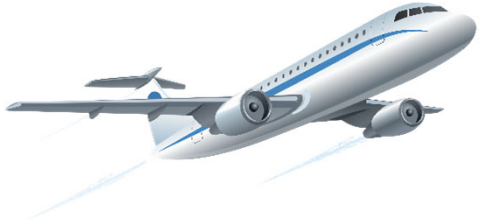
If the system does not react "on time", something can go wrong!

Most embedded systems are real-time!







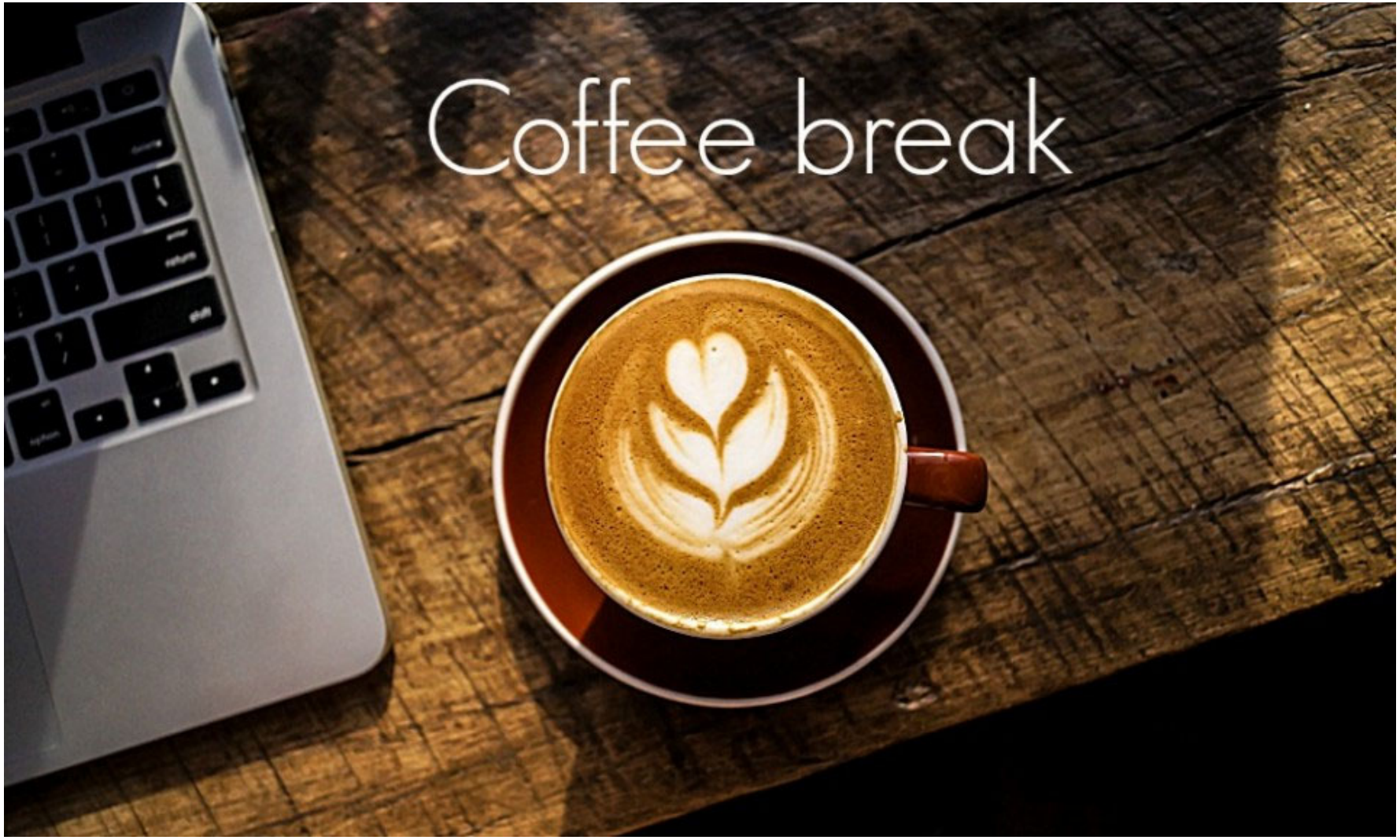
Notes and disclaimer

- **The contents of the course is not identical to the previous years but is very similar.**

- **I have removed one assignment (which was on dynamic programming) and replaced it with 4 quizzes.**

- **I would like to thank Dr. Dip Goswami (previous lecturer) to kindly let me use his slides and assignments.**

5 minutes break



“Real-time” v.s. “real time”

- **When a system must provide its response at the current moment, it is said to be <u>real time</u>.** For example:
  - *“our video processing algorithm is able to process the streams in real time”.*
  - It means that the system’s response time is so small that a human user cannot notice any delays in the response.

- **When the response time of a system must be upper bounded by a given value, it is a “<u>real-time</u>” system.**
  - This does not mean that the system must respond in real time!
  - The system can have a delay that is noticeable by human, however, its largest response time MUST be upper bounded in any situation!
  - Deadlines in real-time systems can also be much smaller than those in real time system (e.g., in the order of micro-seconds). In other words, “real time” systems are a subset of “real-time” systems.