Introduction to Degree Projects

at Bachelor level (course: 2DV50E)

What is a Degree Project?

- A project where you work on a well defined problem.
- You can work alone or in group of two students.
- The project can be carried out at the university or at an external company.
- You will have an appointed university supervisor,
- … and a company supervisor if you do the project at an external company.

What is a Degree Project?

- The project is worth 15 credits.
- It runs on 50% speed over two study periods.
- In total about 20 weeks.
- Prerequisites:
  - At least 75 credits in Computer Science
  - At least 15 of those must be in 2DV… level courses

Requirements

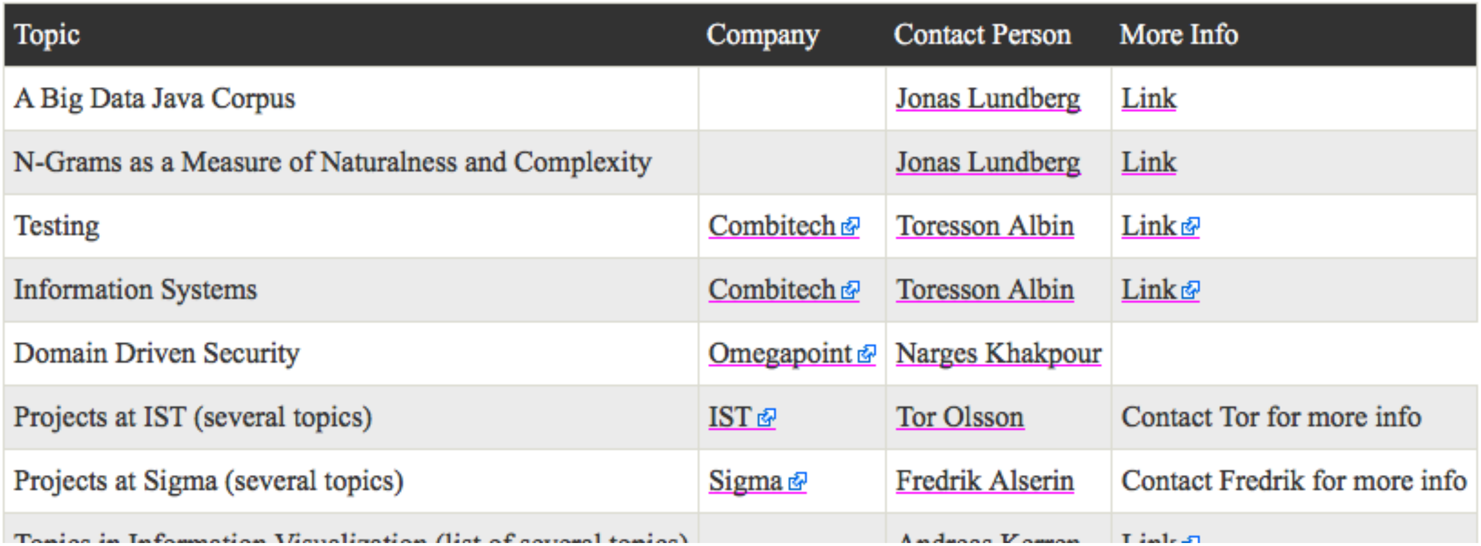
- In some cases you can be admitted to the course ”with conditions”.
- This means that you don’t fulfill all the prerequisites, and you have to discuss with me if you are allowed to take the course.
- It can for example be that you have finished a course but the credits have not showed up in Ladok yet.
- Each case will be handled individually.

Where do you start?

- You need to find a problem for your project.
- You can either:
  - Select an open proposal
  - Ask around for proposals
  - Find your own topic
- It is generally easier to select an open proposal than define your own topic.

Open Proposals

- A list of project proposals is available at:
  - https://coursepress.lnu.se/subject/thesis-projects/proposals/
- The list contains proposals from external companies, or from researchers at LNU.



Topic	Company	Contact Person	More Info
A Big Data Java Corpus		Jonas Lundberg	Link
N-Grams as a Measure of Naturalness and Complexity		Jonas Lundberg	Link
Testing	Combitech	Toresson Albin	Link
Information Systems	Combitech	Toresson Albin	Link
Domain Driven Security	Omegapoint	Narges Khakpour	
Projects at IST (several topics)	IST	Tor Olsson	Contact Tor for more info
Projects at Sigma (several topics)	Sigma	Fredrik Alserin	Contact Fredrik for more info
Topics in Information Visualization (list of several topics)		Andreas Kerren	Link

Select an open proposal

- If you are interested in a proposal:
  - Read all details about it (follow the Link).
  - Make sure you fulfill the specified requirements (if any).
  - Send an email to the contact person telling that you are interested in the proposal.
  - If the contact person accepts that you start the project, notify the course manager by email.
  - The contact person can deny if the topic is already taken.

Ask around for proposals

- Think about a problem area you are interested in.
- Ask a teacher that is experienced in the area if he/ she has any proposals for you.

- Do you know any companies that work in things that interests you?
- Ask them if they have any proposals for you.

Find your own topic

- Start by finding a problem area you are interested in:
  - Software architectures
  - Online security
  - Internet of Things
  - …
- Read about the problem area in books, blogs, tech reports, etc.
- Is there an interesting problem you can work on?
- If so, discuss the problem with a teacher or course manager to see if it is suitable for a degree project.

What is a suitable problem?

- No obvious solution (i.e. it has already been solved in the same context)
  - Example: ”How to sort a list of words” is already solved
- Not too large or too complex
  - Example: ”Creating better UIs for mobile devices” is too large and unspecific

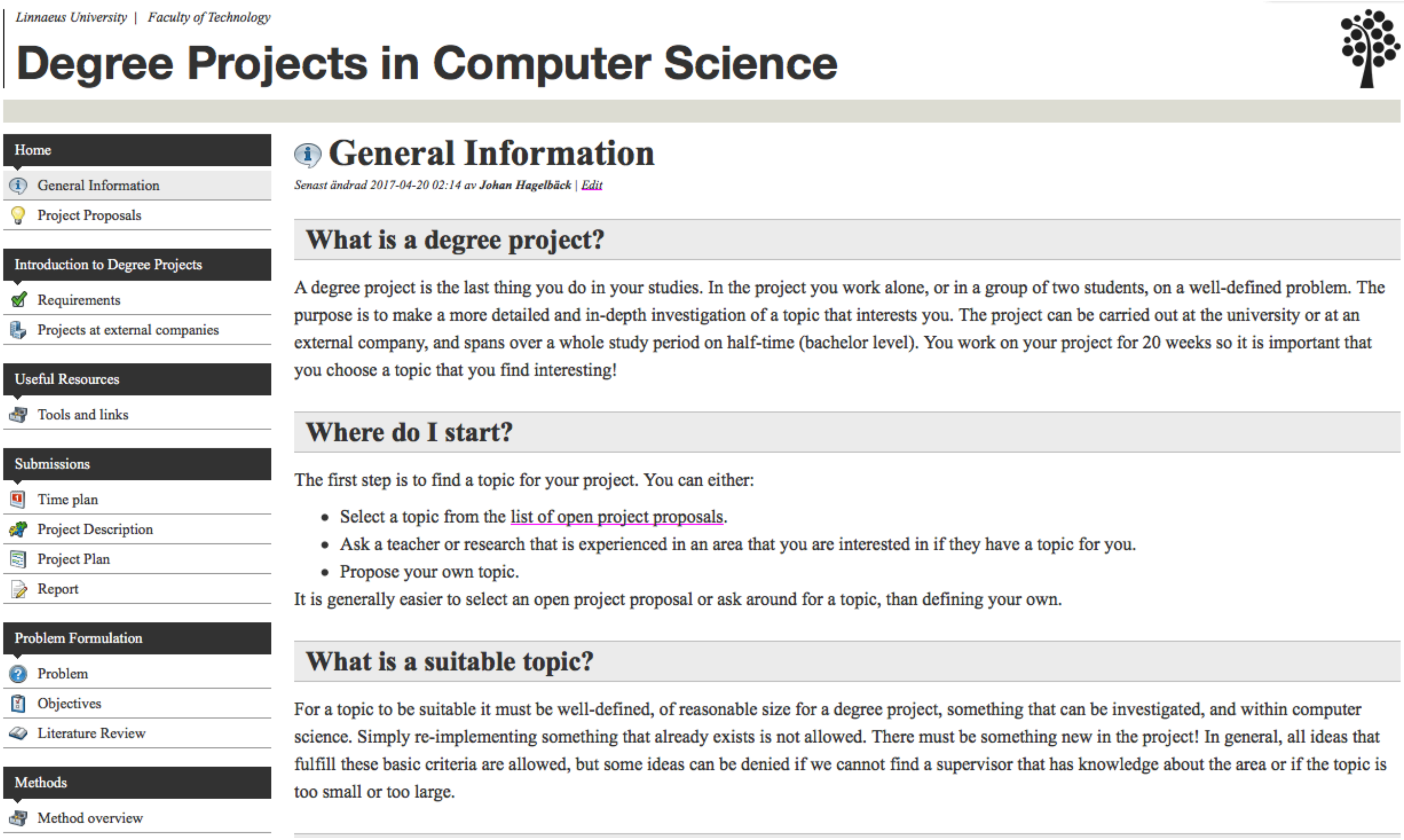
What is a suitable problem?

- Not too small or too simple
  - Example: comparing the UIs in Word and OpenOffice
- Not only implement something that already exists
  - Not a problem, just labor
- There must be something to investigate!
- More about this later.

Project at external companies

- You will have one university and one company supervisor.
- Companies often have different goals than the university. You must make sure that the requirements from both are met.
- It is up to the company if they can offer you a desk at their office.
- You usually have to sign a Non-Disclosure Agreement (NDA). This is usually not a problem, but read what you agree to!
- Since you are not employed by the company, You own what you produce in the project. You can however transfer ownership to the company in a written agreement.

Information resources



Degree Projects in Computer Science

General Information

*Senast ändrad 2017-04-20 02:14 av **Johan Hagelbäck** | Edit*

What is a degree project?

A degree project is the last thing you do in your studies. In the project you work alone, or in a group of two students, on a well-defined problem. The purpose is to make a more detailed and in-depth investigation of a topic that interests you. The project can be carried out at the university or at an external company, and spans over a whole study period on half-time (bachelor level). You work on your project for 20 weeks so it is important that you choose a topic that you find interesting!

Where do I start?

The first step is to find a topic for your project. You can either:

- Select a topic from the list of open project proposals.
- Ask a teacher or research that is experienced in an area that you are interested in if they have a topic for you.
- Propose your own topic.

It is generally easier to select an open project proposal or ask around for a topic, than defining your own.

What is a suitable topic?

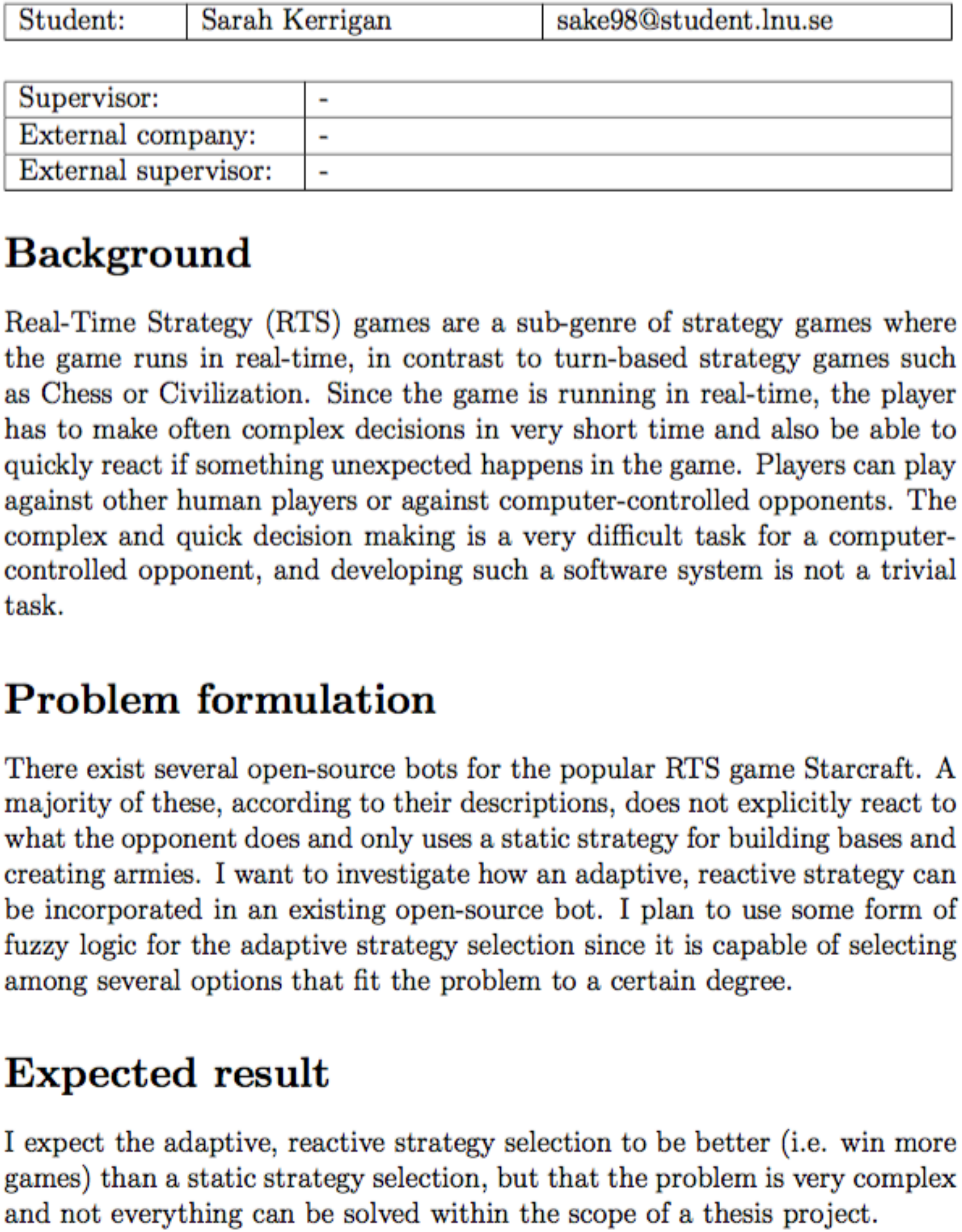
For a topic to be suitable it must be well-defined, of reasonable size for a degree project, something that can be investigated, and within computer science. Simply re-implementing something that already exists is not allowed. There must be something new in the project! In general, all ideas that fulfill these basic criteria are allowed, but some ideas can be denied if we cannot find a supervisor that has knowledge about the area or if the topic is too small or too large.

https://coursepress.lnu.se/subject/thesis-projects/

Project description and Project plan

First submission

- You shall write a one-page project description with:
  - Background. Describe the area of your project.
  - Problem formulation. What specific problem are you interested in finding a solution to?
  - Expected result. What results do you expect from your project?
- Templates and an example project description are available at:
  - https://coursepress.lnu.se/subject/thesis-projects/project-description/
- Deadline and submission: **see Mymoodle**



Student:	Sarah Kerrigan	sake98@student.lnu.se

Supervisor:	-
External company:	-
External supervisor:	-

Background

Real-Time Strategy (RTS) games are a sub-genre of strategy games where the game runs in real-time, in contrast to turn-based strategy games such as Chess or Civilization. Since the game is running in real-time, the player has to make often complex decisions in very short time and also be able to quickly react if something unexpected happens in the game. Players can play against other human players or against computer-controlled opponents. The complex and quick decision making is a very difficult task for a computer-controlled opponent, and developing such a software system is not a trivial task.

Problem formulation

There exist several open-source bots for the popular RTS game Starcraft. A majority of these, according to their descriptions, does not explicitly react to what the opponent does and only uses a static strategy for building bases and creating armies. I want to investigate how an adaptive, reactive strategy can be incorporated in an existing open-source bot. I plan to use some form of fuzzy logic for the adaptive strategy selection since it is capable of selecting among several options that fit the problem to a certain degree.

Expected result

I expect the adaptive, reactive strategy selection to be better (i.e. win more games) than a static strategy selection, but that the problem is very complex and not everything can be solved within the scope of a thesis project.

Discussion Seminars

- The course begins with three seminars where your ideas are discussed and improved:
- You will be divided into groups
- 1 hour per group and week
- Groups and schedule will be posted at Mymoodle after the project description submission
- Distance students discuss their topic ideas with course manager by email or Skype (book a meeting by email)

Discussion Seminars

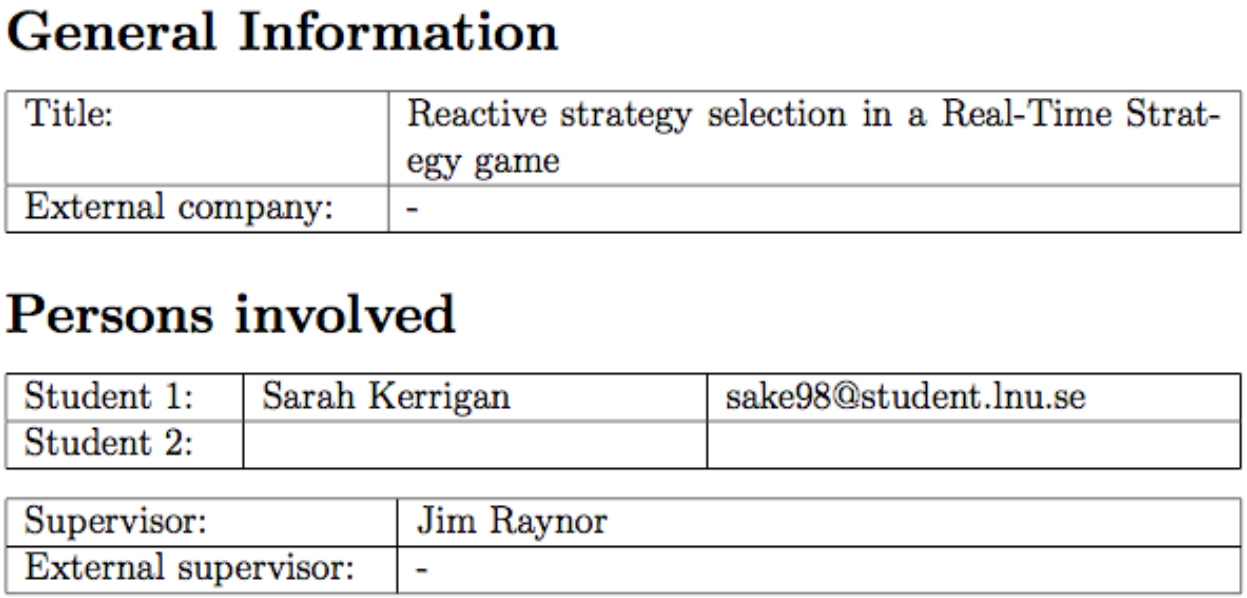
- At the seminars, you discuss in groups and with a teacher:
  - Problem formulation
  - Objectives
  - Method
  - Scope and limitations
  - Expected results
- At each seminar you will get feedback so you can improve your idea for the next seminar, where we further discuss the idea.
- Make sure you take advantage of these seminars!

Project Plan

- After the seminars you shall write and submit a project plan.
- The project plan is a more formal and extensive description of your project, and how you plan to approach the problem.
- It also contains a time plan to help structure your time during the project.
- The project plan tells what to do and how to do it.
- You should start working on the project plan during the seminar weeks.

Project Plan

- The project plan must be accepted by the course manager before you can start working on your project.
- The project plan is very helpful in managing your time and keeping you on the right track.
- Make sure that your time plan contains specific subgoals that are reasonable!
- Templates and an example project plan is available at:
  - https://coursepress.lnu.se/subject/thesis-projects/project-plan/
- Deadline and submission: **see Mymoodle**



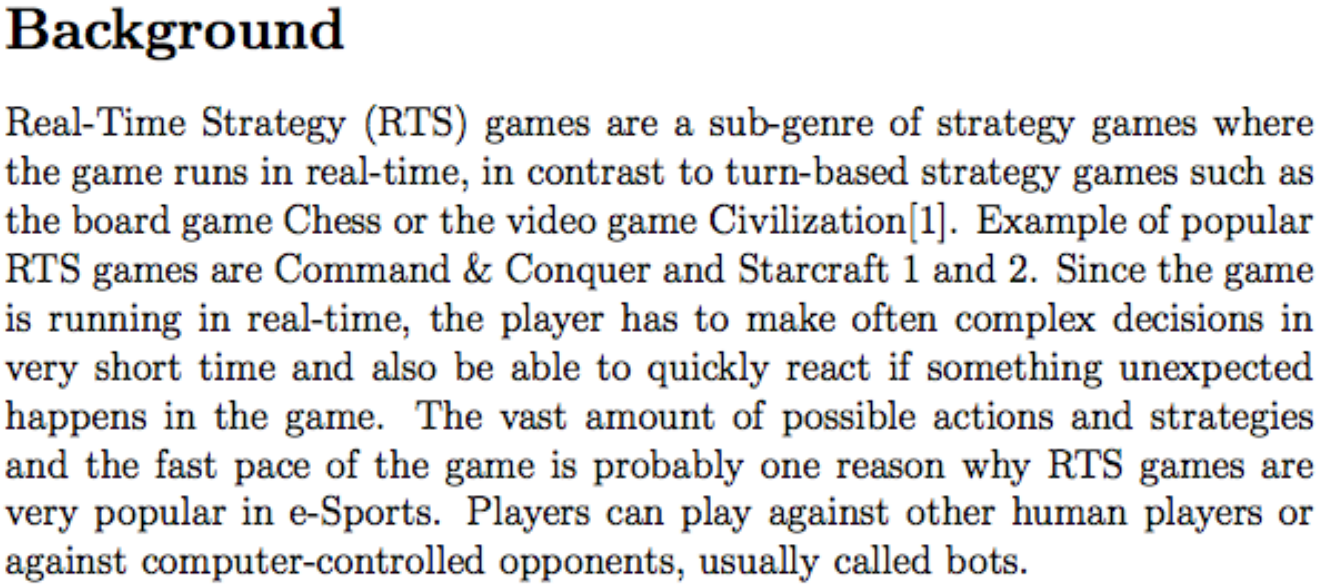
General Information

Title:	Reactive strategy selection in a Real-Time Strategy game
External company:	-

Persons involved

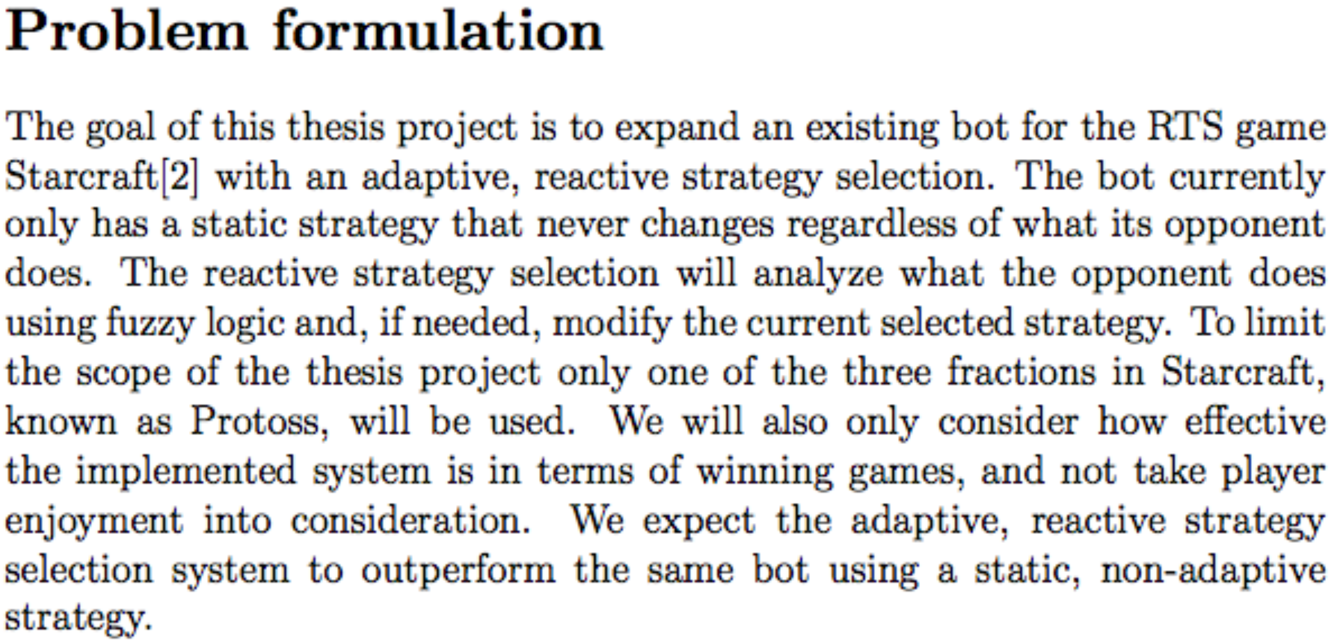
Student 1:	Sarah Kerrigan	sake98@student.lnu.se
Student 2:		

Supervisor:	Jim Raynor
External supervisor:	-



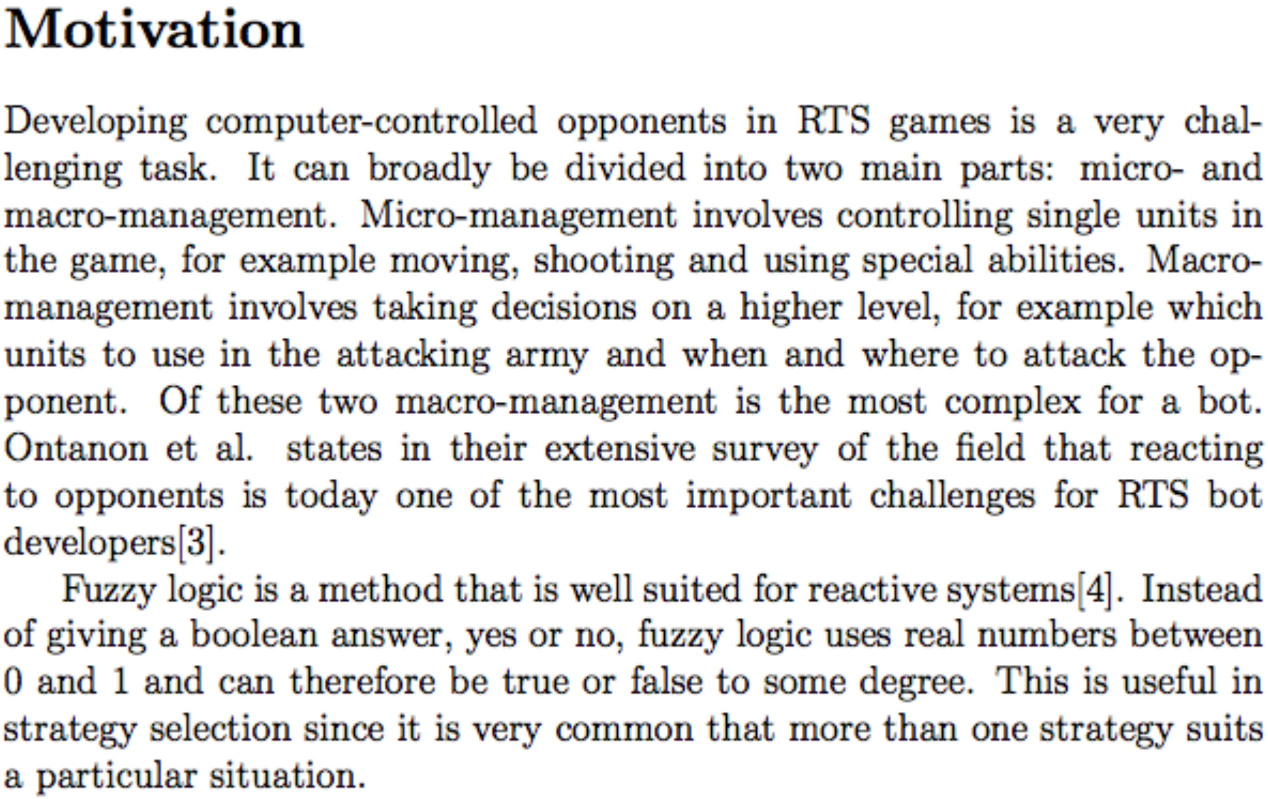
Background

Real-Time Strategy (RTS) games are a sub-genre of strategy games where the game runs in real-time, in contrast to turn-based strategy games such as the board game Chess or the video game Civilization[1]. Example of popular RTS games are Command & Conquer and Starcraft 1 and 2. Since the game is running in real-time, the player has to make often complex decisions in very short time and also be able to quickly react if something unexpected happens in the game. The vast amount of possible actions and strategies and the fast pace of the game is probably one reason why RTS games are very popular in e-Sports. Players can play against other human players or against computer-controlled opponents, usually called bots.



Problem formulation

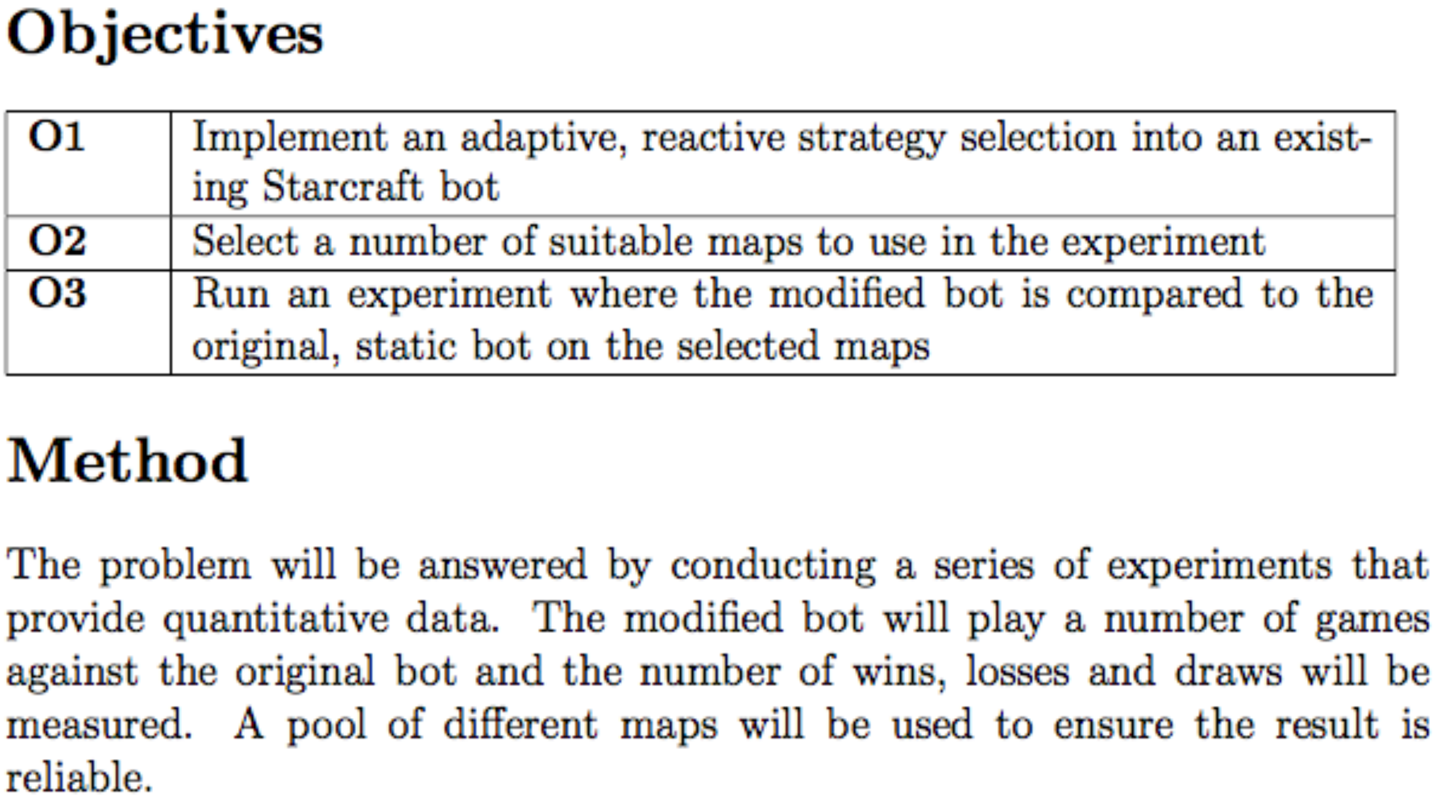
The goal of this thesis project is to expand an existing bot for the RTS game Starcraft[2] with an adaptive, reactive strategy selection. The bot currently only has a static strategy that never changes regardless of what its opponent does. The reactive strategy selection will analyze what the opponent does using fuzzy logic and, if needed, modify the current selected strategy. To limit the scope of the thesis project only one of the three fractions in Starcraft, known as Protoss, will be used. We will also only consider how effective the implemented system is in terms of winning games, and not take player enjoyment into consideration. We expect the adaptive, reactive strategy selection system to outperform the same bot using a static, non-adaptive strategy.



Motivation

Developing computer-controlled opponents in RTS games is a very challenging task. It can broadly be divided into two main parts: micro- and macro-management. Micro-management involves controlling single units in the game, for example moving, shooting and using special abilities. Macro-management involves taking decisions on a higher level, for example which units to use in the attacking army and when and where to attack the opponent. Of these two macro-management is the most complex for a bot. Ontanon et al. states in their extensive survey of the field that reacting to opponents is today one of the most important challenges for RTS bot developers[3].

Fuzzy logic is a method that is well suited for reactive systems[4]. Instead of giving a boolean answer, yes or no, fuzzy logic uses real numbers between 0 and 1 and can therefore be true or false to some degree. This is useful in strategy selection since it is very common that more than one strategy suits a particular situation.

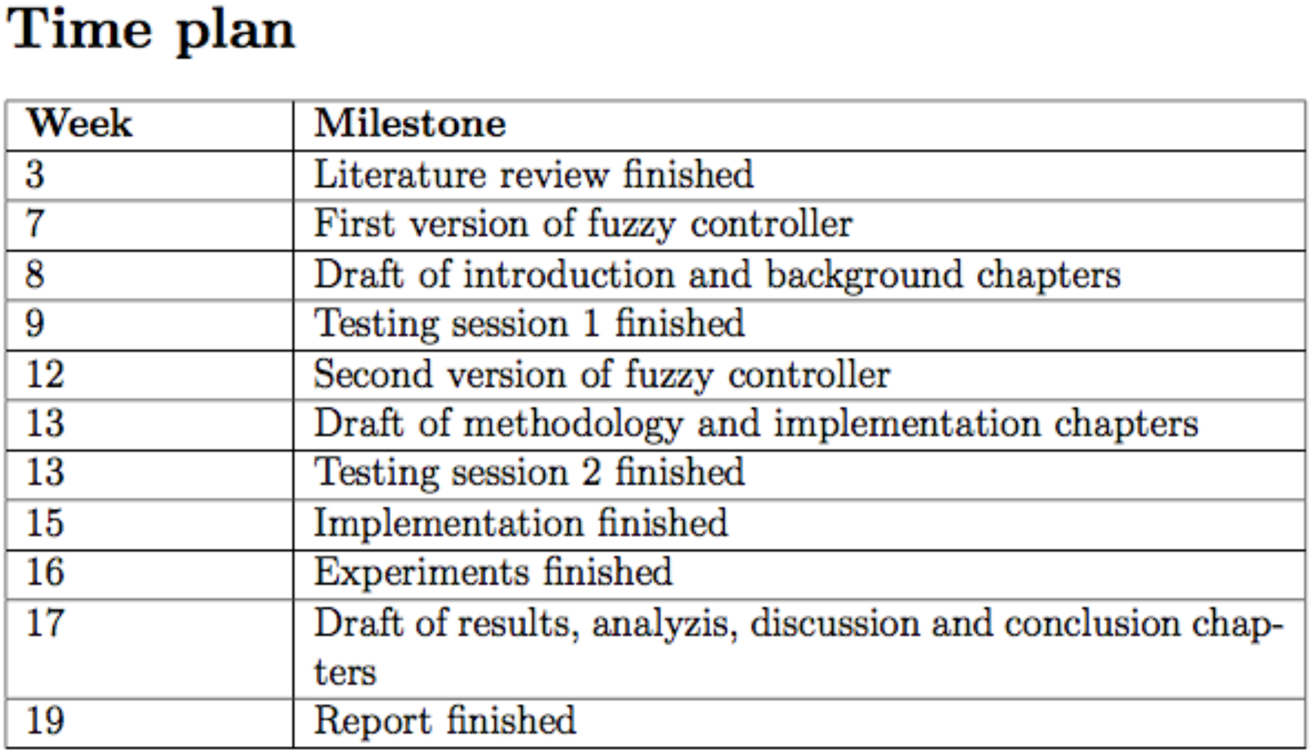


Objectives

O1	Implement an adaptive, reactive strategy selection into an existing Starcraft bot
O2	Select a number of suitable maps to use in the experiment
O3	Run an experiment where the modified bot is compared to the original, static bot on the selected maps

Method

The problem will be answered by conducting a series of experiments that provide quantitative data. The modified bot will play a number of games against the original bot and the number of wins, losses and draws will be measured. A pool of different maps will be used to ensure the result is reliable.



Time plan

Week	Milestone
3	Literature review finished
7	First version of fuzzy controller
8	Draft of introduction and background chapters
9	Testing session 1 finished
12	Second version of fuzzy controller
13	Draft of methodology and implementation chapters
13	Testing session 2 finished
15	Implementation finished
16	Experiments finished
17	Draft of results, analyzis, discussion and conclusion chapters
19	Report finished

Writing recommendations

Writing recommendations

- Start writing early, write regularly
- Don’t wait until you project is finished or until you “feel ready to write”.
- The risk is that you may not write at all!
- Writing about your project helps you develop your ideas and identify what is missing.
- Through regular writing you build your confidence in writing.
- Through revising you select the parts that fit into the final report, and reject parts that doesn’t fit.

Writing recommendations

- Sometimes it is very difficult to start writing.
- You know you have to write, but you stare at the empty page in front of you.
- There are some writing strategies you can try and see if they work out for you:
  - Writing to prompts
  - Freewriting
  - Generative writing
- More information can be found here:
  - https://coursepress.lnu.se/subject/thesis-projects/how-to-write/

Grammar and spelling

- Make sure you use tools for grammar and spell checking.
- I strongly recommend to use Grammarly: http://grammarly.com
- The free version is very good, but consider paying for the Premium version when writing your report.

Roles and Responsibilities

Responsibilities: Student

- The responsibilities of the student are:
  - Write and hand in project description and project plan in time.
  - Together with your supervisor decide how often and where supervision meetings shall take place. Meetings can for example be held every week, every second week or only when you contact the supervisor and request a meeting.
  - Together with your supervisor plan and discuss deliveries (when parts of your project shall be finished and delivered to your supervisor for feedback).
  - Make sure to submit deliveries and report drafts to your supervisor before meetings.
  - Continuously (at least once a week) report progress to the supervisor by email.
  - Maintain progress according to the time plan in the project plan document.
  - Drive the project forward and initiate discussions and meetings.
  - Address and respond to criticism, guidance and suggestions given by the supervisor.
  - Inform your supervisor of any difficulties, technical and non-technical problems or personal circumstances that slow down or halt your work.
  - Proofread your text before sending it to the supervisor.

Responsibilities: Supervisor

- The responsibilities of the supervisor are:
  - Help you plan your work to make sure that it can be completed in time.
  - Make sure that your project and report is of an acceptable standard before you present your work and, if it is not, inform you of what you need to do to reach an acceptable standard.
  - Meet you regularly to discuss the progress in the thesis project and give feedback on your work.
  - Answer your emails within a reasonable time frame.
  - Read and comment on report drafts. Note that the role of the supervisor is to mainly comment on the content. It is the student’s responsibility to make sure the language usage is of an acceptable standard, so the supervisor does not have to spend too much of the limited supervision time on correcting flaws in the language.
  - Notify the course manager if you will be finished in time to present your thesis project at a certain date.

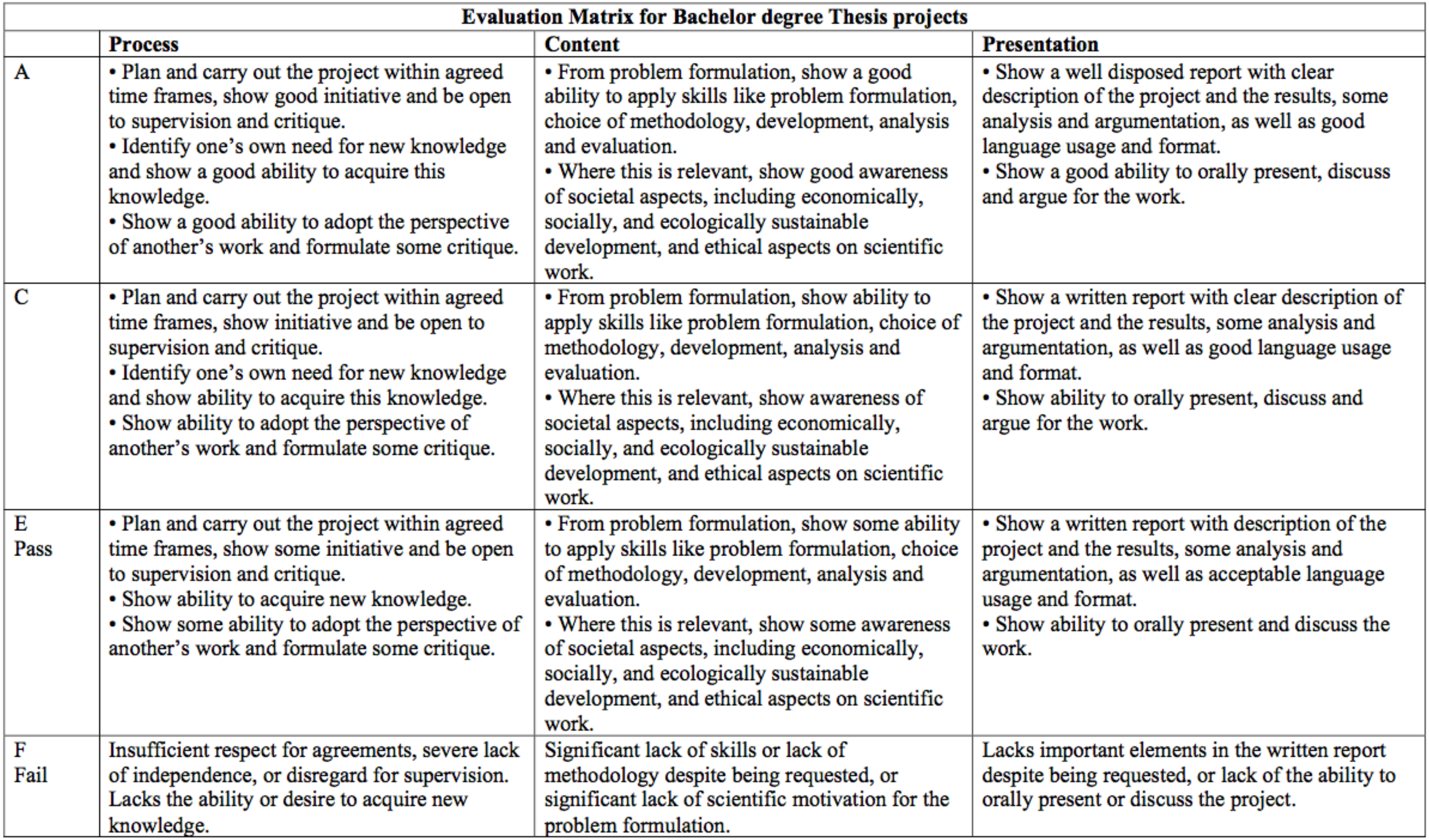
Responsibilities: Course manager

- The responsibilities of the course manager are:
  - Inform students about how to carry out a thesis project at the university.
  - Inform students about where they can find important information (grading criteria, course schedule, etc.).
  - Inform students and supervisors about deadlines (when to hand in the project plan, final report, etc.).

Responsibilities: Examiner

- The examiner assesses your project to see if it meets the requirements for a thesis project, and is responsible for setting a final grade on your project.
- Assessment is done three times:
  - When you hand in the project description. The purpose is to make sure that your project idea is reasonable within the limited time frame of a thesis project, and that it is not too complex for your level of degree.
  - When you hand in the project plan. The purpose is to make sure that the research questions and choice of research methods are appropriate.
  - After the presentation when you hand in the final version of the report. The purpose is to make sure your report is of acceptable quality both in terms of content and language used.

Grading requirements



Evaluation Matrix for Bachelor degree Thesis projects

	Process	**Content**	**Presentation**
A	• Plan and carry out the project within agreed time frames, show good initiative and be open to supervision and critique. • Identify one's own need for new knowledge and show a good ability to acquire this knowledge. • Show a good ability to adopt the perspective of another's work and formulate some critique.	• From problem formulation, show a good ability to apply skills like problem formulation, choice of methodology, development, analysis and evaluation. • Where this is relevant, show good awareness of societal aspects, including economically, socially, and ecologically sustainable development, and ethical aspects on scientific work.	• Show a well disposed report with clear description of the project and the results, some analysis and argumentation, as well as good language usage and format. • Show a good ability to orally present, discuss and argue for the work.
C	• Plan and carry out the project within agreed time frames, show initiative and be open to supervision and critique. • Identify one's own need for new knowledge and show ability to acquire this knowledge. • Show ability to adopt the perspective of another's work and formulate some critique.	• From problem formulation, show ability to apply skills like problem formulation, choice of methodology, development, analysis and evaluation. • Where this is relevant, show awareness of societal aspects, including economically, socially, and ecologically sustainable development, and ethical aspects on scientific work.	• Show a written report with clear description of the project and the results, some analysis and argumentation, as well as good language usage and format. • Show ability to orally present, discuss and argue for the work.
E Pass	• Plan and carry out the project within agreed time frames, show some initiative and be open to supervision and critique. • Show ability to acquire new knowledge. • Show some ability to adopt the perspective of another's work and formulate some critique.	• From problem formulation, show some ability to apply skills like problem formulation, choice of methodology, development, analysis and evaluation. • Where this is relevant, show some awareness of societal aspects, including economically, socially, and ecologically sustainable development, and ethical aspects on scientific work.	• Show a written report with description of the project and the results, some analysis and argumentation, as well as acceptable language usage and format. • Show ability to orally present and discuss the work.
F Fail	Insufficient respect for agreements, severe lack of independence, or disregard for supervision. Lacks the ability or desire to acquire new knowledge.	Significant lack of skills or lack of methodology despite being requested, or significant lack of scientific motivation for the problem formulation.	Lacks important elements in the written report despite being requested, or lack of the ability to orally present or discuss the project.

Any questions about the course structure?

PART 2 - METHODS

Method overview

- In your project you have defined a problem to investigate, and you need some problem-solving activity to answer that problem.
- This is what me mean with a method.
- A method is a proved and structured way of approaching and solving a problem.
- There is a wide range of methods you can use, and we will take a look at some common ones.

Qualitative and Quantitative

- Methods are usually divided into two categories: qualitative and quantitative
- This has to do with what type of data is collected:
  - Quantitative data: numbers, for example execution time or temperature
  - Qualitative data: non-numerical, for example free text answers in a questionnaire

Common methods

- Controlled experiment
- Survey using questionnaires
- Inteviews
- Case Study
- Systematic Literature Review
- Verification and Validation

Controlled experiment

- Systematically test something (a system, an algorithm, …) in a controlled environment.
- Measurements to prove or disprove a hypothesis/ proposition.
- We must define:
  - Dependent variable(s): what you measure
  - Independent variable(s): inputs that affect the dependent variable(s) and that are manipulated in the experiment

Controlled experiment

- Example:
  - Measure computation time for two different parallel algorithms running on a different number of CPU cores.
  - Dependent variable: computation time
  - Independent variables: number of cores, algorithm 1 or 2

Controlled experiment

- An experiment shall, as much as possible, be conducted in a controlled environment.
- What should be described:
  - Hardware setup (CPU type, memory, …)
  - Software setup (operating system version, important software installed, …)
  - Dependent and independent variables
  - Tools used for measurements
- This makes it possible to repeat the experiment.

Survey

- A survey is used to get people’s opinions about something.
- It consists of:
  - Participants (a sample of or the full population, for example 20 students at LNU)
  - A method of data collection (a questionnaire is very common)
  - Individual questions that result in data that can be analyzed

Survey

- There are two common scales used for question answers.
- *Rating scales* have an interval, for example 1 to 5.
- Example:
  - on a scale from 1 to 5, how good do you think the movie was?
- Rating scales can also be ratios:
  - twice as much, three times as much, …
- Example:
  - how much more would you be willing to pay if the software had a specific feature?

Survey

- In a *Likert scale* the participants rate their level of agreement of something.
- A Likert scale can be of any level, but five is the most common:
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

Survey

- When doing a survey it is important that the sample (the selected participants) is representative of the population as a whole.
- Example:
  - if you want to do a survey on LNU students, it is not representative if your sample consists of five male students from the first year in the network security program.
- Having a too small or too homogenous sample is a common error in surveys.

Survey

- A survey can also be qualitative.
- In this case the answers are options or free text.
- Example:
  - what features did you like most in the software?
- A survey can also be a mix of quantitative and qualitative questions (called a mixed method).

Case Study

- An up-close, in-depth and detailed examination of a specific case.
- A case can be a:
  - Individual (an expert in a field)
  - Organization/company
  - Event (a security breach in an IT system)
  - Action (users testing new features in a software)
- Data is collected using observations, interviews, reading documentation and manuals, etc.

Case Study

- The collected data is analyzed to draw conclusions about the case.
- Example:
  - A company wants to test two different user interfaces for managing a database server.
  - Users try both user interfaces.
  - Data is collected using observations (does the users look stressed or frustrated?) and questionnaires (what did the users think about each interface?)

Interview

- Is used to get one or more people’s opinion about something.
- Similar to a survey, but:
  - Survey: many participants, short and simple answers
  - Interview: one or a few participants, very detailed answers
- Interviews can be *open* or *closed*.

Interview

- An open interview is not planned in advance.
- No prepared questions.
- Discussion between interviewer and participant.
- The interviewer guides the discussion to what he/ she wants to talk about.
- The participant is in control of the interview, and talks about what he/she finds important.

Interview

- A closed interview is planned in advance.
- The interviewer has prepared a fixed set of questions to ask the participant.
- The interviewer is in control of the interview.
- Good thing: easier to repeat the interview with more participants.
- Bad thing: the participant might think other topics are more important than what is discussed.

Interview

- Regardless of interview style, recording is important.
- It is not possible to remember everything that was said during an interview.
- Recordings can be:
  - Taking notes: time consuming, and misses a lot of what was said.
  - Sound recordings: recommended, is easy today with a smartphone.
  - Video recordings: captures facial and body gestures that sound recordings miss, best option if you have access to a video camera.

Systematic Literature Review

- SLR is what is called a secondary study.
- No own research is conducted.
- Instead, research made by others are collected and synthesized.
- Synthesizing means summarizing existing research in the area, but also present the own view on the results of others.

Systematic Literature Review

- In SLR the data collection, i.e. which articles to include, is carried out in a systematic way.
- First we must define how to search for articles:
  - Which databases and search terms
  - Which journals or conferences that is of interest
- Articles are included or not based on pre-defined *inclusion* and *exclusion* criteria.
  - Usually checked by reading the Abstract

Systematic Literature Review

- SLR is very common in Medicine and Healthcare.
- For example how effective a medical treatment is or the long-term effects of an added substance in food.
- SLR is also very useful in Computer Science, for example finding pros and cons with outsourcing from a large number of companies.

Verification and Validation

- Verification and Validation is used to check if a software system meets requirements and specifications and that it fulfills its intended purpose.
- You start with a set of requirements (both functional and non-functional) defining what your software shall do.
- Examples:
  - **R1:** The system shall be able to generate arrays of random integer values (between a specified minimum and maximum value) of arbitrary length (max 10 million values)
  - **R2:** The system shall be able to sort an array of integer values using bubble sort and measure execution time
  - …

Verification and Validation

- In the verification phase, you test that the system meets all requirements you have defined by using manual or automated tests.
- Each requirements must have at least one test.
- For each test you must specify:
  - Test id, for example T1
  - Which requirement is tested, for example R1
  - How to execute the test (automated using a test suite, or how to manually test it)
  - Expected result, which is used to see if the test is passed or not

Verification and Validation

- In the validation phase, the system is checked if it fulfills the expectations of the end user or customer.
- This typically involves letting the end user or customer test different features of the system and give feedback to the developers.
- In degree projects, validation testing is typically done by the company you do your project at.

Verification and Validation

- The difference between verification and validation was succinctly expressed by Barry Boehm in 1979:
  - Verification: “Are we building the product right?”
  - Validation: “Are we building the right product?”

Data

Data

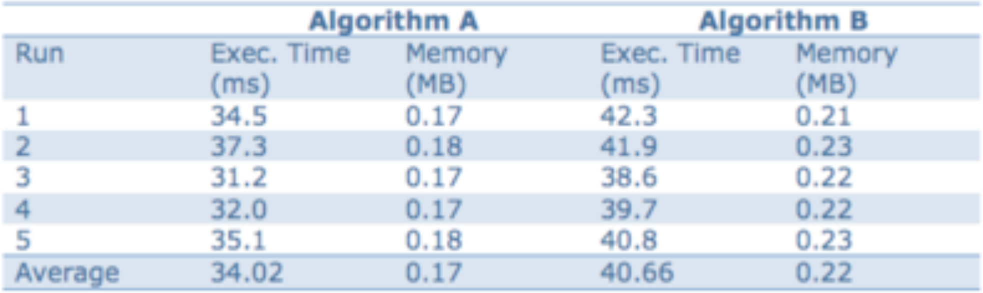
- Depending on the choice of method, different types of data is collected.
- The data shall be presented in your report.
- You shall also draw conclusions from your data, which often requires that you do some analysis.
- Different types of data require different methods for analysis and presentation.

Numerical Data

- Example:
  - Two algorithms, A and B, for solving the same problem are compared.
  - Which algorithm to use, A or B, is the independent variable
  - Execution time and memory usage are the dependent variables.
  - To reduce external validity threat the experiment is repeated 5 times and average values are calculated.

Numerical Data

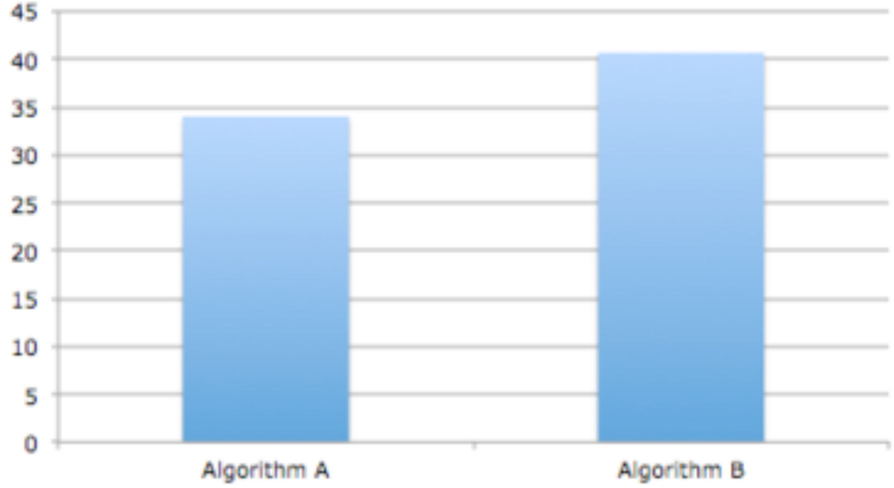
- The measured data is presented in a table:



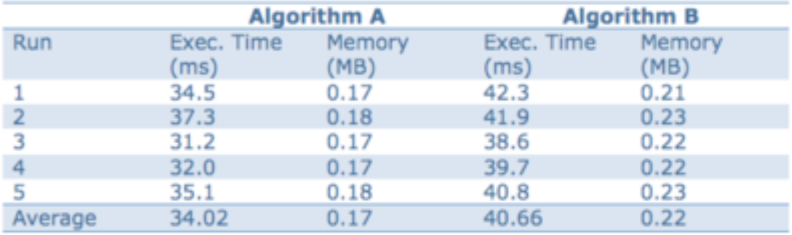
	Algorithm A		Algorithm B	
Run	Exec. Time (ms)	Memory (MB)	Exec. Time (ms)	Memory (MB)
1	34.5	0.17	42.3	0.21
2	37.3	0.18	41.9	0.23
3	31.2	0.17	38.6	0.22
4	32.0	0.17	39.7	0.22
5	35.1	0.18	40.8	0.23
Average	34.02	0.17	40.66	0.22

Numerical Data

- To make comparisons easier for the reader, tables are often complemented with graphs:



Is the question answered?



	Algorithm A		Algorithm B	
Run	Exec. Time (ms)	Memory (MB)	Exec. Time (ms)	Memory (MB)
1	34.5	0.17	42.3	0.21
2	37.3	0.18	41.9	0.23
3	31.2	0.17	38.6	0.22
4	32.0	0.17	39.7	0.22
5	35.1	0.18	40.8	0.23
Average	34.02	0.17	40.66	0.22

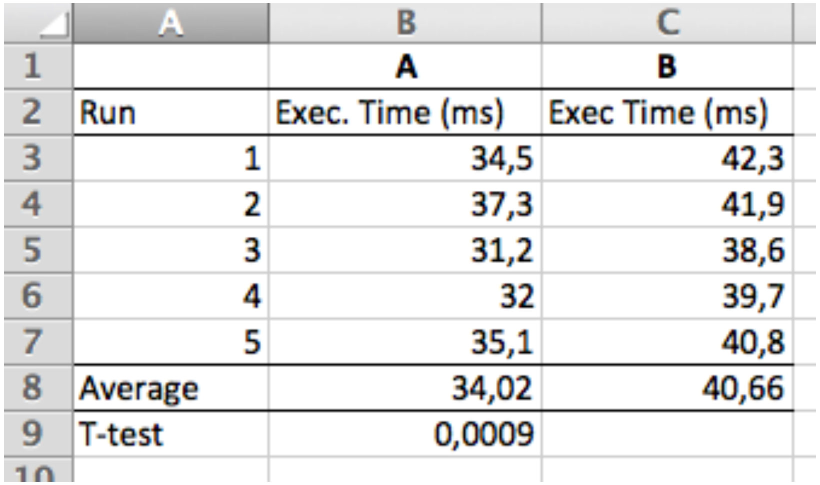
- Can we answer the question:
  - Is Algorithm A faster than Algorithm B for …?
- Yes, the results from an experiment in a controlled environment verifies that A is faster than B.
- There is however a catch:
  - Sometimes the average values are so similar that the difference could be caused by random factors, rather than by the independent variable.

Statistical Significance

- To be absolutely sure, we can use a statistical test to check if two average values are different.
- This is called a T-test, and is available in Excel or other tools:
  - https://sourceforge.net/projects/javastats/
- The test results in a P-value.
- If the P-value is less than or equal to 0.05, we can safely say that there is a difference.
- The result is then *statistically significant*.

Statistical Significance

- T-test on our example:

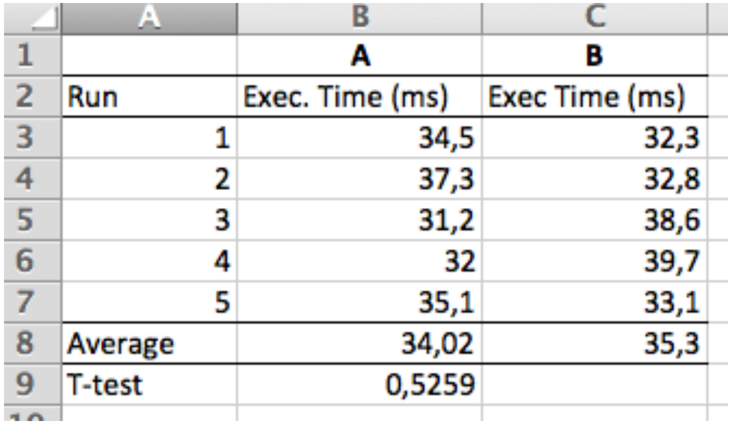


	A	B	C
1		A	B
2	Run	Exec. Time (ms)	Exec Time (ms)
3	1	34,5	42,3
4	2	37,3	41,9
5	3	31,2	38,6
6	4	32	39,7
7	5	35,1	40,8
8	Average	34,02	40,66
9	T-test	0,0009	
10			

- P is less than 0.05. The result is statistically significant.

Statistical Significance

- Same example but with different execution times:



	A	B	C
1		**A**	**B**
2	Run	Exec. Time (ms)	Exec Time (ms)
3	1	34,5	32,3
4	2	37,3	32,8
5	3	31,2	38,6
6	4	32	39,7
7	5	35,1	33,1
8	Average	34,02	35,3
9	T-test	0,5259	

- P value is more than 0.05.
- The result is not statistically significant, even if there is a difference between the calculated values.
- We can therefore say that there is no difference between the average values.

Statistical Significance

- There are a number of of different tests that is used under different conditions:
  - Two average values: T-test
  - Three or more average values: ANOVA
  - Two average values, not normally distributed: Wilcoxon Signed-Ranks
  - Three or more values, not normally distributed: Kruskal-Wallis
- Likert and Rating scales are typically not normally distributed.

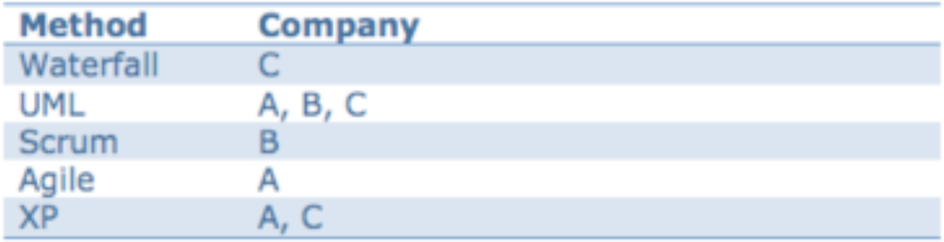
- If you need to do statistical testing on your results, ask your supervisor for help.
- Most tests can be done in the tool JStats:
  - https://sourceforge.net/projects/javastats/

Non-numerical Data

- Data from qualitative methods is a bit more tricky to analyze and present.
- Since non-numerical data is very diverse, you should discuss with your supervisor how to best analyze and present your data.

Non-numerical Data

- Example:
  - Data from a questionnaire asking companies which development methods they use:



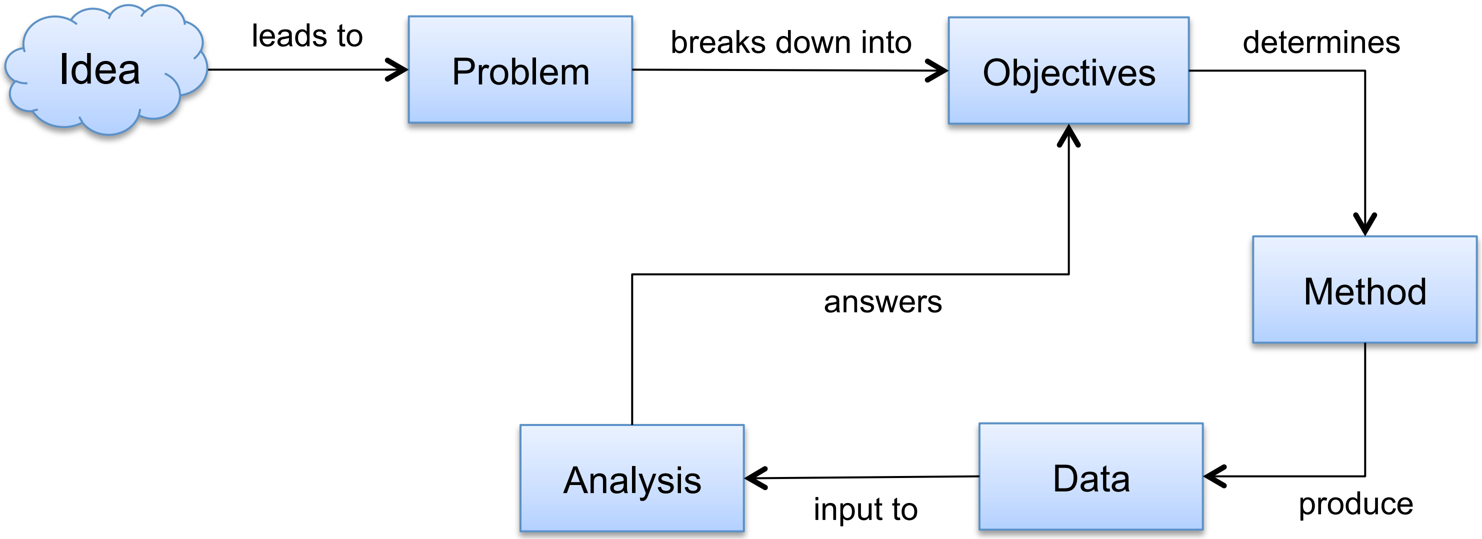
Method	Company
Waterfall	C
UML	A, B, C
Scrum	B
Agile	A
XP	A, C

Validity and Reliability

Validity and Reliability

- To answer your problem you use a method, collect (and usually analyze) data, and draw conclusions from the data.
- It is important that you only draw conclusions that are *valid*, i.e. that is supported by the way you have done your work and the data you have collected.
- Reliability means if others will get the same result as you if they replicate your work.
- Reliability problems can occur if you use the wrong method for data collection.

Summary



The degree project cycle

Questions?