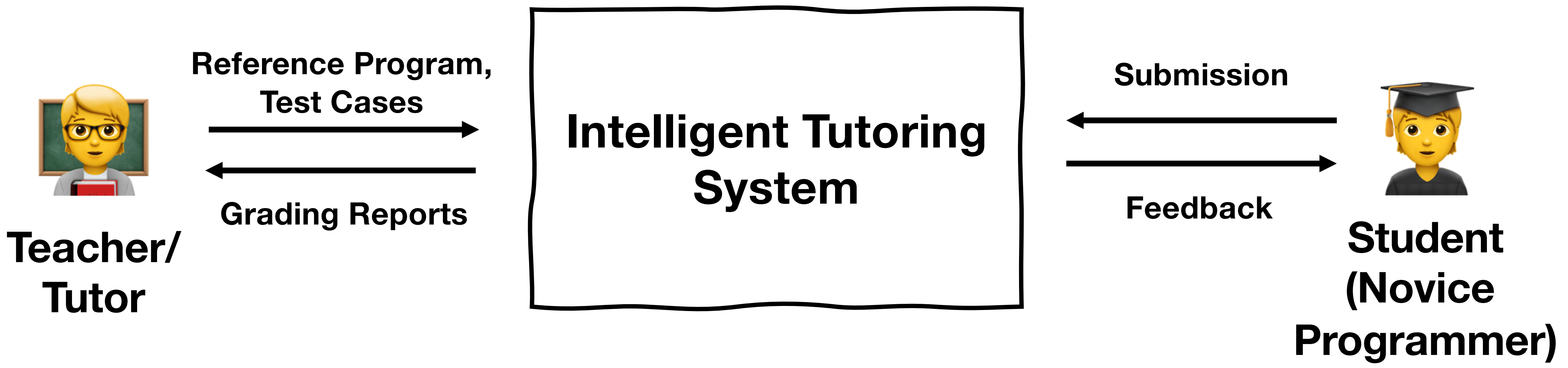
CS3213 Project – Week 1

Introduction to Course Project | 12-01-2022

- ❑ Idea of Course Project
- ❑ Lab Logistics/Amenities
- ❑ Group Selection Process
- ❑ Assignment 1
- ❑ Requirement Elicitation in Week 2

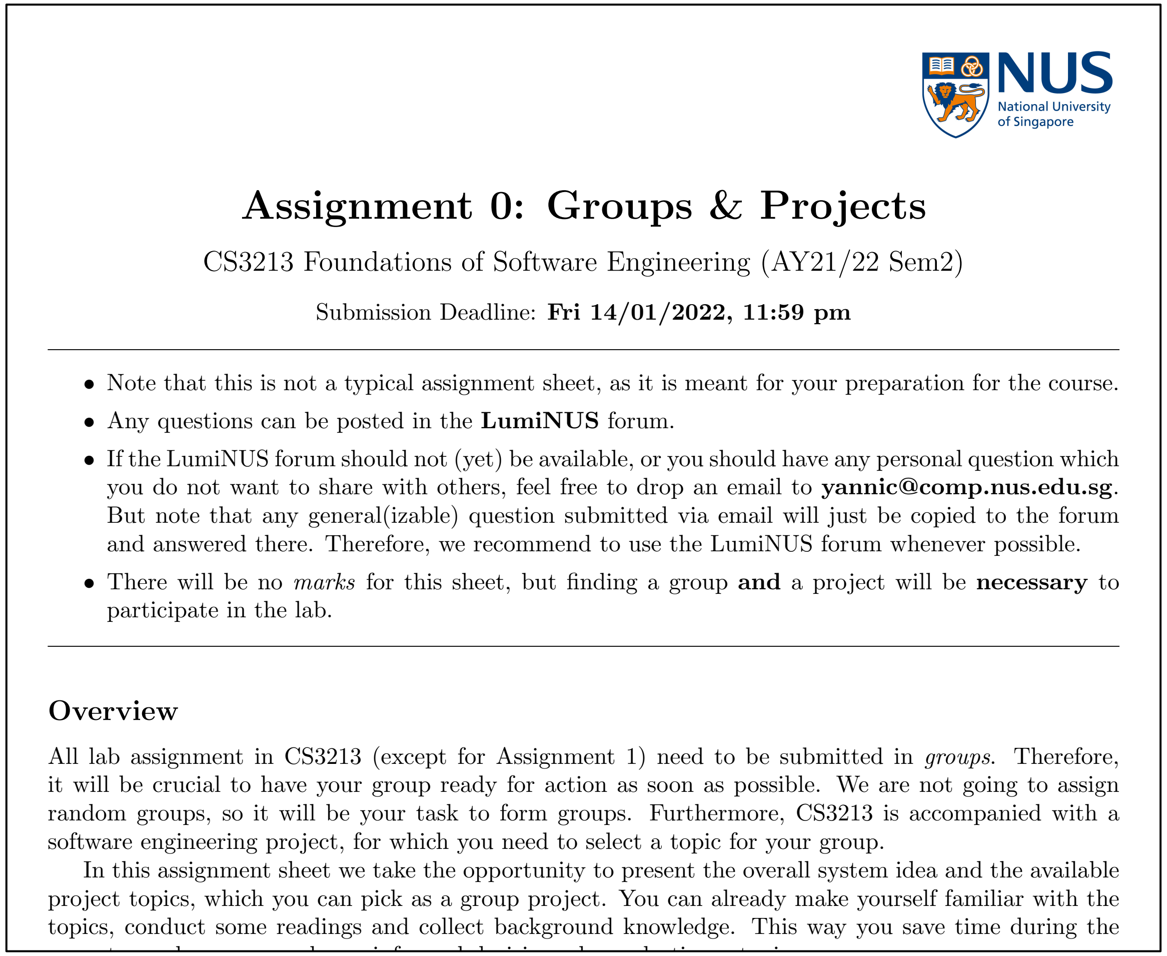
Idea of the Course Project

- ❑ The **lecture** provides software engineering methods, theory, models, patterns, etc.
- ❑ The **lab** provides application of the software engineering principles.
- ❑ Not just any project but related to our **research** including **real customers** at NUS.



Reference Program, Test Cases
Grading Reports
Intelligent Tutoring System
Submission
Feedback
Teacher/ Tutor
Student (Novice Programmer)

Course Project - Topics



Assignment 0: Groups & Projects

CS3213 Foundations of Software Engineering (AY21/22 Sem2)

Submission Deadline: **Fri 14/01/2022, 11:59 pm**

- Note that this is not a typical assignment sheet, as it is meant for your preparation for the course.
- Any questions can be posted in the **LumiNUS** forum.
- If the LumiNUS forum should not (yet) be available, or you should have any personal question which you do not want to share with others, feel free to drop an email to **yannic@comp.nus.edu.sg**. But note that any general(izable) question submitted via email will just be copied to the forum and answered there. Therefore, we recommend to use the LumiNUS forum whenever possible.
- There will be no *marks* for this sheet, but finding a group **and** a project will be **necessary** to participate in the lab.

Overview

All lab assignment in CS3213 (except for Assignment 1) need to be submitted in *groups*. Therefore, it will be crucial to have your group ready for action as soon as possible. We are not going to assign random groups, so it will be your task to form groups. Furthermore, CS3213 is accompanied with a software engineering project, for which you need to select a topic for your group.

In this assignment sheet we take the opportunity to present the overall system idea and the available project topics, which you can pick as a group project. You can already make yourself familiar with the topics, conduct some readings and collect background knowledge. This way you save time during the

❑ **Assignment 0**: Overview about topics and projects

1 Parsing

1.1 C Parser: Develop a parser to transform C programs into a (provided) common data structure based on the control-flow graph (CFG). Additionally, provide a concretizer, which back-transforms the program in the internal common data structure to a C source file.

1.2 Python Parser: Same as 1.1 for Python.

[Coding: High, Theory: Low, Research: -, HCI: -]

2 Aligning / Matching of Programs

2.1 CFG-Based Alignment: Develop an automated alignment of the reference program and the submitted program based on the basic blocks of the programs' control-flow graph (CFG) representation. This also includes the development of an automated mapping for the variables between the reference program and the submitted program.

[Coding: Medium, Theory: Medium, Research: Low, HCI: -]

3 Error Localization / Program Interpretation (1/2)

3.1 C Interpreter: Develop an interpreter that allows to execute a C program with regard to the basic blocks in its CFG. Further, use the provided test cases to identify the root cause of the problem with regard to the basic blocks in the CFG. Implement an error localization that compares the execution traces of a reference program and the submitted program.

3.2 Python Interpreter: same as 3.1 for Python

[Coding: High, Theory: Medium, Research: -, HCI: -]

3 Error Localization / Program Interpretation (2/2)

3.3 Error Localizer: Conduct a literature study on error localization. Develop at least two error localization algorithms from different domains (e.g., statistical fault localization and analysis-based fault localization) for the provided framework and evaluate their efficacy.

[Coding: Medium, Theory: High, Research: Low, HCI: -]

4 Transforming / Repairing Programs (1/3)

4.1 Refactoring-based Repair: Develop a repair workflow that first generates semantic-preserving refactorings of a reference program so that it increases the chances of a structural alignment with a submitted program (see Project 2.1). Afterwards, it uses a matching refactoring to repair the submitted program by mutating program expressions. Strive for a minimal repair which satisfies the failing test case(s).

[Coding: Medium, Theory: Medium, Research: Medium, HCI: -]

4 Transforming / Repairing Programs (2/3)

4.2 Optimization-based Repair: Develop a repair algorithm that (1) generates local repairs at each basic block by matching the submission and the reference solution, and (2) determines the complete repair (i.e., a subset of local repairs) by using some optimization strategy, which minimizes the overall repair cost.

[Coding: Medium-High, Theory: High, Research: Low, HCI: -]

4 Transforming / Repairing Programs (3/3)

4.3 Synthesis-based Repair: Develop a repair algorithm that searches for a repair by synthesizing program expressions. The synthesis will be driven by the available components at the specific source location. It requires a specification inference, which results in a repair constraint.

[Coding: Medium, Theory: High, Research: Medium, HCI: -]

5 Feedback Generation

5.1 Automated Feedback: Develop a feedback mechanism to summarize all obtained results in an appropriate and comprehensible manner for the user. For example, show root causes of the problems and provide explanation by annotating the code.

[Coding: Low, Theory: Medium, Research: Medium, HCI: High]

5.2 Automated Grading: Develop a automated grading mechanism, which is beyond simple output of passing and failing test cases, e.g., it should take into account the necessary effort for fixing the submitted program.

[Coding: Low, Theory: High, Research: High, HCI: Low]

Team

Lecture

Abhik Roychoudhury

https://www.comp.nus.edu.sg/~abhik/

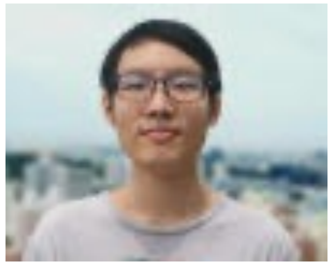
Lab and project coordination

Yannic Noller

https://www.comp.nus.edu.sg/~yannic/

Tutors

Zhiyu Fan



Jon Chua

Guo Ai

Kishore R

Liu Yu

General Setup

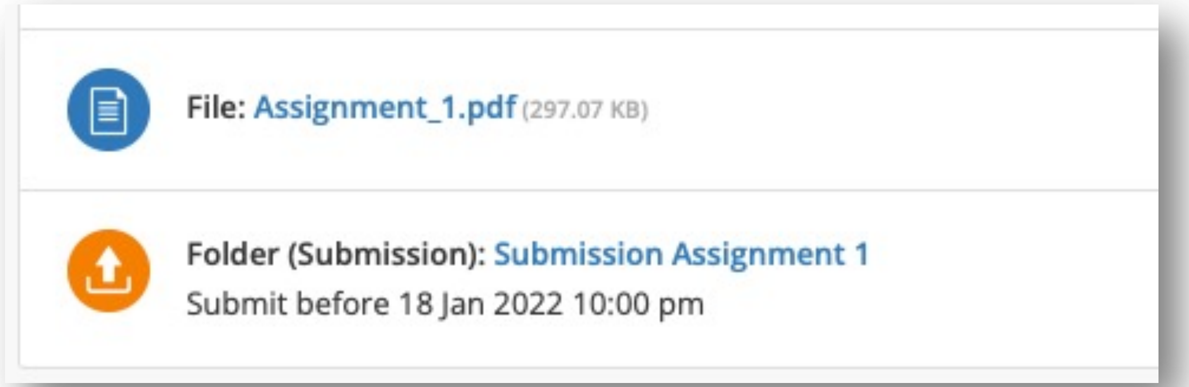
- ❑ After the 2-hour lecture slot, there is a **1-hour slot** with a **general lab session** for all students.
- ❑ Additionally, there are dedicated **tutorial sessions (aka *labs*)** with tutors with a smaller set of students.
- ❑ Until week 5, there is a **weekly assignment** sheet, which needs to be submitted by each group.
- ❑ After week 6, the focus is on project implementation.

Lab Assignments and Timeline

Week	Lab Session	Assignment	Assignment Due
1	Introduction	A1 – Requirements Analysis & Elicitation	Week 2
2	Requirements Elicitation with Customer	A2 – Requirements Modeling	Week 3
3	Requirements Modeling	A3 – Behavioral Modeling & Architectural Drivers	Week 4
4	*ITS Architecture & Projects (CNY)*	A4 – Module Design / Strategy Plan	Week 5
5	Module Structure and Behavior Design	A5 – Project Planning	Week 6
6	Implementation	A6 – Intermediate Deliverable	**Week 7**
R	*Recess Week*	-	-
7	Recap – Requirements & Design	-	-
8	Static Code Analysis	-	-
9	Unit Testing	A7 – Test Case Design	Week 10
10	Fault Localization and Debugging	A8 – Presentation + Final Code	**Week 12**
11	Integration testing	-	-
12	Lab Closing Session	A9 – Final Report	**Week RD**
13	Student Presentations	-	-
RD	*Reading Week*	-	-
E	*Examination*	-	-

LumiNUS Submissions

- ❑ The assignment sheets and lab slides are available in LumiNUS.
- ❑ Each submission will be made by LumiNUS, except for the project code (see next slide).

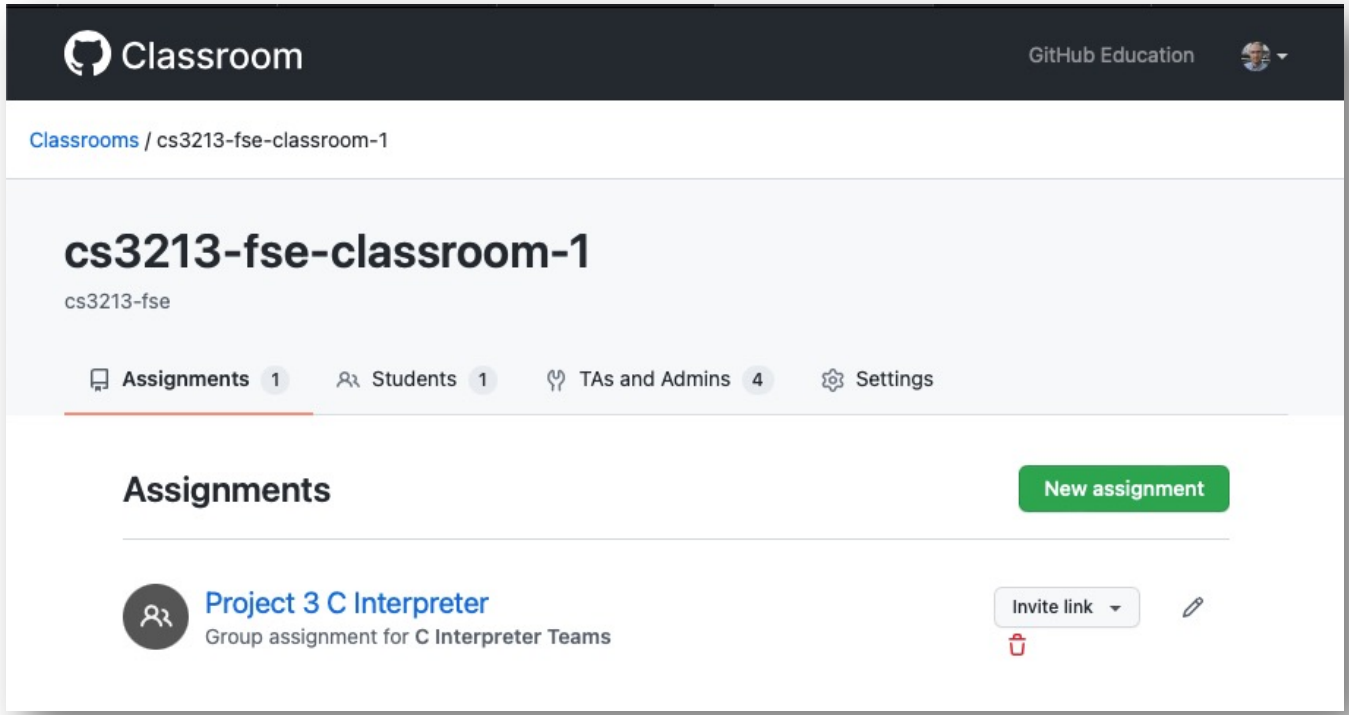


File: Assignment_1.pdf (297.07 KB)

Folder (Submission): Submission Assignment 1
Submit before 18 Jan 2022 10:00 pm

Project Code Submissions

❑ GitHub Classroom with project templates/skeletons and integration and test pipelines.



cs3213-fse-classroom-1

cs3213-fse

Assignments

Project 3 C Interpreter

Group assignment for **C Interpreter Teams**

➪ *More details will follow in the upcoming weeks...*

Group Selection

- ❑ Each assignment (except for the first one) and the project work need to be done in submission **groups**.
- ❑ Each group will have 3-4 students.
- ❑ Coordinate with your fellow students and register in LumiNUS. We provided a Google Sheet[1] for a preliminary selection of groups and projects.

Deadline for group registration in Google Sheet:
Friday, Jan 21, 10 am

[1] https://docs.google.com/spreadsheets/d/15sk6WnvQHTjClhMi_TUuyDkylow6lOmMHVhD5n3Qu-I/edit?usp=sharing

Lab Slots Allocation

- ❑ Make sure that you and your teammates are in the same lab session!
- ❑ Labs happen Thursdays, we have six slots:

Slot Id	Time	Name
T1	10:00 – 11:00	Yannic
T2	11:00 – 12:00	Guo Ai
T3	12:00 – 13:00	Kishore
T4	13:00 – 14:00	Zhiyu
T5	14:00 – 15:00	Jon
T6	15:00 – 16:00	Jon

➪ *The first tutorial starts in week 2, so no tutorials this week!*

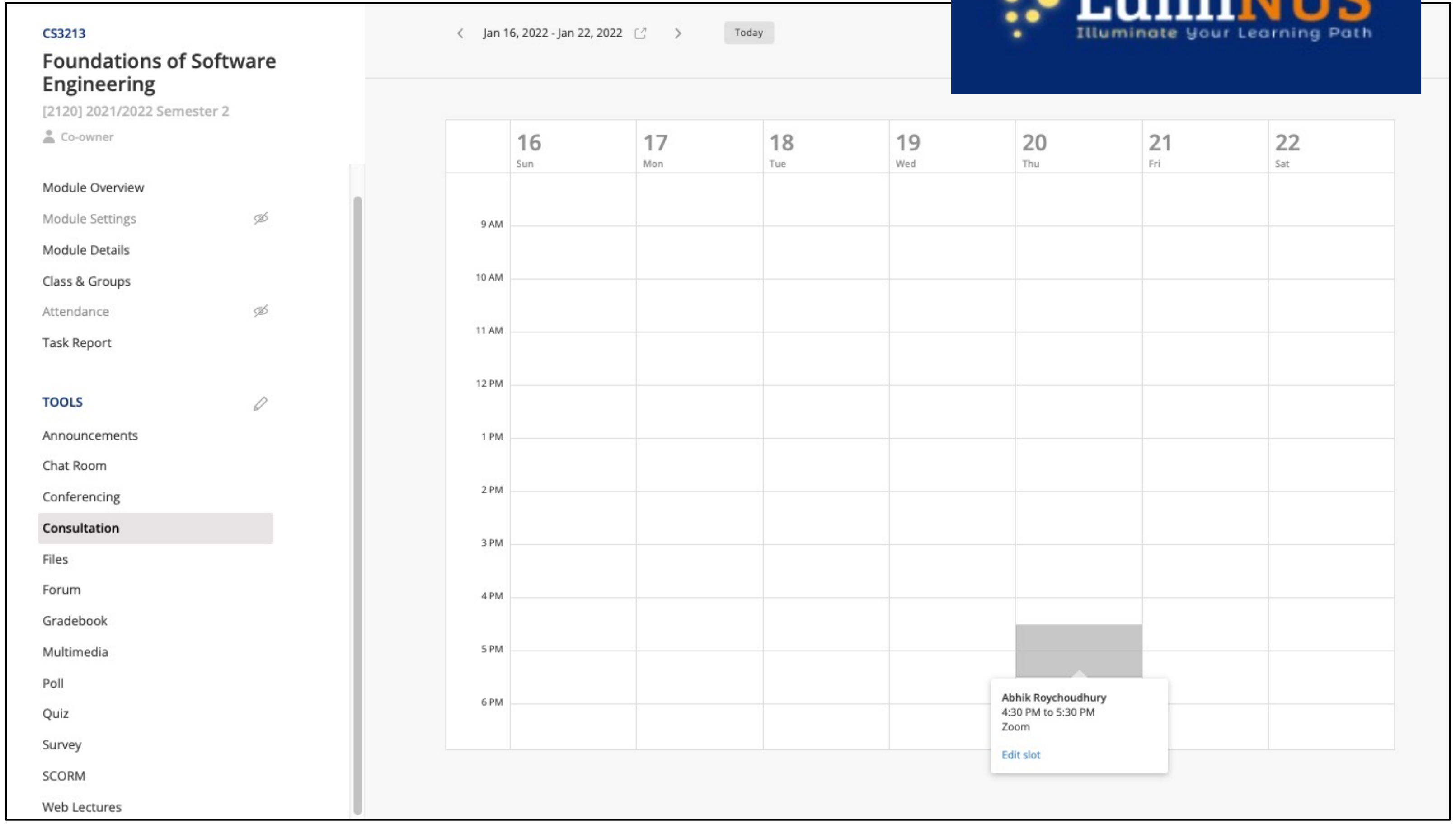
Contacts and Consultation

- ❑ General and assignment specific questions should be always submitted via the **LumiNUS forum**. This way you will get the fastest answer and all students can benefit.
- ❑ For question to your tutorial group you can ask your **tutor**.
- ❑ Otherwise, feel free to contact **Yannic** with all other questions concerning the lab-part of the course.
- ❑ Consider consultation slots we offer every week (next slide).

Contacts and Consultation

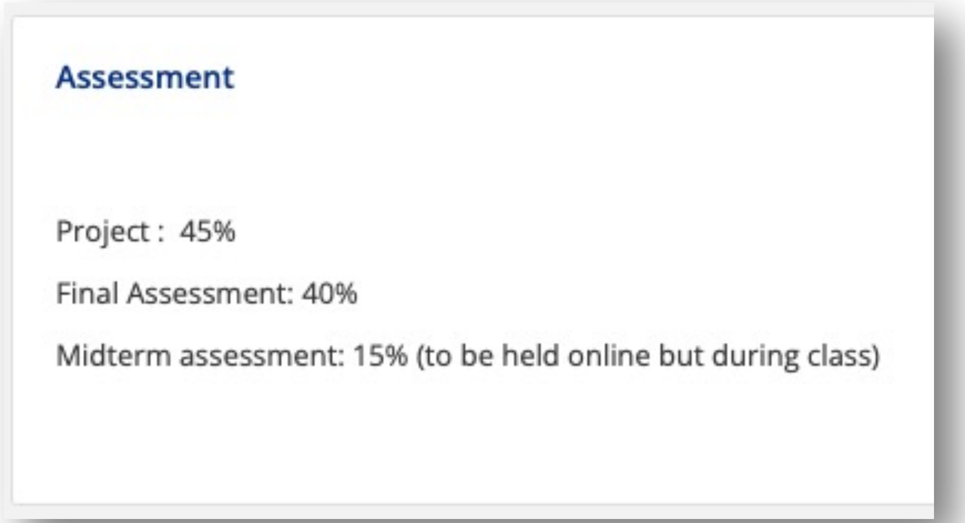
Week	Consultations
1	- *(no consultations)*
2	Lab
3	Lecture
4	Lab
5	Lecture
6	Lab (before long coding period)
R	*Recess Week (no consultations)*
7	Lecture (before midterm)
8	Lab
9	Lecture
10	Lab
11	Lecture
12	Lab (last lab in this week)
13	- *(no consultations)*
RD	Lecture
E	*Examination (no consultations)*

Thursday, 4:30 pm – 6 pm



Abhik Roychoudhury
4:30 PM to 5:30 PM
Zoom

Course Grading



Assessment

Project : 45%

Final Assessment: 40%

Midterm assessment: 15% (to be held online but during class)

https://luminus.nus.edu.sg/modules/76980563-4eb1-48cd-bd13-f3456650b0f1/details/module-description

Lab Grading consists of grading for:	Marks:
6 extra Assignment Sheets (A1, A2, A3, A4, A5, A7)	12
Intermediate Submission of project (A6)	6
Final Report and Presentation (A8+A9)	12
Final Code for Project (A8)	15
Total:	**45**

Aspects for the code submission: *correctness*, *completeness*, *maintainability*

Blue Slide

Do you have any questions so far about the course logistics?

Requirements

"The hardest single part of building a software system is **deciding** precisely **what** to build. No other part of the conceptual work is as difficult as establishing the detailed **technical requirements** ... No other part of the work so cripples the resulting system if done wrong. **No other part is as difficult to rectify later**."

➡ **Requirements Analysis & Elicitation**

Brooks, F. P., "No silver bullet – essence and accidents of software engineering" in IEEE Computer, Vol. 20 (4), 10-19, 1987.

Requirements Elicitation Week 2

- ❑ You can experience requirement elicitation in the 3rd hour of the lecture in week 2 will be an interview session with two real stakeholders:
  - ❑ **Wei Tsang Ooi** (Associate Professor):
    CS1010 - Programming Methodology
  - ❑ **Alan, Cheng Ho-lun** (Senior Lecturer):
    CS 1102S - Data Structures and Algorithms
- ❑ Yannic will act as **moderator**

What needs to be done?

- ❑ **“as-is”** analysis
- ❑ **”to-be”** analysis

- ❑ **Terminology**
  → create a dictionary for special terms?
- ❑ **Documentation**: Traceability of Requirements?

“as-is” analysis

- ❑ Identification of the existing state:
  - ❑ What is the current state?
  - ❑ Why? How did the current state emerge?
  - ❑ What is good about the current state?
  - ❑ What is bad about the current state?

What is the benefit of the ”as-is” state?

It is “real”.

“as-is” analysis – challenges

- ❑ There are **implicit expectations** by the customer for the new system: everything which was acceptable or good in the current system, should remain unchanged or be improved.

Software developers often do no realize that the customer does not primarily wants a **change** but an **improvement**.
→ negligence of the as-is analysis

- ❑ thankless task
- ❑ example: conversation about as-is state for door closing mechanism

You open the **door** at the **main entrance**?

Yes, this is what I told you.

Every **morning**?

Certainly.

Also at the **weekend**?

No, the entrance remains closed at the weekend.

Also at the **public holidays**?

No, obviously it remains closed.

What about if you are **sick** or on **leave**?

Then this is done by Mr. X.

And what about if Mr. X is not **available**?

Then at some point during the morning, a client will knock at the window because he or she cannot enter the store.

What means **morning**? …

“to-be” analysis

- ❑ Collection of **new** requirements
- ❑ Problems?
  - ➢ **unrealistic** expectations by client
  - ➢ **formulation/communication** by customers is incomprehensible by software people
  - ➢ there are multiple stakeholders representing the customer, but **not** every stakeholder has the **same expectations**
  - ➢ the customer/client is **internally** not perfectly organized
  - ➢ the client has desires and goals but no precise requirements
  - ➢ **unspoken/assumed** requirements by clients

What kind of analysis techniques do you know? And what do they target?

Requirement Analysis Techniques

Main Focus

Analysis Technique — “As-Is” State — “To-Be” State — Innovation Impact

Analysis of existent data and documents

Observation

Survey with {closed / structured / open} questions

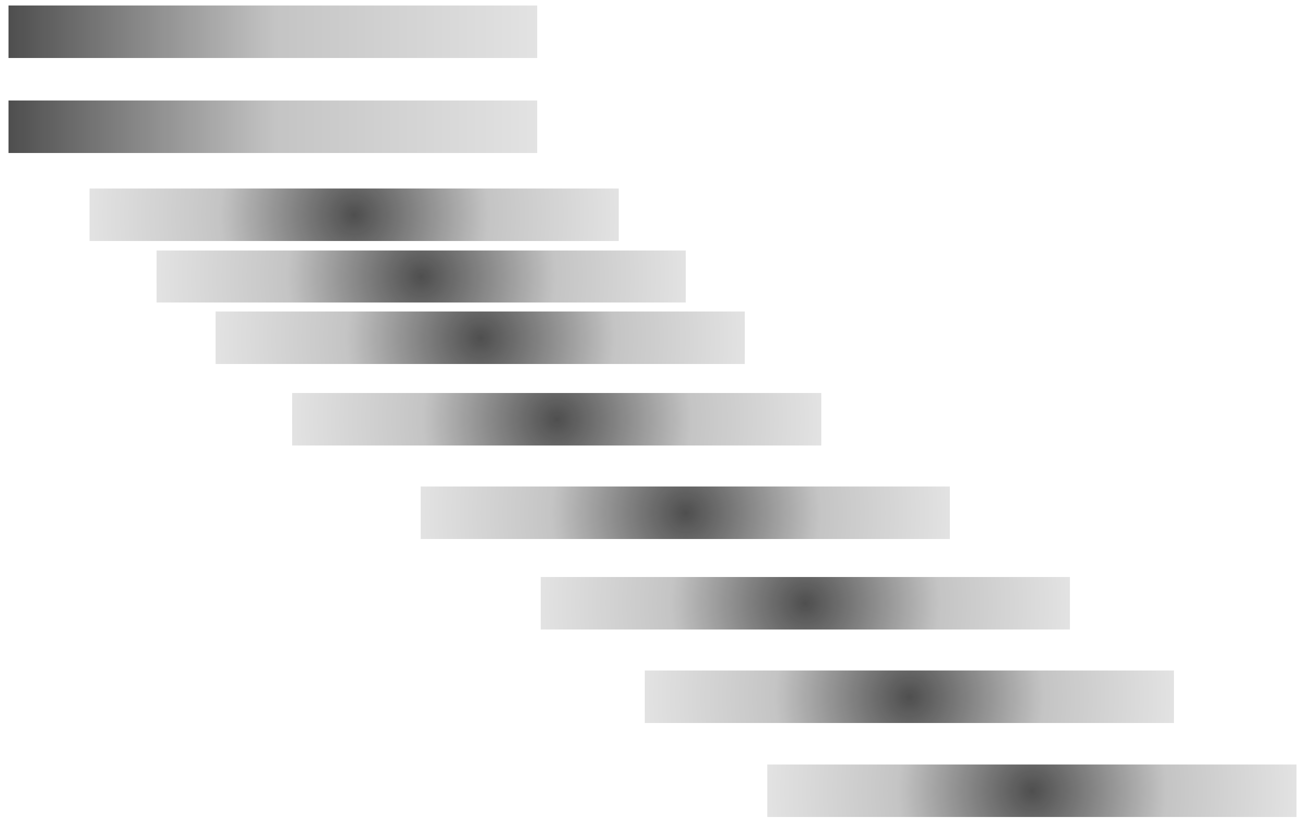
Interview

Modelling

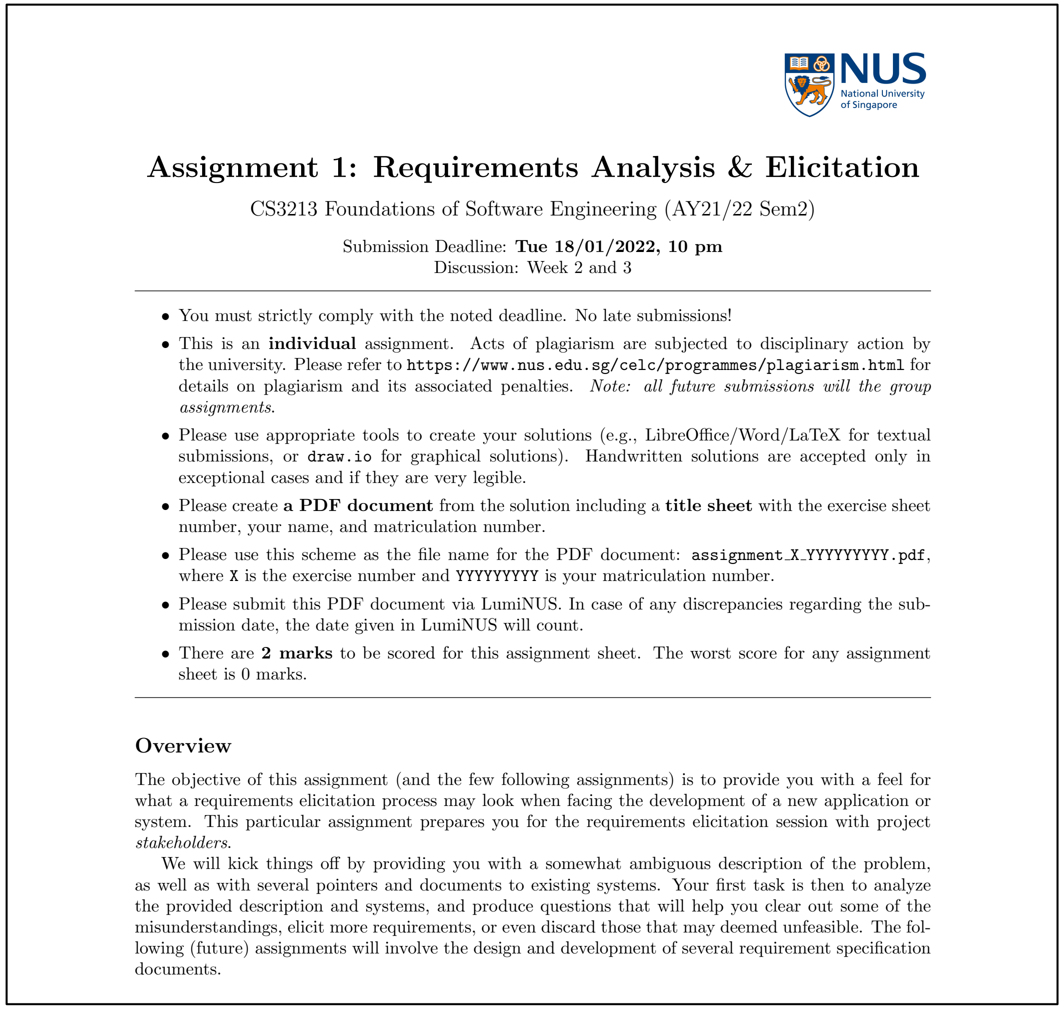
Experiments

Prototyping

Participative Development (wrt analysis)



Assignment 1: Requirements Analysis & Elicitation



Assignment 1: Requirements Analysis & Elicitation

CS3213 Foundations of Software Engineering (AY21/22 Sem2)

Submission Deadline: **Tue 18/01/2022, 10 pm**
Discussion: Week 2 and 3

- You must strictly comply with the noted deadline. No late submissions!
- This is an **individual** assignment. Acts of plagiarism are subjected to disciplinary action by the university. Please refer to `https://www.nus.edu.sg/celc/programmes/plagiarism.html` for details on plagiarism and its associated penalties. *Note: all future submissions will the group assignments.*
- Please use appropriate tools to create your solutions (e.g., LibreOffice/Word/LaTeX for textual submissions, or `draw.io` for graphical solutions). Handwritten solutions are accepted only in exceptional cases and if they are very legible.
- Please create **a PDF document** from the solution including a **title sheet** with the exercise sheet number, your name, and matriculation number.
- Please use this scheme as the file name for the PDF document: `assignment_X_YYYYYYYYY.pdf`, where `X` is the exercise number and `YYYYYYYYY` is your matriculation number.
- Please submit this PDF document via LumiNUS. In case of any discrepancies regarding the submission date, the date given in LumiNUS will count.
- There are **2 marks** to be scored for this assignment sheet. The worst score for any assignment sheet is 0 marks.

Overview

The objective of this assignment (and the few following assignments) is to provide you with a feel for what a requirements elicitation process may look when facing the development of a new application or system. This particular assignment prepares you for the requirements elicitation session with project *stakeholders*.

We will kick things off by providing you with a somewhat ambiguous description of the problem, as well as with several pointers and documents to existing systems. Your first task is then to analyze the provided description and systems, and produce questions that will help you clear out some of the misunderstandings, elicit more requirements, or even discard those that may deemed unfeasible. The following (future) assignments will involve the design and development of several requirement specification documents.

Objectives:

- ❑ provide you with a **feel** for what a **requirements elicitation** process may look when facing the development of a new application or system
- ❑ **prepare** you for the requirements elicitation session with project stakeholders

Task 1: Analyze scenario and prepare brief report about insights

Scenario: "Bob the Tutor"

Bob is a tutor in the programming course for the first-year computer science (CS) students at his university. He had this role in earlier instances of this course, so he knows the challenges ahead of him. It can become quite stressful, also given that this year the number of incoming CS students has increased significantly. As a tutor, Bob does not only have to provide feedback and help the CS students. He also needs to test and grade their submissions. He is unsure how he will cope with so many students and their feedback requests for their programming assignments.

On top of that, Prof. Hopper will be the new lecturer this year for the programming course, and usually, a new lecturer means additions or changes, which cause extra work for Bob. She already informed Bob that this year, the CS students should be able to submit solutions not only in Python but also in the programming languages C and Java. Furthermore, the assignments should no longer be submitted in the form of e-mails to Bob, but via an online submission system. In this way, everybody in the tutor team can keep track of the submissions. Last year, Bob had some issues with his e-mails because some students tried to hijack his account, which resulted in a delicate situation, where Bob was no longer able to check his e-mails, and submissions got lost. Prof. Hopper would like to avoid that in the future. Additionally, she wants to have a weekly PDF report by Bob about the progress in submissions and his grading. Bob will probably start a spreadsheet that contains all this information.

Long story short, Bob now has to prepare additional reference solutions in C and Java, which is not easy for him because he is only an expert in Python. He needs to get familiar with these programming languages to be aware of the typical pitfalls in C and Java to be able to provide meaningful feedback for the students. Usually, Bob takes the submissions, compiles them, and manually runs some test cases. Based on the results, he graded the submissions. He always wanted to automate the build and test process but never found time to figure it out. There are certainly multiple ways to identify the root causes in the programs and also in how to repair the program. But mostly he had no time and just sent the reference solution to the CS students when they had questions for some tutorial exercises. Only on rare occasions, Bob found the time to provide feedback about the fault locations, what the error messages mean, or where to potentially fix the problem. In the past, Bob also offered interactive coding sessions, where he acted as a human debugger who directly gives hints to students as they type their programs. However, this was very time-consuming, and he probably can no longer provide this service to the students. Sometimes, when Bob enjoys his last hot Milo in the late evening, he dreams of a fully automated software system that would help him to cope with all his tutoring tasks. Bob is a senior computer science student, so maybe at some point in the future, he can implement such a system himself...

- ❑ **problem** description
- ❑ "**as-is**"-state
- ❑ "**to-be**"-state
- ❑ the identification **key aspects** for the stakeholders

Task 2: Question Preparation

- You need to **discover** the requirements in the **requirement elicitation** with the **stakeholders**!
- Use scenario and existing documents as baseline.
- Are aspects unclear? Does it make sense?
- Prepare **at least 10 questions**.
- **Everyone** is expected to **ask questions** and **interact** with the customer in a moderated fashion.

How to find good questions?

- ❑ Which topics need to be covered in the requirement specification?
  - ➢ Purpose of the software
  - ➢ Functional Requirements
  - ➢ Requirements to External Interface
  - ➢ Requirements Regarding Technical Data
  - ➢ General Constraints and Requirements
  - ➢ Product Quality Requirements

1. Introduction
- 1.1 Purpose
- 1.2 Scope
- 1.3 Product overview
  - 1.3.1 Product perspective
  - 1.3.2 Product functions
  - 1.3.3 User characteristics
  - 1.3.4 Limitations
- 1.4 Definitions

2. References

3. Requirements
- 3.1 Functions
- 3.2 Performance requirements
- 3.3 Usability requirements
- 3.4 Interface requirements
- 3.5 Logical database requirements
- 3.6 Design constraints
- 3.7 Software system attributes
- 3.8 Supporting information

4. **Verification**
- (parallel to subsections in Section 3)

5. Appendices
- 5.1 Assumptions and dependencies
- 5.2 Acronyms and abbreviations

SRS outline (IEEE 29148:2018)

ISO/IEC/IEEE 29148:2018, ISO/IEC/IEEE International Standard - Systems and software engineering -- Life cycle processes -- Requirements engineering, 2018, DOI: 10.1109/IEEESTD.2018.8559686 → page 67 to 74

Outlook for Assignment 2

- … after the requirement elicitation session you will need to model the the requirements, e.g., with:
  - **Use Cases**, or
  - Behavioural Models like **Activity** Diagrams or **State Transition** Diagrams
- one other way of requirements modelling is called **Goal Oriented Requirement Engineering (GORE)** Modeling

Goal Oriented Requirement Engineering (GORE) Modeling

- ❑ Goal-oriented analysis focuses on the description and evaluation of alternatives and their relationship to the organizational objectives.
- ❑ Goals are introduced for pragmatic or engineering reasons – they help accomplish the objectives of several specific subtasks of RE
- ❑ Definition goal: A goal is a desirable state lying in the future, which is not reached automatically but by specific actions.
    - ❑ a Goal should be proactive.
- ❑ Goals and their dependencies are often described in conceptual models that are based on modeling languages.
- ❑ Definition goal model: “A goal model is a conceptual model. Its goals and decompositions are documented in sub-goals and as necessary further dependencies between (sub)-goals.“

Representations of Goals

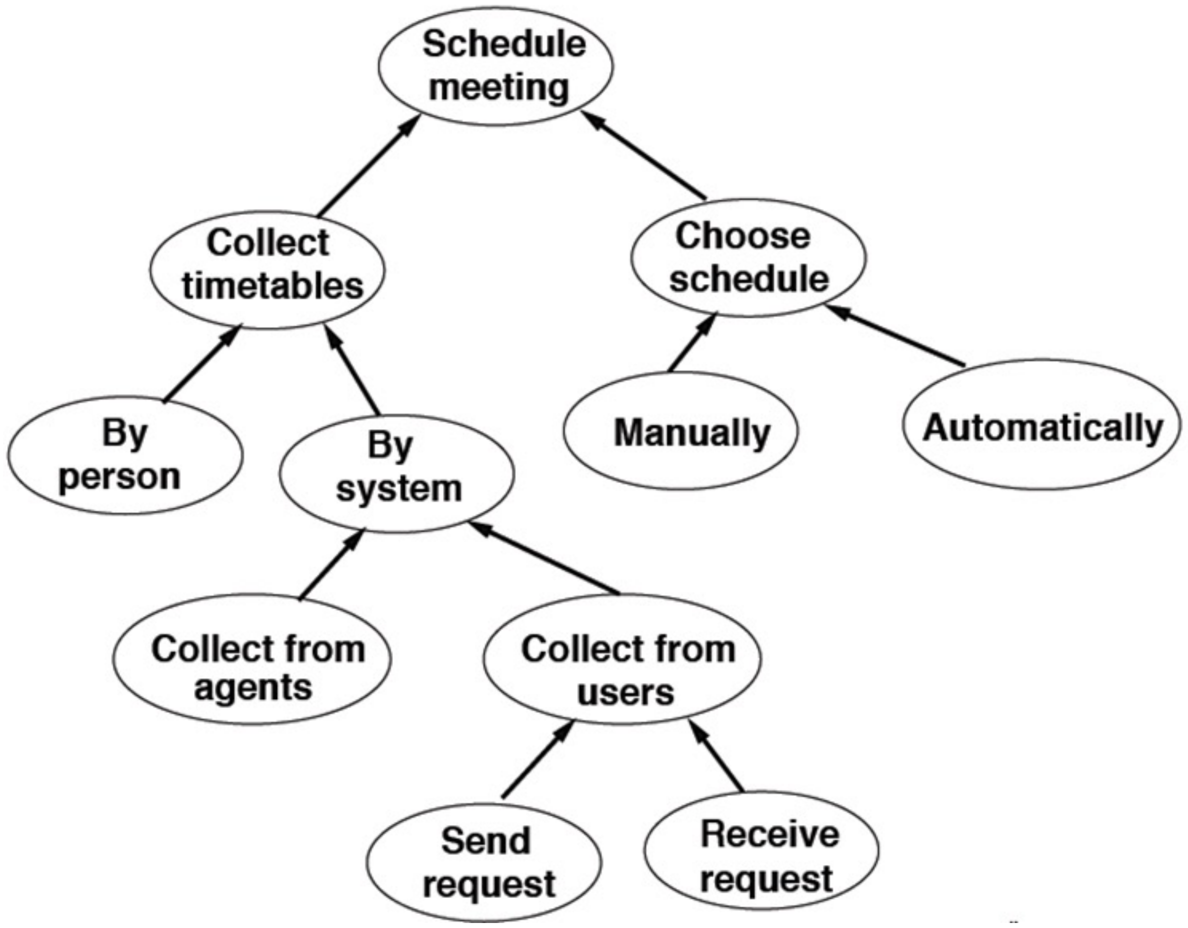
- ❑ **And / OR – Trees**
- ❑ **SIG (Softgoal interdependency graphs)**
- ❑ i-star (i*)
- ❑ GRL (Goal-oriented Requirement Language)

Example

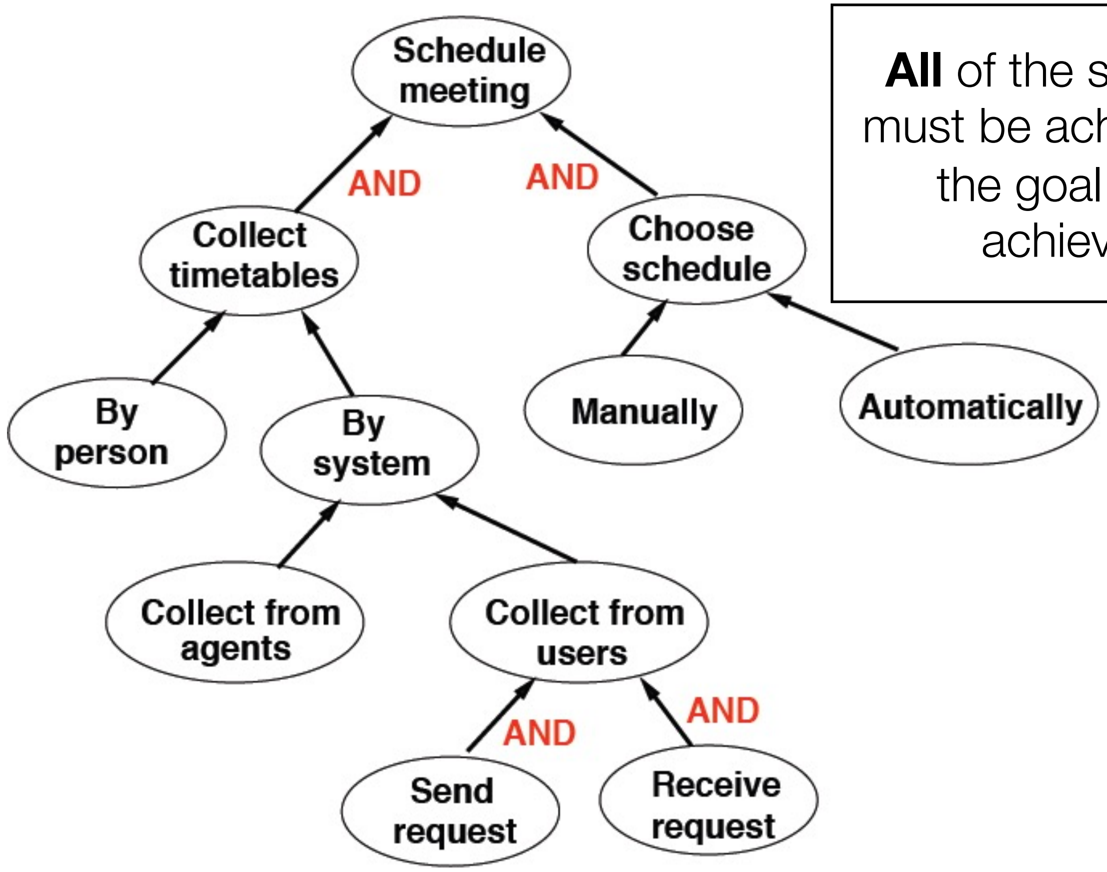
- ❑ Meeting Scheduler
  - ❑ Assists the initiator in scheduling a meeting
  - ❑ Meeting should be convenient for participants
  - ❑ Participants should be available

Based on slides by Betty H.C. Cheng, Professor, Computer Science and Engineering, Michigan State University

Goal Model

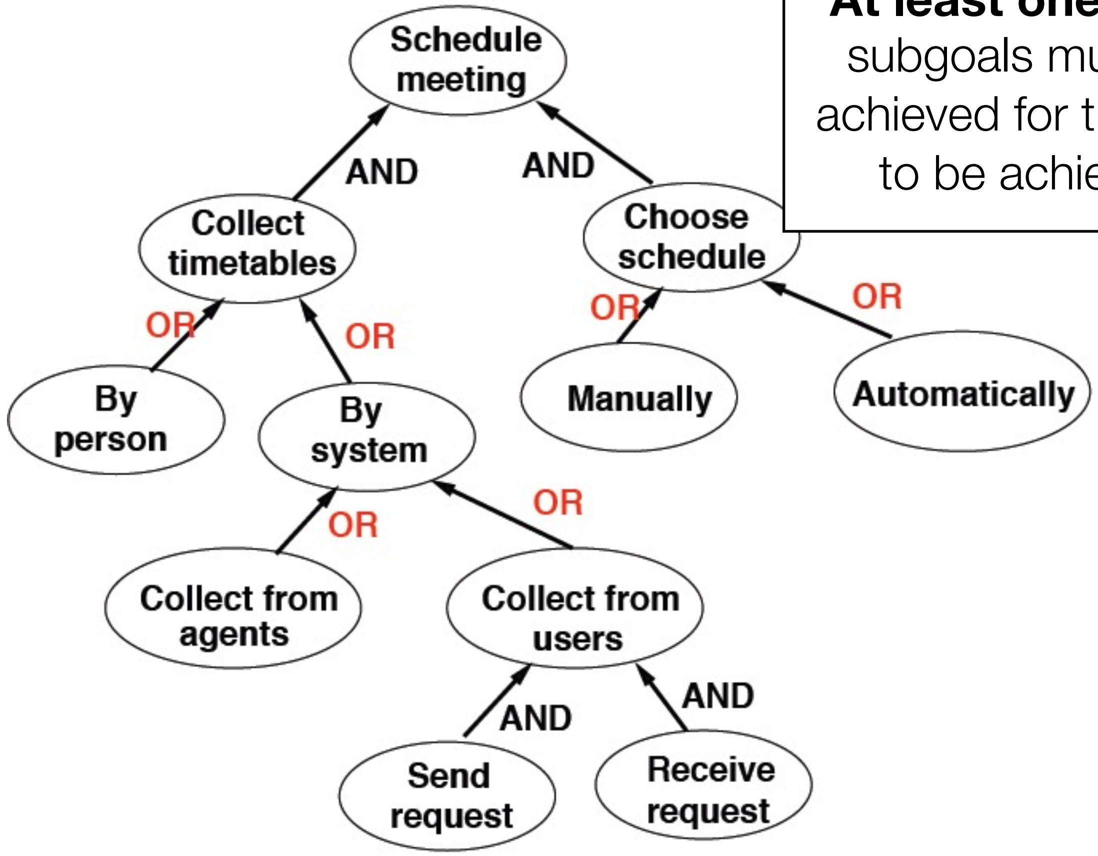

Schedule meeting
Collect timetables
Choose schedule
By person
By system
Manually
Automatically
Collect from agents
Collect from users
Send request
Receive request

AND-Refinement Tree



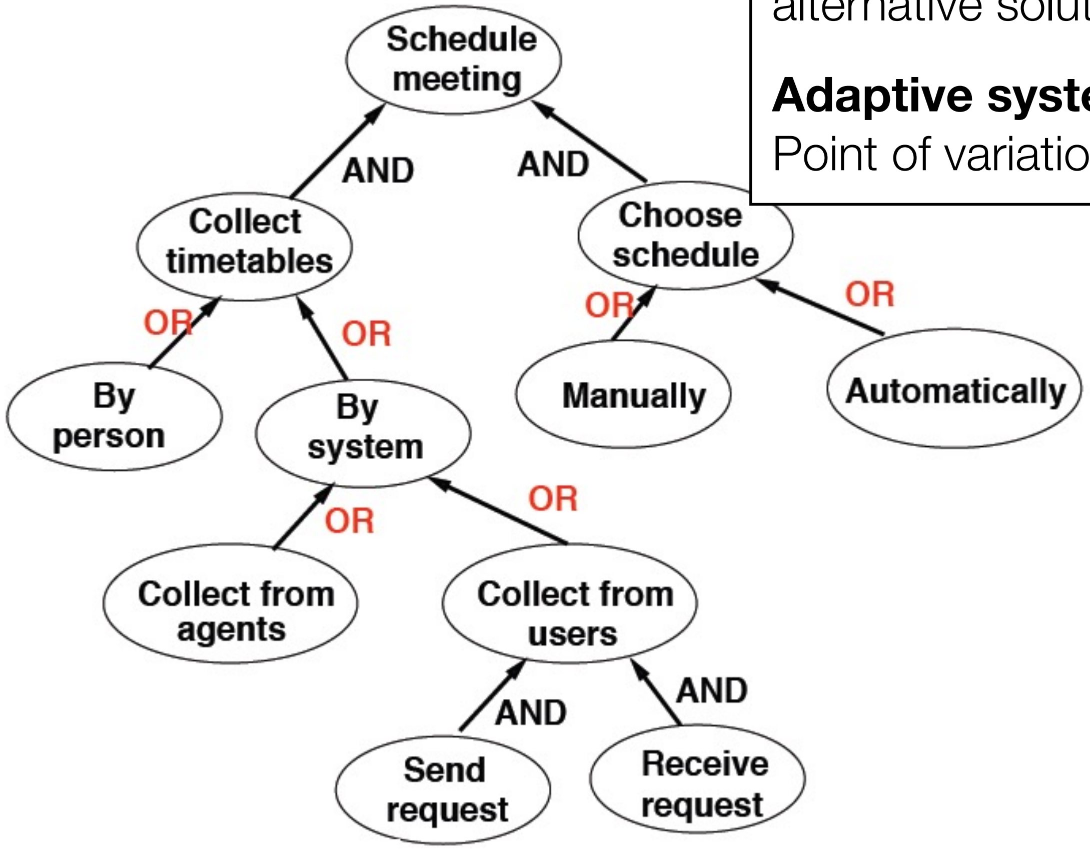
All of the subgoals must be achieved for the goal to be achieved!

OR-Refinement Tree



At least one of the subgoals must be achieved for the goal to be achieved

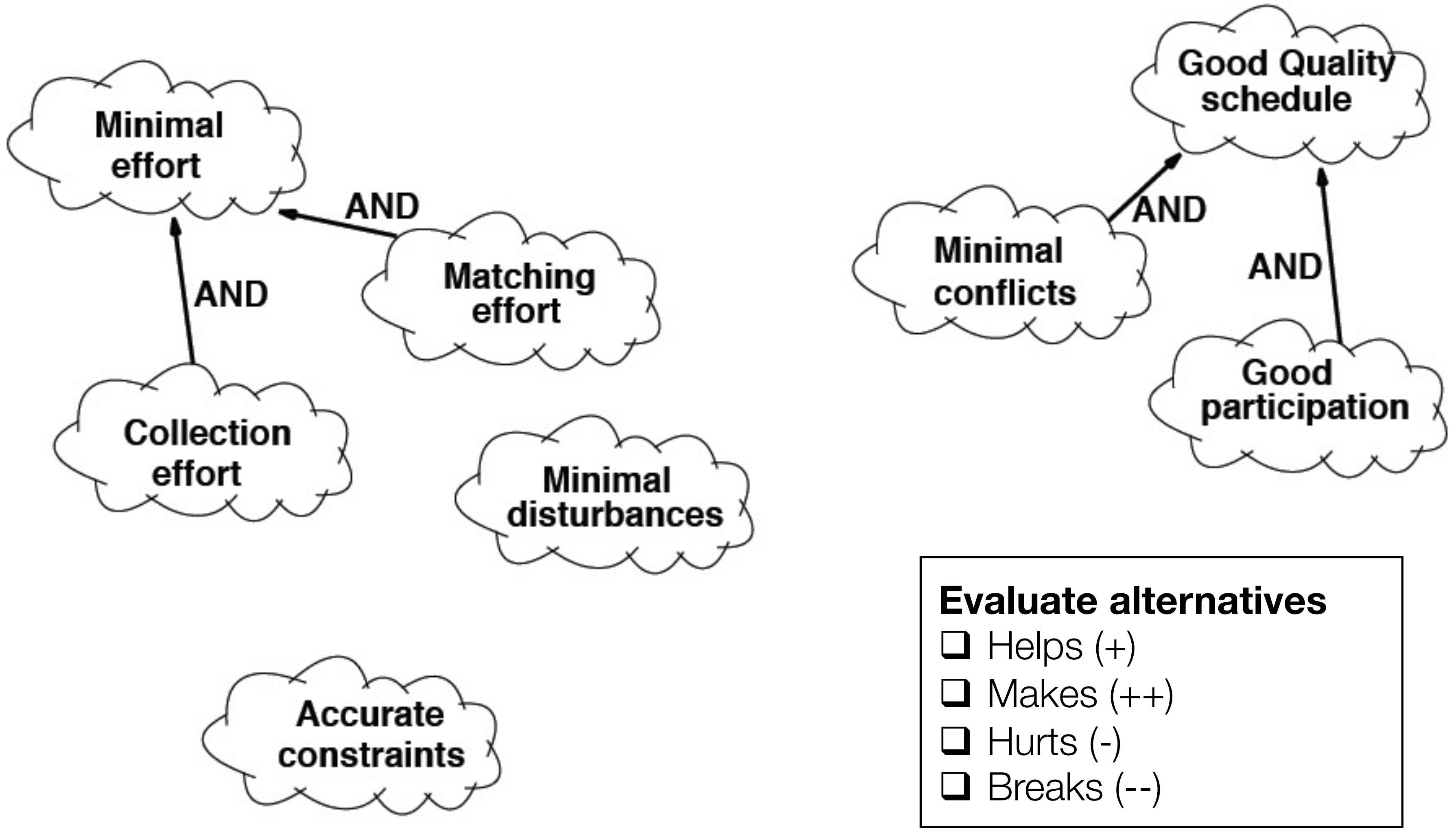
Interpretations of OR Refinements



Static systems – alternative solutions

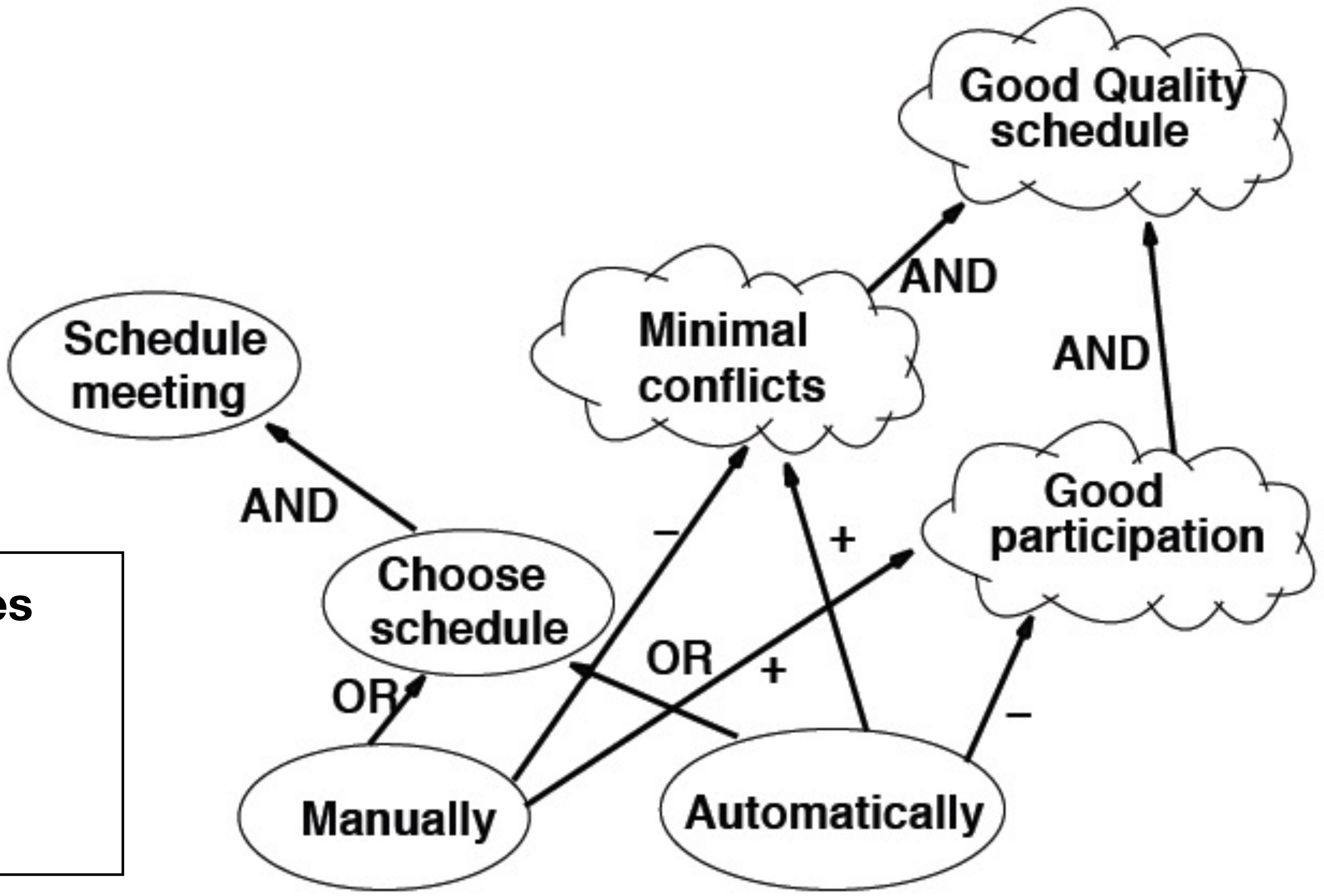
Adaptive systems – Point of variation

Soft Goal Graphs



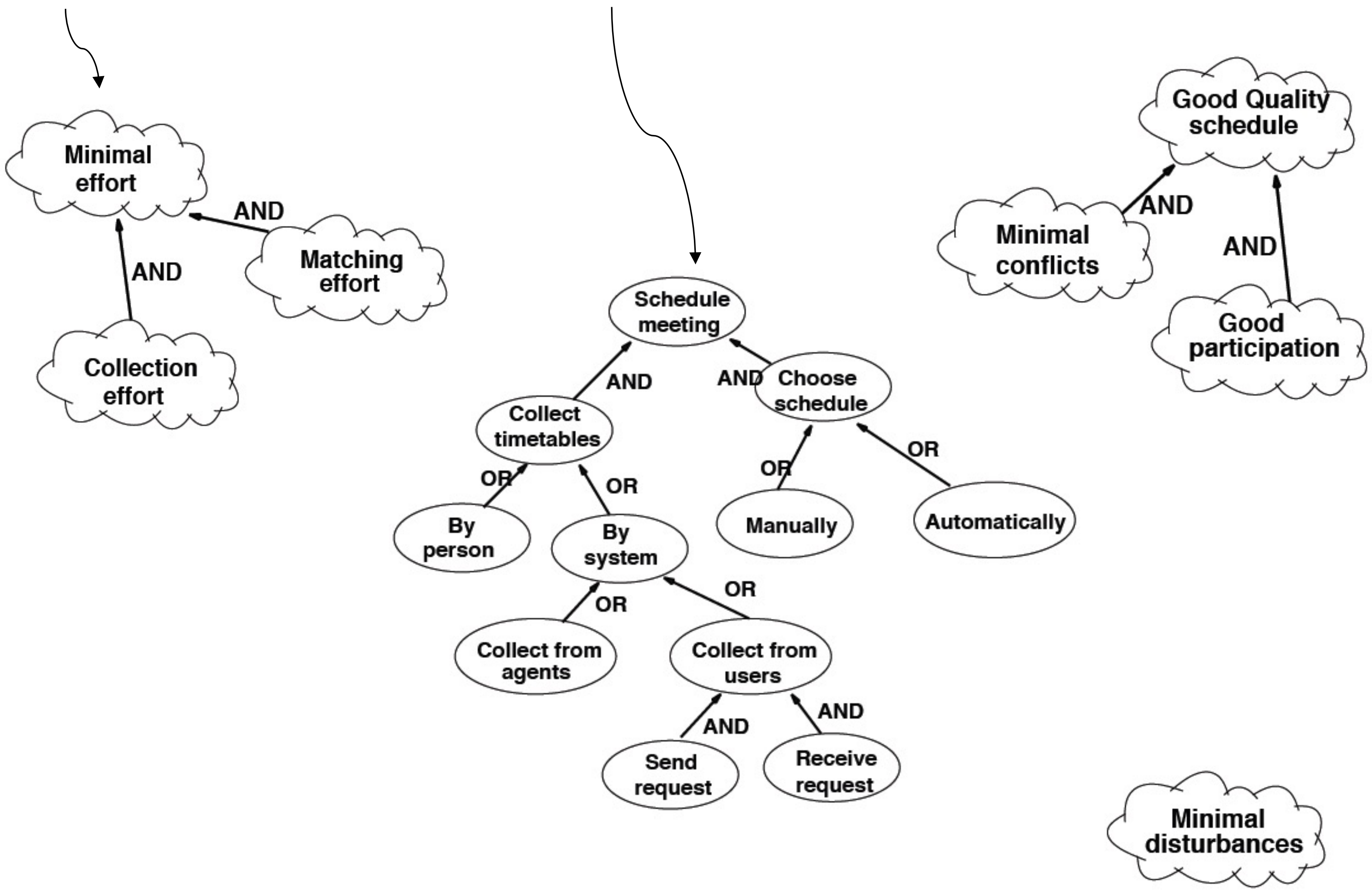
Evaluate alternatives
- ❑ Helps (+)
- ❑ Makes (++)
- ❑ Hurts (-)
- ❑ Breaks (--)

Contributions to Softgoals

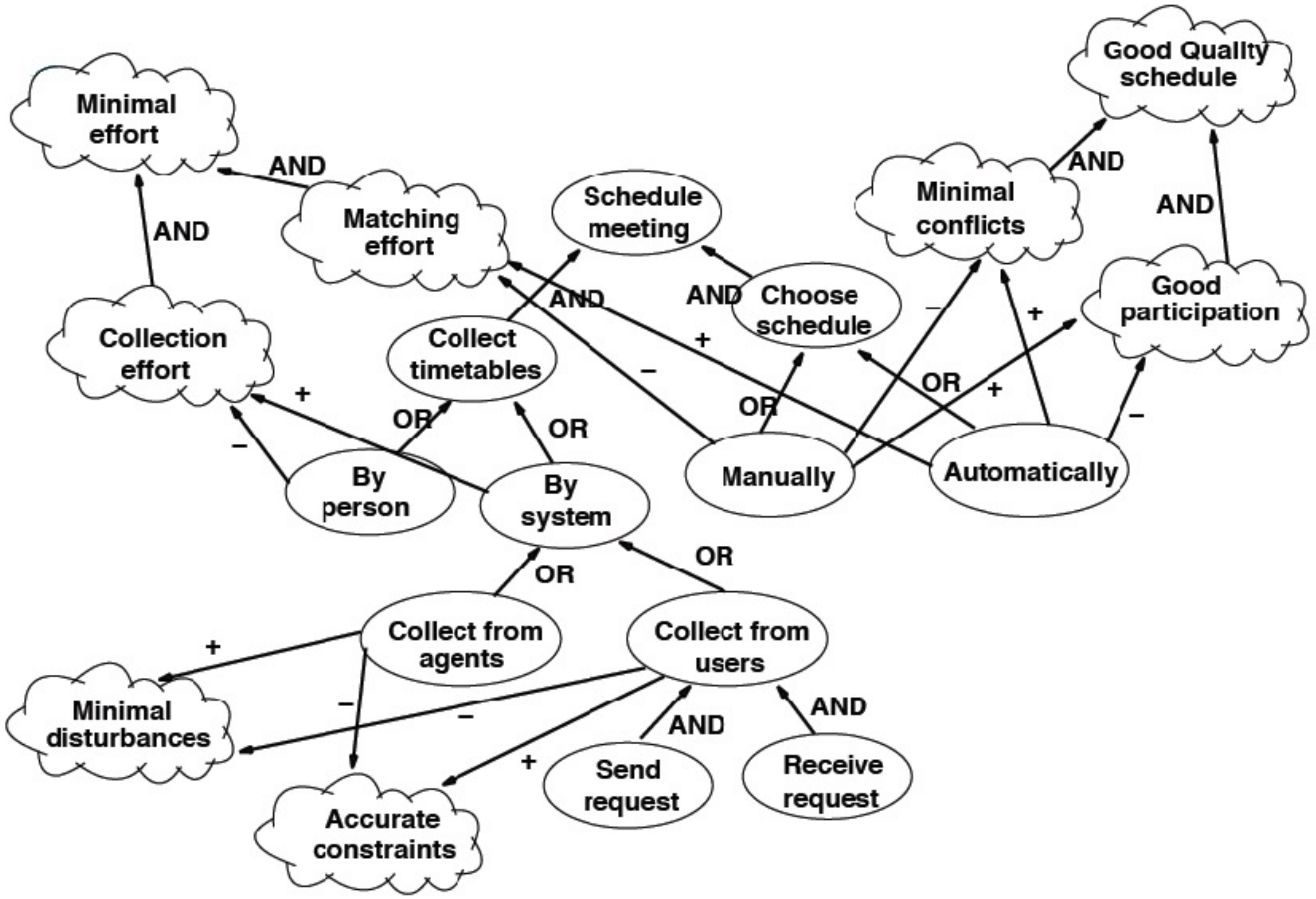


Evaluate alternatives
- ❑ Helps (+)
- ❑ Makes (++)
- ❑ Hurts (-)
- ❑ Breaks (--)

Soft Goals & Hard Goals



How to combine



Any questions about Goals?

Conclusion

- ❑ **Lab** is the practical extension of the lecture. Key aspect will be the **course project**.

Deadline for group registration in Google Sheet:
Friday, Jan 21, 10 am

Next Week:
Requirement Elicitation Session

- ➢ Focus on Assignment 1 and **prepare** for the session!
- ➢ **Everyone** is expected to **ask questions** and **interact** with the customer.
- ➢ Keep in mind that you will have to model the requirements.