

# Project Purpose

The purpose of this project is to give you an appreciation of software architecture in the context of a large software system. You will create a detailed architecture report for a large software system. The report will be updated throughout the term and will be posted online on your group's webpage. At the end of this project, you would have:

1. Gained an overall view of the architecture of a large software system,
2. Recognized the strengths and limitations of the architecture,
3. Verified the architecture against the actual implementation (i.e., conceptual vs. concrete),
4. Proposed an enhancement or a new feature based your gained understanding,
5. Described the steps needed to implement your proposal,
6. Compared alternative implementations,
7. Presented all your findings and proposals to your coworkers and the management team.

# Project Overview

The project will be performed in groups of **six** students. The project consists of **four** deliverables (A0, A1, A2, and A3):

1. A0 – creation of a website about the studied software system.
2. A1 – recovery of the conceptual architecture based on reading documentations.
3. A2 – recovery of the concrete architecture from source code and studying differences.
4. A3 – proposal for enhancements.

You will have to present your findings for A1, A2, A3 online or in class (see Appendix B for presentation guidelines). The specific format of the presentation (online vs. in class) will be announced ahead of time, depending on the pandemic circumstances.

# Project Deadlines

Check course outline for deadline dates for this term.

## **Note:**

1. For each deliverable, a single group submission is required (i.e., only one submission from your group).
2. For deliverables (A1, A2, A3), each member of your group must submit a confidential peer review via onQ 24 hours after the deliverable (see Appendix C)
3. Do not make your report longer than necessary. Write clearly. Organize your report so it is easy to find things in it. Avoid repetition. In general, shorter reports that contain appropriate information are preferred. Your report must not be longer than 15 pages (in the hard copy version), including all diagrams and appendices. Reports are to be interlinked.
4. **Like much work in software development, you are being asked to do more than you have time to do. Part of your job is to choose what you will actually do for each deliverable (hint: make sure you consult the marking scheme for each deliverable).**

# Project Details

## **Assignment 0: Webpage and Links**

For the first deliverable, you are to create a webpage with various links (e.g., tutorials, documents, books, discussion groups, group policy, and source code location) about the studied software system. The webpage should contain sufficient information to help a newcomer to a software project get up to speed.

**Submission Process:** By the deadline date,

1. You should submit the URL of your webpage via onQ.

## **Assignment 1: Conceptual Architecture**

For this deliverable, you will submit a report (10-15 pages long) that gives the abstract (i.e., conceptual) architecture of the studied software system (see Appendix A). Your report should be posted online. It should be web-readable, with appropriate links to web-accessible related content. The report should contain sufficient information to help a newcomer to a software project get up to speed.

Your report should present the conceptual structure of the software system rather than discuss the details of its implementation. When presenting the conceptual architecture, you should include information about:

- What the system does (its functionality) and how it is broken into interacting parts? What are the parts? How do they interact?
- How does the system evolve?
- What is the control and data flow among parts?
- What concurrency if any is present?
- What are the implications for division of responsibilities among participating developers?
- At least two sequence diagrams to explain the flow of noteworthy use cases using the presented conceptual architecture.

**Submission Process:**

1. By the deadline date, you should submit a PDF of your report via onQ.
2. Starting 24 hours after the deadline date (to avoid plagiarism of the current assignment), your report should be accessible on your group's webpage.

## **Assignment 2: Concrete Architecture**

For this deliverable, you will submit a report (10-15 pages long) that gives the as-built (concrete) architecture of the studied software system (see Appendix A). Your report should be posted online. It should be web-readable, with appropriate links to web-accessible related content.

You will need to download from onQ the extracted dependency file of the software system and group the top-level entities of the system into subsystems (and those subsystems into subsystems as necessary). Make sure you describe the process you followed to create your concrete architecture.

In addition to presenting the top-level architecture, your report should delve in the architecture of one top-level subsystems of the studied software system. Each group can choose this subsystem from the list provided on onQ. Your report should describe the used architectural styles and list any noteworthy

design patterns. You need to compare your concrete architecture against your conceptual architecture from Assignment 1 (i.e., perform a reflexion analysis). Make sure you investigate and report the rationales for any discrepancies between both architectures.

Note that you can modify your conceptual architecture to fit your updated understanding, potentially based on another group's conceptual architecture. For example, you might have seen the group's presentation or read the A1 report the group has posted on their website. It is permitted to update one's conceptual architecture based on this information, as long as the report for A2 explicitly describes **how** and **why** your current conceptual architecture is different from the architecture that you submitted in A1.

You should include diagrams of the concrete architecture based on Understand. You might need to redraw the diagrams to make your presentation cleaner and easier to follow. You should present noteworthy aspects of the architecture and its subsystems using sequence diagrams (or state diagrams).

#### **Submission Process:**

1. By the deadline date, you should submit a ZIP file containing a PDF of your report along with your Understand project file via onQ.
2. Starting 24 hours after the deadline date (to avoid plagiarism of the current assignment), your report should be accessible on your group's webpage.

### ***Assignment 3: Enhancement Proposal***

For the final deliverable, you will submit a report (10-15 pages long) that proposes a particular feature or enhancement (in consultation with your TA). The proposed feature or enhancement should not be available in the current version of the studied software system. You must clearly explain the value and benefit of adding this enhancement.

The report should briefly discuss the changes required so the current architecture can support the enhancement. In particular, the report should explain which components and interfaces must change and what should change at the high level. The report should also discuss the impact your architectural change may produce and the potential risks of these changes.

Finally, you should present an SEI SAAM architectural analysis<sup>1</sup> of two different ways to realize your enhancement. Such an analysis consists of:

1. Identifying the major stakeholders of the proposed enhancement.
2. Identifying, for each such stakeholder, the most important non-functional requirements (NFRs) regarding the enhancement.
3. Evaluating for the two suggested ways to realize your enhancement how they impact each identified NFR and stakeholder.
4. Determining which way to realize the enhancement is the overall best one based on the analysis of the previous step.

Your report should be posted online. It should be web-readable, with appropriate links to web-accessible related content. Make sure you use a sequence diagram to explain the flow of at least one use case through the proposed architectural modifications.

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<sup>1</sup> See "SAAM: A Method for Analyzing the Properties of Software Architectures", Kazman et al., ICSE 1994 (<https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.65.8786&rep=rep1&type=pdf>)

**Submission Process:**

1. By the deadline date, you should submit a PDF of your report via onQ.
2. Starting 24 hours after the deadline date (to avoid plagiarism of the current assignment), your report should be accessible on your group's webpage.

# Appendix A: Report Content

Your report should be single space 12 point font. The reports should be 10-15 pages long. The report should include the following information:

**Title:**

About 3 to 6 words making clear what your report is about.

**Authors:**

List of authors, their email addresses, date, etc.

**Abstract:**

About 2/3 of a page giving an overview of the key points and findings in your report. This is targeted to a manager or a developer.

**Introduction and Overview:**

About 1 to 3 pages summarizing the purpose of report, its organization, and its salient conclusions. A person should be able to read just the abstract or just the introduction and have a good idea what is in the rest of your report.

**Architecture:**

Give the overall structure of the studied system, with descriptions of each major component and the interactions among them. These components are to be primarily subsystems or modules, but may also include threads or processes, files, and databases. In your descriptions, concentrate on goals, requirements, evolvability, testability, etc., rather than on lower-level concepts such as classes, variables and control flow. Discuss any parts of the system that are performance critical, i.e., which might not run fast enough. Discuss how the architecture supports future changes in the system.

You should clarify global control flow, such as units of concurrency and method of passing control from one component to another.

Your system's architecture should be easy to understand, with simple interfaces, and modest interactions among subsystems and modules. Clarify the architecture style (in the sense of Garlan and Shaw) that characterizes the overall system and its various parts.

You are not to concentrate on minor components, such as classes and procedures, which are smaller than packages or modules. However, you may wish to discuss important abstractions, patterns, classes, data structures or algorithms that are critical to the success of the architecture.

**Diagrams:**

You should use diagrams that clearly illustrate the structure of your system. You may choose to use various kinds of UML diagrams. Do not give diagrams that are too low level, e.g., do not give diagrams of details within objects, nor within modules. You can use tools such to help you draw diagrams, but this is not required. Do not include diagrams that are difficult to read. **Make sure that all your diagrams have a clear legend explaining the meaning of the various arrows and symbols.**

Use diagrams as needed in your report. You are to include a "dependency diagram", in which the boxes are subsystems and modules, and the arrows are dependencies. A dependency from module M to N

could be due to a call from a procedure in M to one in N, or a reference from inside M to a variable in N, etc. These diagrams can be created using any method you choose.

**External Interfaces:**

List information transmitted to/from the system, such as by Graphical User Interfaces, files, databases, messages or networks. Do not give details such as menus, but rather concentrate on information content. Although information may be stored in a database, the exact form of this data need not be a concern.

**Use Cases:**

Give a small number (at least two) of essential Use Cases which illustrate the use of the system or your proposed feature. Show or explain how each Use Case activates or uses the various major parts of the current or proposed architecture.

**Data Dictionary:**

Include a glossary that briefly defines all the key terms used in your architecture, giving when appropriate, the "type" of the item being explained.

**Naming Conventions:**

List any naming conventions used in the described architecture. Explain any abbreviations that you use.

**Conclusions:**

A summary of your key findings and proposals for future directions.

**Lessons Learned:**

Document any noteworthy lessons: things you would do differently or things you wished you knew ahead of time.

**References:**

List any documents that your reader may wish to or need to read in conjunction with your report. Since the report is to be web-readable, include links to references when appropriate.

## Appendix B: Presentations

As a software architect, you need to have the charisma and communication skills to communicate your architecture and your findings to the developers who will implement it and to your managers to get funding.

In addition you must be willing to:

- take a fresh and unbiased look at your own work,
- get constructive feedback from others and
- backtrack and reconsider.

The presentation of your analysis is your opportunity to showcase your findings and share ideas with your peers. Your target audience is a team of developers who are responsible for the analyzed project and who would implement your proposals.

### **Style**

Each group will be given a 10 mins slot to present their assignment in class or online (depending on pandemic circumstances). The slides must be put online on the group's webpage. Other groups are expected to comment and critique the findings (5 mins).

### **Recommendations**

1. Rehearse and time your presentation ahead of time.
2. Make sure you leave enough time for at least 1 or 2 questions, i.e., finish your talk in 10 minutes.
3. Use slides and make sure you have your architecture diagrams on the slides.
4. Explain and put a diagram legend on your slides.
5. Articulate the principles and key mechanisms used by your group to reach your findings.
6. Present some modeling alternatives that were considered and explain why they were rejected.
7. Highlight any tradeoffs.
8. Be prepared to defend your architecture decisions.
9. Provide constructive feedback to other groups.
10. Document any noteworthy lessons: things you would do differently or things you wished that you knew ahead of time.

# Appendix C: Peer Evaluations of Your Group Members

## ***Why peer evaluations?***

Your group will have to decide how to organize itself. If you are amazingly lucky, your tasks will split naturally into an equal-size task per person, with obvious clean boundaries between them, and the people in the group will have equal skill levels, and everyone will get along so well that you'll want to form a startup company right after exams. More likely, however, you will have to divide labour in some less trivial way, have some people assist others in emergencies, co-ordinate mismatching schedules, and so on.

We expect that all members of your group will receive the same grade for all project deliverables. Because not everything in life works out evenly, we will allow for some accounting of this lumpiness.

We have had some problems with a student not participating very much or even at all in his or her team, expecting that the rest of the team do most or even all the work and he or she gets the same grade as the rest of the team. In an effort to discourage this sort of laziness, we have instituted a way that a student's peer evaluation can affect his or her entire mark for the project: At the discretion of the professor of the course, a student's mark for any project deliverable may be multiplied the percentage that his or her average peer evaluation is of the total possible. Thus, for the final deliverable, if your evaluation is 1 out of a total possible of 5, you may find your mark (out of the 10 possible for the final deliverable) multiplied by 1/5. Moreover, in the extreme case of a student not participating at all with his or her team in a part of the project, the professor may decide to give a 0 (zero) mark to that student for that part of the project. The moral of the story is: *participate, participate, participate!!!*

Therefore, we want each individual to prepare a confidential evaluation of their group members (including themselves). You will prepare three such evaluations, the first will be due within 24 hours after you hand in A1, the second will be due within 24 hours after you hand in the A2, and the third will be due within 24 hours after you hand in the A3. You will submit the evaluations via onQ. **Please send only plain text. No HTML! No Word!**

The group evaluations will help us track the progress of your group throughout the project.

## ***How does it work?***

You are to prepare a short message to be submitted via onQ (*once again, please send only plain text; no HTML! No Word!*). In your message you should clearly indicate your full name, the full names of your group members, and what your group number is.

## ***What should the evaluation look like?***

Prepare a paragraph or two on the contributions of each group member. Try to be as objective as you can. Did they attend all of your meetings? Were they on time for the meetings? Was their work done on schedule/as promised/with due diligence? Did they take on a leadership and/or organizational role? Were they easy to work with? Did their work require extra checking by the rest of the group? Did they stay late when extra effort was required?



Be sure to evaluate yourself as well. Be as honest as you can.

As part of your evaluation, assign each member a numerical grade. **You will be given 5 marks per person in your group to distribute as you see fit, plus one bonus mark if you think it to be appropriate. That is, a group of three will have up to sixteen marks to distribute between the group members.**

### ***How should you distribute the grades?***

Here are some rough guidelines on how you might want to distribute the marks:

- A mark of one or two indicates someone who is an unmitigated disaster. You rue the day they were born, and hope you never end up with someone like this on your team when you work in industry.
- A mark of three indicates someone you really wouldn't want to work with the person again. There are serious shortcomings to their abilities and/or attitude. (S)he is the sort of person you will probably run into in industry, but will try to avoid as much as you can.
- A mark of four means that a group member did reasonable work, but lacking in some area. Their work was OK, but not great, or they weren't serious enough, or ... (S)he is the sort of person with whom you could work without too much trouble, although you wish they were a bit more diligent/easier/committed to deal with/what have you.
- A mark of five indicates a group member did a really fine job on everything that was asked of him/her. (S)he showed up on time to meetings, did their work on time and well, and chipped in as needed. (S)he is the sort of person you would hope to work with in industry.
- A mark of six indicates someone took on a leadership role, did extra work that others did not, perhaps picked up the slack from a member who didn't perform as well, and went well above and beyond the call of duty. You really hope that you'll get at least one person like this on your team when you work in industry.
- A mark of seven indicates someone who leaps tall buildings in a single bound, walks on water, and solves NP-complete problems in linear time. You hope your company has at least one person like this, and that (s)he knows you by name so that there is a chance you might one day get to work on a project with him/her.

**To re-iterate: the maximum number of marks you award must total to no more than  $N*5+1$ , where N is the number of people in your group. You may award fewer if you wish.**

Note that we will not simply take an average of the submissions to determine your mark. Instead, we will use our common sense based on having read all of the evaluations. Thus, if one evaluation seems out of line with the others, it will not unduly influence your grade (so don't just give yourself 7 marks and think we won't notice!).

### ***Notes***

- If you are having serious problems within your group, don't just wait for the evaluations to roll around. Have a meeting with your group and try to address the problems. If that doesn't work, approach the TAs or instructor.
- *Your paragraph(s) of explanation are important. If you do not turn in reasonable justifications of your grades, your own performance evaluation will be a 0 for this assignment.*

- The evaluations are due 24 hours after the major deadlines so that (a) you can get some sleep, and (b) you have a little time to ponder what you want to say. It also allows for some cooling off in case there were some last minute tensions.
- The evaluations will be kept confidential; only the TAs and/or instructor will read them.
- Don't sweat too much about these evaluations. Try to be a good group member and you'll do fine. And remember that in industry, evaluations will be part of your working life.

## **An example evaluation**

Here are some example evaluations for an imaginary programming assignment given on Tuesday and due the following Tuesday.

*Candorsnaffity Hixelbröd was an annoying teammate. He was late for both meetings, and had not looked at the assignment or done any kind of preparation in advance. At the Wednesday meeting, Candorsnaffity offered to do the whole project himself, which the rest of us found very insulting --- maybe he's the best programmer in the class, but the rest of us are still good enough to be successful students. Finally he agreed that he'd do the sushi-ionization module by Sunday afternoon, but he didn't finish it until almost midnight, and the rest of us couldn't combine his work with ours until Monday evening, which meant we had to stay up late to get it done by Tuesday. I'd give him 2 points, except that on Monday evening (after he finally got there), he found all the bugs that the rest of us were missing and got the assignment working with twenty minutes work. He's probably a great hacker when he's alone: honestly, he's the best programmer of the four of us, and we're all annoyed that he was so little help. So he gets 3 points.*

*Prosnitau Sgrachita de la Mnirhoihoi was good, helpful and co-operative. She arranged the first meeting and had worked out a module structure and a division of labour before we met, which we adopted after a bit of bickering. She had her parts of the program done on time, and they only had one small bug in them. And she stayed late to make sure that the integration went smoothly, when we all know she hadn't slept the night before. She gets 6 points.*

*V'snl'chm'tkn!k of the Fortress of Doom (that's me) was an effective worker in this assignment. I had sketched algorithms in advance for two parts, which Wub and I implemented. My code was ready on time, and worked except for one boundary case. Also, I helped Wub with his part of the assignment. I award myself 5 points.*

*Wub Catcherofahundredsquids was willing and enthusiastic. He volunteered for the hardest module, but I had to help him get it working. But he did tell us all on Friday that he couldn't get his part working alone, so at least it wasn't an emergency. He also brought cookies to the Monday meeting, and stayed up extra-late testing the program. I give him 4 points on skill, and 1 more for being helpful: 5 points total.*

[These examples were written by my friend, Dr. Samuel Weber of IBM's T.J. Watson Research Lab near New York City. We apologize in advance if, despite our intentions, these names resemble those of people you know. -- MWG]

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