University of South-Eastern Norway

Faculty of Technology, Natural Sciences and Maritime Sciences
TNM - Campus Porsgrunn

Industrial IT and Automation (IIA) Master Programme

Course IIA1319 - Software Engineering
(Object-Oriented Analysis, Design, and Programming)

Assignment #3

Software design of control systems (A)

Version 0.6

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Chapter 1

Software design of a control system

1.1 Introduction

The focus for this assignment is the design step in Unified Process (UP), designing software for control systems. The first control system is used for controlling the contents of the liquid in a buffer tank. The second control system is used for controlling the temperature of the liquid in a tank. The devices and parameters of interests for both control systems are according to the OODControlProcess application that can be downloaded together with this document.

The goal of the assignment is to practice the usage of patterns and making interaction diagrams, class, and object diagrams. This assignment should be documented in a technical report, including minimum the introduction, results, and conclusion chapters, and must be delivered as a PDF file within the deadline (due time). At least 60% of the tasks must be fulfilled to get the assignment approved, and the assignment must be approved to pass the course. The versions of this document are:

Version	Description	Date
0.1	First version of the document (HiT)	NOS / 2006
0.2	Add more details for the control system	NOS / 2007
0.3	Updated the text for approved / not approved	NOS / 2013
0.4	Minor updates of text and institution (HSN)	NOS / 2017
0.5	Minor updates of text and institution (USN)	NOS / 2020
0.6	Focus more on buffer tanks, minor fixes.	NOS / 2021

1.2 Report introduction (10%)

Download and run the OODControlProcess application, input your name, student number and the semester year, and click the *Get Assignment Information* button. This application will give you a set of parameters that you will use as basis for designing the software of the control systems. See Appendix A.1 for more information about the OODControlProcess application and the devices used. Use the template as basis for your report. The first tasks are:

- Make a technical report and include a screen dump of the **OODControlProcess** application in the introduction section of your report.
- The report should as a minimum include an introduction, result and conclusion chapters.
- Use the template available as the basis for the report.

1.3 Level Control system (55%)

You will do both analysis and design for the first control system.

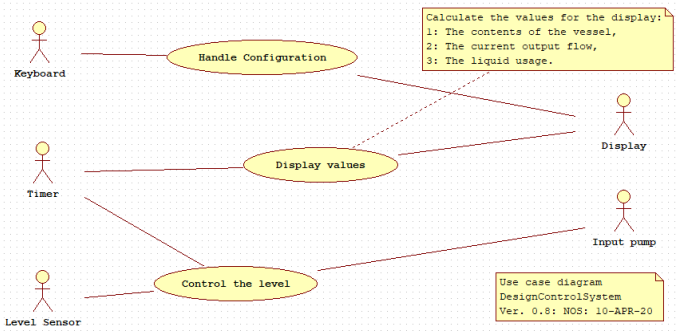

Figure 1.1: The use case diagram for the level control system.

1.3.1 Analysis (15%)

The control system consists of a buffer tank, an input pump, a level sensor, and a display. The shape of the tank is a cylinder with a defined radius and height. The input flow is controlled by the pump trying to keep the level in the buffer tank at a filling fraction of approximately 70%. The output flow is unknown, but the maximum input flow is larger than the maximum output flow. The user wants to get some sort of information of the contents in the buffer tank, the current output flow, and the accumulated usage of the liquid. This information is given in the *OODControlProcess* application.

The use case diagram is shown in Figure 1.1, and shows the actors and the user functions of your system.

Normally the pump control will be non-linear, but assume a linear control signal in this assignment. Make your own control logic, do not use a PID controller. Just remember that the contents should only be approximately so keep your control logic simple. The tasks should at least include:

- Select one use case from the use case diagram in Figure 1.1 and indicate in your own words why you think this use case is the most important use case in the control system.
- Any comments for the analysis step of the software if the relation between the level and volume of the tank is non-linear, regarding the filling fraction?
- Make SSD for this use case.

1.3.2 Design (40%)

You are using the Unified Process (UP) as your development process and should start the design of the most important use case.

- Use patterns to make the interaction diagram of this use case. Indicate which patterns you are using and why you are using these patterns.
- Make a design class diagram from your interaction diagram.
- Explain with your own words what is the most important difference between the SSD and the interaction diagram for this iteration.
- Explain with your own words what is the most important difference between the interaction diagram and the class diagram.
- Explain short in your own words how you will have used the UP to develop this specific software. Focus on this software, not need to waste space nor time on copy the general UP phase information.

1.4 Temperature system (30%)

In your second control system you are going to control the temperature in a set of buffer tanks, using a set of temperature sensors, one mixer and one heater in each buffer tank. Each buffer tank will have different number of temperature sensors. You want to use the same application for all buffer tanks so you will add a configuration section to be able to adjust your application to the settings of each buffer

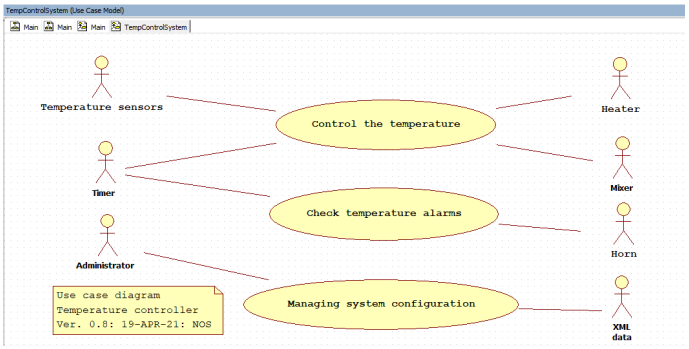

Figure 1.2: The use case diagram for the temperature controller system.

tank. The **OODControlProcess** application will indicate the parameters for one specific buffer tank, these parameters may vary from buffer tank to buffer tank. The use case diagram is shown in Figure 1.2 consisting of a set of user functions. The sequence diagram for the *Control the temperature* use case is shown in Figure 1.3 and the sequence diagram for the *Check temperature alarms* use case is shown in Figure 1.4.

The tasks should at least include:

- Explain shortly with your own words the patterns that you can have used for making these sequence diagrams, and why you will have used these patterns.
- Make a class diagram and an object diagram of the controller system using the information given in the *OODControlProcess* application.

1.5 Conclusion (5%)

Make a short conclusion of the results, and the knowledge of the software that must be implemented for these control systems.

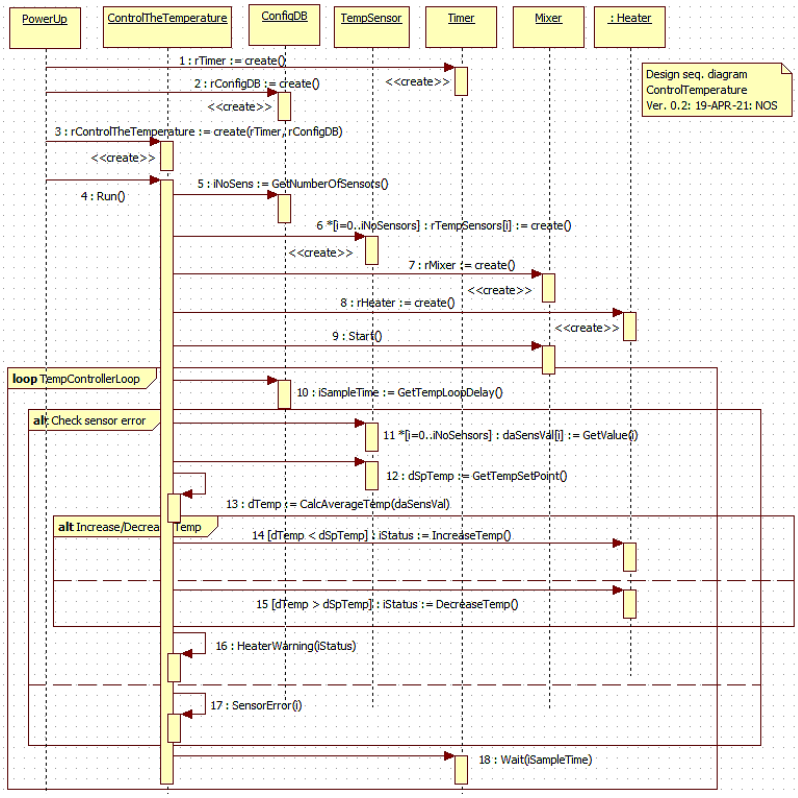

Figure 1.3: An example of a design sequence diagram for the temperature controller.

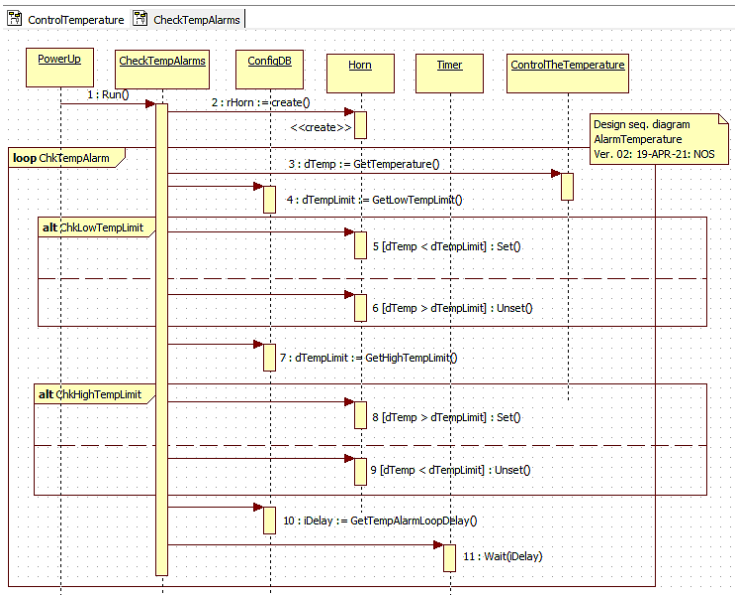

Figure 1.4: An example of a design sequence diagram for the temperature alarm check.

Appendix A

Appendix

The appendix contains some additional information about the OODControlProcess application and the usage of UML diagrams.

A.1 OODControlProcess application

A screen dump of the OODControlProcess application with an example of the information for your exercise is shown in Figure A.1. The information will be different each you are running the application, so please take a screen dump of the application the first your are running the application. A screen dump can be made by using the key combinations <ALT> and <PrintScreen> to copy the image to the clipboard, and use the *paste* option to get the image into your application.

Your level control application is using a sensor for measuring the level, this device can be any of the following types:

1. Radar sensor; this sensor device is using electromagnetic waves to measure the ullage in the buffer tank. The ullage is the distance of the vapor space, the distance from the top of the buffer tank to the liquid level.

2. Contact radar sensor; this sensor device is using a rod or cable for electromagnetic waves to measure the ullage in the buffer tank. The ullage is the distance of the vapor space, the distance from the top of the buffer tank to the liquid level.

3. Ultrasonic sensor; this sensor device is using ultrasonic waves to measure the ullage in the buffer tank. The ullage is the distance of the vapor space, the distance from the top of the buffer tank to the liquid level. The most used device for liquid level measurement.

4. Laser sensor; this sensor device is using light beams to measure the ullage in the buffer tank. The ullage is the distance of the vapor space, the distance from the top of the buffer tank to the liquid level.

5. "Bubble system" sensor; this sensor device is using the pressure of air to measure the level in the buffer tank. The sensor is located at the bottom of the buffer tank and is measuring the level of the liquid. A very cheap liquid level measurement system.

6. "Clamp-on" ultrasonic sensor; this sensor device is using ultrasonic waves to measure the level in the buffer tank. The sensor is located at the bottom of the buffer tank and is measuring the level of the liquid.

The Output flow period will indicate the volume flow for the last period, in this example the volume flow for the last day.

The coding in the design sequence diagrams in Figures 1.3 and 1.4 is based on the upper camel case style and a programming style of the author, you are free to use your own coding style for these diagrams.

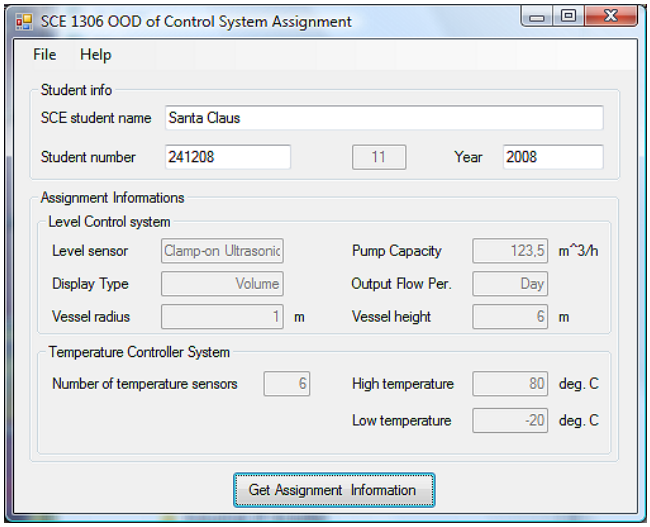

Figure A.1: A screen dump of the OODControlSystem application with a set of assignment information.

A.2 UML diagrams

UML diagrams can be made in any applications or by hand, but remember that these diagrams are part of the documentation and should be clear and easy to understand. Any information about the UML diagrams can be found in the text books (Larman 2002), (Larman 2005), (Manassis 2004) and (Fowler & Scott 1997) or in the lecture notes (Skeie n.d.*a*) and (Skeie n.d.*b*).

Bibliography

Fowler, M. & Scott, K. (1997), *UML Distilled: Applying the Standard Object Modeling Language*, Addison-Wesley, USA.

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Manassis, E. (2004), *Practical Software Engineering: Analysis and Design for the .NET Platform*, Pearson Education, Inc, Boston, USA.

Skeie, N.-O. (n.d.*a*), 'IIA1317: Object-oriented analysis, design, and programming', Lecture notes for the master course IIA1317 at the University College of Southeast Norway (USN) (and SCE1306 at the Telemark University College (TUC)). The Unified Process (UP) as the software process, the Unified Modeling Language(UML) for Object Oriented Analysis and Design, and the C-Sharp programming language for implementation.

Skeie, N.-O. (n.d.*b*), 'IIA1319: Software engineering', Lecture notes for the master course IIA1319 at the University of South-Eastern Norway (USN) (same as for previous IIA1317 and SCE1306 courses). The course uses the Unified Process (UP) as the software process, the Unified Modeling Language(UML) for Object Oriented Analysis and Design, and the C-Sharp programming language for implementation.