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Advanced Topics in Software Architecture (E23)

Evaluating Software Architectures 2

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Agenda

→ Follow-up on midway evaluation
→ Danish student survey
→ Evaluating Software Architectures - 2
→ Exercise

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Where are we?

→ Use cases defined
→ System structure determined
→ Message bus(ses) considered
→ Patterns applied
→ Programming languages considered
→ Databases considered
→ System for experimentation created and run -> ready for experimentation

→ Next:
  → Patterns (lecture 6)
  → Analytical Architecture evaluation (lecture 6)
  → Consider and design experiment (lecture 7)
  → Peer review (lecture 8)
  → Presentation of architectural experiment (lecture 9)
  → Work with experiments and paper (lecture 10-12)

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Learning Objective

→ Describe the architecture of software systems associated qualities
→ Analyze and specify architectural requirements for software architecture
→ Describe advanced software architecture topics to support software architecture processes and modeling
→ Analyze existing software architectures and identify architectural problems
→ Ability to analyze and document software architectures and motivate the usage of adequate software architectures to obtain relevant quality attributes

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Evaluation follow-up

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→ In general most things seem to be working well (but there could be more concrete examples)

→ Below some of the things we can try to improve on or discuss:

→ What do you mean by ”advanced”?
→ If not the I4.0 domain – what could be better – and why?
  → Alternatively – how could it be better introduced?
→ Creating architecture in groups is difficult
→ The exercise is too broad for some - but others find it inspirering for discussion architecture.
→ The relation to the course on the bachelor is tricky
→ Production emulation – how should it be done?

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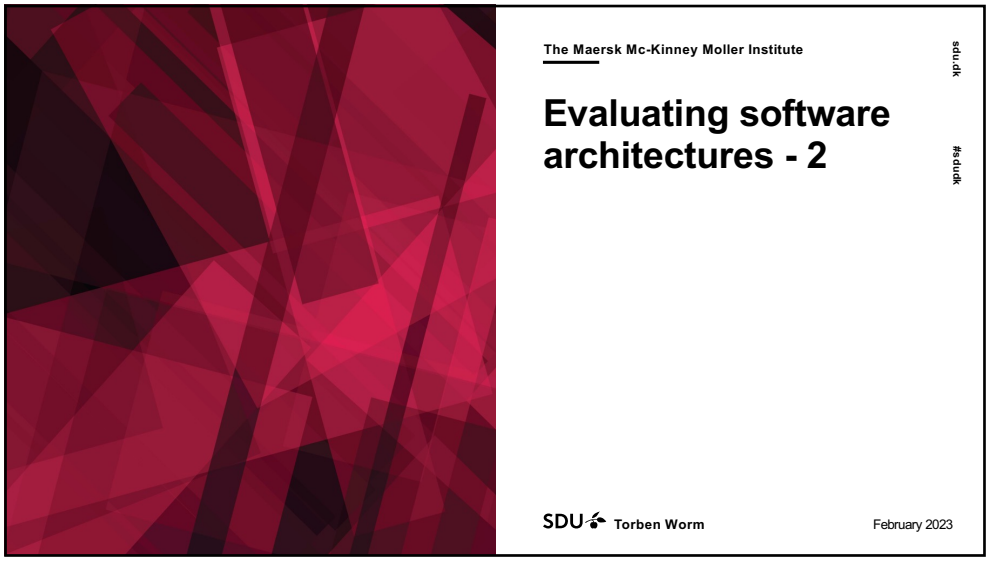

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When should the architecture be evaluated

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- → Early
  - → Discovery review
- → Late
  - → Hold an evaluation when development teams start to make decisions that depend on the architecture and the cost of undoing those decisions outweigh the cost of holding the evaluation

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Mini – Architecture Analysis

1. Review essential use cases (from your assignment)
2. Review your quality attributes
3. Review your architecture
4. Construct (if you didn't in the previous exercise) QA Utility Tree
5. Analyze architectural approaches
6. Capture results
7. Iterate if necessary

→ But can we do more than "just" analyse?

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Experiments

→ Experiments are launched when we want control over the situation and want to manipulate behavior directly, precisely and systematically

→ More than one treatment to compare the outcomes

→ Human-oriented, e.g. applying different inspection methods to the same code
→ Technology-oriented, e.g. applying different tools to the same object

→ The strength of an experiment is that it can investigate in which situations the claims are true and they can provide a context in which certain standards, methods and tools are recommended for use

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What can experiments be used for?

→ Experiments are appropriate to investigate different aspects, including:

→ Confirm theories
→ Confirm conventional wisdom
→ Explore relationships
→ Evaluate the accuracy of models
→ Validate measures

Table 2.2 Research strategy factors

Factor	Survey	Case study	Experiment
Execution control	No	No	Yes
Measurement control	No	Yes	Yes
Investigation cost	Low	Medium	High
Ease of replication	High	Low	High

[Wohlin, 2016]

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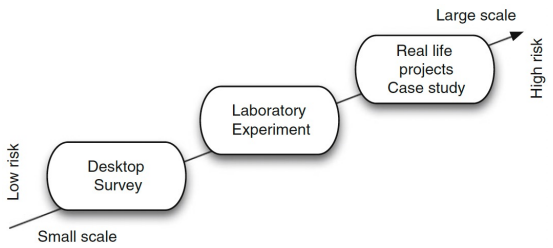
Surveys, experiments, and case studies



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Measurements

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→ "You cannot control what you cannot measure" – Tom DeMarco

→ But what is (a) measure(ment)?

→ "Measurement is the process by which numbers or symbols are assigned to attributes of entities in the real world in such a way as to describe them according to clearly defined rules."

→ A measure is the number or symbol assigned to an entity by this relationship to characterize an attribute.

→ A measure must be valid both analytically and empirically.
  → Analytical validity of a measure relates to its ability to capture accurately and reliably the item of interest.
  → Empirical validity (sometimes referred to as statistical or predictive ability) describes how well, for example, a score correlates to something measured in another context.

→ Without measurements, it is not possible to have the desired control and therefore an empirical study cannot be conducted.

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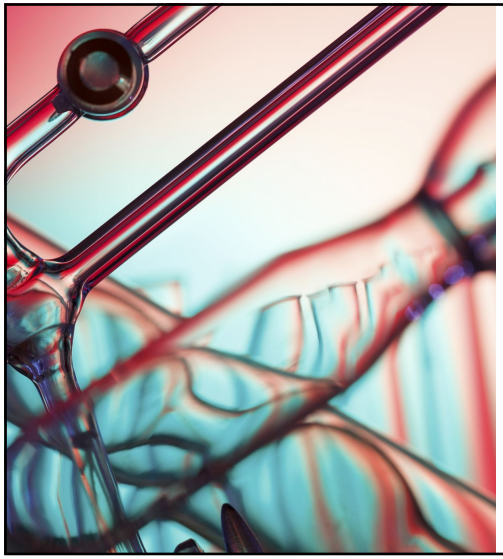

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Experiment

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→ Theory or Hypothesis
→ Cause and effect relationship
→ Experiment to test the theory or hypothesis
→ Test relationship between treatment and outcome
→ Be able to draw conclusions

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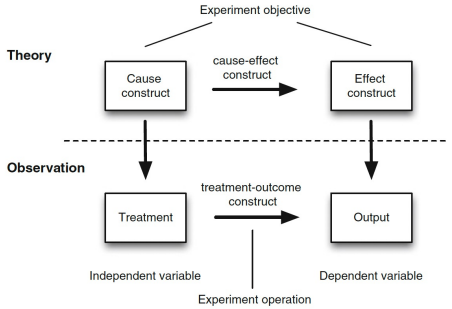
Experiment principles



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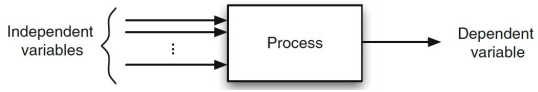
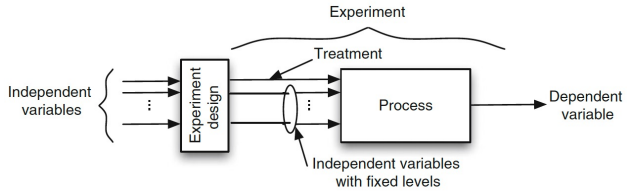
Dependent and independent variables





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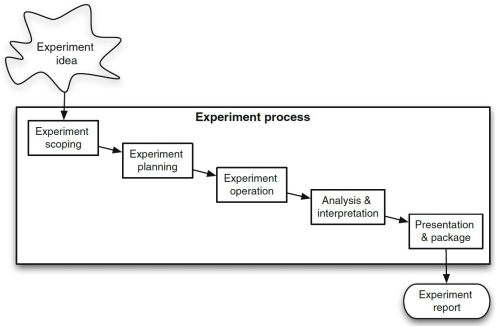
Experiment process

1. Scoping
   1. Problem
   2. Objective
   3. Goals
2. Planning
   1. Design
   2. Instrumentation
3. Operation
   1. Collection of data
4. Analysis and interpretation
5. Presentation and package

→ Not a waterfall! (except from operation)



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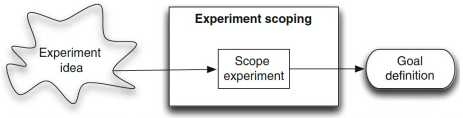
Scoping

→ Object of study (what is studied?)
→ Purpose (what is the intention?)
→ Quality focus (which effect is studied?)
→ Perspective (whose view?)
→ Context (where is the study conducted?)

→ Goal template:
   → Analyze <Object(s) of study>
   → for the purpose of <Purpose>
   → with respect to their <Quality focus>
   → from the point of view of the <Perspective>
   → in the context of <Context>.



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Planning

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→ Context selection, e.g. university, industry
→ Hypothesis formulation, formally stated, null hypothesis, alternative hypethesis
  → In this case the hypothesis may be that one architecture fulfills a QA better than another architecture, i.e. one factor (QA) with two treatments (architectures)
→ Variables selection, independent and dependent variables (including valid values)
→ Subjects selection, e.g. personnel
→ Choise of design type, e.g. randomization of subjects
→ Instrumentation, how do we measure
→ Validity evaluation, e.g. is there a relationship between the treatment and the outcome

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Validity

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Table 8.10 Threats to validity according to Cook and Campbell [37]

Conclusion validity	Internal validity
Low statistical power	History
Violated assumption of statistical tests	Maturation
Fishing and the error rate	Testing
Reliability of measures	Instrumentation
Reliability of treatment implementation	Statistical regression
Random irrelevancies in experimental setting	Selection
Random heterogeneity of subjects	Mortality
	Ambiguity about direction of causal influence
	Interactions with selection
	Diffusion of imitation of treatments
	Compensatory equalization of treatments
	Compensatory rivalry
	Resentful demoralization
Construct validity	**External validity**
Inadequate preoperational explication of constructs	Interaction of selection and treatment
Mono-operation bias	Interaction of setting and treatment
Mono-method bias	Interaction of history and treatment
Confounding constructs and levels of constructs	
Interaction of different treatments	
Interaction of testing and treatment	
Restricted generalizability across constructs	
Hypothesis guessing	
Evaluation apprehension	
Experimenter expectancies	

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Operation

→ Preparation, e.g. forms if there are subjects involved, consent, etc.
→ Execution, runnding the experiment
→ Data validation, evaluate the data

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Analysis and Interpretation

→ Descriptive statistics, i.e. understanding the data
→ Data set reduction, e.g. redundant data
→ Hypotheis testing, method, interpretation

Table 10.1 Some relevant statistics for each scale

Scale type	Measure of central tendency	Dispersion	Dependency
Nominal	Mode	Frequency	
Ordinal	Median, percentile	Interval of variation	Spearman corr. coeff. Kendall corr. coeff.
Interval	Mean, variance, and range	Standard deviation	Pearson corr. coeff.
Ratio	Geometric mean	Coefficient of variation	

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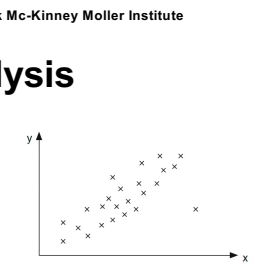
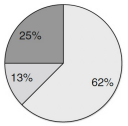
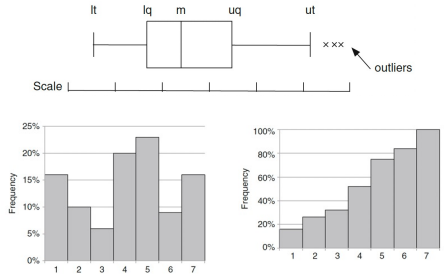
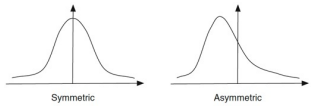
Analysis









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Presentation and package

→ Well, presenting…
→ Documentation

Table 11.1 Proposed reporting structure for experiment reports, by Jedlitschka and Pfahl [86]

Sections/subsections	Contents
Title, authorship	
Structured abstract	Summarizes the paper under headings of background or context, objectives or aims, method, results, and conclusions
Motivation	Sets the scope of the work and encourages readers to read the rest of the paper
Problem statement	Reports what the problem is; where it occurs, and who observes it
Research objectives	Defines the experiment using the formalized style used in GQM
Context	Reports environmental factors such as settings and locations
Related work	How current study relates to other research
Experimental design	Describes the outcome of the experimental planning stage
Goals, hypotheses and variables	Presents the refined research objectives
Design	Define the type of experimental design
Subjects	Defines the methods used for subject sampling and group allocation
Objects	Defines what experimental objects were used
Instrumentation	Defines any guidelines and measurement instruments used
Data collection procedure	Defines the experimental schedule, timing and data collection procedures
Analysis procedure	Specifies the mathematical analysis model to be used
Evaluation of validity	Describes the validity of materials, procedures to ensure participants keep to the experimental method, and methods to ensure the reliability and validity of data collection methods and tools
Execution	Describes how the experimental plan was implemented
Sample	Description of the sample characteristics
Preparation	How the experimental groups were formed and trained
Data collection performed	How data collection took place and any deviations from plan
Validity procedure	How the validity process was followed and any deviation from plan
Analysis	Summarizes the collected data and describes how it was analyzed
Descriptive statistics	Presentation of the data using descriptive statistics
Data set reduction	Describes any reduction of the data set e.g. removal of outliers
Hypothesis testing	Describes how the data was evaluated and how the analysis model was validated
Interpretation	Interprets the findings from the Analysis section
Evaluation of results and implications	Explains the results
Limitations of study	Discusses threats to validity
Inferences	How the results generalize given the findings and limitations
Lessons learnt	Descriptions of what went well and what did not during the course of the experiment
Conclusions and future work	Presents a summary of the study
Relation to existing evidence	Describes the contribution of the study in the context of earlier experiments
Impact	Identifies the most important findings
Limitations	Identifies main limitations of approach i.e. circumstances when the expected benefits will not be delivered
Future work	Suggestions for other experiments to further investigate
Acknowledgements	Identifies any contributors who do not fulfill authorship criteria
References	Lists all cited literature
Appendices	Includes raw data and/or detailed analyses which might help others to use the results

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Example

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Approach

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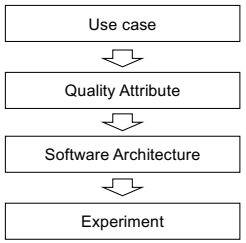
→ A production use case from the company involving production equipment that needs to change a program to enable flexible production

→ The use case serves as input to specify interoperability quality attribute (QA) requirement.

→ A middleware software architecture is developed to fulfill the interoperable QA requirement.

→ An experiment evaluates the middleware software architecture in the I4.0 lab within a real-world context on actual production equipment, and the results are analyzed.



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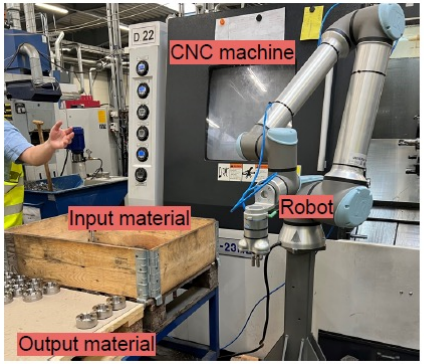
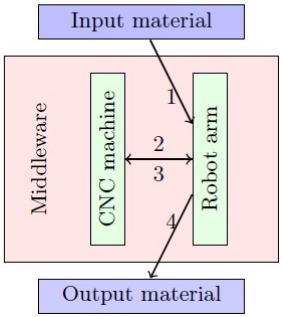
Use Case





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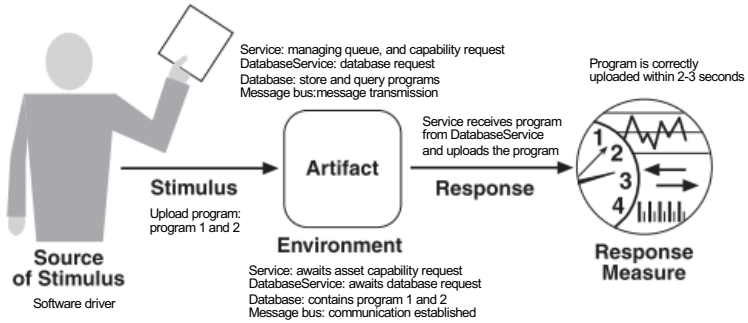
Quality Attribute Scenario



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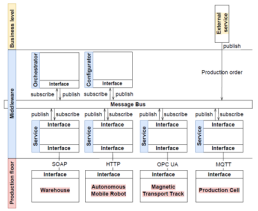
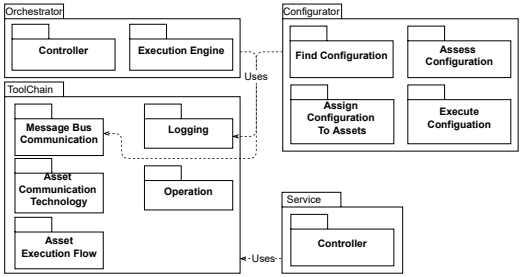
Design

→ Reconfigurable
→ Bus communication
→ Asset communication
→ Execution flow





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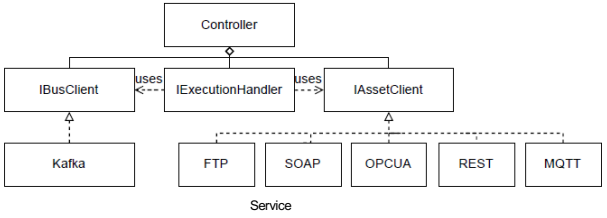
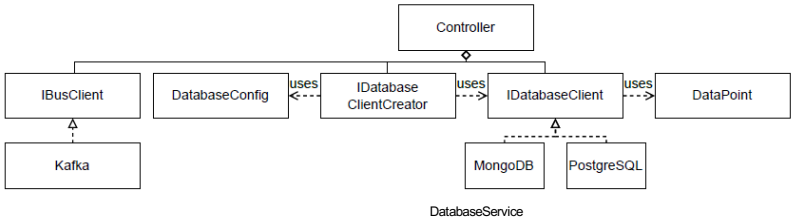
Design





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Tactics

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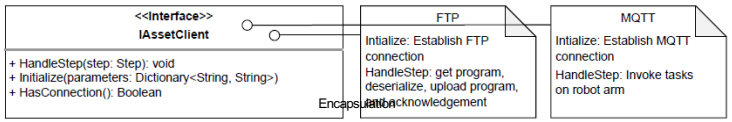

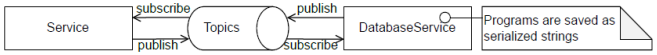

Increase efficiency

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Industry 4.0 Laboratory as testbed

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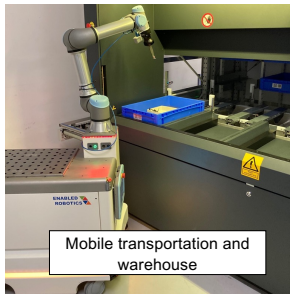
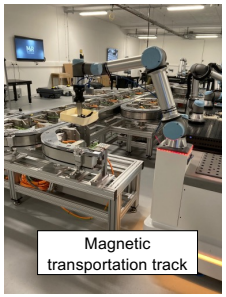
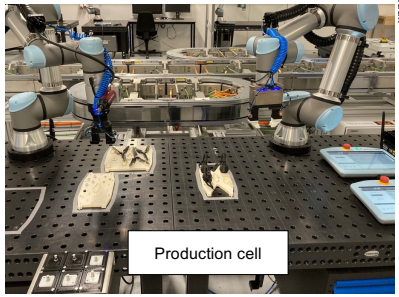

Mobile transportation and warehouse


Magnetic transportation track


Production cell

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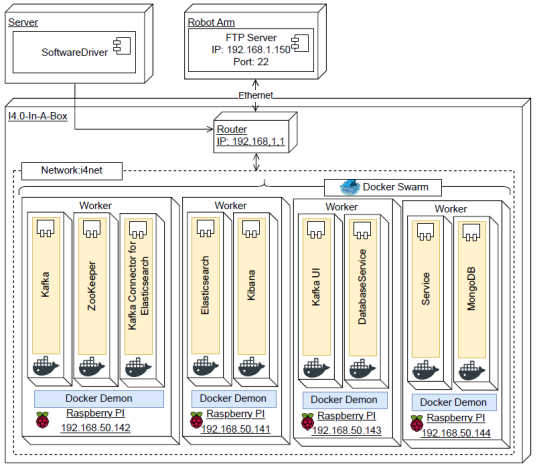
Evaluation

→ Same program with unique file name
→ Pilot test of 10 replications
→ 30 replications



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Measurements

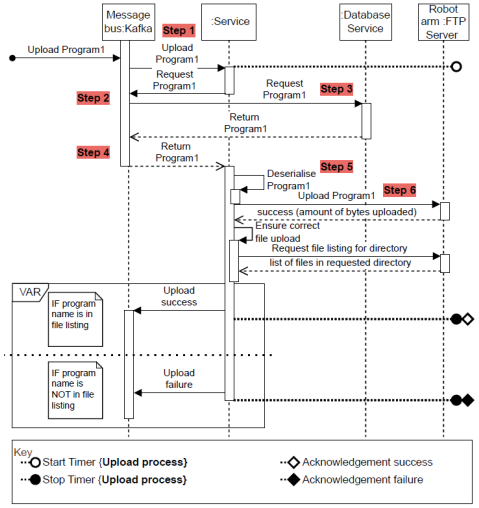

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Fig. 9: Measurements for the uploading process

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Results

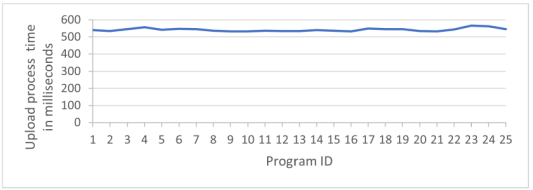

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Fig. 10: Upload process time

Table 2: Acknowledgement of program exchange, timeformat hh.mm.ss.ms

ID	Start time	End time	Ack.
1	16.50.03.296	16.50.03.850	Success
2	16.50.03.852	16.50.04.412	Success
3	16.50.04.414	16.50.04.978	Success
4	16.50.04.979	16.50.05.539	Success
5	16.50.05.540	16.50.06.101	Success
6	16.50.06.102	16.50.06.655	Success
7	16.50.06.656	16.50.07.194	Success
8	16.50.07.195	16.50.07.740	Success
9	16.50.07.741	16.50.08.284	Success
10	16.50.08.285	16.50.09.069	Success
11	16.50.09.070	16.50.09.611	Success
12	16.50.09.612	16.50.10.157	Success
13	16.50.10.157	16.50.10.708	Success
14	16.50.10.708	16.50.11.259	Success
15	16.50.11.259	16.50.11.804	Success
16	16.50.11.805	16.50.12.346	Success
17	16.50.12.348	16.50.12.893	Success
18	16.50.12.894	16.50.13.457	Success
19	16.50.13.458	16.50.14.024	Success
20	16.50.14.025	16.50.14.569	Success
21	16.50.14.569	16.50.15.102	Success
22	16.50.15.103	16.50.15.637	Success
23	16.50.15.637	16.50.16.182	Success
24	16.50.16.183	16.50.16.728	Success
25	16.50.16.728	16.50.17.277	Success

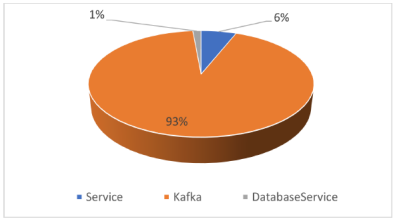

Fig. 11: Upload process distribution time

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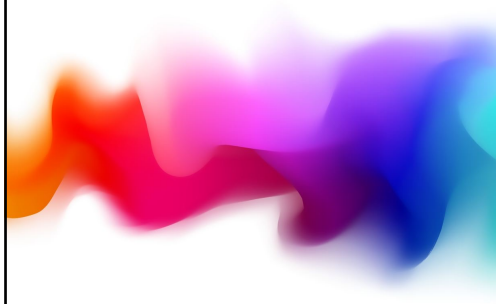
Exercise



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→ Experimentation for quality attribute verification
  → Design
  → Execute
  → Analyse
→ your archtitecture

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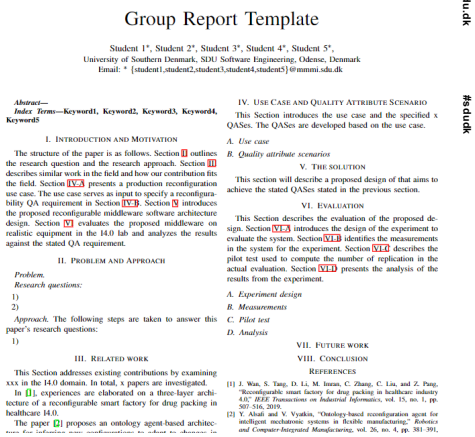
Group Report Template

→ The work must be documented in maxium 10 double column pages using the latex template:

- → Introduction and motivation
- → Problem and approach
- → Use case
- → QAS
- → Design
- → Evaluation (Empirical)
- → Future work
- → Conclusion
- → And 1 page of reflections



Group Report Template

Student 1*, Student 2*, Student 3*, Student 4*, Student 5*,
University of Southern Denmark, SDU Software Engineering, Odense, Denmark
Email: * {student1,student2,student3,student4,student5}@mmmi.sdu.dk

Abstract—
***Index Terms*—Keyword1, Keyword2, Keyword3, Keyword4, Keyword5**

I. Introduction and Motivation

The structure of the paper is as follows. Section I outlines the research question and the research approach. Section II describes similar work in the field and how our contribution fits the field. Section IV-A presents a production reconfiguration use case. The use case serves as input to specify a reconfigurability QA requirement in Section IV-B. Section V introduces the proposed reconfigurable middleware software architecture design. Section V evaluates the proposed middleware on realistic equipment in the I4.0 lab and analyzes the results against the stated QA requirement.

II. Problem and Approach

Problem.
Research questions:
1)
2)

Approach. The following steps are taken to answer this paper's research questions:
1)

III. Related work

This Section addresses existing contributions by examining xxx in the I4.0 domain. In total, x papers are investigated.

In [1], experiences are elaborated on a three-layer architecture of a reconfigurable smart factory for drug packing in healthcare I4.0.

The paper [2] proposes an ontology agent-based architec-

IV. Use Case and Quality Attribute Scenario

This Section introduces the use case and the specified x QASes. The QASes are developed based on the use case.

A. Use case
B. Quality attribute scenarios

V. The Solution

This section will describe a proposed design of that aims to achieve the stated QASes stated in the previous section.

VI. Evaluation

This Section describes the evaluation of the proposed design. Section VI-A introduces the design of the experiment to evaluate the system. Section VI-B identifies the measurements in the system for the experiment. Section VI-C describes the pilot test used to compute the number of replication in the actual evaluation. Section VI-D presents the analysis of the results from the experiment.

A. Experiment design
B. Measurements
C. Pilot test
D. Analysis

VII. Future work

VIII. Conclusion

References

[1] J. Wan, S. Tang, D. Li, M. Imran, C. Zhang, C. Liu, and Z. Pang, "Reconfigurable smart factory for drug packing in healthcare industry 4.0," *IEEE Transactions on Industrial Informatics*, vol. 15, no. 1, pp. 507–516, 2019.
[2] Y. Abali and V. Vyatkin, "Ontology-based reconfiguration agent for intelligent mechatronic systems in flexible manufacturing," *Robotics and Computer-Integrated Manufacturing*, vol. 26, no. 4, pp. 381–391,

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Group Report Structure For the Exam

→ **Abstract:**
- → Breifly describe introduction to the topic, what is the gab, aim, approach, and results (0,25 page)

→ **Introduction and motivation:**
- → Introduction and motivation to the problem domain. (0,5 page)

→ **Problem, research questions, and approach**:
- → What is the problem* to be solved with the architecture you build, and how will the problem be addressed. *The stated problem leads to the stated research question. (0,5 page)

→ **Literature review**:
- → The literature review should review the state of the art consisting of 8-10 papers and should contextualize how this study provides new knowledge to the field. Here you can combine the work from scientific methods. (1/2 page)

→ **Use case**:
- → Unfold the problem with a use case and describe what the use case is about. (0,5 page)

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Group Report Structure For the Exam

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→ **Quality attribute scenario**:
  → The use case is the foundation to describe and specify architectural requirements. (1,5 page)

→ **Design**:
  → Describe the design and argue for the design decision and how it meets the QASes. Part of the design decision must specify which tactics/patterns are used (provide arguments) and the trade-offs. (1,5 pages)

→ **Evaluation**:
  → Describe the evaluation design, measurements of the QASes, pilot test, and an analysis of the results. Describe the design for the evaluation, measurements of the QASes, pilot test, and an analysis of the results. From the analysis, how it answers the research questions must be clear. (3 pages divided into 0,5;0,5;0,5;1,5)

→ **Discussion/Future work**:
  → Discuss how the work can be extended with respect to the approach and/or evaluation (0,5 page)

→ **Conclusion:**
  → A brief closing summary of the work, design, and results. (0,25 page)

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Reflection Report For the Exam

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→ **Contribution**: Specification of your contribution. It must be clearly detailed for each of the sections in the report (introduction; problem, research questions, and approach; etc.) (0.5-0.75 page)

→ **Discussion**: Discuss to what extent the solution achieves the design goals, and if not, why not. Refer to the literature to support your statements. (0.75-1 pages)

→ **Reflection**: Elaborate on what parts of the addressed problem are (not) solved. Reflect on the project, as such, in regard to the stated problem and objectives. The process. Any technical issues, etc. (0.75-1 pages)

→ **Conclusion**: Summarize and outline relevant future work based on your discussions and reflections (0.5 page)

→ Max three pages.

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End of Presentation

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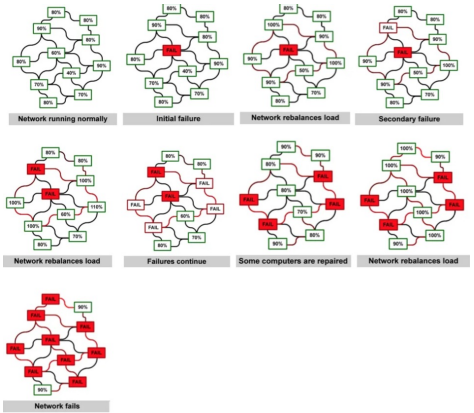
Circuit Breaker Pattern



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