Software From Components

Self-Adaptive Systems

4DV101
Nov. – Dec. 2011

Introduction

danny.weyns@lnu.se - B3009
Course holders

• Lector: Danny Weyns
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Overall course objectives

• Have a good understanding of self-adaptation

• Be able to make a critical evaluation of studies on self-adaptation
Approach

- Learning by doing!
- One introductory lecture
- Go/no go decision after initial study
- Then you learn by studying and evaluating research studies
- Discussion sessions
- Final report
- Retake in August
Overall structure of the course

Week

45  46  47  48  49  50  51..1  2

- Theory
- Discussions example assignment & test
- Retake test
- Assignment
- Evaluation
- Report
Overall structure of the course

• Theory
  – Introduction self-adaptation
  – Evaluation self-adaptation studies

• Example assignment
  – Get familiar with evaluation self-adaptation studies

• Test
  – Go/no go for the rest of the course

• Assignment
  – Evaluation self-adaptation studies in group

• Evaluation
  – Presentation of results and discussions

• Final report
  – Summary of your work
Evaluation

• 20% Test
  – 50% = retake test; fail again = restart course

• 60% Evaluation

• 20% Final report

• –50% overall = retake exam in August
Communication

• Blackboard v9.1 as the primary platform of interaction
  – Add your picture and contact information to the system

• Discuss issues first with your colleague students before contacting the course holders

• If you don’t find an answer, post your message at blackboard

• Private messages
  – To: danny.weyns@lnu.se
  – Subject: [Software From Components]

• Expected response time = 5’ ... 24h
Software From Components
Self-Adaptive Systems

4DV101

Lecture I: Self-Adaptation
Evaluation of Studies

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Overall structure of the course

- Theory
  - Introduction self-adaptation
  - Evaluation self-adaptation studies
- Example assignment
  - Get familiar with evaluation self-adaptation studies
- Test
  - Go/no go for the rest of the course
- Assignment
  - Evaluation self-adaptation studies in group
- Evaluation
  - Presentation of results and discussions
- Final report
  - Summary of your work
Planning course - dates

- Lecture: 8/11
- Example assignment online: 9/11
- Discussions 1st assignment: 15/11
- Test: 22/11
- Assignment + evaluation: 18/11
- Retake test: 18/11
- Report due: 4/1
Goals of this lecture

• Understand the notion of self-adaptation

• Get familiar with the criteria to evaluate studies of self-adaptation
Overview

• Software components
• What is a self-adaptive system?
• Rainbow: an example

• Evaluation of self-adaptation studies
• Example assignment & test
• Report
Software Components

• Software component*
  – “system’s principal computational elements and data stores, including clients, servers, databases, and user interfaces”

• Very different perspectives on the notion of component
  – Component as a runtime abstraction emphasizing separation of concerns
  – Components as modular software entities that communicate with each other via well-defined interfaces; emphasis on encapsulation
  – COTS: Commercially available Off-The-Shelf components; emphasis on compose-ability and reuse

• Some recent technologies
  – Bundles in the OSGi Service Platform (Open Services Gateway initiative framework)
  – Beans in Enterprise JavaBeans (EJB) deployed on a Java EE Application server
  – Fractal component model

*Kramer & Magee, Future of Software Engineering, 2007*
Software Components
Focus of this course

• Changing user needs, faults, changing operational environment, and resource variability pose huge software engineering challenges

• Self-adaptive systems configure and reconfigure themselves (e.g., adapt the component configuration), continually optimize themselves, protect themselves, and recover themselves autonomously

• Self-adaptation is critical to cope with the complexity of today's software-intensive systems
Software Components
Focus of this course

• This course is about understanding
  – An important class of modern software systems
  – Quality properties of software systems
  – Claims and evidence of research studies

• This course is not about
  – Implementation
  – Specific component technologies
Software Components

Focus of this course

• This course requires full commitment from day 1
  – Go/no go decision after test

• The workload is high, but not unreasonable

• A committed student will learn a lot!
Overview

- Software components
- What is a self-adaptive system?
- Rainbow: an example

- Evaluation of self-adaptation studies
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- Report
What is a self-adaptive system?

- A self-managed software architecture is one in which components automatically configure their interaction in a way that is compatible with an overall architectural specification and achieves the goals of the system.*

- Architecture perspective
- Act automatically
- Configure interactions according to specification
- To achieve particular goals

*Kramer & Magee, Future of Software Engineering, 2007
What is a self-adaptive system?

- Self-adaptive systems adapt themselves to changes in the environment and internal dynamics to achieve particular goals. [...] A self-adaptive system comprises a managed and managing part that realize a control loop.*

  - Adapt themselves
  - In response to changes in the environment and internal dynamics
  - To achieve particular goals
  - Comprising managed and managing part that realize control loop

Frameworks and reference models for self-adaptive systems

Rainbow (Garlan et al, 2004)

Control feedback loop (Shaw 1995; Muller et al, 2008)

MAPE-K (IBM, 2000; Kephart and Chess 2003)

3-layer architecture model for self-adaptation (Kramer & Magee, 2007)

Architecture-based self-adaption (Oreizy et al., 1999)
Model of self-adaptive software system
Model for self-adaptive systems

Managing system
Adaptation logic

Analysis

Plan

Monitor

Knowledge

Execute

Managing part of self-adaptive system

MAPE component responsible for one adaptation activity

Model of part of the managed system and its execution environment

Read/write model

Logical flow of activity
Model for self-adaptive systems

• Knowledge often = (partial) architectural model of managed system

• MAPE components are often not explicitly represented (e.g., integrated in one or more components)

• MAPE components + Knowledge can be distributed over multiple hosts

• Self-adaptive systems can have multiple MAPE loops that interact with one another
Overview

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Rainbow: A framework for self-adaptive systems

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Rainbow: A framework for self-adaptive systems

M component that maintains runtime architecture model of managed system

Model includes constraints on architecture (e.g. each client should be connected to server, response time is 200ms, etc.)
Rainbow: A framework for self-adaptive systems
Rainbow: A framework for self-adaptive systems

A component checks the model and triggers adaptations if constraint violation occurs.
Rainbow: A framework for self-adaptive systems

P component determines course of action if constraint violation is detected
Rainbow: A framework for self-adaptive systems

E component carries out the necessary adaptation
Rainbow: A framework for self-adaptive systems

Rainbow engine maintains runtime model of client-server system, with information about load, connection, bandwidth, response time, additional constraints

If e.g response time violation is detected, the engine adapts the configuration
Overview

• Software components
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Evaluation of self-adaptation studies

• To get familiar with the principles of self-adaptation, you will study a number of papers
• You can work in a group, but groups are not allowed to work together

• The goal of your study is based on a set of research questions we have defined
• To answer these research questions you study and evaluate papers based on a set of items
  – Only by studying and applying the items, you will learn them
• The data is collected in a template
Evaluation of self-adaptation studies

• Once all data is collected, we organize discussion sessions to resolve conflicts between findings - you will have to motivate your choices!
• After the discussions, you have to enter the final data in a database (using an online form)
• You have to prepare a final report with an analysis and synthesis of your work providing answers to the research questions
Evaluation of self-adaptation studies

• The concrete goal of the assignment is to get insight in self-adaption by studying
  – the claims that have been made for self-adaptation
  – the evidence that exists for these claims

• Three step process
  – Example assignment to get familiar with the work
  – Test: demonstrate knowledge (go/no go for the rest of the course)
  – Full assignment
Evaluation criteria

• Research questions*

1. What are the claims made for self-adaptive systems?
2. How much evidence is available for the claims? What are the types of evidence?
3. What are the limitations of the current approaches?

*An elaborated description of the research questions and evaluation criteria is available via blackboard
Evaluation criteria

• Data collection to provide answers to the research questions
  – Quality of the studies (i.e. the papers)
  – Documentation items (authors, year, etc.)
  – Data items about studies
Evaluation criteria

• Quality of the study
  – Is there a rational provided for why the study was undertaken?
  – Is there an adequate description of the context of the study?
  – Is there a justification and description for the research design?
  – Is there a clear statement about the findings?
  – Did the researchers critically examined their own role and potential bias in the study?
  – Are the limitations and credibility of the study discussed explicitly?

• Value for each item: 1=yes, 0.5 is to some extent, 0=no
Evaluation criteria

• Data collection to provide answers to the research questions
  – Quality of the studies (i.e. the papers)
  – Documentation items (authors, year, etc.)
  – Data items about studies
Evaluation criteria

• Documentation items
  – Author(s)
  – Year of publication
  – Title of the study
  – Keywords (explicitly mentioned)
  – Citation count (google scholar)
  – Quality score (=sum of scores of quality items)
Evaluation criteria

• Data collection to provide answers to the research questions
  – Quality of the studies (i.e. the papers)
  – Documentation items (authors, year, etc.)
  – Data items about studies
Evaluation criteria

• Date items about the study
  – Category of the study
  – Subject of the study
  – Concrete focus of the study
  – Application domain (if applicable)
  – Disciplined split
  – Concerns
  – Claimed benefits
  – Tradeoffs
  – Assessment / validation approach
  – Evidence level
  – Repeatability
  – Findings
  – Limitations
  – Challenges
Evaluation criteria

- **Category** of the study has the following options:
  - Theory
  - Engineering
  - Application
  - Empirical study
  - Survey
  - Other
Evaluation criteria

- **Subject** of the study refers to the general theme of the study. Options are:
  - Models
  - Requirements
  - Architecture
  - Implementation
  - Framework
  - Testing
  - Verification
  - Process
  - Other
Evaluation criteria

- **Concrete focus** of the study refers to the specific subject of the study. Options are:
  - Monitoring
  - Analysis
  - Planning
  - Execution
  - Runtime models
  - MAPE
  - Control loop
  - Multiple control loops
  - Other
Evaluation criteria

• **Application domain** is the domain in which self-adaption:
  – is studied (in case the study is about a particular application) or
  – applied for evaluation (in case the applications are used for illustration, evaluation, etc.).

• Examples of application domains are robotics, traffic, business management, e-commerce, etc.
Evaluation criteria

• **Disciplined split** is one of the following options
  – Yes (managed and managing system are clearly separated)
  – To some extent
  – No (domain logic and adaptation logic are mixed)
  – Not applicable
Evaluation criteria

- **Concerns** of self-adaption (what is of interest or importance for self-adaption – positively or negatively?). Options are
  - Quality concerns
  - Process concerns
  - Other

- We further refine these options
Evaluation criteria

- Quality concerns is one or more of the following
  - Reliability (fault tolerance, recoverability)
    - capability of software to maintain its level of performance under stated conditions for a stated period of time
  - Availability
    - the degree to which the software is in a functioning condition, i.e. capable to perform its intended functions
  - Usability (easy of learning, communicativeness)
    - effort needed to use the system
  - Efficiency/Performance (time behavior, resource utilization)
    - efficiency of the software by using the appropriate amounts and types of resources under stated conditions and in a specific context of use
Evaluation criteria

– Maintainability (analyzability, changeability, stability, testability)
  • effort needed to make specified modifications
– Portability
  • ability of software to be transferred from one environment to another
– Security
  • ability of the system to protect against misuse
– Accuracy
  • the extent to which the software realizes the intended behavior in a specific context of use
– Flexibility in use
  • capability of the software to provide quality in use in the widest range of contexts of use (including unanticipated change and uncertainty)
– Other (any other quality concern that is not mentioned in this list)
Evaluation criteria

• Process concerns
  – List the engineering process related features for which self-adaptation is applied
  – Examples may be “automation of system management”, “runtime feature selection”, etc.

• Other
  – Any other concern for which self-adaption is applied
Evaluation criteria

- **Claimed benefits** of self-adaptation can be
  - Preserving quality of the software
    - i.e., self-adaptation does not add quality to the system but maintains some quality attributes
  - Improving quality of the software
    - i.e., self-adaptation add some quality to the system, i.e., it improves some quality attributes
  - Assuring quality of the software
    - i.e., self-adaptation guarantees some quality attributes, typically by means of strong evidence or formal proof
  - Improving engineering practice
  - Other

- Refer for each selection to the concern selected previously
Evaluation criteria

- Tradeoffs refers to the implications of using self-adaptation. This can be one or more of
  - Negative impact on quality properties of the system (refer to the qualities selected in F12)
  - Negative impact on the the engineer process of the system (refer to the process features selected in F12)
  - Other
Evaluation criteria

- **Assessment / validation approach** is one of
  - Rigorous analysis (rigorous derivation and proof, suited for formal model)
  - Discussion (qualitative, textual, opinion-oriented evaluation; e.g., compare and contrast, oral discussion of advantages and disadvantages)
  - Example application (application and example to assist in the description, but the example is “used to validate” or “evaluate” as far as the authors suggest)
  - Experience (result has been used on real examples, but not in the form of case studies or controlled experiments)
  - Case study (empirical inquiry that investigates a contemporary phenomenon within its real-life context; must include a clearly defined proposition)
  - Field experiment (controlled experiment performed in industry setting)
  - Laboratory experiment with human subjects (identification of precise relationships between variables in a designed controlled environment using human subjects and quantitative techniques)
  - Laboratory experiment with software subjects (laboratory experiment to compare the claimed properties with other existing systems)
  - Simulation (execution of a system with artificial data, using a model of the real world)
  - Not applicable
Evaluation criteria

• **Evidence level** is one of
  – No evidence
  – Evidence obtained from demonstration or application to simple/toy examples
  – Evidence obtained from expert opinions or observations
  – Evidence obtained from academic studies (e.g., controlled lab experiments)
  – Evidence obtained from industrial studies (e.g., causal case studies)
  – Industrial evidence
  – Other
Evaluation criteria

• **Repeatability** of the study is one of
  – Study is not repeatable
  – The study provides a description that allows performing a similar study
  – Some material is available to repeat the study
  – All the material is available to repeat the study
  – Other
Evaluation criteria

• Findings
  – Briefly summarizes the insights derived from the study

• Limitations
  – Enumerates the stated shortcomings or problems with the study

• Challenges
  – Lists open problems identified for future research
Overview

• Software components
• What is a self-adaptive system?
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• Evaluation of self-adaptation studies
• Example assignment & test
• Report
Example assignment

- Form **teams of 2 students**
- Enter a group for the team in blackboard with the “group feature” (due by 8/11 noon)
- We will assign 2 papers per group that have to be evaluated
- We plan discussions on 14/11
  - Planning will be made available on blackboard
Test

• Demonstrate that you understand the notion of self-adaptation
  – Theory questions
  – Minimal study material = slides + Rainbow paper

• Demonstrate that you understand the evaluation criteria for the assignment
  – Apply a number of evaluation criteria to one or more papers
Overview

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Report

• Proposed structure
  – Introduction, incl. description how you have worked
  – Summary of your results
  – Answer to research questions based on results
  – What have I learned?
  – Conclusions

• 2000 - 4000 words (4 - 8 pages)
• Upload sources + pdf via blackboard
• Deadline Jan. 4, 2012