UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Self-Adaptive Systems

2526-2-F1801Q164

Aims

Students will learn how to design and develop Self-Adaptive Systems able to deal with uncertainties/variabilities and trade-offs among various quality attributes at runtime. Students will also learn how to evaluate the benefits of a Self-Adaptive System and its development effort.

Upon completion of the course, students will be able to:

- understand and explain the concept of self-adaptation (terminology, principles, main characteristics) and its uses in different application domains (**Knowledge and understanding**);
- describe and develop adaptation loops based on the MAPE-K reference model: Monitoring its execution context, Analyzing the gathered information to reveal adaptation needs, Planning adaptation strategies, and Executing the identified adaptation strategies; all the four steps in the adaptation loop share a common Knowledge base expressed as runtime models (**Knowledge and understanding**);
- understand and apply adaptation patterns **(Knowledge and understanding)** (**Applying knowledge and understanding**);
- design and develop an adaptive system able to deal with uncertainties and trade-offs among various quality attributes of the software at runtime based on MAPE-K (**Applying knowledge and understanding**);
- evaluate and critically discuss the benefits of the adaptive software and its development effort using available criteria and metrics (**Making judgements**) (**Communication skills**).

Contents

The course presents the main concepts of Self-Adaptive Systems. It describes how to specify adaptation goals and how to design and develop an adaptation loop – MAPE-K - Monitoring its execution context, Analyzing the gathered information to reveal adaptation needs, Planning adaptation strategies, and Executing the identified adaptation strategies. All the steps in the adaptation loop may share a common Knowledge base.

The course introduces also adaptation patterns, as well as frameworks and tools for the development of Self-Adaptive Systems. It presents evaluation approaches for Self-Adaptive Systems based on cost-benefit analysis.

Detailed program

1. Introduction to self-adaptive concepts. Definition of adaptivity. Design and development of the main components of self-adaptive systems.
2. Self-adaptivity vs smart, autonomous, intelligent system. Machine learning for self-adaptive systems.
3. Self-* properties: self-(re)configuration, self-organization, self-healing, self-protection, self-optimization, self-management, self-adaptation, self-evolution.
4. Uncertainties and variabilities in self-adaptive systems: how to address them at design and runtime. Requirements specification. RELAX language.
5. An architectural based approach to design and implement adaptive software using control feedback loops, e.g., MAKE-K – Monitor, Analyze, Plan, Execute using a Knowledge base.
6. Adaptation strategies. Design and architectural patterns for self-adaptive systems.
7. Reactive, responsive, and proactive adaptation.
8. Frameworks and tools to support design and development of self-adaptive systems. Low level mechanisms useful for adaptation, e.g., reflection.
9. valuation of self-adaptive systems. Trade-offs among quality attributes. Cost-benefit analysis.
10. Examples of self-adaptive systems in various application domains (e.g., Web applications, traffic control, drones, could computing). Adaptivity to achieve sustainability.

Prerequisites

Software Engineering basis
Object Oriented Programming
Unified Modeling Language

Teaching form

The course will be taught in English.

It will consist of lectures (32 hours of content delivery) introducing the main topics of Self-Adaptive Systems and of seminars (22 hours with students interaction) concerning application of adaptation in concrete examples in various applications domains.

Textbook and teaching resource

Weyns, Danny. Software engineering of self-adaptive systems: an organized tour and future challenges. Chapter in Handbook of Software Engineering. Springer. 2017. Available at: https://people.cs.kuleuven.be/~danny.weyns/papers/Self-Adaptation-Organized-Tour.pdf

Danny Weyns. An Introduction to Self-adaptive Systems: A Contemporary Software Engineering Perspective.

Wiley. ISBN: 978-1-119-57494-1. October 2020.

Self-adaptive Exemplars: https://www.hpi.uni-potsdam.de/giese/public/selfadapt/exemplars/

Material (e.g., scientific papers) distributed on the eLearning platform.

Semester

II semester.

Assessment method

Students will be assessed via a team project.
They will identify an adaptation scenario and design the adaptation loop, by indicating all the steps needed for adaption.
Students may use available programming languages, strategies, and patterns, as well as available frameworks for adaptation development.
Students will evaluate their self-adaptive systems using available metrics. They will outline the benefits of using adaptivity mechanisms. Students will also evaluate the development effort of adaptive software.
The team project will include activities about identification of adaptive needs, design and implementation of the adaptation loop, and evaluation of the benefits of adaptation, as well as its development effort. Each team will provide a repository with the developed project, its related documentation and evaluation, and its presentation.

Project evaluation: 0 – 24 points.
Oral presentation of the project and course related concepts: 0 – 5 points.
Task assigned during the course: 0 – 6 points.

Office hours

On appointment.

Sustainable Development Goals

SUSTAINABLE CITIES AND COMMUNITIES