Course Summary and Advanced Software Engineering Techniques

Lecture 13

Topics covered

- ✧ Covered techniques of software engineering
- ✧ Outline of advanced techniques
- ✧ Covered UML diagrams
- ✧ Advanced UML modeling
- ✧ Course follow-up

Covered Techniques of Software Engineering

Lecture 13/Part 1

Software process models

- Software engineering
- Software process activities
  - Software specification.
  - Software analysis and design.
  - Software implementation.
  - Software validation.
  - Software evolution.
- Software process models
  - The waterfall model.
  - Incremental development.
  - Reuse-oriented software engineering

Requirements engineering

- ✧ Requirements and their types
  - User vs. system requirements
  - Functional vs. non-functional requirements
- ✧ Requirements engineering process
  - Requirements elicitation and analysis
  - Requirements specification
  - Requirements validation
  - Requirements management

Focused on functional requirements mainly

Non-functional Requirements Engineering

- Non-functional requirements classification
- Product requirements
  - Availability, Reliability, Safety, Security
  - Performance, Modifiability, Testability, Usability
- Organisational requirements
  - Development requirements
  - Operational requirements
  - Environmental requirements
- External requirements
  - Legislative requirements

Analysis and Design

- Software analysis and design
  - System context
  - Architectural design
  - Analysis and design models
- Structured vs. object-oriented methods
  - Principles
  - Notations
  - Methods

Object-Oriented Analysis

- ✧ Role of the UML in OO analysis
- ✧ Objects and classes
- ✧ Finding analysis classes
- ✧ Relationships between objects and classes
- ✧ Inheritance and polymorphism

Structured Analysis

- Yourdon Modern Structured Analysis (YMSA)
  - Context diagram (CD)
  - Data flow diagram (DFD)
- Data modelling
  - Entity relationship diagram (ERD)
- Relational database design
  - Normalization

High-Level Design

- Design for dependability
  - Dependable processes
  - Redundancy and diversity
  - Dependable systems architectures
- Design for security
  - Design guidelines for security
  - System survivability
- Design for performance, modifiability and usability

Low-Level Design and Implementation

- Low-level design
  - Design patterns
  - SOLID principles
  - Clean code by Robert C. Martin
  - Dependable programming guidelines
  - Low-level performance and testability tactics
- Implementation issues
  - Reuse
  - Configuration management
  - Host-target development

Architectural design

- Architectural views
- Architectural design decisions
- Architectural patterns
  - Model-view-controller
  - Layered architecture
  - Repository architecture
  - Client-server architecture
  - Pipe-and-filter architecture
- Application architectures

Testing, Verification and Validation

- Validation and verification
- Static analysis
  - Verification and formal methods
  - Model checking
  - Automated static analysis
- Testing and its stages
  - Development testing
  - Release testing
  - User testing
- Testing of non-functional properties

Operation, Maintenance and System Evolution

- Evolution processes
  - Change processes for software systems
- Lehman's laws
  - Understanding software evolution dynamics
- Software maintenance
  - Making changes to operational software systems
- Legacy system management
  - Making decisions about software change

Software Development Management

- Project management
- Project planning
  - Scheduling
  - Software pricing
- Risk management
  - Project, product and business risks
- People management
  - Motivation
  - Teamwork
- Tool support

Outline of Advanced Techniques

Lecture 13/Part 2

Software reuse

- In most engineering disciplines, systems are designed by composing existing components that have been used in other systems.
- Software engineering has been more focused on original development but it is now recognised that to achieve better software, more quickly and at lower cost, we need a design process that is based on systematic software reuse.
- There has been a major switch to reuse-based development over the past 10 years.

Component-based software engineering

- Component-based software engineering (CBSE) is an approach to software development that relies on the reuse of entities called 'software components'.
- It emerged from the failure of object-oriented development to support effective reuse. Single object classes are too detailed and specific.
- CBSE essentials:
  - **Independent components** specified by their interfaces.
  - **Component standards** to facilitate component integration.
  - **Middleware** that provides support for component inter-operability.
  - **A development process** that is geared to reuse.

Distributed systems

- Virtually all large computer-based systems are now distributed systems.
  - "… a collection of independent computers that appears to the user as a single coherent system."
- Distributed systems issues
  - Distributed systems are **more complex** than systems that run on a single processor.
  - Complexity arises because different parts of the system are **independently managed** as is the network.
  - There is **no single authority** in charge of the system so top-down control is impossible.

Service-oriented architectures

- A means of developing distributed systems where the components are stand-alone services
- Services may execute on different computers from different service providers
- Standard protocols have been developed to support service communication and information exchange
- Benefits of SOA:
  - Services can be provided **locally** or **outsourced** to ext. providers
  - Services are **language-independent**
  - Investment in **legacy systems** can be preserved
  - Inter-organisational computing is facilitated through **simplified information exchange**

Embedded systems

- Computers are used to control a wide range of systems from **simple domestic machines**, through **games controllers**, to entire **manufacturing plants**.
- Their software must react to events generated by the hardware and, often, issue control signals in response to these events.
- The software in these systems is **embedded in system hardware**, often in **read-only memory**, and usually responds, in **real time**, to events from the system's environment.
- Issues of **safety** and **reliability** may dominate the system design.

Aspect-oriented software development

- An approach to software development based around a relatively new type of abstraction - **an aspect**.
- Used in conjunction with other approaches - normally object-oriented software engineering.
- Aspects encapsulate functionality that **cross-cuts** and co-exists with other functionality.
- Aspects include a definition of **where they should be included** in a program as well as **code implementing** the cross-cutting concern.

Covered UML Diagrams

Lecture 13/Part 3

UML in Software Development

- External perspective models
  - **Use case diagram**
- Structural perspective models
  - **Class diagram**, Object diagram, Component diagram, Package diagram, Deployment diagram, Composite structure diagram
- Interaction perspective models
  - **Sequence diagram**, Communication diagram, Interaction overview diagram, Timing diagram
- Behavioral perspective models
  - **Activity diagram**, State diagram

UML Use Case Diagram

- Use Case modelling
  - System boundary – subject
  - Actors
  - Use cases
- Textual Use Case specification
  - Branching with IF
  - Repetition with FOR and WHILE
  - Alternative flows
- Advanced Use Case modelling
  - Actor generalisation
  - Use case generalisation
  - Relations «include» and «extend»

UML Activity Diagram

- Activity diagrams can model flows of activities using:
  - Activities and connectors
  - Activity partitions
  - Action nodes
    - Call actions, signal actions, time actions
  - Control nodes
    - Decision and merge
    - Fork and join
  - Object nodes
    - Input and output parameters
- **Interaction overview diagrams** as their advanced feature

UML Class Diagram

- ✧ Analytical vs. Design class model
- ✧ Objects and classes
- ✧ Relationships between objects and classes
  - Links
  - Associations
  - Aggregation and composition
  - Dependencies
- ✧ Inheritance and polymorphism

UML Interaction Diagrams

- Four types of interaction diagram:
  - **Sequence diagrams** – emphasize time-ordered sequence of message sends
  - **Communication diagrams** – emphasize the structural relationships between lifelines
  - **Timing diagrams** – emphasize the real-time aspects of an interaction
  - **Interaction overview diagrams** – show how complex behavior is realized by a set of simpler interactions

UML State Diagram

- Behavioral and protocol state machines
- States
  - Actions, exit and entry actions, activities
- Transitions
  - Guard conditions, actions
- Events
  - Call, signal, change and time
- Composite states
  - Simple and orthogonal composite states

UML Packages

- Packages as the UML way of grouping modeling elements
- There are dependency and generalisation relationships between packages
- The package structure of the analysis model defines the logical system architecture

UML Component Diagram

- ✧ Interfaces specify a named set of public features:
  - They define a contract that classes and subsystems may realise
  - Programming to interfaces rather than to classes reduces dependencies between the classes and subsystems in our model
  - Programming to interfaces increases flexibility and extensibility
- ✧ Design subsystems and interfaces allow us to:
  - Componentize our system
  - Define an architecture

UML Deployment Diagram

- The descriptor form deployment diagram
  - Allows you to show how functionality represented by artefacts is distributed across nodes
  - Nodes represent types of physical hardware or execution environments
- The instance form deployment diagram
  - Allows you to show how functionality represented by artefact instances is distributed across node instances
  - Node instances represent actual physical hardware or execution environments

Advanced UML Modeling

Lecture 13/Part 4

Advanced Activity diagrams

- ✧ Connectors
- ✧ Interruptible activity regions
- ✧ Exception handling
- ✧ Expansion nodes
- ✧ Signals and events
- ✧ Streaming
- ✧ Advanced object flow features
- ✧ Multicast and multireceive
- ✧ Parameters and pins

Advanced Interaction diagrams

- Timing diagram
- Interaction overview diagram

Advanced State diagrams

- Composite states
- Submachine states
- Submachine communication
- History

Object constraint language (OCL)

- The Object Constraint Language (OCL) is a declarative language for describing rules that apply to UML models.
  - The OCL is a precise text language that provides constraint and object query expressions.
- OCL statements are constructed in four parts:
  - a **context** that defines the limited situation in which the statement is valid
  - a **property** that represents some characteristics of the context (e.g., if the context is a class, a property might be an attribute)
  - an **operation** (e.g., arithmetic, set-oriented) that manipulates or qualifies a property, and
  - **keywords** (e.g., if, then, else, and, or, not, implies) that are used to specify conditional expressions.

UML Profiles

- A UML profile provides a **generic extension mechanism for customizing UML models** for particular domains and platforms.
  - Extension mechanisms allow refining standard semantics in strictly additive manner, so that they can't contradict standard semantics.
- Profiles are defined using **stereotypes**, **tag definitions**, and **constraints** that are applied to specific model elements, such as Classes, Attributes, and Activities.
- A Profile is a **collection of such extensions** that collectively customize UML for a particular domain (e.g., aerospace, healthcare, financial) or platform (J2EE, .NET).

Course Follow-up

Lecture 13/Part 5

Course finalization

- ✧ Seminar projects
  - Assessment, "Úspěšné absolvování cvičení " IS notebook
- ✧ Exam
  - Number of exam dates
  - Reservation/cancelation policies
  - Legth of the exam
  - Form of the exam – test part and UML modelling part
  - Results and their viewing
- ✧ Opinion poll
  - Do not forget to give us your feedback! ☺

Follow-up and related courses

- PA017 Softwarové inženýrství II
- PA103 Objektové metody návrhu informačních systémů
- PV167 Projekt z objektového návrhu inf. systémů
- PA104 Vedení týmového projektu
- PV207 Business Process Management
- PV165 Procesní řízení
- PV045 Management informačního systému
- PA189 Agile Management in IT
- PV028 Aplikační informační systémy

Follow-up and related courses

- PV043 Informační systémy podniků
- PV230 Podnikové portály
- PV019 Geografické informační systémy I, II
- PV058 Informační systémy ve veřejné a státní správě
- PV213 Enterprise Information Systems in Practice
- PV098 Řízení implementace IS
- PB168 Základy databázových a informačních systémů
- PB114 Datové modelování I
- SSME Courses

Thanks

Thank you for your attention

and good luck with the exam!