Motivation and Contents Overview

Software Engineering
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Course Contents
Goals

- Learning about commonly used approaches to software development (in the small and in the large)
- Developing an understanding of what is good and what is bad software (-construction)
- Knowing and understanding related concepts and terms
- Developing a deeper understanding of the Software development in the large
Software Engineering

- Concepts and constructs for flexible software
  - Programming language (OO)
  - UML representation
  - Frameworks and Design Patterns
  - Software parameterization (configuration files, resources, script languages)
  - Heuristics for adequate flexibility
Software Engineering

- **Concepts and constructs in Component-Based Design**
  - The Module concept
  - Overview of standards for components (WebServices, JavaBeans, OSGi)
  - Heuristics for adequate modularization (balance between coupling and cohesion)

- **Software architectures**

- **Automatic software generation**
Software Technology:
State of the Art and Challenges
Context

- The phenomenon Software
- How can Software be engineered?
The Phenomenon
Software
The Computer as universal machine makes Software pervasive

Airplane/Rocket control

More than 90 processors in a car
What is so special about Software?
The problems with software production stem from the complexity of the achieved product.

- Requirements specification
- Complexity control
- Re-use/Plug-in, expandability and changeability
- Automation in the production process
- Portability
- Documentation
- **Product ergonomics (Human-Computer Interface)**
- Project organization and control
- Quality assurance and evaluation
- Cost estimation

**Related fields:**
- Prototyping
- Programming models
- Design Patterns
- Frameworks
- Psychology (e.g. Piaget)
Quality problems

- Software bugs: deficiencies with drastic effects
  - Incorrect bank transactions
  - Y2K
  - Ariane
  - Mars adventures
    - PathFinder
    - Spirit
Example: Ariane 5

- Construction:
  - 10 years & $7 billion
- Maiden voyage: June 1996
- Payload: 4 scientific satellites
Example: Ariane 5

- Crashed at second 39 in flight
- Software bug: number overflow
  - Wrong sensor data
  - Wrong steering
  - Activate self-destruct
- Software component inherited from previous versions (Ariane 4)
Example: Ariane 5

- Crashed at second 39 in flight
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- Inquiry board conclusion:

  “The Board is in favour of the opposite view, that software should be assumed to be faulty until applying the currently accepted best practice methods can demonstrate that it is correct.”
Example: PathFinder Rover on Mars

- Landed on July 4, 1997
- Problem: frequent total system resets
Example: PathFinder Rover on Mars

- Landed on July 4, 1997
- Problem: frequent total system resets
- Cause: data bus locked longer than expected
- Software tasks:
  - Bus management
  - Communication
  - Meteorological
- Solution:
  - Priority inversion
Example: Spirit Rover on Mars

- Landed on January 4, 2004
- Problem: frequent total system resets
Example: Spirit Rover on Mars

- Landed on January 4, 2004
- Problem: frequent total system resets
- Cause: size of file system
  - DOS FS on flash
  - Mirrored in RAM
  - $\text{sizeof}(\text{RAM}) < \text{sizeof (Flash)}$
Human interaction problems

- Human-Computer Interaction
- Human-Machine Interaction
  - Interaction with automated systems
  - Example: Korean Airlines Flight 007
- Computer pervasiveness makes the human interaction issue very important
KAL007 flight route
KAL007 Navigation Interface

- Navigation routine:
  - Start in Heading
  - Switch to INS
KAL007 navigation modes

- Operating modes:

- Problem: Transition from B to C not clear to the pilots!

[Diagram showing navigation modes A, B, and C.]
Example: Specification problems
An exact specification is often impracticable

given.: \( n \geq 3 \),

\[
L: N_n \rightarrow N
\]

find.: A Program \( P \) that computes

\[
a: N_3 \xrightarrow{\text{inj}} N_n , \text{ such that }
\]

\[
L(a_i) \geq L(a_j)
\]

\( 1 \leq i \leq 3 \)

\( j \in N_n \setminus \cup \{ a_k \} \)

\( 1 \leq k \leq j \)
...while a verbal specification is often inaccurate

Given a list with at least three positive numbers

Find a program P that gives the indices of the three largest elements of the list.
Mastering Complexity
In classical engineering disciplines

- Bad quality can hardly be hidden
  - Door cannot close well
  - Unnecessary artifacts
    - “Fifth wheel to the car”
- Resources are limited
  - Engineering approaches mean optimization under given basic conditions
Bad quality is not so visible in software

- Bad structuring
  - „Spaghetti“ program code:
    - Wheel change -> the motor works no more
  - Replicated program code

- Hardly re-usable code
  - The wheel is always re-invented
Engineering procedures do not seem to pay off

- Hardware resources evolve according to Moore’s Law; thoughtless handling of this issue leads to:
  - Unnecessary complexity
  - No longer understandable artifacts

OberonOS (ETH ZH)
30.000 lines of program code

Windows XP (2002):
40.000.000 (!!) lines of program code

4,1 cm  27,5 m
How can Software be engineered?
What does Software?

Input
- Keyboard
- Mouse
- CD
- Digital camera
- ...

Function
- Main memory
  - fast accessible
  - data + programs
- Processor (CPU)

Output
- Monitor
- Printer
- Disk
- Loudspeaker
- ...

Data

Control signals
Interaction with the environment

- Interactive systems: the computer is the leader of the interaction
  - Examples: Operating systems, Database systems
  - Main issues: Deadlock, Fairness

- Reactive systems: the environment is the leader of the interaction
  - Examples: Industrial process control, airplane control
  - Main issues: Safety, Timeliness
Examples

- ABS in automotive
  - **Input:** Rotational speeds of the wheels and user braking
  - **Function:** Checking whether the speeds are zero when the user brakes
  - **Output:** Appropriate controlling of the braking force

- Bank transfers
  - **Input:** Transfer data (payee, payer, amount)
  - **Function:** Validation of the transaction
  - **Output:** New transaction lines in the accounts