Quality Management of Software and Systems

Introduction and Overview

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Distribution of software systems
Examples

- Consumer electronics
  - Simple machines, e.g., coffee machines, washing machines, and refrigerators contain software systems
  - The major part of modern devices, e.g., cell phones, DVD-player, and digital cameras is software
- Automotive industry
  - Operational sequences, administration, and production are no longer possible without software systems
  - Within a modern automobile approx. 100 microcontroller are integrated
  - More than 50% of all malfunctions are due to software problems
- Information systems
  - Application domains: finance, health care, administration, …
  - Information systems permeate support of business processes to a rate of 60% up to 90%
  - The execution of a business process may require the interaction of at least 15 major applications

Software disasters
Patriot missile

A fatal software failure during the gulf war II

"During the Gulf war, a computer failure was responsible for the failure of a patriot missile to stop a scud missile that hit an American military barracks in Dharan … 28 dead …"

[Quelle: ACM SIGSOFT Software Engineering Notes, vol. 16, no. 3 (1991), S.19f]

Reasons:

- The controller operated 4 days non-stop (instead of the prescribed 14 hours)
- Thus, an overflow in the 24 bit timer register occurred, leading to rounding errors during the trajectory calculation
- If the timer interval has been 1/8 instead of 1/10 seconds, no rounding errors would have occurred
- The interval was changed to 1/10 sec. against the original programming by a manager

Software disasters
Patriot missile

Conclusions from the patriot missile example

- Ensure software against maloperation as good as possible (e.g., raise an alert after a runtime of 14 hours
- Ensure software against coding errors as good as possible (e.g., catch counter overflows by validation checks or exception handling)
- Document important design decisions for maintenance (e.g. “timer interval of 1/8 sec. was chosen, because…”)
- Assign procedures and responsibilities for the software development (to circumvent ad-hoc changes by unqualified personnel)

[Quelle: Mark Minas, Vom Bild zum Programm, S.12f]

Software disasters
Other examples

- 1981: US Air Force Command & Control Software exceeds the cost estimate by a factor of 10: ***US-$ 3.2 mill.***
- 1987-1993: Integration of the Californian driver license and car registration systems aborted: ***US-$ 44 mill.***
- 1992: Integration of the reservation system SABRE with other registration systems aborted: ***US-$ 165 mill.***
- 1997: Development of the information system SACSS for the state California aborted: ***US-$ 300 mill.***
- 1994: Opening of the Denver International Airport was delayed 16 months due to software problems within the luggage transportation system: ***US-$ 655 mill.***
- 2005: German system "Toll Collect" started with a serious delay (Contract signed: September ‘02, projected start date: August 31st, 2003) at January 1st, 2005 and in a reduced version: ***~6.5 bn. €***

Software disasters
Other examples

- □ 1988: An Airbus left the runway due to aquaplaning, because the reverse thrust could not be activated
- □ 1999: Loss of the "Mars Climate Orbiter" due to wrong unit conversion
- □ 1999: 20.500 BMWs (3 series) were recalled due to a software bug within the airbag controller. 50% of all malfunctions are due to software problems. Tendency: increasing
- □ 2002: Due to a software problem, it was possible to draw money with Postbank cash cards using any PIN number on ATM’s from other financial institutions without charging the account
- □ 2004: Siemens S65 was taken off the market due to a software problem causing hearing damage

Increasing QA Requirements

- □ Software bugs are responsible for 50% of all failures in the industry
- □ Problems with reliability due to high complexity
  - p_k : Probability for a component to be fault-free
  - p_s : Probability for a system to be fault-free

Number of components	p_k	p_s
10	0,9	0,35
10	0,99	0,9
100	0,9	0,000027
100	0,99	0,37

- □ Errors in 1.000 LOC
  - 1977: 7 - 20
  - 1994: 0,05 – 0,2
- □ Average software size (in 1.000 LOC)
  - 1977: 10
  - 1994: 800

IT-Catastrophes – individual cases?

- □ CHAOS report
  - Annual report about IT project successes since 1994
  - Approx. 100.000 American IT projects were examined
  - Publisher: Standish Group International, Inc.
- □ CHAOS report ranks IT-projects according to three categories
  - **Successful**: Project was finished within time and budget limits. The result is used and fulfills all requirements
  - **Challenged**: Project is finished and the results is used. But it was not within time or budget, or the specified requirements are not fully met
  - **Failed**: The project was untimely aborted or the result is not used

IT-Catastrophes – individual cases?
IT-project success statistics

	Succeeded	Failed	Challenged
1994	16%	31%	53%
1996	27%	40%	33%
1998	26%	28%	46%
2000	28%	23%	49%

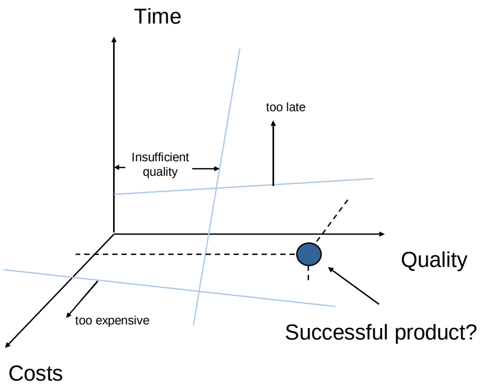
[Quelle: CHAOS Report, Standish Group International, Inc.]

Software Engineering - Definition

- □ Software Engineering is the goal-oriented provision and application of **systematical**, **engineer-like**, and **quantifiable procedures** for **development**, **operation**, **maintenance, and shutdown of software systems**

- □ Goal-oriented implies the consideration of
  - Time
  - Budget
  - **Quality**

Motivation
Trade-off for successful products



Motivation
Legal Accountability

Excerpt from the Safety – Handbook of the German army
SIL Safety Integrity Level

	High			Low	
Attributes	**SIL 4**	**SIL 3**	**SIL 2**	**SIL 1**	**Appl. HW SW**
Requirements and Design Specification	Formal (Mathe-matical)	Semiformal	Informal (e.g. Natural Language)	Informal (e.g. Natural Language)	H/S
Configuration Management	Full (Automated for development and production	Full (Automated for development and production	Yes	Manual	H/S
Structured Design Method; e.g. data	Yes	Yes	Preferred	Optional	H/S

Compulsory activities

Non-operation leads to a legal liability for the engineer!

Even if it is not developed by the state-of-the-art

Motivation
Relevance of proof of safety and reliability analysis

- □ Proof of safety required by legal regulation or admission offices, e.g.
  - Railway transportation: EBA (Deutschland)
  - Medical technology: FDA (USA)
- □ Reliability increasingly required by customers (e.g., automotive industry)
- □ Availability requirements are an integral part of the contract and object of a penalty clause (e.g., public switching technology, rail transportation system)
- □ Product liability stipulates a broad manufacturer accountability (and defines ‘manufacturer’ in a very broad way)

Quality Management

- □ Process definition with respect to the achievement of quality goals
- □ Definition of appropriate techniques for the ‘construction of quality’
- □ Description of appropriate control procedures to analyze and measure quality
- □ Creation of evaluation techniques for the gathered analysis data
- □ Integration of all employees and managers according to their responsibility
- □ Establishing a procedure to continually monitor and improve the aforementioned aspects