Embedded Software Systems
- Challenges
- Potential
- Construction
- Example - the automotive industry

Overview
- The role of information technology (IT)
- Megatrends in software technology
- Software onboard the automobile
  - Market pressure
  - Synergy of technologies
  - Hot spots
    - Larger design space
    - Requirements engineering
    - Software architecture
    - Expanded processes
- Embedded software systems

IT as a Business Factor
- Economical thrust in High-Tech (example Siemens: >50% profit from software (SW))
- Innovative, software-based services products and processes (BMW “digital automobile”)
- Crucial factor for rationalization and systems integration
- Software as a product and commodity (MS, SAP)
- IT as a safety and security risk: critical systems
- Crucial factor: managing complexity
  (Fred Brooks “The Mythical Man Month”)
The 5 development stages of software technology

- Initially: a laboratory discipline - “computing”
- Then: (E)Data Processing - processing of mass data, automating well-known processes [1969, Garmisch NATO conference, created the terms Software Engineering and Software Crisis]
- Yesterday: common infrastructure, everyday use, convenient tool
- Today: enabling technology, new products, new markets, new processes
- Tomorrow: synergies, interworking of applications, interoperability and networking, ubiquitous and pervasive computing

Drivers of the Digital Revolution

- Hardware performance increase - Moore’s law
- Market pressure
- Progress in software technology
- Impact of IT infrastructure
- Innovation in functionality
- Synergies in applications areas

State of Software - IT

- Rapid technical progress - characterized by ad-hoc solutions and immature quasi-standards
- Increasing complexity - mostly “unbewältigt”
- Legacy systems and commitments
- Insufficient matching of IT and applications
- Missing or insufficient user involvement
- Serious deficiencies in quality
- Many pragmatic approaches are not supported by methodical processes
- Modeling paradigms not systematic
- Standish Report, . . .
Reading Assignment #1

- Standish Report

THE STANDISH GROUP REPORT CHAOS
http://learnat.sait.ab.ca/ict/apse401_hayward/Articles/chaos.pdf

IT - Software today - the Deficits

- Insufficient scientific foundation
- Sophistication of users and enterprises not satisfactory
- Insufficient practical experience (missing quantitative results and measures - comparisons)
- Unsatisfactory productivity and quality
- Inadequate training and education, shortage of qualified personnel
- Missing overall competence
- No real "software culture/civilization"

PITAC Report . . .
Prevailing Themes of IT and SW - I

- Requirements Engineering - user participation
- Comprehensive modeling paradigms - UML
- Modeling of the system environment
- Long-lived software architecture ???
- Design Patterns
- Product Lines
- Integration of COTS (commercial of the shelf)
- Component-based development
- Prototyping and incremental development
- Security Engineering (reliability, integrity, safety)

Prevailing Themes of IT and SW - II

- Mobile, dynamic systems
- Legacy Software
- Reengineering
- Universal tool support
- Generating product quality code
- Comprehensive quality assurance
- Flexible, adaptive development model
- Division-of-labor based process
- IT/SW maturity models

Megatrends in Software

- Performance increase and complexity increase
- Virtualization
- Convergence (audio-video-TV/telecommunications/networking)
- Interoperability
- Integration, Standardization, Service-orientation
- Distribution, mobility and internetworking
- Globalization and Internationalization
- IPR, Patents
- Standardization
Trend: convergence of hardware, systems, methods, applications
- Devices
  - Embedded systems - sensors and actuators
  - Mobile, nomadic devices
- Networks (interconnect, local, regional, global . . .)
- System infrastructure: operating systems and middleware support
- Protocols
- Services and applications
- Techniques and notation for modeling and description
- Development processes and actions

Consequences of Convergence and Interoperability Requirements
- Emphasis on services
- Inclusion of applications
- Interoperability
- Openness and extensibility
- Uniformity of interfaces
- Cleanly layered architecture model

immobility of enterprises and systems is ever growing

Key software questions in networks of adaptive applications
- Networks as complex service layers
- Software architecture
- Modularity and interoperability
- Mastering complexity
- Combination of telecommunications and Internet
- Service Modeling and Engineering
- IT modeling techniques (UML, SDL, . . .)
Software onboard the Automobile
- Supplants avionics as driving technology
- Influences traditional solution in automotive technology
- New requirements for SW-technology
- Swing from hardware to software solutions
- Influence on development process and calculation (economics)
- Innovative, decisive functionality
- New business model

Software Contributions
- Novel functionalities
- Linking and interworking of traditional functionalities
- User requirements - MMI
- Personalization
- New technical solutions through software
- Requirements engineering (larger design space)
- Novel solutions centered on automobile (development, construction, production, sales, maintenance, customer relations, new business models)

Automotive Software - technical challenges
- System and software architecture
- Product lines
- Component ware
- Design and production platforms
- Design and development process
- Safety (reliability)
- Requirements engineering (feature interaction)
- Security
Automotive Software - new technical paradigms
- Layered architectures
- Object orientation and model based system and software development
- Service oriented system and software structures
- Interaction of functions and added value through linking of functions
- COTS / IP / PC oriented solutions
- Ad-hoc networking
- Plug-and-Play - Plug-and-Drive
- Emphasis on MMI (man-machine-interface)

Hot Spot: Requirements Engineering
- Completely new functionalities (design spaces)
- User expectations
- Personalization
- From systems to software engineering
- Overall concept
- Process
- Model based validation

Hot Spot: Development Process
- Incremental development
- Model oriented development
- Quality reassurance
- Tool support
- Reusability
- Transparency
- Time and cost control
Hot Spot: System and Software Architecture

From isolated solutions to a comprehensive and integrated concept

- Platform independence
- Decoupling through functional layers
- Longevity
- Uniformity (architectural concepts)
- Application orientation

New Challenges in Systems and Software Engineering

- Universality of development processes
- Mastering quality, cost and deadlines
- Usability of systems
- Interoperability of systems - plug-&-play
- Standardization of solutions
- Reusability
- Longevity of systems
- Adaptability of software systems

Software in the Automobile: From product component to full product

Player:
- Car manufacturer
- Software producer
- Technology provider
- Supplier industry
- Owner - IPRs
- Market
Conclusion:
R&D Profile for Embedded Software

- Universal Process
  - Generality
  - Platform independence
- Modeling and Notation
  - Requirements
  - Environment - context
  - Architecture
  - Performance (real time, quality-of-service)
- Tools

Lessons?

- Industry is moving more and more towards software production
- Products contain more and more software components; example Software Radio
- Developing software is still not well understood
- Maintaining - Modifying software products is very expensive and also not well understood
- Tools are still rudimentary (maybe with the exception of compilers)
- Last not least: Brainware is most important!