Data Management in Engineering Applications

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Agenda

• Required:
  – Computer science
  – Data management

• This lecture
  – Engineering
  – Computer support in engineering
  – Data management in engineering applications

• Goals
  – Overview and basic vocabulary
  – Avoid most common pitfalls
Engineering

The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behaviour under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property.

Cited from Engineers Council for Professional Development by http://www.britannica.com/EBchecked/topic/187549/engineering
Computer Support in Engineering

• ICT inside the product -> DRE
  - Distributed
  - Realtime
  - Embedded

• ICT for the engineer’s daily work
  - Office
  - CAX, FEM, VR
  - ... see Digital Engineering Magazin for current examples

• Integration of engineering data with other company’s aspects
Product & Production Roadmap

• Mechanics
• Mechatronics
• Intelligent Technical Systems, Cyber Physical Systems, Smart Systems ... and many more fancy words for the same issue ...

-> process knowledge moves from mechanics and electrics to software
"Traditional" Automation vs. ICT

Information and communication technology

"traditional" engineering
Traditional Engineering vs. ICT

• ICT influences engineering
  – In product development
  – In marketing
  – In operation

• Today’s successful players draw more innovation from ICT than from “traditional” engineering domains.
Automation Roadmap

State-of-the-art 2013 4.0“

• Management Level
  Manufacturing Execution System (MES)
• Operator Level
  Supervisory Control and Data Acquisition (SCADA)
• Control Level
  Programmable Logic Control (PLC/SPS) today’s examples:
• Field Level    amazon, myhammer eth, can, profibus, interbus, …
Simulation & VR

• Mind-based vs. computer-based simulation
• Information Islands -> Information Integration
• Presentation of simulation data
  – Figures
  -> Models
  -> Virtual Reality

• Interleaved evolution
Information Integration in Engineering

- Simulation integration
- Model exchange

In 2013, “traditional” engineers still assume file exchange as state-of-the-art. (!!!)

- Whether it’s file-based or network-based, it’s a matter of interoperability.
Interoperability

inter: between components, operation: something happens
Interoperability

- Plenty of research on i14y.
- We use Manso, Wachowicz and Berabé’s taxonomy
- Original domain: GIS
- Meta-study about i14y-taxonomies
- Declares seven levels of i14y
- Levels are not hierarchical
Taxonomy is the practice and science of classification. The word is also used as a count noun: a taxonomy, or taxonomic scheme, is a particular classification. The word finds its roots in the Greek τάξις, taxis (meaning 'order', 'arrangement') and νόμος, nomos ('law' or 'science'). [...] In a wider, more general sense, it may refer to a classification of things or concepts, as well as to the principles underlying such a classification.
Seven Levels of Interoperability

• Technical
• Syntactic
• Semantic
• Pragmatic
• Dynamic
• Conceptual
• Organisational
We define technical interoperability as the one enabling the interconnection of systems through common communication protocols allowing information exchange at its most basic level: bits and bytes.

... hardware and software ... communication infrastructure ... the communication protocols ... regardless of format, meaning of the information ... including character sets, character encoding, file identifiers, computer environment descriptions, file names, services types and version, transfer size, format name and versions, medium name and density, links, and protocols ...
(2) Syntactic Interoperability

Syntactic interoperability is about the information exchange between systems by using a common data format or structure, language, logic, registers and files.

... standards or format specifications ... structure information ... processed and interpreted ... XML formats ... data schemas ... standardized graphic formats ... schemas for web applications and web services ... data encoding languages ... 

Software library signatures?
(3) Semantic Interoperability

Semantic interoperability is about information exchange using a shared, common vocabulary that avoids inaccuracies or mix-ups when interpreting the meaning of terms.

... standards or specifications ... information exchange schemas ... unambiguous meaning of every element ... Web Service Description Language (WSDL) ... Simple Object Access Protocol (SOAP) ... Geographic Mark-Up Language (GML) ... Style Layer Description (SLD) ... Common Query Language ... Filter Encoding (ISO19143) ... most of ISO 191xx ...

What about your domain?
(4) Pragmatic Interoperability

Pragmatic interoperability is about interconnected systems knowing each other, so they are able to exploit application/services interfaces, to invoke methods or procedures, and handle the data they need to exchange with other systems.

... system negotiation ... service interfaces [...] flawlessly defined ... methods that can be invoked and the data to be exchanged be known ... query the capabilities ... implemented operations ... access to point of services ...
(5) Dynamic Interoperability

The dynamic interoperability allows the systems to monitor the running of the other systems and to respond to the changes in the transfer of information by taking advantage thereof.

... service dynamic exchange capability ... switching from [...] one service to another ... cover the required needs ... no longer available ... monitor the network and other services .... dynamically discover the existence of services ... service discovery ... information describing services (service metadata) ...
Conceptual interoperability is about knowing and reproducing the functioning of a system based on documentation usually articulated in a format as used in engineering.

... data and system model ... standardized and interchangeable documentation ... from an engineering viewpoint ... regardless of the model utilized to describe it ... GML Application schema format ... modeling or CASE tools ... class diagrams (UML) ... restrictions and comments ...
(7) Organizational Interoperability
The organizational interoperability allows knowledge of business targets, process models, regulations and policies of access and use of data and services...

... expectations, contracts and culture ... policies of access and use of data and/or services ... personal or institutional responsibilities ... objectives and goals ... identification information ... metadata elements ...
Patterns of Interoperability

• Unstructured hell
• Naive adapters
• Interoperability platform

▶ Maintenance
Summary
Literature


How to meet MD’s community?

• OvGU’s Center for Digital Engineering
  ExFa, Sandtorstraße 23, 4th floor.

• Fachtagung Digital Engineering; 16. IFF-Wissenschaftstage; 18th to 20th of June, 2013.
  http://www.wissenschaftstage.iff.fraunhofer.de/

• Gastvortragsreihe Virtual Reality; 16th October to 27th November, 2013; Wednesdays 17:00 – 19:00 at VDTC; Dates and facts not online yet.
Thank you! Questions?