IF2261 Software Engineering

System Engineering

Program Studi Teknik Informatika
STEI ITB

Overview

- Before software can be engineered:
  - the system it is part of must be understood,
  - the overall objective of the system must be determined,
  - the role of the system elements (hardware, software, people, data, etc.) must be identified, and
  - the operational requirements must be created.
- Don't take a "software-centric" view of the system; consider all system elements before focusing on software.
- Good system engineering begins with a clear understanding of the "world view" and progressively narrows until technical detail is understood.
- Complex systems are actually a hierarchy of macro-elements that are themselves systems.

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System – Definition

Webster's Dictionary

- *A set or arrangement of things so related as to form a unity or organic whole*
- *A set of facts, principles, rules, etc., classified and arranged in an orderly form so as to show a logical plan linking the various parts*
- *A method or plan of classification or arrangement*
- *An established way of doing something; method; procedure….*
- …..
- ….

Computer-Based Systems

[PRE2005]

- *A set or arrangement of elements that are organized to accomplish some predefined goal by processing information*
- The goal:

  To support some business function or to develop a product that can be sold to generate business revenue
- To accomplish the goal, a computer-based system makes use of a variety of system elements

Computer-Based System Elements

- Software
- Hardware
- People
- Database
- Documentation
- Procedures

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System Engineering Hierarchy

- World view → WV = $\{D_1, D_2, D_3, \ldots, D_n\}$
  - Composed of a set of domains (D_i) which can be each be a system or system of systems
- Domain view → DV = $\{E_1, E_2, E_3, \ldots, E_m\}$
  - Composed of specific elements (E_j) each of which serves some role in accomplishing the objective and goals fo the domain or component
- Element view → EV = $\{C_1, C_2, C_3, \ldots, C_k\}$
  - Each element is implemented by specifying the technical component (C_k) that achieve the necessary function for an element
- Detail view

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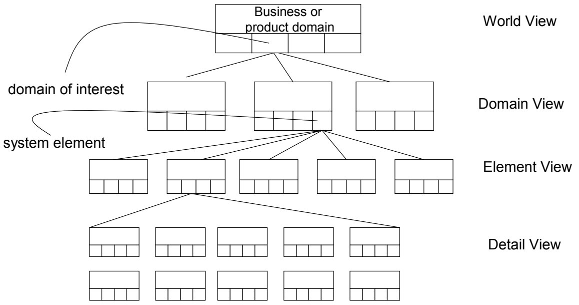
System Engineering Hierarchy



System Modeling

The engineer creates models that:

- Define the processes that serve the needs of the view under consideration
- Represent the process behavior and the assumptions on which the behavior is modeled
- Explicitly define the exogenous (links between constituents) and endogenous (links between constituent components) input to the model
- Represent all linkages (including outputs) required to understand the view

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System Model Restraining Factors

- Assumptions
  - reduces the number of possible variations
- Simplifications
  - enable the model to be created in a timely manner
- Limitations
  - help to bound the system
- Constraints
  - guide the manner in which the model is created and implemented
- Preferences
  - indicate the preferred architecture for all data, functions, and technology

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Systems Modeling Process

Hartley-Pirbhai Modeling

- System Context Diagram (SCD)
  - top level node in system hierarchy used to establish the boundary between the system being implemented (system model template serves as its basis)
- System Flow Diagram (SFD)
  - refinement of the process and control functions from SCD, derived by identifying the major subsystems and lines of information flow
- Initial SFD is becomes the top level node of a hierarchy of more successively more detailed SFD's
- System Specification
  - developed by writing narrative description for each subsystem and definitions for all data that flow between subsystems

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System Model Template

Hartley-Pirbhai Modeling

- User interface
- Input
- Process and control functions
- Output
- Maintenance and self test

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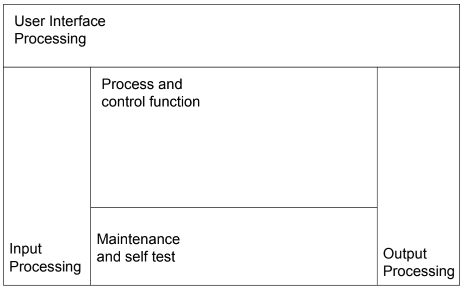
The Template


User Interface Processing

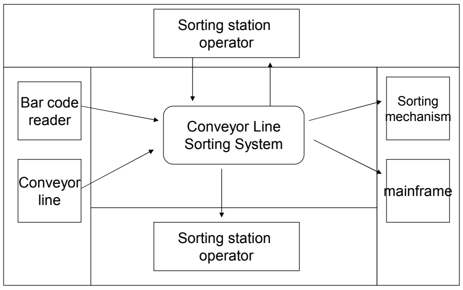
Process and control function

Input Processing

Maintenance and self test

Output Processing

SFD for CLSS



System Modeling with UML

- Deployment diagram
  - depicts hardware elements that are part of the physical architecture of the system
- Activity diagram
  - used to represent the procedural aspects of the system software elements, similar to a flowchart in that system functions are shown as nodes, decision points are shown as diamonds, and arrows are used to show flow through the system
- Class diagram
  - shows the class attributes and operations that may be applied to the class within the context of the system
- Use-case diagram
  - illustrates the manner in which an actor interacts with the system, each labeled oval within a system boundary represents one text scenario or use-case

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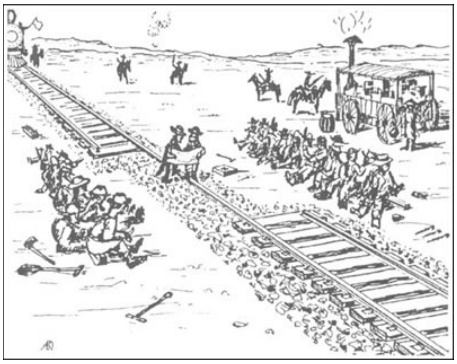

Business Process Engineering

- Goal
  - to define architectures that will enable a business to use information effectively
- Architectures
  - Data architecture
    - provides framework for information needs of a business or business function
  - Applications architecture
    - those system elements that transform objects within the data architecture for some business purpose
  - Technology infrastructure
    - provides foundation for the data and application architectures

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Business Process Engineering (2)

- Hirarchy
  - Information Strategy Planning (world view)
  - Business Area Analysis (domain view)
  - Business System Design (element view - software engineers)
  - Construction and Integration (detailed view - software engineers)

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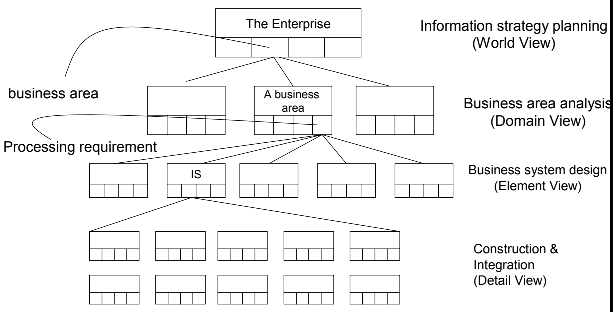
The Business Process Engineering Hierarchy


The Enterprise
Information strategy planning (World View)
business area
A business area
Business area analysis (Domain View)
Processing requirement
IS
Business system design (Element View)
Construction & Integration (Detail View)

Product Engineering

- Goal
  - to translate the customer's desire for a set of defined capabilities into a working product
- Hirarchy
  - Requirements engineering (world view)
  - Component engineering (domain view)
  - Analysis and Design modeling (element view - software engineers)
  - Construction and Integration (detailed view - software engineers)

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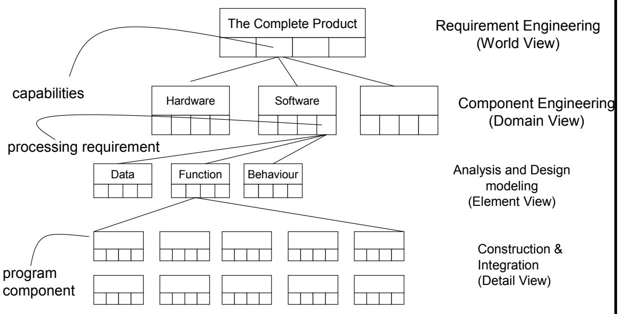
The Product Engineering Hierarchy


The Complete Product
Requirement Engineering (World View)
capabilities
Hardware
Software
Component Engineering (Domain View)
processing requirement
Data
Function
Behaviour
Analysis and Design modeling (Element View)
program component
Construction & Integration (Detail View)

Systems engineering

- Specifying, designing, implementing, validating, deploying and maintaining socio-technical systems.
  - Systems that include technical systems but also operational processes and people who use and interact with the technical system. Socio-technical systems are governed by organisational policies and rules.
- Concerned with the services provided by the system, constraints on its construction and operation and the ways in which it is used.

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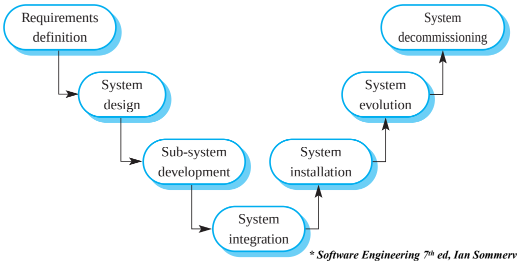
The Systems Engineering Process



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System Requirements Definition

- Three types of requirement defined at this stage
  - Abstract functional requirements.
    - System functions are defined in an abstract way;
  - System properties.
    - Non-functional requirements for the system in general are defined;
  - Undesirable characteristics.
    - Unacceptable system behaviour is specified.
- Should also define overall organisational objectives for the system.

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System Requirements Problems

- Complex systems are usually developed to address wicked problems
  - Problems that are not fully understood;
  - Changing as the system is being specified.
- Must anticipate hardware/communications developments over the lifetime of the system.
- Hard to define non-functional requirements (particularly) without knowing the component structure of the system.

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The System Design Process

- Partition requirements
  - Organise requirements into related groups.
- Identify sub-systems
  - Identify a set of sub-systems which collectively can meet the system requirements.
- Assign requirements to sub-systems
  - Causes particular problems when COTS are integrated.
- Specify sub-system functionality.
- Define sub-system interfaces
  - Critical activity for parallel sub-system development.

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System Design Problems

- Requirements partitioning to hardware, software and human components may involve a lot of negotiation.
- Difficult design problems are often assumed to be readily solved using software.
- Hardware platforms may be inappropriate for software requirements so software must compensate for this.

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Requirements and Design

- Requirements engineering and system design are inextricably linked.
- Constraints posed by the system's environment and other systems limit design choices so the actual design to be used may be a requirement.
- Initial design may be necessary to structure the requirements.
- As you do design, you learn more about the requirements.

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Sub-System Development

- Typically parallel projects developing the hardware, software and communications.
- May involve some COTS (Commercial Off-the-Shelf) systems procurement.
- Lack of communication across implementation teams
- Bureaucratic and slow mechanism for proposing system changes means that the development schedule may be extended because of the need for rework.

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System Integration

- The process of putting hardware, software and people together to make a system.
- Should be tackled incrementally so that sub-systems are integrated one at a time.
- Interface problems between sub-systems are usually found at this stage.
- May be problems with uncoordinated deliveries of system components.

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System Installation

- After completion, the system has to be installed in the customer's environment
  - Environmental assumptions may be incorrect;
  - May be human resistance to the introduction of a new system;
  - System may have to coexist with alternative systems for some time;
  - May be physical installation problems (e.g. cabling problems);
  - Operator training has to be identified.

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System Evolution

- Large systems have a long lifetime. They must evolve to meet changing requirements.
- Evolution is inherently costly
  - Changes must be analysed from a technical and business perspective;
  - Sub-systems interact so unanticipated problems can arise;
  - There is rarely a rationale for original design decisions;
  - System structure is corrupted as changes are made to it.
- Existing systems which must be maintained are sometimes called legacy systems.

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System Decommissioning

- Taking the system out of service after its useful lifetime.
- May require removal of materials (e.g. dangerous chemicals) which pollute the environment
  - Should be planned for in the system design by encapsulation.
- May require data to be restructured and converted to be used in some other system.

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