TDT4252 / DT8802
Enterprise Modelling and Enterprise Architecture

Sobah Abbas Petersen

Adjunct Associate Professor
sap@idi.ntnu.no

NTNU – Trondheim
Norwegian University of
Science and Technology

Today's Lecture

- Introduction to AKM

- Enterprise Knowledge Spaces

- Based on:
  - Lillehagen and Krogstie (2008), Chapters 1 & 13, Springer-Verlag, Berlin, Heidelberg. pp. 1-25.

- Acknowledgements:
  - Frank Lillehagen, Håvard Jørgensen, John Krogstie
  - Based on lecture notes from spring 2009 (Krogstie), presentations by Frank Lillehagen and Håvard Jørgensen.
 - http://activeknowledgemodeling.com/
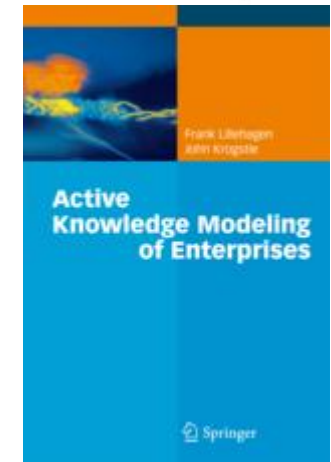
Challenges in industrial IT support (1)

- Aligning business, ICT and Knowledge Management (KM).

- Reducing costs for application portfolio management and integration.

- Achieving more effective solutions development, delivery, deployment and integration.

- Achieving predictability, accountability, interoperability, adaptability and trust in networked organizations.

- Achieving ease of re-engineering, reuse and management of solutions.

- Supporting concurrency, context-sensitivity, and multiple simultaneous projects and business processes.

NTNU – Trondheim
Norwegian University of
Science and Technology

Challenges in industrial IT support (2)

- Supporting multi-dimensional, collaborative product design and life-cycle innovation and knowledge capture.

- Providing self-organizing, self-managing and re-generating solutions.

- Semi-automating information and knowledge reuse and management.

- Supporting learning-by-doing, enabling users to acquire and activate new knowledge as work is performed.

- Achieving independence of system and IT experts.

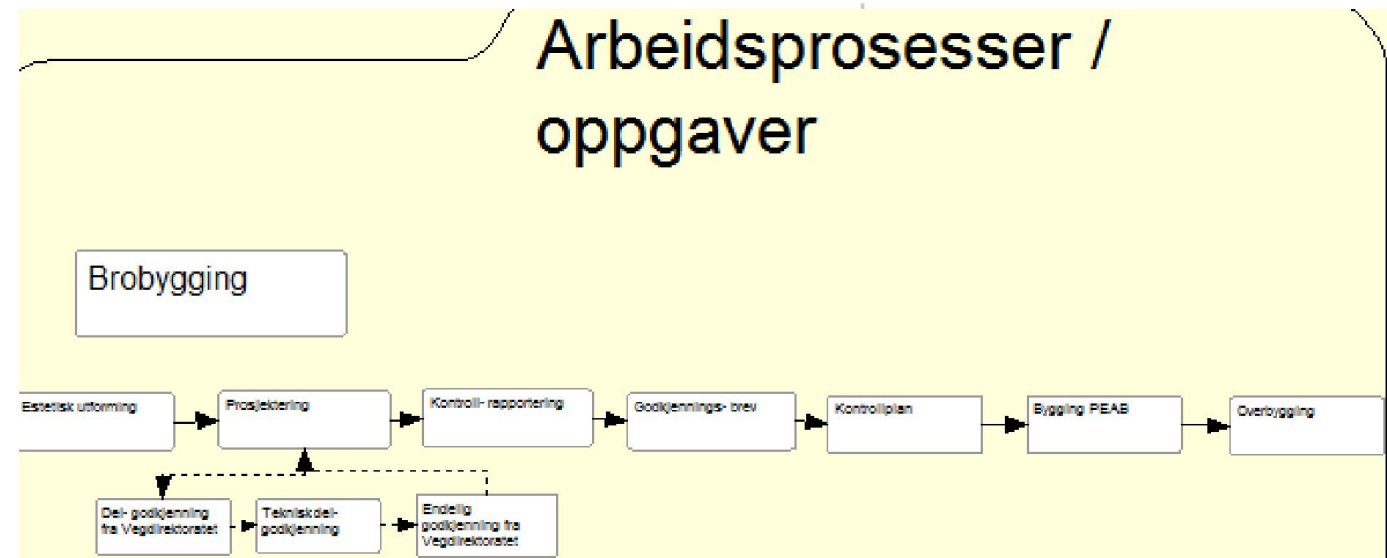- Designing personal workplaces and harmonizing work environments.
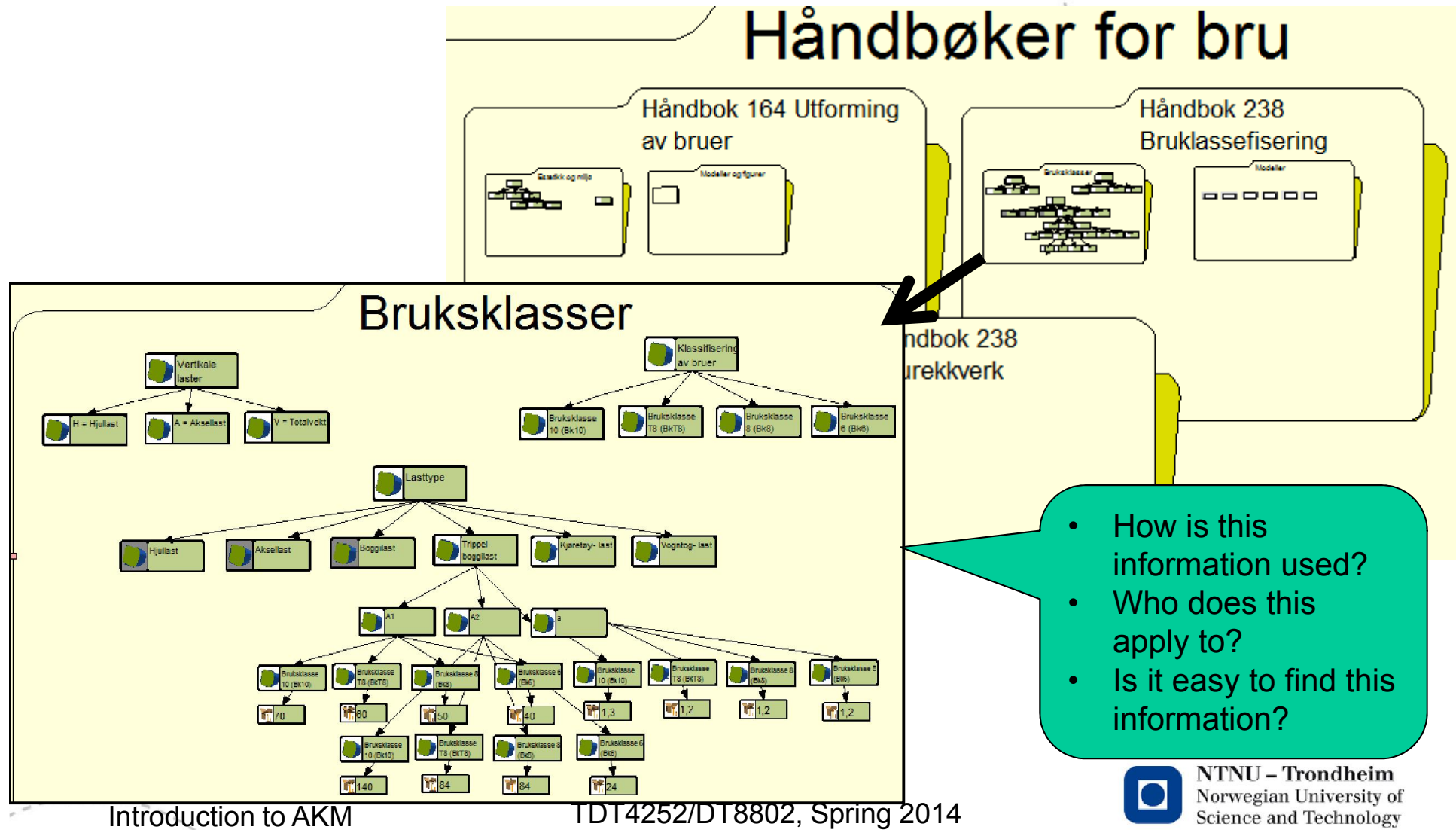
NTNU – Trondheim
Norwegian University of
Science and Technology

An example from Road Building (1)

An example from Road Building (2)

Arbeidsprosesser / oppgaver

Brobygging

| Estetisk utforming | Prosjektering | Kontroll- rapportering | Godkjennings- brev | Kontrollplan | Bygging PEAB | Overbygging |

Del- godkjenning fra Vegdirektoratet → Tekniskdel- godkjenning → Endelig godkjenning fra Vegdirektoratet

Prossessroller

SVV landskaparkitekt — Byggeleder bro — SVV brodesign konsulent — Brobyggings- ekspertise — Driftansvarlig — SVV Planlegger bro

KS konsulent — PEAB-bro konsulent

Under- leverandører

- How do these relate to the rules and procedures in the Handbooks?

Introduction to AKM

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

An example from Road Building (2)

Arkitektur for byggeplan
Havnekrysset - Kvithammar
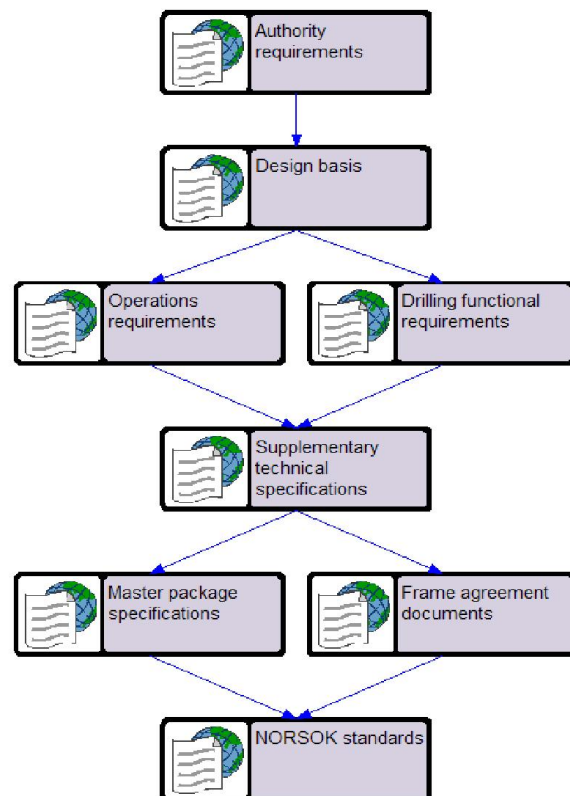
NTNU – Trondheim
Norwegian University of
Science and Technology

Documented Knowledge

Hierarchy of regulation, codes and practices

- Authority requirements
- Design basis
  - Operations requirements
  - Drilling functional requirements
- Supplementary technical specifications
  - Master package specifications
  - Frame agreement documents
- NORSOK standards

How do we manage change?

Which information is current?

ne Skjærstein, orizontal Water Injectors Grane", July 1999,

rnstein Waldum, Petrophysical Field Study, lermod Area, PL169".

Marie Weider and Jan Ove Selboe, "Grane Design Data Base", 1999,

Grane platform location", Report R-082408.

rik Ellertsen, Kenneth lordbø, "Well 5/11-T-21A, Fluid

"Norsk Hydro Slangehåndbok", ID-200630,

"Program for systematisk

What is relevant for me?

Site and Soil Data". SCM eference: 8-1A-NH-X52-00001, 03M

"Halliburton Test Sep. Design report......", Autumn 1999.

Marie Weider, "Grane Production Chemistry Summary Report",

Norsk Hydro, "Bathymetri Grane Platform Area", Doc. m2092.

How do we manage design dependencies across documents?

enneth Nordbø, Erik llertsen, "PVT-study. Bottom hole samples well

Fiona F. Stewart, "Drilling Constraints report: 25/11-BHI", A 1997,

Norsk Hydro, "Grane Safety,

Duplication across documents?

Introduction to AKM

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of Science and Technology

Structured Product Data Management

Web portal

Reports, queries, views

Central Data Hub

Documents

Ownership

Milestones

Product model

Design objects
Structures
Relationships
Metadata
Status
BOM

Data progress

Data quality

Revisions

Reference data

Catalogues | Specs | Numbering rules | Project rules | Codes

Meta model

Planning — Activities, milestones / Quality and progress

Process design — Tag/line information / Tag/line connections / Pipe spec parameters

EIT design — Eng. index data / Term./loop drawing ref. / Datasheets / Hook-up items / Part catalogue / Eng. index data

3D design — Center of Gravity, MTO / Drawing ref., ISO drawings / Hook-up items / Pipe spec, part catalogue / End. index data, line info

Document control — Document meta data / Electronic files / Tag document ref.

Material management — Package information / Order information / Engineering requisition / Bulk MTO

Fabrication need / Fabrication status / Eng. index data / Bulk MTO

Completion status / Eng. index data

Change numbers

Eng. index data / Document data

Data quality — Quality and progress

Client — Handover data

Vendor/sub-contractor — Various project data

How can this data be more easily reused in future projects?

Can the global metamodel cover all needs?

Can we simplify coding standards?

Once this is in place, will we ever be able to change?

How do we merge different system aspects?

Static data structures

Integration by data mapping

Integration by programming

Introduction to AKM

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

AKM View of EM

Case tools

Process Modelling

Enterprise Modelling

Product structures

Information structures

"Model-based approaches must enable regular industrial users to be active modellers, both when performing their work, expressing and sharing their results and values created, and when adapting and composing the services they are using to support their work."

NTNU – Trondheim
Norwegian University of
Science and Technology

Limitations with current Enterprise Modelling approaches (1)

- Enterprise knowledge can only be represented in predefined, vendor proprietary or prematurely standardized modelling languages.

- The modeling approach, roles to engage, tasks to support and views to create are predetermined and cannot be adapted to the case in hand.

- Modelling is not an integral part of engineering or product development, but performed in isolation by specialists.

- The user interface is static and systems engineer oriented, and supports just one style of modeling.

- There is limited support for knowledge externalization, sharing, reuse and management.

Limitations with current Enterprise Modelling approaches (2)

- Most models are collections of static views and diagrams and give no support for adaptation and extension of meta-models.

- Models and modeling environments are detached from solution execution platforms.

- The leading concepts for modeling languages, view management and parameter definition are restricted to object-oriented thinking.

NTNU – Trondheim
Norwegian University of
Science and Technology

Active Knowledge Architecture (1)

- Purpose: to provide product designers, engineers, architects and other stakeholders a common language and workplace contents for building interoperable, collaborative and reusable services and knowledge elements.

- Early phases of projects lack adequate support:
  - Effective and holistic design.
  - Conceptual design of products.
  - Collaborative design.
  - Means to capture the design rationale and the knowledge of the designers and engineers.

- Designers and engineers must feel ownership of the knowledge.

NTNU – Trondheim
Norwegian University of
Science and Technology

Active Knowledge Architecture (2)

- Designers and engineers must have a workplace and the services that evolve with knowledge that is created and aggregated.

- The data and knowledge stored in and reactivated from an Active Knowledge Architecture (AKA).

- Active: implies that AKA's contents (roles, task patterns, information structures, etc.) will automatically configure the workplaces. Work-centric data created in the workplaces are automatically folded back into the AKA.

AKA **configures** → Workplaces

New knowledge ←

NTNU – Trondheim
Norwegian University of
Science and Technology

www.ntnu.edu
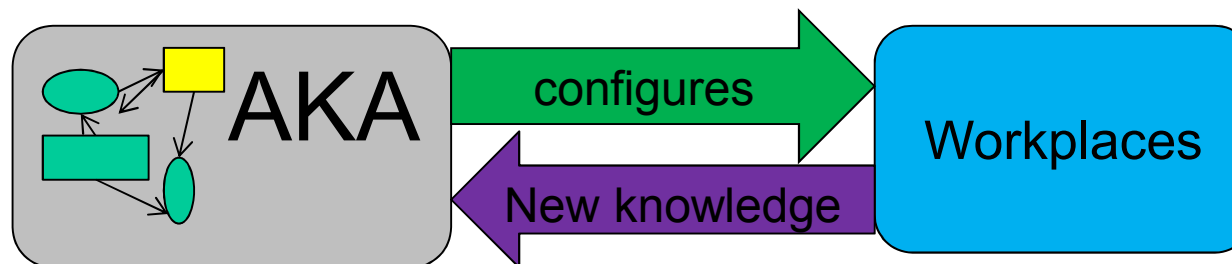
AKA: An example

Workplaces for roles

Active Knowledge Architecture
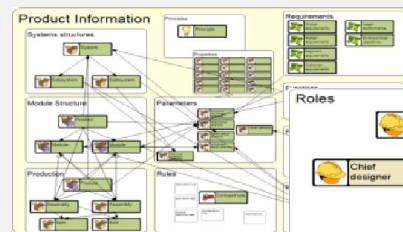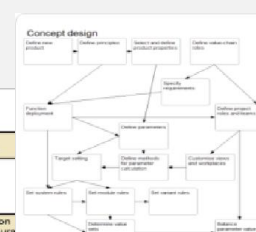
Products · Organization Roles · Processes, Tasks · Systems, Views
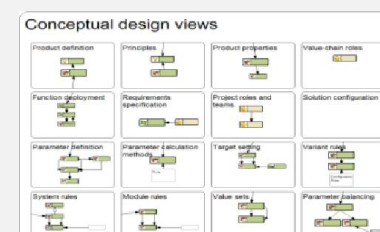
Courtesy of Commitment AS

Introduction to AKM   TDT4252/DT8802, Spring 2014

What is an Active Knowledge Model?

- To be an active model:

  – A visual model must first and foremost be available to the users of the operational information system at the time of execution.

  – The model must automatically influence the behaviour of the computerised work system support and workplace.

  – The model must be dynamically extended and adapted; users must be supported in changing the model to fit their local needs, enabling tailoring of the work environment's behaviour.

- Active knowledge Modelling is capturing knowledge involved in building workplaces, in supporting work execution and knowledge generated by work execution.

- An active knowledge Model must support reflective views of the knowledge aspect.

NTNU – Trondheim
Norwegian University of
Science and Technology

Software Engineering Models

- Data/information
  - Objective
  - Rational
- Code
  - Formal
  - Static
- Rigid systems
  - Global logic
  - No change during execution

Design time

Run time

Models

Design

Metadata

Classes

Objects

Code

Data

Active

Passive

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

Active Knowledge Models

- From data to knowledge models
  - Pragmatic
  - Situated, contextual
  - Socially constructed and (inter)subjectively interpreted
  - Multiple views
- From code to active models
  - Adaptive systems
  - Local
  - Living, growing open system

Models

Design   Metadata

Classes   Objects

ActiveKnowledge

Design and run time

Active

NTNU – Trondheim
Norwegian University of
Science and Technology

Interactive (active) models

- Visual (graphical) models of enterprise aspects (goals, tasks, roles, organizations, persons, information, systems...)

- Available for normal users to be viewed, traversed, analyzed, simulated, executed, and adapted

- Changes to the models influence the information systems supporting (part of) the enterprise

Interactive model

Information Resources

Tools

Process

Organisation

Introduction to AKM   TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology
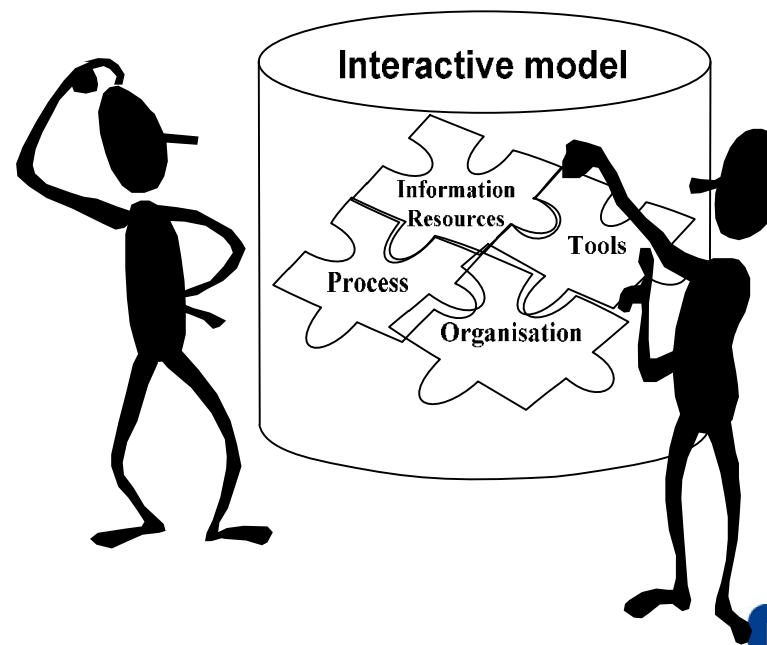
AKM extends the role of Enterprise Modelling (1)

- Modeling specific roles, tasks, information and views to capture context, and to configure and generate role-specific workplaces.

- Modeling products, organizational resources, processes and systems to support core industrial design and engineering knowledge.

- Modeling properties and their values and value-ranges as separate structures, independent of objects.

- Managing corporate modeling elements and workplace contents in an active knowledge architecture (AKA).

- Managing contextual descriptions of work, and workplace configurations to support extensive reuse of knowledge and data.

- Enabling industrial users to build and manage their own working environments, workplaces and services.

NTNU – Trondheim
Norwegian University of
Science and Technology

AKM extends the role of Enterprise Modelling (2)

- Enabling life-cycle data and knowledge management, capturing and sharing experiences, unresolved issues and lessons learned.

- Expressing knowledge readily reflected as updated menus and views in model-configured workplaces.

- Building knowledge models and architectures of methodologies, information libraries and reference models, currently only available on paper.

- Building collaboration spaces and visual scenes for design, engineering, work process experimentation, validation and pro-active learning.

NTNU – Trondheim
Norwegian University of
Science and Technology

Main Concept: AKA

- Visual modelling replaces programming.
- Learning by doing, practise and experimenting.

Information   Tasks, Processes

Organization, Roles   Systems, Views
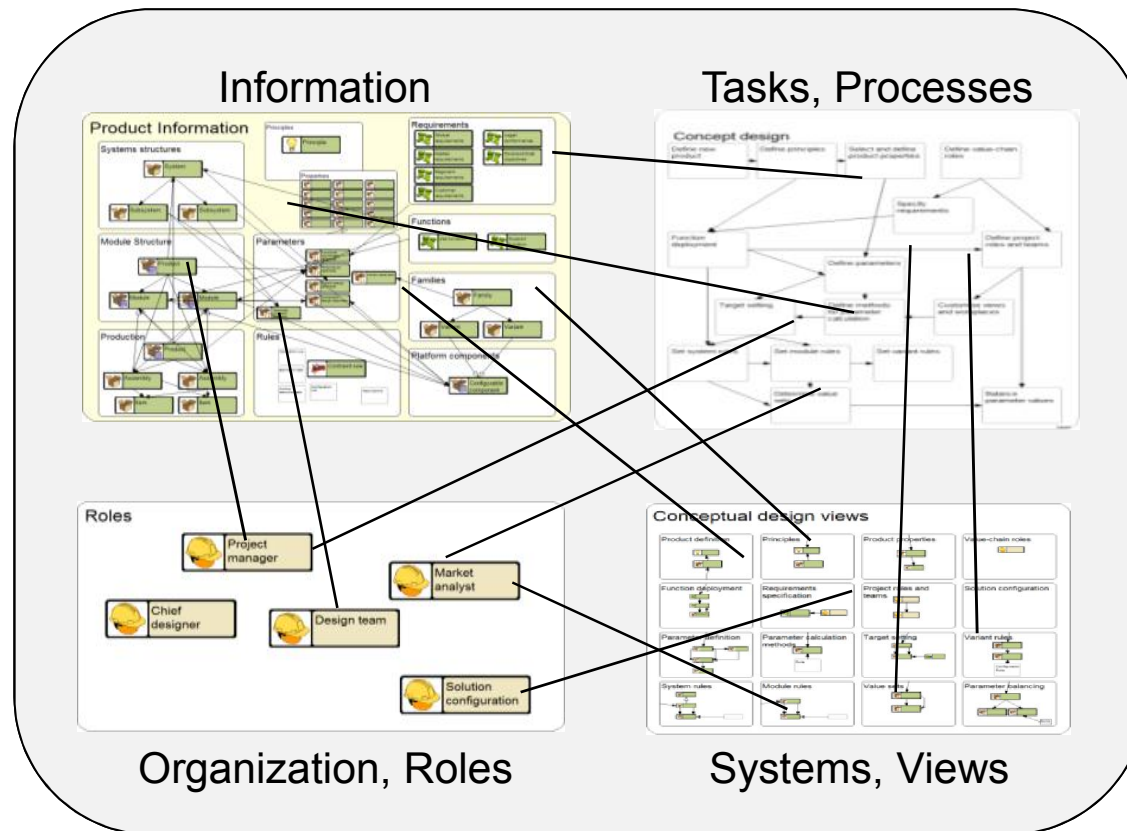
Right operation,

by the right person,

at the right time,

with the right effect.

Courtesy of Commitment AS

Introduction to AKM   TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

Case: Model-driven applications

Workplaces
for roles

Create operational
solutions without
programming

Utilise methods in the
operational solutions

**Active
Knowledge
Architecture**

Products	Organization Roles	Processes, Tasks	Systems, Views

Project
management

Systems
engineering

3D Layout

Document
management

Etc.
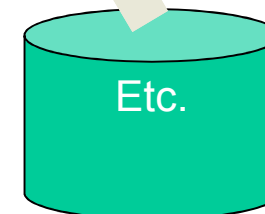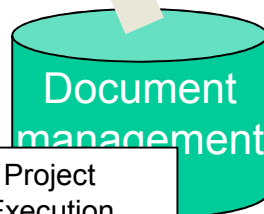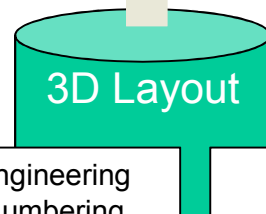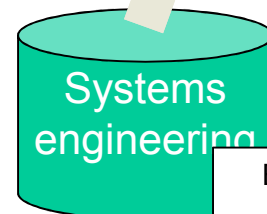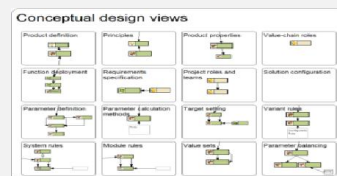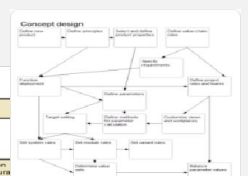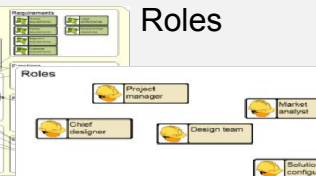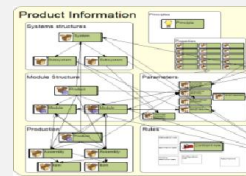
Engineering
Numbering
System

Project
Execution
Model

Courtesy of Commitment AS

Introduction to AKM

TDT4252/DT8802, Spring 2014

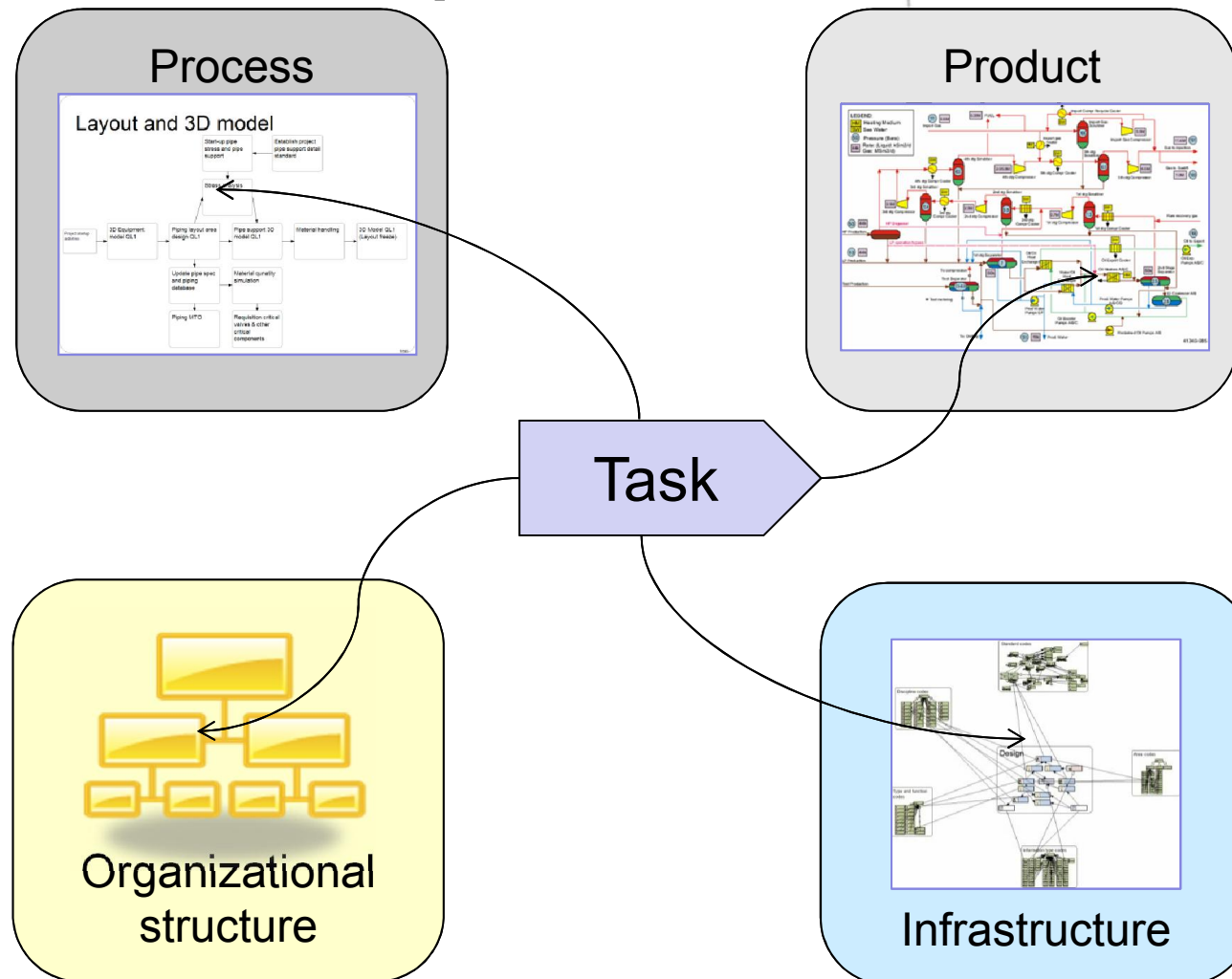**NTNU – Trondheim**
Norwegian University of
Science and Technology

Prosess Management – Work decomposition

Courtesy of Commitment AS
Introduction to AKM

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

Inter-related operations

Operational task patterns constructed from all four surrounding dimensions, and bottom up by users

Process

Product

Task

Organizational structure

Infrastructure
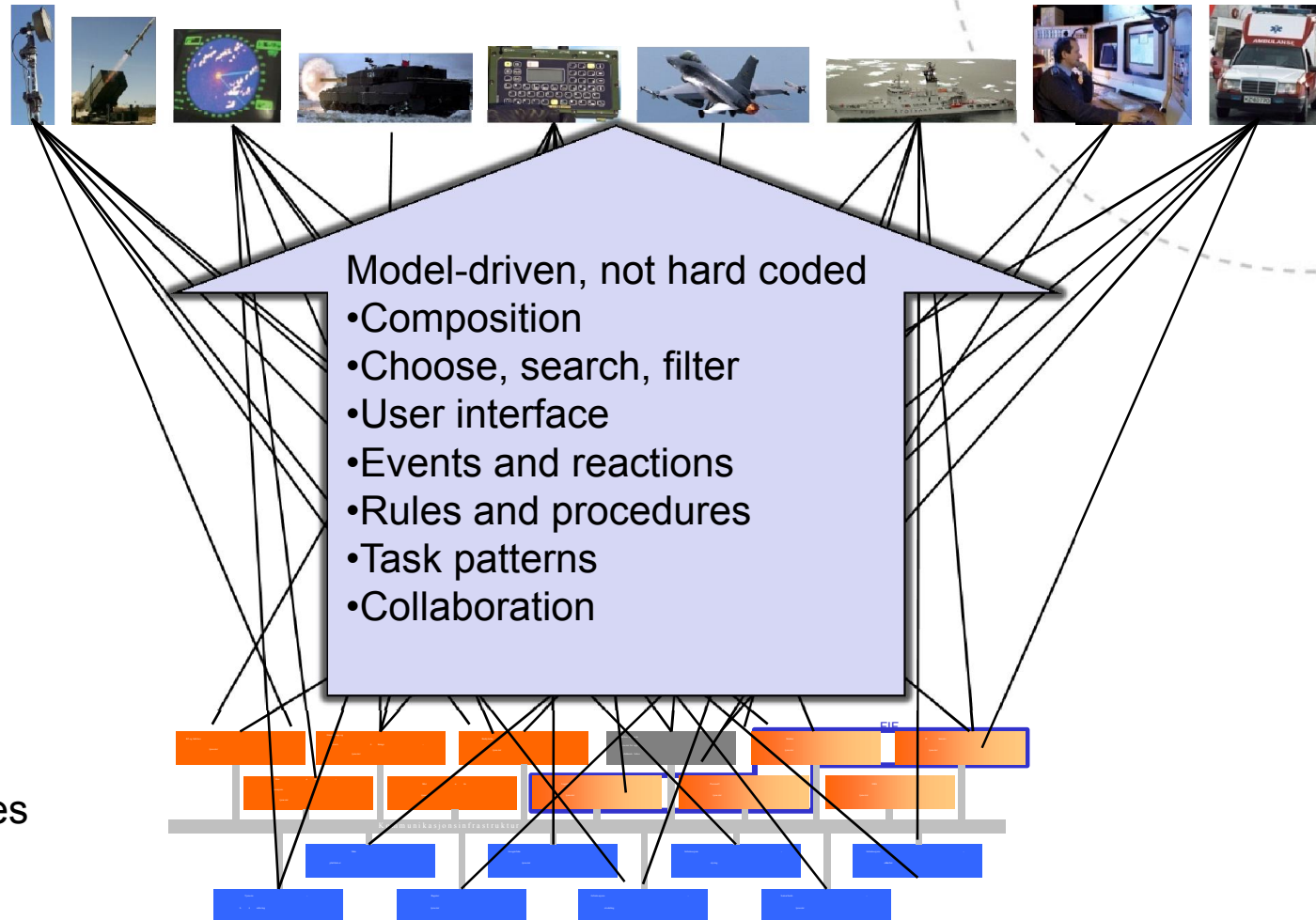

Courtesy of Commitment AS

Introduction to AKM

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

Active Knowledge-driven Services

Correct
combination of
services for
different situations

Model-driven, not hard coded
• Composition
• Choose, search, filter
• User interface
• Events and reactions
• Rules and procedures
• Task patterns
• Collaboration

Basic ICT-services
from a variety of
systems

Courtesy of Commitment AS
Introduction to AKM

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
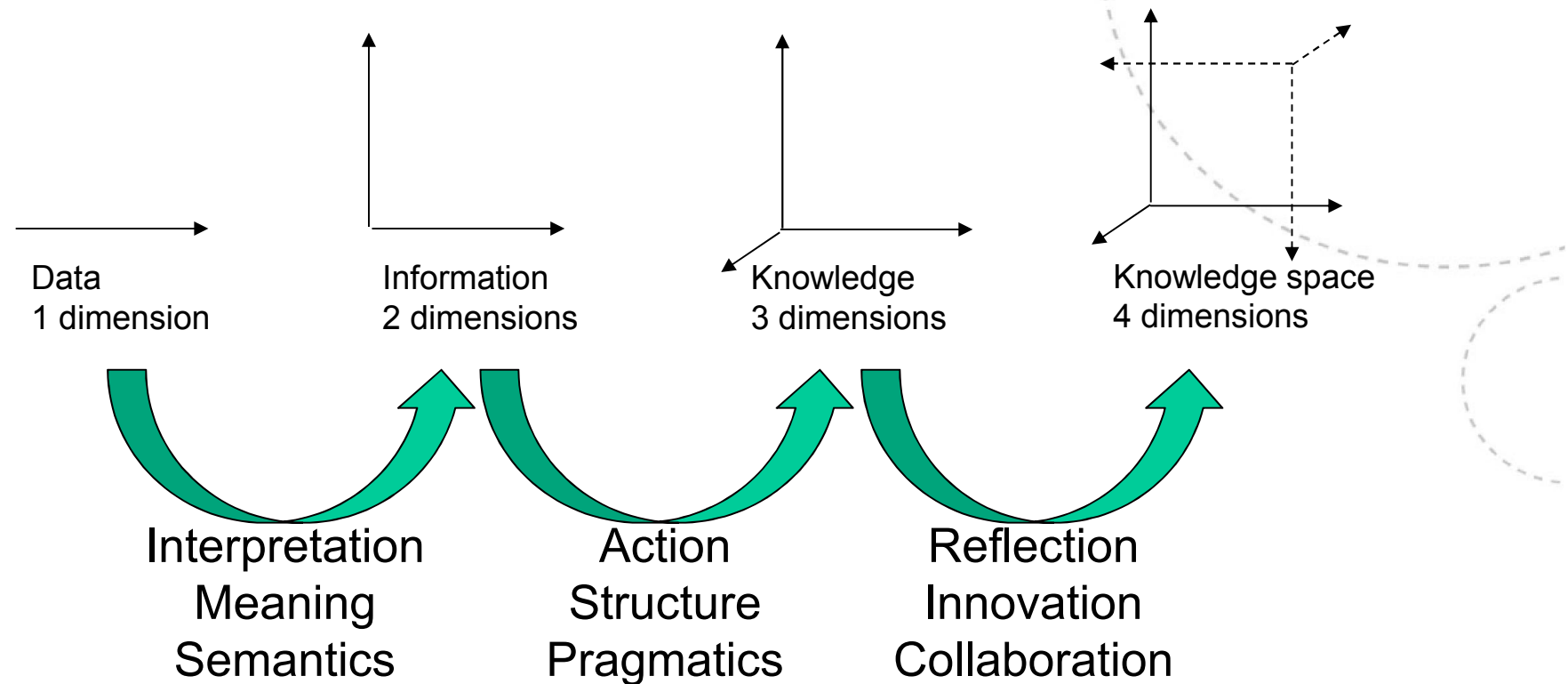Norwegian University of
Science and Technology

Visual Scenes

- Visual scenes are "ensembled views to interrelated active knowledge models supporting archetypical work in an organisation."

- Four visual scenes for future enterprising:
  - *The* Innovative scene where focus is to invent, reuse, design and learn (industrial war room concept).
  - *The* Operations scene where focus is to operate, generate, adapt, extend, manage and terminate (e.g. collaborative product development).
  - *The* Governance scene where focus is to govern, plan, decide, assign, measure and strategise.
  - *The* Evolutions scene where the focus is to analyze, configure, change, transform, align, and manifest.

Introduction to AKM TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

Enterprise Knowledge Spaces

- ## Introduction to AKM

  - (Based on Lecture Slides"Active Knowledge Modelling, Introduction", John Krogstie, Spring 2009 and a Presentation by Frank Lillehagen, Commitment AS)

- ## Based on:

  - Lillehagen and Krogstie (2008), Chapter 13: Modeling of Enterprise Knowledge Spaces, Springer-Verlag, Berlin, Heidelberg. pp. 387-398.

NTNU – Trondheim
Norwegian University of
Science and Technology

Multi-dimensional Knowledge

Data
1 dimension

Information
2 dimensions

Knowledge
3 dimensions

Knowledge space
4 dimensions

Interpretation
Meaning
Semantics

Action
Structure
Pragmatics

Reflection
Innovation
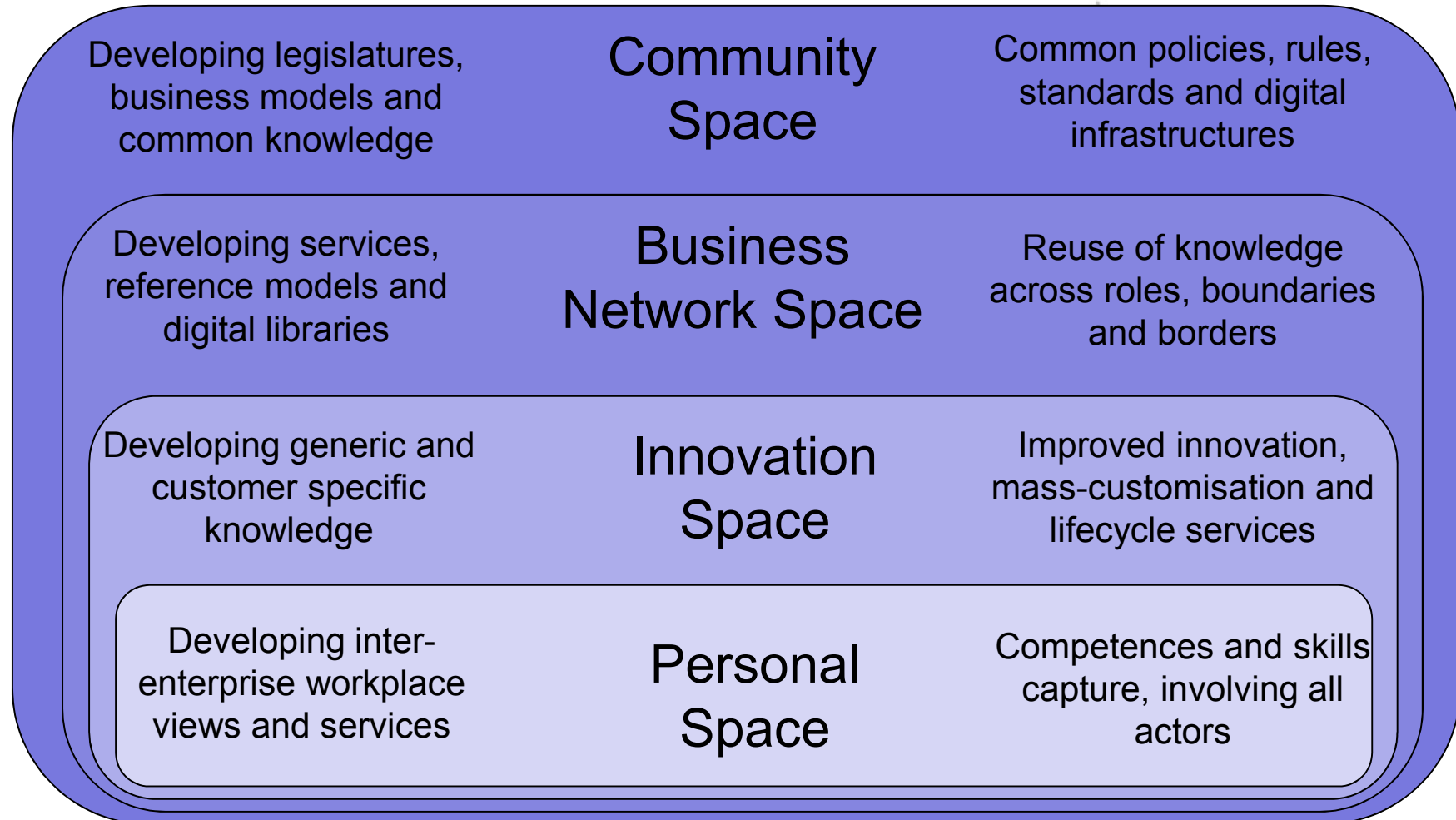Collaboration

Introduction to AKM

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

Enterprise Knowledge Spaces (1)

- A knowledge space is a four-dimensional representation, where the dimensions are mutually reflective, capable of altering each others' meaning.

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

www.ntnu.edu

Enterprise Knowledge Spaces (2)

Developing legislatures, business models and common knowledge	**Community Space**	Common policies, rules, standards and digital infrastructures
Developing services, reference models and digital libraries	**Business Network Space**	Reuse of knowledge across roles, boundaries and borders
Developing generic and customer specific knowledge	**Innovation Space**	Improved innovation, mass-customisation and lifecycle services
Developing inter-enterprise workplace views and services	**Personal Space**	Competences and skills capture, involving all actors

Enterprise Knowledge Spaces (2)

- Personal Space: reflects a user's work and knowledge so that information systems can adapt to it, as information content, roles, tasks and views (IRTV).

- Innovation space reflects the products, organisations, processes and systems of an interdisciplinary collaborative team, e.g. in product design (POPS).

- Business Network space reflects how companies come together in value networks and supply chains, their services, networks, projects and platforms (SNPP).

- Community space reflects how larger industries, sectors, cultures and societies function, their values, resources, initiatives and infrastructures (VRII).

NTNU – Trondheim
Norwegian University of
Science and Technology

Personal Workspace (1)

- A personal workspace should contain everything that someone needs for performing their work. Personal workspace models are executed by the AKM platform.
  - Information management
    - Data and metadata
  - Role management
    - Workplaces and access control
  - Task management
    - Process enactment, task automation, rules and events
  - View management
    - Workplaces, navigation, visualisation
- Other knowledge spaces become operational through the IRTV dimensions.

NTNU – Trondheim
Norwegian University of
Science and Technology

Personal Workspace (IRTV)
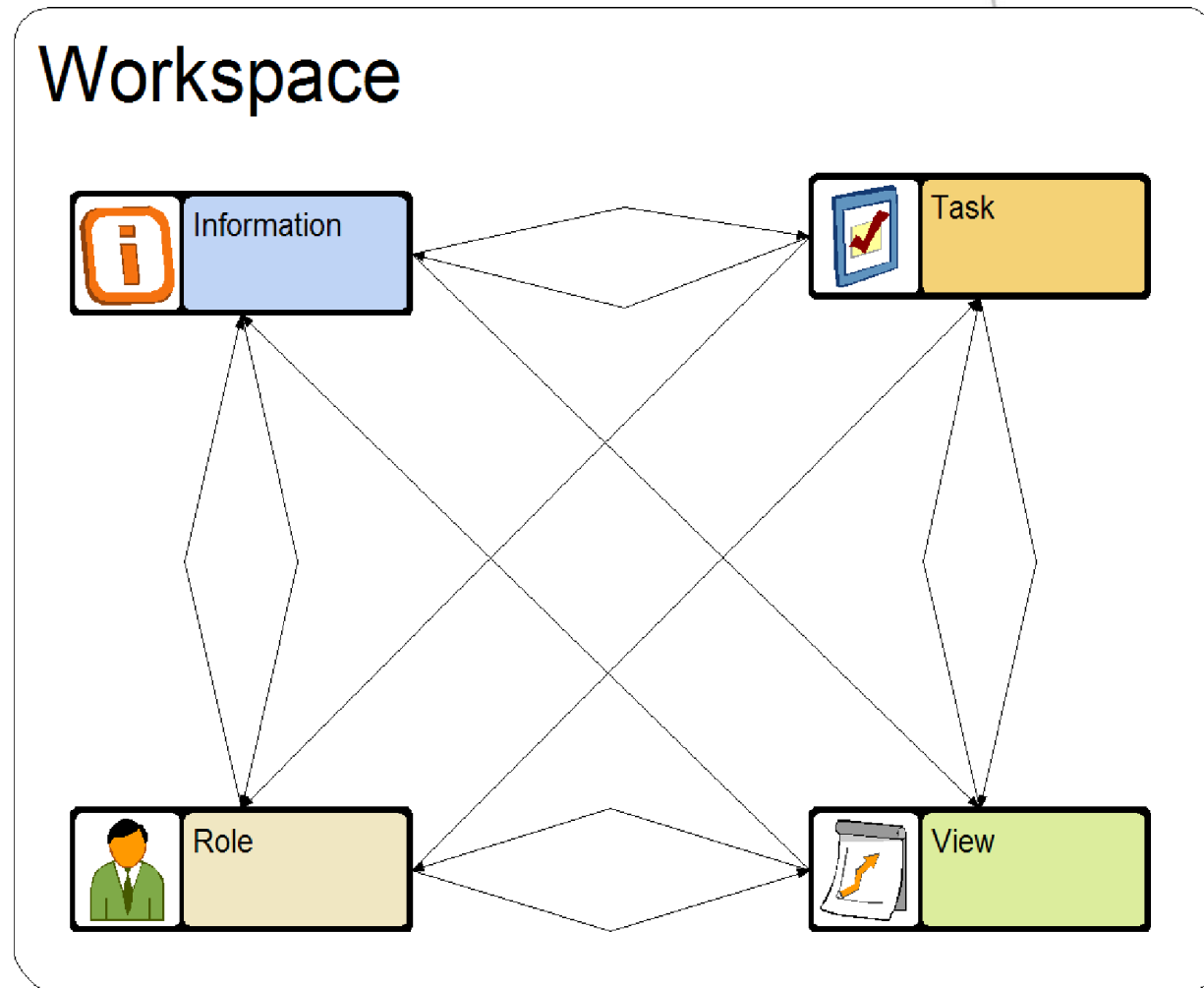
Innovation Space (1)

- In a design project, a process is followed by an organisation using a system to develop a product.

- These dimensions are mutually dependent on each other.

- The innovation space typically contains hierarchical and aspect-oriented structures for each of the dimensions such as work-breakdown structures for processes and components hierarchies for products.
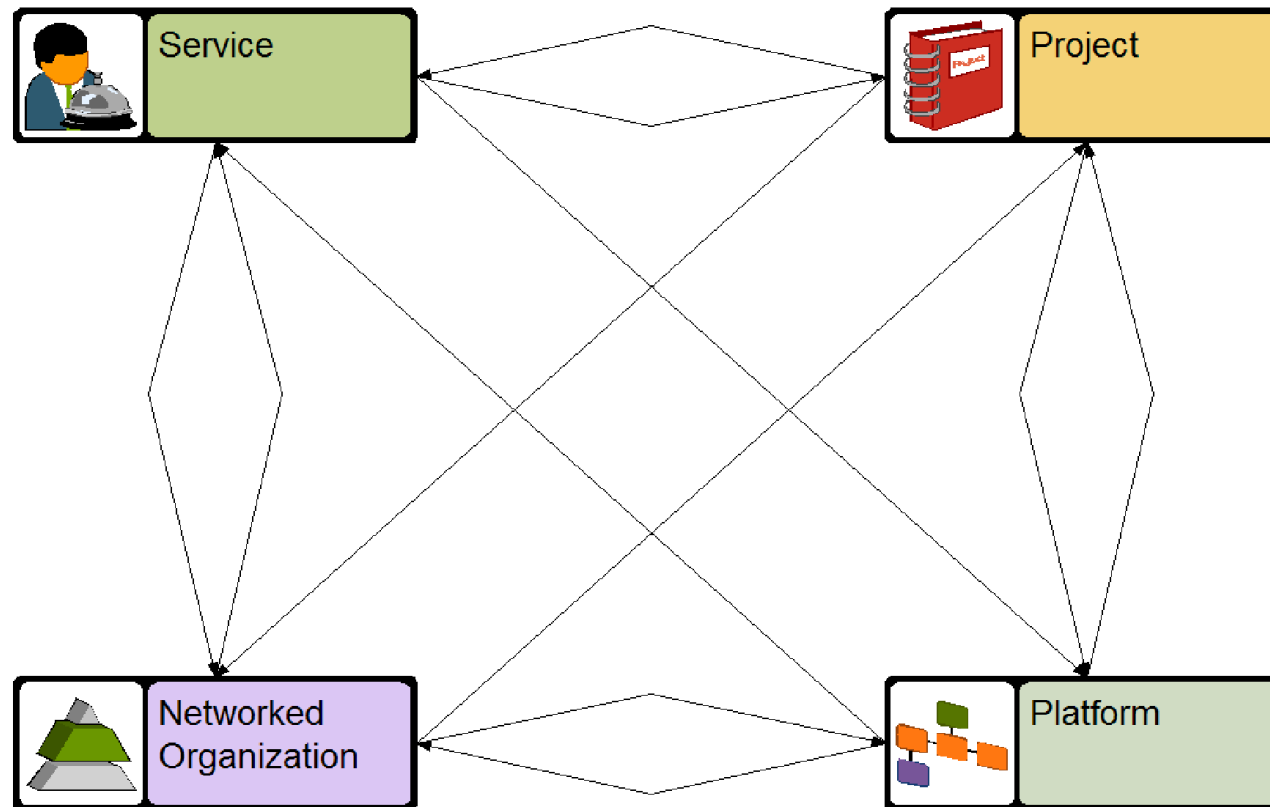
Innovation Space (POPS)

NTNU – Trondheim
Norwegian University of
Science and Technology
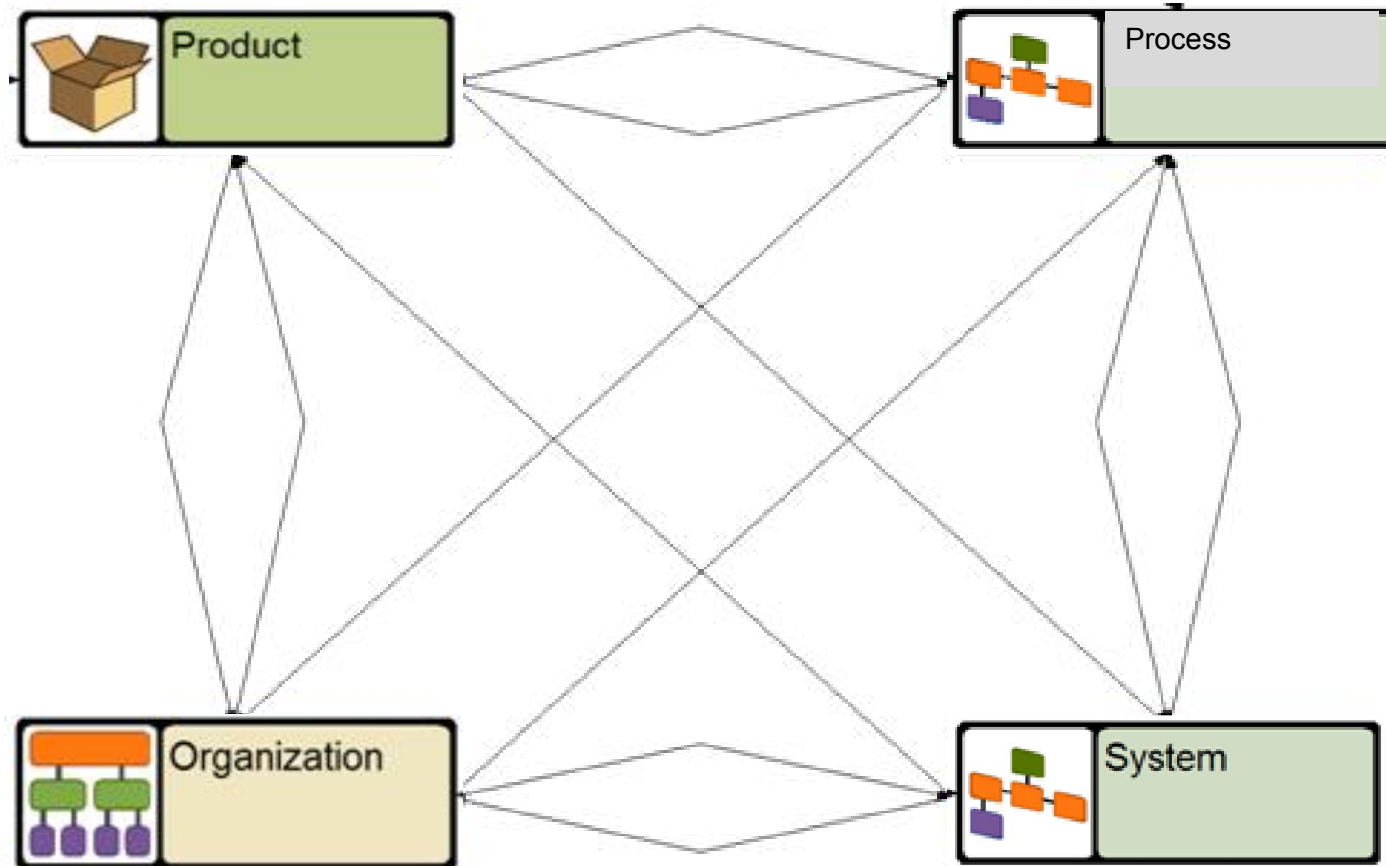
Business Space (1)

- Behind the creative work performed in innovative spaces, we find strategic management and business transactions, establishing networks of groups and companies, working together in value and supply networks, markets and consortia.
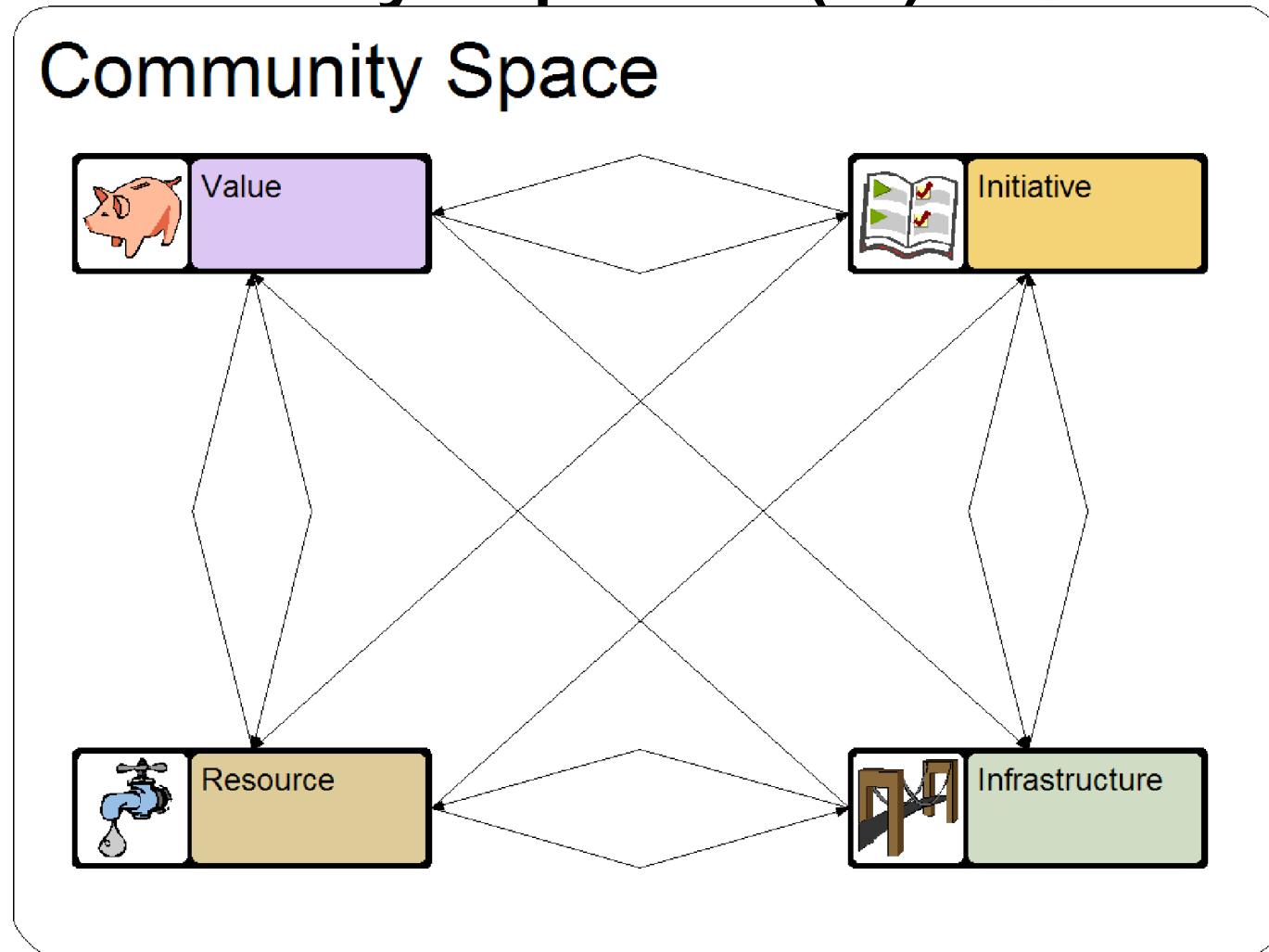
NTNU – Trondheim
Norwegian University of
Science and Technology

Business Space (2)

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

Community Space (1)

- The backbone of personal knowledge spaces, innovative teams, business networks, is the society, culture and industrial setting, where the business operate.

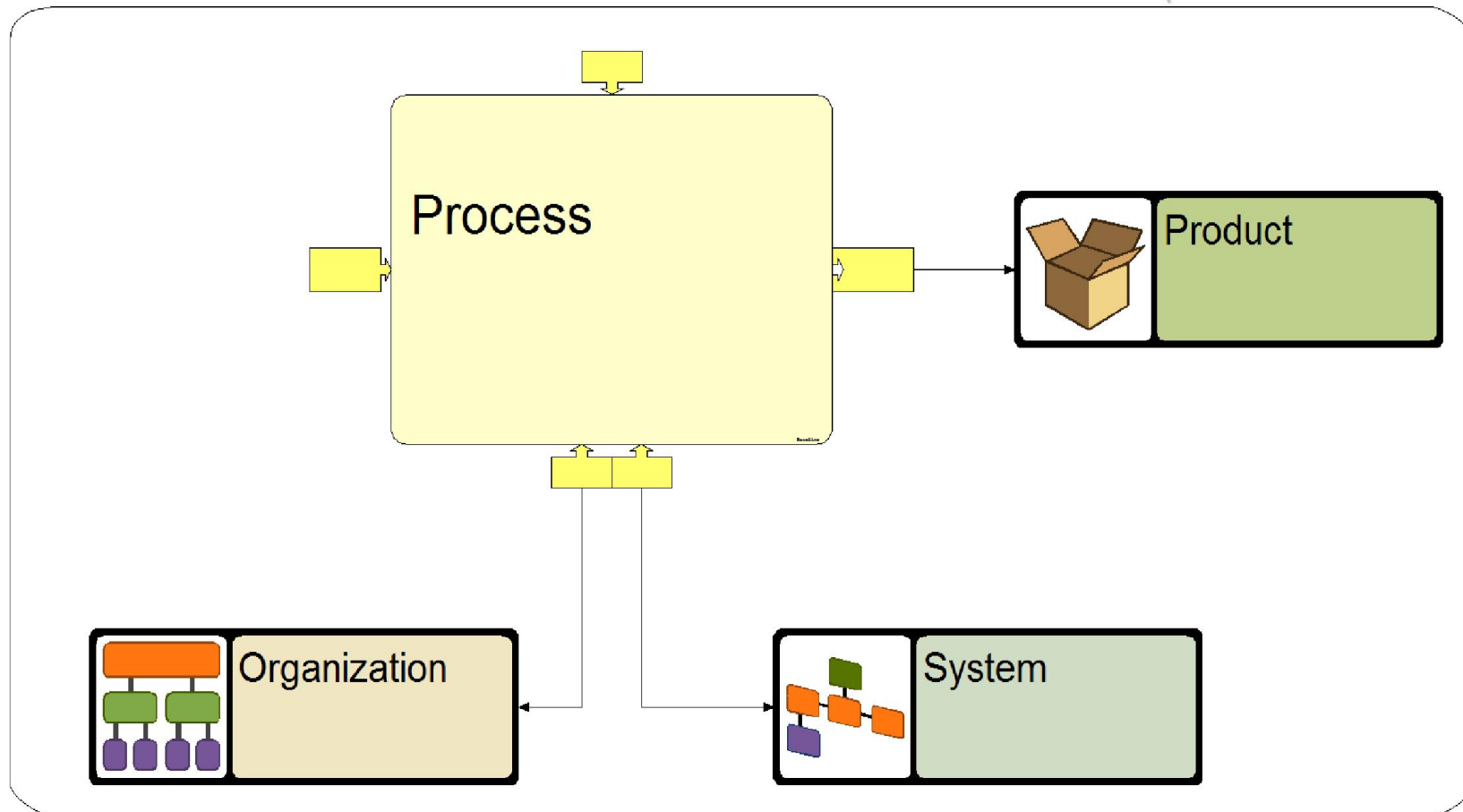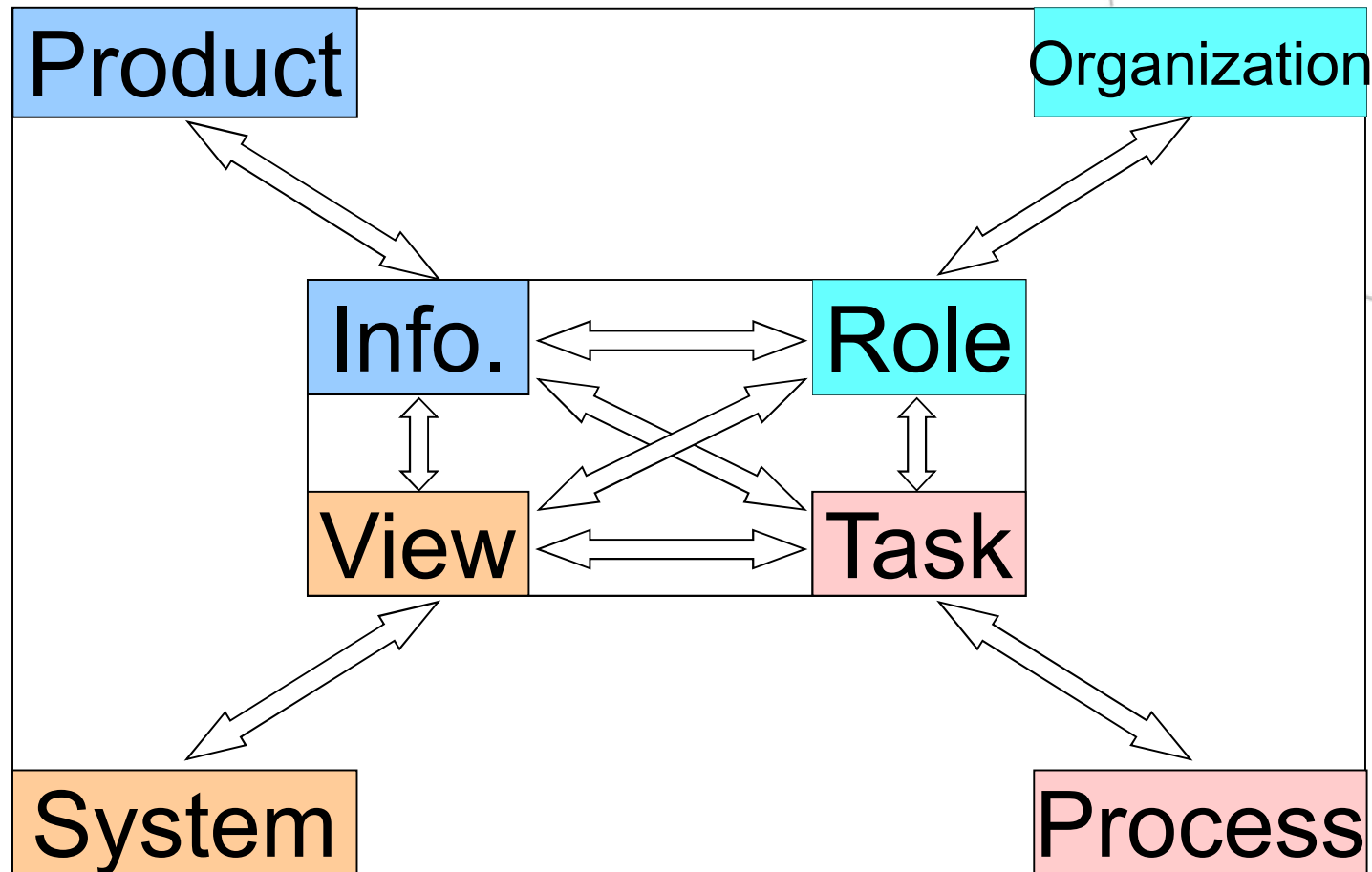- Although these are not under the control of the business, they influence the operation of the business.

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

Community Space (2)

NTNU – Trondheim
Norwegian University of
Science and Technology

Spaces in AKA

	What/Why	Who	How	Enabler
Community and network	Value	Resource	Initiative	Infrastructure
Business	Service	Network	Project	Platform
Project team innovation	Product	Organization	Process	System
Individual	Information	Role	Task	View
Software	Data	User	Code	Programming

NTNU – Trondheim
Norwegian University of
Science and Technology

Reflective Views

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

Reflection Across Knowledge Spaces
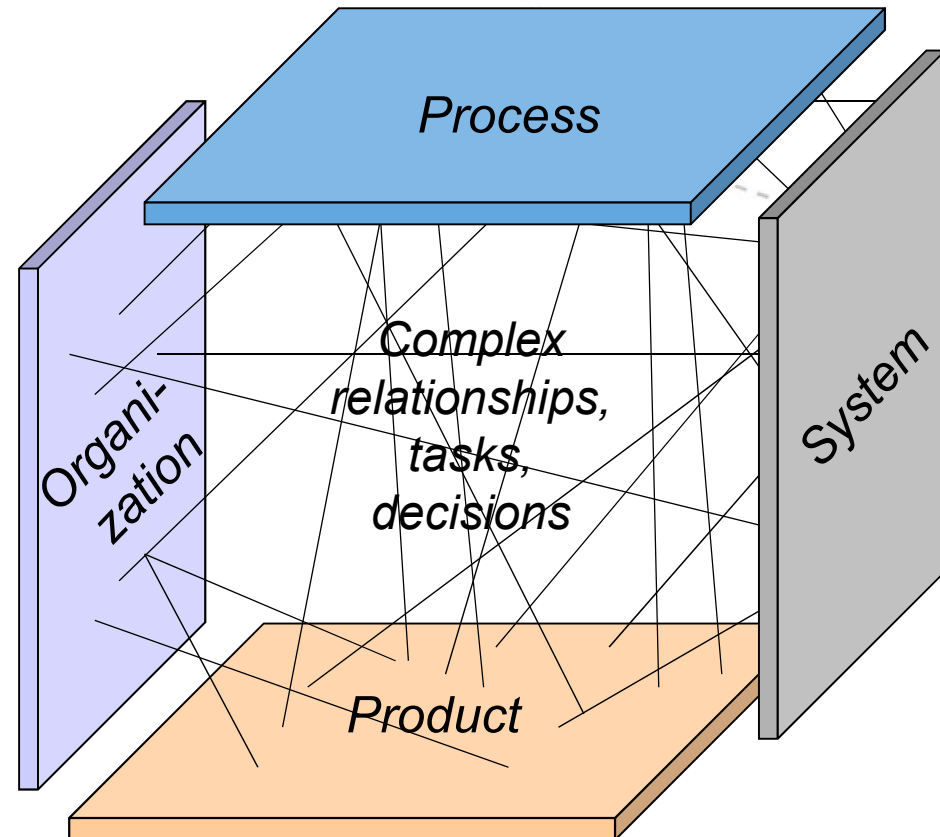
NTNU – Trondheim
Norwegian University of
Science and Technology
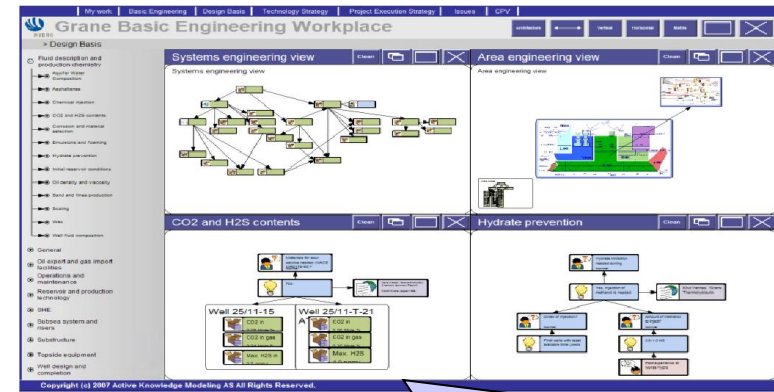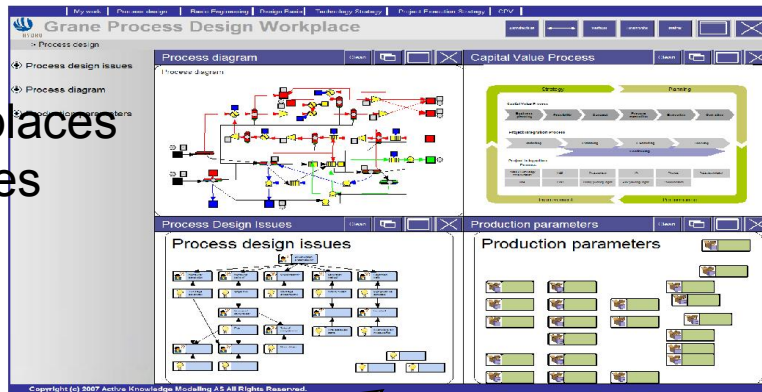
www.ntnu.edu

Mutually Reflective Views

- An object in one view may have reflections in the other dimensions
    - No layered meta-hierarchy
    - No difference between modeling and metamodeling
- Inter-view connections continually discovered, designed and created
- Types of views for each design role and discipline
- A model is a constellation of views
    - Integrating roles and disciplines
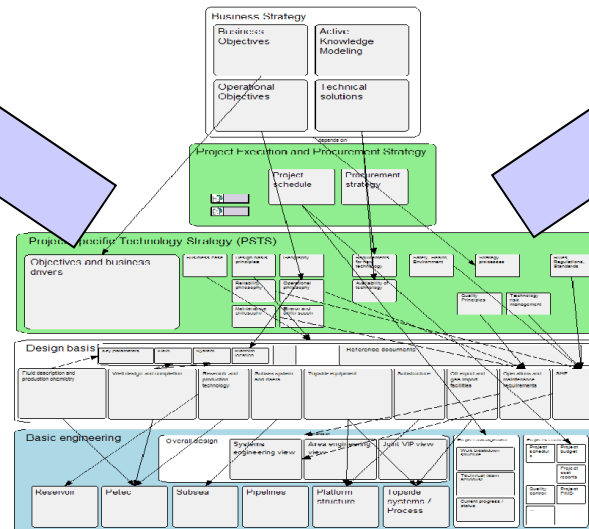- The meaning of any element may depend upon all the other elements (holistic models)

Process

Organi-zation

Complex relationships, tasks, decisions

System

Product

TDT4252/DT8802, Spring 2014

NTNU – Trondheim
Norwegian University of
Science and Technology

CVW – Configurable Visual Workplaces (1)

Workplaces for roles

Active Knowledge Architecture

NTNU – Trondheim
Norwegian University of
Science and Technology

Task Management

- Design work is creative
  - It does not follow a fixed process.
  - It is often based on predefined task patterns, but it will deviate by including new tasks, skip tasks, modify tasks, etc.

- Business processes that can be adapted by business users
  - Ad-hoc changes supported and managed in emergent workflows, the subject of 10 years of research by AKM.
  - Simple, straight-forward task planning, execution, coordination, monitoring and management.
  - Easily combined with routine procedures automated by customers' process engines.

- Task-oriented, model-configured workplaces, bringing the users what they need in a context they recognize and control.

NTNU – Trondheim
Norwegian University of
Science and Technology
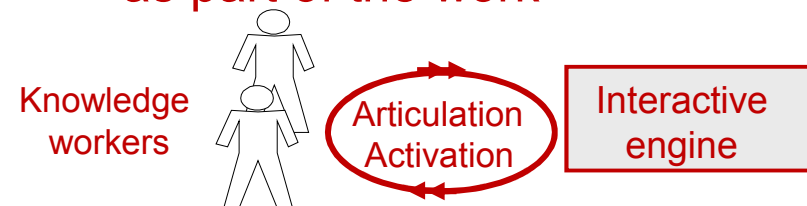
Business Process Management

Conventional BPM

- Labour/capital intensive work
- Active models
- Automatic enactment
- Repetitive processes
- Modelled by experts
- Separated definition, monitoring and enactment

Process expert

Work performer

Workflow model

Enactment

Algorithmic engine
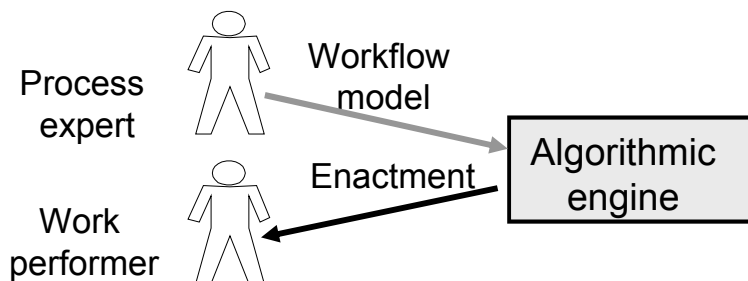
AKM: Emergent Tasks

- Knowledge intensive work
- Interactive models
- Interactive activation
- Unique processes
- Modelled by participants
- Integrated process articulation and activation
- Model and structure emerges as part of the work

Knowledge workers

Articulation Activation

Interactive engine

NTNU – Trondheim
Norwegian University of
Science and Technology
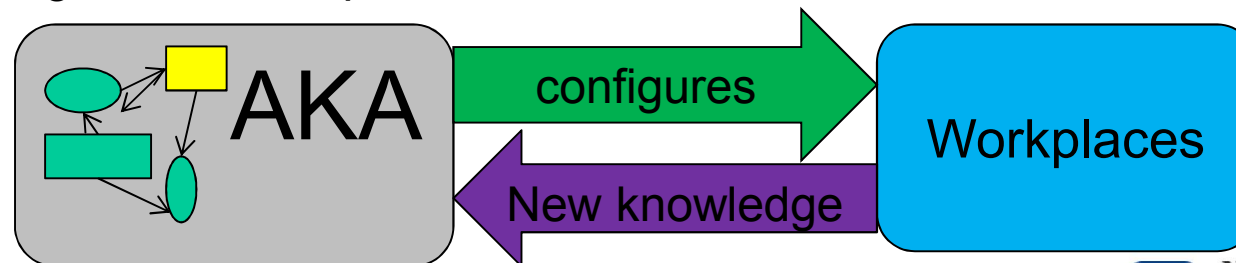
Learning & Reuse

- **Externalizing core design know-how**
  - Automatically captured as tasks
  - Articulated into models

- **Made reusable as templates**
  - Repeatable task patterns and processes
  - Adapted to new rich contexts

- **Joint experimentation and discussions around models**
  - Fostered by view and communication facilities

NTNU – Trondheim
Norwegian University of
Science and Technology

AKM Technology - strengths

- Supports creative work
  - The core processes that brings competitive advantage
  - Early phases of design
- Is controlled by business and industry people, not IT specialists
  - Model-configured, customized and contextualised
- Supports knowledge sharing, communication and learning
  - Human languages, not programming languages
  - Multiple perspectives
- Visual user interaction
- Interoperable, open execution system
  - Integration through modeling, e.g. web services, databases and XML content
- A scalable way of delivering IT solutions
  - Team organization around layered service architecture

NTNU – Trondheim
Norwegian University of
Science and Technology

AKM: Summary

- We have looked at the following:
  - Active Knowledge Modelling and Active Knowledge Models (AKM)
  - Active Knowledge Architectures (AKA)
    - AKA's contents (roles, task patterns, information structures, etc.) can automatically configure the workplaces and knowledge from the workplaces can be incorporated in the AKA.

- Key concepts with AKA and AKM:
  - Visual models
  - Reflective views
  - Configurable workspaces

AKA → configures → Workplaces
AKA ← New knowledge ← Workplaces

NTNU – Trondheim
Norwegian University of
Science and Technology

Knowledge Spaces: Summary

- A knowledge space is a four-dimensional representation, where the dimensions are mutually reflective, capable of altering each others' meaning.

- Four dimensions:

    - Personal Space

    - Innovation space

    - Business space

    - Community Space

NTNU – Trondheim
Norwegian University of
Science and Technology

Next Lecture

– AKM Guest Lecture by Frank Lillehagen, Commitment AS.

- Friday, 28 March 2014, 1415-1500hrs, room R93

NTNU – Trondheim
Norwegian University of
Science and Technology