NTNU – Trondheim
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The Open Platform for Design and Operation of Networked Enterprises

Agile Knowledge Architecture Frameworks

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Abstract

The digital technology is accelerating innovation and opportunities for improving society and industry. Public authorities, industries and societies are facing increasing complexity and new challenging needs and business opportunities, requiring instant collaboration, big data collection, knowledge sharing, competence transfer, and autonomous methods to coordinate stakeholder and user collaboration.

Stakeholders in both societal and industrial sectors realize that coded applications will not support the agile approach and exploitation of the digital technologies. Emergent solutions and dynamic work environments are required to deal with the challenging needs. Emergent solutions require agile approaches and adaptive methods, enabled by open networked enterprise platforms, and active knowledge architectures.

Networked enterprises must be co-designed by teams of architects, users and experts simultaneously by designing and building the agile approach, active methods, emergent solutions, and extending the core platform with required capabilities. Agile approaches to holistic design supported by open collaborative platforms that enable new emergent methods, and model-based, architecture-drive solutions have been prototyped. The next is the development of novel concepts, networked enterprise knowledge architecture, and enhanced modelling and execution platform capabilities.

Delivery and use of ICT will have to undergo a disruptive transition period. Generic applications should be complemented by sector-specific dynamic platforms and services to build, adapt and reuse solutions and knowledge, and build stakeholder workspaces and collaboration spaces.

The goal of the Master project has been to contribute to the development a first version of an Active Networked Enterprise Knowledge Architecture, describing its criteria and the capabilities needed to build and deploy it. The new knowledge architecture will be an Active Knowledge Architecture enabling:

- Agile approaches based on model-based, architecture-driven workplaces
- Adaptive methods enabled by user-driven modelling of active models
- Emergent Solutions enabled by supporting concurrent modelling and execution
- Open, extendable platforms supported by modern ICT trends and capabilities

The Master project has had these objectives and main tasks:

- Learn about the Model-based, Architecture-driven Design and Operation of Networked Enterprises
- Study the results achieved so far in R&D projects and industrial pilots, and discussed in newly submitted research projects
- Study the international trends in networked enterprise design, in IT development, and in Emergent Enterprise Knowledge Architecture

The outcome is a first version of the Networked Enterprise Criteria and Capabilities Architecting Framework developed from the perspective of Open Collaborative Enterprise Platform building and operation.

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Acronyms and abbreviations

AKA – Active Knowledge Architecture

AKM – Active Knowledge Modelling

BPMN – Business Process Model and Notation

CPS – Cyber-Physical Systems

EA – Enterprise Architecture

EEA – Emergent Enterprise Architecture

EKA – Enterprise Knowledge Architecture

EKS – Enterprise Knowledge Space

EM – Enterprise Modelling

GEM – Generic Enterprise Modelling

IRTV – Information Roles Tasks Views

ICT – Information and communications technology

MBADS – Model-Based, Architecture-driven Solutions

NECCAF – Networked Enterprise Criteria and Capability Architecting Framework

OCEP – Open Collaborative Enterprise Platforms

POPS – Product, Organization, Process and Systems

SDLC – Systems Design Life-Cycle

SKA – Sector-specific Knowledge Architecture

SMEs – Small and medium enterprises

Acknowledgements

I would like to thank Commitment AS for making AKM and more recent project materials and reports available, see reference list, and Frank Lillehagen for providing many of the figures and explanations and organizing several working meetings to help me understand the AKM technology.

1. Introduction

The work described in this report has as main objective to develop a framework of design and operational criteria and capabilities that must be supported by future Open Collaborative Enterprise Platforms (OCEP). Open can be described by means of availability, accessibility, adaptability, extendibility, and affordability by companies including SMEs and citizens, and safe, secure and effective operations. New business models for networked enterprise partnering will have to be developed to balance costs and benefits of using and contributing active models and software components to building networks.

Future platforms must be designed to support collaborative design, engineering, building, operation and management of multiple emergent enterprise networks. Concurrent business development and delivery, technology research and implementation, recruitment and training, resource and knowledge management, and innovation and learning will be decisive for competitive performance. Instant collaboration, event- and situation-driven, must be enabled to rapidly come up with best-fit actions. New approaches to work management and progress and quality monitoring and management are also needed. Industrial and societal needs and challenges are dealt with in chapter 3.

The Criteria and Capabilities Framework, described in chapter 7, must support agile approaches, adaptive modelling methods, self-configuring platform extensions, and interactive design across present horizontal and vertical flows. All federated and managed in active knowledge architecture. Operation and management of the solutions, the approaches, the methods, and the platform components, federated in active knowledge architecture, will demand new business models and collaboration among the actors involved.

Enterprise Modelling [1, 2] was innovated in the late 1980's and several frameworks for building Enterprise Architecture [38] were developed through the 1990s. The ambition of framework developers were never to support networked enterprise design, but rather to support as-is modelling and a step-wise transformation to future to-be states. Enterprise Modelling is still mainly a mean for stakeholders to express their requirements, concerns, and demands, supporting consultants and ICT teams in developing and coding static and generic application systems. Some new initiatives [3, 4] are emerging, but it is still early days.

Since 1997 a group of Norwegian industrial R&D persons have developed the Active Knowledge Modelling (AKM) technology [5, 6]. They could soon be ready to offer sustainable open collaboration platforms and services to tackle the demanding needs and rapidly growing challenges. The realization of the AKM approach to Emergent Networked Enterprise design and operation is dependent on the commitment of leading companies adopting new business models to Open Platform building and management. An organization or company providing a use-case or business case involving key customers, partners and suppliers, their workspaces and collaboration spaces will provide the knowledge spaces to be modelled. The networked business solutions must provide increased values to all partners. Agile approaches to holistic design, supported by open collaborative platforms that enable new adaptive methods and model-based, architecture-driven platforms and solutions are being developed, prototyped and validated.

This work started with an assessment of the present ways of working, and a survey of needs and challenges for future industrial and public enterprises in order to help us appreciate the demand for new agile approaches, self-adapting methods, model-configured platforms and interactive work environments. To concurrently design, operate and manage enterprise networks, solutions and supporting platforms require new thinking and understanding from people, implementation of paradigm-shifting concepts, and committed use-case workers and managers.

Model-Based, Architecture-Driven Solutions (MBADS) workplaces have been prototyped and validated in four EU projects and three industrial pilots [8, 9]. The approach has so far given some very promising results, and the potential benefits and savings are huge. A good example of possibilities and opportunities in the public sector is found with the National Road Authorities. A student project was launched to build active knowledge models of enhanced contents of handbooks to support the design of infrastructures for road design and building. The holistic design approach applied is shown in figure 1 below. This is taken from Minh Vu Bui's work in collaboration with people from a building project of the Norwegian Road Authorities [3].

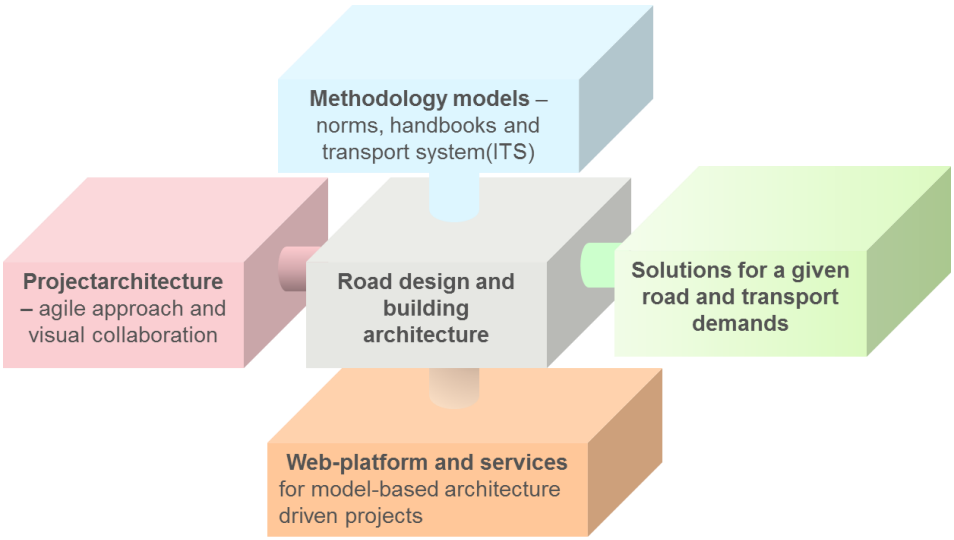

Figure 1 - Holistic design and building of roads. Road knowledge is exchanged by other public or industrial products and services.

The project architecture has models of the many coordinated approaches to major road design tasks and competences. The methodology models are modelled from knowledge in road building handbooks, and practical methods and work processes to apply for good road building based on aggregated experiences. This project illustrates the tremendous savings potential, but also the many challenges that need to be solved to attract greater interest in the MBADS approach and methods.

The Open Collaborative Enterprise Platform (OCEP) for Networked Enterprise Design and Operation and Open Innovation [40] represents disruptive technology for industrial and societal computing infrastructures and solutions, and future ways of working. Whereas today most companies and organizations are concerned about common networking services to plan and perform networked project work and information exchange, the future holds many novel challenges but also great opportunities.

2. Data, Information and Knowledge Management Practices

This chapter looks at the prevailing practices and what is being done to improve the situation and be able to exploit modern digital technologies to remove human as well as technical barriers.

Existing enterprises, pubic as well as industrial, are dominated by information or rather document flows, paper snapshots and natural language thinking. Data and information management are based on natural language and semantic structures and codes, and on beliefs that required enterprise knowledge can be expressed by natural language and software coding. These manifested practices represent some of the most challenging barriers to surmount in order to support holistic design, and collaborative design and operation of future networked enterprises. Recently Mark Bergmann [17], a leading enterprise architect in MITRE Corp. presented new ideas for Designing Living Interactive Systems by applying Agile Development Operations. Figure 2 illustrates the system development process focussing activity break-down and slicing according to stages determined by information flows. Bergmann proposes vertical slicing, but without any support for holistic design. This means that features can be well adapted to life-cycle demands, but design of capabilities and properties with parameters to be balanced in projects, products and systems may face growing barriers.

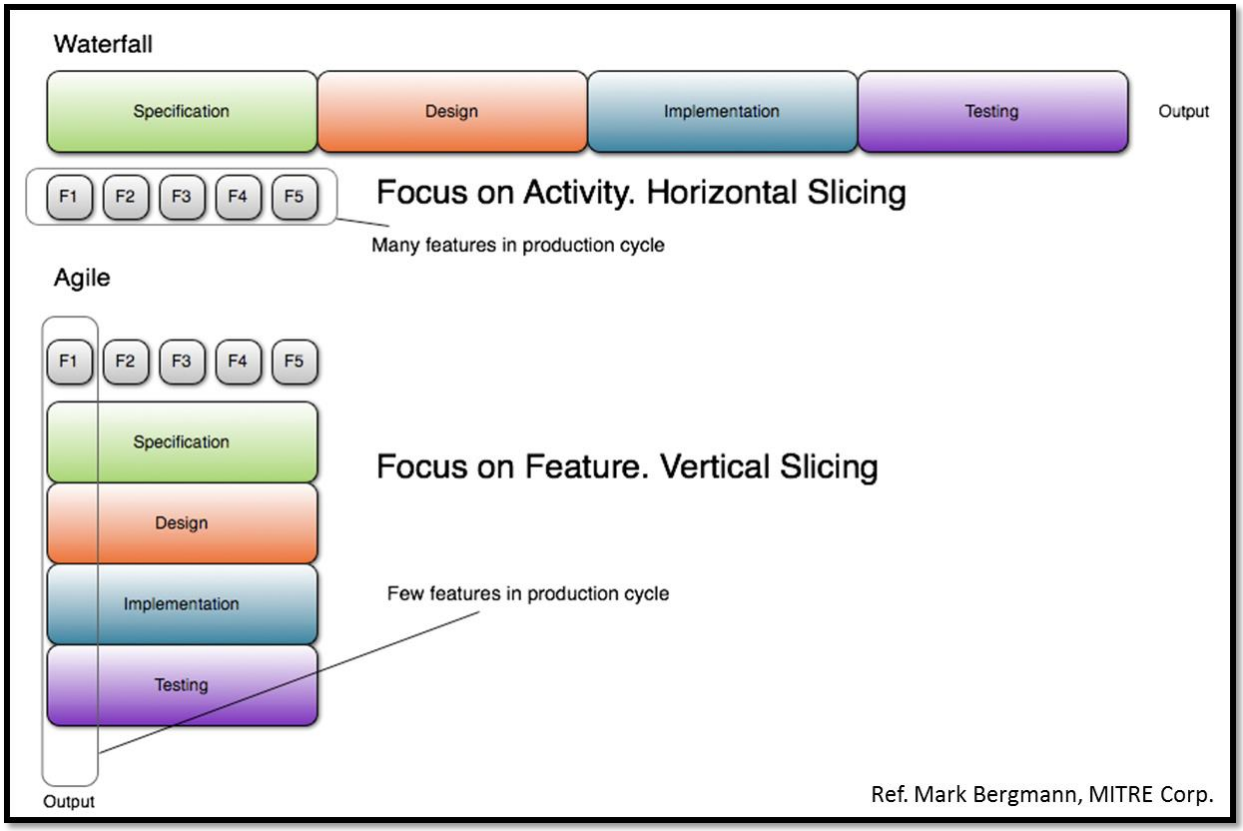

Figure 2 - Removing prevailing data, information and knowledge sharing barriers are among the challenges faced.

Current development approaches and solutions do not meet these needs and challenges, and new business, societal, human and scientific advances and opportunities will be lost. Agile approaches, adaptive methods, open platforms and emergent solutions, supporting interactions and concurrent solutions design and operations are required.

2.1. AKM and International trends

Future organizations and companies will need to concurrently participate in multiple emerging networked enterprises. Business, innovation, customer delivery, research, learning, training and servicing must be supported for simultaneous monitoring, performance and management.

Open collaborative innovation enabled by agile architecture-driven approaches, holistic design methods, and managed in role-oriented and adaptive work-environments - are required for collaborative concurrent design and operation of products, processes, systems and platforms, enhancing life-cycle and value- and supply-chain practices. The new agile approaches, self-adapting methods, extendable platforms and emerging solutions are based on the eight AKM paradigm-shifting concepts developed from the recognition of the AKM discoveries, described in [6, 5]. These novel concepts enable concurrent design and operations, and continuous alignment of performance parameters, services and properties. Knowledge sharing, competence transfer, and open innovation and learning involving customers and partners are some of the capabilities supported.

The novel AKM concepts are explained in chapter 6. The proposed agile approach to holistic design will enable model-based, architecture-driven solutions, and remove existing interoperability and collaboration barriers. Benefits and positive impacts on approaches, methodologies, solutions, and human values will enhance computing.

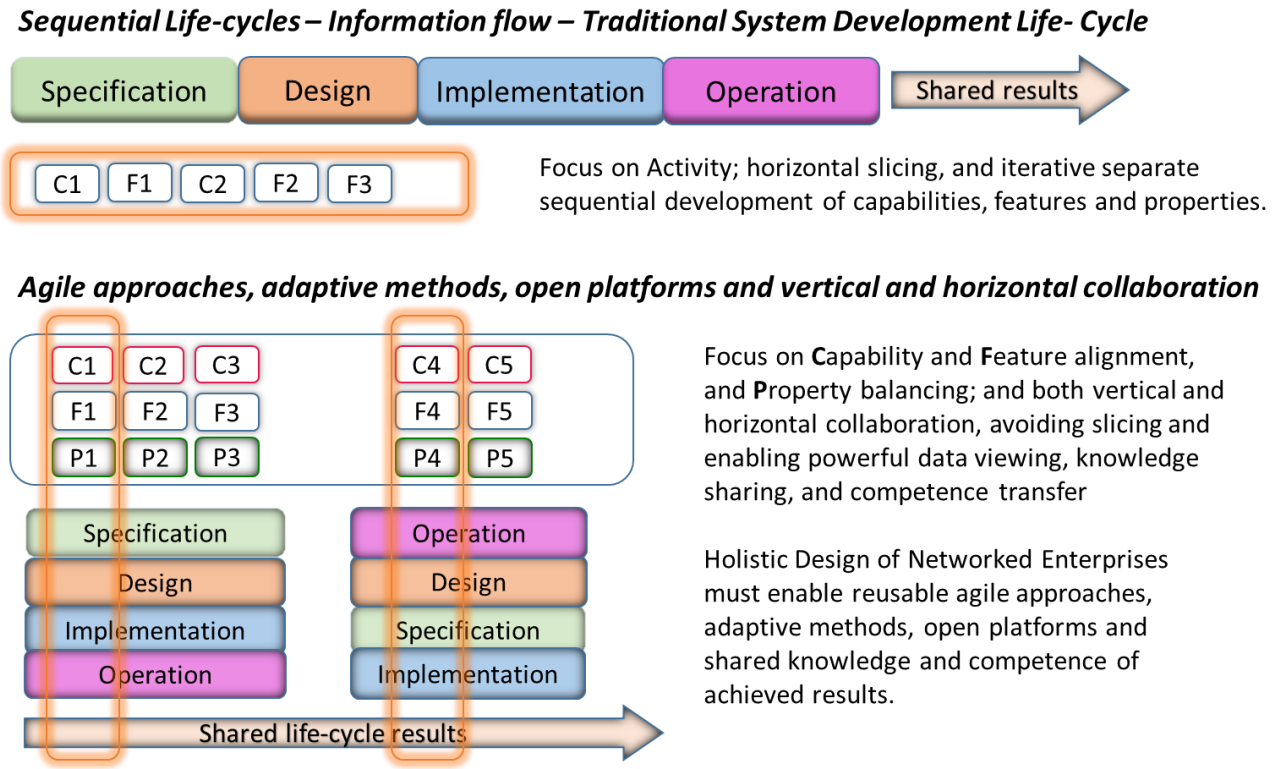

Figure 3 - Removing prevailing data, information and knowledge sharing barriers are among the challenges faced.

There are currently strong international trends and initiatives worth following:

1. The AEA initiative to develop emergent Enterprise Architecture, and adaptive methods [19].

2. The Open Group initiative to develop an Open Platform [4], motivated by new ICT technology.
3. The Gartner Group's new approach to Enterprise Architecture [20].
4. The AKM Holistic Design approach enabling OCEPs, knowledge sharing and reuse [23].

The AEA Californian Chapter had two AKM presentations in the autumn of 2011. Many needs for emergent EA were recognized. New ideas on how to implement them need to follow.

The Open Group vision of Boundary-less Information Flow™ [18] will help enterprises to use Cloud, Social, and Mobile Computing, and handle Big Data. This will be accomplished by identifying a set of new platform capabilities, and architecting and standardizing a platform by which enterprises can reap huge business benefits. These capabilities will enable enterprises to:

- Process data "in the Cloud"
- Integrate mobile devices with enterprise computing
- Incorporate new sources of data, including social media and sensors in the "Internet of things"
- Manage and share data that has high volume, velocity, variety, and distribution.
- Turn the data into usable information through correlation, fusion, analysis, and visualization.

Open Platform 3.0 is a new architecture platform being defined by The Open Group to help enterprises to use emerging technologies such as Cloud, Social, and Mobile Computing, and Big Data. Broadcast live from The Open Group conference in Amsterdam, this webinar is about what Open Platform 3.0 is and how it will deliver value. It is hosted by Stuart Boardman, and includes presentations on Open Platform 3.0 from functional and non-functional perspectives, and a panel session discussing the value that it will bring [4].

The Gartner Group has followed Enterprise Architecture [20] closer and closer, and three years back started performing their own research, developing their own tools, and organizing annual regional Summits. This year the European Summit[1] focuses on new approaches and methods for transforming Enterprise Business. The invitation this year even mentions disruptive methods.

These initiatives and reports from international contacts prove that more and more people recognize the need for new agile approaches, adaptive methods, emergent solutions and open computing platforms. However, based on what is published and presented so far the thinking is still dominated by traditional ICT development and system engineering. The paradigm-shifting concepts and discoveries of AKM are still unique to Commitment. AKM is based on role-oriented knowledge spaces and workspaces, holistic design and novel knowledge management concepts across value-chains and life-cycles.

[1] http://www.gartner.com/technology/summits/emea/enterprise-architecture/agenda.jsp

3. Industrial and Societal Needs

Most of the contents, including figures, of this chapter is taken from the MALABS project at Commitment [8], and from EU project calls and proposals [10, 11, 12] where the AKM technology will be further researched and prototyped. Many needs and challenges are common across most societal and industrial sectors. The most focused needs collected and challenges discussed are:

1. Data must be open, secure and easily accessible
2. Information and knowledge management must be simple and autonomous
3. Knowledge sharing and competence transfer must be facilitated
4. Services must be composed from generic components to fit local working environments
5. ICT solutions must be designed applying holistic design methods
6. Projects must apply agile approaches to improve collaboration and become more sustainable
7. Open innovation and lifelong learning must be supported by active knowledge architecture
8. Role-oriented organizations must be designed to take advantage of workspaces
9. Graphic symbolic languages must be applied to capture local pragmatics and context
10. Principles for holistic design must be understood and applied
11. Project stakeholders and students should be collaborating in innovation and learning
12. New business models are required for platform components, models, services and support

Open data is particularly important in the public sectors, in particular concerning personal citizen registers, security, healthcare, climate, energy, and societal infrastructures. Personal data is owned by the citizen, so security and safety is instrumental. Public data is owned by public institutions or government, while most industrial data are owned by companies, and employed users, and governed by commercial contracts and individual property rights.

Information is created, used and managed as documents and database files. Information databases should be protected from people who do not have access rights. Role-oriented access control has become the most effective method for security, preservation and reuse of content. Most databases should have simple but safe access through user interfaces and a common API, allowing solution designers and owners to tailor user interfaces for information management needs.

Knowledge Management has many novel concepts and aspects developed to exploit digital technologies. One main purpose is still to make data and information accessible and active. Knowledge Management (KM) embraces knowledge creation, adaption, storage, retrieval and sharing, and with the advent of multi-dimensional Enterprise Knowledge Architecture (see section 4.2). One of the hard problems in implementing KM is getting users to participate. When people have information about work they do from people who have done this work before they will improve and gain time.

Enterprise networked services should be model-composed, and adapted and managed in active knowledge architectures. Model-composition would open up for interactive collaborative composition of user services based on generic software components, standard content models, and self-adapting local models. For users to better understand and apply services they should be model-composed to fit local context, user tasks, domain knowledge and working environments. Services to perform the same operations are not necessarily interchangeable across sectors or projects.

Agile approach to design and development means that the methods applied by users to arrive at solutions have to be activated and applied in repeatable task-patterns, supporting re-iteration and modified reuse of the methods. Holistic design drastically simplifies model-based, architecture-driven workplaces enabling agile approaches.

Open innovation and life-long learning is dependent on implementing the latter three capabilities: building active knowledge architecture, supporting holistic design and agile approaches to solutions design and building. This will enable workplace replication for student training by sharing practitioner approaches, methods and experiences.

Role-oriented organizations enable to capture workspace context-rich pragmatic knowledge, and take full advantage of the capabilities of the human mind and its mental models by building user-driven digital models: - creating reflective views, repetitive task-patterns, repeatable template, and reusable models and solutions.

Graphical symbol languages for conceptual modelling and concept recognition must complement natural language. It has its strengths and weaknesses. Natural language supports human communication and coordination, and abstractions from real-world situations. The latter is also one of its biggest weaknesses, as it fails to capture action-centric contexts. Natural language depends on agreed global structures, e.g. location and time, or ontologies and thesauri in order to capture knowledge.

Holistic enterprise methods imply that properties and their application and discipline specific parameters and values, within set scope, should be modelled and agreed in separate aspects and views from product structures, organized resources, processes and systems and platforms. All involved designers, engineers, users and experts have to agree on component properties, balancing discipline and application parameters and minimum, maximum and nominal values. The parameters and values are the basis for a series of rules, rules for design, composition, configuration and adaptation, including support for self-adapting and semi-autonomous tasks and workspaces. As scope is extended to cover more of the life-cycle the modelling, collaboration, and balancing has to be re-iterated.

Principles for Holistic Design as applied in AKM are not supported by systems development and system engineering methods (figure 4).

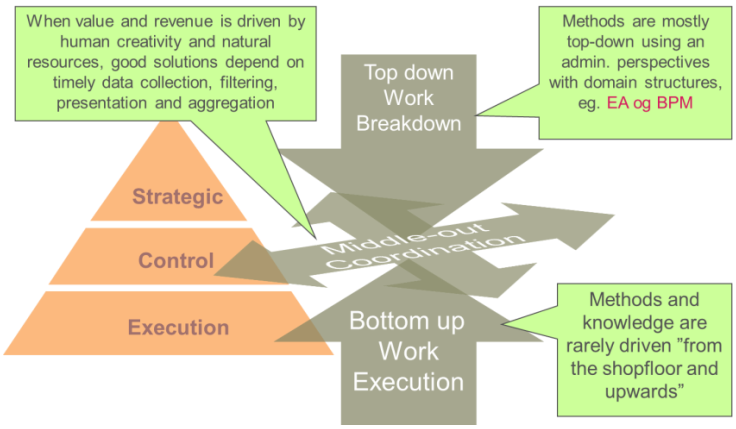

Figure 4 - Holistic design principles involve being able to work top-down, bottom-up and middle-out.

Holistic Design is achieved through Enterprise Modelling working top-down, bottom-up and middle-out. Design and Architecture must be performed top-down to align goals and plans and calculate Cost ,Time and Resources (CTR), bottom –up to capture local contexts, practical work and methods, competence and nuances, and manage calculations and aggregations, and finally middle-out to balance variant, configuration, modularization and design parameters to meet qualities, capabilities, capacities and benefits.

Innovation and learning is best performed at the project workplace, and should involve both practitioners as mentors, trainers as controllers and students as learners. Innovation and learning for balancing exploration and exploitation of technology, human and business opportunities is dependent on most of the other topics described.

Ideation and conceptual design of modern complex products, engineering and development projects, and customer delivery projects are not adequately supported by present ICT methods. Graphical idea capture and conceptual design exploiting active knowledge modelling must be supported in future Open Collaborative Enterprise Platforms (OCEPS).

Classification and categorization of objects as knowledge assets is today implemented as disjoint application systems and is therefore mostly performed by sector dedicated methods that do not take care of the classification rules. This implies that semi-automatic object management and reuse is dependent on the user ability to access, search for and find the classes and its member objects.

Open Collaborative Enterprise Platform will require new business models for composing, using and operating collaborative networked platforms. Customers and users will not pay license fees for generic software applications and tools as this is why they cannot afford joining networked bids, projects and customer delivery. A platform manager splits operational costs on all value-sharing participants.

3.1. Industrial Needs

Industrial design and manufacturing [8, 10] is in most sectors performed in hierarchic value-chains, where little horizontal and vertical collaboration and sharing are possible.

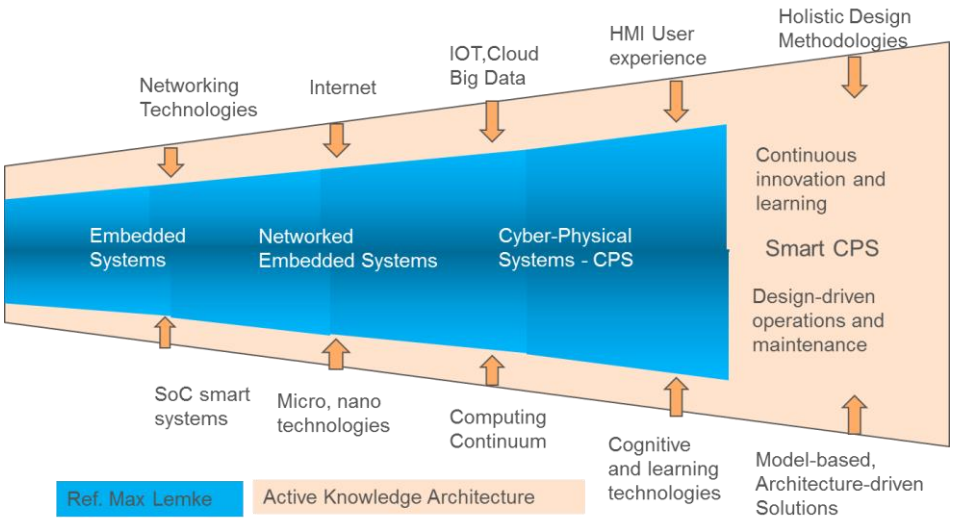

Figure 5 - Smart solutions enabled by model-based, architecture-driven agile approaches, adaptive methods and open platforms.

Data, information and knowledge are communicated by exchanging documents among the partners in isolated layers and sequential stages linked by controlling gateways. Present ways of planning and executing work are not exploiting modern digital technologies, nor supporting human exploration of new capabilities in collaboration, knowledge management and competence transfer.

An example from research on smart Cyber-Physical Systems (CPS) [10] illustrates the added capabilities supported by holistic design methods and active knowledge architecture, see figure 5 above.

The most pressing needs and challenges are:

1. Improve ownership and access to data to support new working methods
2. Introduce graphic symbolic languages to capture local context and work-centric knowledge
3. Support agile approaches to improve innovation and continuous improvement
4. Model holistic design methods, aspects and rules to support emergent collaboration
5. Develop a model-based, architecture-driven design methodology to enable smart solutions
6. Enable model-based, architecture-driven workplace composition to improve usability
7. Capture local pragmatics to improve decision-making, traceability and predictability
8. Capture workspace context to simplify work by autonomous processes and tasks
9. Capture rules as task-patterns for learning from practical work and use of products
10. Reuse knowledge and competence by reusing generic architectures aspects
11. Improve communication and interaction by simplifying user interfaces
12. Recruitment of students trained by performing project work sharing practitioner workplaces

Ownership to data will allow leading discipline users to aggregate parameters and values to detect trends, detect limits, and capture rules for validity of design, modularization.

3.2. Societal Needs

Western democracies are currently exposed to a digitization storm [8], aiming at simplifying operations, avoiding duplication, enabling sharing of data and knowledge, reducing costs and creating common service components across sectors.

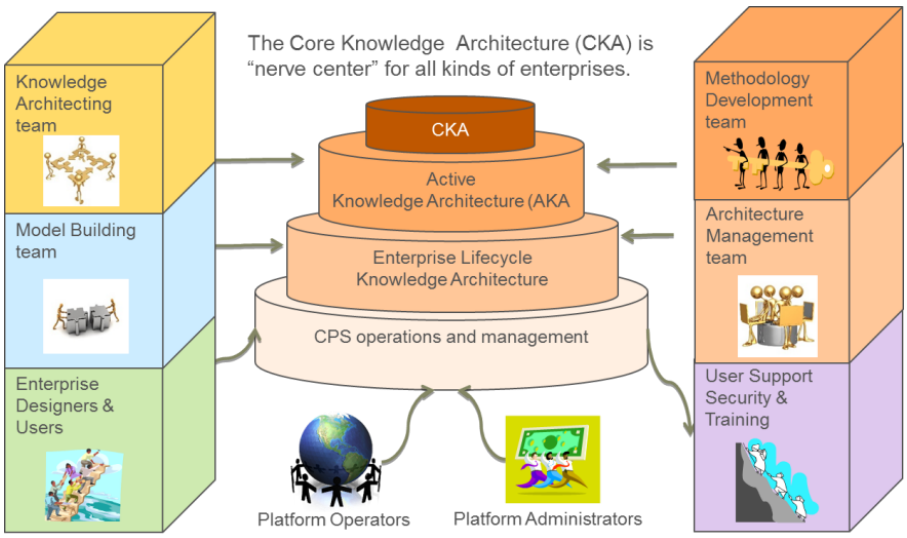

Figure 6 - Adaptive role-based solutions across societal sectors allow improved public sector and citizen collaboration.

Major needs of future societies and public services are:

1. Create open data that are easily accessible by most regions and public units
2. Most public services can and should be model-composed from generic components
3. Environment, resource and portfolio models across sectors will avoid data replication
4. Visual aspects of common reference registers models will reduce semantic meta-data
5. Role-oriented organizations will facilitate collaboration, sharing, exchange and reuse
6. Develop smart services and tools that guide users in performing their roles and tasks
7. Training and learning from model-based workplaces and pragmatic scenarios
8. Security and open democracy– scenarios for experimentation and knowledge validation
9. Military operations – situation-controlled configuration of capabilities and operations.
10. Police investigations, reconstructing events and applying new analysis methods
11. Crisis response – resource planning, training, execution and management
12. Catastrophe management – collaboration for surveillance, action and prevention

Open data from our public personal registers, atmosphere and climate, our country and its various resources, about public facilities and services, and international operations and infrastructures can reduce the need for many similar application systems and customized installations.

Model-Based, Architecture-Driven Solutions (MBADS) could meet most of the industrial as well as the societal needs and challenges, providing solutions that would revolutionize networked collaboration, knowledge sharing, competence transfer and monitoring conditions or progress. However, transforming ICT from proprietary domain generic application systems to MBADS is hampered by several serious challenges as most people involved in ICT in society and industry have learned that generic ICT application systems, SOA and Cloud computing is all that matters. ICT professionals know very little about enterprise work-centric knowledge, about graphic modelling and agile approaches to networked enterprises, and about MBADS.

3.3. Future Networked Enterprises

Present industrial and public project life-cycles and value-chains are currently driven by layers of sequential information flows supported by static system landscapes. These structures must be transformed to facilitate more opportunistic joint-venture business engagements, supported by collaborative capabilities, competence transfer, and improved or more autonomous knowledge management.

The future networked enterprise will be driven by the recognition of novel paradigm-shifting concepts, exploring human mental models and exploiting modern digital technologies. The networked enterprise will be the enterprise realization where business processes and customer design and delivery will be performed. Present enterprises will primarily be responsible for strategy management and governance, and human and technology resource management [19, 20].

Conceptual design and design for life-cycle knowledge sharing, self-adaptive solutions, continuous learning and innovation, and selective reuse will decide the market winners and determine the future for small and medium sized enterprises. The most competent practitioners are too busy with critical business tasks to engage in emergent Enterprise Architecture development, and other important

research and development programs. Human involvement, innovation and learning are crucial for user-driven enterprise architecture design, operation, management and effective reuse.

The initiatives described in sub-chapter 2.1 may lead to public and industrial revolutions, but we believe it will all depend on the discoveries of enterprise knowledge spaces and workspaces, and deep understanding of the concepts described in chapter 6.

New business models, inviting and supporting collaboration among customers, partners and citizens, and across sectors, are already being proposed [18]. Development of new knowledge management services, supported by product and service families, ambidextrous organizations [25], self-adapting and autonomous work-processes, and user-composed, model-configured solutions are terms that will appear in most future Networking Enterprise and Open Platform trend analysis.

Also ambidextrous organizations [39] balancing exploration of new approaches, methods and technologies and exploitation of the established approaches, methods, and deliverables will be a strategic challenge in all public and industrial sectors.

4. Background and Motivation

This chapter describes the thinking, discoveries and development behind the AKM technology, implementing agile approaches, adaptive holistic design methods and open platforms, enabling open networked enterprise design and operation. The design and operation of emergent enterprise architectures and solutions, as illustrated in figure 7, will transform public as well as industrial production and delivery of products and services.

The need for agile approaches to design has been recognized since the early days of interactive CAD systems development around 1973, but so far no ICT solutions supporting agile approaches and conceptual design are known. Agile Approaches are discussed in the context of human collaboration to develop and support networking platforms, but little is said about support for redesign based on pragmatic logic modelled in active knowledge architecture. Support to enable traceability, decision-support, reuse, and predictability is becoming increasingly important [41].

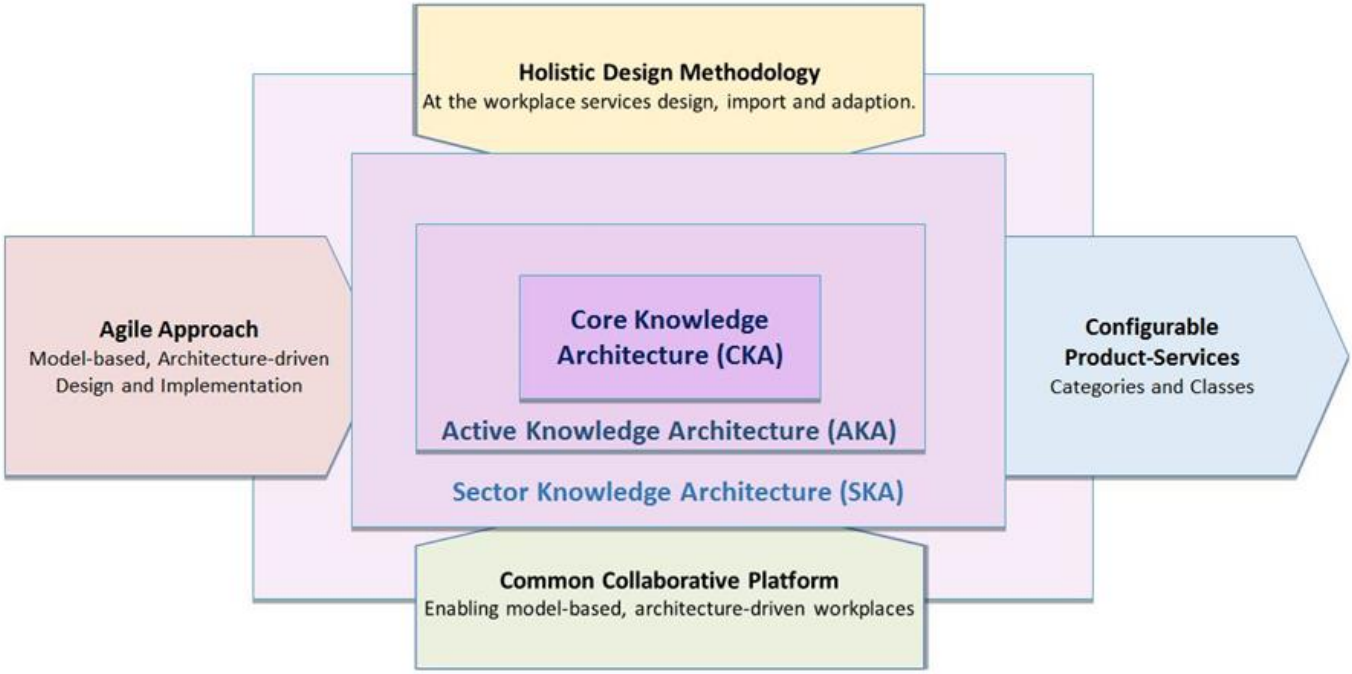

Figure 7 - Holistic design implies multi-dimensional thinking, and agile modelling of enterprise knowledge spaces and workspaces.

Holistic thinking has been discussed, but holistic design has not been a topic since the days of design theorist Vladimir Hubka and his followers [21], focussing product design. Few have truly understood his concepts and key design principles. It is from these paradigms and concepts, pedagogy, phenomenology, neuroscience and other sciences that AKM has developed its design concepts, principles and methods. Realizing conceptual design, separate property and parameter modelling, design embodiment of parameters into object types and classes, and definition of holistic design as defined chapter 3, and implemented in section 6.6.

Holistic design is discussed by many people, but either limited to product design and implying a life-cycle wide scope and considerations. The AKM approach to holistic design handles scope as decided by the tasks and roles affected. It is not defined to cover entire life-cycles. Holistic design is dependent on the recognition of multi-dimensional knowledge spaces [5], and deep understanding of

how to apply an agile approach and adaptive methods. Some methods, such as ways of presenting big data to the different users, must be self-adaptive, otherwise users may not be able to process data in time for roles to react.

Open platforms in the context of networked enterprises, enterprise knowledge modelling, and knowledge model-composed services and capabilities has been discussed at international conferences, but it is only recently that The Open Group has started their initiative as discussed in section 2.1. They operate with version 3.0, but as with their TOGAF EA Framework version 3.0 was introduced as their first official version.

To federate, align and manage these dynamic knowledge spaces, their many dimensions and workspaces AKM has conceived and developed the knowledge architecture layers depicted in figure 9. The core knowledge architecture is like a meta-meta model for the AKA and SKA and any operational architectures.

In the following sections the core AKM concepts, criteria and capabilities, will be explained. First, the functionality needed in active models is introduced, then the relevance of existing software components is analysed, and finally the capabilities and characteristics of active knowledge models and architectures are described.

4.1. Active models

A model is *active* when it directly influences what it reflects. *Model activation* or execution involves actors applying the models to perform tasks, and adjusting their behaviour accordingly. This process can be:

- *Automated or autonomous*, where a software component interprets the model,
- *Manual*, where the model guides the actions of human actors, or
- *Interactive*, where aspects of the model are automatically interpreted and ambiguous parts are left to the users to resolve.

In order to achieve simplicity and flexibility, the Active Knowledge Architecture should be constructed to support interactive execution. By updating an active model, users adapt the system to fit their local workspace pragmatics. This concurrent process of modelling and execution is depicted below.

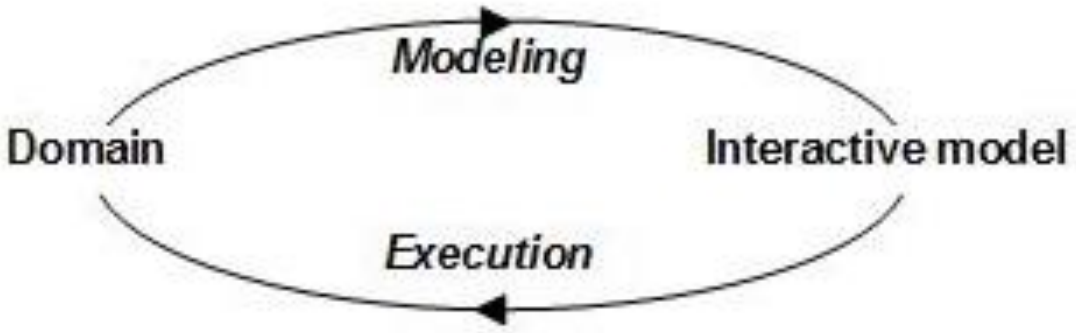

Figure 8 - The context of visual modelling.

An open platform should offer four main kinds of services for knowledge architects, method experts and end-users to collaborate in capturing knowledge spaces and build workspaces by modelling:

- ***Information management***
  Knowledge architecture content creation involves definition of templates and reusable elements, management of libraries of generic definitions, inheritance with aspect merging, creation of new elements based on templates, including connection of patterns to the pre-existing context etc.
- ***Role management***
  Role management implements model-configured access control, role-specific and personalised filtering, creating navigation structures, and adapting workspace layout and organization as well. Since access control is about giving actors (roles) access to perform operations (tasks) on some objects (information) through some user interface (view), the IRTV architectures are used directly for access control.
- ***Task management***
  Execution of task patterns and processes involve activating the task hierarchy and sequencing structures, including manual or automatic decisions that lead to scheduling, branching, or reallocation of work. Task-patterns allow real-time modifications of all aspects of workspaces. Different types of tasks may require different states and transition rules. Ad-hoc creation of subtasks from templates and handling of repetitive tasks and processes are also needed. Sometimes task repetition is controlled by other structures, e.g. information collections or participant lists (roles). Automation of tasks in the form of rules or scripts, and triggering by events, potentially based on complex conditions and context identification schemes, is also needed. Finally, task execution requires a simple and general mechanism for binding parameter values (inputs and outputs) to tasks.
- ***View management***
  Model-configured workspaces, perspective views on models, management dashboards and other user interfaces require powerful functionality for querying, filtering, structuring and presenting information. Visualization rules, coupling information to visual characteristics such as location, grouping, symbol, colour and size, are highly useful. Finally, functionality in the form of services and available task-patterns must be configured according to the current user context.

Experience has shown that the combined use of the IRTV dimensions greatly reduces the complexity of user interface models. This simplification is crucial to enable end users to define and adapt their own workspaces and aspects in collaboration spaces. The four core services of an AKA platform complement each other to achieve an agile and flexible execution platform. All services are modelled and executed as tasks, and often as composite task-patterns. Dependencies between model elements are managed through derivation and propagation of values, while rules control the triggering of tasks as well as the propagation of values. Like other models, tasks and rules are defined through the basic modelling services.

4.2. Active Knowledge Architecture

Any active knowledge architecture is developed from an abstracted common Core Knowledge Architecture, as illustrated in figure 9 below.

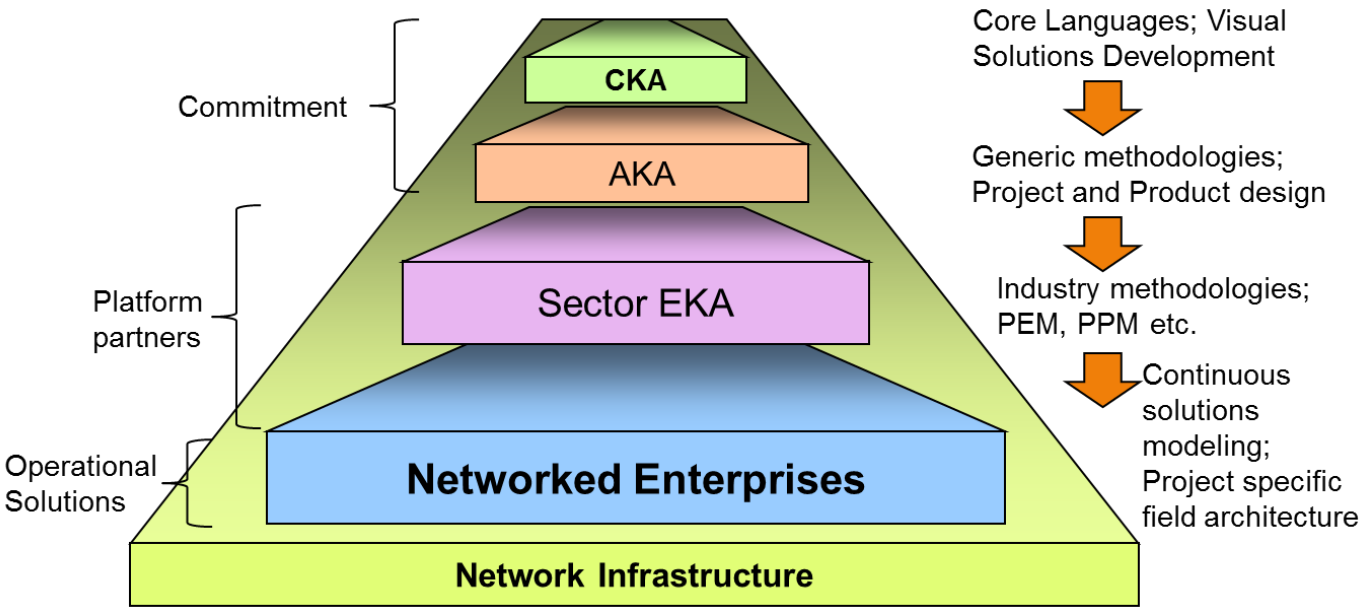

Figure 9 - Layers of visual knowledge architectures federate architecture design across sectors.

The CKA is fairly simple, but very important for expressing the core capabilities and structural elements of any enterprise. It may be regarded as a meta-meta model supporting any kind of enterprise. The agile approach, enabled by MBADS workplaces and IRTV modelling allow partners to build a generic platform for active and sector-specific enterprise architecture. Operational architectures and platforms will include roles and their workspace to coordinate work and control outcomes and resources. Knowledge architectures and graphic modelling enable:

- Replacing fixed program code with emergent task- patterns and models
- Replacing unstructured documents with structured information models
- Complementing standardized database schemas with evolving data-models
- Complementing formal models and logic with local pragmatics and models
- From fixed user interfaces to model-configurable interactive surfaces
- From bottom-up abstraction from computing platforms to top-down and middle-out design, performed by teams of professionals, governed by business perspectives

The active digital models and MBADS workplaces will simplify user interaction and interactive surface design, and digital models will be used to enhance human mental models and transfer competence. Active Knowledge Architecture will transform data, information and knowledge management and reuse.

4.3. Software Components

The picture below provides an overview of an infrastructure used in an industrial pilot in 2009 for capturing and utilizing Active Knowledge Architectures (AKA).

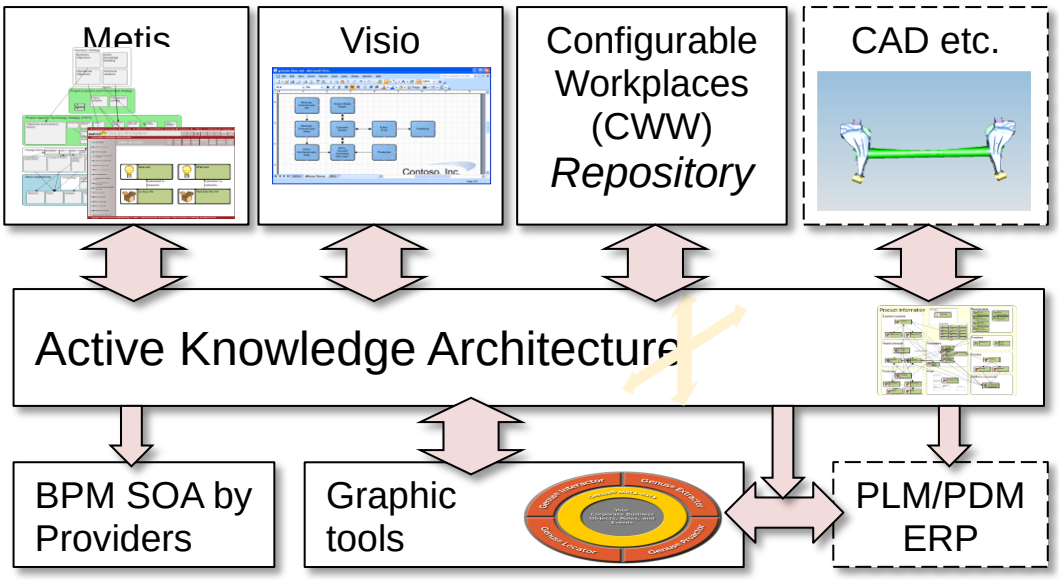

Figure 10 - An overview of the AKA platform used in pilots in 2008 and 2009.

Pilot customers involved in innovation projects are able to influence the design of visual knowledge architecture front-ends to integrate operational systems and extend platform capabilities. The key knowledge model and component in this framework is the Active Knowledge Architecture (AKA). Its main functionality was outlined above. A key issue is to which extent any AKA can rely on functionality provided by proprietary applications and tools, and which new AKA services must be implemented for open availability.

4.4. Configurable Visual Workplaces (CVW)

The AKA platform, where the IRTV modelling framework drives agile approaches to operational solutions, was implemented as extensions to the Metis modelling tool. This platform utilises the capabilities of Metis for visualising and managing large visual models, multiple views on modelled elements, adaptive symbols, and extensible modelling languages through forms-based meta-modelling. The CVW methodology is one of twelve components of the Collaborative Product and Process Design (CPPD) Methodology [7].

CVW simplifies interaction with models by providing a model-driven runtime platform and functionality:

- *Information management* with user defined templates, extensible property sets for instances and types, and multi-dimensional classification schemes.
- *Role management* for role-specific workplaces, navigation, filtering and access control.
- *Task management*, rule driven process execution that supports both structured workflows, ad-hoc task patterns, and other evolving process structures. Every action is captured as a task.
- *View management*, controlled by flexible viewing capabilities and visual path queries that define which elements to show.

The figure below illustrates this approach. It shows workplaces for four different roles:

1. The product designer (second from the left),
2. A parts supplier (to the right),

3. The solution developer (left), who uses the operational model-configured solution for AKM's visual solutions development methodology to define the IRTV structures driving the other workplaces,
4. A methodology developer workplace used by third party and customer experts to define specific solutions for their own methodologies, whether they are part of product design, organizational development, or some other domain.

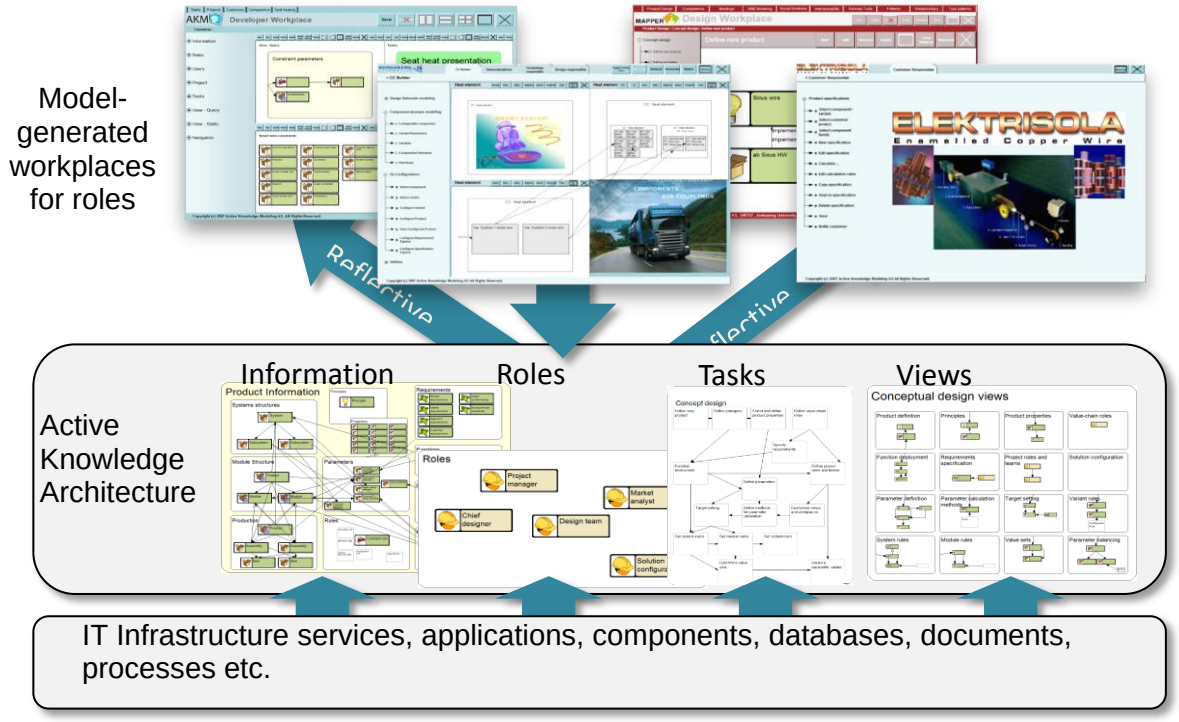

Figure 11 - Model-based, AKA-driven workplaces built in the MAPPER project, 2006 - 2008.

Since the CVW solution includes an IRTV model definition of the visual solutions development methodology, CVW itself includes the modelling services needed for defining knowledge architectures and operational solutions. It is a self-configuring and –adapting component.

The configuration of an AKM solution is quite simple. One just needs to model the *information* that should be processed, the *tasks* that people should perform, and the *queries* that define which information is manipulated in each task. Role-specific access is optional.

4.5. AKA and tools integration

The AKA concepts and most proprietary modelling tools, as those described in chapter 5, have several similarities, such as:

- Providing configurable solutions
- Being based on a foundation of explicit metadata or information models
- Rule actions are triggered by events and controlled by conditions
- Actions in user interfaces, menu and push-buttons, is a task/action
- Web-services are automatically included by importing WSDL files
- Data collection, aggregation and integration is facilitated
- User-defined queries for view management are supported

- Access control is secured by role-based authentication.

There are however also some crucial differences:

- AKA is instance-oriented, while most other tools are class-oriented.
- AKA apply multiple inheritance and aspects, while other tools use class composition
- AKA supports property modelling independently of object-oriented structures and classes
- AKA provides relationship and role management in addition to object classes
- AKA is based on multiple views with local pragmatic logic and semantics
- AKA provides a configurable model-based user interface (content, visualization/presentation, structures, navigation, services), while tools give access to configurable content through a more fixed user interface, though with dynamic forms and reports.
- AKA relies heavily on task patterns and process enactment

As a visual environment that covers multiple aspects, not just an information model, and offering each user a customized view on the whole model, the AKA should be able to assist users in managing larger and more complex knowledge architectures, collaborative solutions and working environments.

AKA on the other hand supports methods to mimic human communication, conceptualization and learning, as illustrated in figure 12. This demands a more selective, high-level, pragmatic, multi-facetted and extendible modelling framework as illustrated in figures 6 and 8.

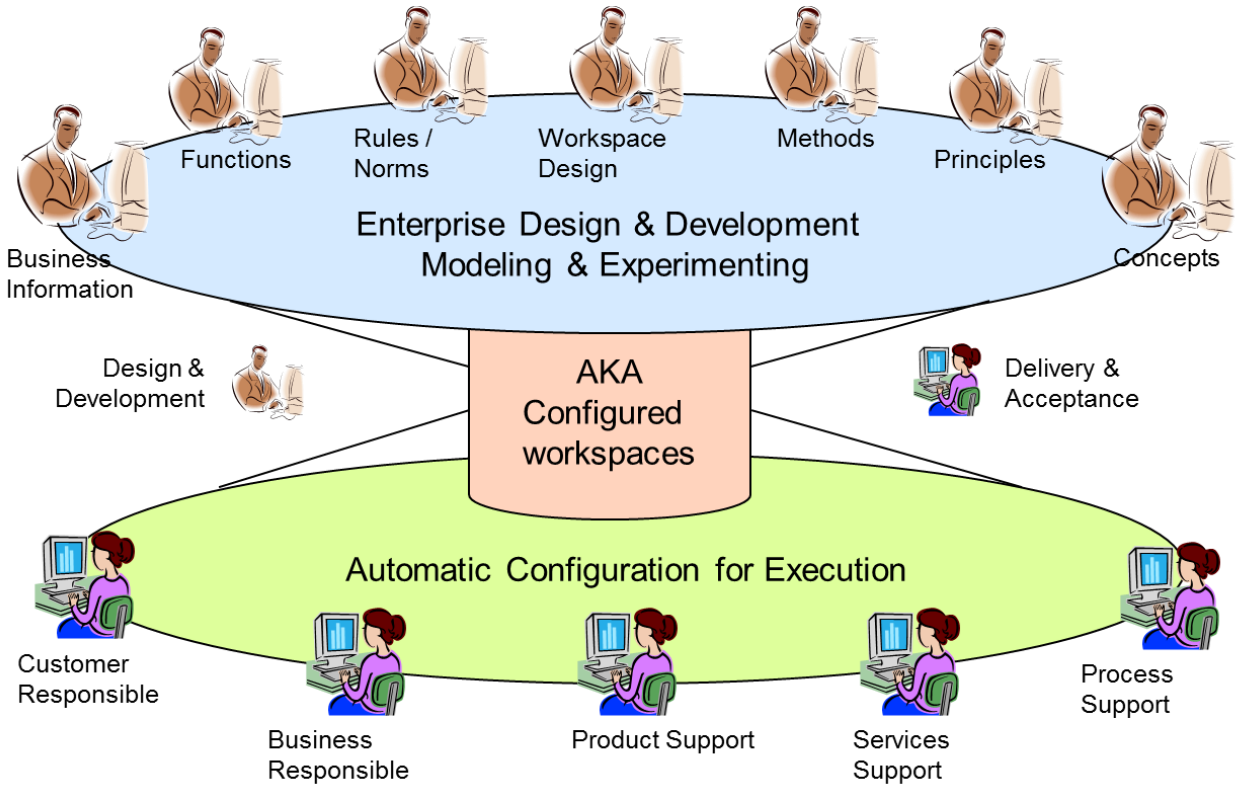

Figure 12 - Model-based, AKA-driven workplaces enable instant collaboration and parallel work execution.

Innovation starts with individual ideas, beliefs and concepts, and common understanding in groups, companies, and cultures. An AKA can represent these stages and knowledge spaces, e.g. as information elements and graphic language symbols. If by linking local business concepts such as project, cost, and benefits to the core domains of knowledge spaces more structure content and behaviour is added to these elements. This is further continued all the way down to the IRTV modelled role-specific workspaces, which is directly adaptable and executable on the AKA platform. Software tools on the other hand, imports, visualizes and utilizes database structures more or less directly, adding some logical names and identification of implicit relationships based on e.g. naming standards. A lot of the critical conversion from the business world towards technology is achieved through the building of an AKA.

5. State-of-the-art in Enterprise Modelling

The main challenges are found in Product, Organization, Process and Solution (POPS) design, engineering and operation of any enterprise, called the innovation space. However, collaboration and innovation challenges are also found in the project and program domains, and in the business and market strategy and operations spaces. All these spaces are multi-dimensional and in order to capture the knowledge content of these spaces we must design role-specific workspaces applying the IRTV language and agile approaches using MBADS workplaces. The Solution for POPS should be an Open Collaborative Enterprise Platform (OCEP).

The figure below is from 2003, and has been the core focus of the AKM technology development and discoveries. Active knowledge created in multi-dimensional enterprise knowledge spaces is used to plan, execute, govern and support work. Pedagogues use the terms situated or work-generative knowledge [16], and recognize that knowledge exists in multi-dimensional reflective layers, very much like the AKM discovery of multi-dimensional Workspaces and Enterprise Knowledge Spaces (EKS) [5, 6].

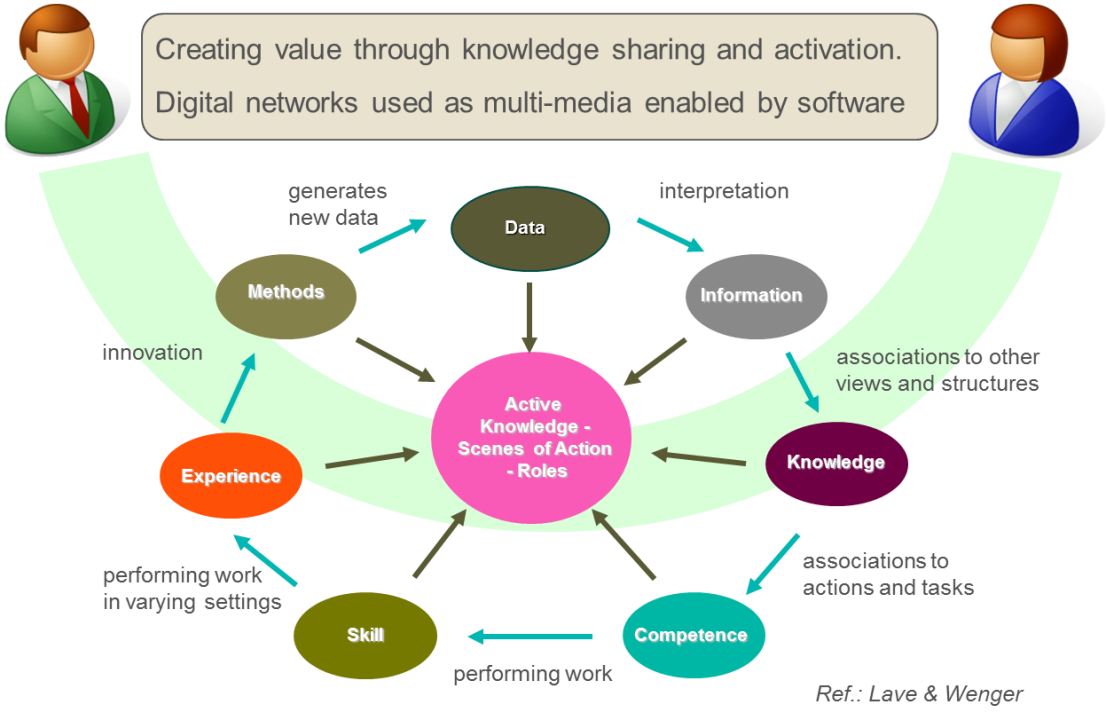

Figure 13 - The visual learning cycle for practitioners.

The figure above illustrates the spiral from data to information, through templates or views, to knowledge through associations to other views and structures, to competence through use in actions and tasks, to skill by performing work, to experience by performing work in varying settings, to methods evolution through gradual improvement, which generates new data.

5.1. EA frameworks

Some of the first EA frameworks were developed by the US military, inspired by the Zachman framework [42]. The US military developed the C4ISR framework and TAFIM early in the 1990s,

and when the Clinger-Cohen act was passed in the US Congress work was started on the DODAF framework. The first version were developed using the METIS modelling tool and methods. In parallel with the work on DODAF started work on TOGAF. Again the Metis and Popkin tool providers played a major role in defining and implementing the first three versions. The first version released was version 3.0 in 2002, and many changes from the internal versions built by Metis and Popkin were implemented. The changes were not attractive to the directions that leading customers demanded, so the collaboration between METIS and The Open Group was terminated.

Already in 1994 discussions on executable modelling started with groups of system and product designers. A group of people at Boeing Commercial Aircraft initiated the discussions on how to make models executable. Still, no commercially available EA framework is able to support agile approaches, holistic design, and model-based, architecture-driven workplaces and executable solutions [19].

5.2. Product Modelling

Product modelling performed with current methodologies, as found in EA frameworks, is based on predefined objet types and classes. This seriously limits their capabilities in supporting traditional product design approaches and methodologies. Modelling the early design phases, from idea to detailed design and supporting design embodiment and life-cycle experience capture are still unsolved challenges. Some research has been performed to develop new holistic design methodologies. The figure below is from the MAPPER project, where the configurable components methods were implemented and validated [9].

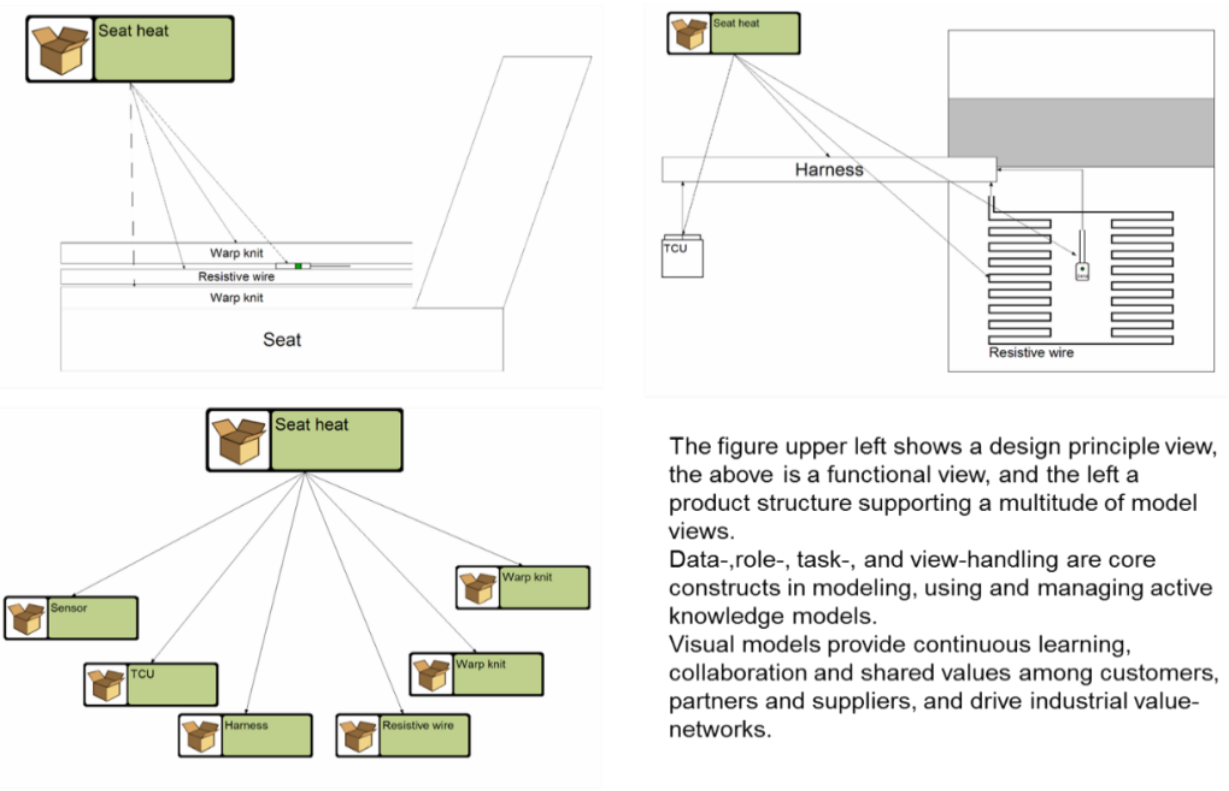

Figure 14 - IRTV and AKA open up for new modelling approaches and principles, enabling holistic design.

Future architecture-driven solutions must enable modelling and operational support for building:

1. Life-cycle management structures, classes, categories and families
2. Products, organs, systems, modules, components, parts and materials
3. Conceptual, functional and services design, and property structures
4. Product discipline, system and component supporting services
5. Shape, functional, technical and geometrical engineering structures
6. Production, manufacturing, and assembly services
7. Structure matrices to represent and share properties and features

A multitude of relationship types exists, most of these are dependencies created by assumed, normalized and balanced parameter values among design and engineering disciplines and groups.

5.3. Organization Modelling

Traditional public organizations are hierarchic and/or networked, while industry have introduced matrix organization, multi-disciplinary teams and sector groups for e.g. standardization. Most present public and industrial organizations are a combination of hierarchies, networks and matrix organizations. Networked enterprises show a need to complement these structures with role-oriented structures to capture role-oriented workspaces and enable knowledge sharing and management.

Structured roles and work-centric knowledge form the basis for a *new form of smart organization*. A smart organization of service-teams must be able to design and engineer roles and workspaces as projects evolve to capture practical rules and methods. Agile project teams with clear responsibilities and rules for providing services to each other should be designed as part of enterprise design [37].

In most IT applications authorization is isolated from the tasks, the enabling methods and data. Roles and role-specific workplaces with tasks and views are not supported, so coherence, coordination and collaboration are poorly supported. Workplaces are programmed and cannot be designed in context-rich workspaces.

Role-oriented organizational modelling performed in workspaces created by work-centric and situated knowledge will transform networked organizations and services. Creating what is termed Ambidextrous Organizations [25] developing strategies and actions to balance exploration and exploitation is considered one of the major challenges for future management teams.

In order to support holistic design, collaboration and enable knowledge externalization, sharing, elicitation and activation we need to recognize and model role-oriented organizations as depicted in the figure above. This is a generic view, so in a real sector case these roles will recognize by well-known symbols and working environments. These structures will complement the organizational structures already known.

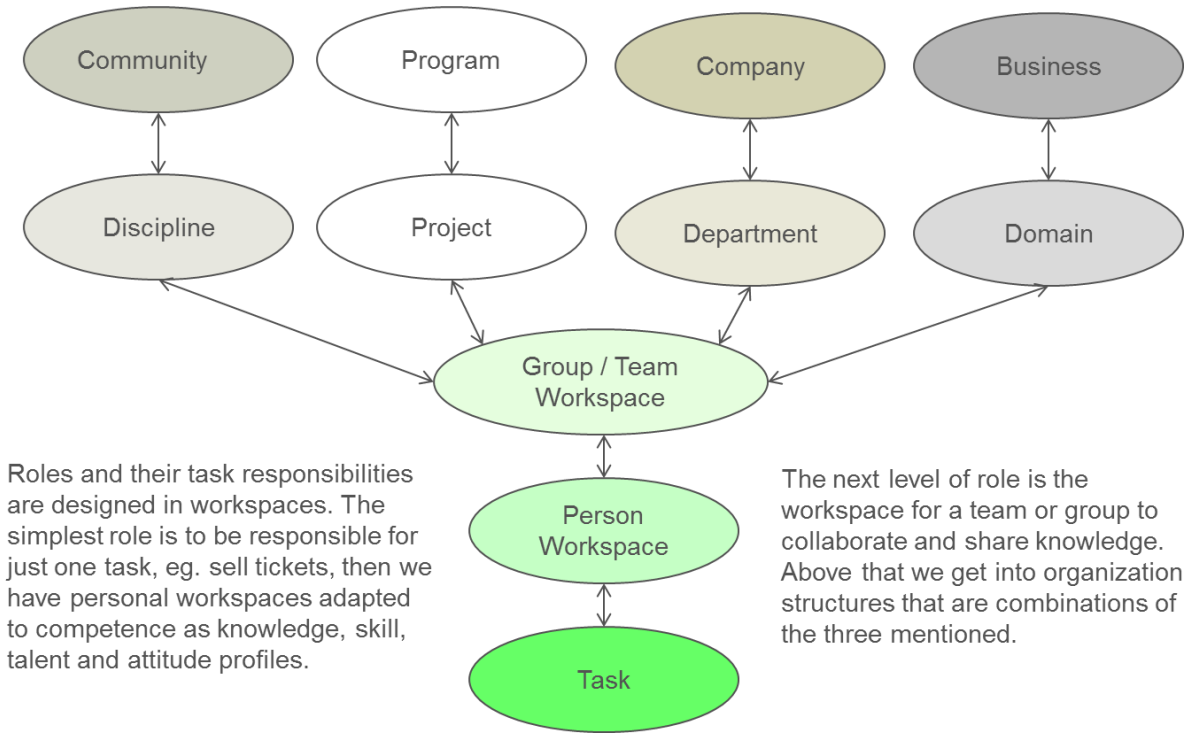

Figure 15 - A generic model of role-oriented networked enterprise organizations.

5.4. Process Modelling

Several languages have been proposed for business process modelling. Though most of them follow the conventional representation of processes as a series of steps, they emphasize different aspects of process and related structures, such as organizations, products, and data. Consequently, they are suited for different kinds of processes. Even if you are determined to use a particular technique, knowledge of alternative approaches can still guide the modelling, by surfacing complementary points of view. In addition to the common transformational process models, this post discusses block structured languages, storytelling, and process modelling languages that are hierarchical, flow-oriented, role-oriented, communication-oriented, declarative, goal-oriented, timelines, product and document state machines etc [6, 11].

5.4.1. Transformational Process Models

Most process models take a transformational (input-process-output) approach. Processes are divided into activities, which may be divided further into sub-activities. Each activity takes inputs, which it transforms to outputs. Input and output relations thus define the sequence of work. Commonly, control flow structures for sequences, iteration, parallel and alternative branching are included. This perspective is chosen for the standards of the Workflow Management Coalition (WfMC) and the Object Management Group (OMG) as well as most commercial systems. BPMN, IDEF, Data Flow Diagrams, UML Activity diagrams, ARIS Event-driven Process Chains, and Petri nets are well-known transformational languages.

The example below shows a typical transformational process model, with decomposition, sequences and branching. In this case, it is combined with organizational roles and information resources as mechanisms, similar to IDEF [6].

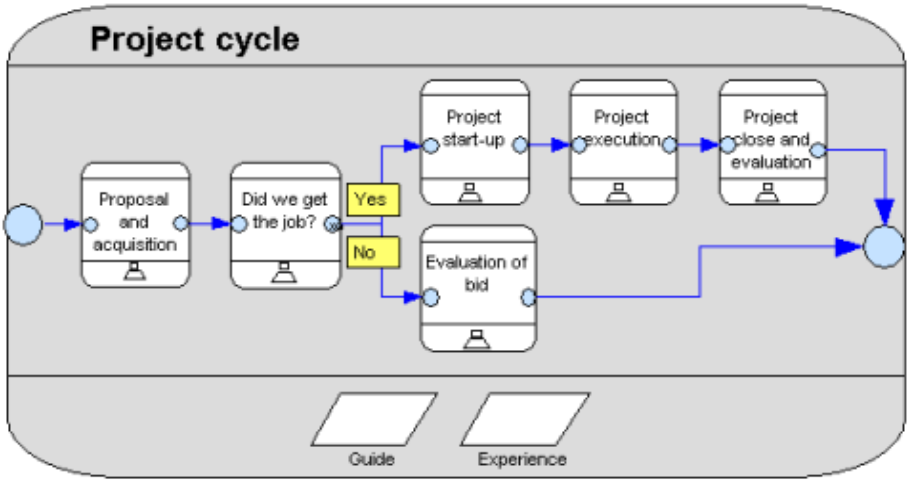

Figure 16 - Traditional top-down activity break-down approach to process modelling.

5.4.2. Hierarchical Process Models

Project management, planning, and monitoring typically relies on manual scheduling of activities. Rather than complete process graphs, work breakdown structures (WBS) or process trees are most common in this domain. Typically the tree is complemented by a numbering of tasks that propose a logical sequence, but detailed routing logic is seldom modelled. A hierarchical model directs attention to *what* should be done, without bothering too much about the details of *how* it should be coordinated. Some task modelling languages add more structure to process trees by defining different kinds of decompositions, similar to gateways in transformational process:

- Multiple, for repetitive loops,
- AND for concurrent subprocesses,
- XOR for alternative subprocesses,
- OR for more complex or uncertain structures,
- Sequential, for ordered processes, and
- One-at-a-time, for sub-processes to be executed in any order, but only one at a time.

Compared to the standard transformational languages, these features open up for more partially structured, semi-formal processes. By focusing on the breaking up of processes into steps, hierarchical languages further avoid some of the dangers of over-serialization associated with transformational models. Studies have shown that some modelling consultants project the sequence of the interview with users onto the resulting process models, introducing sequences that are not really required for the processes to work correctly. Increased concurrency is important for process improvement aiming to reduce cycle times, so over-serialization is a real problem [6].

5.4.3. Flow-Oriented System Process Models

In process industries, there are business process modelling notations that apply ideas from the chemical process plants that are the core of that industry. For instance, piping diagrams show the flows between activities as pipes. Different sizes of pipes are used to separate the major strands of the workflow from the rarer special cases and exception handling flows. This metaphor, seeing the

process as a fluid flow, directs focus to the size and content of the workflow, not just the activities of the diagram. It is very similar to standard transformational process models, but with a twist in perspective that is the opposite of the one achieved by hierarchical process models [6].

5.4.4. Timeline Process Models

Gantt charts and similar models that organize process steps along the time axis, is particularly useful for project management, planning, and monitoring. Some of these diagrams explicitly represent sequential order relationships between activities, but more commonly the dependencies are implicitly represented in the ordering along the time axis. In quality management, process models typically include many concurrent activities, with well-defined phases and decision gates controlling the handover from one phase to the next. With the strong emphasis on stages and gates, these models are typically also laid out in a timeline, though the many concurrent activities create a matrix structure, rather than a timed sequence.

5.4.5. Process Models Focusing on Artifact States

In some domains the end result of the process is most important. In bureaucratic case processing, legal rules typically define the different documents that are to be produced. Systems have therefore been designed that define the process as a set of state transitions on the case file, which represents the process instance. State transitions deal with addition and revision of documents or a change in the state of a document (e.g. from draft to approved). This approach makes it simple to document legal compliance and compliance with ITIL and similar standards. In product design and engineering, document status is also important, but the status of the different product elements is even more essential. For instance, a quality control process model defines each milestone in terms of which status the different product elements should have, according to this state transition diagram:

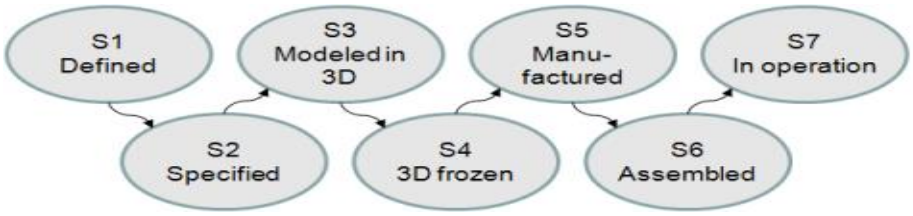

Figure 17 - Process model represented as a state machine of components.

One important benefit of this approach is of course that it directs focus on the value-adding steps in the process. It is also aligned with current project and process management practices in many industries. In these domains, the dependencies between product components are often far more important for collaboration and coordination than the dependencies that can be represented between process steps. The process above is extremely simple, the complexity of the full business process arises from the number of concurrent process instances (up to several thousand), and the dependencies between these instances, because the product components they work on are connected in some way. Some transformational languages, e.g. event-driven process chains (EPC), allow a combination of a product- and a process-oriented approach, through constructs like event or state that are connected to the sequence flows between activities.

5.4.6. Role-Oriented Process Models

Roles can be applied as an optional primary structure for processes in BPMN and in UML activity diagrams. This technique originates in earlier languages such as Role Interaction Nets (RIN) and Role Activity Diagrams (RAD). In these notations, the activities performed by a role are grouped together in the diagram, either in swim lanes (RIN), or inside boxes (RAD). The design and use of roles as a structuring concept, makes it very clear who is responsible for what. RAD has also been merged with speech acts (see below) for interaction between roles.

The old role-based approach also has limitations, e.g. making it difficult to change the organizational distribution of work. It primarily targets analysis of administrative procedures, where formal roles are important. However with the discovery and modelling of role-specific workspaces, role-oriented process modelling will go through a revolution. Work processes will be model-configured workspaces enabling user-driven collaboration and autonomous service composition.

Figure 18 shows an example from a BPMS application, where the roles involved are different infrastructure layers, rather than organizational roles [6, 11].

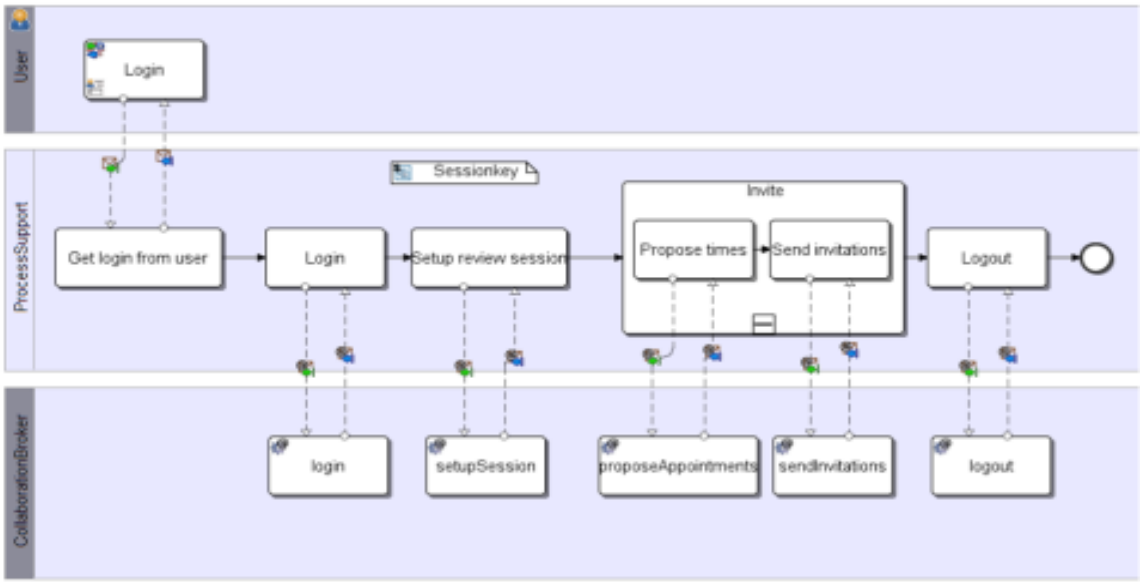

Figure 18 - Role-oriented process model (in BPMN, for BPEL execution in Intalio).

5.4.7. Process Models for Communication and Collaboration

The Action Works process support system is informed by speech act theory, which extends the notion that people use language to describe the world with a focus on how people use language for coordinating action and negotiating commitments. The main strength of this approach is that it facilitates analysis of the communicative aspects of the process. It highlights that each process is an interaction, represented as a cycle with four phases: preparation, negotiation, performance and acceptance. The dual role constellation is a basis for work breakdown, e.g. the performer can delegate parts of the work to other people, and she then becomes the customer of their tasks. Process models may thus spread out through decomposition.

This explicit representation of communication and negotiation, and especially the structuring of the conversation into predefined speech act steps, has also been criticized. The danger of minimal support for situated conversations that explication leads to increased external control of the work, and a simplistic one-to-one mapping between utterances and actions are among the weaknesses. On the other hand, it has been reported that the language-action approach is useful when people act pragmatically and don't always follow the encoded rules of behavior, i.e. when the communication models are interactively activated. The language action approach has also found new application areas in electronic business transactions and web services.

Communication loops can also be applied for capturing the processes of more creative collaboration. This and other situation –caused events can be modelled as expandable task-patterns.

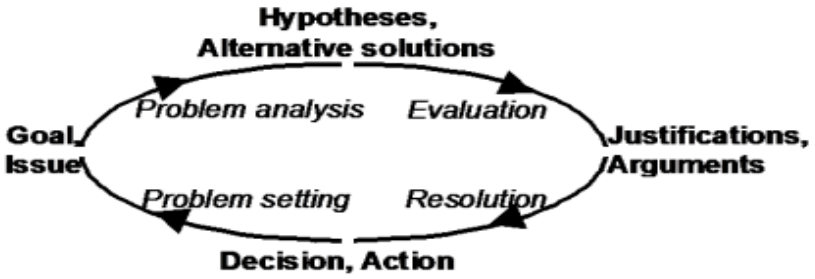

Figure 19 - Reflective design process loop.

Decision rationale loops can be decomposed by spreading out new loops for sub-discussions, just like Action loops. The strength of this approach is that it combines an intuitive language for representing argumentative structures (IBIS) with a process loop. The decisions made and the rationale behind them i captured for later reference and learning. On the other hand, this notation does not fully cover business process modelling, so it should be combined with other approaches.

5.4.8. System Dynamic Process Models

Holistic system thinking regards causal relations as mutual, circular and non-linear. The straightforward sequences in business process models are seen as an over-simplification that hides important facts. This perspective is also reflected in mathematical models of interaction. System dynamics are utilized for analysis of complex relationships in cooperative work arrangements. A simple example is given below. It shows one aspect of the interdependencies between design and implementation in a software project.

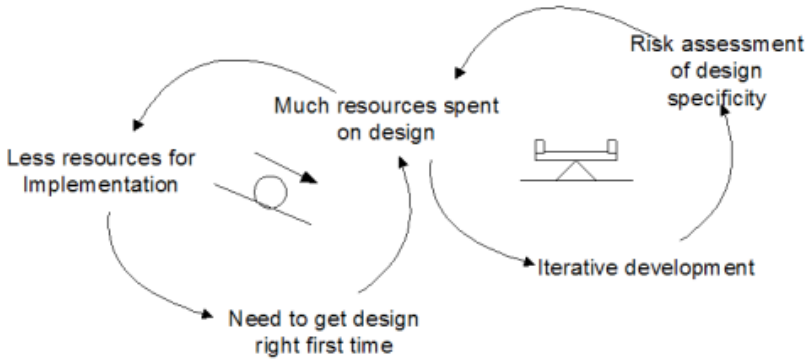

Figure 20 - A simple system dynamic process model with causal loops.

The more time one spends designing, the less time left for coding and testing, hence the design should be right the first time. This creates a positive feedback loop, a "snowball effect" similar to "analysis paralysis" that must be balanced by some means, in the example above iterative development.

5.4.9. Goal-Oriented, Declarative and Constraint-Based Process Models

Declarative process modelling languages have also been promoted. Constraint based languages do not prescribe a course of events; rather they capture the boundaries within which the process must be performed, leaving the performers to control the internal details. Constraints define the goals and activities, the *why* and *what* of the processes, but not the *how*. Instead of telling people what to do when, these systems warn about rule violations and enforce constraints. Thus, common problems with over-serialization are avoided. On the other hand, the resulting models are logic formulas, and not very comprehensible. A graphic depiction is difficult since it would correspond to a visualization of several possible solutions to the set of constraint equations constituting the model. The support for articulation of planned tasks is limited. Consequently, constraints are often combined with transformational models. Constraints mainly capture outside control on the workflow, not articulation inside the process group. On the other hand, these approaches put forward a central question to how we interpret business process models. *Agent-based process environments* often use goal-oriented, declarative process models. Agents are assigned goals and constraint rules, but are left to work out for themselves the details of how to reach these goals. Such systems facilitate adaptive, distributed, and decentralized process execution. Typically, the work breakdown structure, reflecting goals and sub-goals, is represented, but the ordering of the tasks is not. Scheduling of tasks is done dynamically during process enactment, influenced by modelled preconditions, inputs and outputs that reflect causal dependencies among tasks. Fuzzy logic can be applied to open up a richer set of alternatives to the agents that interpret and activate the model.

5.4.10. Process Visualization

In addition to the different kinds of graph structures applied in process modelling notations, other visualization tricks can be applied to represent and communicate a business process more clearly. Symbols, colors, positions, and sizes of activities can say a lot to human actors, without formally representing anything according to the modelling language rules. These useful visual techniques include placing related activities together, placing activities roughly in the order from left to right that they should be performed in, and using colors to separate different kinds of activities or the roles and disciplines responsible for them. Size is typically used for saying something about the importance or amount of work involved in each task. Some go even further, developing full-fledged process visualization tools.

5.5. Experimenting with Modelling Tools

A process modelling has tested in a number of tools in order to get hands on experience.

5.5.1. Agilian evaluation

Collaboration

The Agilian tools support online synchronous, exchange of models and data-driven collaboration. It supports VPository and Teamwork Server (figure 21), SVN, Perforce, ClearCase and CVS. Teamwork Server helps to create a version in background. It lets to review, or even roll back to a previous version whenever necessary. PostMania, a private social networking platform designed for software development teams, facilitates easy discussion of software designs. It enables team members to post and reply discussions to a diagram or a shape.

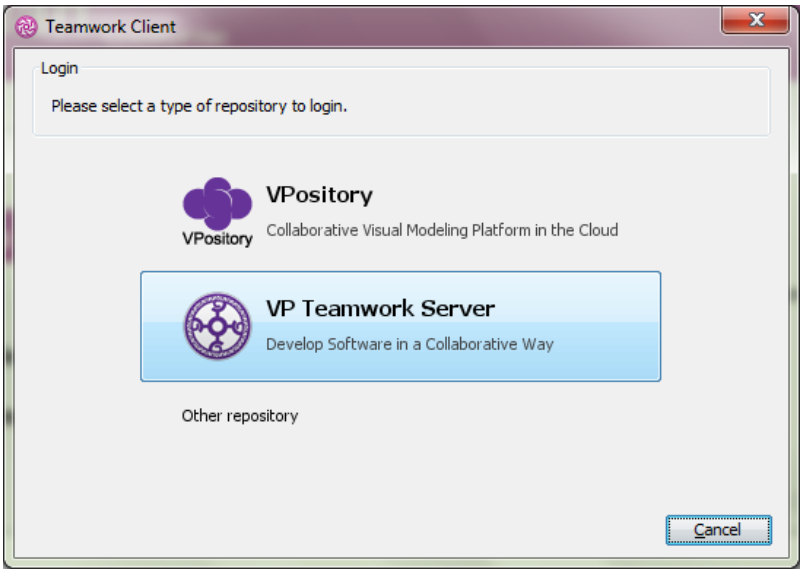

Figure 21 - Types of collaboration.

Types of modelling

Figure 22 shows different types of modelling. They are: UML, Business, SysML, Requirement, Enterprise, SoaML and Database modelling.

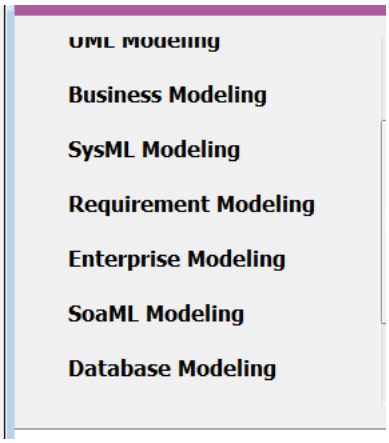

Figure 22 - Types of modelling.

Meta – modelling

There are many types of modelling in this tool. Figure below shows many types of meta-models.

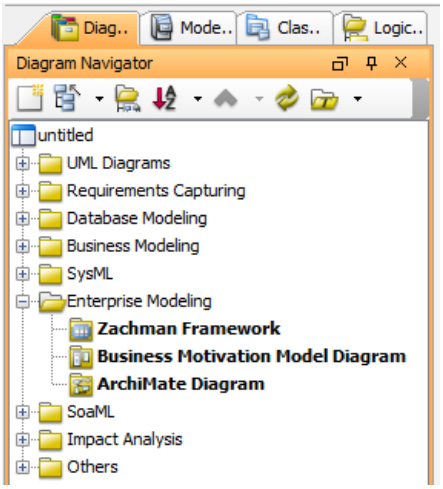

Figure 23 - Meta – models in Agilian.

Views

In Agilian views called Layers. In different diagrams main model is located in default layer. After a creation model user can create layers as in our case is two layers: Department of environmental safety and Offices. In model user can choose one element and put it in layer because all elements are in default layer after their creation (figure 24).

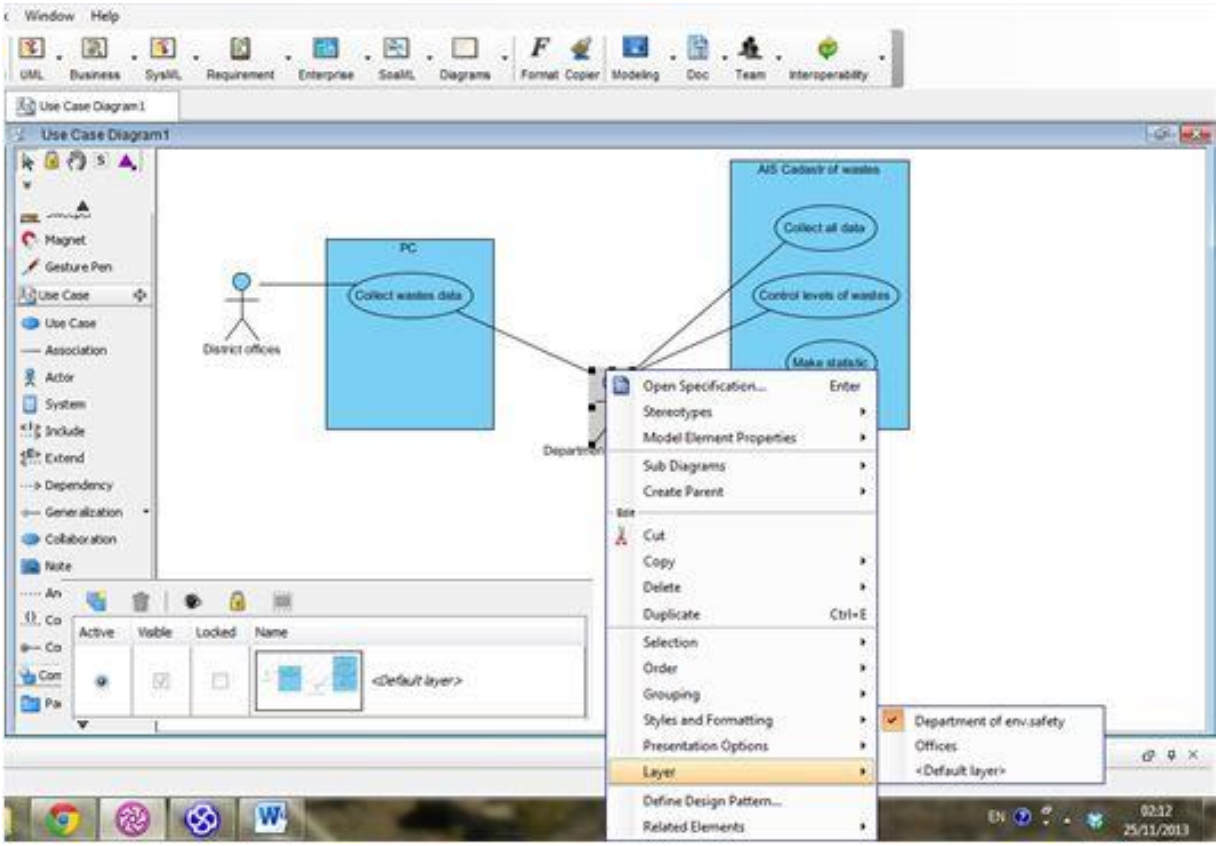

Figure 24 - Layers.

After user can choose which layer to make visible layer and hide another as shown in figure 25.

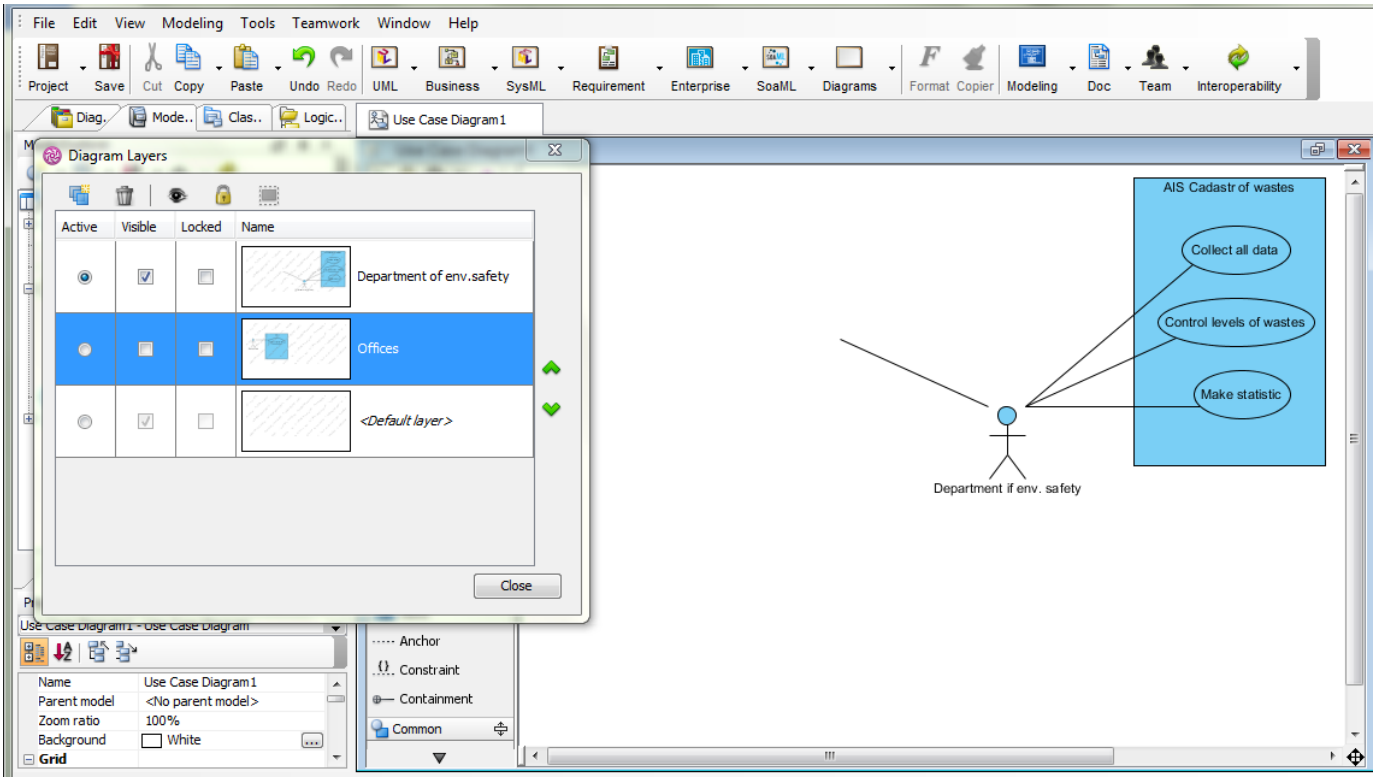

Figure 25 - Example of using layers.

Roles

In Agilian roles modelling is possible in SoaML Modelling as shown in figure 26. Service interface includes two roles as Order Placer and Order Taker.

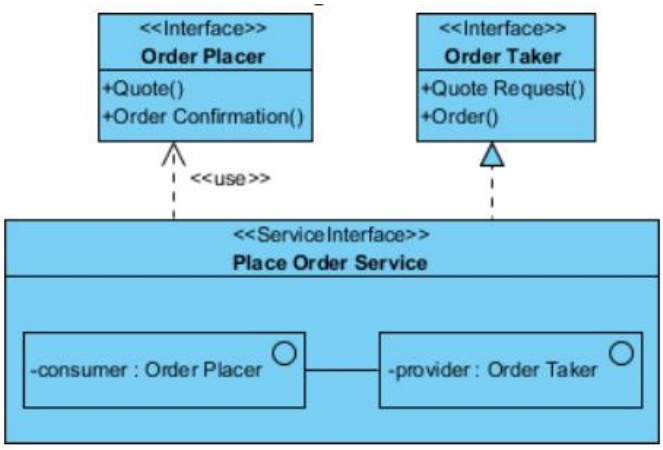

Figure 26 - Roles in modelling.

Open platform

In Agilian user who imports a model into Teamwork Server become an Administrator, who can give roles to people in a team like to read or to update a project.

5.5.2. Archi evaluation

Collaboration

In Archi there is no online or tool-based synchronous collaboration. It supports exchange of models/views and data-driven collaboration. It is possible to send a created model and stakeholders can open this model in their computers in case if they have Archi on their computers. The intent with Archi tools is to develop modelling methods, models and knowledge architecture to support model-based collaboration. This will enable projects to create many modes of data- and event-driven collaboration.

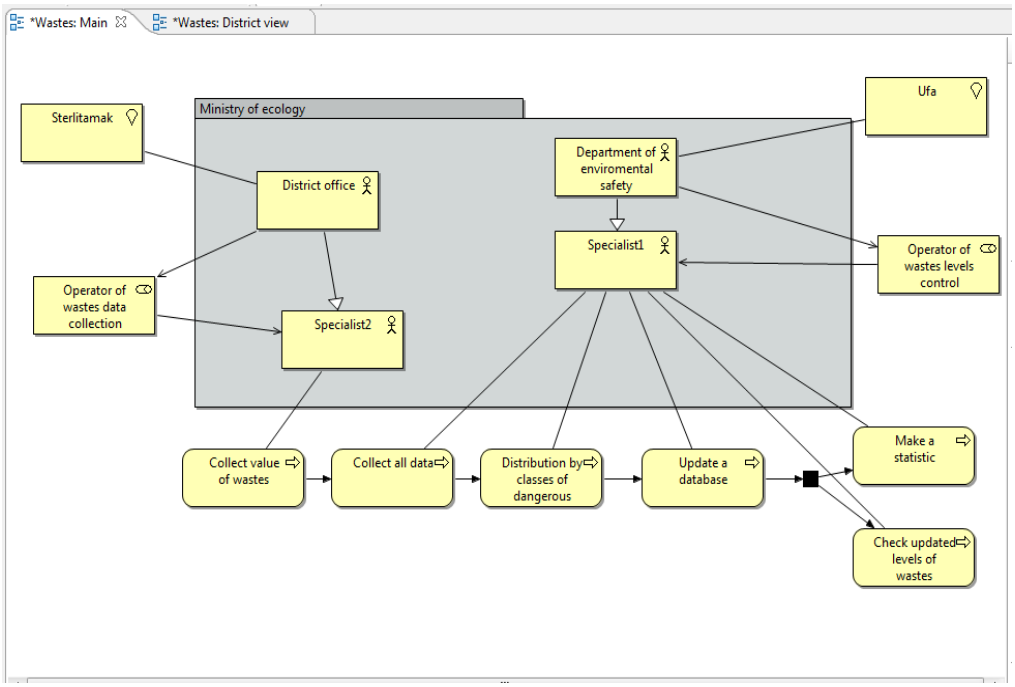

Figure 27 - Elements of different domains.

Types of modelling

In Archi it is possible to implement a business product, organization, system and process modelling with *ArchiMate Enterprise Architecture modelling language*. Figure below shows templates in Archi. They are Business Model Canvas, Customer Journey Canvas and SWOT.

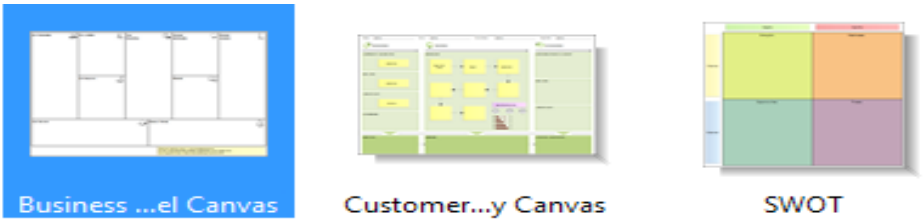

Figure 28 - Canvas templates.

Meta-modelling

In this tool users can create ArchiMate models fully aligned with TOGAF.

Views

In Archi tool it is possible to create views. Figure 29 shows a main view and, for example, the District view. After creation of the District view the whole model coped into the view and user can delete objects which are not relevant there.

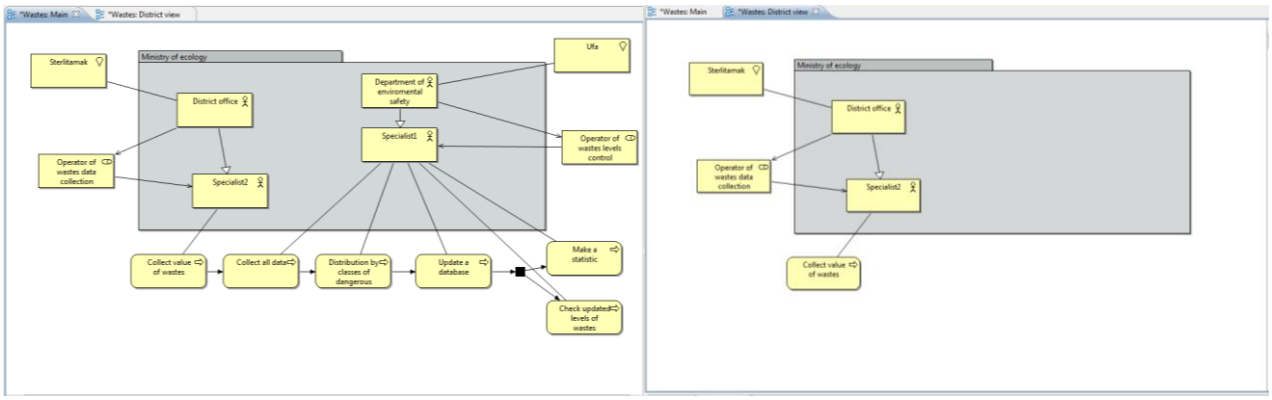

Figure 29 - Main and District view.

Roles

Roles can be created to build business role-oriented organizations for processes, projects and entire networked enterprise operations.

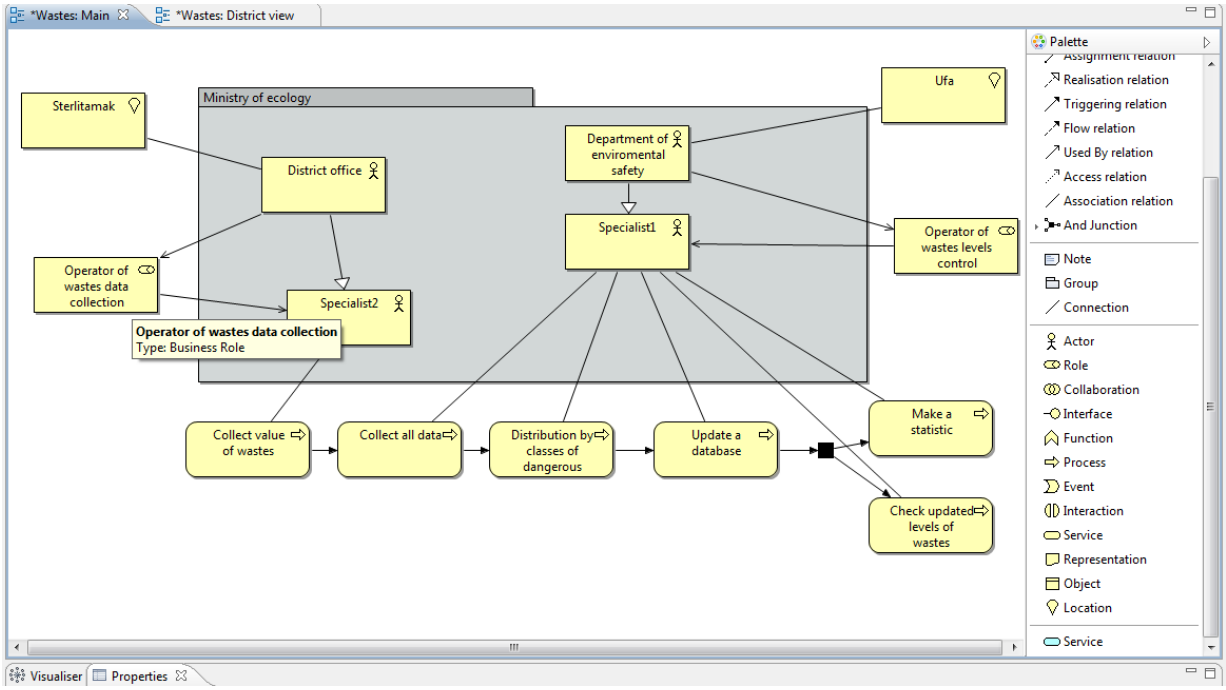

Figure 30 - Role-oriented organizations are important for improved design of model-based solutions.

Open platform

An Open Enterprise Platform should support modelling as demonstrated above, that is creating meta-models of modelling elements supporting. Everyone who has installed Archi tool can work on created model.

5.5.3. Enterprise Architect evaluation

Collaboration

Enterprise Architect supports a synchronous web-based exchange of model/view, data-driven and tendency-driven collaboration. Enterprise Architect users can use DBMS (server based) repositories. Enterprise Architect supports the following DBMSs as model repositories:

- Access 2007;
- MS SQL Server;
- MySQL;
- Oracle;
- PostgreSQL;
- Progress OpenEdge;
- MSDE Server;
- Adaptive Server Anywhere.

Users can use Enterprise Architect's XMI facility to share model information between developers. XMI enables to export discrete packages or entire model branches into XML files, which can be imported into other models or maintained in a version control repository. Enterprise Architect Team Review facility helps users to discuss the development and progress of a project. Team members can view and post messages within the modelling environment and can link their posts directly to elements within the model. For distributed team environments, users can connect their Enterprise Architect model to a Team Review hosted in a remote model repository.

Types of modelling

Enterprise Architect supports Business Process modelling, Information and Data modelling, Requirements management, Model-based engineering of spatial data and geodatabase designs, Strategic Modelling, Systems engineering, Test management.

Meta-modelling

Figure above shows many types of meta-models which can be used to create models in Enterprise Architect.

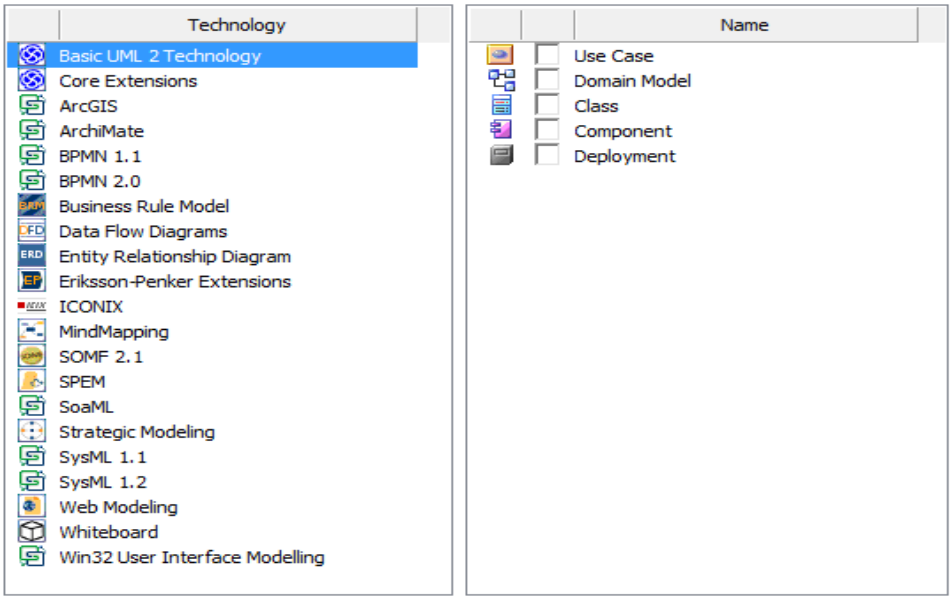

Figure 31 - Many types of meta-models can be implemented and used.

Views

Enterprise Architect's Model Views window provides a filtered view of elements from the underlying model hierarchy. User can organize elements according to search criteria, favorite elements and diagrams, or technology-specific information, such as elements belonging to a particular framework view point. Views can be stored locally for use by individuals or included in a shared repository to achieve collaborative views. Automatic notifications can be set for a given Model View to alert you when an element created by another author is added to the view.

Roles

Creating roles in Enterprise Architect is possible in Strategic modelling in Organization chart. During modelling user can add to his model organization chart with support to create roles (figure 32).

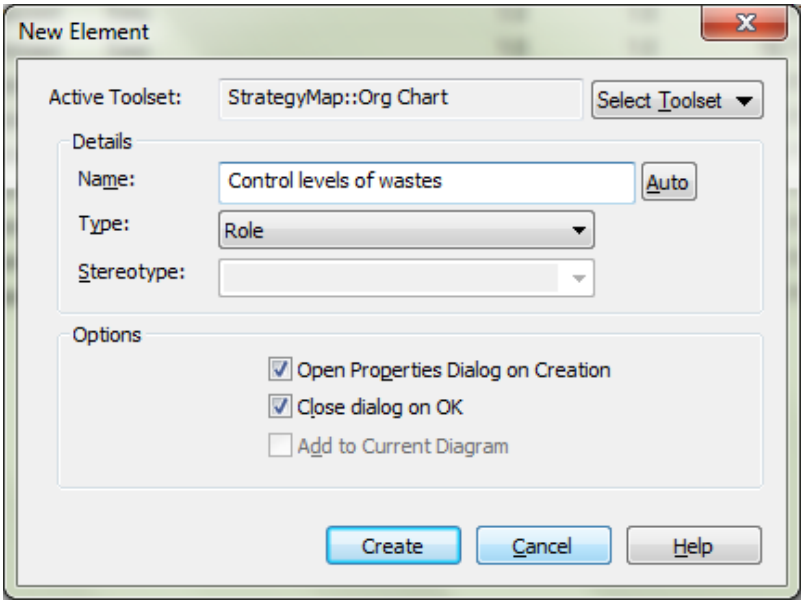

Figure 32 - Assigned the role.

Open platform

In this tool users control access to various editing functions by requiring that authors log in to the model with certain privileges. It also allows model authors to lock elements per-user or per-group. This can help to improve collaborative modelling by preventing different users unintentionally editing the same information at the same time. It also limits the possibility of inadvertent model changes by users not designated as model by authors.

5.5.4. Metis evaluation

Collaboration

In Metis there is no online or tool-based synchronous collaboration only exchanges model/view and data-driven collaboration. It is possible to send a created model and stakeholders can open this model in case if they have a Metis on their computers. In model stakeholders can leave comments inviting collaborative action as shown in figure 33. The intent with METIS tools is to develop modelling

methods, models and knowledge architecture to support model-based collaboration. This will enable projects to create many modes of data- and event-driven collaboration.

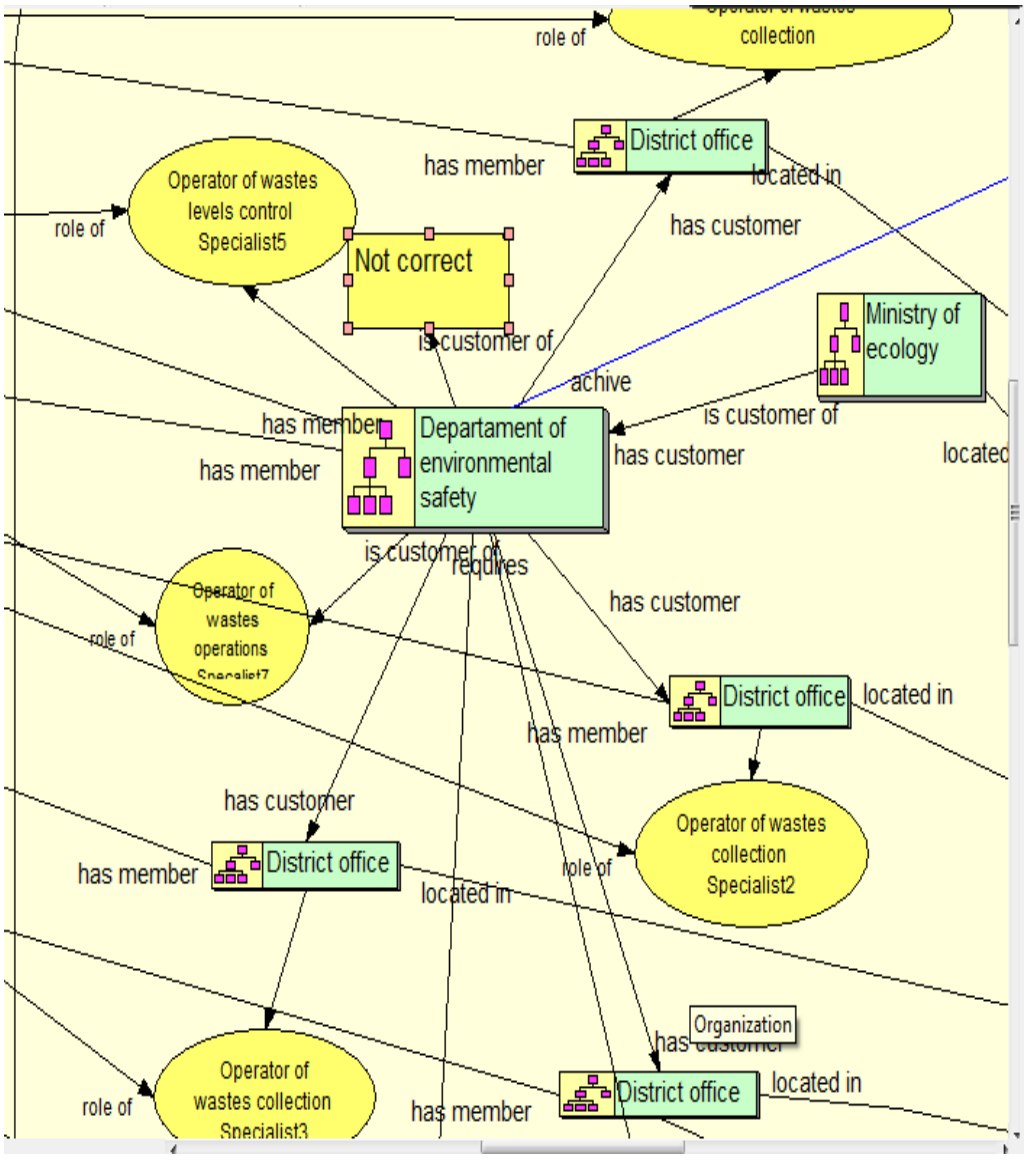

Figure 33 - Collaboration can be invited by sharing comments or modelled.

Types of modelling

In Metis users can create their own meta-models and mix several in order to get access to the modelling elements required in a given sector, area and knowledge domains. The early meta-models of Metis were built by the tool vendor to meet the needs of multi-dimensional enterprise knowledge modelling. The first meta-model and modelling framework was called Generic Enterprise Modelling (GEM). Its main domains are depicted in figure 34 below. Later many new meta-models have been developed. The Metis MEAF – Modelling Enterprise Architecture Frameworks was used to create the first versions of TOGAF.

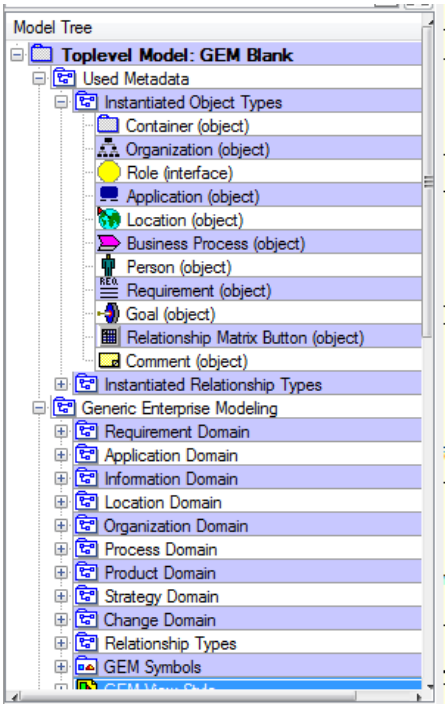

Figure 34 - Elements of the GEM meta-model and its many domains.

Meta-modelling

Figure 35 shows many types of meta-models which can be used to create models in Metis.

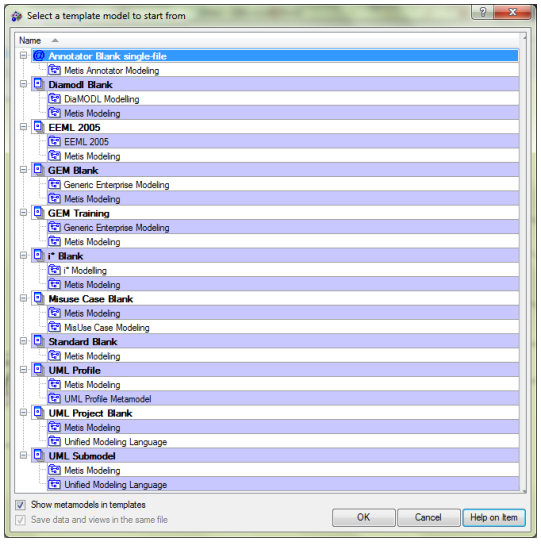

Figure 35 - Many types of meta-models can be implemented and used.

Views

To make it easier to understand models in Metis it is possible to put relevant parts of model in different views. For example, figure 36 shows a whole model of Wastes level control, and figure 37 shows view for Ministry of ecology and their roles with their relevant information. It is easy to create views in Metis by selecting what have to be in a view and create a view.

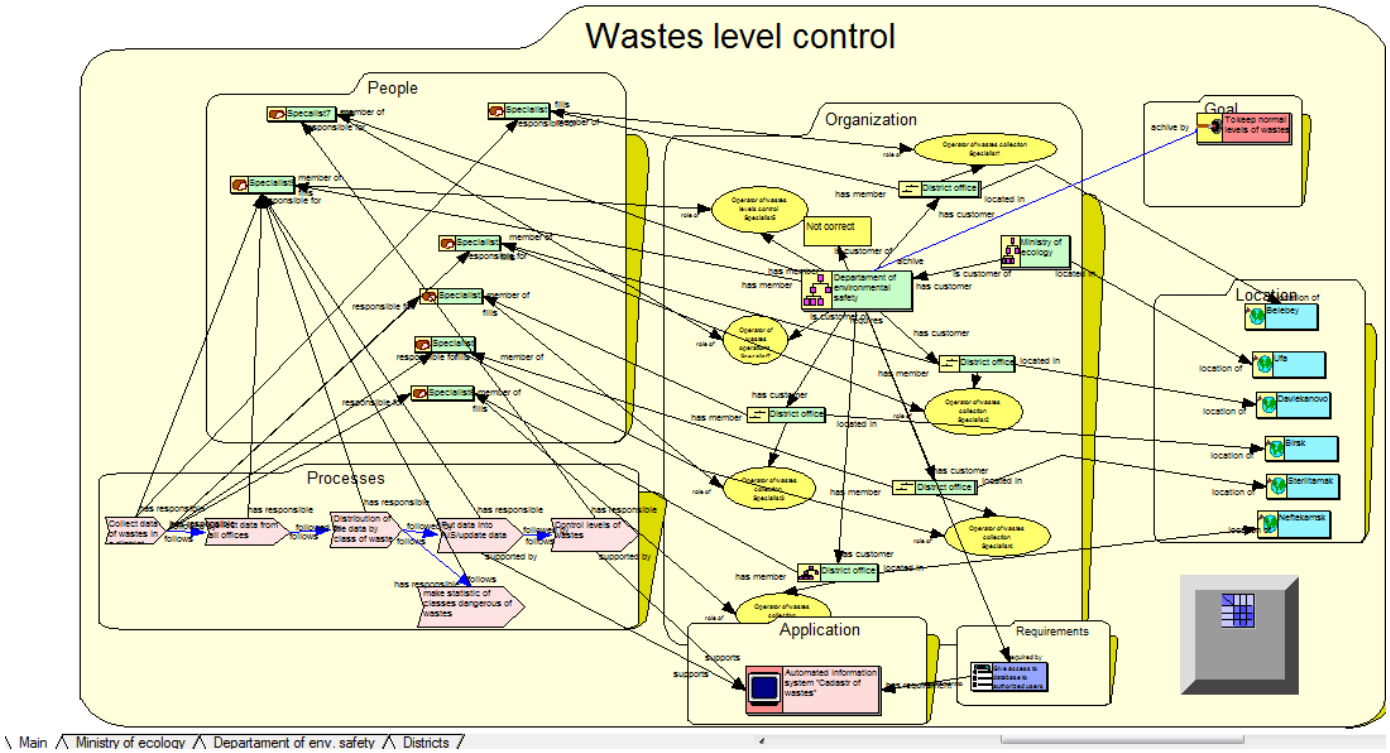

Figure 36 - Model of waste Control process, information sources and department resources.

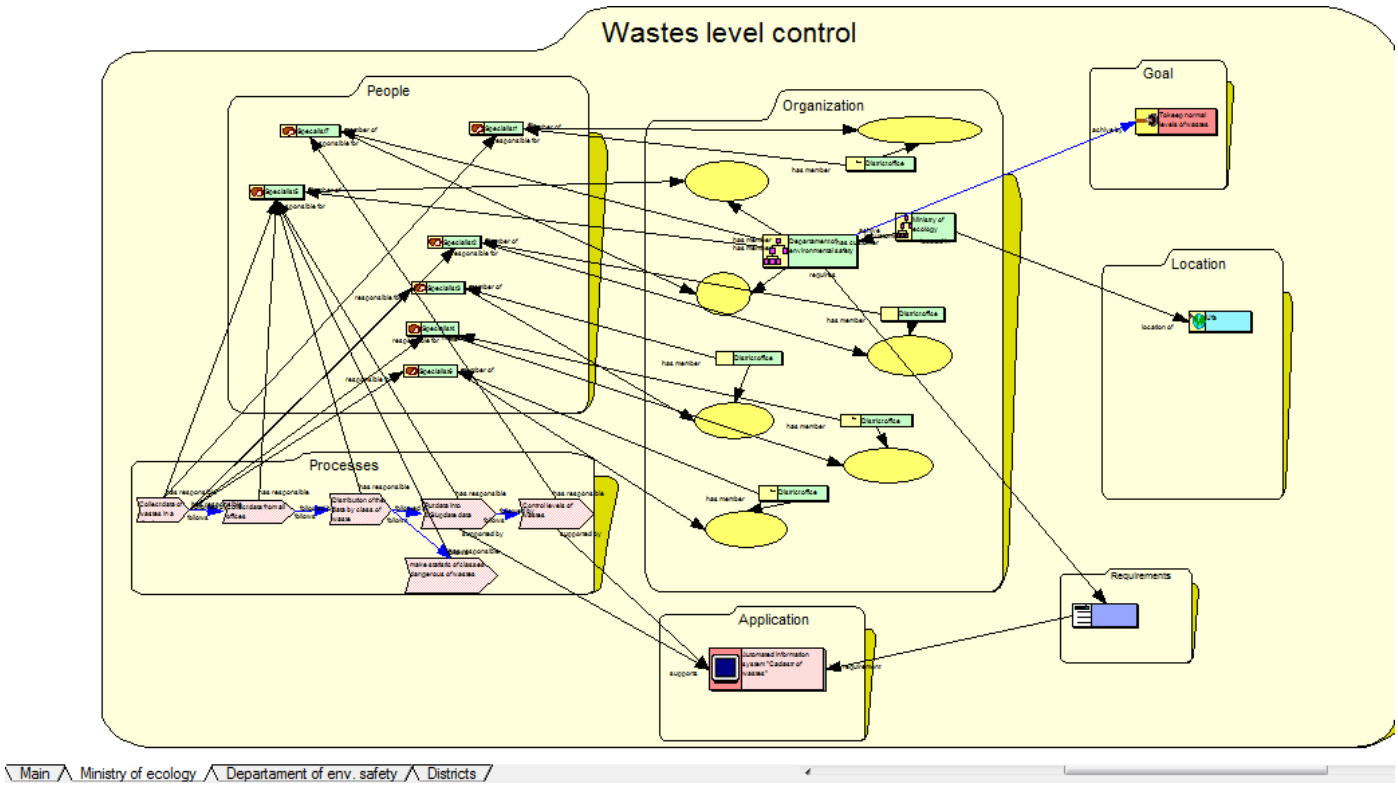

Figure 37 - Views.

Roles

Roles can be created to build role-oriented organizations for processes, projects and entire networked enterprise operations (figure 38).

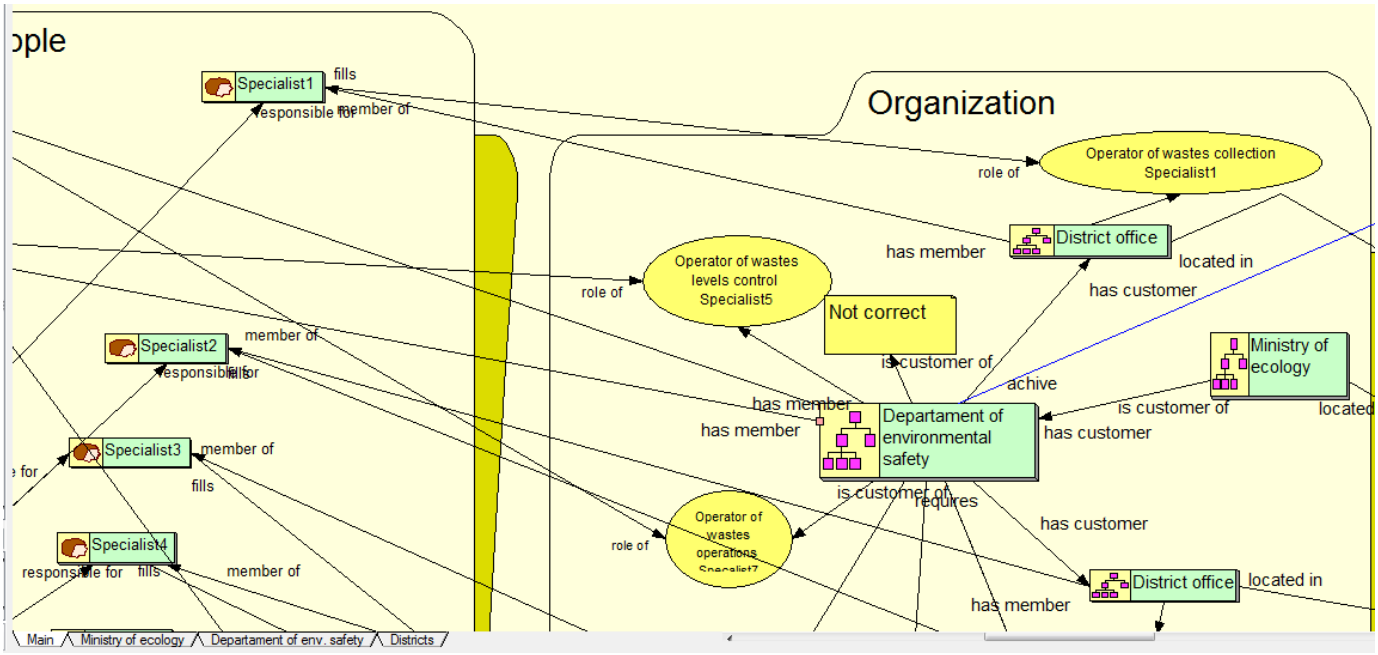

Figure 38 - Role-oriented organizations are important for improved design of model-based solutions.

Open platform

An Open Enterprise Platform should support modelling as demonstrated above, that is creating meta-models of modelling elements supporting.

To model get access everyone but in Metis it isn't possible to edit online or to synchronize model so users have their version of models.

5.5.5. Signavio evaluation

Collaboration

A Signavio is Web-based synchronous and data-driven collaborative tool. In this tool after creation a diagram user can send an invitation to comment his diagram as shown in figure 39. Figure 40 shows an interface of invitation.

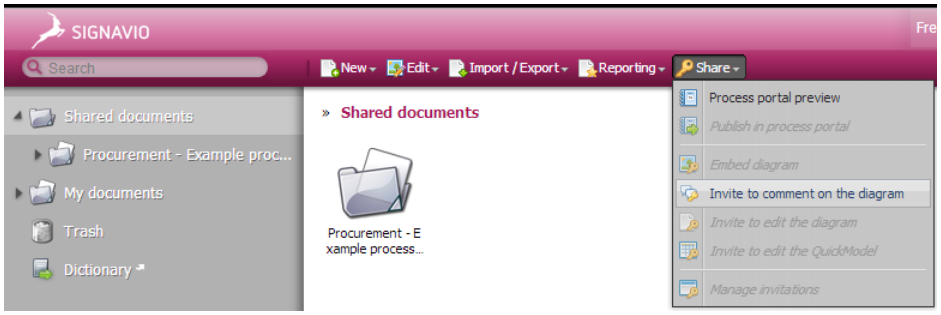

Figure 39 - Collaboration can be invited by sharing comments.

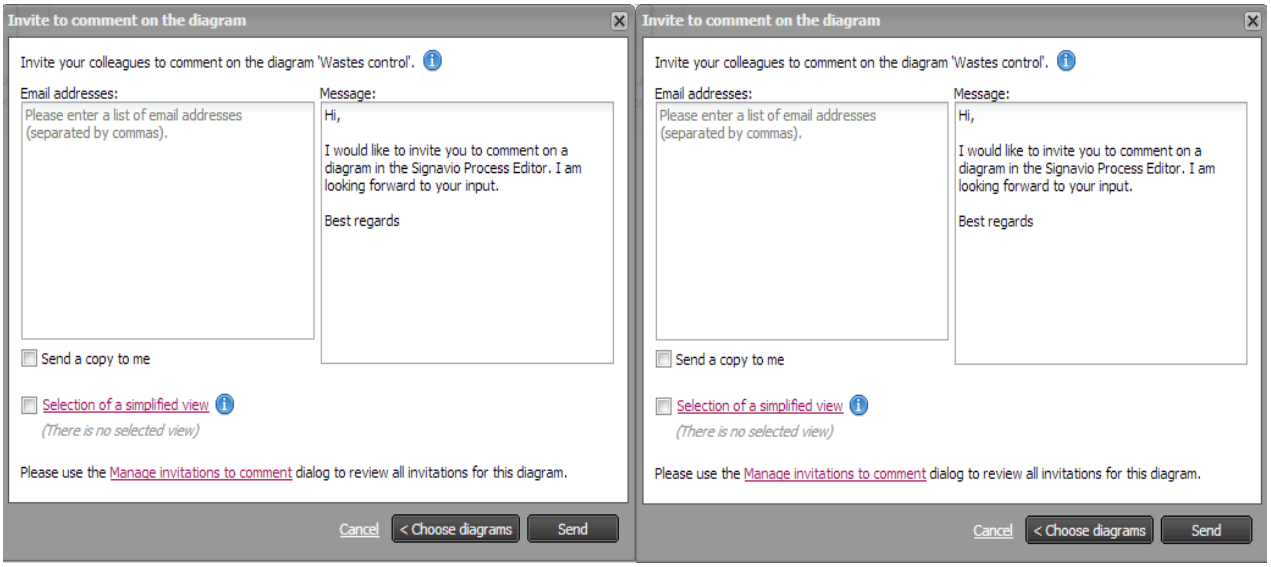

Figure 40 - Invitation forms.

To leave comments can only authorized user by selecting an element and writing down notes as shown in figure 41.

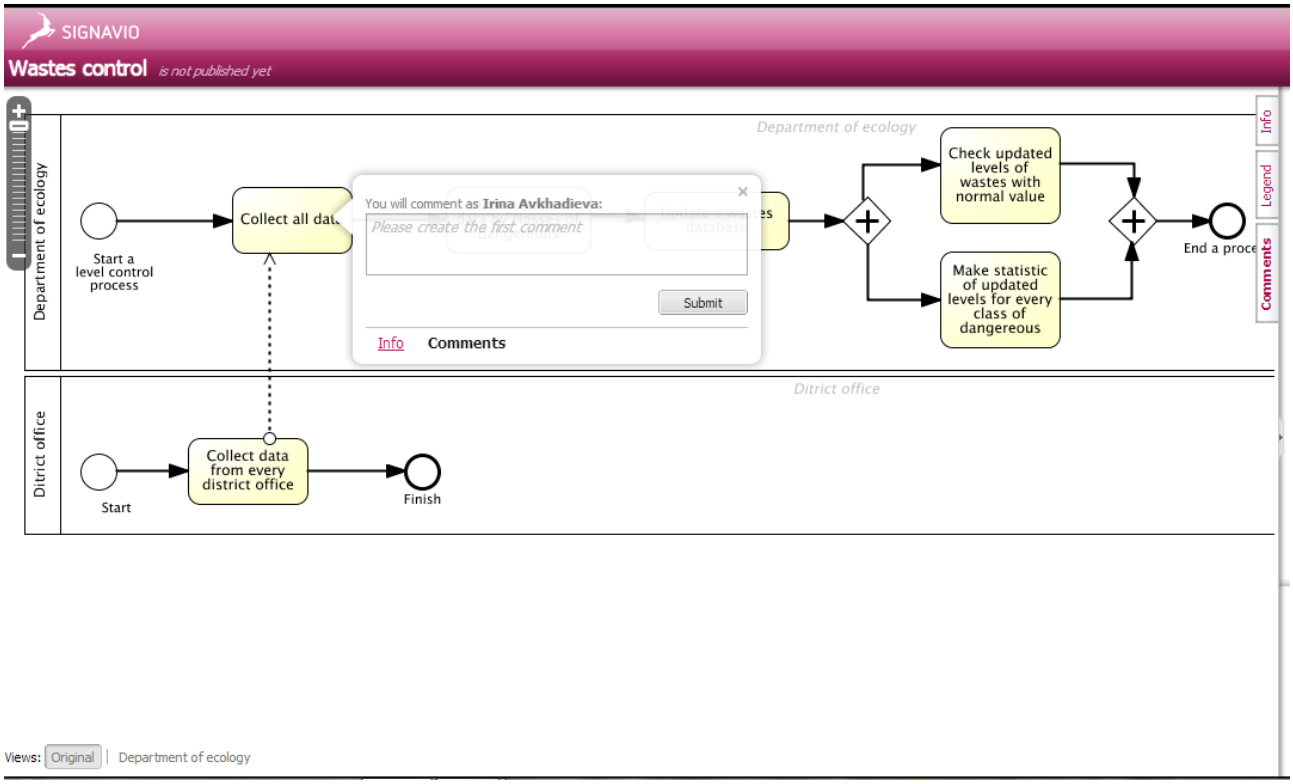

Figure 41 - Form to submit a comment.

Types of modelling

A Signavio tool is used for process modelling with Business Process Diagram (BPMN 2.0) and Event-Driven Process Chain (EPC), organization modelling with Organization Chart which is shown in figure 42.

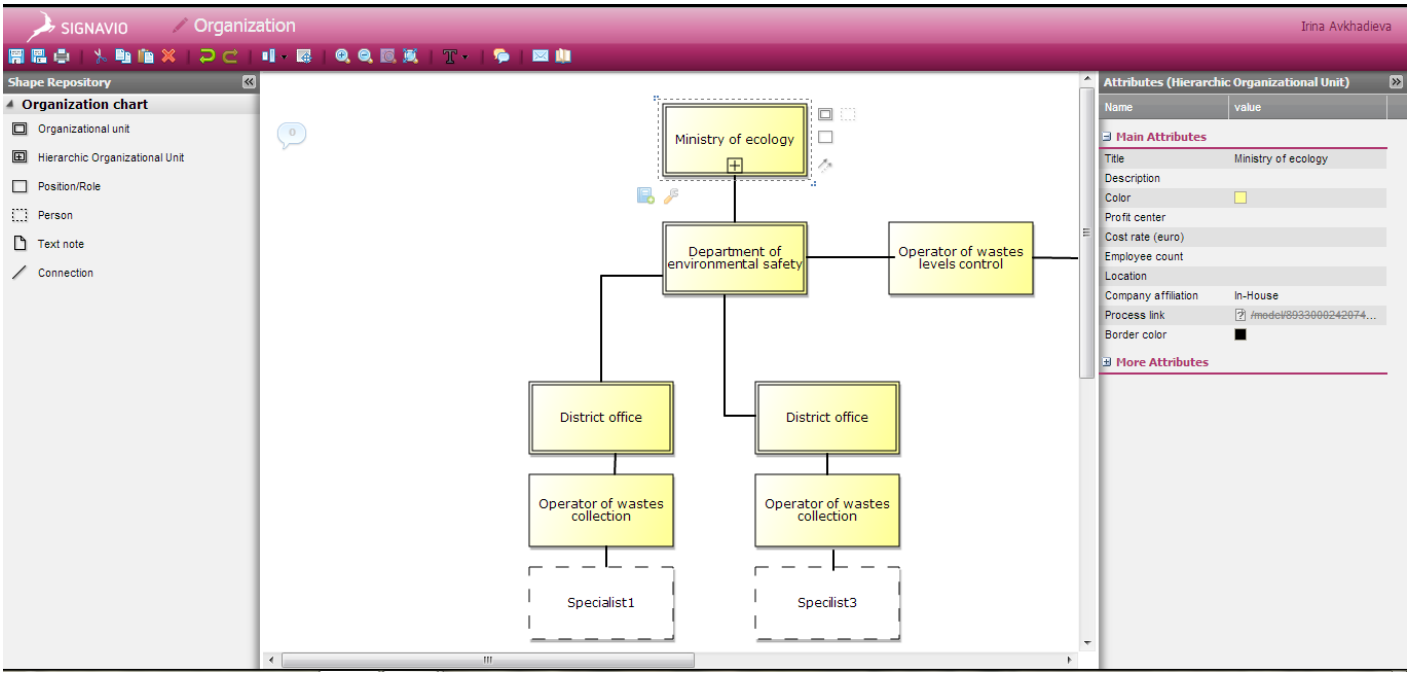

Figure 42 - Organization structure.

Meta-modelling

Figure 43 shows meta-models which user can choose to create models in Signavio.

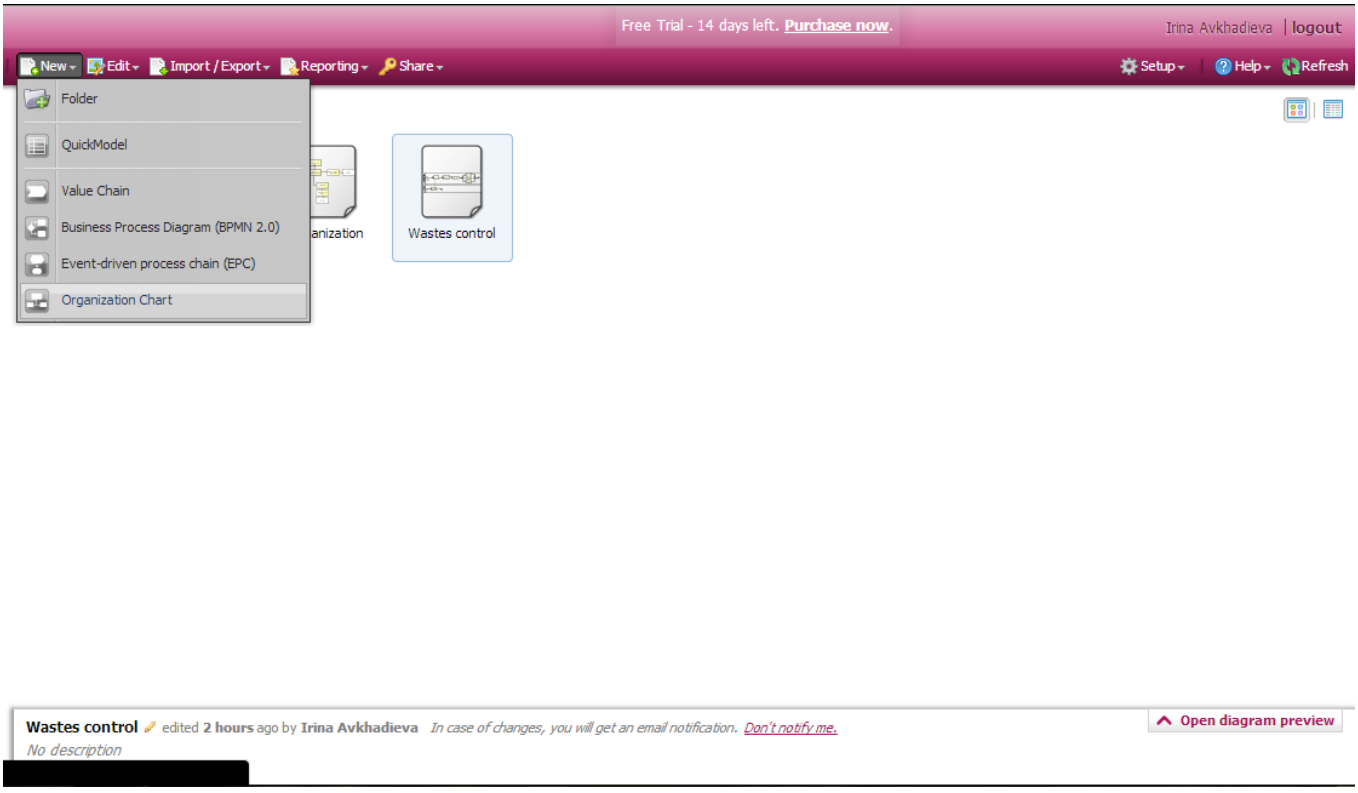

Figure 43 - Types of meta-models can be used.

Views

An opportunity to help of understanding process model in Signavio is a creation views. Figure 44 shows how to create new view. The result is shown in figure 45.

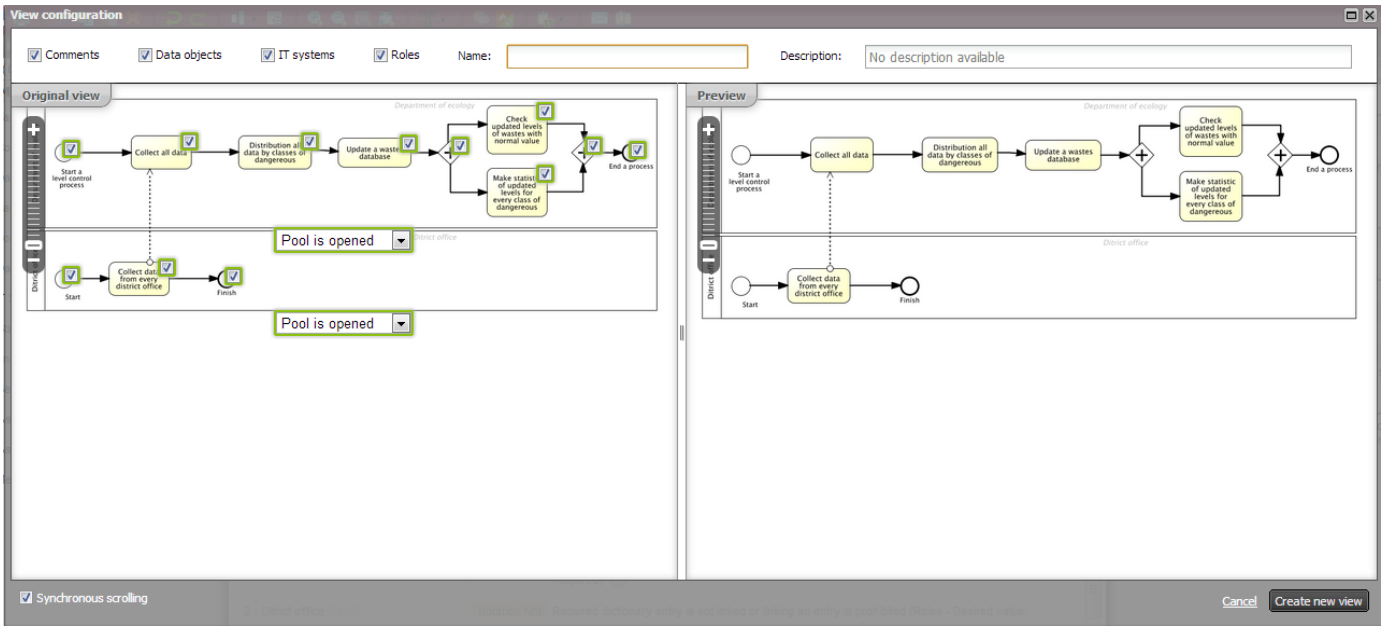

Figure 44 - Creation of view.

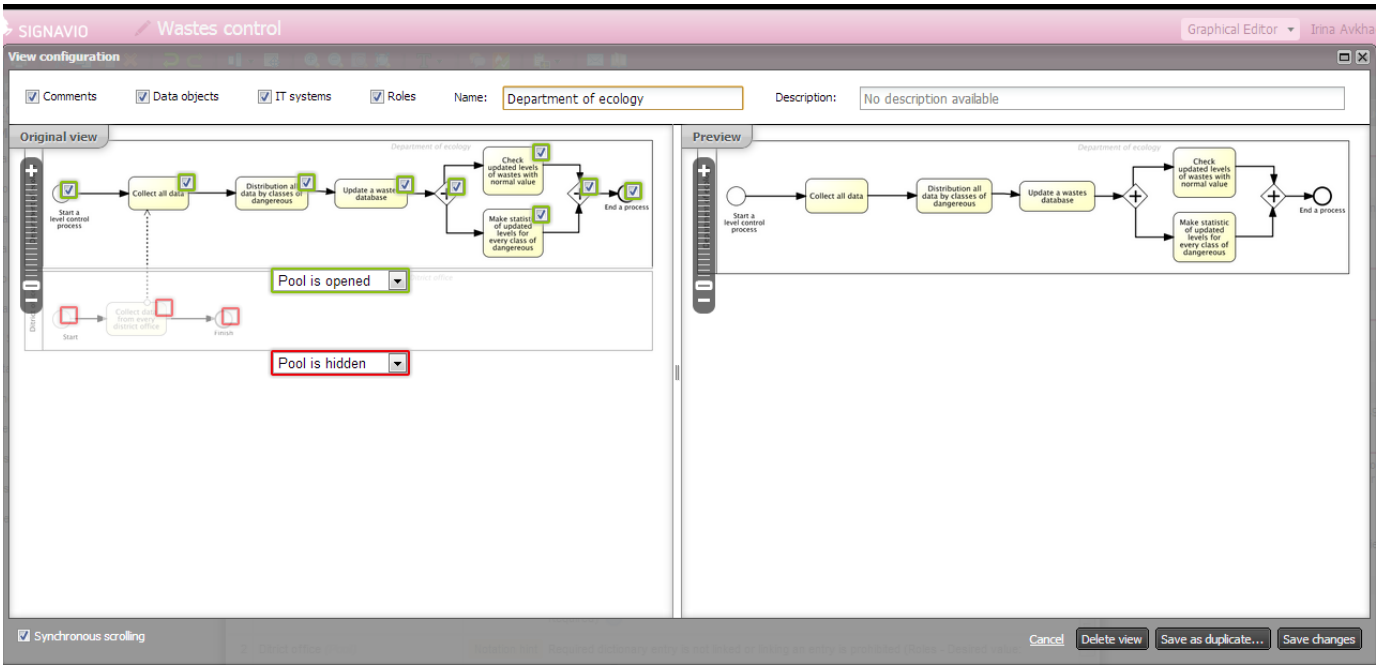

Figure 45 - Department of ecology view.

Roles

In this modelling tool it is possible to put roles in Organization Chart. Figure 46 shows the Organization Chart where every department or office has some number of roles and each role is owned by specialist. So during an enterprise process roles can be the same but the specialists could

be moved to other roles. It is possible to show even if one specialist has many roles or one role include more than two specialists which work in different department.

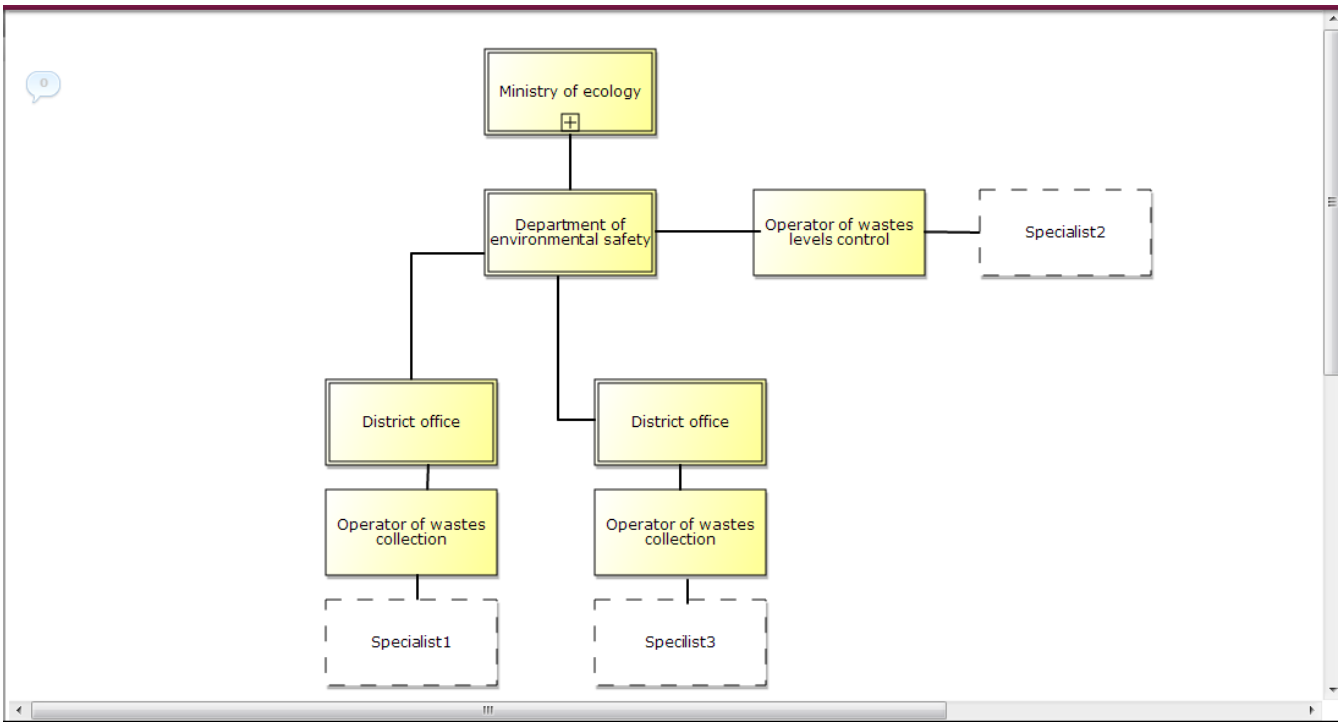

Figure 46 - Organization structure.

Open platform

An Open Enterprise Platform should support modelling as demonstrated above that is creating meta-models of modelling elements supporting. In Signavio is possible to share a model with stakeholders. So they all can comment it at the same time.

5.6. Results

As the result of the evaluation these five tools the table 1 was produced. It shows a summary of features which they have.

Tools	Collaboration	Types of modelling	Meta-modelling	Views	Role modelling	Open platform
Signavio http://www.signavio.com/products/process-editor/process-modelling/	**yes**	**yes**	**yes**	**yes**	**yes**	**no**
Enterprise Architect http://www.sparxsystems.com.au/	**yes**	**yes**	**yes**	**yes**	**yes**	**no**
Metis http://www.enterprise-architecture.info/Images/Computas%20Metis/Metis%20overview.htm	**yes**	**yes**	**yes**	**yes**	**yes**	**no**
Agilian 10.2 Enterprise http://www.visual-paradigm.com/product/ag/features/modellingtools.jsp	**yes**	**yes**	**yes**	**yes**	**yes**	**no**
Archi http://archi.cetis.ac.uk/	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**

6. Novel Concepts and Methods

There are eight paradigm-shifting concepts that enable enterprise designers, architects, engineers, ICT and other life-cycle actors to design novel agile approaches, adaptive methods, extendable platforms and emergent solutions. These concepts are required to meet the growing needs and challenges described in chapter 3, but also to pursue new business opportunities. The most important concepts contributing to implementation of agile approaches and open collaborative enterprise platforms supporting concurrent enterprise design and operations are:

1. *Role-oriented Organizations - capturing work-centric contexts*
2. *Enterprise Knowledge Spaces - multi-dimensional spaces simplify modelling, collaboration and property parameter management*
3. *Context-rich Workspaces – enabling simultaneous model-based workplaces design and execution*
4. *Active Knowledge Architecture (AKA)- integrating approaches, methods, services and platforms*
5. *Model-based, Architecture-driven Workplaces - configuring agile workplaces and solutions*
6. *Holistic Design Methodology– working top-down, bottom-up and middle-out*
7. *Concurrent Modelling and Operation – closing gaps between design and execution*
8. *Visual Work Environment – simplifying networked collaboration*

The major concepts, their properties, enabling capabilities and business impacts are combined to support new agile approaches, develop new adaptive methodologies, and extendable open platforms. This is illustrated in figure 47 for the design of Cyber-Physical work environments as presented in the TOPSCENE EU proposal [12].

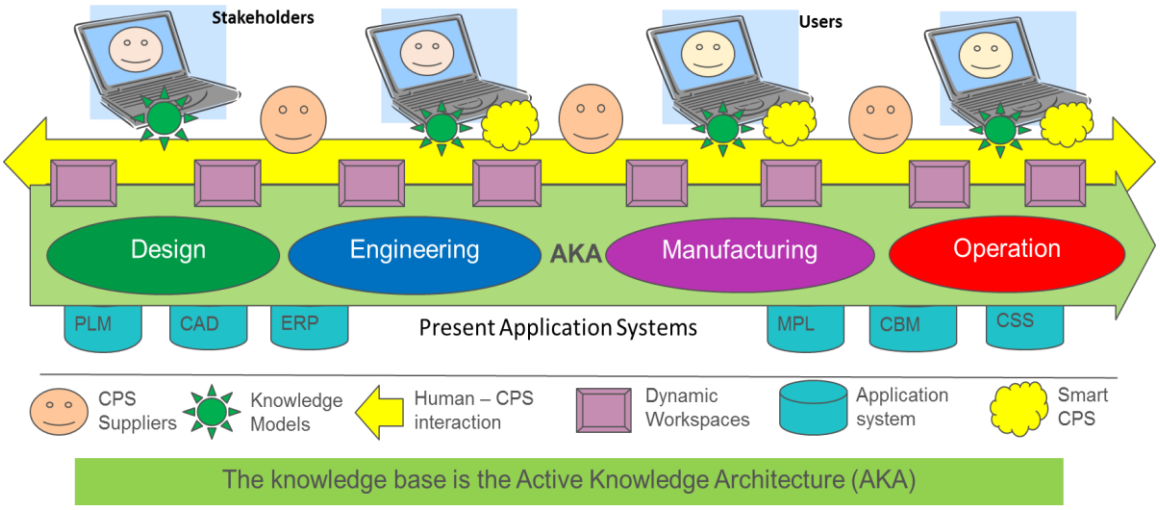

Figure 47 - Emergent networked enterprises - simultaneous design and operation.

Multi-dimensional enterprise knowledge spaces, smart role-oriented organizations, workspace properties, AKA modelling, and the AKM methodologies and principles are explained in detail in the AKM blog [6].

The novel concepts, their most important criteria, and the capabilities to be enabled and supported are briefly explained in the following sections. The figures and concepts are taken from the MALABS project reports [8], and the HODEPS and TOPSCENE EU proposals [11, 12].

6.1. Role-oriented Organizations

Existing organizations, hierarchies, networks or static collaborating teams - were never designed to fit their business objectives, customer usability, manufacturing expertise, life-cycle support services, or operational services to be delivered to customers. Hierarchies are still the dominant structure for enterprise business management, and management of resources and human competence and skills. Networks are complementary structures mainly used for communication of data and information exchange and flows between main contractors and partners. Matrices are used for work planning, execution and follow up, and for understanding and resolving complexity and resource dependencies.

With the advent of modern digital technologies and the recognition of human mental models and networked enterprise workspaces, role-oriented organizations will become as central as the hierarchies currently are [11, 12]. So, roles are important for defining networked enterprise criteria and capabilities (NECCAFs), and for future MBADS for participation in multiple networked enterprises. With time and experience it will be possible to structure the criteria and capabilities according to teams and roles across sectors.

Human mental models have properties, such as reflective views and repeating task-patterns, and both pragmatic and scientific capabilities allowing user-driven design and adaptation of digital knowledge models. However, all the known organizational structures should be combined in models of an AKA and EKA. The interaction among roles, their tasks, and the resources allocated and spent will need data from all these structures. The people assigned to roles should be supported by model-based, architecture-driven workplaces, allowing them to perform at-the-workplace design modelling, task execution, and task-pattern composition closing the gaps between design and execution. While performing modelling and execution of creative tasks access to previous similar solutions and the knowledge assets created are important in order to perform effective knowledge management.

Much research is currently performed on ambidextrous organizations [25]. The main challenge is managing business strategies and balancing operations between exploitation of the known, and exploration of the unknown.

6.2. Enterprise Knowledge Spaces

Enterprise Knowledge is created in multiple reflective dimensions by the people assigned to roles in the various enterprise activities and domains [5, 6, and 15]. Smart networked enterprises cannot be built by acquiring or developing application software systems alone, and adaptive services cannot be delivered by current methods creating services in the cloud without user-driven capabilities for re-configuration and adaption.

Future development, use and value of ICT, will be managed by externalizing and sharing situated enterprise knowledge, competence transfer among actors, and reuse of role-oriented workspaces, models and architecture-driven workplaces. Powerful viewing and interaction, and autonomous coordination and collaboration tasks are capabilities that should be supported.

The nature of practical knowledge spaces and workspaces must be understood by users applying graphical modelling to capture work-centric knowledge and context. Active knowledge architectures, building active knowledge models, can support user-driven development and situation-driven adaption to solutions and operations, meeting unforeseen needs. Knowledge and experience sharing will be facilitated, and knowledge assets management and reuse will be decisive for future competitiveness and progress.

6.3. Role-specific Workspaces

Local practical workspaces are developed over years by the most experienced and creative workers [15]. With the digital technologies and the AKM discoveries of EKS and workspace modelling it is possible for all networked workers to benefit from knowledge sharing and competence transfer, and autonomous knowledge elicitation, management and reuse.

A range of new model-composed capabilities can be made available at each workplace by workers collaborating in role-designed teams allowing designing and experimenting with alternative solutions. The contents of most workspaces consist mostly of tacit knowledge that can only be transferred by either close collaboration and sharing of models or by providing fine-grained modelling tools to the users. Graphic modelling of work-sensitive data and context enable humans to express their tacit knowledge, and enhance their mental models for work management [8, 15].

6.4. Active Knowledge Architecture

An agile holistic design approach, based on the AKM discoveries, concepts and methods, will provide practitioners with model-based workplaces, the required adaptive visual working environments, and the methods and capabilities needed. The AKA is composed by holistic thinking across agile approaches, novel design methods and principles, and active models of enterprise knowledge spaces and role-oriented workspaces. Visual modelling and new design methodologies enable new approaches to application solutions, knowledge management and competence transfer, whatever sector or application concerned.

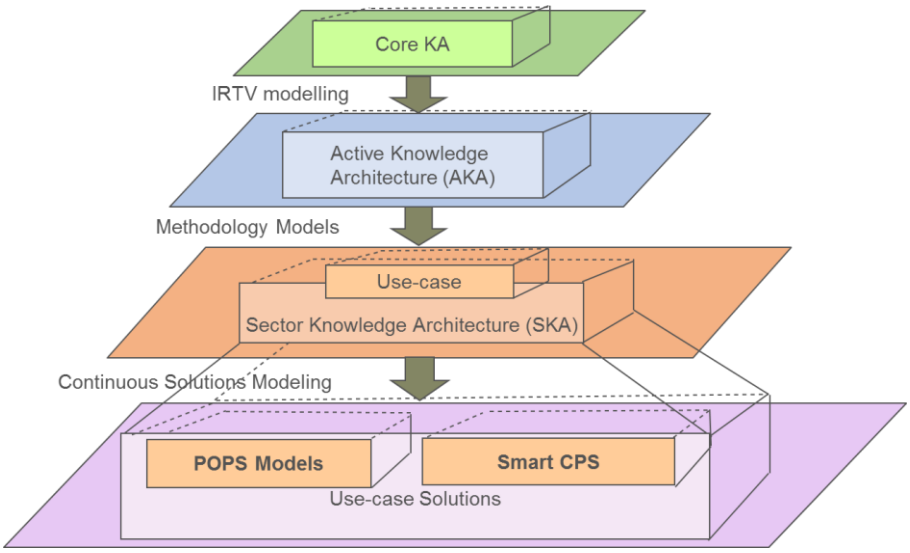

Figure 48 - Stages in Enterprise Knowledge Architecture (EKA) development and management.

The Core Knowledge Architecture (CKA) is common to all knowledge architectures across sectors, methodologies and platforms see figure above. It is therefore regarded as a meta-meta knowledge model from which all refined active knowledge models and architectures are built. The figure above is a cross-sectional view of the birds-eye view presented in figure 7 at the start of chapter 4, and has a slightly wider perspective than the view in figure 9.

By graphic modelling of knowledge models of approaches, methods, platform work environments and solutions aspects applying the IRTV language, the design of sector specific AKA is enabled throughout. Adding active models of approaches and methods, and core roles and workspaces builds networked enterprise reference architectures.

6.5. Model-based, Architecture-driven Workplaces

Workplaces of application systems are hardcoded, so what users can adapt, change and extend are limited to what has been included as code from the vendor or developer. Change and extension would therefore imply recompilation and change of the code and runtime behaviors.

Model-based, architecture-driven workplaces have been prototyped in five pilots. Solutions development is based on collaborative visual modelling of active knowledge models, enabled by architecture-driven workplaces, involving teams for architecting, application and methods modelling, and platform building.

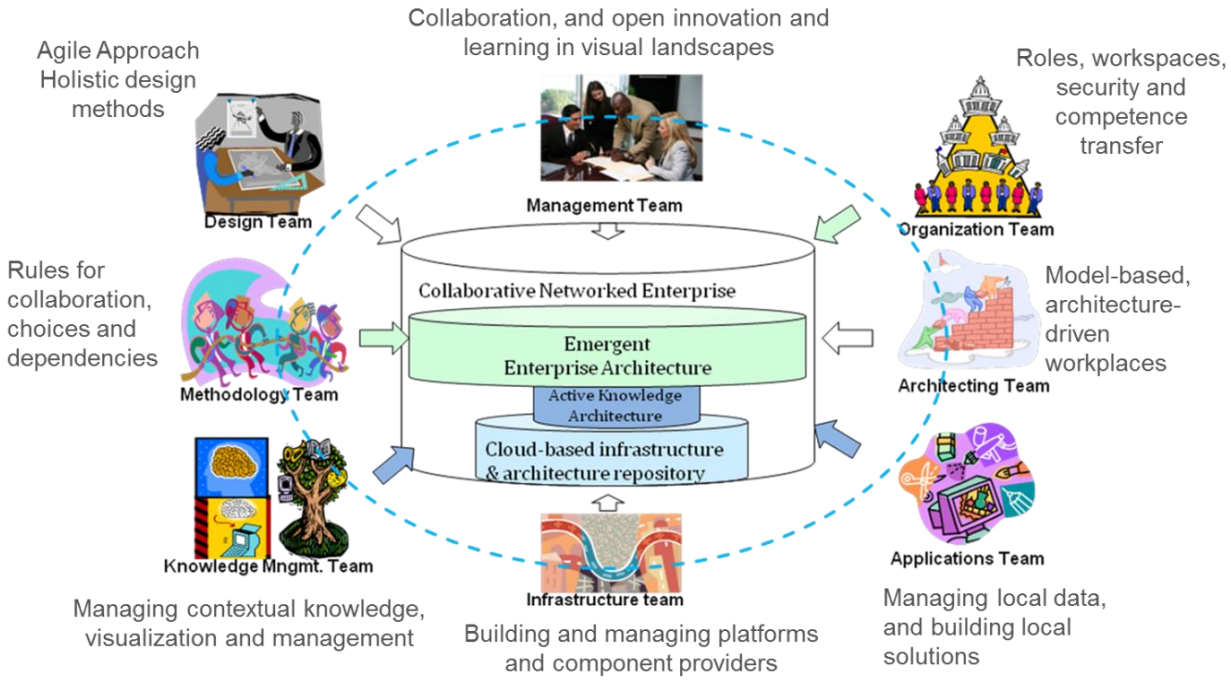

Figure 49 - Team-working, teams, roles and responsibilities.

Collaborative open innovation and learning, and continuous design and operation of emergent networked solutions are enabled. Agility and emergence can be achieved by building model-based, architecture-driven workplaces, providing capabilities for autonomously extending and modifying the AKA, for managing knowledge assets in classes and categories, and to reflect operations across workspaces.

6.6. Holistic design

Holistic design is more than a simple move from the modern to the post-modern, as it represents both an ontological change in the consideration of organizations, a shift in our understanding based of Cyber-Physical Systems (CPS), user-driven active knowledge architecture, and systems engineering [12, 13]. The people involved in enterprise design, development and management must adopt holistic thinking, and become familiar with the AKM concepts and methods. In AKM holistic design implies modelling top-down to support planning and control, bottom up to capture work-sensitive data and context, and middle-out to balance property parameters across disciplines and partners. This is the foundation for new paradigm-shifting computing approaches and human-driven methods. Active knowledge models and architecture components will be key economic assets for the coming knowledge and digital economy.

The stages of evolution and the growing contents of the approaches, methodologies, solutions and platform will be further explained in chapter 7.

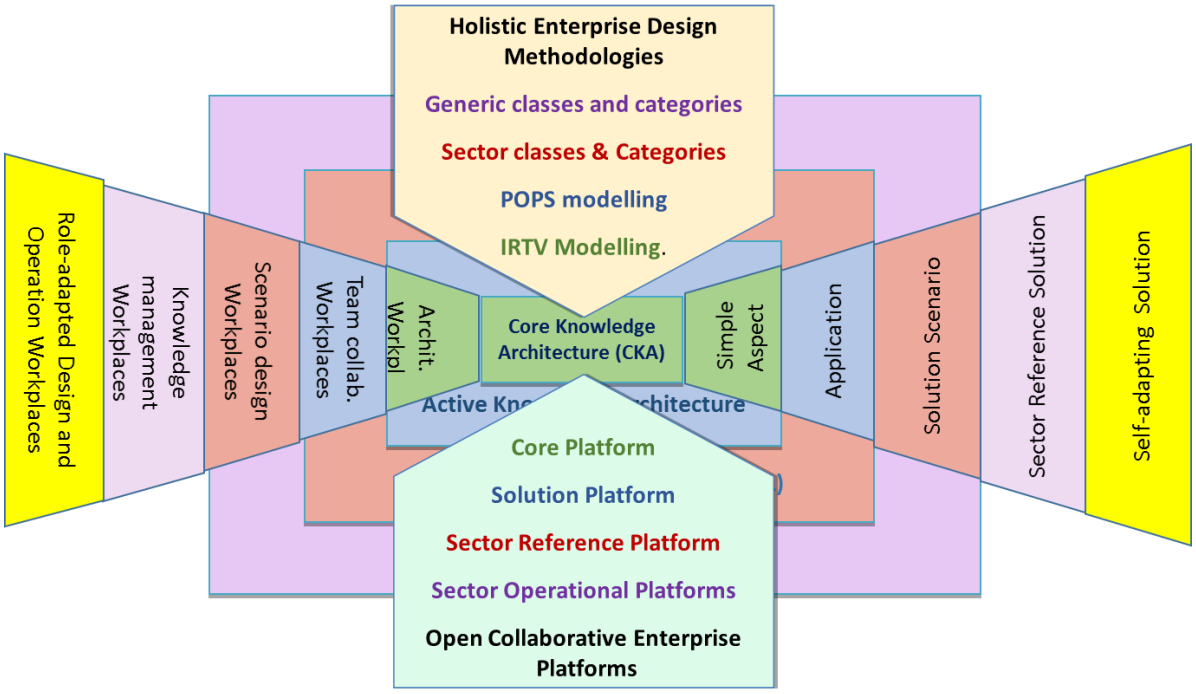

Figure 50 - The agile approach implies adding role-specific workplaces, adaptive methods, and platform capabilities.

6.7. Concurrent Modelling and Operation

Capturing role-specific workspaces and knowledge spaces, applying holistic design methods, is performed by teams interacting and collaborating to design, use, adapt, upgrade, and manage the shared active models of approaches, methods, application domains and human as well as technological aspects. Innovation and learning will be driven by experimentation, exploring new opportunities and exploiting existing knowledge [25]. The current gaps in modelling and execution and in design and operation will be closed, and users can experiment with concurrent alternatives, and variants of families of solutions.

6.8. Visual work environments

Visual work environments allow users to observe monitor and share status of roles and the tasks allocated. Powerful architecture-driven viewing of task-specific and common business views provide effective support for collaborative overall performance and management of properties, features, values, and acceptable results. Traceability, decision-support, predictability, and assessment of trends and situations will give users enhanced capabilities to deal with effective work management, uncertainties and risks. User-driven autonomous tasks can be composed to communicate and manage changes and knowledge assets.

7. Network Enterprise Criteria and Capabilities Framework

Validated prototypes exist as evidence that in order to meet the needs and resolve the challenges described in chapter 2, new agile approaches and methods for concurrent design and operation of networked enterprises urgently needed. The operational base for active knowledge models, emergent architectures, visual working environments, and digital collaboration is an Open Collaborative Enterprise Platform (OCEP), enabled by agile Model-Based Architecture-Driven Solutions (MBADS) workplaces.

This chapter contains an overall Networked Enterprise Criteria and Capabilities Framework – NECCAF description. We are not yet able to describe sector and role specific frameworks, so NECCAF described herein is formulated based on an imaginary OCEP perspective. Other perspectives like the agile approaches, adaptive methods and emergent solutions will be described when a core OCEP is available and some use-cases are prototyped. More detailed architecture-driven networked enterprise frameworks will be built from modelled and executed sector specific use-cases. This is illustrated in figure 51.

Figure 51 - Different NECCAF levels of abstraction and definitions of knowledge perspectives.

Level 1 in figure above has been the focus of this work. For the NECCAF to really have an impact and value for OCEP design and operation there is a need to implement levels 2 and 3 from the figure above. Sector specific NECCAFs will be operational Sector - Specific Knowledge Architectures (SKA) as illustrated in figures 46 and 48 in chapter 6. Developing these NECCAFs and matching OCEPs could therefore take several projects and years, involving leading actors, stakeholders and educational and research projects.

In order to support NECCAFs and build OCEPs for any given public or industrial sector we need first to develop an open core platform and a sector specific Active Knowledge Architecture (AKA) platform. The AKA platform must be adaptable and extendable by the stakeholders involved, in order to fit the products and services to be designed and delivered, and existing stakeholder systems must be integrated through models in the OCEP and NECCAF architectures.

Graphic symbolic modelling languages will be built as part of an AKA. The language constructs and symbols are tailored to each sector, product and services, application domains and disciplines, but certain aspects need common symbols and visualization templates.

Composing, establishing and operating NECCAF-driven OCEPs demand new criteria definitions and development of AKAs and SKAs. Business models for sharing the expenses and revenues, created in one or more operational networked enterprises, will be developed. This is work that will be undertaken in R&D projects, starting in 2014.

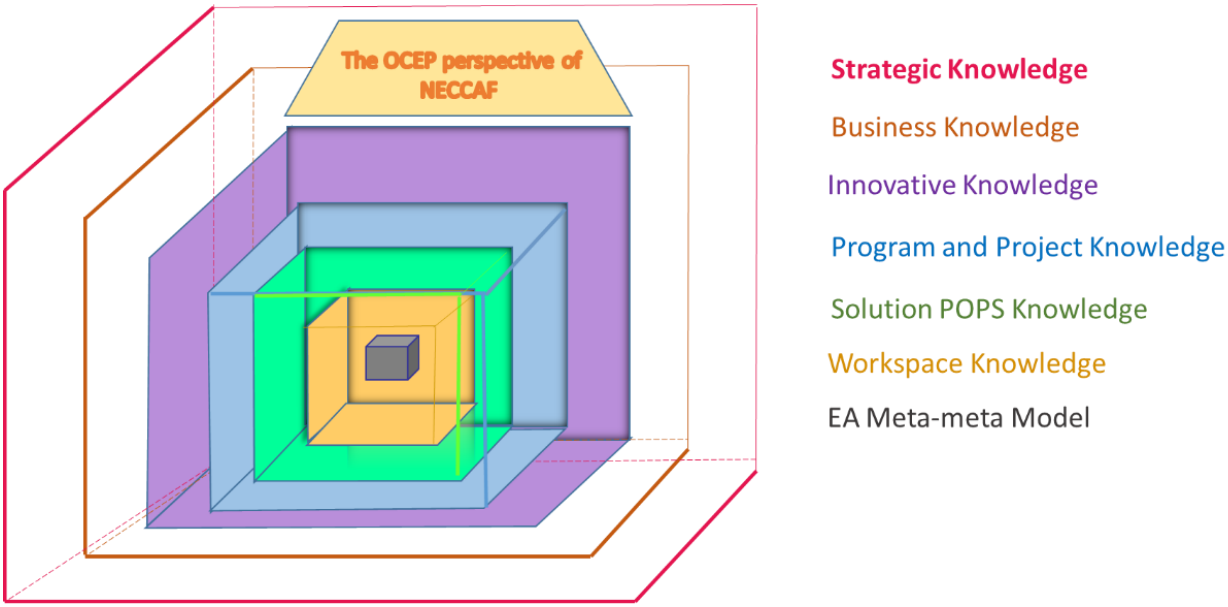

Figure 52 - Criteria and capabilities are mainly found in the Innovative and POPS spaces.

The following four sub-chapters and sections define and describe the criteria and capabilities for designing, building and operating an OCEP, based on available NECCAF knowledge and experiences collected so far. The two last sub-chapters are describing some criteria and capabilities that are special for given sectors.

7.1. Open Platform Criteria

The design and operation of OCEPs will have to consider criteria from most all other sector knowledge spaces and role-based aspects. Looking at references, many criteria are found that are specific to given knowledge spaces, particularly the innovation, the project and the POPS knowledge spaces. Many of these criteria are really generic or applicable in a wider perspective. Also there are criteria that with the agile MBADS approach will be described as solution-specific capabilities; an example is innovation and learning. Many of the innovation and learning criteria are applicable across all domains and levels as described in this chapter. Transforming enterprise architecture from sequential development processes and snapshot views to collaborative design processes and views means that criteria definitions also transform.

The criteria and capabilities are described in twelve categories. The numbering is mostly alphabetic, but is really random.

7.1.1. Generic Criteria

Today most of the generic criteria are described in more sector and aspect specific references e.g. industrial product design criteria [26].

1. Networked Enterprises must be designed and operated, building emergent AKAs,
2. Emergent Networked Enterprise Architectures is the knowledge and services base,

3. Adaptability, work environments and workplaces and graphic symbols for modelling whatever,
4. Aesthetics, work environments must follow HRM regulations and policies,
5. Availability and accessibility, fast and easy but safe and secure,
6. Controlling risks, instant viewing of property and performance parameter violations,
7. Life-cycle of the technology for sustainable solutions and work environments,
8. Measured benefits, economic and other values should be measurable,
9. Performance monitoring, design and innovation for enhancements to improve performance,
10. Reduce uncertainties, current methods carry too many uncertainties causing delays and errors,
11. User-driven modelling, this is particularly important for the POPS space and workspaces,
12. User involvement is mandatory for user-driven solutions.

7.1.2. Strategic Criteria

Strategic Criteria are influenced by new global business opportunities, new markets and new technologies [27]. A good explanation and overview of strategic criteria is given by Rowans Head[2], and by the growing discussions about ambidextrous organizations [25].

1. Digital and IT leadership
2. Exploitation, getting the ultimate values out of current business offerings,
3. Exploration, experimenting with new offerings to new customer-groups,
4. Favorable growth prospects, find and assess,
5. History of profitable growth, both in turn-over and market share,
6. Improved HR Management, attract the most competent people,
7. Open Innovation, particular emphasis on meeting the digital torrent,
8. Engaging customers and partners in R&D and training clusters,
9. Build strong regional competitive positions.

7.1.3. Business Criteria

Business criteria are influenced by new global markets, customer needs and demand for new services. Some new ideas and entrepreneurial criteria are described in [34].

1. Asset Management, reuse quality solution components and knowledge,
2. Business Growth, know the market potential, and size of markets,
3. Communicate your business idea, all stakeholders and partners should comply,
4. Emergent business model, know best approach to customers,
5. Globalization of markets, prepare for distributed team-building,
6. Master complexity, find approaches and methods, principles and rules,
7. Sustainable customer base and solutions,
8. Timing (seasonality, market, billing, etc.)

[2] http://rowanshead.com/business-marketing-consultants/strategic-marketing/what-are-the-%E2%80%98strategic-criteria%E2%80%99-and-how-companies-evaluate-them/

7.1.4. Program and Project Criteria

Criteria for accrediting engineering programs can be downloaded from ABET[3], and criteria for societal and industrial programs and projects are found in several places. A good source is Global Environment Facility [35]. Governance and control has become a major task for most programs and projects.

1. Continuous planning and follow up, plans change with progress,
2. Governing environmental properties, adhering to regional legislation,
3. Manage scope and life-cycles for all services and results,
4. Get to know stakeholders, their expectations, involvement and contributions,
5. Meeting societal and human standards, think and act holistically,
6. Support emergent collaboration with partners,
7. Handling risks and uncertainties, applying holistic design methods,
8. Monitoring progress, shared views of progress towards end result,
9. Monitoring critical conditions, new methods of analyses.

7.1.5. Product Criteria

Product design criteria have been key knowledge for most design theories developed in the last century [26]. The most well-known design theory thinkers start their design process with a set of criteria as input to ideation and selection of design concepts [21]. Among the criteria to design and evaluate a product may be the following criteria:

1. Utility and capability, know the operational environment and customer expectations,
2. Functions and features, the life-cycle capabilities of sustainable services,
3. Services and properties, the need for novel MBADS methods for design,
4. Appropriate service availability, making sure life-cycles roles can share knowledge,
5. Design, manufacture and life-cycle support of smart components and devices,
6. Product disposition (infrastructure, alternatives, impacts),
7. Properties and parameters modelling, separate aspects before design embodiment,
8. Live-cycle serviceability, providing roles along the critical life-cycle stages,
9. Life-long innovation and learning, removing horizontal slicing,
10. Protect environment, monitor and manage pollution and waste.

7.1.6. Organization Criteria

Criteria for modern enterprise organizations and networked enterprise design and operation should be built on the principles and criteria developed for more traditional organizations. Many useful sources are found on the web[4].

1. Effectiveness is the “bottom line” of organizational performance—achieving the outcomes,
2. Efficiency, the resources consumed to accomplish a task or produce an outcome,
3. Quality is applicable everywhere; it has to do with how closely work conforms to goals,

[3] http://www.abet.org/DisplayTemplates/DocsHandbook.aspx?id=3143
[4] http://www.managingwithmeasures.com/the-six-criteria-for-measuring-organizational-performance/

4. Designing organizational structures, blending hierarchies, networks, matrices and roles,
5. Competent resource availability, introduce new methods in work planning,
6. Education and recruitment, networking with universities,
7. Preserving competence and skill, developing competence and skill profiles,
8. Managing roles and their responsibilities, task, ownership and collaboration,
9. Role-specific workplaces, allow users to replicate workspaces and transfer competence.

7.1.7. Process Criteria

Process modelling for collaborative networking needs rethinking and redesign from the disjoint process perspectives as described in chapter 4. At least four process aspects should be emphasized: the top-down activity-decomposition aspect of management, the bottom –up aspect of workers or performers, the middle-out aspects of humans involved, and then the middle-out aspect of smart devices used.

1. Adaptability of models to new sectors and application areas,
2. Competence Transfer, transformable role-specific workspaces,
3. Designing and blending hierarchical, networked, matrix and role-oriented models,
4. Flow- orientation, to maintain effective information flows to some stakeholders,
5. Performance monitoring, sharing views of timing, resource consumption,
6. Smart components, exploiting the digital technologies and new processor architectures,
7. Role-oriented work management, enabling autonomous knowledge management,
8. Collaboration in across teams, instant creation and re-opening of collaboration spaces,
9. Establishing holistic design approaches to process design and operation,
10. Model-configured autonomous processes to handle remote and hidden tasks.

7.1.8. System Criteria

Systems Engineering [43] is a broad field that can look back on 30 years of intensive research and development. IT and product engineering, manufacturing and support systems and future NECCAF environments must rethink and redesign most concepts and redesign most approaches and methods to systems engineering and operations. Applications and system components already in use must be integrated and adapted to architectures and work environments to provide improved user interfaces.

1. Adaptability, systems must be adapted to the IT architecture of the solutions,
2. Interoperability, systems must be able to exchange data and share knowledge,
3. Extendibility, systems must be easily extended with new properties, functions and features,
4. Sustainability, by building self-adapting systems or user-driven solutions,
5. Performance optimization, testing and monitoring,
6. Model-configurable development and experimentation, replacing modelling and simulation,
7. Applying Holistic Design to enhance systems design, integration and maintenance,
8. Replace system of systems thinking with Active Knowledge Architectures,
9. Incorporate the roles, assigned to humans and smart devices, as data and component owners.

7.1.9. Service Criteria

There are lots of websites about service design, delivery, quality and other aspects. Good sources on service quality are available as are sources for business[5] and engineering. Municipal and societal services are described in “Engineering & Environmental Services" [36]. Services in an OCEP context are composed by and of active models and enabling software and hardware components, supporting model-based configuration of user-adaptable services.

1. Involvement of roles that contributes to design, usability and management of services,
2. Services adapted to work environments, roles and user competence,
3. Easily proven quality[6], seven qualities, emphasizing mental attitudes, reputation and recovery,
4. Easily configured from active models and hardware and software components,
5. User-driven interactive or autonomous model-based composition of business services,
6. User-driven interactive or data-driven services for data presentation and viewing,
7. Confidentiality and privacy, avoiding leakage of private or secret data,
8. Shared and managed by designed roles and workspaces,
9. Delivered with acceptance by customer and stakeholders,
10. Service management, for ease of collaborative composition and reuse.

7.1.10. Work Environment Criteria

Workspaces, defined in chapter 3, explain many of the criteria that future work environments must support. Other criteria including computing workplaces and user interfaces to smart devices, machines, robots and novel mobile devices are:

1. User-tailored, allowing users to adapt interface to needs and level of competence,
2. User-controlled, by giving users control over accessible network sources and contacts,
3. User-configured, by allowing user-driven configuration,
4. Ergonomics are important for user interfaces,
5. Social and personal appeal, is particularly important in public sectors,
6. Local pragmatics capture, is particularly important for sectors involving creative work,
7. Environmental soundness, saving energy and avoiding waste and pollution,
8. Agile MBADS Approach supports traceability, decision support, and predictability,
9. User-configured communication and collaboration spaces,
10. User- driven viewing, from task-specific to situation-specific views, and common views,
11. Support for ideation and conceptual design,
12. Automatic saving and recovery, including preset conditions.

7.1.11. Data and Knowledge Management Criteria

Most industrial data and knowledge is presently owned by application system databases. Attempts have been made to improve the situation with clusters of domain databases complementing the main database, but the experiences are that this adds a lot of management burdens on the users. Users must

[5] http://www.aicpa.org/InterestAreas/InformationTechnology/Resources/TrustServices/Pages/Trust%20Services%20
[6] http://www.slideshare.net/aarni/service-quality-18291224

own their data and knowledge. Data aggregation to support decision – making, design rules, trend analysis, and predictability – must be supported.

In future, networked enterprises data and knowledge, including strategic and business data, must be owned by managers and users assigned to designed roles. Knowledge management processes must be simple in order to relieve users of complex searches in vast commonly structured repositories. Autonomous processes for storing and retrieving data, knowledge and entire workspaces, including asset classes and categories, must be developed. These criteria are dependent on implementing the concepts described in chapter 6.

1. Building active knowledge models to support data aggregation and methods,
2. Build active models to manage and present views of data from smart devices,
3. Designing rules and structures for classes of data and knowledge assets,
4. Designing rules and structures for categories based on autonomous working rules,
5. Ease of data and knowledge management, choice of degree of autonomy,
6. Preparing views to support other roles and users, adapted to local workspace context,
7. Preparing knowledge models that collect / distribute data from many roles/devices,
8. Use of novel data and knowledge repositories, powerful workspace viewing,
9. Graphic navigation of contents based on roles and main tasks,
10. Visual navigation in data, information and knowledge landscapes.

7.1.12. Human Resource Management Criteria

Competence and skill patterns have been researched since the turn of the millennium, and should possibly be extended with social and work attitudes. Competence and skill management of roles and personnel will be increasingly important as work forces become globalized and mobilized.

1. Overview of workload versus resource availability,
2. Building competence and skill profiles for roles and individual workers,
3. At-the workplace education and training,
4. Replication of workspaces for rapid competence transfer,
5. Extending C&S profiles with attitudes and behaviors,
6. Views of strategic objectives, project goals, personal ambitions and performance parameters,
7. Recruiting personnel, and mentoring students,
8. Transferring competence to build distributed teams,
9. Training and experimenting to raise competence and improve approaches and methods,
10. At-the-workplace life-long learning.

7.2. Open Platform Capabilities

The main capabilities are decided by the criteria defined by the OCEP perspective, sub-chapter 7.1, and the experiences gathered from modelling as described in chapter 5. To enhance the definition and communication of OCEP capabilities use-case AKAs and SKAs should be built. Use-cases will provide proven knowledge to build operational NECCAF asset repositories.

7.2.1. Generic Capabilities

User adaptable workplaces applying the MBADS agile approach must be cheap and easy to build. Users must be able to include and support new users without changing software, or having to call on expert support.

1. The CKA should be revised to ensure modelling and meta-modelling of new concepts,
2. Agile Approaches to MBADS composition and operational capabilities,
3. Holistic design methods and solutions, should be active knowledge model-driven,
4. Emergent solutions, configured by rules provide a set of alternatives,
5. Graphic language symbol libraries must be developed for sectors,
6. Templates for knowledge structures and diagrammatic views should be sector standards,
7. Modelling and Meta-modelling must be derived from the CKA and be AKA consistent,
8. Powerful viewing, task- and role-specific and common views must be model-generated,
9. Modelling should be based on holistic design concepts and principles,
10. The transition from CKA to AKA is a potential standard workspace across sectors.

7.2.2. Strategic Capabilities

Business and market strategies and operations are mostly known in the heads of managers today. With networked enterprises and NECCAF, supported by OCEPS, role-adapted views of strategies, business value, and performance parameters can be model-based and architecture-driven.

1. Build strategy models, and support strategy modelling, and communication to roles,
2. Build agile business models and perform business alignment throughout networks,
3. Build customer delivery models and models for value-creation and performance management,
4. Support experimentation with ambidextrous strategy and business teams,
5. Develop sector-specific knowledge models, offering agile approaches and emergent solutions,
6. Offering training and experimentation environments for customers and partners,
7. Offering educational programs/seminars, collaborating with educational institutions,
8. Offer test use-cases for potential customers and partners,
9. Initiate regional clusters, to leverage values of open collaborative innovation,
10. Provide services to manage common data, information sources and shared knowledge.

7.2.3. Business Capabilities

Most actors and sources agree that networked enterprises, whatever technology is used, call for new holistic thinking, concepts and business models. However, the ambitions of how to develop and use a business model vary greatly across sectors and sources. With the NECCAF and OCEP the ambition is that business models are active knowledge models as most all other models. The business strategist and manager are potentially both active in planning, governing and managing networked enterprises.

1. Active business model services to assist in business decision and control,
2. Active models as the main business commodity, models of generic approaches and methods,

3. Facilitate regional cluster networks across similar use-cases to invite collaboration and sharing,
4. Support for integrating existing systems and tools, and transforming data sources,
5. Support for modelling customer specific methods and work environments,
6. Services and methods for engaging customer's partners and customers,
7. Offer powerful repository, storing and retrieving workspaces and elements,
8. Methods for characterizing and comparing alternative business solutions,
9. Supporting methods for after sales business, selling life-cycle services,
10. Capture and evaluate business opportunities, short- and long-term values.

7.2.4. Program and Project Capabilities

Public sectors and some industrial sectors have a history of planning and performing programs composed of many complementary projects. In most industrial sectors programs are not known, not even considered.

1. Planning and work environment models, generic models across,
2. Methodology models for planning and follow-up of progress, visual work environments,
3. Methodology models for quality design, and production control and reporting,
4. Support for designing constructive follow up actions and updated plans,
5. Models for supplier involvement, communication and follow up,
6. Communication and collaboration, data- and event-driven instant collaboration,
7. Distributed team-building and collaboration, develop replicable collaborative workspaces,
8. Front-end loading, developing generic sector platforms, architectures and models,
9. MBADS mobile workplaces for project work execution, follow up and reporting,
10. Program and project progress and history management.

7.2.5. Product Capabilities

Product modelling is an area that surprisingly is rather poorly developed and understood, as compared to process modelling. Product modelling and IT support is presently focused on object-oriented structures for engineering design. There is little or no support for ideation, conceptual design and modular design for flexible manufacturing.

1. Support entire product life-cycles, transforming product design, delivery and maintenance,
2. Support for product data and knowledge exchange along life-cycle, enabling open innovation,
3. Support for smart holistic design and operations, collapsing horizontal and vertical sequences,
4. Active knowledge, networked software, and digital components, for bi-modal enhancements,
5. Knowledge models of methodologies, configurable components, and modular manufacturing,
6. Separate modelling of product functions, components and properties,
7. Life-cycle collaboration, sharing, exchange and management of data, common product services,
8. Model viewing to support collaborative design, manufacturing and life-cycle services,
9. Improved collaborative work environments for collaborative design and production.

7.2.6. Organization Capabilities

Capabilities for design and operation of modern enterprise organizations and networked enterprise resource management are relatively new application areas. It is only recently that people have started talking about organizational design.

1. Develop HRM methods and capabilities fitting for sector,
2. Design complementary organizational structures, serving different HRM tasks,
3. Design collaboration spaces, adapting workspaces of roles involved, replaces work process,
4. Adapt models for HRM management and control,
5. Develop Competence & Skill Models for roles and people, consider adding Attitudes,
6. Enable workspace storage and retrieval, for transferring to various work devices,
7. Enable workspace replication, for educational and training purposes,
8. Support user-driven career planning and work assessment methods,
9. Support automatic tracking of employees' locations.

7.2.7. Process Capabilities

The generic criteria are similar to the criteria for the Open Platform. More specific criteria are related to the implementation of the eight paradigm-shifting concepts.

1. Support top-down modelling, activity decompositions, for planning and CTR analysis,
2. Support bottom-up modelling, capturing local pragmatics and contexts,
3. Support modelling inside-out, capturing smart digital devices and human concerns,
4. Support interacting workspaces, to create self-adapting work processes and workplaces,
5. Support situation monitoring, capture device data and present task-specific views,
6. Support self-adapting work processes, adding autonomous control and management services,
7. Monitor conditions and situations, capturing big data and presenting role-specific views,
8. Enable the data, information and knowledge sharing, optional autonomous management,
9. Design visual work environments where HR development and management is aligned.

7.2.8. System Capabilities

IT industry and systems engineering has for the two last decades been dominated by system-of-systems thinking, assuming that the world is composed of systems and humans are system components. Systems should be composed from and linked to generic component sources, where human interaction is predetermined and thus can be implemented entirely without software coding.

1. Systems must be designed in an agile approach and applying adaptive design methods,
2. Support configurable components methodology, hardware, software and knowledge,
3. Support adaptable methods for all from planning to quality control,
4. Support Configurable Components Methodology, prototyped in [8] in 2008,
5. Support Modular Manufacturing Methodology, enabling predictive maintenance,
6. Support authentication and security, role-based authentication and C&S profile security key,
7. Enable model-based integration of remote systems and components,
8. Storing and retrieving core workspaces capabilities, including cloud-based services,

9. Providing legacy client support, guarantee client services to perform over customer life-spans.

7.2.9. Services Capabilities

Services may be divided into three categories: - Business services, User-driven services and Generic IT services. They are designed and composed differently, and managed by different roles. They require separate modelling, execution, and management capabilities.

1. Business services, model-based composition, adapted to customer and operation environment,
2. Business service execution, communicating with receiving customer and involved stakeholders,
3. User-driven model-based composition and delivery of life-cycle support services,
4. User-driven and IT services for data, information and knowledge capture and management,
5. Support event- and situation-driven design and composition of services,
6. Support condition and value-driven execution and monitoring of services,
7. Storing and retrieving core workspaces capabilities,
8. Replicating services design workspaces and methods,
9. Characterizing, managing and recovering categories of services.

7.2.10. Work Environment Capabilities

OCEPs and visual work environments must be designed by applying agile MBADS based on active knowledge architectures. MBADS introduces novel ways of providing tailored computing capabilities and interactive surfaces, and OCEPS extends the capabilities to novel ways of collaboration and management. Creative work environments[7] are discussed and also human capabilities theory[8].

1. Support MBADS design of visual work environments, improve on past MBADS [11, 12]
2. Support OCEPS design of novel methods, to enable execution of new tasks,
3. Support template building for data, information, and knowledge management,
4. Support control with progress and quality, real-time goal and objective views,
5. Support standards for interactive surfaces layout, build models of layout and contents,
6. Capturing issues and experiences relative to plans, tasks and methods, task-patterns,
7. Integrating scientific capabilities, introducing science-driven methods in workspaces,
8. Introducing methods to enhance human capabilities, exploiting human mental models,
9. Introduce novel interaction techniques to facilitate graphic navigation and operations,
10. Enable interactive surfaces on novel mobile devices, facilitating mobile workers.

7.2.11. Data and Knowledge Management Capabilities

To build asset repositories for effective reuse of OCEPs and NECCAFS need to include autonomous processes for storing and retrieving data and knowledge with special services for building and

[7] http://www.sciencedirect.com/science/article/pii/S1048984303001000
[8] http://link.springer.com/article/10.1007/s10551-005-1423-6

managing asset classes and categories. There are few sources on the web that have relevance for OCEPS and AKAs.

1. Building classes of data and knowledge assets, capturing design rules, and user services,
2. Building categories based on common properties and configuration rules,
3. Develop autonomous processes for storage and retrieval of categories of knowledge assets,
4. Develop models for building repository structures for managing data for various purposes,
5. Building methods for storing, retrieving and replicating workspaces, competence transfer,
6. MCADS workplaces, interactive surfaces, for rapid knowledge repository contents viewing,
7. MCADS workplaces , interactive surfaces for authentication and access to contents
8. Find the best repositories servers for the OCEP.

7.2.12. Human Resource Management Capabilities

To be assigned to roles need to include competence and skill management of roles and actors. Actors can be a single human, a group of people, or a mixture of people and digital actors (smart devices and robots). A single person may be responsible for many roles. This is one of the best sources[9].

1. Building competence and skill profiles (C&S profiles), for roles and actors,
2. Build methods to determine gaps and minimum required C&S profile values,
3. Design and adapt the HR Capability Assessment Model, driving users self-assessment,
4. Designing and evaluating various social systems and methods,
5. Design and evaluate adding attitudes and behaviors to C&S profiles,
6. Build repository structures for adding competence and skills within knowledge spaces,
7. Establish capability management practices, and assessment methods,
8. Monitor impact of capability management practices.

These twelve criteria and capability knowledge spaces and dimension will receive updated structures and contents as more use-case projects are performed.

7.3. Sector Specific Criteria and Capabilities

All public and industrial sectors have the majority of core and modelling and execution OCEP capabilities in common, but some sectors have roles and tasks, and environments that pose particular criteria, and require special capabilities.

As stated earlier, performing use-cases to implement OCEPS and NECCAFs will provide much more concrete knowledge models and repository structures and contents to visualize the criteria and capability diversification across sectors. The work should hopefully start in 2015.

7.3.1. Societal and Public Criteria and Capabilities

Public and societal sectors have more diverse criteria as is briefly described below. Here are the most well-known criteria. The most obvious sector-specific criteria are listed below.

[9] http://www.slideshare.net/getsantanupathak/hr-capability-management-revisited

Citizen Services

The most challenging criteria are possibly including national legislation criteria. Another area is finding graphic symbols and deploying visual displays for communicating the messages to citizens and visitors.

Health care

The special criteria here concerns the protection of personal data, but work is planned in [12] to look into how the legislation can be adhered to without interfering with the quality of services to patients and next of kin.

Education

The special criteria here are dependent on the curriculum offered by the institution or school. More and more education must focus of practical work environment training and delivering customer services. This is particularly true for health care and care for elderly.

Transportation

Road and street design is an area where there are possible major benefits to harvest. Roads can be built by applying an OCEPD and developing specific models to facilitate the involvement of local authorities, regional authorities, local industry and business.

EU projects are looking at effective transportation in and around major cities at rush-hours. Here there are great opportunities for smart digital devices and sensors, but the infrastructure and quality displays must be implemented.

National and Local Security

Here the approach should be based on creating the secure citizen that could involve equipping selected citizens with interactive sensors and mobile devices to communicate dangerous or suspicious events and situations to police or other public authorities.

Military Operations

NATO has initiated many interesting projects to better support the Observe- Orient- Design and ACT – the OODA loop, and to improve planning and situation-driven execution of military missions.

7.3.2. Industrial Criteria and Capabilities

The automotive and aerospace industries are facing many of the same challenges and the criteria and capabilities for an OCEP and operational NECCAF. These sectors are characterized by extremely complex products, design, manufacturing and assembly processes.

Manufacturing industries

Increased customization demands adaptive product manufacturing environments, tooling, and work processes. Autonomous monitoring of manufacturing tools and performing maintenance services should be achievable with OCEPs capabilities.

Consulting

Agile approaches, methods adaptation and delivery, and emerging solution design require expert knowledge and competence, experiences from many sectors and differing environments.

Environmental services

Monitoring and controlling environmental impacts on nature, wild life, and climate is becoming the highest priority objective of many governments worldwide.
The will require OCEPs and smart device actors to monitor situations and capture, display and manage big data.

Energy and material

Saving energy and avoiding waste of energy is a major objective for all western industries and manufacturing research programs.

Customer Services

Product life-cycle services and user services is an area of high priority for all industry sectors.

Training and Support

Networked enterprises will need to recruit people that will need quality training to get to the required level of C&S profile values.

8. New Business Solutions and Opportunities

The Networked Enterprise Criteria and Capability Architecting Framework (NECCAF) will be a knowledge base for societies and industries and actors interested and involved in designing and operating future networked enterprises. NECCAF is knowledge about new paradigm-shifting open networked computing, enabling new business approaches and supporting enhanced society, industry, technical and human opportunities.

When implemented as operational Sector-specific Knowledge Architectures (SKAs) NECCAF will complement and gradually replace the present EA frameworks, such as TOGAF [30] and Artemis [31]. Present EA frameworks and customer architectures are used primarily to capture and present knowledge as snapshot views to improve traditional systems implementation and integration. There are no active models, and no support for implementing the most critical capabilities described in sub-chapter 7.2.

The chapter is composed of eight sub-chapters, dealing with major initiatives, impacts and enhancements from new business models to more engaged and committed citizens. These initiatives are mainly driven by business experts following the digital technology, transforming IT, industries, public institutions, and ICT technology. Most of these initiatives will benefit greatly from an OCEP driven by operational NECCAF knowledge architectures.

8.1. New Business models

The present societal and industrial approaches and development methods must be improved as stated in chapter 2, and the needs and challenges described in chapter 3 must be solved. Western industry nations are working hard to develop new business models [27, 28], and exploiting the exploding digital technology, micro- and nanotechnology [29], and revitalizing the IT technology [27]. The Gartner Group CIO Agenda produces monthly reports on how enterprise IT needs to be transformed, and how enterprises are meeting the challenges by creating new management positions, recruiting Digital Enterprise Officers (DEO).

New business models, effective data and knowledge management, and user-driven solutions and innovations are the recognized challenges. These should be met by knowledge architectures, and continuous collaboration and innovation, as the main novel instruments of the needed transformation, as illustrated in the figure below, copied from [27]. There are no mentions of new approaches, modelling methods, active models, knowledge spaces and novel concepts, or using software purely as an enabler.

A rapidly growing crowd of educators, researchers, scientist and users are searching for novel IT approaches, methods, web-platforms and solutions. Most of them understand that present software development practices, principles and concepts represent major hurdles that must be surmounted. However, very few have the required insight into holistic design of networked enterprises, or any of the novel concepts described in chapter 6.

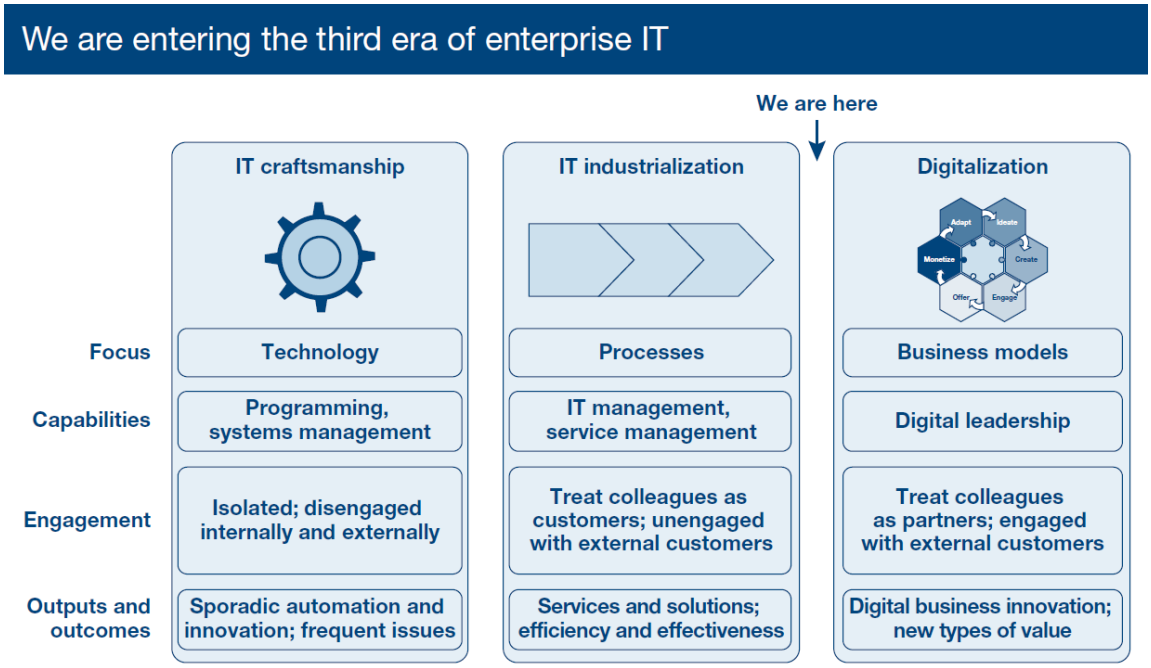

Figure 53 - The world is facing the third era of enterprise IT.

NECCAF and future enterprise knowledge architectures will play a major role in the foreseen transformation of enterprise IT enabled solutions, and give software its new role of becoming a visual modelling and execution enabler. The main objectives of new business models should be: "pay for what you use" and "charge for what you contribute".

8.2. New computing paradigms

Selling licensed application software for enterprise operations and management will be limited to mobile devices. Enterprise business management, design, engineering, manufacturing and life-cycle collaboration will be supported by emergent platforms built by collaborating partners, providing active models, and model-based services – all supported and enabled by generic software components.

Micro- and nanotechnology has propelled the development of new multi-processor hardware architectures, like the COM architecture[10], blending traditional CPUs, GPUs and other special purpose processors [29]. Visual collaborative work environments enabled by OCEPs and operational NECCAFs will give stakeholders and users effective means of performing the tasks of the roles assigned to these smart devices. Smart devices and robots can perform certain tasks faster and safer than can humans, but both will benefit from having their roles and workspaces modelled and shared in active knowledge architectures. NECCAF and active SKAs will accelerate the transformation, and introduce new paradigm-shifting concepts and solutions.

8.3. Autonomous Data and Knowledge Management

Effective Enterprise Data and Knowledge Management is more challenging and time consuming than managers, scientists, and IT experts acknowledge. The complexity of designing and operating

[10] http://msdn.microsoft.com/en-us/library/dn720897(v=vs.85).aspx

emerging collaborative work environments and role-specific workplaces, building and reusing workspaces and categories of classes from past solutions, will be too complex for most partners and human workers to handle. So developing rules and autonomous management processes for knowledge storage, recovery and reuse will be very important. The tasks and rules should therefore be modelled as task-patterns.

Task-patterns, enabling autonomous operations, can easily be linked to tasks in role-specific workspaces, so users and smart devices can easily modify them and manage them. To enable this, knowledge repositories and services must be supported by the OCEP and the repository structures and capabilities must be built by MBADS approaches.

8.4. Supporting Innovation and Learning

Innovation and Learning has been a research theme since the establishment of ISPIM[11] by Professor Knut Holt, NTNU in 1984. ISPIM has since developed some impressive results and conference programs, such as the work "Open services innovation" [32]. European research projects and centers of excellence have made several attempts at implementing prototypes to enhance open innovation and continuous learning, but few significant results have so far been produced.

The ISPIM innovation experts, advisory board, and organizers, have finally come to agreement; the IT development and implementation must change in order for their visions and objectives to be researched and implemented in industry and societies.

8.5. Enhancing Education and Research

New styles of designing networked enterprises and supporting open enterprise platforms must be taught at universities and applied in research projects. OCEPS and operational NECCAFs must be available to support life-long education and training. Knowledge sharing, event- and situation-driven collaboration, and competence transfer can then be implemented and supported.

Universities and research institutions may do this best by collaborating with industrial and societal networked enterprises, and getting access to their knowledge architectures and workspaces. Competence transfer can be performed by replicating digital knowledge models of role-specific workspaces. Digital workspace models can be used to enhance human mental models; creating what some we may call "creating the digital apprentice".

8.6. Enhancing Human Sciences and Services

Present scientific research to advance the methods of many sciences like neuroscience, phenomenology[12] and epistemology[13], and pedagogics and psychiatry, stand to benefit tremendously from problem-specific operational NECCAF knowledge architectures and supporting OCEPs. Visual models and environments for rapid modelling of roles, experimenting tasks, and holistic non-deterministic analyses of behaviors (task-patterns) can be built and analyzed by the roles involved.

[11] http://conference.ispim.org
[12] http://plato.stanford.edu/entries/phenomenology/
[13] http://plato.stanford.edu/entries/phenomenology/

Phenomenology will find new ways of representing and sharing event- and situation-driven knowledge. Epistemology may discover new sources and move the limits of knowledge existence.

Pedagogics, psychology and psychiatry in particular are in need of workspace or event-space visual modelling and analyses by instant collaboration. This would support studying and analyzing human behavior, feelings and reactions to unexpected events and situations. The services offered by healthcare can be drastically improved, as will be proven in proposed EU projects [12].

8.7. The Engaged Citizen

One of the major challenges nowadays is to provide up to date and quality data, information and knowledge to citizens, and to engage them in contributing to model, monitor, and even control or prevent local situations.

NATO started its MAJIIC[14] project in 2005. One of its ambitious goals is to enable NATO forces to involve local competence, citizens and smart devices without risks of failures or technical difficulties. Another example is the research projects performed in Oxford UK[15] by the Oxford Research Group. One project was to minimize criminal street activities, all from violence to illegal trading, where elders were equipped with tools to monitor street activities after dark. This reduced criminal activity significantly. Over 12 months the criminal activity and police cases were reduced by 80%.

8.8. Reindustrialization of Western Societies

The EU has started a major initiative to enhance the European manufacturing industries [33]. Several initiatives are started, spanning from political strategies to basic research and education. One of the major initiatives is the announcement of a research program for new EU R&D infrastructures. This is a golden opportunity for NTNU and partners to realizing OCEP prototypes [12], and operational NECCAF Sector-specific Knowledge Architectures in selected sectors.

[14] http://www.defenseindustrydaily.com/Shared-ISR-More-MAJIC-for-NATO-06812/
[15] http://www.oxfordresearchgroup.org.uk/rcac

9. Discussions and conclusions

AKM technology is not easy to grasp and understand based on pure textual description with snapshot figures. To ease the understanding more work should be performed on the transformation from traditional IT application systems development to MBADS, NECCAF (Networked Enterprise Criteria and Capability Architecting Framework) and OCEPs enabled solutions.

It is believed that creating a use-case enabled OCEP demonstrator, building an operational NECCAF, is an activity that should be modelled. That is, first, building a core OCEP with the capabilities described, and then enhancing it by co-designing use-case and NECCAF extensions. It would be necessary to perform the modelling in one or more sector-specific use-cases, applying agile MBADS approaches, and working on emerging solutions. This is crucial as it is the use-case knowledge spaces and workspaces that are the drivers for designing and implementing the operational solutions.

This would enable users to run practical demonstrations of all four knowledge dimensions, the design steps, and how the solutions in all dimensions are interdependent of each other. These interdependencies rely on the design and operational criteria of sector-specific networked enterprises. These demonstrators would ease the communication of the AKM technology, the agile MBADS approach, NECCAF, and the practical solutions, and prove the high potential benefits.

There are five clear trends in international ICT:

- Cloud computing is taking over more and more of the services market and reducing the application license sales
- Big data, representing opportunities for common cross-border services
- Information management using social media is being promoted
- Mobile computing, enabling people freedom from local networked PCs
- Multi-processor hardware architectures with CPUs, GPUs and Smart to enhance networked capabilities.

Other trends are:

- Model-Based Systems Engineering (MBSE) is catching momentum
- Open innovation and learning, open big data, and open common platforms
- Knowledge modelling, sharing and management
- Mobile computing and generic applications
- Building open platforms, where open means what is described.

AKM also recommends certain novel concepts and innovations, such as workspaces, enterprise knowledge spaces and holistic design methods, to be adopted to get maximum value and benefits from team collaboration and the networking efforts [7, 8, 9 and 11].

This work shows that the current Enterprise Architecture Frameworks must be redesigned to produce living knowledge. The future networked enterprise will be driven by the recognition of novel paradigm-shifting concepts, exploring human mental models and exploiting modern digital technology.

NECCAF will be a knowledge base for societies and industries and institutions interested in and involved in designing and operating future networked enterprises. NECCAF is knowledge about new paradigm-shifting open networked computing, enabling new business approaches and supporting enhanced society, industry, technical and human opportunities.

When implemented as operational Sector-specific Knowledge Architectures (SKAs) NECCAF will complement and gradually replace the present EA frameworks, such as TOGAF [30] and Artemis [31], and create a future of knowledge architecture driven industries and societies. Present EA frameworks and customer architectures are used primarily to capture and present knowledge as snapshot views to improve traditional systems development, implementation and integration.

Operational NECCAFs will take Enterprise Modelling way beyond state-of-the-art as described in chapter 4. An OCEP, designed according to these concepts and needs, will also realize the solutions prototyped, described in chapter 3, and it could revolutionize public and industrial knowledge management and computing. The digitalization wave could transfer and enhance human competence and skills, and improve global project collaboration in most sectors.

Adding living knowledge architectures and visual work environments to old and new sciences could bring sciences forward, and enable them to innovate and learn from another.

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