Holistic Design of Visual Collaboration Arenas and Intelligent Workspaces

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Abstract. Future industrial and societal projects must be designed for sustainable operations, evolutionary capabilities, and business operations. To exploit the potential of digitalization, we must design practical cases and roles, workspaces and collaboration spaces, creating evolutionary action- and work-sensitive contexts. Intelligent workspaces and operation models will complement, enhance, and replace natural language specifications, coded systems and information flows. Design of visual knowledge models, enabled by Active Knowledge Architectures, will revolutionize industrial computing and collaboration. The MADONE partners have performed industrial and public pilot projects verifying that sector adaptable platforms give actors agile approaches and evolving collaboration capabilities and services. Evolutionary workplaces and collaboration spaces resolve present challenges and open new opportunities, supporting flexibility, adaptability, reusability, traceability, predictability and sustainability. Holistic design of projects and operations is the industry case demonstrator described.

Keywords: *Holistic Design, Agile Approaches, Intelligent Workspaces, Visual Collaboration Arenas, Sustainable Operations and Practice-driven Innovation.*

1 Present Use of ICT

Most projects, system developers and consultants, architects and users, are still supported by domain-specific layered approaches and paper-based methods and disjoint work environments. Each layer is divided in discipline-dominated stages connected by gateways, and supported by linked application systems. Instant collaboration, dynamic viewing, data analyses, knowledge sharing and reuse, and competence transfer among stakeholders, users and suppliers is limited, if not altogether prohibited. Agile design approaches to visual enterprise arenas and workplace design, responding to growing variety, emergence and complexity of markets and companies are being researched [1], but holistic design of reusable knowledge-driven solutions are so far ignored. There are still political and commercial barriers preventing new styles of computing, transforming coded applications and workplaces to dynamic model-based, architecture-driven workplaces and visual work environments.

Most industries and public sectors are involved in innovation projects developing Cyber-Physical Systems (CPS) [2, 3, 4]. CPSs are a result of progress in sensor technology and digital technologies, but does not enable cyclic design. CPS presents a new level of prescribed intelligence that is characterized by interaction and collaboration of computing and physical processes, as well as structured human machine interaction.

Future computing will be composed of these components: hardware, software, smart digital devices, and Active Knowledge Models (AKMs). Categories of AKMs support cyclic design and execution of Visual Collaboration Arenas (VCAs), evolutionary platforms and intelligent workspaces, and will enable autonomous data, knowledge and work management. The Active Knowledge Modelling (AKM) technology [5] enables disruptive new approaches, so existing ICT business, research and education will be transformed. Collaboration across teams of users, designers, suppliers, and digital actors implies that they own and manage their workspace data and tasks, discipline parameters and design and engineering rules.

2 Design and Innovation of Visual Collaboration Arenas

Dynamic CPS design and operation will enable new applications in numerous public domains, like eHealth, where new solutions will enhance healthcare practices and services. Dynamic CPS design will also have beneficial impacts in industrial domains, such as Factories of the Future (FoF), where business models may be influenced by data from the sensing devices of a CPS. However, in most sectors there are life-cycle challenges and needs, such as innovating new approaches and practical methods for design and operation of new products and processes. This practice-driven innovation and learning and cyclic design and execution is not supported by CPS systems.

The discovery of human mental models [6] created in our brain when performing or observing practical work and events enable humans to capture practical work-sensitive knowledge and build new services [7]. AKM partners [8, 9] have invented an at-the-workplace modelling approach enabling workers to express their tacit knowledge and design mental models as digital models as work is being performed.

2.1 Implementing Visual Collaboration Arenas

VCAs are supported by Model-based, Architecture-driven (MBAD) project platforms and workplaces, and are built by these collaborating teams:

- A user-team composed of users, engineering and supplier experts, and use-case experts is responsible for customer solutions, capabilities and values.
- A knowledge modelling team composed of people with competence in holistic design methods and principles, and in building knowledge products, Active Knowledge Models (AKMs) and Active Knowledge Architectures (AKAs).

- An Evolutionary Project Platform (EPP) team with competence in using the core EPP &VCP tools, reusing knowledge models, and extending the contents, methods and capabilities, managed in the Project Knowledge Repository.

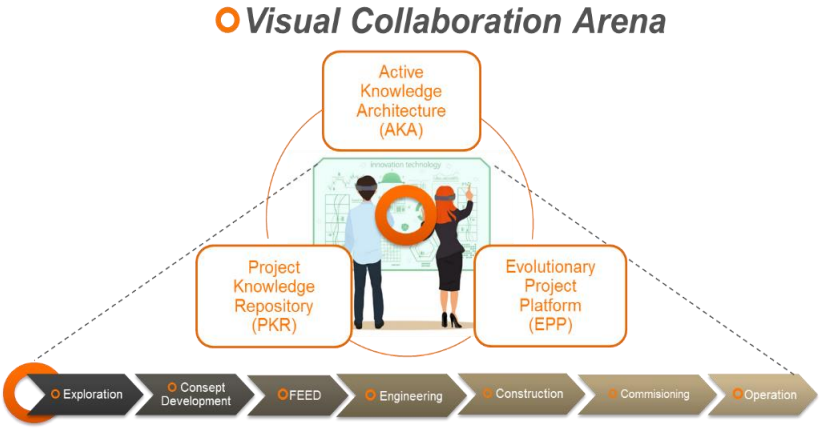

Fig. 1 New approaches and methods for project VCA design and operation.

Reference project and sector-solution AKAs will be built to ease front-end loading, supporting cyclic design and execution, and kick-starting new projects cutting calendar times and costs by factors. Fig. 1 illustrates the transformation of project design and execution enabled by VCAs. One key characteristic of the new agile approach is user-enabled visual modeling rather than prescribed coding to capture work-sensitive context. A second key characteristic is: supporting categories of users in capturing and sharing situations, decisions, dependencies, and local pragmatic knowledge spaces by modelling role-oriented workspaces. To implement these characteristics software will be applied as an enabler for workspace and knowledge modelling of AKA and MBAD workplaces, supporting enhanced communication, collaboration, configurations and competence transfer. The AKM approach [8, 9] and holistic design methods will have revolutionary impacts on business models, project methodologies, organizations, products and processes, knowledge management and reuse, and ICT development across industries and public domains.

2.2 The Industrial Pilot

Building on the insight from many Oil & Gas fields and exploration projects a holistic design approach [9] to field development and operations is conceived and tested. This pilot will combine the insights from the Woodside[1] project with state of the art knowledge capture and modelling, and create a practical demonstrator that validates holistic design methods and enhanced life-cycle collaboration and interaction.

[1] http://www.woodside.com.au/Pages/home.aspx

The Woodside project (SPE MS176813) has documented that the Capex can be reduced by 10-35%, and the Opex by 30-80%, and reliability increased from 95 to 97+ % by adopting low-manned/unmanned remotely operated facilities [10]. The prerequisite for such success is that the operations philosophy and model is defined upfront in the concept phase, acknowledging that the operations model is a design driver, not as it is today, where the facility design drives the operations model. The operations model with facilities and resources and product design models support the stated mission, as illustrated in Fig. 2. The architecture of the pilot consists of role and task specific collaboration spaces that support the early phases (Concept & FEED) of a project that delivers an operations model and product design supporting the stated mission. The mission statement should be articulated on the form; a minimal manned, remotely operated installation that is profitable at a price point of $25/bbl.

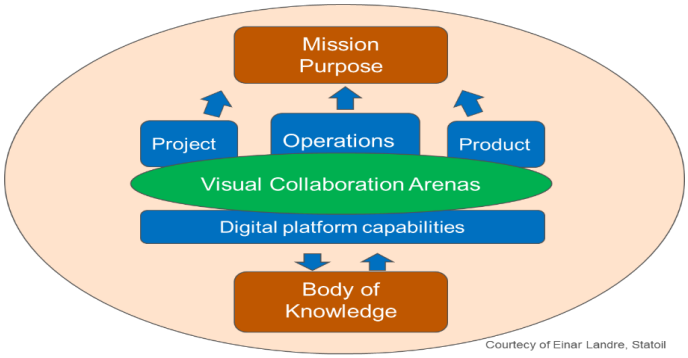

Fig. 2 Capabilities and knowledge models for designing Visual Collaboration Arenas.

Our approach is to combine the insights from the Woodside project with state of the art knowledge capture and modelling, and to create a technical demonstrator that validates new holistic design methods for projects, products and work environments.

3 Towards Holistic Project Design and Operations

The people responsible for designing projects and enterprises and operations must apply holistic thinking and adapt and implement the VCA concepts and AKM methods [9]. Holistic design of projects, products, organizations and processes implies modelling top-down to support resources and time, bottom-up to capture work-sensitive data and workspaces, and inside-out to balance discipline parameters across life-cycles and value-chains. Supporting holistic design requires fine-grained knowledge modelling of workspaces and collaboration spaces, and support for conceptual design based on active knowledge models of life-cycle operations and customer values.

Active knowledge models and architecture elements will be major assets in the growing Circular Knowledge Economy and the Digital Single Market [11,12].

3.1 The Evolution of Design Methods

Design methods have been a major domain for research and development, since the early 1980's when Beitz & Roth extended product design to embrace manufacturing, and Hubka introduced the principles of design embodiment to separate conceptual design properties and the balancing of discipline parameters and their tolerable values. Design embodiment implies that properties and parameters are modelled separately, and parameters are balanced across disciplines before they are embedded in objects.

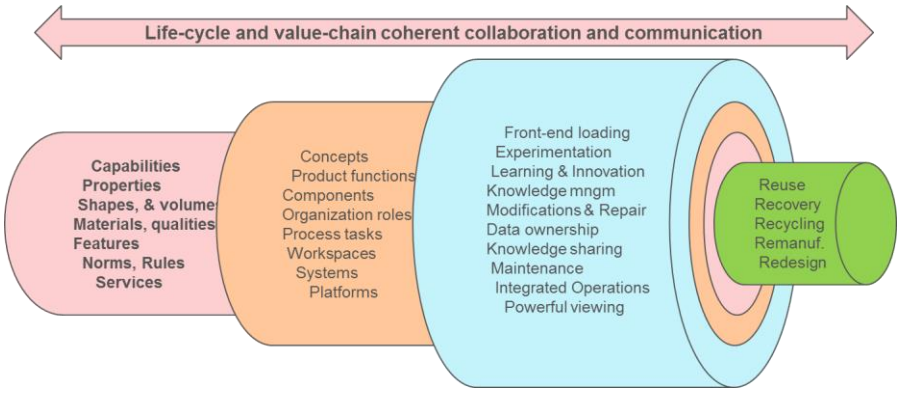

Fig. 3 Evolutionary VCA design of industrial meta-knowledge concepts.

The Holistic Design methods must be implemented, adapted and validated in industrial pilot projects. The core knowledge domains, the design meta-knowledge, as illustrated in Fig. 3 are composed of concepts, capabilities, properties, qualities, shapes and volumes, features, eco-norms and rules, and extensive life-cycle services.

4 Novel Paradigm-shifting Concepts

There are several paradigm-shifting concepts supporting the design and operation of VCAs, designing life-cycle workspaces, agile workplace approaches, and emergent methods, platforms and solutions meeting growing market needs and opportunities. The most important concepts enabling emerging approaches and solutions supporting concurrent project design and sustainable operations are:

1. *Enterprise Knowledge Spaces - multi-dimensional knowledge spaces emergent models, collaboration, and data and knowledge management.*
2. *Context-rich Workspaces – enable simultaneous workplace design and execution.*
3. *Sector-specific Knowledge Architecture - integrating operations and new methods.*
4. *Model-based Architecture-driven Collaboration (MBAD) - configuring agile solutions and enhancing collaboration.*

5. Contributions to Sustainability - Concurrent Modelling and Operation, enabling life-cycle design and execution.
The major concepts, their properties, enabling capabilities and business impacts are illustrated in Fig. 4, and will be explained in the following sub-sections.
Multi-dimensional enterprise knowledge spaces, smart role-oriented organizations, workspace properties, AKA modelling, and the AKM methodologies and principles are explained in more detail in the entries of the AKM blog [1].

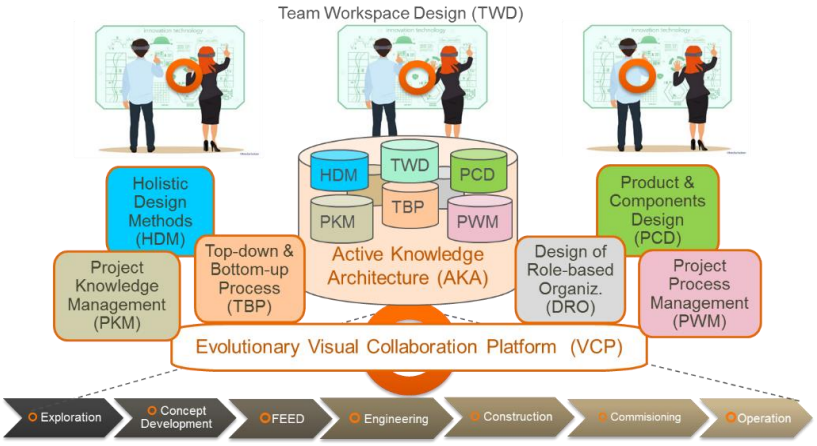

Fig. 4 Emergent networked enterprises – enabling life-cycle design and operation.

4.1 Enterprise Knowledge Spaces

Enterprise Knowledge is created in multiple dimensions by the people involved in the various enterprise activities and domains [7]. The nature of practical knowledge spaces and workspaces must be understood by applying visual design modeling to capture work-centric knowledge and context. Enterprise knowledge spaces span the individual workspaces, the organizational space of product design and development, the organizational network space of collaborating entities and further to the societal space where an organization and its work are affected by the environment they operate in and the social norms and legislation. Knowledge, data and experience sharing must be facilitated, and knowledge assets management and reuse will be decisive services for future competitiveness and progress.

4.2 Context-rich Workspaces

Existing organizations, composed of hierarchies, static networks and collaborating teams require innovative design to fit the design, production and life-cycle support of projects, products and operations. The people assigned to roles must be supported by reusable MBAD agile workplaces, allowing them to perform at-the-workplace design, modelling and task execution, closing the gaps between project stages. Visual

modelling of work-sensitive data and contexts enable capture of tacit knowledge in digital models, which could enhance their mental models for enhanced local work execution, coordination, collaboration and work management [8].

4.3 Sector-specific Knowledge Architectures

Active Knowledge Architectures (AKAs) are composed by collaborating teams, agile approaches, novel design principles, and active models of knowledge spaces and role-oriented workspaces. Visual modelling and holistic design methods enable new approaches to workplace and solution design, whatever the sector and application. The present EA frameworks must be extended by AKM methods to support sector-specific holistic design of AKA models and MBAD workplaces and solutions. A Core Knowledge Architecture (CKA) can be reused in all knowledge architectures of projects in any sector. By graphic modelling of knowledge spaces, using the IRTV language [9], design and operation of project- specific AKAs is supported.

4.4 Model-based, Architecture-driven Collaboration

Collaborative open innovation and learning, and continuous design and operation of emergent networked solutions is enabled. Agility and emergence are achieved by building MBAD workplaces and collaboration spaces, providing capabilities for autonomous sharing of views and for extending and modifying AKMs and AKAs.

Design modelling of conceptual objects, capabilities, features and properties is supported, and discipline parameters, values and goals are balanced to support design embodiment and creation of design, configuration and collaboration rules. Decision-support, predictability, traceability and assessment of trends will provide users enhanced capabilities to deal with uncertainties and assess risks. Change management is minimized by product family variants and comparable alternatives.

4.5 Contributions to Sustainability

The model-based, architecture-driven approach is ideal for what is described as the reindustrialization of industry and enhanced international collaboration.

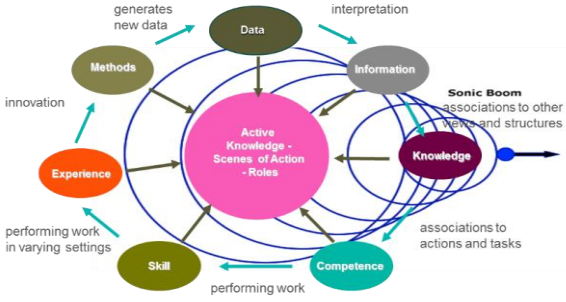

Fig. 5 Knowledge concepts, classes and categories will be built, managed and reused.

As illustrated in Fig. 5, common approaches for industrial and public enterprises can be composed by architecting teams applying fine-grained modelling methods. Adding designer and user teams, modelling to cover structures and aspects of product, organization, process and system, enables and is enabled by the design of sector-specific knowledge models and architectures.

5 Conclusions

To meet the rapidly growing challenges and opportunities industry and public sector are facing [11,12], there is an urgent need for new ways of building and applying computing power. The AKM technology enables the implementation of new concepts, capabilities and properties required to provide new, agile approaches, adaptive methods, and visual work environments. Future research, innovation and experimentation, must focus on developing and providing sector-specific and life-cycle agile approaches, holistic design methods, knowledge architectures and open modelling and computing platforms. Active knowledge models of approaches, methods, solutions and operations will be normalised and managed for reuse in private and public sector knowledge bases.

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