BUILDING AUGMENTED KNOWLEDGE ARCHITECTURES: REQUIREMENTS FOR COLLABORATION PLATFORMS OF NEXT- GEN CONCEPT ORGANIZATION TOOLS

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Abstract

Computer enhanced technology gives us access to collective knowledge that needs to be contextualized, personalized, and reorganized. This is a major task for next generation learners and knowledge workers for whom searching, gathering, digesting, producing, and presenting information makes sense in personal problem solving contexts. Personal ways of knowledge acquisition and its cooperatively manageable organization represent meta-information concerning the problem situation that determines the conceptual structure of the problem space. Representation of the search for information and its conceptual organization provide keys to problem definition and consequently to its solution. We reconsider concept organization and visual knowledge representation tools that augment human problem solving. By “augmented knowledge architectures” we refer to Douglas C. Engelbart’s (1962) conceptual framework for augmenting human intellect. Reconsidering his vision we argue, that in order to realize the potential of human-computer interactions for building augmented knowledge architectures we need to develop platforms for cooperative problem solvers along the lines of a ‘Wikipedia of Concepts’. Analyzing next generation techniques such as Google’s Knowledge Graph and existing relational representations and visualizations of knowledge structures we make explicit proactive requirements for next generation platforms, called “Conceptipedia”, in the spirit of Engelbart’s original approach.

Conceptipedia is constituted as a graph of ‘Things’ that enables us to define relations between concepts within a meta-knowledge graph. Whereas Wikipedia is a web of hyper-linked pages, Conceptipedia is a hyper-wiki that can also be modeled as an ontology for defining aspects and new relationships between concepts and things via navigable hyper-links. It is a collaboration platform for building Knowledge Graphs by researching, exploring, capturing, articulating, mapping and visualizing concepts and their various relationships. We illustrate the advantages of such a platform with the use cases of the already existing personal knowledge organization tool: WikiNizer, a Wiki like orgaNizer of one’s Personal Knowledge Repository. We demonstrate that satisfying the proactive requirements it can also be used as a tool for visualizing the development of problem specific conceptual relations of the creative mind and one’s related web research.

Keywords: knowledge management, knowledge architecture, e-content, knowledge graph, Wiki, WikiNizer, Conceptipedia, ontology of relations, Semantic Meta Design, hyper graph, augmentation.

1 INTRODUCTION

Collaborative Networked Learning is usually considered as a new knowledge building paradigm made possible by such social knowledge management tools as wikis, or Knowledge Plaza. Wikis proved themselves as knowledge building interfaces of personal and collaborative learning [1,2,3], as valuable instruments of collaborative writing [4,5], and other knowledge building processes [6,7,8]. Knowledge Plaza also utilizes Micro-wikis while Diigo, for example, already combines group based collaborative research with personal learning networks supporting cloud based information management. We encounter new special purpose mobile applications for personal knowledge management every day while collaborative knowledge management steps over the educational contexts of knowledge creation within the learning organization. [9]

Even though new software (SaaS) and platforms (PaaS) as a service fall from the cloud we argue that they do not came out of the blue. What is rather surprising is that computer-supported collaborative learning and work (CSCL/W) seems to face crucial knowledge representation problems of augmenting human intellect only today, half a century later than they were raised in Douglas C. Engelbart’s 1962

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Conceptual Framework [10]. It will be instructive to reconsider some of these problems before analyzing and setting up requirements for collaboration platforms of next generation concept organization tools.

2 KNOWLEDGE REPRESENTATION PROBLEMS OF THE AUGMENTED INTELLECT

The term "Augmented Knowledge" emerges in Engelbart's Conceptual Framework [10] as a groupware oriented conception for augmenting cognitive structures by interactive computer environments and networks. [11] For him human–machine interaction is an essentially problem oriented activity: "By »augmenting human intellect« we mean increasing the capability of a man to approach a complex problem situation, to gain comprehension to suit his particular needs, and to derive solutions to problems." [10] The purpose of augmentation is to help cope with *problems*, moreover, *complex* problems that are difficult to gasp: "We do not speak of isolated clever tricks that help in particular situations. We refer to a way of life in an integrated domain where hunches, jumping to cut-and-dried conclusions, intangibles, and the human »feel for a situation« usefully co-exist with powerful concepts, streamlined terminology and notation, sophisticated methods, and high-powered electronic aids." [10]

The "integrated domain" that Engelbart is calling for, the habitat where human problem solving co-exists with computer support and the problem solvers' new "way of life" is "an open foundational, cross-cutting *knowledge architecture*, endowed with certain key features – *still largely missing* from today's information technology paradigm – that can dramatically improve how people can work together to solve important problems." [12, (italics ours)]

The term *knowledge architecture* rings the bell "information architecture", a term coined by Richard S. Wurman who as a student of Louis Kahn extended ideas of the structuralist movement in architecture to representations of information and user experience design. [13] For Wurman the design of information architectures starts with the *conceptualization* of the problem in a pragmatically given problem situation from the point of view of the user of information. The information available in the given situation has to be organized in order to give it a particular form that is conceived anticipating its use. For him developing abstract representations of information consists of shaping and designing its users' experience. [14]

Similarly, for Engelbart concepts have to be created by mental acts, components of the problems have to be formed out of data, a task that is hard to cope with in case of complex problems. The role of computer support is generic: it must help to fashion notions and their relations, aggregates of relevant information not only in the mind, but in an inter-subjective environment where problem solvers can work together to develop meaningful representations in order to structure the problem. Designing a solution is not simply a mapping from the context of a problem to the constructs of the lexicon of a programming language. Problem solving consist of inventing a context dependent habitat for the problem, where its representation exists independently of individual minds in a dynamic computational environment that itself can be collectively further developed via bootstrapping methods [15] to accelerate its solution.

Introducing the concept of *knowledge architecture* into CSCL/W we suggest abstracting the activity of the information architect in Wurman's and Engelbart's spirit in order to design a computer supported representation process of *concept organization* in a collective problem solving environment.

2.1 Information Architectures versus Knowledge Architectures

2.1.1 Information architectures

Wurman who coined the phrase "Information architect [L infotectus] n." described the new profession blending computer scientist into architects as "(1) the individual who organizes patterns inherent in data, making *the complex* clear, (2) a person who creates the structure or map of information which allows others to find their personal paths to knowledge, (3) the emerging 21st century professional occupation addressing the needs of the age focused upon clarity, human understanding and the science of the organization of information." [14] Wurman's information architectures are abstract representations of use-specific information that are semantically interpretable in themselves within a given problem situation, such are his well known inventions of metro maps and ACCESS guides:

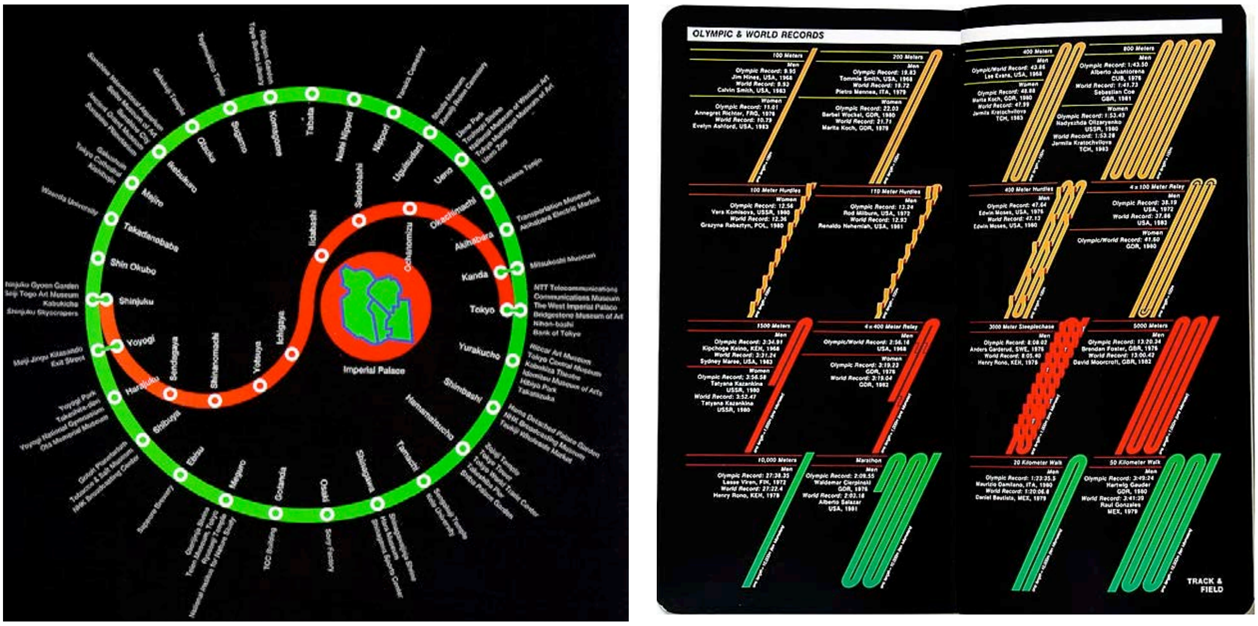

Figure1-2. Examples of Wurman's Information Architectures: 1. Tokyo Subway map; 2. Double page spread on Olympic and World Records, from Olympic Access [16].

These graphic architectures represent information visually so that it can be perceived at a glance often without verbalization or without conscious thought. As opposed to visual representation a text has a primer (not necessarily, but usually) serial structure, that is utilized in well written stories that play with the information that is made accessible via the text: the story depends on what information is presented (and how) in the linear order. It also imposes however meta-structures that consist of aspects, and relations of elements of the story, places, roles, common, or permanent properties, simultaneous and parallel events, etc., that can be analysed and presented in alternative structured ways. These meta-structures that supervene on the primer information can serve different purposes and reveal patterns and potential extensions of the original structure. An information architect discovers and exploits these meta-structures and uses them for the organization of information for specific purposes. Rosenfeld and Morville in their famous "polar bear" book on *Information Architecture for the World Wide Web* [17], spell out that organization systems are composed of *organization schemes* and *organization structures*. "An organization scheme defines the shared characteristics of content items and influences the logical grouping of those items" whereas, its organization structure "defines the types of relationships between content items and groups." There is a long standing debate between information architects and their next generation, user experience designers, what information design is all about: its main task is to (re)present content, or shape configure it for its users needs. Soergel slices the Gordian Knot. He points out that the issue "really **is** all about meaning: Meaning is where content and user meet. It is the job of the information architect to discern the internal structure of content and then give it external form *to support users in constructing meaning, in relating the content to their own knowledge, needs, and purposes, and thus making sense of the content.* This is exactly parallel to the job of the building architect, which is to discern the functions and intentions of a building's users and then give external form to these intentions and support the users' functions." [18]

In the context of learning and in the broad context of Knowledge Management (KM), we use the distinctive term *Knowledge Architecture* (KA) for all information organization structures (structures carrying semantic information) that lend themselves for design and representation in an *interoperable*, machine independent, *human interpretable* form. KAs always apply organization schemes. Their structure, however, can be spelled out and represented too, as long as their final items are semantically interpretable, that is, consist of semantic information. These schemes can be explicit or implicit, the (actual) interpreters may, or may not be aware of their internal structure but it is crucially important whether we provide tools to represent their structure — usually, but not necessarily, at a different level. For a user experience designer the critical task is to express, or to suppress these 'internal' structures depending on the intended use of the IA. For a learner or a knowledge worker, however, 'first thing first', it is to explore them: the cognitive activity consists of discovering, or even inventing the semantic or conceptual structures themselves not only at the object level but as need arises at meta-levels. The need for changing meta-level structures can be illustrated by the introduction of analytic geometry into conceptualizations of geometry that brings about changes in both the lexicon and ontological structure of the domain.

The abstract structure of a KA is different from sets or modules of so-called 'units of learning', the sequences of learning objects (LOs) and their actual presentation in the form of a textbook, or a multimedia supported e-learning lesson for example. KAs are representations of the conceptual structures of these items on all levels of semantic granularity. In an abstract sense the conceptual structures of a book or a video presentation, or a web page could be considered as KAs as long as they integrally contain the information required for their interpretation in an organized form. The presention of learning objects can rather be considered as an IA: an exhibition of certain relations of the KA for a specific use. In this sense Wurman's Tokyo metro map, or other graphical representations and mind mapping techniques can be seen as applicable common patterns, or organization schemes that emphasize the meaning that is generated for/by the user as the suggested interpretation of the graphical representation. KAs should also be distinguished from the architecture (partly of IT connotation) of the learning/knowledge management environment serving knowledge transfer (KT) in an online network or groupware, a subject of design itself, consisting of elements, functions, interfaces for plannable activities, which establish contact between structural elements of the KAs, and their users. For Engelbart the knowledge architecture (especially that of the environment of 'Augment', his oNline System) includes these functions, and networking channels as well. We suggest making a distinction in this respect, and calling the configuration of the environment "knowledge transfer architecture" since they serve interaction and communication.

2.1.2 Visual Knowledge Representation and Graph Based Concept Organization

Knowledge Visualization (KV) is considered as an emerging new field of interdisciplinary research even though concept maps belong to the well worn toolkit of Artificial Intelligence and Natural Language Processing. [19] Keeping an eye on knowledge management Burkhard recently suggested a distinction between KV and information visualization (IV). "Information visualization aims to explore large amounts of abstract (often numeric) data to derive new insights or simply make the stored data more accessible. Knowledge visualization, in contrast, aims to improve the transfer and creation of knowledge among people by giving them richer means of expressing what they know. [20]

The role of visual mental representations in inventive problem solving and in the creation of knowledge, that is the emergence of *previously non-existent knowledge* as a result of visualizing our conceptualisation seems somewhat to fall between the chairs. Mental visual knowledge representation is behind both KV and IV. We go along with Charles S. Pierce's arguments in favour of visual thinking and pictorial representation that are with us for over more than a century. [21]

Organization and reorganization of semantic information is the essence of creation of new meanings, a process that is to be supported by computational tools, especially in case of complex problems. The key insight in this respect is that representation, especially visual representation of the organization of our knowledge is *knowledge* itself. As Pierce already pointed out visual representation has the advantage that (contrasted with linguistic syntax) it is able to represent information in a form that reflects the structures inherent in our objects of knowledge. The importance of visualization for scientific research, creative thinking and learning is widely recognized in the educational context for this reason. It is important, however, to add to Peirce's point that we are also able to represent structures of information visually which are not analogous with actually visible (or existing) structures of the subject of study (such as the jin-jang form of Wurman's Tokyo metro map, for example). We can exploit the visual capacity of mind and machine to impose structures on information or transpose them from other fields in order to make it more transparent or suitable for certain use in problem solving. This is also the main motivation behind Engelbart's program of augmenting human intellect: "If my mental processes were more powerful, I could dispense with the cards, and hold all of the card-sized concept structures in my memory, where also would be held the categorization linkages that evolved as I worked (with my feet up on the artifacts and my eyes closed). As it is, and as it probably always will be no matter how we develop or train our mental capabilities, I want to work in problem areas where the number and interrelationship complexity of the individual factors involved are too much for me to hold and manipulate within my mind. So, my mind develops conscious sets of concepts, or recognizes and selects them from what it perceives in the work of others, and it directs the organization of an external symbol structure in which can be held and portrayed to the mind those concepts I cannot (reliably) remember or whose manipulations I cannot visualize. The price I pay for this augmentation shows up in the time and energy involved in manipulating artefacts to manipulate symbols to give me this artificial memory and visualization of concepts and their manipulation." [22]

Various schemata and techniques for visualizing ideas, processes, concept organizations are used in learning contexts: mind mapping, radial hierarchies, tree structures, etc. [23] Conceptual Graphs (CG) and various extended graph representations along the lines of Peirce's existential graphs have been designed for logic of semantic networks and knowledge representation [24] Joseph Novak's technique of concept mapping is just one graph based approach, but is more flexible than Mind Mapping [25] or Topic Maps [26]: it does not fix on a single conceptual vocabulary and lends itself for abstraction and clustering. Topic Maps have the advantage, especially for semantic web technology, that they are standardized to ensure interoperability (between W3C's RDF, OWL or visual languages, like SPARQL) but standardization has a price: it makes representations static and hard to extend.[27]

As most semantic structure can be mapped to various types of graphs, e.g., trees, hypergraphs, etc., it is not surprising that graph and tree visualizations of all kinds are getting widely adopted, especially because they are also behind the efforts of W3C's ontological representations. [28] Graph knowledge bases [*Neo4J*, for example] provide more powerful data archiving tools for visual knowledge representation than classic relational databases. Many 2 dimensional, but also 3D visualizations came out in the last few years and knowledge representation in general is becoming more visual. If we are interested in the KAs of different domains (at all possible levels of conceptual resolution) we have to look for semantic representations that address the problem of concept organization the most universal and versatile way possible. Graph based concept organization has the advantage of integrating expressive power and the didactic advantages of visualization. Building Augmented Knowledge Architectures (AKA) enhancing human capabilities to support complex problem solving as Engelbert dreamed about call for open KT environments that have personal knowledge management tools for visual concept organization.

2.1.3 Personal Knowledge Management as Semantic Wiki-like knowledge organization

A Personal Wiki is a wiki maintained primarily for personal use. Personal wikis allow people to organize information on their desktop or mobile computing devices in a manner similar to community wikis, but without the need for collaboration by multiple users. The attraction of Wiki as a model of personal knowledge organization is rooted at the very concept of a Wiki. To paraphrase the point Cunningham made in a talk [29], Wiki is the tool that enables you to work at the edge of the information you are collecting – what you need to know. When we bump up to the part that has not been written, or maybe has not even been discovered yet, we have the option of creating a sub page that shows up connected to the existing body of our Personal Knowledge. These connections are always established automatically spanning a hierarchy or outline. Additionally, they can be set up as wiki-like hyperlinks forming a non-linear web of links, creating your own Knowledge Graph. We use the term here in the abstract semantic sense of 'Generalized Knowledge Graph', not as a reference to Google's Knowledge Graph application that is under development (see below). [30]

In a semantic-Wiki based personal knowledge management environment one can "Go Meta", using the term introduced by Simony for his favorite gambit for representing problems at a meta-level [31]. Such an approach is very much in tune with Engelbar's vision to augment human intelligence with the computer supported ability to

- use semantic information on graph nodes (i.e., pages, hyperlinks, etc.) as in a Semantic Wiki
- turn any page one creates with some intention into an entity that can be related to other entities,
- collaborate in terms of evolving ontologies, or any other meta properties at a meta level ("Going Meta"),
- have full control at a meta level, to elaborate your personal domain specific ontology, taxonomy, tags and any other aspects of your items that you find in a given context relevant
- define arbitrary relationships that you find relevant define whole Page/Type hierarchies, and containment schemes,
- to specify domain specific inference schemes, graph traversal schemes, and rules at the meta level that can be used, as a minimum, to give quick access to related things, with additional information about what those relations are.

These relationships between your typed nodes form a graph equipped with appropriate meta-structures for using them to visualize, publish, present and manipulate your entities as graph nodes for any purpose that you see fit. As a result one can have full control over explicating what any node "means" for the user.

If the knowledge worker does this in a given domain of personal interest, and remains faithful to what she “means” (the intention that she had in mind when she created the page, in the first place) eventually she can arrive at a rich explication of the very concept that is the focus of her interest. Moreover, in doing all this, the possibility opens up to find common patterns at the meta level. These patterns can be distilled and shared so that others can use and debug the shared patterns and conceptions. This process leads ultimately to concepts that are better understood proving their viability in use. In what follows we give an exemplar of such a platform, WikiNizer, an already existing personal knowledge organization tool.

2.1.4 Features of a New Personal Knowledge Management Application: WikiNizer

We introduce WikiNizer’s [32] salient defining features, and show how it can integrate and improve the best of breed features of Wikis targeting learning and knowledge management. WikiNizer is a Personal Semantic Wiki like orgaNizer of one’s Personal Knowledge Repository and a visualizer of Ideas, Web Searches and Resources. A system that supports meta-design and meta-reflection not only to organize one’s personal knowledge but to define and make use of the ways a knowledge worker may wish to carry out organization, production and sharing of information. At its core, WikiNizer is built to be the "perfect" note-taking and bookmarking (or NoteMarking) application as dreamed about for years by discerning seasoned knowledge workers at cloudnotes.net. CloudNotes blog, a Blog about note taking and bookmarking on the web, or “note-marking”. Their summary of most desirable features is exactly what WikiNizer has to offer at it’s core: "a perfect notemarking application […] an integrated solution that [you] could access both online and off. It [has] fast searching and tagging capabilities. It […] include[s] some social / sharing features, but with privacy controls that were powerful enough to make it useful at work. It [...] includes some near-frictionless method of adding notes & bookmarks from the Web browser." [33]

Beyond being the "perfect notemarking application”, supporting seamless integration of knowledge gathering, search, digesting, producing, visualization, repurposing, presenting and sharing information to create personal problem solving contexts in which creativity meets productivity with a view to sharing. These personal ways of knowledge acquisition and its cooperatively manageable organization represent meta-information concerning the problem situation that determines the conceptual structure of the problem space that can be shared and worked upon individually and collaboratively in WikiNizer. By incorporating standard knowledge management capabilities of Semantic Wikis, WiiNizer can enhance the users’ capacity for organizing his or her knowledge in terms that are her own. Knowing full well, that when needed these can be shared, consolidated or integrated into larger Semantic systems.

What makes WikiNizer a powerful tool of Personal Knowledge management beyond all these features, is that it also supports Meta-Design and Meta-reflection, in ways that go beyond existing attempts. This empowers individuals as problem owners to work out, share and import solutions to all their knowledge management problems and work towards the system exhibiting desired new behaviour.. “*Meta-design*” as defined by Fisher "extends the traditional notion of system development to include users in an ongoing process as *co-designers,* not only at design time, but throughout the whole existence of the system” by providing “advanced features [tools and social structures] permitting users to create complex customizations and extensions". [34] *Meta-reflection* as defined in [35] characterizes a system if it is “reflective because it makes visible and accessible parts of its infrastructure to the user”.

WikiNizer makes meta-design possible by providing facilities for users to elaborate (as meta-level content within the Wiki) entirely new content types for the system and the means of processing and interpreting them within the system. The new content types may include bibliographies, tasks, projects, PIM features, and anything else that the user wishes to work with. The means of processing reusing content for a multiplicity of purposes are specified at the same level of intellectual manageability than any other content at the object level. Consequently users can truly become co-designers of their own system by simply using available knowledge organizational capabilities to describe what content they want to include and how they are going to process them. Without any programming experience, such descriptions can be produced with a very shallow learning curve, empowering problem owners to propose solutions. A meta-design described in terms of appropriate proper concept organization schemes and represented by a proper concept organization form can, be viewed as a KA of its comprehensive formal requirements definition. A fully elaborated conceptual structure of new contents and their intended processing capabilities (expressed in organizational schemes) constitutes a new type of Conceptual Knowledge Architecture (CKA) that we would like to call a "meta-design specification". Of course like any new content, meta-design specifications at higher levels can be given appropriate meta descriptions, formulated as meta-circlular meta design specifications. If the CKA is spelled out to the finest conceptual granularity, a "meta-design specification" can be viewed as a comprehensive formal requirements definition. If it is elaborated to maximal resolution, it can be turned into working functional capability by the skilful injection of code as primitives. We are currently engaged in respecifiying and rebuilding WikiNizer in the terms alluded above, so that the next version will indeed be fully extensible at the meta-levels.

The Lite version of Wikinizer, is due out in Beta by the 24th of November. The full version that will be available for purchase at app stores, will have the ability to manage up to 40 projects and integration with the user's cloud storage for backup and collaboration purposes. The version with all the meta-design capabilities will be launched as an Open Source project, once it is proven in practice that it can indeed be used to come up with the “seed version” [40] of a much richer Personal Workbench as envisaged by Engelbart. Meta-level exensibility and features for developing personalizable meta-design specifications by end users are under development for next versions, thus opening the way towards the development of Conceptipedia proper, the next generation collaboration platform that we are putting forward here. .We hope that it will evolve towards reincarnating most of what Engelbart’s NLS has achieved and making his Vision of Augmenting Human intellect a reality.

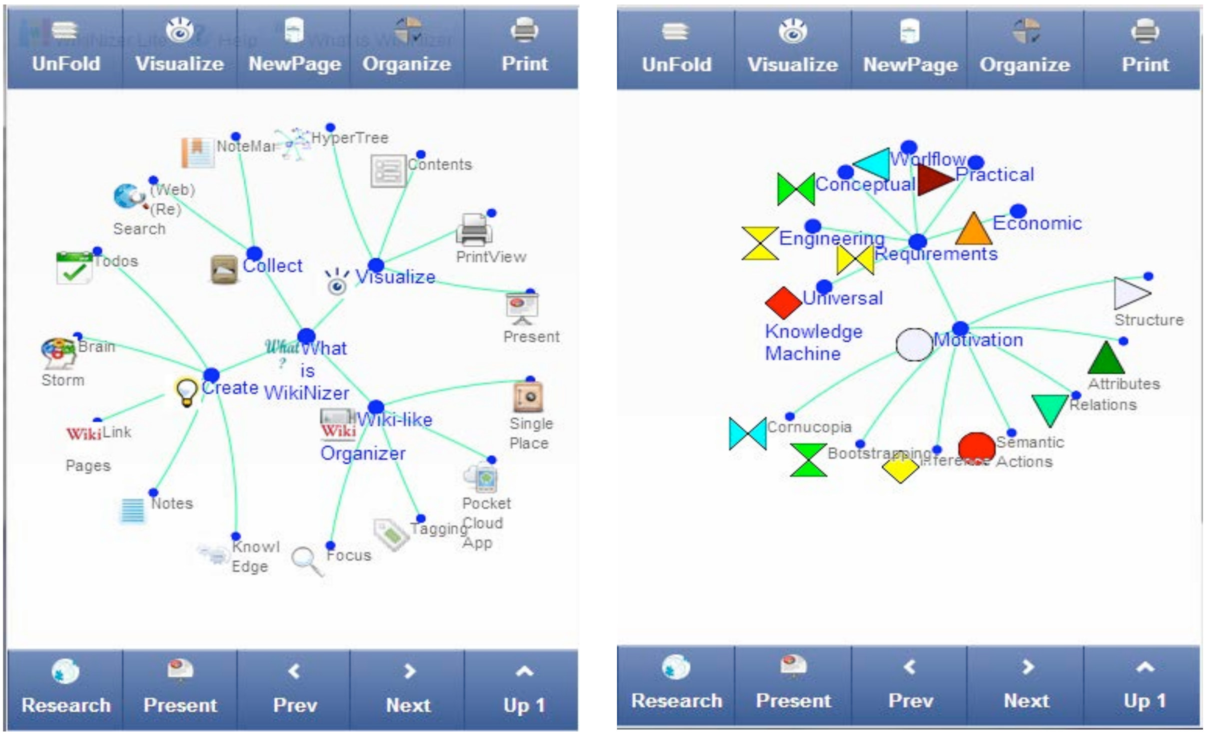

Figure 3-4: Navigable Hyper Tree Visualizations of Page structures in WikiNizer

The most important features of WikiNizer can be summarized as follows:

- It is a Personal Wiki that runs on a mobile device.
- Yet it is accessible from any desktop with a browser as it was in the Cloud. Hence it is termed as a Pocket Cloud App (c.f. pocketcloudapps.com).
- It gives a single place, a personal digital archive, to store and use whatever content the learner/knowledge worker need to gather, organize, explore, reuse in a form that meets personal needs, and produce artifact in a form that she specifies, to harness personal creativity to personal problem solving.
- As a Semantic Wiki it is built on graphs and web scale graph databases.

- It constitutes a meta-design framework supporting co-design, End User Development, co-evolution and meta-reflection.
- It is a Web Scale collaboration platform: giving full interoperability either with Peers or as "clients" to a Collaborative/Social version of the same system.
- It provides a visualization framework using extendable and graph representations (hyper graph, radial and space graph visualizations).

2.1.5 WikiNizer as a Semantic Wiki

WikiNizer is also Semantic Wiki for Personal use. It has the following capabilities, when viewed as a Semantic Wiki:

- Ontology, Taxonomy, Tags and other mechanism of meta data creation are supported in a fully extensible way
- Export/Import of content in standard formats: RDF and OWL
- Supports Peer to Peer collaboration, with one master and up to 40 collaborators
- The same mechanism can be used in the future to collaborate with a cloud based groupware version that will be @ conceptipedia.com, where the same semantic features will also be available.

2.1.6 Semantic Meta-design and Concept Organization

As we have seen WikiNizer supports personal empowerment and use and brings in collaboration as and when the user requires it. It is also built as a Semantic Wiki with implications for the attainable level of meta-design capabilities. WikiNizer renders explicit all the system capabilities in a comprehensive executable description that user's can reuse, restructure, tinker with and extend at will. The approach is an independent rediscovery of Englebart's Command Language Vision [39], and his use of Meta-compiler [39], an insight that Engelbart has achieved 40 years ago in his NLS system: "The Mother of All Demos".

With the true advances in computer capacity and technology we can pick up the paradigm begetting vision of Engelbart. Due to the organizational principle of rendering as "first class object" the descriptions of the capabilities of the entire system, WikiNizer can support meta-design at a much higher level of abstraction and intellectual manageability then it is achievable in say MikiWiki. [35] The key to all this is that WikiNizer can bring to bear to this task all the modelling and expressive power of Semantic Wikis. On that account, and to distinguish this approach from meta-design, it may be called "Semantic Meta Design". This we could see as denoting a new feature set of a Wiki destined for co-evolving knowledge management systemss.

In the context of peer to peer (P2P) collaborations the proposed system for Personal Knowledge Work can act as a P2P server. It is possible to build a CSCW system that has at its core all the functionality of a Computer Supported Personal Work (CSPW). If the functionality that would turn WikiNizer into a CSCW will be added, the result can be total interoperability between CSPW and a CSCW so constructed. This possibility gives us the basis for formulating the requirements for collaboration platforms of next-generation concept organization tools.

2.2 Interrelations between Personal and Collective Knowledge Work

2.2.1 Two-way interaction in CSCW

Computer enhanced technology gives us access to collective knowledge that needs to be contextualized, personalized, and reorganized. This is a major task for next generation learners and knowledge workers for whom finding, digesting, producing and presenting information makes sense in personal problem solving contexts. As described, WikiNizer in its existing version is an example of a personal knowledge management environment that is able to produce thematic knowledge architectures that incorporate Web Searches and Resources and construct one's Personal Knowledge Repository visualizing the structure of ideas. Graph representation of the search for information and its conceptual organization provides keys to problem definition and consequently to its solution. Personal ways of knowledge acquisition and creation represent meta-information concerning the problem situation that determines the conceptual structure of the problem space. Since WikiNizer makes explicit the meta-descriptions of the conceptual structure in an executable form that user's can reuse, restructure and extend, it naturally lends itself for collaborative use in various forms of learning and cooperative work. As a tool for knowledge architecture based collaboration it can be used as a two way street: on the one hand, it makes the personalization of collective knowledge possible, on the other, it is able to present the structure of personal knowledge in a shared, collectively extendable form.

2.2.2 Collaborative Knowledge Management in a 'Wikipedia of Concepts'

Collaboration, however, not only has to be built on understandable and extendable knowledge architectures, but also requires a knowledge transfer environment to manage the shared personal knowledge architectures. Hence, in order to realize the potential of human-computer interactions for building augmented knowledge architectures we need to develop platforms for cooperative problem solvers along the lines of a 'Wikipedia of Concepts'. Such a knowledge transfer environment can be envisaged as a dynamic collaboration platform for building shared Knowledge Graphs by researching, exploring, capturing, articulating, mapping and visualizing concepts and their various relationships.

Our aim with 'Conceptipedia' is to integrate the Computer-supported Personal Work environment provided by WikiNizer into a Computer Supported Collaborative Work Framework along the lines of Englebart's vision that requires total Interoperability, both at the level of Knowledge Structures and Meta Structures that relate Semantic properties as well as "first class" descriptions of system capabilities that can be shared, consolidated and tinkered with in the spirit of meta-D]design as explained above. These requirements can be satisfied in the framework of further functional services for communication and interaction. In what follows we attempt to spell out the requirements for such a Knowledge Transfer Environment (KTE).

3 PROACTIVE REQUIREMENTS FOR COLLABORATIVE CONCEPT DEVELOPMENT

When we are considering the requirements for future collaborative platforms for building augmented knowledge architectures, we try to accomplish two tasks: (1) to reflect on the state of Knowledge Management (KM) per se, vis-a-vi our vision for augmented knowledge architectures identifying pain points and address them. (2) Integrate considerations that relate to the technical architectural possibilities that we expect to have at our disposal. The discussion below can be seen as providing much of the background thinking that went into the design of WikiNizer itself, and into the plans for Conceptipedia that is intended to be a collaborative integration point for all the Personal Knowledge Work that can be realized with WikiNizer.

3.1 Pain Points

3.1.1 State of the Art in Personal Knowledge Management

In 1995 Engelbart considered Computer Supported Personal Knowledge Work on a par with Computer Supported Collaborative Work. [36] The latter was envisaged to be built on the first. If one surveys the available computer support for knowledge management, it is staggering to find that it is mostly about Collaborative Work. To illustrate the point, if we run the Google search "CSCW computer supported collaborative work" we get over 42000 hits. For CSPW "computer-supported personal work" we get around 8000. We see far too much emphasis on collaborative document management and retrieval, repositories and groupware for bookmarking, etc., and too little on personal work on knowledge architectures (KAs). The personal needs of the knowledge worker are hardly ever catered for, even though the content dependent conceptualisation of a domain is a prerequisite of collaboration Similar points can be made with respect to the collaborative use of the existing learning and content management systems. Efimove in a paper on "Understanding personal knowledge management" characterises the situation thus: "Much of knowledge management research and practice is focused on an organisational level; interventions and systems are designed and implemented without much thinking of how they would match the practices and daily routines of individual knowledge workers." [37]

We see Efimove's words as an indication that Knowledge Management as a field, has largely lost focus. In Engelbart's terms KM should be about Augmenting *Human* Intellect, so far the only intellect we have at our disposal. The first step towards augmentation is to promote computer enhanced learning by supporting the articulation and organization of personal knowledge, the constitutive element of collective knowledge, in a form that have collectively interpretable and extendable machine representation. In order to achieve this goal we should not lose sight of the individual, and the creative process of building his/her personal knowledge architectures. Our first experiences with WikiNizer support our conviction, that the key to successful knowledge and learning management is to reverse current trends: Empower knowledge workers first, bootstrap and work out the best ways of collaborating, then machines can pick up the pieces of knowledge architectures in a machine interpretable form and transfer them between different systems and thematically similar learning contexts. To sum up: knowledge and learning management should go back to the roots, and be rebased on personal knowledge acquisition and management as the starting point.

3.1.2 Interoperability in Collaborative Environments

The critical prerequisite of turning personal knowledge to common, or shareable collective knowledge is the representation of the knowledge domains in commeasurable structures. Once the collaborative agents can move to the meta-level of their personal knowledge architectures they can explicitly compare and match the lexicon, the relations and other meta-structures of their architectures. This way they can merge their knowledge and extend their knowledge domains. As Engelbart notes: "as the number and scale of knowledge domains involved in a given CSCW »web« increases, so does the need for »online interoperability«." If we are consequent in our distinction of knowledge architecture and knowledge transfer environment it turns out that here we talk about two different senses of "interoperability". The first one that can rather be called "commensurability of knowledge architectures" concerns knowledge representation, the second is about standardization of meta-data, document templates, etc., in order to guarantee content exchange between different knowledge and learning management systems for the sake of knowledge transfer and reusability.

There is a growing literature on the interoperability of learning and content management systems and electronic document management systems of the enterprises, and hardly any attempt is made to ensure the interoperation, or rather the commensurability of the results (the knowledge architectures) of personal knowledge work, a precondition that makes collaboration possible. If we are ever going to be able to cooperate on a global scale in given knowledge domains, as envisioned by Englebart from right at the start, it follows that we should develop collaboratively a shared common or commensurable conceptual framework to articulated understanding. We interpret Engelbart's latent and somewhat nebulous conception of "interoperability" between different knowledge domains in this sense: "The purpose of interoperability is to avoid having information islands between which information cannot flow effectively". [38]

There is another meaning of "interoperability" in Engelbart's writings, that is often ignored or not understood. It is the requirement of "total interoperability" at the system capability level. It may be called "functional interoperability" that promotes knowledge transfer within and between collaborative environments. In his vision and in his practice, explicit description of the system's capabilities he made it surveyable, and even tinkerable using the normal capabilities of the system. He did not call this meta-design, but in practice, as can be seen from the design of his Command Language Interpreter (CLI) module, it was a close match. [39]

In order to achieve content domain integration, and functional interoperability of KTEs in a 'wikipedia of concepts', the collaborative, or groupware editions of wiki-like organizers, we need to go well beyond common command vocabularies (the basis of Engelbert's CLI), and meta-data standards . We need to develop *commensurable architectures of conceptualisations*. This requirement implies a hierarchy of levels of reflection. At the meta level we need to be able to specify our ontologies, identify broad knowledge domains, meta-ontologies for describing relations and aspects. Last but not least we need to build up explicit meta-models of system capabilities with appropriate mechanism for user extensions, domain specific visualizations and personalizations. These user extensions will inevitable contain specifications of "domain specific inference rules", i.e. rules that within a domain or specific context, can be considered truth preserving and consistent to a practically meaningful extent. The necessity of these levels of reflection has been rediscovered in the concept of "*meta-design*" and *End User Development*. [40] We shall see in the next section how addressing these pain points correlates with technical possibilities.

3.2 Technical Possibilities

Technical capabilities can make or break an idea. The chances of "Bootstrapping" and Augmenting Human Intellect as envisioned by Engelbart 50 years ago, are much better today, just because virtually everybody is online, and devices that run in our pockets are thousand fold more powerful then the milli iPhone-capacity of a multi million dollar computer, that Engelbart and his team used to build the the NLS system and demonstrated in "The Mother of All Demos" in 1968. At the same time, we have distributed computer systems with staggering numbers of cooperating server nodes delivering millions of concurrent requests with 10s of a millisecond of response times. 10 years ago, although, we may have proposed knowledge architectures that would have envisaged a social graph of 10 million contributors, creating and collaborating on knowledge graphs of items in the billions, but it would have had no chance of becoming a practical reality. Today, especially with the development of Web Scale, NoSQL/Graph/Big/Linked/Data databases and related technologies, pioneered by Google, Amazon and Facebook, all this is now possible, with a low barrier of entry. We can start small and buy scalable capacity from Amazon, for example.

We need to examine current mega-trends and game changers that shape technological/cultural space where new Knowledge practices can be developed. From our point of view the most important trends and changes influencing the future shape of Knowledge Management are the following:

- Semantic Web: Technologies are destined to be integrated into new type of large scale graph-based visual applications. In this direction Google's Knowledge Graph [30] is a nice example of recent powerful development.
- Social and hyperlocal Apps: There is a gold rush going on to be the next Facebook. [41] Hundreds of social sites are launching every month, hoping to become the next big thing.
- Cloud computing: People are beginning to realise that they are paying with their privacy for free cloud services. Check out the internet meme: "When something online is free, you're not the customer, you're the product." [42]
- Big Data: Global Giant Graph of billions of connected things.
- Pocket Cloud Apps: like WikiNier, as Colony the CEO of Forrester stated recently: "The Cloud Computing model was also dead because it <<doesn't leverage power in your pocket>>. Future architecture will marry powerful data capabilities, held in the Cloud, with powerful apps on personal devices". [43]
- Mobility v2. Everyone will have a mobile device that is as powerful as any desktop a couple of years ago serving users in many locations with many devices.

Next generation concept organization tools should be updating Engelbart's vision taking into account technology development, like the web, mobile computing, graph databases, pocket cloud apps, peer to peer communication, existence of a lingua franca for programs: JavaScript and JavaScript Object Notation data everywhere. The goal here is to give people the technology that enables them to make ever more intelligent use of ever extending capabilities of computers. Not the other way round: making humans to work hard just to enable machines to extend their capabilities. As we sketched in 3.1.2 among the above mentioned technological trends Semantic Web is tied to our proactive requirements and should be underlined as a promising technology from the point of view of concept organization.

3.2.1 Semantic Web Technologies

Semantic Web Technologies are destined to be integrated into new type of large scale applications. One only has to look at what Goggle's Knowledge Graph is capable today, to appreciate the significance of this development.

Figure 5: The opening page of Google's Knowledge Graph [30]

It is also a testimony for the power of maturing Semantic Wikis, like freebase.com that enables Google queries to return information about related things. That is, if from the query terms it can be inferred with a good degree of probability, that the query is about some thing, that Google has included in its Semantic model, then following relational links, related things can also be shown along with the "textual matched" resources.

3.2.2 Semantic Wikis

Freebase brings the collaborative power of Wikis to ontology creation and organization of information along ontologies. The new version of freebase in beta makes graph navigation along relations as edges more apparent then before. OntoWiki another semantic wiki has comparable powers. The recent development of both of these Wikis show a growing awareness of the power of collaboratively creating complex graphs structure of nodes with structures that are defined at some meta level.

3.3 Requirements for Augmented Collaborative Knowledge Transfer Environments

We are now in a position to formulate proactive requirements for next generation collaborative platforms:

- Support Personal Knowledge Work in a Personal, Semantic Meta Design Wiki, which is totally interoperable across Peers. (Personal in this respect means Private: only running on the user's device, but it can be accessed as if it was a cloud app, i.e. it is a bona fide Pocket Cloud App.)
- All the capabilities one would expect from a best of breed Semantic Wiki.
- Support Semantic Meta Design: all the system's capabilities should be described fully within the system utilizing Semantic Wiki capabilities, so that "meta-design" is possible. (I.e., users can be co-designers and if a user or one of his peers has some java script knowledge even new functions can be implemented.)
- The Personal Knowledge Work platform be made to interoperate with a whole range of Existing Collaborative platforms and of course it should act as a client to a Collaborative version of itself which is scalable to millions of users and billions of nodes.
- Serve as a platform for reviving the Augmentation Project for Augmenting Human Intellect, but this time starting at the *personal level* and provide the means of *total interoperability* at the *collaborative*, *social level*.
- Provide knowledge transfer capabilities for communication, interaction and exchange of organization schemes. These may include automated comparision and merge of ontologies, meta-structures and KAs.

3.3.1 Knowledge Organization in the framework of Conceptipedia

"Conceptipedia", constituted in the spirit of Engelbart's original approach, is designed as a graph of 'Things' that enables us to define relations between concepts within a meta-knowledge graph. Whereas Wikipedia is a web of hyper-linked pages, Conceptipedia is a hyper-wiki that can also be modeled as an ontology for defining aspects and new relationships between concepts and things via navigable hyper-links. It is a collaboration platform for building knowledge graphs by researching, exploring, capturing, articulating, mapping and visualizing concepts and their various relationships. Conceptipedia will be a collaboration platform for building knowledge graphs by researching, exploring, capturing, articulating, mapping and visualizing concepts and their relationships. In this sense it is a Wikipedia of Concepts.

Wikipedia can be thought of as a free form web of hyperlinked pages on topics. In contrast, Conceptipedia can be thought of as a hyper wiki, where each node representing some concepts can have an arbitrary number of aspects, defined explicitly as relationships, and presented as navigable hyperlinks, called aspects links. So instead of the only type of link between "Pages" in Wikipeadia, representing some form of relevance, or further details, within Conceptipedia, one can define any number of possible links representing defined aspects or relationships.

Since the aim of Conceptipedia is the elaboration of concepts, it is constituted as a graph of things, together with their relationships, that are also modeled as a graph of connected pages, It offers total interoperability with the Personal Semantic Meta-Design Wiki: WikiNizer. Conceptipedia can be seen as a collaborative repository where personal knowledge can be integrated and consolidated into collaborative knowledge and KAs can be merged. It supports Semantic Meta Design, just like WikiNizer, as it has explicit meta-descriptions of the systems total capabilities. With explicitly expressed and consolidated semantic information Conceptipedia is amenable to collaborative editing and co-evolution of the capabilities of the system.

4 REFLECTIONS

The closest comparable system that exhibits meta-design and meta-reflection capabilities we have found so far is MikiWiki [35]. There is considerable overlap in approach and architecture between WikiNizer and MikiWiki. The reason being that both systems have attempted to realise the same idea: using Wiki as the vehicle of knowledge management and aiming to provide an End User Extensible system. WikiNizer's focus on Personal Knowledge resulted in making different technology choices with significantly different system characteristics.

Beyond these, the most significant differences are that MikiWiki seems to lack the following features:

- Support for Personal Work
- Semantic Wiki Features
- Higher meta-level meta-design capabilities, that can themselves bootstrapped. [15]
- Interoperable extension mechanisms for KAs.

The primary mechanism of extensions in MikiWiki is meta pages that contain HTML templates and applicable JavaScript. This approach is fine for adding new functionality fast, and appropriate as the means of doing exploratory programming and system development. WikiNizer aims to improve on this approach, by making the full power of it's semantic wiki features to bear on the problem of describing its own extensions, resulting in a fully elaborated meta-circualar executable specification.
The AKWS group at the University of Leipzig that among others hosts the OntoWiki project [http://aksw.org/groups/es] has a research group on Emergent Semantics which explores the possibilities for bootstrapping semantic collaboration and the semantic web in general. They are also focusing on engineering tools just to explore the possible implications for broader goals. OntoWiki is a fine tool for collaboratively developing RDF ontologies. Like most other systems it does not support the personal knowledge worker in creating domain-specific ontologies for himself.

Google's Knowledge Graph and freebase.com focuses on Linked Data that can be extracted from Wikipedia and other sources into a semantic framework of general applicability, with not too much depth and complications. That approach can indeed help to improve the relevancy and contractual efficacy of searches and consequently is a great contribution to the advancement of knowledge. If we want to bring out the richness of conceptual structures that give meaning to our concepts we need to find ways of going much deeper. We should articulate much richer conceptualizations to help us in our Personal Knowledge Work and eventually to get to the point where these complex structures can be made interoperable through a process of co-design and co-evolution in an open system, as envisaged here for Conceptipedia.

5 SUMMARY

Nothing characterizes more the significance of knowledge for our age then the bold ambition of *Intentional Software Corporation*: "Turn your knowledge into software!" [44] The requirements set out in this paper are intended to bringing substantive improvement in Building Augmented Knowledge Architectures along the same lines. Acting on these proactive requirements for collaboration platforms of next-gen Concept Organization Tools new levels of capabilities can be achieved. We illustrated the satisfyability of these requirement with respect to Personal Concept Organization with the introduction of a new Personal Knowledge Management tool, WikiNizer. We described a change of focus first in Personal Knowledge Management, and as a second step suggested to extend it to Collaborative Knowledge Management. Empowering the individual and offering a greater level of expressive power and extensible capabilities through Semantic Meta Design the use cases of WikiNizer demonstrate that satisfying the proactive requirements it can also be used as a tool for visualizing the development of problem specific conceptual relations of the creative mind and one's related web research. The goal of developing such concept organization tools is to use our knowledge to co-evolve systems like WikiNizer and Conceptipedia to augment our abilities to manage knowledge.

REFERENCES

[1] Han, H.-S., Kim, H. & Han, S.-G. (2006) 'Analyzing the effectiveness of collaborative condition monitoring using adaptive measure', WSEAS Transactions on Information Science and Applications, vol. 3, no. 8, pp. 1495–1500.

[2] Forte, A. & Bruckman, A. (2007) 'Constructing text: wikis as a toolkit for (collaborative?) learning', International Symposium on Wikis 2007, Montreal, Canada, 21–23 October 2007, ACM Press, New York, pp. 31–42.

[3] Peters, V. L. & Slotta, J. D. (2007) 'Using wikis to create pedagogical scripts for knowledge communities', in International Symposium on Wikis 2007, Montreal, Canada, 21–23 October 2007, ACM Press, New York.)

[4] Wei,C. & Maust, B. & Barrick, J. & Cuddihy, E. & Spyridakis, J. H. (2005) Wikis for Supporting Distributed Collaborative Writing. In: Proceedings of the Society for Technical Communication 52nd Annual Conference, Seattle, WA, May 8-11.

[5] Schroeder, R. & Den Besten, M. (2008) 'Literary sleuths online: e-research collaboration on the Pynchon Wiki', Information, Communication & Society, vol. 11, no. 2, pp. 167–187.

[6] Ebner, M., Kickmeier-Rust, M. & Holzinger, A. (2008) 'Utilizing wiki-systems in higher education classes: a chance for universal access?', Universal Access in the Information Society, vol. 7, no. 4, pp. 199–207.

[7] Moskaliuk, J. & Kimmerle, J. (2009) 'Using wikis for organizational learning: functional and psycho-social principles', Development and Learning in Organizations, vol. 23, no. 4, pp. 21–24;

[8] Trentin, G. (2009) 'Using a wiki to evaluate individual contribution to a collaborativelearning project', Journal of Computer Assisted Learning, vol. 25, no. 1, pp. 43–55.

[9] Hayes, Niall (2011): Information Technology and the Possibilities for Knowledge Sharing. In: Easterby-Smith, Mark and Lyles Marjorie, A.(eds.) (2011): Handbook of Organizational Learning and Knowledge Management , 2nd. Ed. Chichester: John Wiley & Sons.

[10] http://www.dougengelbart.org/pubs/augment-3906.html (09.06, 2012.)

[11] Ter Hofte, Henri, G. (1998) Working Apart Together: Foundations for Component Groupware. Telematica Instituut Fundamental Researh Series No. 001 (TI/FRS/001) Enschede, NL.

[12] http://www.dougengelbart.org/library/books.html (09.06, 2012.)

[13] Katz, J. & Wurman, R. S. (1975): The Architecture of Information. AIA Journal. (10), 40-45. See also: Knemeyer, D. (2004). Richard Soul Wurman: The InfoDesign Interview. http://www.informationdesign.org/special/wurman_interview.htm

[14] Wurman, R.S. (1996). Information Architectects. Graphis Press Inc., Zurich,

[15] http://www.dougengelbart.org/about/bootstrapping-strategy.html (10.02, 2012.)

[16] Olympic Access (1983), Access Press Ltd, 1983. Written and art directed by Richard Saul Wurman, illustrated by Michael Everitt.

[17] Rosenfeld, L. & Morville, P. (1998, 2006). Information architecture for the World Wide Web (3rd edn.). O'Reilly. p. 58.

[18] Soergel, D. (2006). The Architecture of Meaning. A Commentary. In: Perspective on Cognition, A Festschrift for Manfred Wettler. Rapp R. and Sedlmeier P.(eds.), Pabst Science Publishers, Lengerich, pp. 501-16.

[19] http://www.medien.ifi.lmu.de/lehre/ws0809/hs/docs/meyer.pdf (10.02, 2012)

[20] Eppler, M.J., Burkhard, R.A., Knowledge Visualization – Towards a New Discipline and its Fields of Application, ICA Working Paper #2/2004, University of Lugano, Switzerland, 2004.

[21] Peirce, Charles S. (1931-58.) Burks, A., W. & Hartshorne, C. & Weiss, P. (eds.), Collected Papers of Charles Sanders Peirce. Cambridge: Harvard University Press, 1931-58. (4. 321-4.514)
— — (1977) Semiotic and Significs: The Correspondence between Charles S. Peirce and Victoria Lady Welby. Edited by Charles S. Hardwick. Bloomington: Indiana University Press. p.11ff.

[22] http://www.invisiblerevolution.net/engelbart/full_62_paper_augm_hum_int.html (10.02, 2012)

[23] http://thejit.org/ (10.02, 2012)

[24] http://conceptualgraphs.org/ (9.02, 2012)

[25] http://en.wikipedia.org/wiki/Mind_map (10.02, 2012)

[26] http://www.topicmaps.org/ (10.02, 2012)

[27] http://news.ycombinator.com/item?id=2175161

[28] http://techwiki.openstructs.org/index.php/Ontology_Tools (10.02, 2012)

[29] http://www.youtube.com/watch?v=Io-86pFPCsg (10.02, 2012)

[30] http://www.google.com/insidesearch/features/search/knowledge.html (10.02, 2012) (In 2010 Google acquired Metaweb with Freebase, a community maintained graph database of information taken from Wikipedia and other sources and develops it as a graph based repository of knowledge.)

[31] http://www.technologyreview.com/featured-story/407091/anything-you-can-do-i-can-do-meta/ http://www.languageparallax.com/wordpress/?p=38] (10.02, 2012)

[32] http://WikiNizer.com (10.04, 2012)

[33] http://www.cloudnotes.net/2008/06/statement-of-purpose.html (10.02, 2012)

[34] http://l3d.cs.colorado.edu/~gerhard/papers/CACM-meta-design.pdf (9.02, 2012)

[35] http://www.wikisym.org/ws2011/_media/proceedings:p53-zhu.pdf p. 53. (9.02, 2012)

[36] http://www.dougengelbart.org/pubs/boosting-ciq.html (9.02, 2012)

[37] https://doc.telin.nl/dsweb/Get/Document-44969/pkm_weblogs_final.pdf (10.02, 2012)

[38] http://www-sul.stanford.edu/depts/hasrg/histsci/ssvoral/engelbart/append3-ntb.html (9.02, 2012)

[39] http://www-sul.stanford.edu/depts/hasrg/histsci/ssvoral/engelbart/append2-ntb.html (10.02, 2012)

[40] Fischer, G. (2009) End-User Development and Meta-design: Foundations for Cultures of Participation. In: IS-EUD '09 Proceedings of the 2nd International Symposium on End-User Development, Springer-Verlag Berlin, Heidelberg. pp 3 – 14.

[41] http://www.slideshare.net/jimmyschwarzkopf/stki-summit-2012-main-presentation (10.02, 2012)

[42] http://futureoftheinternet.org/meme-patrol-when-something-online-is-free-youre-not-the-customer-youre-the-product (10.02, 2012)

[43] http://www.financetechnews.com/eulogy-for-faceook-and-the-cloud/ (9.02, 2012)

[44] http://intentsoft.com/ (9.02, 2012)