OPAALS PROJECT

Contract n° IST-034824

WP 10:Sustainable Community Building

D10.5- Principles, Models, and Processes for the Development of the Open Knowledge Space

Project funded by the European Community under the "Information Society Technology" Programme

Contract Number: IST-034824

Project Acronym: OPAALS

Deliverable N°: D10.5

Due date: 31 January 2007

Delivery Date: 27 July 2007

Short Description:

The deliverable discusses principles, models, and processes for the development of the Open Knowledge Space and seeks to bootstrap the emergence of an Open Knowledge community inclusive of all stakeholders of regional economies, but in particular academic institutions and SMEs.

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Made available to: Public, unlimited distribution

Versioning

Version	Date	Name, organization
1	15 June	LSE, UniKassel
2	27 July	LSE

Quality check

Internal Reviewers:

Andrea Nicolai, T6

Robin Mansell, LSE

Dependences:

Work Packages	Indicate which WP could benefit from this Deliverables and if possible with planned tasks, including a clear justification
Partners	indicate which partner could benefit from the reading of this deliverable
Domains	specify the scientific domains involved in this deliverables and clarify to which extend they are covered by this report
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0. Introduction

This deliverable discusses principles, models, and processes for the development of the Open Knowledge Space (henceforth OKS). The OKS can be regarded as a cornerstone of the OPAALS project as it represents both the methodological and practical framework for the objectives: (a) to create a community of research that will support the on-going trend toward the extension of traditional disciplines for an integrated foundation for digital ecosystems research; and (b) to initiate a recursive process of knowledge creation within the research network itself that will engender a self-sustaining and self-renewing process of research and innovation in the wider Open Source community, thereby catalysing the emergence of an Open Knowledge community inclusive of all stakeholders of regional economies, but in particular academic institutions and SMEs.

The outputs of this recursive process are to be captured in the form of the OKS through the following four activities[1]:

1. A reflexive analysis of the Open Source community process as it applies to OPAALS, with consequent development of policies for the construction, and eventually for the governance, of the wider OKS.
2. The development of a visualisation of the OKS inspired by Semantic Web technologies.
3. The development of a sustainable way of managing the knowledge accumulation process as it is driven by the funded research activities and leading to the definition of a knowledge model for the OKS (Open Knowledge Space Model, or OKSM).
4. The development of collaborative working tools based on the concept of Wikis and relying on the distributed P2P run-time architecture of digital ecosystems, a first version of which is already available through the DBE[2] integrated project.

The continuous and recursive application of these four reflexive activities will enable the bootstrap of an OKS that will grow out of the project.

The OPAALS comm5unity hence plays a major role in the development of the OKS and therefore cannot be neglected when developing the OKS model. Regarding the community building process, OPAALS is taking inspiration from the Open Source community process to create the conditions whereby an Open Knowledge community of research can form and grow (see also objective a). This is why the team involved in this deliverable intended to initiate a collaborative development effort within the OPAALS community (i.e. consortium) in order to derive a comprehensive set of ideas and needs regarding the OKS spanning all disciplinary domains of OPAALS and specific task necessities. The involvement of the whole community in the development process was also directed towards the emergence of a better (self-) understanding of the OPAALS community, that is to say a direct means for community building.

The challenge of this integrative approach is two-fold: Firstly, the project postulates the self-generation of an organisational structure that is able to generate recursively other versions or

1 OPAALS Description of Work, p. 6
2 Digital Business Ecosystem, http://www.digital-ecosystem.org

copies of itself as this represents the essence of autopoiesis. This means that the shaping of the OPAALS community cannot be postulated and structured in a hierarchical top-down approach but rather needs to emerge gradually and 'independently' by means of different activities, tasks, and initiatives. Consequently, the development of the OKS can only succeed if it is an open, evolving process reflecting, to a certain extent, the community building process itself, and not a closed, pre-structured activity with a clear-cut temporal ending. However, for the production of this deliverable, a concrete time-line was given and a cut had to be made at a certain point of time. Therefore, this deliverable represents only the first milestone in the collaborative development of the OKS rather than a 'final' and fixed model. By means of methodologies from the social science domain, the on-going process will be continuously fostered and at the same time scientifically observed in order to gain valuable insights from the OPAALS community building process which can be applied to other projects and, moreover, in Phase II&III to a broader scope of OPAALS' addressees and actors, namely in addition to researchers and scientists, also SMEs. The following chapter will therefore explain the social science approach of this deliverable and the building/fostering of the OPAALS community.

The second part of the two-fold challenge is reflected by a different set of 'actors', namely the role of information and communication technologies (ICTs) and, in a broader sense, of the intrinsically different scientific domains that constitute OPAALS. The OKS combines two main frameworks: knowledge production and knowledge management. A definition of the OKS model therefore cannot be separated from the collaborative working tools that the OKS will integrate. This deliverable will encompass a detailed discussion of community building, knowledge (production), and tools. Taking as point of departure, the notion of the social construction of technology (SCOT), the community plays again a vital role as it means that the tools to be integrated into the OKS need to be decided upon and shaped by the community and not – as used to be the traditional approach in software development – by a group of computer scientists that might be part of the OPAALS community but cannot possibly capture and integrate the specific usage patterns of ICT by all other members. This challenge will be discussed in the following chapters and besides this deliverable in the OKS User-Group which integrates the results and findings of task T10.7 and of this deliverable and will focus on the actual ICT usage options and strategies for the OKS[3].

This deliverable is split into three main sections, encompassing the three constitutive paradigms 'Principles', 'Models', and 'Processes' of the OKS. While the 'Principles' section is more focused on the underlying theories and methodologies, the 'Processes' section is more applied and development oriented. The third section – 'Models' – is a combination of both and therefore represents an important interface between the two paradigms: Analysis-driven frameworks (principles) and synthetic frameworks (processes) that are associated with a social science and an engineering background, respectively.

The 'Principles' section focuses on three core elements: knowledge, collaboration/community, and language. We argue that a profound and integrative discussion of these constitutive elements is necessary as a first step in order to address the aforementioned challenges and to set the broader agenda of task T10.7 “Principles, models and processes for the development of the Open Knowledge Space” which will continue its work throughout Phase I.

Chapter 1 presents the overall social science methodological framework underlining the

3 For further information on the OKS User-Group see http://www.opaals.org/OKS_User_Group

approach of deliverable D10.5 and task T10.7.

The “Theoretical Foundations” regarding the three core elements knowledge, collaboration, and language will be discussed in Chapter 2. Trying to define principles and paradigms for the development of an Open *Knowledge* Space, we will apply a knowledge focus throughout this chapter.

Moreover, this is the first chapter that integrates the deliverable's intrinsic goal of addressing the overall aim of OPAALS: Like the whole document, it was written collaboratively by consultants, researchers, and scientists from different domains. Therefore, it does not exclusively reflect the “traditional” approaches that, for example, a linguist or social scientist might apply but, rather, a interdisciplinary[4] approach. This means the document demands a different mode of reading and discussion: avoiding a domain-dependent strict and rigorous scientist's point of view, and applying a meta-level view that offers the opportunity of gaining new insights from other scientific domains and practical experiences.

The 'Models' section starts with Chapter 3 “Definition of the OKS and Proposed Approach” and represents the transition from the primarily theoretical 'Principles' section to the more applied and developmental 'Processes' section. It discusses the approach to a collaborative development of the OKS model proposed by the team of T10.7. Therefore, it begins with a general discussion of different approaches and then introduces initial feedback gathered from the OPAALS community.

Chapters 4 and 5 “An Ontology for the OKS” and “High-Level Architecture of the OKS” are also contained within the 'Models' section. Chapter 4 integrates a stronger technological point of view and Chapter 5 depicts the concrete results of discussions within the OPAALS community regarding principal modes of interaction in the OKS. These chapters are quite brief and are meant to be instances of the iterative methodology upon which the OKS development process rests. In other words, at the time of writing, the ontology and the information/knowledge architecture of the OKS can only be known in a very approximate way. These two chapters therefore represent a first attempt at capturing what seem like the important aspects of these two aspects of the OKS. The implication is that through dialogue, through the development process itself, and through use, our understanding of the ontology and architecture of the OKS will improve, leading to changes in the material and figures presented in these two chapters. The mode of communication adopted in this deliverable, but especially in these two chapters, is related to the governance process for the OPAALS community and regards the material presented as the first part of a conversation, to which a reply is expected. it is therefore important to emphasise that nothing in this deliverable should be considered top-down "dictum". However, dialogue and dissent do carry more *responsibility* than acquiescence. What we are working towards, therefore, is not just to build the models and the processes of the OKS but also the *governance* framework based on the principles of engagement, transparency, and accountability. We know that knowledge implies community and community building, what is less explicit is that it also implies governance – this deliverable is an invitation for the community to engage in creating these structures of governance.

4 In this deliverable, we understand and use the term “interdisciplinary” to mean a process of seeking insightful points of contact between disciplines without compromising the rigour and methodology of each discipline. We use the term “multidisciplinary” to refer to parallel yet separate disciplinary approaches to a common problem, and the term “transdisciplinary” to refer to the application of theories and methodologies from one discipline in another.

The complement of a governance process informed by a social constructivist perspective and predicated on transparency, accountability and the assumption of responsibility is a distributed system architecture that guarantees local autonomy and avoids central points of failure or control. The OKS is therefore built on top of the distributed DBE P2P architecture whose foundations were laid in the DBE project. Even though throughout this report the emphasis is placed on the interaction between knowledge and community mediated principally by Web technologies, the enabling infrastructure will rely on such a P2P architecture, the achievement of whose 'pure' form is a subject of intense research also within OPAALS (WP3). The user interface will adopt whichever HCI mode seems most appropriate, either oriented toward the still emerging Web 2.0 approach or a client-oriented approach (such as the OKS Desktop), depending on the application and intended user community. The DBE service architecture will likewise be reused in the form of the ServENT (SERVer + cliENT) application container for those interactions that require more CPU-intensive remote service invocations.

“Usage Models” and “OKS User and System Requirements” (Chapters 6 and 7) finally represent the 'Processes' section where actual user involvement is discussed by means of applying different usage models and system requirements that aim to trigger collaboration towards joint knowledge production and management within the OKS. Understanding of “how” the OKS will be used is an important step towards the definition of information and data architecture. These chapters will present several use cases, such as the contribution to knowledge, the search for relevant information, and the personalization of the interface. These use cases will be used to validate the development phases.

Throughout this deliverable, a process view to knowledge production and management serves as the foundation for all collaborative tools and principles that we propose. This process-driven view emphasises the value of the manner in which certain goals are achieved as opposed to focussing only on the actual achievement of the goals. The approach is therefore reflexive, inclusive and open-ended rather than outcome-oriented, and it is particularly suited to a shared, collaborative approach to developing our knowledge model. This process view should also consider the context within which tools are put forward, used and developed, community members participate, and the entire OKS evolves.

This diachronic impetus corresponds to Suchman's (1987) concept of situated actions, where actions and context build a constitutive and defining model, and to the methodological framework of epistemic studies (Latour & Woolgar, 1979; Knorr-Cetina, 1999), which focuses on the analysis of the construction of knowledge within specific community settings, rituals, production practices, and communication patterns. Finally, considering the overall framework of OPAALS, Digital Ecosystems (DE), we acknowledge an a priori highly dynamic context, which is defined by its inherently ongoing evolving patterns and processes. Cultivating the DE thus demands paying attention to these patterns and focussing on processes and (changing) dynamics, as there is no final, static end-product in any autopoietic process.

1. Overall Methodological Framework

The OPAALS network is a heterogeneous and highly diversified network with no clear-cut boundaries. For example, in its initial phase OPAALS consists mainly of researchers and scientists with only a few practitioners. Hence, one could define the OPAALS community as a scientific or academic network. However, in its subsequent phases, OPAALS will open to the wider Digital Ecosystems community and invite SMEs and generally 'everyone' who is interested in this network to participate. Therefore, we cannot focus on the development of the OKS for a strictly academic audience but have to take into account other communities with their respective needs and practices.

However, even OPAALS's stakeholders from scientific and academic backgrounds are highly heterogeneous as the project spans different domains, research institutes and regions. Multidisciplinary and dispersed collaboration would hardly be possible without ICT, but what is more important is the question of how to build a new multi- and interdisciplinary research *community*. The difficulties of initiating a collaborative development process of the OKS within a community that is still in its infancy and evolving had been discussed in the introductory chapter, and the important role of the social science domain in this intricate process was also outlined. This chapter provides an overview of the overall methodological framework for task T10.7 and deliverable D10.5 and will argue that, besides the importance of practical outcomes and developmental research, a sound methodological and theoretical basis is to be applied in order to offer objective and formal evaluation environments. Especially in large, dispersed, non-hierarchical and highly heterogeneous research projects which include the experience of multiple researchers and practitioners, a common ground is useful: A common ground means that not only the mere results of the project need to be assessed but also the processes which lead to the results.

1.1 Action Research Approach

For the overall methodological framework for task T10.7 and deliverable D10.5, an action research approach was chosen. One of its advantages is that it provides a democratic and participatory framework which conforms to OPAALS's concepts of collaboration and bottom-up development.

Action research defines knowledge as a social construction with 'research' being embedded in a system of values. The action research approach therefore claims the inadequacy of any attempts regarding an objective, value-free approach to knowledge. One important question within action research is therefore how knowledge can be created that is both valid and helpful for individuals, communities and supports democratic participation (Brydon-Miller, Greenwood & Maguire, 2003):

> Action research [...] aims to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously. Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in changing it in what is together regarded as a desirable direction. Accomplishing this twin goal requires the active collaboration of researcher and client, and thus it stresses the importance of co-learning as a primary

> aspect of the research process. (Gilmore, Krantz & Ramirez, 1986, p. 161)

According to Reason & Bradbury (2001), action research is:

> a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes, grounded in a participatory worldview which we believe is emerging at this historical moment. It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities. (p. 1)

Action research differs from other types of research as it regards any stakeholder of a project or community as a researcher: Research takes place in real-world situations and is aimed to solve real problems (O'Brien, 2001). Hence action research combines theory and practice through change and reflection within a certain framework. It also combines researchers and practitioners, which means, regarding the OKS, that any participant in the collaborative process of defining the OKS is at the same time researcher and practitioner. Whereas the first status refers to each participant's actual status within this Network of Excellence, the second status 'practitioner', refers to each participant's background regarding her work experience, i.e. tool usage (ICT), communication patterns, etc.

What separates action research from general professional practices, consulting, or daily problem-solving is, according to O'Brien (2001), “the emphasis on scientific study, which is to say the researcher studies the problem systematically and ensures the intervention is informed by theoretical considerations” (¶ Definition). In the work of our deliverable the major aspect is to inform the “practical” and applicable definition of the OKS with theoretical approaches from organisational studies and research results from other investigations. This conforms to a general consensus among researchers regarding the usage of ICT: often, its actual usage diverges from the planned modes that had been intended by the designers (Jankowski, 2007 ¶ Further investigation of e-science). Furthermore, although specific communities may develop certain accepted and trusted usage modes, individuals may resist different uses of ICT.

The combination of theory and practice in action research, however, has led to critical opinions regarding this approach. Gustavsen (2003) speaks of a 'tension' between theory and practice in action research, which may result in the loss of performing good research. He also points out that a sound discussion of the historical background of this 'tension', namely within the theory of science domain, can help to overcome this problem. He refers to Kierkegaard and states: “Theory [...] can act as filters and screening mechanisms that steer us in a wrong direction as much as in a right. The point is to understand the world as it is by confronting it directly; by trying to grasp the phenomena as they really are.” (Gustavsen, 2003, p. 156).

Foth (2006) introduces network action research as a timely methodological variant of action research, based on the concept of a changing nature of community interaction and social formations within a network society. 'Network' represents an important concept in OPAALS as it refers to the technological and social dimension. The first dimension represents questions regarding the technological infrastructure of the OPAALS network, whereas the social dimension integrates all aspects of community building and working. As in networks people operate in a variety of roles, and hence are constituted by a shifting quality of communicative behaviour. According to Foth: “These networks make up a communicative ecology that is very

unlike a collective 'Gemeinschaft' ['community', see Tönnies, 1887] and resembles more a swarm or an urban tribe." (Foth, 2006, p. 209). Taking into account that the OPAALS community is still evolving, Foth's network action research approach offers the possibility to adapt to the intrinsic dynamics of the evolving community.

Among the challenges of a traditional collective approach to action research is the question as to whether the applied communication strategies are suitable for all members. Based on the fact that face-to-face meetings are rare in our daily OPAALS work and that a lot of decisions and discussions take place via ICT, it is likely that some members might be put off by large open discussion forums (the foreign language aspect also plays a vital role here: the minority of the OPAALS members speak English as their first language, hence linguistic problems and discrepancies are likely to occur and hinder members participating in open discussions). A suggestion from network action research therefore calls for additional "informal peer-to-peer channels that provide a more private, intimate and ethnographic way of communicating with community members" (Foth, 2006, p. 210). This strategy is actively applied in OPAALS where all members that might be able to contribute are encouraged to participate in ongoing discussions by means of directly addressing questions regarding the specific topic to those members who tend to be less active in discussions and separate communication channels as used next to the open discussions via email or wiki, such as one-to-one emails or phone calls.

Another important point is to enable that open learning and knowledge production processes are spread through the community at large and reach all members. One of Foth's answers is to develop a flexible communication structure which allows upwards and downwards communication processes. This deliverable is one example of the application of this strategy: It represents the successor of a discussion paper on principles, models, and processes for the development of the OKS model which had been produced by the team members of task T10.7 and discussed with all partners during the Kassel general meeting. The responses in turn were fed into this deliverable.

Finally, action research had been successfully adopted in information systems in the 1980s and early 90s and is currently being re-adapted in this field, and in closely interlinked fields, such as e-collaboration (Kock, 2007; 2005; 2003). In fact, two special issues in information systems journals were dedicated to action research: Information Technology & People 14(1) in 2001; and MIS Quarterly 28(3) in 2004. One of the most cited reasons for the reason of applying action research in information systems science is its relevant outcomes for industry practitioners. Therefore, an action research approach in OPAALS represents a valuable interface between social science and computer science; and between researchers and practitioners. The latter point also promises an advantage regarding OPAALS' Phase II, when the community will be directed more concretely towards SMEs.

1.2 Applying Action Research to the OKS Discussion

Coghlan & Brannick (2001) suggest an action research cycle, comprising four basic steps: Diagnosing, planning action, taking action, and evaluating action. The first step – diagnosing – is strongly connected with a sound understanding of the actual context and purpose. Planning action derives from the analysis of the context and the goals of the project. It involves the collaborative development of alternative actions to reach the identified improvement and knowledge development. During the taking action step then, the plans and actions are

implemented. Evaluating action involves the study of the outcomes of the selected plans and actions, both intended and unintended. Susman and Evered (1978) proposed in their seminal article in the field of organisational action research a fifth step “specifying learning”, which involves the assessment of the outcomes of the evaluation step and knowledge production in form of a theoretical or conceptual model describing the context and situation under study (Kock, 2004). This deliverable covers the first two steps (diagnosing and planning action), further research steps will be elaborated by the task T10.7 team.

Regarding the constitutive (from a theoretical and practical point of view) role of the OKS it is crucial to apply a collaborative and bottom-up development model rather than a top-down approach. For example, the development of the OKS ontology (see Chapter 4) should be considered a community responsibility and requires a degree of commitment from all members of that community. According to Hepp (2007), creating an ontology requires resources from the contributing individuals and an ontology should be both technically possible and actually be yielded and adopted by freely acting, rational individuals. Hepp outlines various challenges to the creation of ontologies, but emphasizes that they exist as community projects, socially embedded processes and a bottom-up model, even though they are usually created by a small community and intended to be used by a much larger community. He suggests that useful ontologies must be small enough to have reasonable familiarisation and commitment costs and they must be big enough so that there is a substantial value added by using them (Hepp, pp. 92-94). In other words, they must be small enough so that they are easy to learn yet expressive enough so that they can scale up.

In short, the proposed approach for the collaborative development of the OKS is a bottom-up, process-oriented, community-driven option, a choice that although somewhat more difficult and complex than a top-down, centre-managed option, is perceived to be of greater relevance, value and significance to members of the community, particularly those who have participated in its development. It is therefore more likely to be scalable and recursive, i.e. to apply beyond the boundary of the project to the wider and as yet non-existent OPAALS Community.

In order to realise this sophisticated endeavour, communication is the main tool. Any democratic bottom-up process relies on communication. We therefore decided to structure the development of the OKS as a communication process between the task T10.7 team and the broader OPAALS community as well as between theoretical foundations and practical implications. Figure 1 visualises the communicative development process of this deliverable.

Although several authors emphasise the importance of face-to-face contacts in the form of conferences and workshops for sustainable community building (Finholt, 2003; Cummings & Kiesler, 2005), there is no “magic bullet” as to how to build a sustainable community. Regarding the dispersed nature of the OPAALS community, we decided to combine face-to-face interactions with a computer-mediated discussion on the OPAALS project's Wiki.

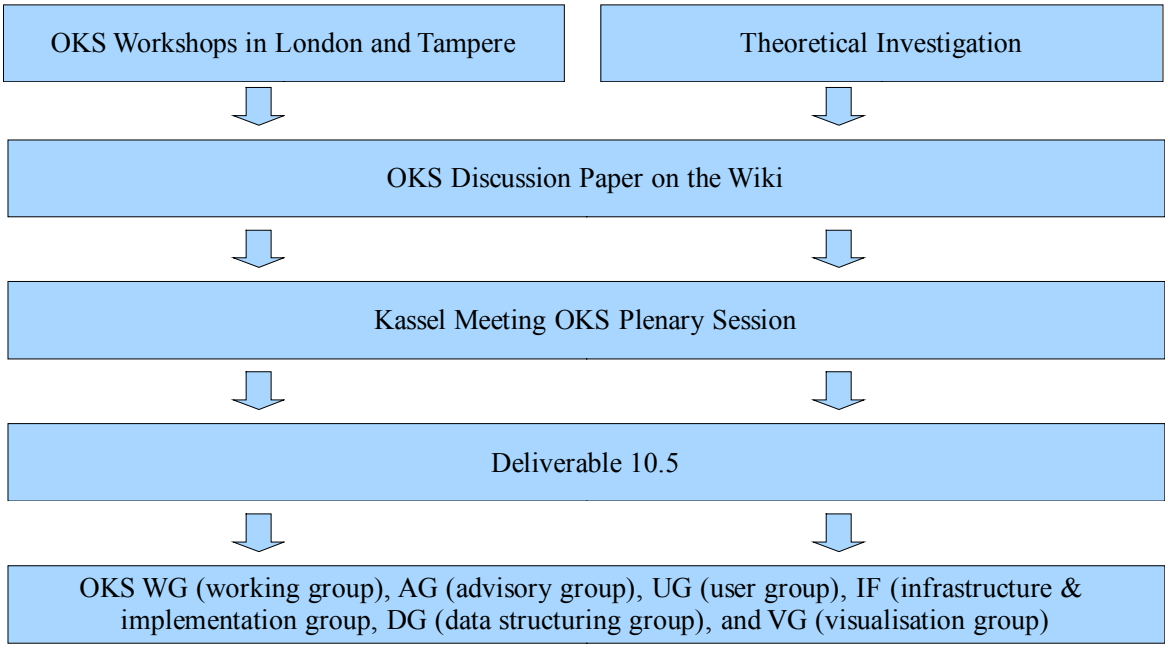

Figure 1: The process view on Deliverable 10.5

During the initialisation phase of the OPAALS community two workshops took place. The first workshop took place during the "kick-off"-meeting in London in June 2006, and a second workshop in October 2006 in Tampere. A very important face-to-face event was the OPAALS general meeting in Kassel in March 2007. Several workshops dealt with the OKS and a whole plenary session was conducted to introduce the members and discuss their visions concerning the OKS. The importance of the general meeting is also based on a diachronic account: the meeting took place in Month 10 of the project which means that first collaboration experiences within the project and among the participants had already taken place. Therefore, relying on a background of experiences that started ten months ago (plus the general experience of each participant), it was likely that expectations and attitudes towards/about the OKS had changed and were more mature in comparison to the first workshops.

Whereas the first two workshops were part of the diagnostic phase within the action research cycle, the general meeting (Kassel) already marked the beginning of the planning phase. As stated before, a certain amount of time was needed in order to provide an understanding of the context and purpose of the OKS, which was achieved by means of (a) the first two workshops; (b) asynchronous communication (email and Wiki) regarding certain community topics such as Online Journals, the OKS in general, tool usage (Wiki), etc.; and (c) practical experiences using the first tools (such as the Wiki and OKS Desktop[5]) and collaborating on certain tasks.

The general meeting in March therefore captured the current status of the diagnostic phase

5 http://wiki.opaals.org/OKSDesktop?highlight=%28CategoryOKSDesktop%29

(at that point of time) and integrated the first concrete planning activities of the planning phase with the pre-structured and planned activities formalised in the project's Description of Work. The status capturing was triggered firstly by a discussion paper which had been produced by the task T10.7 team with collaboration from researchers in the visualisation domain (Tampere). The discussion paper had been disseminated 10 days before the meeting took place with the announcement that the paper's rationale was to be the precursor of this deliverable and that it should bootstrap a discussion on the OKS among all project participants and integrate the results of this discussion. This discussion took place during the plenary session, where all members of the consortium present were invited to speak to their vision of the OKS. Everyone's statements were recorded and placed in MP3 format on the Wiki. Furthermore, notes were taken, which were also placed on the Wiki, where everyone was free to edit, adjust or add to their statements. Finally, an aggregation process took place, where an attempt was made to identify the places in which the many opinions expressed overlapped, and in which the various visions could be seen as shared. Although there were, of course, many differences in opinion and a diversity of views, it was necessary to pragmatically identify places of convergence and agreement, and to use those as a starting point. The broad human needs of “collaboration”, “communication”, “community” and “convenience” were identified from the plenary meeting in Kassel, should form the bedrock of our shared understanding of the community's current expectations of the first iteration of the OKS, and should be borne in mind during the discussion of the principles of online communities discussed in Chapter 2. In Chapter 7, we discuss in more detail the tools that users need and the corresponding requirements of the system, based on these four human needs.

Secondly, during the meeting in Kassel, first results from a survey among the OPAALS researchers were introduced. The survey had been conducted within WP6 and aimed to capture the researchers' different communication patterns, structures, and ICT usage. Regarding the appropriateness of different collaboration tools related to the OPAALS project, face-to-face group meetings were regarded as most appropriate, followed by face-to-face interaction and e-mail. This emphasis is not surprising, as other studies reveal similar results. Many-to-many electronic interaction tools as mailing lists and the OPAALS project wiki are also valued by the OPAALS community. However, the OPAALS forum and the chat programme were considered the least appropriate collaboration tools so far. As the reasons for using or not-using specific tools were not asked, further research is necessary in order to inform the development of the OKS.

Regarding the planning phase, during the general meeting an OKS Working Group (OKS-WG) was initiated with the aim of providing a structure to manage the development process of the OKS. In other words, parallel to the high-level, theoretical and philosophical approach towards understanding the OKS that is outlined in this deliverable, a low-level, practitioner-centred approach to its actual engineering has also taken place. The OKS-WG comprises of software engineers, computer scientists and social scientists and is informed by a user-focussed community of practice model. It will focus on practical and technological aspects of the OKS and leveraging its development and integration. A working paper is currently in development, which aims to critically engage with the vision of the OKS, and pragmatically plan for its implementation from both a top-down and bottom-up perspective (see our discussion of our epistemological approach in Chapter 3). The aim of the working group is both to discuss and debate the vision of the OKS at a high level, and to test and utilise it on a practical level in order to facilitate its ongoing development and uptake. Three sub-groups will focus on user-

testing and feedback of pre-release versions of the OKS, data-structuring and visualisation respectively. The results of the OKS-WG will be presented at the first OPAALS review.

2. Theoretical Foundations

In order to initiate a recursive process of knowledge creation within the OPAALS research network itself that will engender a self-sustaining and self-renewing process of research and innovation, we need to address as a first step in this theoretical foundations chapter the specific concepts and principles of 'knowledge' that are applicable to OPAALS. Regarding the OKS, the two overarching focal points are collaborative knowledge creation/production and knowledge management. A broad resource of studies discusses and deals with the definition of knowledge and how knowledge is “created”, “fostered”, and “protected” in scientific contexts (see for example Bos et al., 2007). Likewise, knowledge creation and management are important topics in the field of organisation studies and information management, addressing the goals to optimise a company’s performance and competitive edge by creating knowledge networks.

2.1 Knowledge and Information

Based on feedback from the discussion paper (see Chapter 1.2), this section starts with the two overall questions: “What is knowledge?” and “What is the difference between knowledge and information?” The question about knowledge definition is a live debate for philosophers and researchers. There is no single definition of knowledge on which researchers and philosophers would agree, but rather numerous theories and continued debates about the nature of knowledge. Therefore, these questions can hardly be answered exhaustively in this deliverable. Consequently, the following sections will discuss the most important aspects for the definition of principles of the OKS according to the authors of this deliverable.

Historical roots of knowledge definition rely on the work of two philosophers: Plato and Aristotle. Aristotle discusses in his work “Posterior Analytics” topics of demonstration, definition, and scientific knowledge. Plato defines three criteria that need to be fulfilled in order to identify knowledge (Bostock, 1988):

- A statement must be justified,
- a statement must be true,
- a statement must be believed.

Regarding knowledge definition and management, there exists the differentiation between tacit and explicit knowledge. Tacit knowledge is knowledge that is hard to encode and communicate (Polanyi, 1967). It is personal, context-specific and hard to formalise (Nonaka & Takeuchi, 1995).

According to Hey (2004), explicit knowledge can be encoded and is transmittable in language. Several researchers have explored different forms of tacit knowledge. Yang (2003) for example, considered that knowledge is about understanding reality through mental

correspondence, personal experience and emotional affection with outside objects and situations. Hence, there are three interrelated facets of knowledge – explicit, implicit and emancipatory (Williams, 2007). Styhre, on the other hand, argues that the distinction between tacit and explicit knowledge is a "false problematization because, in practice, they are inseparable. Instead, knowledge is an assemblage of cognitive capacities within which intellect and intuition represent different forms of thinking. Moreover, knowledge is 'always an unstable, fluid, rather elusive capacity to know, to do, to think things'" (Styhre, 2004, p. 185).

Knowledge incorporates concepts and is expressed by means of language. Therefore, interdependencies between knowledge and language are essential for the definition itself. Hey (2004) defines knowledge as generally personal, subjective and inherently local. Knowledge is internalised by the "knower", and as such is "shaped" by their existing perceptions and experiences (p. 9). In contrast, explicit knowledge is that portion of knowledge which is encode-able, storable, shareable and transferable.

Moser, Mulder and Trout (1998) differentiate between a priori and a posteriori knowledge. The difference between a priori and a posteriori knowledge is "the function of experience in the justification of known propositions" (p. 17).

The social significance of language, writing, printing, data storage etc. are significant factors in symbolical knowledge representation and providing of objectified knowledge. Stehr therefore demands to regard knowledge as a capacity for social action. In this sense, knowledge can be seen as an universal phenomenon, or an anthropological constant. In the context of knowledge creation, Stehr (1994) defines three categories of knowledge produced by the scientific community:

1. Meaningful knowledge: The knowledge of most of the social science disciplines and the humanities is knowledge which in its primary social function affects mainly the (social) consciousness of members of society.

2. Productive knowledge: Most of the traditional disciplines in the natural sciences generate productive knowledge in that such knowledge can be converted into ways of directly appropriating natural phenomena.

3. Action knowledge: The most recent form of knowledge, as an immediate productive force, may be considered to be action knowledge because such knowledge is already a direct form of social action. (p. 100)

The next question has to be whether it is still possible and sensible to distinguish between information and knowledge. Foskett (1982) defines knowledge and information as follows:

- knowledge is what I know
- information is what we know (p.1)

Stehr distinguishes the difference between knowledge and information in the context of action and function. Knowledge constitutes a capacity for action and allows an actor to generate a product or some other outcome. But knowledge is only a necessary and not a sufficient capacity of action:

> The function of information is both more restricted and more general. It is more general

> because information is by no means as scarce as is knowledge. In addition, access to and the benefits from information are not only or as directly restricted to the actor or actors who come into the possession of information. Knowledge use is more restricted and more limited in its use-value because knowledge alone does not allow an actor to set something into motion though information may be a step in the acquisition of knowledge. (Stehr, 1994, p. 120)

Therefore the distinction between information and knowledge adopted in this report is:

- information is accessed or accessible,
- knowledge is 'learned' and contextualised.

2.2 Knowledge in Organisations

Knowledge has occupied philosophers and sociologists of science for several hundreds of years and only recently have organisational researchers started to investigate this topic (Orlikowski, 2002, p. 250). Orlikowski (2002) discerns two different approaches to knowledge in organisational studies. The taxonomic approach is based on the notion that different types of knowledge can be identified. It is based on the classical distinction between tacit and explicit knowledge (Polanyi, 1967). Explicit knowledge is easily to articulate and to express formally and in clear terms, whereas tacit knowledge is personal knowledge which is embedded in individual experiences. Tacit knowledge therefore involves factors like beliefs, perspectives and values (Paavola, Lipponen & Hakkarainen, 2004; see also section 2.1).

Another taxonomy was developed by Blackler (2002) who identifies (building on a taxonomy by Collins [1993, 1995]) five different types of knowledge. Knowledge can be embrained, embodied, encultured, embedded and encoded. Embrained knowledge is knowledge that depends on conceptual skills and cognitive abilities. Embodied knowledge is action-oriented and is likely to be only partly explicit. Encultured knowledge refers to the process of achieving shared understandings, while embedded knowledge is knowledge that resides in systemic routines. Encoded knowledge is information conveyed by signs and symbols. Traditional forms of encoded knowledge are books, manuals, codes of practice. “Stickiness” or “leakiness” of knowledge (Brown & Duguid, 2001) refer to a different framework for the categorisation of knowledge. Some “forms” of knowledge appear to be sticky and are not transferable to other units within organisational settings while others seem to be leaky and travel from one organisation to another (which is normally not intended by the management of an organisation). The variety shown here implies that the issue of knowledge within and across organisations is very complex (Blackler, 2002).

Probably the kind of knowledge the OPAALS community will create is conceptual in its characteristics, for example models, theoretical reflections. In a second step this “formal”, explicit knowledge can be adapted to reach practical goals.

The aforementioned approaches to knowledge are critically debated and challenged by many scholars. Especially western culture emphasises the importance of explicit formal knowledge. However, this emphasis is criticised as knowledge should not be conceived as a timeless body of truth that experts have internalised (Blackler, 2002). Cognitive anthropologists, ethnomethodologists and other scholars regard knowledge creation as a cultural process.

Brown & Duguid (2002) coin this approach with the suggestion to look “at knowledge through the prism of practice – the way in which work gets done and..., knowledge is created“ (p. 200). By focusing on “knowing”, rather than “knowledge”, the distinction between knowledge and learning is avoided (Blackler, 2002). This approach might complement the understanding of organisational effectiveness by highlighting the important role of situated action in constituting knowing in practice. Individuals are understood to act knowledgeably as a routine part of everyday activity (Orlikowski, 2002). Blackler (2002) suggests addressing the academic debate from the viewpoint that knowing is mediated, situated, provisional, pragmatic, and contested. Rather than focussing on the different types of knowledge, attention should focus on the systems through which knowing and doing are achieved (Blackler, 2002, p. 59).

- Knowing is situated: this concept emphasises the significance of participants’ interpretations of the contexts within which they act.
- Knowing is also provisional, which means that knowing is developing.
- And knowing is pragmatic: collective action is driven by the conceptions people have of the object of their activities.
- Finally, knowing is contested: concepts of power and knowledge are interrelated.

Blackler (2002) suggests that knowing should be “studied as practice, and practice should be studied as activity that is rooted in time and culture” (p. 63), which, finally, refers to OPAALS overall interest and Action Research Approach.

2.3 Knowledge Communities and Creation

Since the emergence of the internet, the notion of communities, especially online communities, has become widespread (Rheingold, 2000; Orlikowski & Yates, 1994; Hemetsberger & Reinhardt, 2006; Ducheneaut, 2005; Wenger, White, Smith & Rowe, 2005). When dealing with communities within the organisational studies domain, the “community of practice” concept is often applied.

According to Wenger (n.d.) “communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (p. 1). It is a group whose members engage in sharing and learning based on common interests. Communities of practice can be identified by a shared domain of interest. Members of communities of practice engage in discussions, help each other and share information (Lesser & Storck, 2001). Relationships are enabled that help them build a community and shared repertoire of resources, experiences, stories and tools and build a common practice. According to Wenger, the domain, the community and the practice together build a community of practice. The practice is developed through a variety of activities as, for example, problem solving, requests for information, seeking experience, reusing assets, coordination and synergy, discussing developments, the documentation of projects, visits, and the mapping of knowledge and identification of gaps (Wenger, n.d., 2f.).

In recent years, ICT has facilitated the development of communities of practice whose members are not co-located. Communities of practice are becoming recognised as valuable organisational assets and “overcome the inherent problems of a slow-moving traditional hierarchy in a fast-moving virtual economy” (Lesser & Stork, 2001, p. 832), being recognised as a means to share knowledge outside of organisational boundaries and to develop an

organisational memory.

Regarding the OPAALS project, the “community of practice” concept's advantage is that it is open for anyone who can contribute to the development of knowledge concerning a special domain.

In contemporary organisational theory three additional models of innovative knowledge communities can be found: The first model is the model of knowledge creation (Nonaka & Takeuchi, 1995). The second one is the model of expansive learning (Engeström, 1999). Another model is Bereiter’s model of knowledge building (Bereiter, 2002).

These models present attempts to determine how innovative communities are and should be organised to facilitate advances in practices and knowledge creation (Paavola, Lipponen & Hakkarainen, 2004). Paavola, Lipponen and Hakkarainen (2004) show that, despite their differences, these three approaches have many similarities: Knowledge creation is not linear and requires sustained periods of time, nor is it correctly described by traditional narratives where heroic individuals are making discoveries. Indeed, knowledge creation is a fundamentally social process. New ideas and innovations “emerge between rather than within people” (p. 564). However the importance of individual activity is not neglected. This is why innovation or “intelligence” arises from systemic features of a whole community. Knowledge creation is not only a matter of individuals; epistemological processes require social processes.

2.4 Knowledge Management and the Role of ICT

The challenge of knowledge management is not only due to a multiplicity of different forms of knowledge. It is also important to clarify the interdependence between knowledge and the organisational context (Ciborra & Andreu, 2002). The previous chapter discusses several theoretical links to knowledge and organisation (knowing, communities of practice, etc.). When focussing on “knowledge management” systems we can conclude that different knowledge management systems are needed for different organisational contexts. The context of the OKS and the OPAALS community is an arrangement of universities, research units and multiple businesses. This means that knowledge does not belong to a single stakeholder and its boundaries are blurred. The challenge is how to manage knowledge in a floating and rather undefined context (Ciborra & Andreu, 2002).

ICT solutions and tools are often designed and adopted to support, facilitate and rationalise ongoing activities and expected to enable ways of working that are different and more efficient than others (Hanseth, 2002). When addressing knowledge management and systems that aim to manage its creation and sharing, the social context in which this takes place needs to be taken into account. In this process the development of ICT plays a major role.

Scientists are said to be early adopters of new technology (Bos et. al., 2007). Therefore, it is not surprising that there are many examples of ICT environments that were designed to facilitate communication and collaboration among scientists. Researchers that use online resources thereby facilitate a shift in the nature of scientific knowledge (Schroeder, 2006). Such developments are described with various terms, like for example cyberscience (Nentwich, 2003) cyberinfrastructure (Atkins et al., 2003), and e-science (Jankowski, 2007). According to Jankowski (2007) e-science embraces “many of the features commonly

associated with how scholarship is conducted in a network environment, utilizing Internet-based tools and involving collaboration among scholars often separated by large distances on a global scale" (¶ Introduction). The features, mentioned in the definition are international research collaboration, the use of high speed connected computers and Grid-architecture, visualisation of data, the development of Internet-based tools and practices, the construction of virtual organisational structures in order to conduct research, and electronic publication (Jankowski, 2007). There are several significant programs initiated under the umbrella of e-science. The vision is that new tools will produce new structures for communication and collaboration via networks, and will thus enhance research and enable new forms of worldwide collaboration (Schroeder & Fry, 2007). As Finholt points out, communication alone is not enough for dispersed scientific communities. Geographically distributed scientists also need data sharing and data exploration tools. One approach to enhanced data access is the concept of "collaboratories" (Finholt, 2003) which is a hybrid of 'collaborate' and 'laboratory' and defined as:

> An organizational entity that spans distance, supports rich and recurring human interaction oriented to a common research area, and fosters contact between researchers who are both known and unknown to each other, and provides access to data sources, artifacts, and tools required to accomplish research tasks. (Science of Collaboratories [SOC] research group, 2001, p.2.)

The development of collaboratories emerged when scientists recognized the potential presented by expanding national and international computer networks (Finholt, 2003). The greater size and complexity of research tasks is reflected in a higher need for collaboration. This trend towards an increase in collaboration can be found in all disciplines (see Finholt, 2003, p. 8).

One advantage of using ICT in science is that remote scientists can use tools such as email to connect with elite communities and therefore increase involvement by non-elite scientists in cutting-edge research. Sproull and Kiesler have suggested with their "peripherality hypothesis" that the introduction of new information and communication technologies may produce universal benefits, benefits for those who are privileged and benefits for those who are disadvantaged. Several studies in business settings revealed how ICT enables peripheral employees to gain access to the same activities and information as centrally located collaborators (Finholt, 2003). Some studies indicate that computer-mediated communication enhances scientific productivity and supports more dispersed collaborations (Finholt, 2003; Orlikowski & Yates, 1994).

Finholt (2003, p. 19) concludes:

1. Use does not need to be constant to provide value.
2. Systems that are easily integrated into existing work environments are more readily adopted.
3. Some domains of activity are more naturally inclined toward collaboration (data collection vs. contemplation, idea formation).
4. Long distance collaboration creates new expectations for participants, including altered roles.

The most significant barrier to the design and use of collaboratories is that practices and

routines assume a shared space. The reflexive development of the OKS provides such a shared space.

Bos et al. (2007) introduce a taxonomy of collaboratories. They identify seven types of collaboratories:

1. Shared instruments often provide remote access to expensive scientific instruments and are supplemented with communication tools.
2. Community data systems are information resources that are designed, maintained or improved by a geographically-distributed community. Information resources are semi-public. One example is model organism projects in biology.
3. Open community contribution systems are open systems that aggregate efforts of many geographically separate individuals toward a common research problem. The difference to community data systems is that the contributions are in form of work in addition of data.
4. Virtual communities of practice are networks of individuals who share a research area and communicate about it via ICT (see above).
5. Virtual learning communities aim to increase the knowledge of participants. However original research is not necessary.
6. Distributed research centres work like university research centres but at a distance. The centres are unified by topic areas of interest and joint projects in this area. Most communication is human-to-human.
7. Community infrastructure projects try to develop infrastructure to further work in a specific domain. 'Infrastructure' encompasses resources that facilitate science, for example software tools, protocols, new types of scientific instruments, and educational methods. Bos et. al. (2007) claim that such infrastructure projects are often interdisciplinary and bring together private sector contractors, funding officers, and computer scientists.

The OPAALS community and the OKS cannot simply be subsumed under one type of collaboratory. Aspects of all the listed types of collaboratories can be identified.

However, most of the collaboratories' outcomes failed to sustain participation, scientific breakthroughs, etc. Bos et al. (2007) provide three general explanations as to why knowledge management is so difficult to sustain in a scientific context. Firstly, scientific knowledge is difficult to aggregate. Scientists generally work with ideas that are on the cutting edge of what is understood and which in turn demand expertise. Another aspect is that scientific knowledge often changes very quickly making it difficult to manage across large distances and disseminate to large groups. Secondly, scientists usually work independently and tend to probably reject control mechanisms. Thirdly, the difficulty of cross-institutional work in relation to funding and intellectual property acts as a barrier.

Several studies explore both the constraints and the enabling factors of successful collaboration in interdisciplinary and dispersed teams.

Hara et. al. (2003) define a range of factors impacting on collaboration: compatibility, work style, writing style, work priority and other forms of compatibility ("chemistry"), work connections, incentives and the socio-technical infrastructure. A good fit of these factors

between several collaborators enhances the quality of the work.

Cummings & Kiesler (2005) conclude that so far there is a lack of clear guidelines to manage multidisciplinary collaboration. There is no theory of the “ideal” level of collaboration in multidisciplinary science. Results of their study reveal that the outcome of collaboration among many universities was smaller than when only a few universities participated in a project. However, work on tools and infrastructures such as software was not impeded by multiple disciplines and universities, where face-to-face supervision and coordination were of importance. The authors therefore suggest holding more project-related conferences, workshops, sabbaticals, and trips to other research sites. The use of communication technology like email, instant messenger, phone and video conferences did not result in added advantage for universities. Finholt (2003) also highlights the importance of face-to-face contact as an initial factor and also as a critical filter on scientific participation.

Drawing from their results, Cummings & Kiesler (2005) suggest that the following tools are required for successful collaboration across disciplines and distance:

- tools to manage and track the trajectory of tasks over time,
- tools to reduce information overload,
- tools for on-going conversation (perhaps some version of IM for scientists),
- tools for awareness with reasonable interruption for spontaneous talk,
- tools to support simultaneous group decision making,
- tools to schedule presentations and meetings across distance.

2.5 Online Communities: Principles and Dimensions

This section elaborates seven dimensions of online communities. As this field can be depicted as still evolving from a scientific point of view and being constituted by an intrinsically dynamic character (based on the ongoing development in the ICT field), a single and clear-cut approach which is applicable to any community does not exist. According to Preece and Maloney-Krichmar (2003) there is no commonly acknowledged definition of an online community. The authors cite the results of a workshop which identified several core characteristics of online communities: Members should share a goal, engage in repeated active participation and activities, have access to shared resources. In addition, there are policies to determine who has access to such resources, a reciprocity of information is important, and a shared context of conventions exists. When dealing with online communities, more characteristics can be found in the literature, for example roles, reputations, group identity, history, etc. Preece and Maloney-Krichmar (2003) argue that depending on one's perspective and scientific domain, different characteristics of online communities take-on different levels of importance. The following dimensions are a selection from the relevant research literature and practitioners' approaches in the field of online communities: communication, purpose, trust and identity, reputation, boundaries, history, and expression.

These dimensions of online communities, when present in a favorable way, indicate the health, potential and vitality of a community. They are underwritten by governance. Governance appears with respect to registration and moderation, for instance, and is obviously influenced by the cultural norms of the community (Preece & Maloney-Krichmar,

2003). All communities need to create and/or endorse a form of (self) governance; explicitly or implicitly agreed-to rules of association and interaction, at both formative and evaluative stages, as well as from both top-down and bottom-up perspectives. The OPAALS community has to develop its own governance procedures. Questions are: “What type of governance?”, “Should it be democratic?”, and “What kinds of policies and social procedures are needed?” (Preece & Maloney-Krichmar, 2003).

The discussion of these dimensions provide a transition to the “Models” section of this deliverable as it combines theoretical concepts, practical examples and transitions.

Communication

Communication can be depicted as being fundamental to community building as the basis of interaction and collaboration. Social cues of communication such as tone of voice, facial expressions and body language that are normally available in face-to-face communication represent a vital reference. In digital, non face-to-face communication settings these cues, key to community building, are lost; they need to be substituted. In fact, most discussions about online communities focus mainly on the digital tools that people use to communicate and not enough on the actual communication processes. Reduced Social Cues (RSC) research argues that participants in computer-mediated communication use contextual cues from the environment to make up for the absence of social cues (Wise, Hamman & Thorson, 2006). Baym (1998), for example, states that some participants use the frequency of messages as one such cue, other approaches to RSC suggest that timing of messages can serve as a proxy for a sense of social presence, as an indication of attentiveness or respect, and as a clue to the sociability of a community (Wise, Hamman & Thorson, 2006).

One could, however, argue that online collaboration and community building also (besides altering communication patterns) requires a shift in professional ethics and human dynamics. In online collaboration, it is likely that hierarchies become flatter and less layered. For the online collaborative environment to be open and transparent it needs to become more democratic in nature than, for example, an offline traditional meeting environment. This of course affects directly the communication processes of the community and needs to be mirrored in the changing processes, modalities and tools of communication.

Ultimately, the design of online communities is to be vital in stimulating participation. Although the question as to why they joined the community is not of primary importance for OPAALS members (as all researchers and administrators are automatically signed up to the OKS), the intrinsic reasons for participation (as opposed to “lurking”) are of great importance for a joint research project. Ridings & Gefen discovered, for example, that “across all types of communities, information exchange was the most commonly cited reason for participation. People want access to information that interests them” (Wise, Hamman, & Thorson, 2006, ¶ 4, cited from Ridings & Gefen, 2004). Within a network of knowledge production and management, it is not surprising that “information” is the main motivational factor. However, how can information be adequately displayed and communicated such that each member of the online community feels attracted and stimulated to participate? Certain surveys represent somewhat contradictory findings with regard to the aforementioned assumption that hierarchies flatten and become less layered online. One is that a moderated online community elicits greater intent to participate than an unmoderated online community. Moderators take on important normative functions such as keeping a conversation on topic (Wise, Hamman & Thorson, 2006). Frequently, the main role of a moderator is to prevent harmful attacks.

OPAALS is both an online and offline community. Its members interact and relate to one another in both the face-to-face and digital environments. This is likely to have an effect on the project's reputation-building processes as well as the ways people communicate with one another. The fact that people often know one another offline will affect how their online communications are interpreted, and could have a great impact on the dimensions of reputation and trust as potentially problematic concepts in the OPAALS community. It is important to bear in mind a simple truism, namely that we are not changing human nature but rather some processes, modalities and tools of communication.

Purpose

Communities are said to form around a shared purpose, they are made up of people who come together to do something that they cannot do alone. According to Porter (2004), online communities are "an aggregation of individuals or business partners who interact around a shared interest, where the interaction is at least partially supported and/or mediated by technology and guided by some protocols or norms" (Porter, 2004, abstract). Each community exists in order to accomplish something that is important to the people who are involved in an activity – and that they can do only, or best, as a group. If people do not have a compelling reason to come together, and if they are not provided with the means to accomplish that shared sense of purpose, the community is likely to fail.

There is a difference between people who have a shared purpose and people who merely have something in common. A community cannot be built around people who use Apple Macs, for example. Big corporations tend to try to build communities from teams that have something in common, but fail to think of a common purpose or a shared interest (Wenger, 1998). Important to note here is that one of the prerequisites for a community to flourish is that the purpose must be derived from an actual common need as opposed to an artificially created one in order to propagate usage of online tools. In the case of OPAALS, real-world activities will only flourish on the OKS if it satisfies the needs underpinning that/those purpose/s.

Trust and Identity

Social cues and communication modes in general define the way a community expresses itself, i.e. each community – including the OPAALS community – has a soul or personality that is shaped by its language and the different identities within that community.

A viable community environment among people also needs to be built on trust and identity. It is therefore vital that community members have consistent identities. Repeated encounters with consistent identities enable people to build communal trust, foster collaborative work, and assign different duties to each other, i.e. facilitate governance. Identity is different from reputation. Identity is based on who somebody says they are, whereas reputation is based on what somebody does and how others evaluate this. Reputation provides a context for members of a community to judge the value of other members' contributions. And trust is required for members to feel “safe” and confident while building their reputations. Both principles (identity and reputation) can only be established within a community or network. They foster interaction but also represent a community's tradition, point of view, and cultural background which can all be related to social capital theory. According to some social scientists, social capital is the glue that holds communities and other social networks together (Preece, 2002). Putnam (2000) states, for example, that social capital encourages collaboration and cooperation between members of a group for their mutual benefit and their

individual purposes.

Reputation

On Amazon.com members can vote on how useful they found another member's book review. On eBay, members can rate the quality of their experience with other members, and these opinions are aggregated into a “communicative symbol” for each member — a star of varying colour depending on their rating level. So reputation is important within a community, and a good reputation helps members to become established and to accomplish the community aims (here again is the notion of strong purpose). Making reputations, based on the overall rating of contributions, visible to others is also an effective way to encourage members' loyalty to the community.

In the context of OPAALS, symbols may not be an appropriate way to signify or display trust as it is currently not a particularly large community. Nevertheless, the practice of establishing reputations in other, more developed, online communities has demonstrated that it brings with it a sense of belonging and achievement to the ‘owners’ of those reputations. In successful communities (in fact we could even say in our daily lives) people are motivated by status symbols. It is hard to leave a place where you've become somebody important. Smart communities understand this principle. On eBay, the highest status symbol is a shooting star (which reflects 10,000 positive feedback postings from the community). Let us say someone has 9,500 positive-feedback points. Is s/he likely to leave that community and join another one, where they're a “nobody”, i.e. do not have an established identity or reputation?

If a community develops a way of awarding status that is visible to other members and therefore prestigious and desirable, people may be encouraged to strive to achieve it.

This is an interesting point in relation to the change in professional ethics and human dynamics that often occurs in online communities – the flattening of knowledge and social hierarchies. In the context of OPAALS, it will be useful to document members' current interactions with online tools, the frequency thereof for certain collaborative tasks, and then in a more informed manner understand and support the transition to online collaboration dynamics or a mixture of on and offline collaboration.

Boundaries

If membership of a community is indiscriminately open to anyone, then can it really be termed a community? Boundaries are necessary: Who can join? Who cannot? How do people join? Who decides whether they belong? There are many ways to define and implement boundaries (see for example Hess & Ostrom, 2006; Ostrom, 1990).

One reason for establishing boundaries is to ensure that the people who join a community are actually committed to taking part in it and share the common identity and sense of purpose. But even when the boundaries are defined clearly, not every member will actively participate. Participation rates are almost always the same: only 10% to 30% of a site's members are usually active at any one time. Another reason for establishing boundaries is so that they can represent an important demarcation line. Inside this demarcation or “framework”, the community can establish its specific language, communication practices and value system to establish a sense of belonging and stimulate a process of identity definition and shared purpose. But the boundaries cannot be too strict or rigid. Their flexibility needs to offer the possibility to “outsiders” to adapt to the community and become active members.

The community should allow members to discriminate between active and passive members. The community core team needs to accept that there will be passive members and work to identify and reward the more active participants by enabling the building of their reputation thus also enticing and facilitating the transition from lurkers to engaged participants. One way of approaching the challenge of boundaries and participation might be the tool of the "invitation", which could offer a powerful way of extending membership in a strategic and structured manner. Invitations should be personal in order to be effective, and custom requires that they are not ignored – a response is necessary in order to safeguard relationships and reputation. Invitations also set boundaries, as they are discreet and pointed, they are usually not open to everyone unless explicitly specified as such. A viral method of growing and managing the community through an "invitation only" strategy (which allows anyone invited who accepts to invite someone else and is therefore not completely closed and still democratic) may have potential for effective boundary expansion and management. This idea of "viral" growth and "management" of the community ties in with, for example, the idea of identifying synergies and contacting the relevant partners and inviting them to contribute to the OKS.

History

A sense of history is vital for an online community, especially as it grows over time. But forgetfulness is part of history too. It is easy for a Web site to "recall" everything that is ever happened there, however it could end up with enormous quantities of data with little practical value. The important question for a community is: How do we remember what we need to remember in order to develop a shared history? Members could decide, perhaps through a process of voting, to delete things that they think are no longer relevant. One might also choose to have only the most recent posts appear on the site, or develop a system for identifying what information is useful, up-to-date or just "aged". Member-generated content should be archived for historical reference; individual transgressions should have a statute of limitations. Members should be able to redeem themselves: A successful community learns from its mistakes.

Expression

Finally, every community needs to have a unique sense of expression. The expressive elements of the community could be tied in to its design and visualisation (see Chapter 5) as well as to various opportunities for members to express themselves through personalisation (see Chapter 4). The shape of the OKS should express the status of the community, and it should encompass the kinds of tools that allow members to express themselves too. Members need to have an easy way to check the pulse of the community or get an update at a glance. What topics are currently under discussion? Who's on the site now? How many people joined today? What are the top 10 hot topics of the week? Are we accomplishing what we're here to accomplish? This is also in order to express the community's work in progress to potential new members and existing lurkers. Expression is therefore linked to communication as well as identity, and in large part needs to be addressed from a design perspective.

With these principles in mind, underpinned by shared, co-constructed systems of governance, we are able move on to a definition of the OKS and an overview of the proposed approach to its development.

3. Definition of the OKS and Proposed Approach

This chapter marks the transition to the 'Models' section of Deliverable 10.5. As we move from the primarily theoretical 'Principles' to the more applied and developmental 'Processes' of the OKS, this chapter seeks to discuss the approach to a collaborative development of the OKS 'Model' as proposed by the team of task T10.7. To this end, there follows a general discussion of different approaches and then an introduction to first feedback results gathered from the OPAALS community. Thus, having used a knowledge-focussed basis to define some principles and paradigms for the development of the OKS, we now propose an approach for the development of the OKS, and put forward methods of fostering awareness and community building.

As pointed out in Chapter 1, an OKS Working Group has been established, and is tasked with implementing and testing many of the principle and models discussed in this deliverable. Although there will be inevitable slippage between high-level theorising and low-level implementation and testing, both the authors of this deliverable and the members of the OKS-WG seek to establish links between efforts on both levels (indeed, membership of OKS-WG overlaps with the authorship of this deliverable). Just as our theorising in this deliverable has been shaped and constrained by the empirical needs of our community; the implementation and processes put into play by the OKS-WG is shaped and constrained by the principles and theoretical models that form the basis of our collective action-research. In many respects, the first step of the OKS-WG is to select principles to shape its structure and guide its processes (the following steps respectively, which will roll out parallel). Many of the structures that have emerged from the OKS-WG are discussed in more detail in Chapters 4 and 5 of this deliverable. Here we discuss our approach to processes.

The OKS can be described as a set of tools, structures, processes, and social rules aimed at enabling the formation of communities and the creation of knowledge. It is the place where community members can collaborate and contribute to the creation and sharing of knowledge and can search and access information and knowledge.

It is neither merely a set of tools and a passive infrastructure, nor simply a content repository, nor only a collection of documents and text-based information. The OKS is more than the sum of its parts : it is a knowledge platform that will contain content created by researchers in the language used by the community, and will be an active and evolving environment which is continuously built and shaped by the users/community. The OKS can be used:

- As a means of collaboration on documents and deliverables,
- As a way to collaboratively define a research topic or item and arrive at a rich and consensual outcome,
- As a way to brainstorm and gather multiple views on a given topic,
- As a way to animate and manage the communities,
- As an ongoing recursive process of identifying, establishing and reinforcing professional/behavioural online ethics, and

- As a navigable, multi-dimensional living map (structured as a multi-layer ontological space and implemented as a distributed Google Earth-like 3D virtual space) of the relationships between the research concepts and activities, the people, and the institutions characterising the OPAALS community.

Of course, this is only a selection of possible OKS uses, through the work of the OKS-WG more applications may come to the fore.

Informed by the rich body of literature on knowledge in organisations (see Chapter 2), a process view to knowledge production and management is prioritised, and can be considered the bedrock to all collaborative tools and principles put forward. A process view emphasizes the value of how things take place in order to achieve certain goals rather than focussing exclusively on the achievement of the goals themselves. It is reflexive, inclusive and open-ended rather than outcomes-oriented, and particularly suited to a shared, collaborative approach to developing a knowledge model. A process view should also be considered the context within which tools are put forward, used and developed, community members participate and the entire OKS evolves. All research projects must specify their epistemological framework and rationale for their proposed approach. The former has been discussed at length in Chapters 1 and 2, i.e., located within a broad-based body of scholarship concerned with understanding the concepts and operations of "knowledge" and within the methodological praxis of "action-research", the latter is dealt with in the following section.

3.1 Proposed Approach

There are several routes towards defining and implementing Principles, Processes, and Initial Models for the Collaborative Development of the OKS. These approaches could be broadly simplified into those of the top-down and bottom-up variety. The easiest way, and perhaps the approach familiar to most researchers, would be the former, which would involve starting by defining the model and the ontology, or series of ontologies, or folksonomy used and then to implement a structure in which researchers may create their contributions. This approach has its advantages – for example, it is easy to understand and track progress, and facilitates making the knowledge ready for visualisation. However, as we have discussed, our approach to research is both participatory and action-oriented, and the epistemology of a top-down approach, such as “data classification”, is simply not appropriate for a project that aims to reach a state of collaborative knowledge development.

One way to achieve a balance between the two approaches is to shift the structuring of the knowledge up one "meta" level: from the structure of the knowledge to the structure of the team that will generate the structure of the knowledge. The latter is *not* the structure of the team that will generate the knowledge itself. The team that will generate the knowledge is the *community*, and it will need to find its own (surely dynamic and time-varying) structure through the on-going governance and knowledge production processes. The structure of the community and the structure of the knowledge will influence each other, making it impossible to predict ahead of time what form each will take.

Operationally, the various OKS Groups who, through a blend of social and design processes, will find a structure and will define knowledge formalisation processes for the OKS that are relevant *today*. Because they needs to be compatible with the principles already discussed, the structure and processes will embody the ability to change because they will be closely

coupled to the community itself. As the community evolves, the knowledge structure and production processes will change as well.

The unique knowledge characteristics of our project (it is interdisciplinary, transdisciplinary, inter-related and continuously evolving) insist that we select an approach that maximises researchers' abilities to create and share their own knowledge and contribute to the community's knowledge. It should reflect the evolving and merging aspects of the knowledge and not result in a space that will be either empty or unused; a space with an artificial ontology and structure rather than one that has evolved and emerged naturally from the requirements and the behaviour of its users.

In other words, our approach to developing the OKS needs to eschew an elitist top-down approach and favour a bottom-up, participatory, community-involved approach. Building an environment that focuses on its inhabitants (us, the users), and emerges according to our requirements and behaviours, requires collaborative decision making processes and active participation from as many users as possible (in our case OPAALS partners) instead of a top-down development of the OKS from a restricted number of partners. Yet our approach cannot entirely exclude top-down elements for both pragmatic and epistemological reasons. Pragmatically, a certain degree of leadership and project management will be necessary in order to ensure that a completely bottom-up approach does not lead to anarchic, out-of-control and uncoordinated efforts. Epistemologically, it is clear that binary oppositions such as top-down/bottom-up are too simplistic, and exclude the possibility of productive tensions and relationships between the two opposing sides. It is important therefore to make it clear that our preferred bottom-up approach is contextualised within an understanding of the need for various loose, open-ended and very flexible top-down nuances. An example is the organisational structure of the OKS development team, the OKS-WG, which will itself evolve over time in response to both top-down and bottom-up forces. Some others of the integrated top-down elements that we propose considering are discussed further in Chapters 4 and 5.

Russell and Norvig (2003, (pp. 262-266)) offer an approach to knowledge bases and ontologies within the broader field of Artificial Intelligence. Using the perspective of a knowledge engineer, they claim that any undertaking regarding knowledge bases can be started by using a seven-step process for the ontology development:

- Identify the task (i.e. decide what to talk about),
- Assemble the relevant knowledge (knowledge acquisition),
- Decide on a vocabulary of predicates, functions, and constants,
- Encode general knowledge about the domain,
- Encode a description of the specific problem instance,
- Pose queries to the inference procedure and get answers,
- Debug the knowledge base.

These steps illustrate a kind of integrated top-down/bottom-up approach – although there is a loose framework in place for guiding the process of knowledge development, a great deal of space and flexibility is left for community innovation, feedback and collaboration. Although it may appear contradictory, it is precisely the tension between the seemingly opposed approaches that may be most fruitful for a community such as OPAALS. In this sub-chapter,

however, we feel it most crucial to emphasise that an organic, community-driven approach forms the core of our approach and epistemological outlook. Although certain top-down elements may be unavoidable and certain teething pains may exist in facilitating bottom-up approaches, which may call for temporary top-down solutions, the bottom-up philosophy is prioritised and preferred.

In short, therefore, this approach for the collaborative development of the OKS is a process-oriented, community-driven option within a loose and dynamic organisational structure that is directly coupled to the community's governance process and is of greater relevance, value, scalability, and significance to members of the community, particularly those who have participated in its development. Naturally, the outcome of this democratic, collaborative and thus less structured approach is more difficult to predict and will also present some challenges in the visualisation and representation of the knowledge, as well as in the mobilisation of the community to participate.

From a technical as well as social perspective, the idea of a collaborative bottom-up model of development rather than a rigid top-down approach is sensible in the case of the OKS. The development of the OKS ontology should be considered a community responsibility and requires a degree of commitment from all members of that community. This ties in with Hepp's (2007) discussion of the requirements for building an ontology, which must balance top-down elements with bottom-up approaches (see Chapter 1).

To conclude, this bottom-up epistemology can be complimented with temporary, open-ended and community-ratified top-down measures, which may be necessary in order to encourage community uptake, participation and contribution to the building process. This will require the fostering of community awareness, which is discussed in the following section.

3.2 Fostering Awareness of Community Building

According to Wenger, White, Smith & Rowe (2005) a community faces three tensions. The first implies the experience of “togetherness” which extends through time and space. All members of a community contribute to community building by participating. The question is how this togetherness can be established without predominant face-to-face-contact. The second point is the issue of “multi-membership”. The OPAALS community won't be the only community its members will participate in and there will be significant differences in commitment among them. Issues of boundaries and trust and identity are challenged by this multi-membership. Thirdly, the role of “technology-mediated togetherness” is, especially for the OPAALS community, of high relevance. The OPAALS community is in its composition quite heterogeneous and locally dispersed. Therefore technology plays a major role as mediating factor. Computer-mediated communication can evoke a “community experience”, however a community is more than a collection of CMC-tools. Especially the literature dealing with organisational media choice emphasises the importance of collective perceptions of the appropriateness of different media in order accomplish specific tasks (Dobos, 1992; Sitkin et al., 1993; Bouwan & van de Wijngaert, 2002). Media choice shapes the “communication” dimension of online communities, as outlined in Chapter 2.4. There is the need for shared and agreed views on the appropriateness of different communication channels and media. This aspect also influences the perception of the purpose, and especially the trust and identity dimension. Lack of trust in specific communication channels or media might lead to the

application of “avoidance” strategies among community members (Dobos, 1992). Another crucial aspect may be the computer-literacy among community members. An example of an on-going discussion in the consortium that is compatible with these points concerns the definition and development of an online conferencing tool. The community is participating in the specification of such a tool, and the IPTI partner, who has much experience with Web technologies and has already developed a limited version of such a tool, will perform the implementation of the added functionality and its porting to the OKS platform.

However, not only technological aspects are of importance and may potentially create tensions for the development of the OPAALS community. Regarding communication, different communicative styles in different domains or cultures may appear to be problematic. Regarding the purpose, different expectations of the outcome might interfere with the success of the community. Chapter 2.3, dealing with academic communities and collaboratories demonstrated such critical factors.

Wenger, White, Smith & Rowe (2005) summarise the act of community as “a very creative act by which communities and their members invent ways of dealing with these tensions” (p. 2). These tensions appear in interacting, publishing, and maintaining; that is, in every aspect of community life. A community exists through the participation of its members. However usually it is one person or a small group of persons who “cultivate” the community. Wenger, White, Smith & Rowe (2005) therefore suggest “technology stewards” in order to find the technology the community needs. Although community members serve here as “gatekeepers” for technology choice, this approach seems to offer a hierarchical and somewhat “top-down” procedure which needs to be balanced with our bottom-up epistemology.

We propose to go one step further in fostering awareness of community building. It should be recognised that the idea of online community building may require a period of education and adjustment before it can be actualised and contributed to by all members. The reason for emphasising awareness, therefore, is to encourage keeping in mind the principles of online community building, now, at the beginning of the process, as well as throughout the process that will unfold. This is a pragmatic as well as team-building approach because, from a technical perspective, the identification and creation of solutions for user requirements necessitates that the users be aware of them in the first place, in order for them to be utilised and thereby assist the growth of the community of users .

Therefore, fostering awareness of community building is decisive for the emergence of a prospering OPAALS community. The question is to develop a framework that allows all members to contribute to the community building process, especially when considering the phenomena of “lurking” and “opinion leading”. Fostering awareness thus must be accompanied by (action) *research* and ongoing *reflection*. A mix of interviews and focus groups will provide appropriate methods for engaging these concerns. This is necessary so as to become aware of possible tensions. It is also in keeping with our overall action-research approach. As discussed previously, at present a Working Group and various other sub-groups have been initiated to focus on the practical and technological aspects of the OKS (see Chapter 1). Another valuable part of these working groups will be the study of community dynamics, social processes, and developing rules. Due to the overall action research framework, the results of the accompanying research will be made public to all community members.

To sum up, therefore, our epistemological approach to the development of the OKS is

process-driven, bottom up and reflexive, and framed broadly within the prerogatives of action -research.

4. An Ontology for the OKS

In this discussion paper on the Open Knowledge Space we have made strong explicit connections between knowledge and the users who create it. We have made an explicit claim that knowledge creation and community building processes are inextricably linked; that these processes need to be understood epistemologically as bottom-up and systemic. This could be said to represent a point of view on knowledge creation that is biased toward social science and is mainly analytical. This view is in many ways idealistic, and should be understood as a both a goal for which the community agrees to strive and a group of shared principles that will underwrite efforts towards achieving that goal. These theoretical principles, however, need to be applied with a pragmatic spirit, hence the creation of a preliminary architecture, which cannot help but be top-down in order to be workable and of benefit to the community that will eventually be able to shape and (re-)construct the system in a bottom-up, organic fashion. It is true that an epistemological gap exists between the bottom-up theoretical principles upon which we base our ideas of the OKS and the pragmatic architectures that we will propose in the chapters that follow. Yet this gap is partially bridged by a reflexive understanding that the apparent contradictions between these two epistemologies exist in dynamic tension – necessary in order to allow the OKS to be workable and to become a reality. In this chapter and the chapters that follow, therefore, we offer “meta-architectural” options. These are simply temporary top-down models and processes intended to bootstrap a bottom-up community-led process – the ultimate goal of the OKS. When speaking about the “knowledge model” of the OKS, we will always implicitly include the users, as individuals, institutions, and disciplinary domains. As such, the “knowledge model” will always also implicitly be understood as a precursor to and an integral component of the “knowledge process”. A knowledge process, in turn, will also always require and imply an organisational structure, albeit preliminary and temporary now, and flexible and dynamic eventually. It is this organisational structure that requires a degree of modelling in order to make the bottom-up emergence and collaborative development of the OKS feasible.

The emergence of an organisational structure can be understood as a universal process of institutionalisation that characterises the dynamics of all social groups. From a social constructivist point of view this phenomenon is associated with the formalisation of power relationships mediated by language. If allowed to develop spontaneously and unhindered, therefore, such a process can become an obstacle for democratic processes or knowledge production. A natural science metaphor throws some light on a similar process: the balance between crystallisation (order, equilibrium) and randomised reconfiguration (chaos, constant variation) that biological organisms are able to strike is a fundamental requirement to remain alive. The "biological condition" can thus be characterised by its ability to harness its perpetual "falling" *toward* equilibrium as an "engine" that drives order construction processes in the presence, however, of a constant flow of energy, mass, and information that maintains the organism perpetually *far* from equilibrium and able to adapt to changing environmental conditions. The three characteristics of living systems that we are interested in highlighting here therefore are: (1) crystallisation, (2) randomised reconfiguration, and (3) openness to new materials, energy, and information. Similarly, communities' organisational structures – in

the case of OPAALS the OKS – need to strike a balance between the self-organised emergence of top-down power structures and 'chaotic', randomised bottom-up processes of reconfiguration in the presence of openness to new members and points of view.

From the social constructivist viewpoint the constraints on the knowledge production processes brought about by spontaneous institutionalisation processes could imply a constraint on the social dynamics, and therefore a possible erosion of the democratic processes themselves upon which the community is based. It is therefore important (1) to acknowledge the emergence of power relationships and hierarchies as a direct consequence of the mediation of social interactions by language and communications; and (2) to devise a governance process that can maintain the dynamics of the community "far from equilibrium". In other words, an open community will allow a constant flow of members and ideas to influence its internal knowledge production and decision-making processes. Such a constant flow of "new blood" will counteract the encroachment of incumbents and the formation of monopolies on any aspect of the knowledge or the community. The mechanisms by which the "counteraction" is achieved depend on transparency and accountability. The former depends upon and reinforces trust, the latter implies a process of formalisation of behaviour and its comparison with a shared memory of agreed principles of behaviour. Such a shared memory implies a rudimentary form of collective intelligence. We therefore see how the processes of formalisation of knowledge necessarily must begin with a fundamentally reflexive activity of formalisation of community through a transparent and open governance process. Although individual and collective behaviours are neither always nor entirely predictable, the ongoing formalisation of certain organisational and (self-)governance structures will offer the possibility to balance such integral uncertainty. The dependence of knowledge production in a sustainable community on the formalisation of governance hints at the possibility to apply the same reasoning recursively as a general requirement of communities of practice, which could thereby evolve into epistemic communities. The next step in this line of argument would then be to attempt to extend the metaphor to autopoietic systems, but this is best done at a later stage in the project.

Put another way, both the static models and the dynamic processes will gravitate around the concept of community. In a sense, in this deliverable thus far we have established an Ontology for the OKS, where Ontology with the capital “O” is meant in the philosophical sense (i.e. not a computational ontology, of which more in the chapters that follow). The main concepts of our Ontology, so far, are Model, Process, Community, Organisational Structure, Equilibrium, Governance, Power, Mediation, Open, Flow, Transparency, Accountability, Trust, Memory, Collective Intelligence, and Autopoiesis .

As we descend from these philosophical heights towards the practial task of the realisation and reification of the concepts, principles and processes, we realise that knowledge creation, exploration, and retrieval is forced to rely on and requires a “technology”. Technology is placed in inverted commas because it is meant in the widest possible sense, encompassing everything from the boundary with human languages at the upper end to the P2P architecture at the lower end (we take the Internet and underlying hardware for granted). We could define a Technology as something that has some Structure and performs some Function, regardless of its level of abstraction. We find at all levels of human experience that structure and function are closely related. In biology they are very closely interdependent, to the point that they determine each other. Thus, while discussions about the importance of the OKS communities

and their processes are best served by a perspective which can be variously characterised as interpretive (hermeneutic), subjective, inter-subjective, social constructivist, phenomenological, socio-technical, etc., when we switch gear from an analytic to a synthetic viewpoint to ask, “How do we achieve all this?”, we cannot overlook the functionalist perspective that underpins most technical and engineering disciplines. In the meantime, we seem to have picked up a few more terms of our Ontology: Technology, Structure, Function.

Even though we are exploring Evolutionary and other biological bottom-up order construction processes for their potential ability to play a central role in the Self-Organisation properties of Digital Ecosystems, it is not clear yet to what extent they will be directly applicable to the OKS. In any case, we need to start building the OKS even while we are still understanding the biology and mapping its core concepts to computer science. Thus we need to bootstrap the OKS by enacting a more traditional Design process, which necessarily begins with a best-guess at the user requirements and relies on future iterations to achieve progressive improvements. Thus, proposing a structure for the OKS based on initial perceptions of high-level user requirements, which we might venture to call a high-level architecture, is a necessary complement to the community building and evolutionary bottom-up processes. Four more terms emerge: Evolution, Self-Organisation, Digital Ecosystem, Design.

To conclude, we can now bring in the final concept of our Ontology, that is capable of supporting all of the above: Language. We are of course concerned with both human languages and so-called formal languages. Figure 3 summarises a first stab at the OKS Ontology. The figure indicates the dependencies between concepts with arrows that also express a workflow. In other words, Language leads to Power, which leads to Organisational Structure. Adding Transparency, Accountability, Identity, and Trust leads to an Open Governance and Institutional Innovation process, which breathes new air in the OKS Community. The consequence of community renewal is the keep it open to the production of new knowledge. In the absence of Open Governance, the spontaneous (Self-Organisation) processes of institutionalisation would cause the OKS Community to "fossilise" making self-renewal more difficult and leading to rigid and hierarchical command and control structures. On the right of the figure a similar flow can be seen between more technical concepts and components, also depicted with thicker arrows. This second process is also important for the enablement of the self-renewal of the OKS Community.

Current research in WP10 is therefore also focused on understanding and defining the criteria by which knowledge, community and governance are interrelated, with the objective of transitioning from the project's current management structure toward a sustainable open knowledge community after the end of the project. In some respects, then, this ontology for the OKS is an acknowledgement that the preliminary phases OKS will be rolled out in a top-down manner, but it must be remembered that this is tempered by a holistic buy-in to bottom up principles and processes. It is a temporary solution in order to make the OKS workable and in order to create a starting block from which the community can (self-)organise ongoing iterations of the OKS as a tool for the collaborative creation and sharing of knowledge. We do not believe that these temporary top-down strategies conflict with the bottom-up principles upon which our efforts are based; again it is worth reiterating the dynamic tension between bottom-up and top-down approaches, and the holistic process view within which they are contextualised.

Feedback from the partners is needed to make sure this makes sense to everyone, or to

make adjustments/additions/corrections in the spirit of an open and accountable governance process enabled by trust, a shared memory, and an emerging collective intelligence.

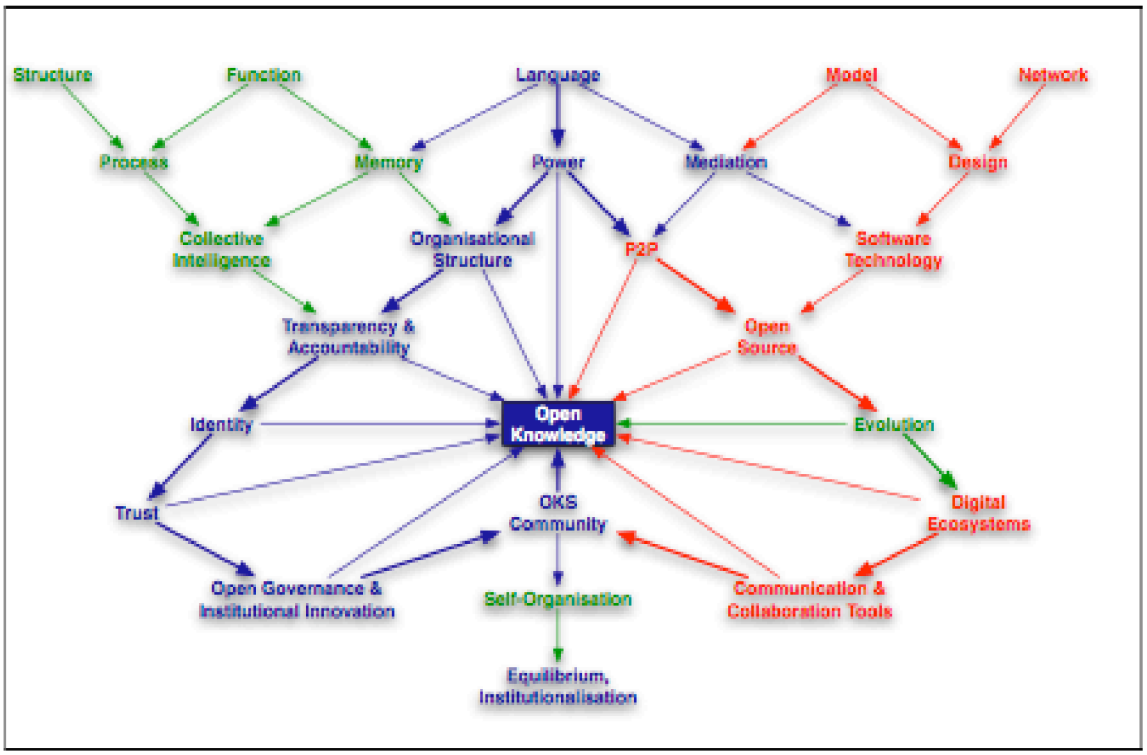

Figure 2: A first stab at a possible OKS Ontology

5. High Level Architecture of the OKS

At the Tampere OKS Workshop in October 2006, some very high-level concepts were discussed by the OPAALS community. One that seemed to make sense to most people was that there will be two principal modes of interaction between community members and the OKS. Although overlapping and interdependent, these modes can be summarised as “Write” and “Read” modes. The former will essentially allow the collaborative creation of knowledge, while the latter will allow that knowledge to be created, learned from and shared. “Write mode” can be associated with the OKS (both the web-based version and the Desktop) and other editing and collaboration clients, “Read mode” can be associated with sophisticated search and navigation tools. Both are closely associated with and defined by visualisation options.

These different modes need to have some correlation with access rights. Figure 3 shows the initial high-level architecture that was presented in Tampere.

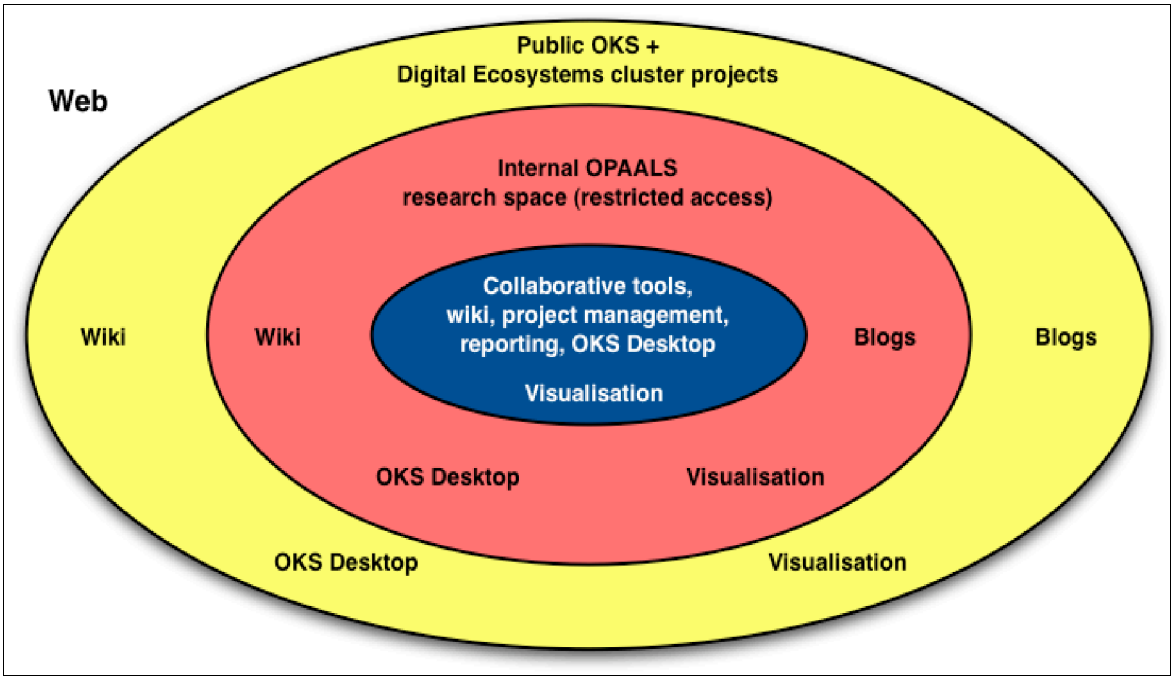

Figure 3: High-level architecture of the OKS

In terms of usage, the Write mode will be more closely associated with the inner project team, whereas the Read mode will be more closely correlated with the outer, public space – as shown by the concentric spheres in the figure above. This architecture is not set in stone; it is a suggested starting point, which will evolve and progress through feedback from and involvement with the entire community.

As mentioned in Chapter 3, a 3D distributed virtual environment similar to Google Earth may prove to be appropriate for the Read mode. The creation and visualisation of the computational ontologies[6] that such a navigation environment implies will need to adhere to

6 Knowledge and language are typically linked to a context (such as geography, sector or topic). Computational

the community-based principles discussed in order to avoid technologically deterministic outcomes.

This overall architecture may appear simplistic, but it should be read in the context of the extensive usage models described in the following chapter, as well as the user and system requirements listed exhaustively in Chapter 7. What connects this architecture, however, is an element that will shape the level of interaction between “Write” and “Read” modes as well as between members of the entire community, and eventually the OKS and the broader research community; this is visualisation.

5.1 Visualisation

An important part of the architecture of the OKS will be the way in which it is visualised, in other words, the way in which its functions and content are graphically *designed*. This is not to suggest that an “aesthetically appealing” visualisation of knowledge alone is synonymous with a thriving online community but rather to highlight the importance of the aesthetic structure of the OKS in its functionality. This is with regard to the actual hosting structure of the OKS as well as for modes of visualising the knowledge that it will contain. For the visualisation of knowledge to be effective in terms of supporting community building, it needs to suit the emotional needs of its particular target community and the conditions (trust, common purpose etc.) required by that community to grow.

For example, Kollock noted already in 1996 (discussing one of the first online graphical communities):

> It is telling that the most successful online graphical community at this time – WorldsAway – is also the system with the oldest and least impressive "look." […] The community succeeds not because of flashy graphics, but because it contains many of the requisite elements for a successful community: identity persistence, a sophisticated set of rituals, an internal economy with a monetary system, [...], a rich set of documents recording the history of the community, a coherent sense of space, casual interaction caused by the fact that one must "walk" most places, and a moderate level of risk. WorldsAway certainly has its problems and limitations, but the lesson of its success in creating a lively, elaborate social system is that there are design elements that can have an important effect on encouraging (though not guaranteeing) successful online communities (Kollock, 1996, P 2).

Although, as Kollock cautions, visualisations should not be considered a means to an end, effective visualisations can support online community building and the development of an architecture for the OKS in several ways. For instance, effective (i.e. commonly perceived as lively, inviting, intuitive, enticing, “sticky”) aesthetics (i.e. graphics, visualisations) can be seen as a means to increase the motivation to offer input to the community. As well as this, they can act as a reward for active community members who have contributed input, and can then enjoy seeing their contribution made visible in ways that demonstrate connections to other

ontologies were proposed around 1990 in the context of artificial intelligence research. They provide a formal and generally computable organisation of concepts based on meta-concepts such as inheritance, dependence, relationships ("property of", "is a"), etc. Semantic networks are the less formal equivalent, and class diagrams are the equivalent construction in an object-oriented software engineering context. They all provide a context for any one concept.

pieces of information and representations of knowledge in the OKS. Visualisations can also help community members to find and navigate interesting or “dynamic” areas of knowledge in the OKS, thereby also helping them to know where to contribute and in turn making their contributions easier for other members of the community to find. In a sense, visualisation can also be considered as a form of validation for the member's input, allowing them to evaluate whether the contribution had the intended effect in the OKS. Visualisation could allow for an increased awareness about current topics that the community is working on, what kinds of collaborations and processes are in existence, and generally what is happening in the community.

Visualisation therefore plays a significant role in the internal life of the community. It also plays an important role in the outward-looking life of the community. Aesthetic architecture will ensure that the OKS has an appropriate image within the broader research community, and help to attract new members. It can also play a role in setting the project apart and highlighting its unique contribution to research.

Another point worth making is that visualisations can be understood as stimuli that interact constructively with our cognitive processes. If this relationship between visual inputs and cognitive processes is indeed as common as it would appear, then the way we think about visualisation in the OKS could change from an arbitrary or subjective choice for knowledge representation to a more “absolute” and “objective” structure that is integrated into the way we think, similar to the syntactical and grammatical rules of language itself. It would be helpful if we could consider the possibility, therefore, that such visual “structures” may be legitimate representations of knowledge and knowledge creation processes. Again, although such visualisations may be correlated with a “top-down” approach, this is underwritten by bottom-up philosophies, with an ultimate goal of community-led and user-driven visualisation tools that will allow a wide range of visualisation options to be available within the OKS.

In a pragmatic sense, this implies that the OKS will need to be “designed” from a visual, aesthetic perspective parallel to its architecture from a software perspective, and its construction from a community knowledge-making perspective. The “look” of the OKS must not be considered an accessory to the structure, but an integral part of the structure itself. Again, although “design” is traditionally a top-down process, it will be important to integrate bottom-up and open-ended approaches to this element of the architecture, such that all members of the community are invited to participate in visualisation, either of their own contributions or of their personalised versions of the OKS.

6. Usage Models

This chapter will address various usage models and scenarios for the OKS and it marks the focus on Models that this Deliverable points toward in its title.

Figure 4 shows a representation of the OKS biased toward tagging. In this approach, every piece of information needs to be tagged using either an ontology or a folksonomy. This enables better management of the content and easier forming of the context of each knowledge asset such that users can make the most of them. Some tags will be system generated to facilitate the better management of the knowledge base, and will also allow access to information such as the latest peer reviews, the experts that have contributed, the age of the content since the last review, the number of times accessed, in which context, etc.

The method that will be used to tag the knowledge in the OKS will be highly dependent on the context on the day on which the tagging takes place. The combination of tags will help semantically describe the knowledge, which will help the user to access the most relevant knowledge and also to use the semantic meaning of the tags to retrieve similar knowledge assets from different sources. As the tags used will be meaningful on the day of the tagging, it is possible that specific combinations of tags may not mean the same thing in the future. This could be due to the emergence of new words or new meanings due to changing social contexts (for example, the word “wireless” meant “radio” some decades ago, it now refers to wifi, GPRS or the interoperability of devices that are not physically cabled). A similar analysis could be done for languages in various other sectors and disciplines. Our challenge is to link the meanings of tags used over time and across communities. This challenge will require much more analysis and invites contributions from the various disciplines and researchers of the OPAALS community.

The architecture will offer a specific tool for each main functionality of the knowledge life cycle (from creation to management to tagging and to keeping it up-to-date). Feeds will also be tagged as knowledge assets, thereby enabling them to be retrieved as objects themselves. Specific tools will help the management of the community, including the reputation and roles of members and the overall purpose of the community. Community members also become knowledge assets at the same level as the other *“knowledge assets”,* and therefore will be tagged too.

The rest of this chapter will present some usage cases in more detail:

- Accessing, navigating and searching for information in the OKS,
- Contributing to the information to the OKS,
- Personalising the user interface,
- Use of the OKS by an extended community.

The usage cases are based on the following proposed information architecture. This architecture has be defined from the analysis proposed in this document on the needs for the extended community and future communities that will use the OKS. It takes into consideration the requirements around an evolving and self-sustaining ontology for the structure of the information and data that will be stored and managed within the OKS. Due to the nature of the

information which is unknown and undefined at this stage as it will be based on future research, there cannot be a pre-defined and pre-determined structure. In this context, a self-emerging and self-managed structure based on a folksonomy is recommended. Also, as a folksonomy is self-sustained, and emerges from the needs of the community, it is more likely that this ontology will provide a more appropriate way of navigating and will avoid both the "empty room" and "junkyard" syndromes.

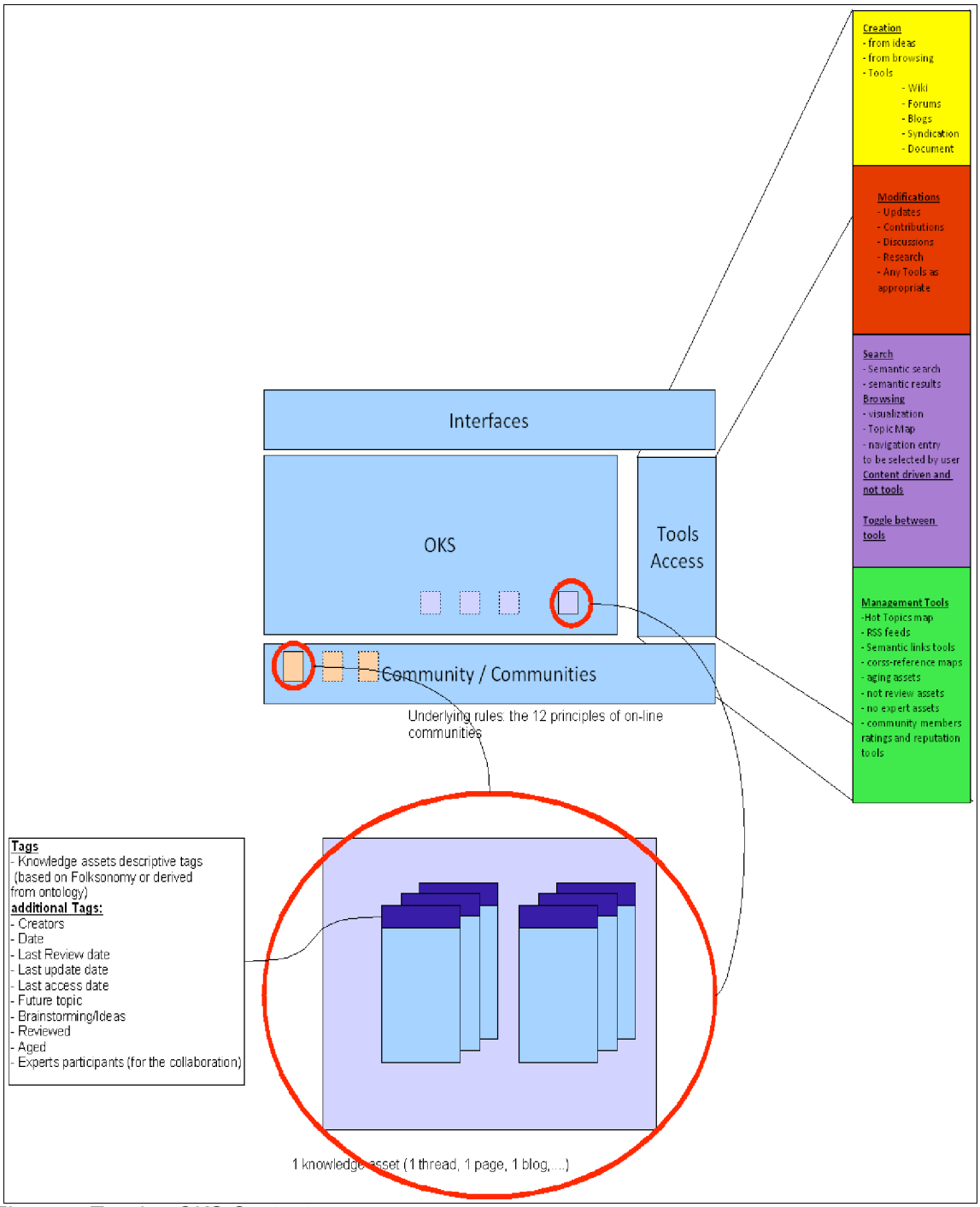

Figure 4: Tagging OKS Content

The OKS will also need to implement and facilitate the tools and processes that will help realise the principles of on-line communities, and enable the communities' members to start working collaboratively. The principles determine constraints and requirements for the architecture of OKS. The information architecture proposed in Figure 5, defines only the type of data structure that will enable the implementation and the development of functionality of the OKS.

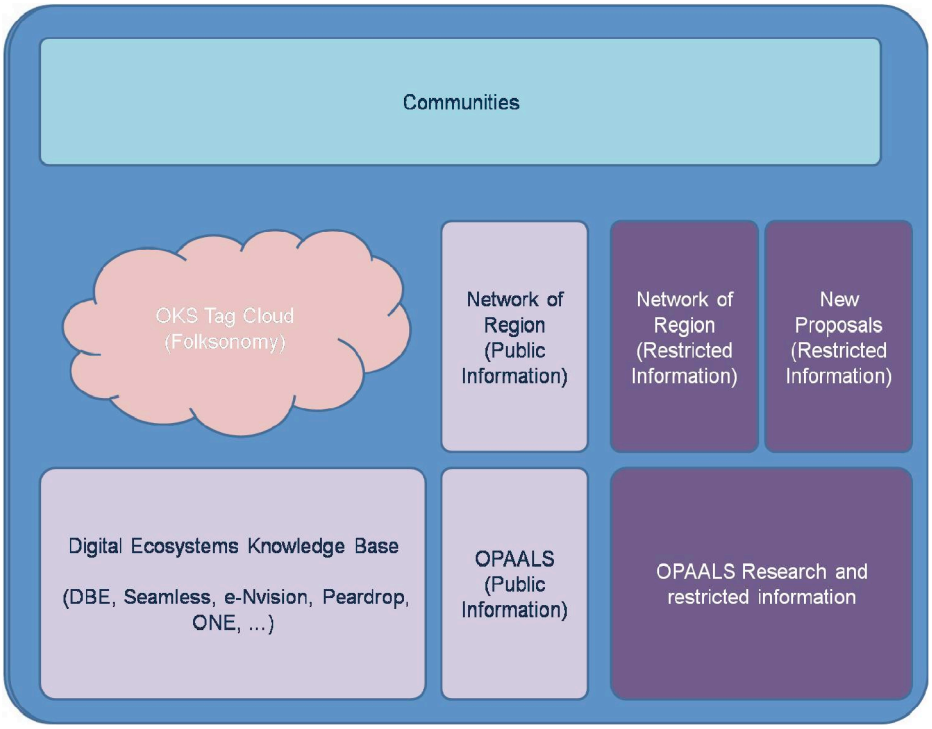

Figure 5: Information Architecture

The common Tag Cloud is the representation of the folksonomy and can be used to describe all the information in the OKS. In the bootstrapping phase, the Tag cloud can mainly represent the knowledge of the research areas of OPAALS and the information of the Digital Ecosystems cluster. This tag cloud (folksonomy of the OKS knowledge) can be used to search the OKS and navigate in the OKS, as will be described in section 6.1.

Using the folksonomy to describe the information in the OKS would enable the searching of information so that ALL and ONLY the relevant information is retrieved for the different members of the community. There is no need to know where the information is located and which tool to use. With folksonomy, there would be little overhead management needed to keep it up to date and relevant.

Tagging the knowledge i.e. aiding the finding of knowledge, and navigation to it using the tag cloud is only one category. Here we will only address some of the principles of on-line communities, discussed in Chapter 2.4. A high level additional tagging structure is identified as necessary, including, specifically “systems tags” and “expert tags”.

The **systems** tags can be generated automatically by the OKS. These can describe dates,

names of contributors, changes, type of tool used to define the contribution, number of times viewed and accessed, number of times referenced (linked from), and numbers of links to additional content. These tags can help address, for example the ***history*** principle. It will also allow for a ***traceability*** of the knowledge.

The second category is **expert** tags, which can be assigned by experts that would review the contributions. These tags can help address other principles such as ***trust*** (partly), ***relevance***, ***reputation*** and ***purpose.*** Expert tags can be used, for example, to add comments, rate the contribution, rate the contributor (indirectly), rank the status of the contribution, note missing references, highlight paragraphs that need more work, rate relevance, and suggest additional tags.

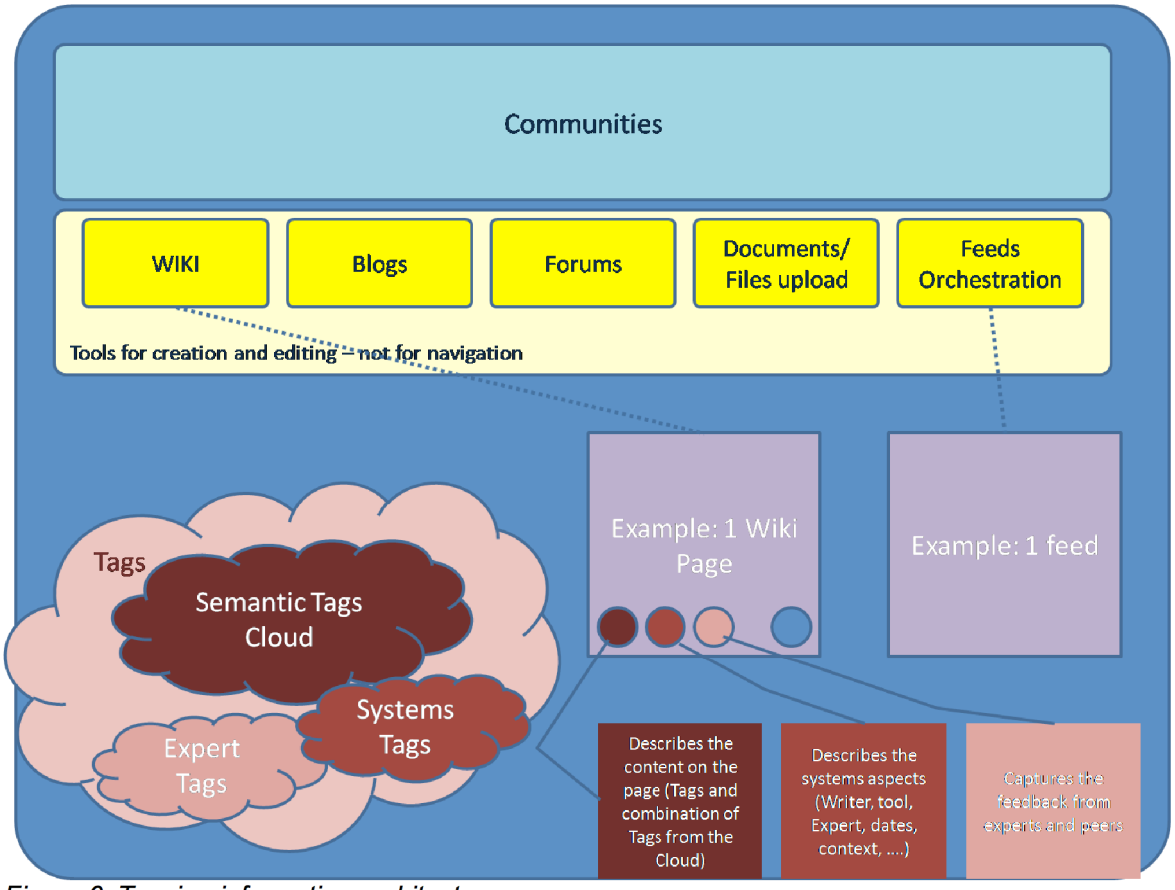

Figure 6: Tagging information architecture

Although governance guidelines with regards to how these experts are selected can and should emerge from the community itself, it is clear that preliminary qualities are as follows:

- Each expert must be a **recognised** community member. This means that they can be nominated by the community and/or that their overall contributions have been highly rated by the community.
- The **area of expertise** will be allocated using the ta**gs defined in the folksonomy**. These tags can be either defined by the community, by the expert or based on the history of contribution/rating/reputation

This is not to suggest that other members would not also be able to add their own experts' tags but to ensure that some experts take responsibility for tagging, which would be in the interests of the entire community. All ratings, suggestions and comments would be classified as community feedback. All of these would feed into the reputation of the contributor(s).

The ***reputation*** of the members could be derived from such factors as:

- Overall number of contributions
- Area of expertise
- Overall rating (quality) of contributions
- Overall relevance rating of contributions
- Activity in the community (peer reviews and expert reviews)

As well as contributing to the reputation of each member, the tagging architecture would support the navigability of the OKS, as discussed in the next sub-section.

6.1 Accessing, Navigating and Searching

This usage case is probably the most important as this is the way that researchers and users can access the knowledge base contained and managed by the communities.

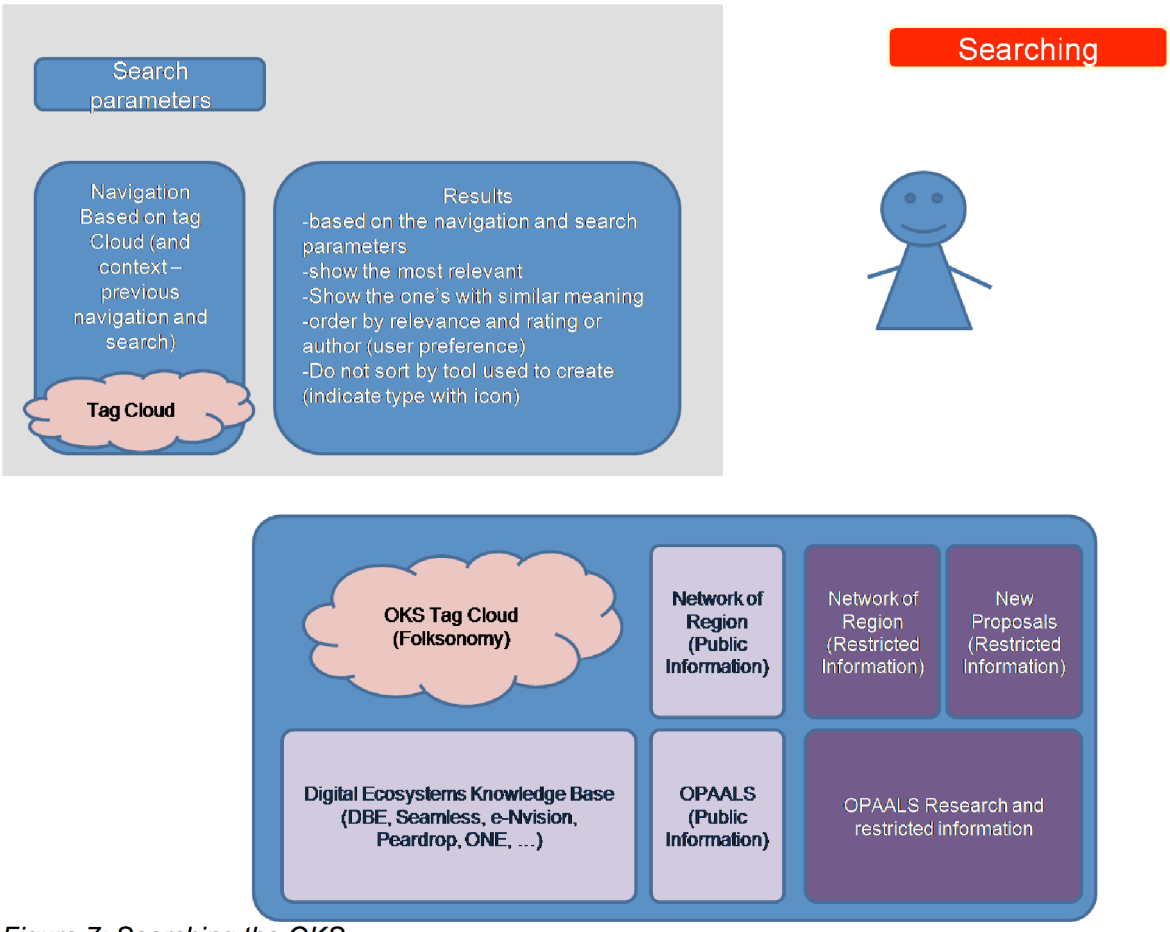

Figure 7: Searching the OKS

This search and navigation should not be based on the tools used to create the data but rather on the information itself. There are three ways to access the required knowledge:

- Searching using the ontology or the tags cloud,
- Navigating by using the visualisation (based on the ontology/tags cloud),
- Combining the above two methods: for example the initial search could be done using search criteria and then the navigation based on the visualisation can be used to refine the results.

The search process can be envisioned as appearing in two forms. The first would be the form of community Tag Clouds, or the ontology as defined by the overall community. The second would be a personalised ontology - “my tag cloud”, based on the profile of the user, his/her interests and recent searches.

The search criteria can be either typed, in the form of free text input, in the search box or selected on the tags presented in the Tag Cloud. The cloud would reflect, using size, clicks on the required tags. As the search is refined, the tag clouds presented to the user would change to reflect the current context as well as display the number of articles and assets available. Once all the search criteria have been entered/selected, the list of relevant articles, assets, documents, feeds are displayed. The user would be able to sort the list by diverse variables, such as, contributor, rating, relevance, and reputation of the contributor. Additional information, such as external links based on Google searches and semantically related search results can also be included. It would be possible to “enlarge” the search results by eliminating the tags and search text, as well as navigate from the search results to to all linked articles, contributors and networks, ranked from most to least relevant.

The alternative way to find information could be based on a visualisation engine. This engine should represent the tag cloud (and if possible other attributes such as the contributors). As the user travels in the navigation, the information extracted from the tags cloud changes and allows the user to travel further in the knowledge base.

This usage case presents some challenges as there is a need to have flexibility for the researchers to enable them to access the most relevant information to suit their needs. The main assumption is that the Tag cloud (the user defined and managed ontology – e.g. the community folksonomy) is up-to-date and well maintained.

This is the aim of the next use case: contributing and managing the information and knowledge of the OKS.

6.2 Contributing knowledge

The creation, as well as the updating and amendment, of knowledge can be done using the tools made available to the communities.

As this action can be carried out after a search, or a navigation based on visualisation techniques based on the knowledge structure, it is important to acknowledge that the modification and addition of information is ***not*** **done by navigating using the tools**. In fact, it is achieved by finding the information and then the OKS should select the appropriate tool to edit this information (for example, when the information has been initially created using a wiki, the system selects the wiki tool to edit it).

Once a new piece of information has been created, and in order to allow the communities to find and access this information, the user adds semantic meaning by assigning tags to the asset. The contributor can use the Tag Cloud to do so, and selects the most relevant tags for his/her information. The system should help him or her to select the tags based:

- On his/her profile (area of interest, latest contributions),
- On the context (after a search or navigation, the system should recommend the tag used to define his/her search for the description of the contrition),
- On the community tags association, as the user adds tags, the system should recommend the most used association.

As the data organisation is based on folksonomy, the community can create the overall folksonomy structure over time. When adding a new contribution, the user has the possibility to add tags and combinations of tags, to describe their contribution. In this way, the folksonomy structure can evolve for the benefit of the community and also update the contributor's profile. This enables the growth of the tag cloud, and indirectly of the OKS knowledge base, the self structuring of the information, and an evolving navigation based on the cloud.

The contributor is able to add contributions using various tools, including the Wiki, their blog, the document repository, feeds, chats and forums. He/she can add a variety of content, including documents, multimedia assets and even records of conversations and chats.

In the diagram, several colours has been used to describe the various types of tagging. This is described in the overall data architecture section of the document.

6.3 Personalising the experience

Different users will come from different communities and have different interests and needs. One of the weaknesses of the web is that it is very difficult to personalise pages.

In the OKS, based on the searches performed and the interests of the users, it must be possible to personalise page views, and create mashups so that all the topics of interest to the viewer can be displayed in a manner most useful to the user. The content needs to be updated dynamically. There is no restriction to this: many pages can be created and feeds orchestrated using several information concentrators (or portal pages). Each component of the page can be set up by the user and have search criteria relevant to the research and personal purpose of each user.

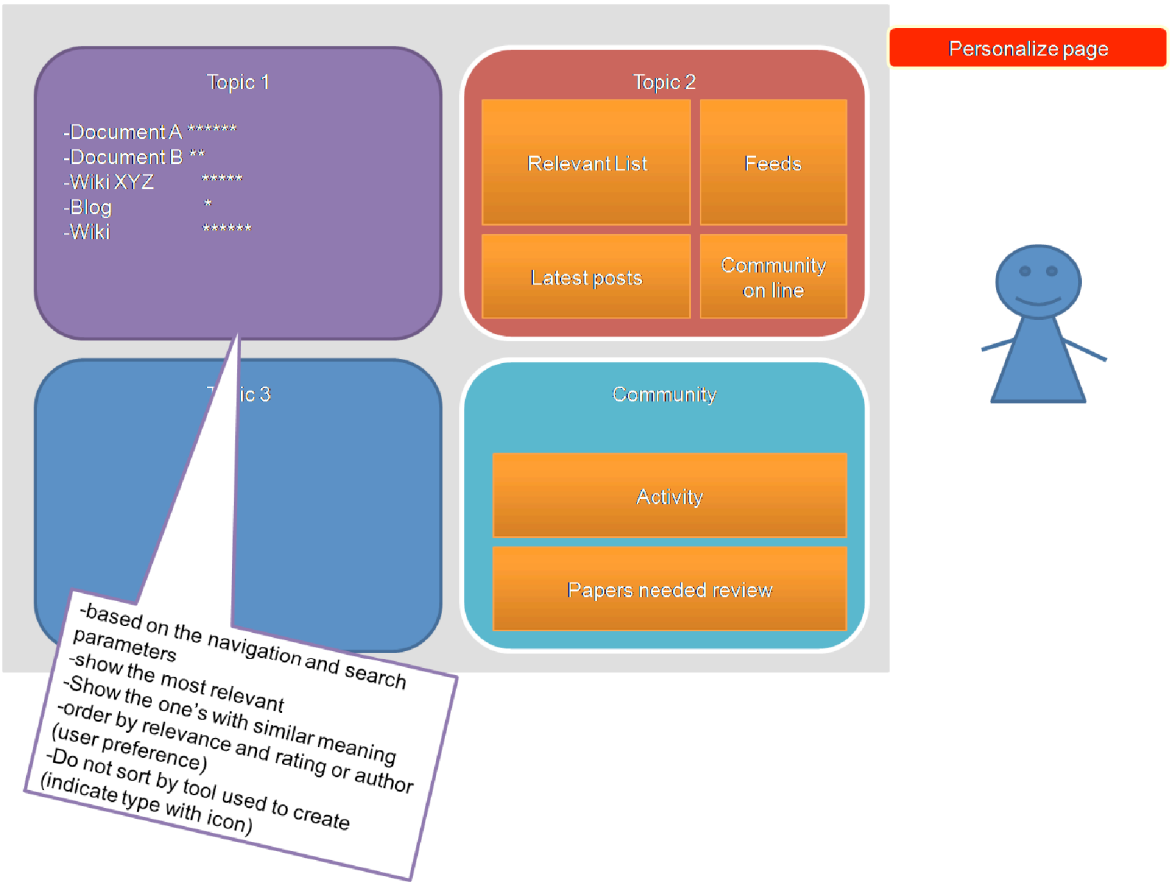

Figure 8: Personalising the Experience

This personalisation could be visualised as follows (in Web 2.0 look and feel):

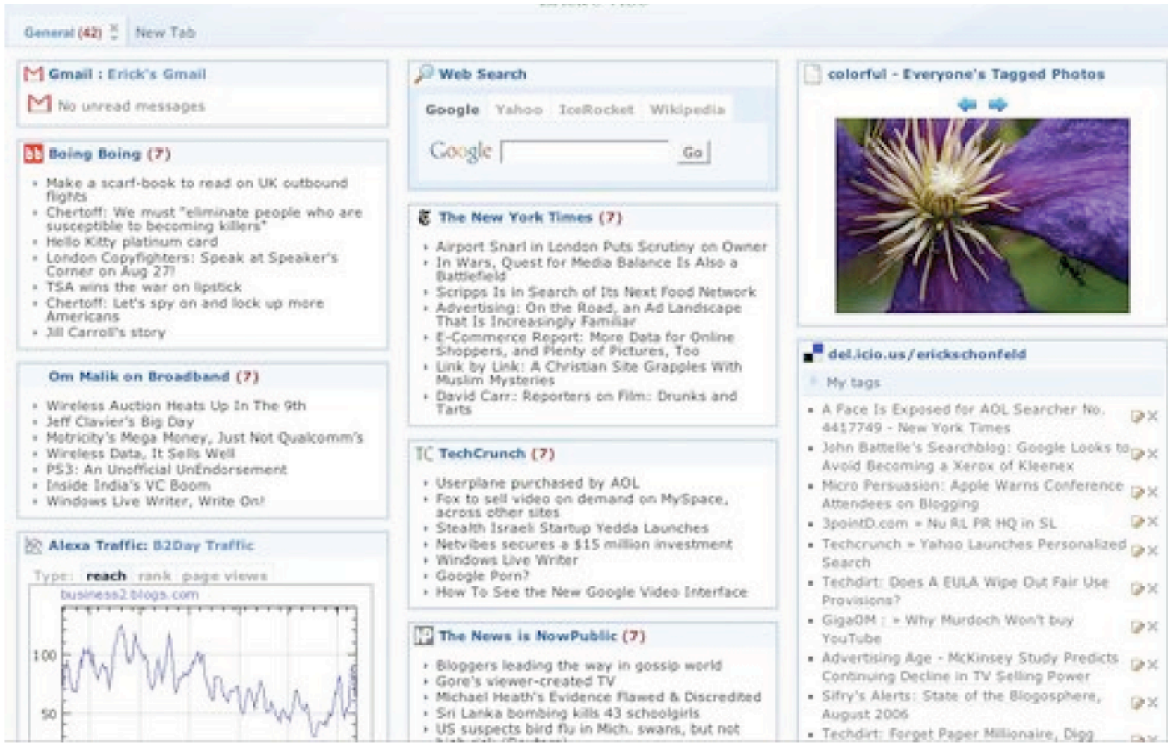

Figure 9: Example of personalised portal based on Web 2.0 look and feel

6.4 Accessing Digital Ecosystems information

This following is a suggestion for the creation of a Web presence for the Innovation Ecosystems. All projects could be referred to from a central portal, and should be linked to the OKS as a central reference for Innovation Ecosystems information.

This portal could enable access to the wealth of information and knowledge generated within the Digital Ecosystems communities. The information could be sourced from the outcome of the research conducted within the OPAALS consortium, the DBE project, all the related Digital Ecosystems projects from the cluster, and other initiatives. Combining the wealth of information for these different sources, would enable the creation of a body of knowledge that would cover different aspects, such as the technology, contractual management, utilisation in specific sectors.

The OKS would then become the first point of entry for the Digital (or Innovation) Ecosystems. The Tag cloud could be used to describe all the information and provide a unique way of navigating into the OKS regardless of the source of this information.

Existing project teams (for each of the projects) could become the catalysts for communities, and would create additional information.

This could be a good example for the use of the tag cloud and the definition of pre-defined searches (see personalisation section).

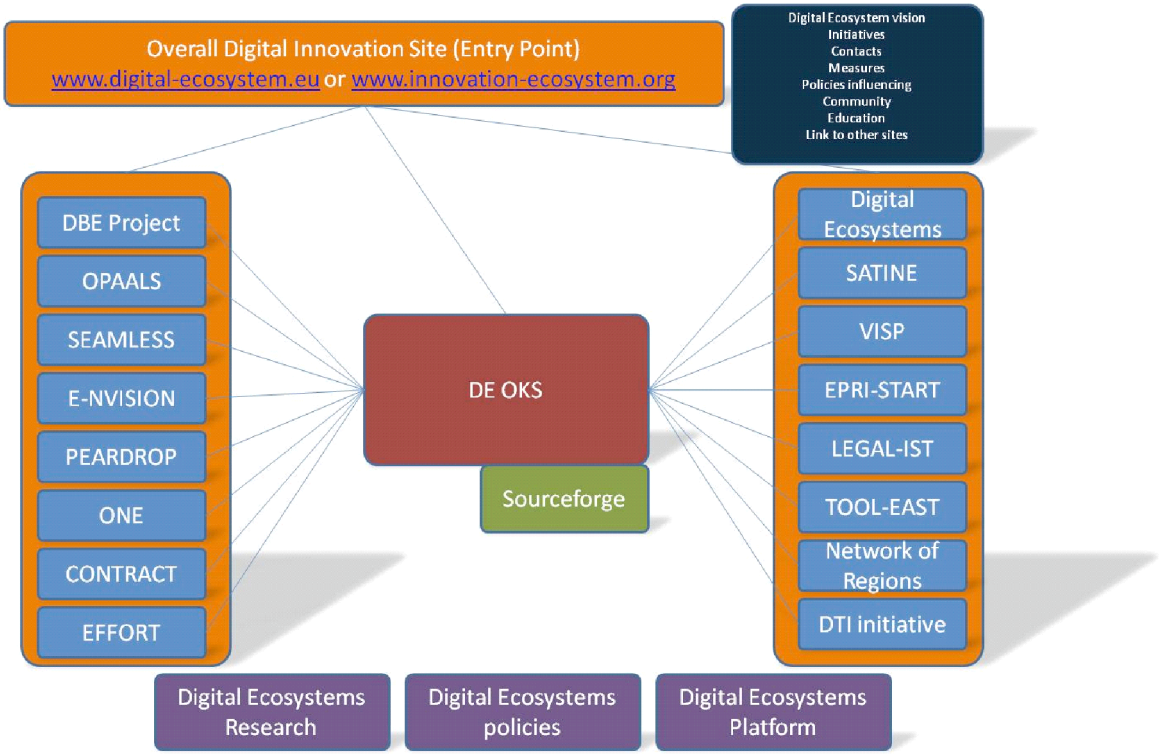

Figure 10: The OKS and tags clouds as the unified knowledge repository and description for the information generated around the innovation ecosystem concept.

6.5 Validation of the Architecture

This section maps the proposed architecture with the seven principles of online communities, as well as with core principle of "governance" underlying them as discussed in Chapter 2.5. This mapping is important as it helps to validate the architecture and the information structure against the theoretical foundations offered in this deliverable.

Table 1: Validation of the OKS Architecture against the Principles of Online Communities

Principle	**Summary**	**Architecture**
Governance	The facilitators and members of the community assign management duties to each other, allowing the community to grow.	This is an aspect that could be facilitated by the architecture but not implemented by it. The governance model will need to be defined by the community and will emerge over time, through the architecture.
Communication	Members must be able to interact with each other in a variety of convenient ways.	There are several tools communications (wikis, blogs, forums, chats, etc). Feeds and personalised mashups would also enable the communication of the last topics. Other community tools such as IM, Skype and on-line conferencing will also enable effective communication.
Purpose	Community exists because the members share a common purpose which can only be accomplished jointly.	The Tag Cloud navigation can help with accessing and filtering (using personalisation) the information relevant to the purpose. The folksonomy created can also describe the information contained by the OKS. People can then understand what the community/ies is/are about and decide whether or not to join. The tools that would be made available would enable (new and existing) members to participate and collaborate, and use the tagging structure to describe their contribution.
Trust and Identity	Building trust between members and with community facilitators increases group efficiency and enables conflict resolution. This is crucial so that members can identify each other and build relationships.	Trust is two fold: that about members and that about information. The proposed architecture supports this by enabling experts to rate contributions, and by assigning a rating and a reputation to members. Members could be related to each other with the tag cloud linked to them and to their contributions. All users would need to be authenticated. It is also possible to add the list of members that are more relevant to search or navigation. One mashup in the personalisation could display the list of "linked" members and whether they are online, and show their latest contribution.
Reputation	Members build a reputation based on the expressed opinions of others.	The proposed architecture would allow members to "rate" the contributions of others. This would help in building the reputations of members. The overall reputation would be based on the quality and relevance of the contribution (rated by experts and peers) and activity levels (system generated based on the level of contribution of the member). There is no policing foreseen by the architecture. Poor rating would lead to poor reputation and therefore allow for a self-policing community (as contributions submitted

		by poorly rated members are more likely to be ignored).
Boundaries	The community knows why it exists and what or who is outside and inside.	The tag cloud could be dynamic and evolving. The same apply for the groups that would be actively participating in a given topic or have an interest in the topic. The boundaries would then form naturally and evolve. Experts of the OKS would also help in making them a little more apparent.
History	The community must keep track of past events and must react and change in response to it.	The tag cloud would have several attributes. One of them is managed by the system, time-stamping every contribution. This could be used to graphically show the progression of the cloud, and others for given topics (contributions, members of the group). The difficult aspect of history that it would need to be modeled taking into account how the tags evolve over time.
Expression	The community itself has a "soul" or "personality"; members are aware of what other community members are doing.	The OKS architecture navigation would be based on the tag cloud. The tag cloud would describe information and members. This would allow transparency with regard to who is collaborating on what, and who the experts are. It is expected that core groups would represent the expression and the authority for given topics.

Furthermore, the architecture of the OKS proposed here takes into account principles of Exchange and Groups. In terms of the former, the OKS will allow members of the community to engage in various forms of exchange of knowledge and feedback to the knowledge of others. In terms of the latter, the OKS will also allow for the emergence of groups through the discovery of shared interests via shared links and tags, as well as through the systems of expression and communication in place.

7. OKS User and System Requirements

In this chapter, following on from our proposed architecture, we aim to list the requirements for the OKS based on the needs of its users. First, we will present an overview of user needs, then an overview of system tools required in order to meet those needs. The former were identified and developed through a process of intensive discussion amongst the authors of this working paper, as well as through the discussions at a broader forum at the OPAALS general meeting in March 2007. At this meeting, every consortium member present was invited to speak to their vision of the OKS; to express what it is that they wanted the OKS to "be and do". These statements were recorded and notes were taken, both of which were placed on the OPAALS wiki for members to view, add to and edit. Members not present had an opportunity to add their viewpoints to the wiki too. An aggregation of the common ground shared by these statements is included in this review of user requirements. This process, and the results shared here, will be complemented by an OKS grounded requirements gathering questionnaire that will be implemented parallel to the development of the OKS. The feedback gathered via this questionnaire will be incorporated in the future work of task T10.7.

In the following table (Table 2), we list a range of user requirements and corresponding implications for a follow-up table (Table 3) of suggested tools in section 6.1 and elaborate on the concrete implications and potentials for the OKS. The requirements have been expressed as user requirements and system requirements. User requirements refer to what users should be able to do when using, or expect from, the OKS. These could also be termed use cases. System requirements are derived from user requirements, refer to functionality and will feed into the design and the development of the OKS. Before listing these user needs and system requirements, however, it is important to contextualise who these users are, and what the human needs underpinning their "user needs" are.

Although OPAALS "users" are academics, intellectuals, researchers and experts in their various fields, and tend to have a high degree of computer literacy and experience in using various online "tools" and very specific preferences about the kinds of tools that they would like to use in a research environment, they are first and foremost human beings. This means that, along with the various professional, research, and technical needs that they may have, they also have many "human" needs that must simultaneously (and fundamentally) be addressed in the development of the OKS. These human needs are subterranean, they are often not expressed explicitly, and may not be considered of primary importance in the technical development of tools such as the OKS. They are, however, crucial, and showing awareness and sensitivity in addressing them should be understood as the foundation of successful uptake of the OKS. Based on the input that we have received in researching this paper, these human needs can be summed up in the ideas of 'collaboration', 'communication', 'community' and 'convenience'. This generalised description of human needs is of course selective, and should be read in the broad context of seeking to create a more holistic foundation for user needs discussed later.

In terms of collaboration, the human need can be located in the desire for (emotionally and professionally) effective teamwork. This translates as a need for intellectual and professional input, inspiration and support from a diverse peer group and the feelings of achievement, camaraderie and intellectual growth that results from a job well done as a team. This also

implies a need to receive (and give) constructive engagement, appreciation, feedback, support and understanding from team members, based on the assumption that everyone is working together towards common goals. An understanding of this human need is crucial in order to underpin the technological development of collaborative knowledge creation and the interdisciplinary goals of the project.

In terms of communication, the OKS needs to help researchers get to know one another better as human beings. This is of course absolutely relevant and necessary in terms of professional interests, but members also need to be able to 'socialise' (as they might around the water cooler or during a coffee break at a conference) and get to know one another as personalities, not just as brains; they should develop respect for and interest in one another as holistic human beings, not simply as intellects. Members needs to be able to use the OKS to 'meet' one another, talk and listen, have conversations, debates and meetings, and establish personal as well as professional ties. This is especially important for a dispersed, international consortium such as OPAALS, where members often only meet face-to-face a handful of times per year.

In terms of community, the human need is to 'stay in the loop', in other words, to somehow keep in touch with one another's work and thinking as well as with developments within the community as a whole. No one likes to be left behind, or be the last to know something that may have relevance to themselves or their community. This need, although often expressed in terms of a technical need for updates, alerts and newsletters, is a fundamental human need: to feel included, updated and connected to the community of which one is a part, and its events and happenings.

Finally, in terms of convenience, it is important to recognise that users do not wish to do more work than is absolutely necessary in order to use the OKS. The human need here is one of simplicity, efficiency, and an aversion for time-wasting, perhaps best expressed in the rhetorical question, “Why should I use a new tool if I already have something that does the job just as well?”. This should not be confused for Luddism or laziness, but recognised as a feature of the inevitable multitasking that every member of the consortium must do in the many professional and personal roles that they may need to play in their everyday, modern lives. Furthermore, human beings do not always welcome change, as it often requires an investment of extra time and energy in order to adjust to or take advantage of that change. In the context of the OKS, many users express a need for synchronisation or convergence with existing tools that they use (and sometimes prefer). In order to develop a system that best serves and reflects its users' needs, it is therefore important that we recognise the human need for convenience and simplicity as far as possible. The OKS should offer a path of least resistance; it should not be prohibitively difficult or so complicated such that users are discouraged from finding the time or motivation to even try. This applies specifically to the tools that will make up the OKS as the way in which users interact with it, and is specifically connected to a need for good, clear, user-friendly search and alert tools.

The user requirements in the table below address the technical needs expressed by OKS users, which are underpinned by the various human needs discussed above. They are arranged hierarchically, with those considered more important being listed and discussed first. This hierarchy has emerged through the process of researching and writing this deliverable, as well as through the process of engaging with the community and understanding its collective needs.

A crucial part of the development and definition of the OKS will be an ongoing iteration of these needs, and a process of matching the process of technical development to the evolving needs of the users. To this effect, once the needs and requirements have been covered in detail, an assessment is made of some potential problems that the consortium may face, as well as an assessment of existing elements of the OKS, and how it might be possible to maximise usage and adoption by users.

Table 2: User requirements and implications for the OKS

	User Requirements	**Implications (requirements) for OKS System**
Collaborative Knowledge Creation	Ability to author and edit documents together, from point of conception, brainstorming, writing and delivery. Ability to annotate and comment on documents in progress. Ability to brainstorm and work together as a team rather than in little pockets in isolation. Ability to add information in various forms (text, image, multimedia) and avoid duplication of work. Ability to create links to and from existing content and contextualise the knowledge created. Possibility to comment on and discuss work in progress (some way of integrating concept maps and other brainstorming tools). Ability to keep track of various versions of and comments in a document.	The OKS should allow teams to write, edit and create sophisticated documents together, at the same time. The OKS should also offer a version tracking and filing system so as to facilitate group editing and writing and ensure that an e-paper trail is easily accessible so as to allow for reviews of the collaboration process. The OKS should also allow for a sophisticated system of creating links between existing content. Overall, the OKS should facilitate a wide range of multidisciplinary and collaborative research tasks that create knowledge through the identification of synergies and the facilitation of knowledge creation by more than one person at the same time.
Communication and Interaction	Ability to meet other researchers through OKS tools, see their faces, learn about their research and other interests. Ability to initiate and contribute to debates and discussions, and to have effective team meetings online. Ability to share ideas, ask for inspiration and input, offer feedback, information and links when requested. Ability to comment on others' ideas and share own ideas.	The OKS should allow for a wide variety of professional and less formal communication, including the integration or convergence of existing tools such as chat, e-mail, telephone, used by members at present and the development of new tools that may become necessary. The OKS should include and incorporate a sophisticated online conferencing/meeting tool.
Content Access	Ability to have all existing forms of content hosted on an accessible database or storage system. Ability to search by keyword and browse using a predefined taxonomy,	The OKS should establish a sophisticated online file storage system, which will allow users to retrieve several types of information, including: other relevant searches, what other people navigated next, all other sources of

	visualisation and search results. Ability to filter search results and search semantically so as to access additional/related content based on the ontological model. In addition to regular search and filtering functionalities, automatic, semi-automatic and manual means to associate resources would be highly useful for finding new interesting information (such as, similar articles or other people with similar interests). Ability to refer to a dynamically built Lexicon when, while accessing content, a user comes across unknown terminology from a different domain.	related information (documents, discussion boards, forums, feeds, websites), the combination of tags (with weights) that will define the best content, other semantic searches, the possibility to toggle between a list and a visualisation. Visualisation could be by relevance, tag, date, type of content and level of recent activity. The OKS should allow users to refine their search or to start a search within the current subset of content such that they can search further (free text and semantic); choose from tags to refine the search; or start navigating/browsing using a visualisation tree. In the long term the OKS should also address the potential of offline access to the content base, through multiple devices (such as mobile phones or PDAs). The OKS also needs to incorporate collaboratively authored resources such as an interdisciplinary lexicon, and a list of acronyms.
Awareness Building Services	Ability for users to be kept aware of the latest additions, discussions and brainstorms about a given topic, as well as developments relevant to entire community. This is crucial in order to provide channels for users' knowledge to be shared and also to trigger more reflection, content creation and refinement.	The OKS needs to operationalise RSS feeds to users, in all of its elements, including the wiki and blogs and the public website, as well as send automatic e-mails showing updates with the latest discussions on forums. The OKS also needs to incorporate a regular, formalised newsletter to the community reporting on advances and achievements made by individual and institutional community members.
Knowledge Management	Ability to tag information to enable access via visualisation or semantic search. Ability to correct inaccuracies such that changes are traceable and irreversible. Ability to flag content that needs to be reviewed, is out of date, has not been reviewed yet, or when an expert reviews has taken place. Ability to receive alerts with regards to all such notes, specifically if the user is an expert (or has the reputation seen as an expert in a given domain) who could review the relevant content.	When adding and tagging, the OKS should give a list of relevant knowledge assets enabling the user to review and update and cross-reference them in a simple, easy to understand, and user-friendly system, as well as enable the updating of the ontology through adding or changing the links. If the content is not reviewed, a list should be sent to reviewers of this topic in the community including information that content has been added and relevant linked information (by ontology, taxonomy, links, or folksonomy) so as to trigger the review process.
Cross-referencing and Convergence	Ability to have OKS content contextualised within the broader research community and landscape of collaborative knowledge creation. These requirements are about the	It has to be possible to link the OKS to external sources by: checking if existing links are still valid, adding and managing the relevant links and resources (manually by the community), adding possible links based on automatic

	enrichment, the referencing and the extension of existing knowledge bases outside the OKS.	searches. The search can be coded automatically and the search can be based on the existing ontologies of the OKS. Search results can be filtered manually or automatically. Cross-syndication from various sources, including adding RSS feeds and manual contextualisation, will be necessary. Similarly, all content within various parts of the OKS needs to be linked to other relevant content in other parts of the OKS, so as to ensure that an integrated web of information and concepts exists and that all possible hyperlinks are made.

7.1 Suggested Tools

In order to support and enable knowledge creation and collaboration between researchers, an initial infrastructure needs to be set up, which can draw from the examples provided by other online communities around the world. Some of these communities, such as those in Brazil (see http://www.estudiolivre.org; http://www.estudiolivre.org/el-tag_cloud.php), have already achieved interesting and valuable results using a variety of tools, many of which are listed below as a preliminary attempt to get to grips with the various elements that may make up the envisioned OKS. As we have already demonstrated with our foundational emphasis on the human needs of our community, it is important to remain aware of the pitfalls of a wholly technology driven approach (referred to as technological determinism; see also Bijker, Hughes & Pintch, 1987; Bijker & Law, 1992). Technological tools cannot "do" anything, it is the human users and communities who create, adopt and use those tools that "do" things and achieve outcomes. The success of the tools that OPAALS will use will depend on how they are perceived by users in the facilitation of their work and collaboration and communication in general, as well as how they are built in order to address the human, social and professional needs of their users. The following table (Table 3) contains a description of different tools, and some of their respective potential uses for the OKS. They are presented in a theoretical manner, and their potential for the OKS is hypothesised with a view to opening discussion as to their pragmatic potential. It should be remembered, of course, that the practices and the realities of implementation rarely matches theoretical premises, and that the actual real-world development of the OKS will not be a linear, neat and simple process that involves adding each of the tools in this table as though working through a checklist. The list of tools here should therefore be understood as a theoretical starting point for a fluid, horizontal, iterative and ever-evolving practical implementation and collaborative development of the OKS that will take place in tandem with the top-down architectures already discussed in this deliverable. Some hierarchisation has already taken place from a top-down perspective – for example, visualisation has been considered a crucial part of the architecture. Nevertheless, bottom-up prioritisation from a community level is necessary in order to confirm or reject such proposals. The suggested tools are therefore not arranged hierarchically in Table 3, as it is difficult to theoretically prioritise certain tools over others in terms of importance. In practice, of course, hierarchies of importance have been, and will need to be continuously established in order to avoid the impossible situation of trying to do everything at once: this will be the work of the community as represented in the OKS Working Group, specifically the OKS User Group.

Table 3: Suggested tools and their potential uses for the OKS

Tool	**Description**	**Potential for the OKS**
Blogs	Personal, web-based "journals" that express opinions, ideas and experiences in a chronological way. Collaboration is limited, but anyone can comment or make a suggestion. The name and reputation of the author is often as important as the content.	Blogs are appropriate for the OKS in that they allow individual researchers to express their ideas, share their reviews, and opinions in an unmediated and personal manner. Blogs allow individuals to carve out a personal space for themselves within the consortium, and they provide a counterbalance to wikis (where text/content takes precedence over author). As the nature of blogs renders the reputation and identity of the author as important as the text, blogs thus provide opportunity for the building of reputation, identity, and trust in a community, as well as excellent mode of self-expression. Currently, each member of the OKS has a special OPAALS blog space created for their exclusive use. Only a handful of members use this resource at present.
Forums	Web-based forum rooms are used to debate and discuss specific topics. Knowledge is tacit, and the context resides within the forum and within the message trail. Knowledge is usually searched by keywords, there is no tagging, and the reader needs to follow the trail. Forums need to be moderated and social rules need to be put in place and agreed upon. The principles of online communities also apply in forums and additional rules defined by the moderators of the forum may need to be added.	Forums offer a good start for generating ideas and discussion points that can feed into a wiki (or a collaborative work environment) and as an entry point for the creation of explicit knowledge (either a document, a suite of documents, a repository). Forums also allow for more informal discussions, and could act as the OKS' "agora" for wider interaction, brainstorming and debate. A special Forum Room does exist within the OKS as it stands at present, and although somewhat under-utilised by the community to start with, is becoming less so.
Syndication Tools (RSS)	Feeds are set up with a source and can be filtered by topic. They are automatic, and can be tagged, so that the results of a search will include the feeds. They are usually used in mash-ups (see below). Feed units should be considered as standard knowledge objects, and have an owner/expert that validates the feed initially and monitors the quality and the pertinence of the feed over time, as well as re-tags, filters or cancels syndication as needed.	Feeds can operate within the OKS in the following ways: from the world to the OKS, from the OKS to the outside world, from the OKS to the community and the experts of the community. At present, the only OKS tool that employs RSS feed options are the blogs, which means that any OKS member can subscribe to updates on colleagues' blogs. RSS feed options also need to be made available on other elements of the OKS in order to ensure that there are full opportunities for members to choose to be updated on a particular topic. Users should also be able to subscribe to a formal newsletter.
Subscription services such as alerts	These include specific alerts so as to draw subscriber's attention to new knowledge about a topic. Subscription services enable the user to receive information about new content concerning topics of	In the OKS, users should be able to choose to be alerted when new content is available, whether it be categorised by subject or contributor. This could be applied in the context of quality assurance. For example, if the user is an expert in a certain area, the

	her or his interest. Such services may be received either by email newsletter or RSS-feeds. While newsletters usually demand an editor who decides which information will appear in the newsletter, RSS-feeds are generated automatically.	system should prompt the user that new content has been created and may need his/her contribution or validation in terms of accuracy. In turn, other users should be alerted of the status of content, i.e., whether it is peer reviewed or opinion. Alerts should take place both when new content is added and when content as topics, and if a topic has aged and may need review or updating (similar to Wikipedia).
Feedback algorithms such as reward systems	These include tools used to manage the community through ratings and reputation by enabling rewards, feedback loops and algorithms to measure the performance of each member. Experts and the area of expertise enable the link to the semantic value of the tags of content and area of expertise.	Community tools can be used in the OKS to measure and record, for example, the number of posts, level of expertise, average rating of the content the member has written/reviewed, positive feedback as a team member in a collaborative environment, average time to respond, etc. The OKS could implement such reward systems in terms of a specially created “community currency” that allows member to earn points for various contributions and inputs.
Mashups	A mashup is a website or web application that seamlessly combines content from more than one source into an integrated experience. Content in mashups is sourced from a third party via an API or feeds (e.g. RSS or Atom) and JavaScript. Examples of mashup experiments include eBay, Amazon, Google, Windows Live, and Yahoos APIs. Mashups offer results and resources around a given topic, which can be expressed by browsing in a predefined taxonomy/ontology.	Mashups have the potential to provide enriched, diversified content on the OKS in a meaningful context. They can extend from OPAALS community to include other related and meaningful synergies. A mash-up can be the design paradigm followed to allow for the seamless integration of components within the OKS, where combinations of tools can be created as per users' specifically tailor-made preferences.
Wikis	Wikis are web-based collaborative content creation tools that simplify the creation of web pages. They are not personal but shared by a community. Everyone in that community can create and contribute to content, which is more important than single authors. The aim of a wiki is to enable the authorship of information that progresses towards objectivity and accuracy. Wikis therefore tend to have a reputation as a source of information, as authors are often a group of 'experts'.	Wikis are appropriate for the OKS as information can be created, authored, edited, changed or deleted collaboratively, with the involvement and observation of the whole community. Wiki pages represent consensus (insults are deleted, spam is removed and incorrect statements are corrected rather than left to stand). What remains is collectively perceived as meaningful and consensual as it has been collated from multiple points of view. To make an impact on a wiki, content needs to be generated by a community of users seeking to achieve a shared goal. An OPAALS wiki exists, and is used extensively by the majority of members of the community. However, it is somewhat overloaded, as a wide range of information not directly related to collaborative authorship projects is posted on the wiki instead of other locations.
Semantic	These are web-based collaborative	Semantic wikis would enable greater

wikis	content creation tools that add relations and computer-readable semantic information. They offer increased usability and usefulness of the knowledge space and its interconnected resources. They also allow for easier access to information (better search, context) and visualisation.	contextualisation of the content on the existing OKS wiki thereby facilitating greater understanding between multi-disciplinary workpackages and domains. Adding a way to insert semantics to the wiki (which is now possible, for example, in simple format by FactsAbout cards) would enable constructing the models collaboratively.
Folksonomy and Tags Manage-ment Tools	A folksonomy is an internet-based information retrieval methodology consisting of collaboratively generated, open-ended labels that categorise content such as web pages, online photos and weblinks. Authors of the labels are the main users of the content. Tag management tools allow for the management of synonyms, and the management of “meaning” (based on the context).	Tags can be used to describe the assets across the OKS. The same tags need to be used, and a typical combination needs to be proposed Synonyms need to be shown as well as a list of related knowledge. For the OKS, a tagging system needs to be developed that does not require intensive investment from users; a preliminary tagging structure may need to be provided in order to ensure the efficacy of this tool.
Repositories	A repository is a library of documents and other knowledge assets including: articles, documents, podcasts, drawings, links and resources, RSS feeds, blogs, etc.	The OKS should be not only a repository for information but also a model that supports a positive feedback loop of knowledge creation. An OKS repository currently exists.
Search & Navigation	Search offers a full view of the most relevant pieces of knowledge related to user's search attributes. Results are content-driven and not tool driven. Browsing tools allow users to find their way around an online environment using the ontology of the folksonomy map to navigate the content.	OKS search capacities should cover all relevant information including feeds, wiki pages, etc. Additional results could be those that are semantically close to the initial search results, as well as those on other “close” or “derived” topics. When search attributes cannot find a match it could make an external recommendation (such as in eBay). OKS browsing should use the visualisation to navigate. At any time, the user should be able to browse further or deeper or to do a sub-search. Currently a search function exists on the OKS wiki, but it needs refinement and improvement, and to be extended to all aspects of the OKS.
Visualisation	Visualisation systems provide the necessary component for designing, exploring, and sharing OKS data with respect to a set of visual access paradigms. In the abstract sense, the visualisation system is composed of two modules: the design and publishing tools, and the end-user visualisation clients. For purposes of administration and scalability, the emphasis lies within data-driven, dynamically updated, and mechanically computed visualisations that are based on	The OKS should allow users to create various kinds of graphical representation of knowledge, be it in the form of a graph, a chart, a diagram or a slideshow. Other visualisations could allow for abstract representations of data, if necessary, as well as more direct imaging of less abstract information. Visualisations could also be used to show progress on tasks in the work packages, and the project as a whole, as well as other things such as world maps showing the locations and movements of various community members. Visualisations also have the potential to add a dimension of pleasure, play and fun into the OKS, and to

	visual templates.	offer more light-hearted and enjoyable interfaces for users.
Predefined knowledge templates	These are a pre-defined set of search attributes so that the knowledge corresponding to these search criteria is automatically retrieved and displayed. Similar concepts and related knowledge (for example, on the same topic, by the same author, and sharing similar tags) can also be displayed (such as in Amazon).	Uses could be given the opportunity to get an overview of all of the content available in one specific knowledge domain. If this is connected with information about the authors, new collaborations could emerge. If similar or related content (such as from other disciplines) were to be displayed, new ways of thinking and combining interdisciplinary knowledge could be inspired.
OKS Desktop	This refers to one platform which combines the aforementioned tools in a synthetic graphical environment. Usually such an environment is visualized by the desktop metaphor (mostly all operating systems use the desktop metaphor).	The desktop metaphor has the potential to create a unique space for knowledge exchange and knowledge creation. Because all the tools are part of this desktop space, communication and collaboration might lead to the emergence of an open knowledge community, assembled in the Open Knowledge Space. Learnings from the DBE Project (DBE Desktop), however, would advise against this. Nevertheless, desktop application could offer long-term solutions for offline accessibility of knowledge and access through multiple devices, such as mobile phones and PDAs.

It is very important to note that the OKS is already a partial reality. Some of the tools listed above already exist, are available for use by the OPAALS community, and are used to varying degrees. It is important, therefore, to treat the tools that already exist and are in use (to whatever degree) differently to those that have not yet been developed or integrated. Tools that exist need to be assessed, in terms of whether they have been used, how and why they have been used, and how they can be improved. Tools that have not yet been made available need to be assessed in a more forward-looking manner, and a great deal of thought and community involvement needs to take place in order to plan how their integration(s) will take place. Again, these will largely be the tasks of the OKS Working Group. Tools that exist are the wiki, blogs, forums and a file repository. An observation of the knowledge created with these tools shows that the OKS wiki is 'full', almost overloaded, with content, while the blogs and forums have been hardly used at all. Part of the strategy for moving ahead with the development of the OKS needs to address this imbalance, and seek to understand what some of the human, social and professional reasons may be behind this reality.

The following section attempts to highlight some of the possible issues and difficulties that the ongoing, collaborative development of the OKS may pose, and attempt to suggest possible strategies for dealing with them.

7.2 Possible Issues and Difficulties

The definition and the use of the Open Knowledge Space poses several challenges. Most crucial perhaps, is the lack of a consortium-wide recognition of the usefulness of tools that exist, and a broader buy-in to testing, improving and developing them through *use*. One of the main challenges that the development faces at present is the fact that although certain tools

exist, they are not being used or maximised, and lie “empty” and “gathering dust”. Although there is no denying that the OKS needs much work in terms of the development of new tools so as to reach the vision of the OKS as it has been articulated by the community, it is equally important to acknowledge that some of the needs that have been expressed by the community can in fact be met by the tools that we already have in existence. This should be balanced by a critical assessment of whether the bottom-up development of tools will necessarily lead to greater use thereof. This could be addressed through greater communication, including the availability of training resources that show how the tools work and connect their usability back to the philosophy, aims and goals of OPAALS. The need for this awareness is partially addressed in Chapter 3.2 and will be further addressed through the ongoing work of the OKS User Group.

Other, more specifically identified, challenges include:

- *Motivation to participate*: As tool such as wikis and blogs are 'public', it may be difficult to motivate participation due to the absence of direct addressing from identifiable, concrete actors. A public tool that invites everybody to participate lacks direct addressing and therefore risks inviting nobody in particular instead. Moreover, communication is largely dependent on the sender (who produces specific communicative output), as recipients use the sender's features (such as social background, status and communication characteristics) as part of the decoding process, i.e. to understand a message. The publicness of blogs and wikis may also discourage researchers who are used to working on their own, in isolation and in private before sharing their findings and thoughts with a wider community. Blogs in particular tend to support a 'work in progress' mentality, with bloggers sharing their thoughts, processes, notes from readings, and ideas before they are fully formed and 'publishable'.

- *Willingness of researchers to allow their text to be changed and enriched*: As the wiki is the most-used aspect of the OKS, this may be the OKS' greatest challenge, as its philosophy signals a paradigm shift and aims to enact a cultural change in the research community. Wikis can be described as one-to-many and asynchronous tools. This means that a person produces certain input on the wiki without receiving direct feedback (asynchronous) and thus cannot react dynamically to feedback. At the same time, producers are aware of the fact that they produce content for a large audience (one-to-many), hence feedback is very likely although often anonymous. Some researchers may object to having their work changed by parties with whom they cannot identify or interact directly. This challenge can be addressed by ensuring that researchers are aware that they can use their blogs for knowledge that they wish to share with the community but do not want other members to edit, and that they can reserve the wiki for specific collaborative authorship tasks.

- *Appropriateness of rating and reward tools*: It is possible that some of the rating tools proposed will conflict with norms of propriety in the academic community, as well as some of the human needs outlined at the beginning of this chapter. Rating users' contributions to the OKS may serve certain purposes in terms of managing the community and data structuring, but there is potential for damage to reputation – which could act as a strong deterrent to participation and community growth. It may be

necessary to delay the development of such aspect of the OKS until the community is more established and has existing norms and protocols upon which such systems can be based.

- *Integration of several tools*: How can the numerous online tools that we all already use be integrated – from applications through to online presences? Community members own and use a variety of digital tools, such as e-mail addresses, blogs, web-pages, Skype accounts, Flickr accounts and MSN accounts, many of which are not hosted on or linked to the OKS. Will we need to offer ways to converge these tools and bring them all together in order to continuously share knowledge in various ways? Users might feel overwhelmed with the many ways that they already engage online and ask why they should invest additional time and energy into mastering yet another one. This is a concern raised by many members of the consortium, and it needs to be addressed largely from a technical viewpoint as the OKS continues to develop.

- *Voice and multimedia assets*: The lack of voice refers to the asynchronous characteristic of a wiki. Additionally, as a two-dimensional tool, a wiki lacks a certain degree of multimedia implementation, e.g. dynamic visualisation techniques, which can enhance communication by addressing different channels of perception. This can be addressed through the explicit integration of voice over IP chat and meeting programmes, such as Interwise, into the OKS.

- *Understanding and usage of Folksonomy*: Thomas Vander Wal's informal article "Folksonomy Definition and Wikipedia" is often referred to as the article that introduces the concept of folksonomies for the first time (Vander Wal, 2005). He explains that in most cases a folksonomy is a set of personal tags that a user can add to the content of an application. The tags are, in addition, exposed to other users as well and hence enable an expressive way to associate the pieces of content. However, when dealing with a set of personal tags, differences in individuals' associations regarding tag choice have to be taken into account (see also the following point). It is also crucial to remember that tagging takes a lot of time and energy from the user, something that is a major obstacle to many OKS members who may simply not be able to invest this kind of time. The OKS needs to address this very real challenge by innovating a tagging system that is user-friendly, as time-efficient as possible, and offers a 'path of least resistance'.

- *Buy-in to potential of semantic wikis*: Semantic wikis represent a dynamic, flexible and very promising solution as they are both one-to-many communication in the standard wiki sense, but also one-to-one in that the semantics draw upon the associations of a specified word with other concepts. These key-word associations have to be implemented by each user (a process called tagging), which underlines the one-to-one notion. Such conceptual mapping can also be enhanced by means of visualisation. One disadvantage however, is, that the realisation can prove to be difficult from a technological and a social perspective. As discussed above, tagging is a time-consuming process that many users will be resistant to. Furthermore, the difficulty of reaching a consensus between a group as large and diverse as the OPAALS consortium is equally challenging when it comes to conceptual mapping, key word definitions and associations and visualisation techniques.

8. Conclusion

This deliverable has attempted to offer a theoretical and philosophical basis upon which further thinking about the OKS may be based, as well as a starting point from which an overall vision of the ontology and architecture of the OKS can emerge. Specifically, it has discussed principles, models as well as processes for the development of the OKS.

We have located our epistemological framework within a broad-based body of scholarship concerned with understanding the concepts and operations of “knowledge” and located our methodological approach within the praxis of "action-research". We have contextualised the OKS within broader principles of online communities and located our proposed approach within the fruitful tensions between top-down and bottom-up traditions. Although we highlight, exhaustively, the necessity for collaborative, evolving, bottom-up mechanisms, we have offered open-ended and flexible frameworks for this in our discussions of the OKS ontology, its high-level architecture and user and system requirements.

We remind readers that the OKS will be a living system, and that this deliverable should likewise be considered a living document, and input, feedback and contributions towards its development are not only welcome, but necessary to the ongoing collaborative development of the OKS.

Furthermore, this deliverable should be considered in the context of the ongoing practical work of the OKS Working Group (WG). In one sense, this deliverable is the methodological and ontological arm of the OKS-WG, with the OKS-WG being the pragmatic, implementation arm of this deliverable.

Future iterations of the concepts and suggestions contained within this deliverable should be measured against the work of both the OKS-WG and User Group (UG) and vice versa. The WG and UG are being set up at the time of writing of this deliverable and will establish and validate an implementation roadmap for the OKS based initially in the tools and environment identified in this deliverable. Although "delivering" on certain representations of the development in the collective thinking of the OPAALS consortium regarding the OKS, this deliverable should not be considered a static empirical conclusion to this process, but rather a clearly marked starting point from which the OKS can grow.

The continuous and recursive application of reflexive activities around the construction, visualisation, management and collaborative tools based on P2P run-time architecture will enable the bootstrapping of the OKS that will grow out of the project and feed into further iterations of this deliverable.

We hope however, that this deliverable can contribute in some way to creating and fostering a community of research that will support the on-going trend toward the extension of traditional disciplines into new disciplines for an integrated foundation for digital ecosystems research; that it will bootstrap the recursive process of knowledge creation within the research network itself that will ultimately lead to a self-sustaining and self-renewing process of research and innovation in the wider Open Source community, and thereby enable the emergence of an Open Knowledge community inclusive of all stakeholders of regional economies, but in particular academic institutions and SMEs as an immediate community.

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