The Semantic Web as a Knowledge Management Environment

by

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DECLARATION

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SUMMARY

In Chapter 1, the basis of the thesis is discussed, and presents the question, “How can we apply the methodologies that make up the semantic web to to the practice of knowledge management, in order to assist knowledge workers to better do their jobs?” A few premises are established and definitions provided for key concepts.

Chapter 2 provides an understanding of learning and organisational theory. It covers some aspects of the history and context of organisational learning and hones in on which theories are most suited to understanding the focused area of technology enhanced learning.

In Chapter 3 the focus is placed on online collaborative learning theory and why it is required as a new learning theory for the knowledge age.

Chapter 4 introduces the idea of semantics and more particularly, the semantic web. Components of the semantic web and their uses are discussed before the chapter is concluded with current criticisms and industry applications of the semantic web.

Chapter 5 relates what has been discussed in chapters 2 and 3 to semantic web tools discussed in chapter 4. The concept of the semantic learning organisation is introduced and the various possibilities for semantic web applications within the learning organisation are discussed.

In chapter 6, several problems with the semantic web are presented after which the researcher proposes a possible solution to the problems. Finally, an example implementation is presented and a few observations explored.

The thesis comes to the conclusion that implementing a semantic learning network is possible, but only by incorporating its social aspects. Guidelines are presented for organisations for implementing a semantic learning infrastructure. Avenues for further research are outlined and the parameters for the final test implementation are proposed together with a short description of possible problem areas.

OPSOMMING

In Hoofstuk word die basis van die tesis bespreek, en stel die vraag: Hoe kan ons die metodologieë van die semantiese web toepas op kennisbestuur ten einde kenniswerkers te help om hul werk beter te doen? In die proses word die tesis se aannames gestel en die sleutelkonsepte gedefinieer.

Hoofstuk 2 gee 'n oorsig van leer- en organisasieteorie. Dit dek 'n paar aspekte van die geskiedenis en konteks van organisatoriese leer en identifiseer daardie teorieë wat geskik is vir die verstaan van die fokus-area van tegnologie-gesteunde leer.

In Hoofstuk 3 verskuif die fokus na aanlyn samewerk leer-teorie (online collaborative learning theory) en waarom dit benodig word as 'n nuwe leerteorie vir die kennis-era.

Hoofstuk 4 stel die idee van semantiek en in besonder, die semantiese web, bekend. Komponente van die semantiese web en hul gebruike word beskryf en dan krities bespreek voor die hoofstuk afgesluit word met 'n oorsig van die toepassings van die semantiese web in die organisasie-wêreld.

Hoofstuk 5 bring die leerteorieë van hoofstukke 2 en 3 in gesprek met die semantiese web gereedskap wat in hoofstuk 4 bespreek is. Die konsep van die semantiese leerorganisasie word hier ontwikkel en die verskillende moontlikhede vir semantiese web programme in die lerende organisasie word bespreek.

Hoofstuk 6 bespreek verskeie probleme van die semantiese web, waarna gespekuleer word oor moontlike oplossings vir hierdie probleme. Ten slotte word 'n voorbeeld implementering beskryf en 'n paar waarnemings word op die basis hiervan gemaak.

Die tesis kom tot die gevolgtrekking dat die implementering van 'n semantiese leer netwerk moontlik is, maar slegs deur sosiale aspekte in te sluit. Riglyne word voorgestel vir organisasies vir die implementering van 'n semantiese leer infrastruktuur. Daar word gespekuleer oor moontlike verdere navorsing en die parameters vir 'n finale toets implementering saam met 'n kort beskrywing van moontlike probleemareas.

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Chapter 1 Introduction

1.1. Case study

The need for research into expediting learning within a team and hence the organisation, was founded on a real world problem. It is this problem that will guide the entire research paper. I will use this case study to introduce a few nuances that are compounded by the challenges mentioned below. The case study will be referenced in the rest of the paper, in order to direct our attention to the key aspects of the learning dynamic within an organisation and the improvements which can be brought about by using semantic web technologies.

The focus of the study is the ICT (information and communication technology) department at Etruscan[1] Ltd (a pseudonym) in Cape Town, South Africa. The researcher is located within this department as a senior analyst developer, dealing mostly in web application and system development. Part of this role is the mentoring of new recruits and ensuring that they are able to contribute effectively to the goals of the department and organisation in as short a time as possible. There have been three phases in this case study. The first is before any learning framework was implemented i.e. new recruits are expected to learn what they need to by actively participating in projects and asking questions. The second is a year into the observed period and involves an "on-boarding" process proposed by the human resources department. This serves to introduce the new recruit to the organisation and organisational processes. The final stage is the main focus of the paper, and involves using semantic web technologies to improve the on-boarding process as well as adding new methods to enhance new recruit learning.

This case provides an example of an application where semantic web technologies could be used to advance the organisation as a learning organisation, one where employees constantly have the opportunity to learn during the normal work day[2] (or whenever they choose to learn). The learning organisation must implement a system that allows its employees to interact, ask questions and provide insight into the business (an area often neglected because inexperienced employees' opinions are not highly regarded). The learning organisation will promote systemic thinking and the building of organisational memory[3]. The learning organisation, as discussed further in chapter 5, is only a component of the broader topic of organisational learning.

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[1] Greek god of change (particularly of the seasons)

[2] LANGER, A. 2004. *IT and Organisational Learning: Managing Change through Technology and Education [Kindle Edition]*. CRC Press. Location 395-400.

[3] LANGER, A. 2004. *IT and Organisational Learning: Managing Change through Technology and Education [Kindle Edition]*. CRC Press. Location 400-406

Etruscan Ltd is a firm with approximately 250 employees, which over the years has become increasingly dependent on the use of technology to run its business (this is not uncommon as technology becomes a ubiquitous part of our lives). While the actual industry of the organisation is not important, it is important to note the role of the ICT department within the organisation. Usually, the ICT department would serve only the organisation in terms of support. However, in this organisation, the ICT department is involved in internal software development and support roles as well as a client facing role where software development is done according to client specifications. This creates another level of complexity for the employee to come to terms with. What follows is an overview of the main issues facing this department.

1.1.1. Staff turnover

In the case department of just eighteen employees, there have been five employees that have had to be replaced due to them moving on and a further three employees that have moved from permanent to contract employment. The researcher has not factored in the cost of the move from permanent to contract employment, as this is a point for discussion separately and is not the focus of this paper. The question we have to ask is what does it mean when someone leaves and a new recruit has to take their place?

The main factor to consider with the problem of employee induction is continuing the learning, not starting anew. The cycle of staff turnover results in a lack of growth. An employee learns, becomes competent, moves on and the gained competence is lost to the team. It is important to note that individual learning within the organisation needs to be superseded by the need of the organisation as a whole to learn, to advance. In an ideal world, all the knowledge that an employee has gained would be transferred to a new employee when they leave. Unfortunately, this is not the case. In most cases, indeed all cases which the researcher has been involved in, the incumbent starts their employment after the current employee has already left. This leaves current, often more senior employees, to get the new recruit "up to speed". These are employees that have other demands on their time, demands that "pay the bills". What is needed is a dedicated means of learning, a way for the new recruit to drive the learning process. According to Peter Senge, the most productive learning occurs when skills are combined in the activities of advocacy and inquiry[4].

Managing the impact of IT staff turnover means doing much more than just managing personnel. It requires a structured plan and resources at the employee's disposal from the outset.

1.1.2. Employee isolation

A problem which is usually present with ICT departments is their isolation within the organisation in terms of decision making and general organisational operations. Luckily, the organisation has put in measures to ensure that this does not happen, most likely because the organisation is so dependent on the ICT department for day to day running of the business.

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[4] SENGE, P M. 2010. *The Fifth Discipline: The Art and Practice of the Learning Organization [Kindle Edition]*. Cornerstone Digital. Location 466-71.

This includes involvement in projects from the development of strategic goals right through to implementation.

However, the same cannot be said at the individual level. Employees within the department are isolated not from the rest of the organisation, but rather from each other. Physical isolation is achieved with cubicles for each employee. It is the belief of the researcher that because of the nature of software development, mental isolation occurs when extreme focus is required to complete tasks, especially since tasks are often small enough to be completed by a single developer. While this is a requirement for many developers, a balance has to be maintained between isolation required to complete tasks and the need for interaction for learning.

The problem of isolation is further compounded by the method in which work is assigned and tracked. At the start of the week, each developer meets with the project manager to determine the tasks for the given week[5]. There is no way for the developer to gain an overall view of what the department is trying to achieve. Focus was not given to this in the past as the only unit of measurement for the individual was whether the tasks assigned to the developer were completed on time and to standard.

Much has been written about the negative impact of marginalisation on individuals that are part of communities. Research has shown that adults in various settings are negatively affected by marginalisation and the result is reduced self-efficacy[6]. The research will show that semantic web technologies can be used to limit isolation while still maintaining the work environment which the developers feel comfortable with.

1.2. Basic definitions

The elements described in the research question require some definition before continuing. This will not be the end of the discussion about these topics, as they will be continued throughout this paper.

1.2.1. Knowledge

We understand knowledge to be the human capacity (potential and actual) to take effective action in varied and uncertain situations. Knowledge is tied to action because it is only through action that changes can occur and results be obtained. Tying knowledge to action recognizes the importance of tacit and implicit capabilities to take actions. It produces understanding and brings meaning to a situation.

1.2.2. Learning

Learning is considered to be the creation and acquisition of knowledge, both potential and actual. Thus, learning and knowledge are closely related but not identical. Learning is a

[5] A week is the typical timeframe for the development cycle within the department.

[6] SCHLOSSBERG N. 1989. *Marginality and mattering: Key issues in building community. New Directions for Student Services*. In LANGER, A. 2004. *IT and Organisational Learning: Managing Change through Technology and Education [Kindle Edition]*. CRC Press. Location 411-16.

process that creates new meaning from experience and new capabilities for action. Knowledge may be a process (taking action) or an asset (capacity) residing in the minds of knowledge workers. Often, we do not know what we know until we say or do something. Knowledge, like memory, is often created and brought forth from the unconscious mind when we need it.

1.2.3. Knowledge-centric organisation

A knowledge-centric organisation is one in which knowledge is recognized as a key success factor and is systematically managed. When there is a strong relationship between individual employees and knowledge management practices, the result is sustainable competitive advantage and increased performance. There are things that the worker can learn, know, and do that will significantly impact organisational learning and performance. At the same time, there are many things the organisation can do to support and help their knowledge workers perform more effectively. Both parties will benefit from continuous collaboration and support.

1.2.4. Knowledge workers

The term knowledge worker was first used by Peter Drucker to describe the highly skilled and experienced people who seek and create temporary work rather than permanent jobs[7]. In our context, the term will be used to describe individuals whose primary role is the use and manipulation of data and information to create new knowledge within an organisation. Knowledge workers may be found across a variety of information technology roles, but also among other professionals like teachers, librarians, lawyers, architects, physicians, engineers and scientists (this list is by no means exhaustive). As businesses increase their dependence on information technology, the number of fields in which knowledge workers must operate has expanded dramatically.

Due to the rapid global expansion of information-based transactions and interactions being conducted via the Internet, there has been an ever-increasing demand for a workforce that is capable of performing these activities. Knowledge workers are now estimated to outnumber all other workers in North America by at least a four to one margin[8]. The eighties were the time of greatest popularity of expert systems but interest started to lag thereafter. There is however no denying that as the complexity and volume of work for knowledge workers increases, so does the need for some of this work to be semi-automated or completely automated. The issue is how to implement solutions that free up the time of knowledge workers to create new knowledge and add value to the organisation.

Typical knowledge workers in the age of knowledge economy must have some system at their disposal to create, process and enhance their own knowledge. In some cases they would

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[7] DRUCKER, P F. 1996. *Landmarks of Tomorrow: A Report on the New "Post-Modern" World*. Transaction Publishers.

[8] HAAG, S, M CUMMINGS, and D J MCCUBBREY. 2003. *Management Information Systems for the Information Age*. McGraw-Hill Companies. 4.

also need to manage the knowledge of their co-workers[9]. Nonaka described knowledge as the fuel for innovation, but was concerned that many managers failed to understand how knowledge could be leveraged[10]. Companies are more like living organisms than machines, he argued, and most viewed knowledge as a static input to the corporate machine. He advocated a view of knowledge as renewable and changing, and that knowledge workers were the agents for that change.

1.2.5. Knowledge worker productivity

Drucker defines six factors for knowledge worker productivity[11]:

- Knowledge worker productivity demands that we ask the question: "What is the task?"
- It demands that we impose the responsibility for their productivity on the individual knowledge workers themselves. Knowledge workers have to manage themselves.
- Continuing innovation has to be part of the work, the task and the responsibility of knowledge workers.
- Knowledge work requires continuous learning on the part of the knowledge worker, but equally continuous teaching on the part of the knowledge worker.
- Productivity of the knowledge worker is not — at least not primarily — a matter of the quantity of output. Quality is at least as important.
- Finally, knowledge worker productivity requires that the knowledge worker is both seen and treated as an "asset" rather than a "cost." It requires that knowledge workers want to work for the organisation, in preference to all other opportunities.

While these are all important factors to consider if organisations wish to harness knowledge workers to ensure a competitive advantage in the knowledge economy, this paper will focus primarily on the fourth point. The researcher has observed that the accumulation of knowledge within the organisation for knowledge workers is often done in a hap hazard way. This means that there is no way to ensure that knowledge workers have at least the knowledge that they need in order to accomplish day-to-day required tasks. This is the base requirement for learning and without it the knowledge worker will not have the opportunity to extend the knowledge base and thus add to organisational knowledge. The organisational learning environment then is at the heart of the paper.

1.3. Challenges facing knowledge workers

The previous section alluded to the point that changes to the work environment have increased the demand for, and requirements of knowledge workers. Enhancements in

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[9] TOFFLER, A. 1991. *Powershift: Knowledge, Wealth, and Violence at the Edge of the 21st Century*. Bantam.

[10] NONAKA, I. 1991. The knowledge creating company. *Harvard Business Review*. **69**. 96 – 104.

[11] DRUCKER, P F. 2009. *MANAGEMENT CHALLENGES for the 21st Century*. HarperCollins e-books.

technology, specifically communications technology, and the resulting globalisation have caused organisations to have to change in significant ways to deal with it.

1.3.1. Complexity of open systems

Open systems architecture enables the parallel development at multiple levels of a system. The system may be computer software/hardware, communications platforms or even a retail product. Add to this the distributed nature of many of these systems and it becomes clear that a single person could not hope to have a thorough understanding of the entire system. Anyone needing to contribute to the system will have to deal with this complexity. One way of coping with the complexity is to focus on only the section of the system you deal with. This is indeed the case with knowledge workers who are involved with the maintenance of a system. The converse of this are the knowledge workers that are required to have a conceptual, high end view of the entire system, such as architects or system developers.

1.3.2. Depth vs. breadth of knowledge

The entire product development life cycle requires a depth and breadth of knowledge. The complexity described above means that a single individual can't possess the entire spectrum of knowledge required to develop such systems. For this reason, teams of knowledge workers that span the necessary knowledge domains have become the primary method of meeting this requirement. Using teams for the product development life cycle necessitates the need for learning environments to enable collaboration between team members. Having team members with depth of knowledge in particular fields requires a leader with the breadth of knowledge to support and enable the entire team. This problem is further compounded by the fact that team members are often distributed, meaning that it is important to create a virtual space for working and learning. In the case study, contractors are often part of development teams and they may not be working in the same geographic location. In an environment where recognition, structures, work processes, training and documentation are usually directed toward the individual, it is critical that the learning environment be redesigned to support team learning and development.

1.3.3. Iterative, customer centric development

Changes to technology, and the pace at which changes take place, have resulted in organisations having to change their processes and methods in product creation. The new global market has necessitated the need to reduced time-to-market and constantly improve and update products. The *systems approach* to product development aims to make the basic processes work faster and better by automating each step in the development cycle (often called the *waterfall method* in software development). Incremental or iterative development is a departure from the standard systems approach and is known in also referred to as *agile development* in software development circles.

Modelling is the process of design before any of the actual production begins, but can be extended to actual development without any changes. Below is a summary of the main difference between the agile modelling and standard approaches[12]. It is based on the software development industry, but could be extended to any product development cycle.

- The waterfall method dictates that once a stage has been completed, we do not return to it. This means that most software designed and implemented under the waterfall method is hard to change according the progress of user needs. The problem can only be fixed by going back and designing an entirely new system, a very costly and inefficient method. Agile methods adapt to change, allowing the developers the scope to go back and amend facets at each stage. Its design allows developers to cope and adapt to new ideas from the outset, allowing changes to be made easily. With Agile, changes can be made if necessary without getting the entire programme rewritten. This approach not only reduces overheads, it also helps in the upgrading of programmes after release.
- Another agile method advantage is that the product of each stage is something which can be used and tested. This ensures bugs are caught and eliminated in the development cycle, and the product is double tested again after the first bug elimination. This is not possible with the waterfall method, since the product is tested only at the very end, which means any bugs found results in the entire programme having to be re-written.
- Agile methods allow for specification changes as per end-user's requirements, meaning that customers are satisfied. As already mentioned, this is not possible when the waterfall method is employed, since any changes to be made means the project has to be started all over again.
- However, both methods do allow for a sort of departmentalisation e.g. in waterfall departmentalisation is done at each stage. As for Agile, each module can be delegated to separate groups. This allows for several parts of the project to be done at the same time.

These changes to the development environment have had a profound effect on the learning environment within the organisation. Before, organisations had the luxury of producing documentation on products or services that were stable for an extended period of time. Developers, maintenance staff as well as sales staff have great difficulty keeping track of the rapid changes to products and services.

1.4. The new corporate learning environment

Senge stated that the organisation that will truly excel in the future will be the organisation that discovers how to tap people's commitment and capacity to learn at all levels in the organisation[13]. The key is providing a framework for organisations in order to create the

[12] AMBLER, S W. 2005. *The principles of agile modeling*. [online]. [Accessed 9 January 2011]. Available from World Wide Web: < http://www.agilemodeling.com/principles.htm >

[13] SENGE, P M. 2010. *The Fifth Discipline: The Art and Practice of the Learning Organization [Kindle Edition]*. Cornerstone Digital. Location 241-47.

learning environment. Based on the challenges facing knowledge workers, it is possible to extrapolate six areas of importance within the organisation[14].

1.4.1. Team management and support

There is a quote by Peter Senge used in many discussions on the value of team work within an organisation. He asserts that:

Most of us at one time or another have been part of a great "team", a group of people who functioned together in an extraordinary way – who trusted one another, who complemented each other's strengths and compensated for each other's limitations, who had common goals that were larger than individual goals, and who produced extraordinary results.[15]

But what contributes to making a team successful? Many research papers as well popular literature have focused on this topic. Below are eight dimensions that are regularly associated with team excellence[16]. These dimensions are not exhaustive as all teams would have different dynamics. It is however useful to keep them in mind as we explore solutions to team learning and thus development.

- *A clear, elevating goal* – The clarity ensures that the members have confidence in the direction of the goal.
- *A results driven structure* – Teams are rewarded for reaching their goals.
- *Competent team members* – Effective teams are comprised of effective individuals, just think of the phrase "a chain is only as strong as its weakest link".
- *Unified commitment* – This is in essence what team work is all about, working together towards a common goal.
- *A collaborative climate* – It is important to ensure that working in a team does not constitute extra effort for the individual.
- Standards of excellence – By having these standards, all team members know implicitly what is expected of them.
- *External support and recognition* – The team must not be isolated from the rest of the organisation.
- *Principled leadership* – Leaders are focused on the vision of the team and apply moral and ethical standards as well as values and virtues to decision-making.

1.4.2. Knowledge generation and sharing

[14] KLEIN, J and D ESERYEL. 2005. The corporate learning environment. *In*: *Intelligent Learning Infrastructure for Knowledge Intensive Organizations: A Semantic Web Perspective*, Information Science Publishing. 1 – 38.

[15] SENGE, P M. 2010. *The Fifth Discipline: The Art and Practice of the Learning Organization [Kindle Edition]*. Cornerstone Digital. Location 245-50.

[16] LARSON, C. LAFASTO, F. 1989. In DUYGULU, E and N CIRAKLAR. 2008. *Team Effectiveness and Leadership Roles*. Munich Personal RePEc Archive.

A fundamental requirement of the corporate learning environment is capturing internal corporate knowledge and making it available to every member of the organisation (or at least to every member that requires it in order to fulfil their role within the organisation). It is important at this stage to differentiate between information being captured in documents and actual knowledge. Referring back to our definition of knowledge, it is clear that knowledge is inly created when information is made useful to employees. The goal then is not only to assist capturing and sharing of information in documents, but also to allow employees to take this information and contextualise it for their personal needs.

It is by no means the intention for the above paragraph to belittle the role of information documentation and sharing. Without it, there would be little foundation for knowledge generation and sharing. In fact, document management systems form a pivotal role in many knowledge management systems.

1.4.3. Learning and training management

Methods associated with knowledge management, lend themselves to the support of learning. Departing from traditional learning environments such as the school classroom though, the user decides what to learn and when to learn it. The organisation may also prescribe learning methods to meet predefined learning objectives. There are three general categories of systems used by the organisation in order to support the learning; performance support, learning management and training management.

Chapter 2
Learning Theories and Technology

The purpose of this chapter is to provide an understanding of learning and organisational theory. It will cover some aspects of the history and context of organisational learning and hone in on which theories are most suited to understanding the focused area of technology enhanced learning.

2.1. Introduction to learning theory in the knowledge age

Our personal, professional, social and cultural lives have been affected and transformed by the computer networking revolution: email, mobile phones, text messaging, Twitter, participating in social networks, blogging and accessing powerful search engines using computers and more recently, mobile devices, are common aspects of most individual's daily lives.

In our personal lives, we have embraced new technologies for social communication. New technologies are reshaping the way we function within our communities and even how we form them. We use email, Twitter, texting; participate in online forums and social networks (such as Facebook, MySpace); search massive databases; access wikis, blogs and user-generated content sites (YouTube, Flickr); or shop online using stores like Amazon. But in our professional lives, despite our interest or need, there has been little opportunity to consider and explore new learning paradigms.

Rather than transform learning by using opportunities afforded by new technologies and the changing socio-economic context of the 21st century, a common tendency has been to merely integrate technology into traditional ways of teaching and learning. Examples of migrating traditional teaching approaches to the Web are common and include the use of email, wikis and web portals for: transmission of course information and content to students, communication between student and teacher/tutor, transmission of lectures (PowerPoint slides, videoconferences, podcasts), administering quizzes, assessing quizzes and posting grades.

Such use of the Web for traditional teaching methods represents the most common educational applications of the Web, and for man, the only way of using the Web. Adopting the new technologies to serve traditional practices may not be bad in itself, but we may be missing opportunities to introduce better, different or more advanced ways of learning.

2.2. What is learning theory?

A theory of learning aims to help us to understand how people learn. Many theories of learning were generated in the 20th century, and in this section we will examine the major theories and how each provides an overview and guide whereby we may gain an insight into learning. The theory that we use, be it consciously or not, forms our frame of reference. This in turn influences what we see, what we consider to be important and thus how we will design and implement decisions. By understanding learning theory, we can reflect on their practice, improve upon, reshape and refine their work and contribute to advancing the discipline.

Theory helps us formulate ideas; it informs the creative process. When we see the world differently, we act to make things different via the relationship between theory and design or between science and technology. Such relationships allow for new technology or conversely, "…a new technology spawns new theory."[17]

The discussion of learning theories in this book has an epistemological and a scientific component, and emphasizes as well the role of knowledge communities. Knowledge communities are the forums or processes of discourse and debate, whereby scholars advance the state of the art in that particular discipline. These three terms are discussed below as providing the cornerstones of theory. Deciding what to study when we seek to explain how people learn or deciding how to teach depends upon our disciplinary beliefs and perspectives: theories of learning are based on epistemologies, scientific methods and the views of knowledge communities of the time.

2.2.1. Theories and Epistemology

Epistemology asks: what is knowledge? How do we know? These questions are important because 20th- and 21st-century learning theories are based on epistemologies that began to challenge the concept of knowledge beyond the view of knowledge as divine that was dominant up until the 19th century. The two major epistemologies of the 20th and 21st centuries are objectivist epistemology (reflected in behaviourist and cognitivist theories of learning) and constructivist epistemology (reflected in constructivist and the online collaborative learning theories).

One kind of knowledge that traditional college and university education especially values because it is long-lasting, is knowledge of the conventions of traditional education themselves. Instructors are responsible not only for imparting knowledge that was imparted to them, but also imparting knowledge as it was imparted to them.[18]

Didactic methods of teaching are the accepted and traditional way of imparting knowledge. Didactic teaching involves transmitting knowledge from the teacher to the student, just as it was earlier transmitted to the teacher when she or he was a student. This is imperative if the view of knowledge is objectivist, foundational and absolute according to Bruffee, who writes that the objectivist view holds that knowledge is a kind of substance contained in and given form by the vessel we call the mind. Professors' mental vessels are full, or almost full.

[17] WILSON, B. G. 1997. Thoughts on Theory in Educational Technology. *Educational Technology*. 22.

[18] BRUFFEE, K A. 1999. *Collaborative learning: Higher education, interdependence, and the authority of knowledge*. Baltimore, MD: Johns Hopkins University Press. 152 – 153.

Students' mental vessels are less full. The purpose of teaching is to transfer knowledge from the fuller vessels to the less full.[19]

In contrast to the objectivist version of the authority of knowledge is the more recent constructivist epistemology, which holds that knowledge about the world is constructed through our perceptions and interaction and discussion within various communities of knowledgeable peers. *The nonfoundational social constructionist understanding of knowledge denies that it lodges in any of the places I have mentioned: the mind of God, touchstones of truth and value, genius, or the grounds of thought, the human mind and reality. If it lodges anywhere, it is in the conversation that goes on among the members of a community of knowledgeable peers and in the "conversation of mankind."*[20]

The two dominant epistemological positions in higher education today are objectivism and constructivism: [21]

Objectivists believe that there exists an objective and reliable set of facts, principles, and theories that either have been or will be discovered and delineated over the course of time. This position is linked to the belief that truth exists outside the human mind, or independently of what an individual may or may not believe.

On the other hand, constructivist epistemologies hold that knowledge is essentially subjective in nature, constructed from our perceptions and usually agreed upon conventions. According to this view, we construct new knowledge rather than simply acquire it via memorisation or through transmission of those who know to those who did not.

2.2.2. Theory and scientific method

The first theories of learning can be traced to the late 19th century, related to the emergence of positivism (a term coined in 1847 by the French philosopher, Auguste Comte) and scientific inquiry. Whereas *philosophies* of learning deal with values and worldviews, *theories* of learning emphasize an empirical element and a formalized way of study, analysis and conclusion.

It is this distinguishing quality of theory, its empirical nature, that remains relevant today, although the rigid aspect of positivism that restricted the study of learning to observable behaviour is less accepted by educational researchers.

2.2.3. Theory and knowledge communities

[19] BRUFFEE, K A. 1999. *Collaborative learning: Higher education, interdependence, and the authority of knowledge*. Baltimore, MD: Johns Hopkins University Press. 152.

[20] BRUFFEE, K A. 1999. *Collaborative learning: Higher education, interdependence, and the authority of knowledge*. Baltimore, MD: Johns Hopkins University Press. 153.

[21] BATES, A W and G POOLE. 2003. *Effective teaching with technology in higher education: Foundations for success*. San Francisco, CA: Jossey-Bass. 28 – 29.

Knowledge communities refer to groups associated with a particular field or related to a discipline. It is the work of the members of a knowledge community to define the state of the art and to advance that state in a particular discipline or field of work. Scholarly or knowledge communities are associated with all scientific, cultural and artistic fields of endeavour. Other terms used to describe this concept are knowledge societies, scientific communities, invisible colleges and schools of thought. The concept itself, however, is key because theory building is typically conducted by and within the context of a particular knowledge community. Members collaborate and argue, agree and disagree, and introduce new information and empirical data to contribute to and advance knowledge in the field.

In every progressive discipline one finds periodic reviews of the state of knowledge or the *state of the art* in the field. Different reviewers will offer different descriptions of the state of knowledge; however, their disagreements are open to argument that may itself contribute to advancing the state of knowledge[22]. Creation is a deliberate process of advancing the frontiers in a particular discipline. Knowledge, thus, is viewed as constructed through informed dialogue and conversations conducted among members of a knowledge community.

The concept of knowledge communities is key in this paper. The four major learning theories discussed here represent the state of the art as articulated by particular knowledge communities, which flourished at particular points in time. Theories exist in context, and both reflect and illuminate that context. Theories change and improve over time. Knowledge in a field does not merely accumulate, it advances. The next section introduces the theories of learning in the 20th and 21st centuries, and discusses briefly the essence of each theory and how it evolved within the social context of its time.

2.3. Learning theories of the 20th century

2.3.1. Behaviourist learning theory

Instructional technology has its roots in behaviourism. The rise of scientific methodology and the study of how people learn coincided with mechanization in the labour force and demands for an increasingly educated population.

Industrialization required workers who could read and follow instructions as they were required to be able to perform their tasks repeatedly and reliably. Education had to be able to teach literacy and to instil the discipline for repetitious behaviour and predictable performance at work. Mass schooling and compulsory education were developed to meet these needs. These needs were also fuelled by World War II and the need for highly skilled workers, which required major training initiatives.

Behavioural learning theory lent itself not only to instructional design based on very specific and discrete learning steps, but also to mechanization of this process through new forms of

[22] BEREITER, C and M SCARDAMALIA. 2006. Education for the knowledge age: Design-centred models of teaching and instruction. *In*: *Handbook of educational psychology*, Mahwah, NJ: Lawrence Erlbaum Associates. 100.

learning technologies. Learning technologies that were intended to encourage practice and reinforcement of specific tasks were developed. Mechanization also appealed to the need for efficiency and to making instruction more methodical. Two major examples of technologies based on behaviourist learning theory emerged:

2.3.1.1. Teaching Machines and Programmed Instruction

Teaching machines were first developed in the mid-1920s as self-scoring testing devices. The teaching machine housed a list of questions and a mechanism through which the learner responded to questions. Upon delivering a correct answer, the learner is rewarded. The earliest examples of teaching machines included automatic (chemically treated) scoring cards used for self-checking by students while studying the reading assignment. A similar form of individualized learning and immediate feedback was achieved with the use of punch cards.

Another early example is the testing device developed by Sidney Pressey, an educational psychology professor at Ohio State University. He developed a machine to provide drill-and-practice items to students in his introductory courses. He stated, “the procedures in mastery of drill and informational material were in many instances simple and definite enough to permit handling of much routine teaching by mechanical means.”[23] The teaching machine that Pressey developed, resembled a typewriter carriage with a window that revealed a question with four possible answers. On one side of the carriage were four keys. The user pressed the key that corresponded to the correct answer. When the user pressed a key, the machine recorded the answer on a counter to the back of the machine and revealed the next question. After the user was finished, the person scoring the test slipped the test sheet back into the device and noted the score on the counter.

Skinner updated the teaching machine in the 1950s, under the name of programmed instruction (PI). PI derived from teaching machines by linking self-instruction of the content with self-testing. This approach dominated the field in the 1960s and 1970s. Whereas earlier forms of teaching/testing devices employed multiple-choice approaches, Skinner required students to form composed responses (words, terms) and he sought totally correct answers; PI would reinforce a response that was close to the correct answer/behaviour and through successive approximations would seek to achieve the desired behaviour and avoid any wrong answers.

PI was based on Skinner’s theory of verbal behaviour as a means to accelerate and increase conventional educational learning. It consisted of self-teaching with the aid of a specialized textbook or teaching machine that presented material structured in a logical and empirically developed sequence or set of sequences. PI allowed students to progress through a unit of study at their own rate, checking their own answers and advancing only after answering correctly. In one simplified form of PI, after each step, students are presented with a question to test their comprehension, then immediately shown the correct answer or given additional information. The main objective of instructional programming is to present the material in

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[23] PRESSEY, S L. 1926. A simple apparatus which gives tests and scores-and teaches. *School and Society*. **23**(586). 73 – 376.

small increments so that students could approximate and eventually achieve total accuracy in their responses.

Teaching machines and PI emphasized the development of hardware rather than software (or content). Even though PI eventually moved to focus more on content and analysis of instruction, it soon disappeared from educational consideration and use.

2.3.1.2. Computer-assisted instruction (CAI)

Computer-assisted instruction (CAI) was developed during the 1950s for teaching and training. CAI is essentially a drill-and-practice approach to learning, and the control is with the program designer and not the learner (although small levels of individual customization were implemented). It is the earliest example of educational applications of a computer. Computing in the 1950s and 1960s was very complex but educational applications were already being envisioned and implemented. Due to significant technical problems, lack of quality software and high costs, this approach did not initially flourish. However, the US Department of Defense became a major, and occasionally the major, player in funding CAI developments during the 1950s and until today[24]. Two early projects were PLATO and TICCIT. PLATO (Programmed Logic for Automated Teaching Operations) was specifically designed for developing and presenting instruction. PLATO was one of several projects at the University of Illinois Coordinated Science Laboratory funded by the military in the 1950s. Its major impact is considered to be in "encouraging individuals to develop and use CAI"[25]. TICCIT (Time-shared Interactive Computer-controlled Television) was developed at the University of Texas, and later Brigham Young University, as a computer system designed to implement formal principles of instructional design. Many of the techniques developed for PLATO and TICCIT found their way into K-12 and university education.

In the 1980s, with the rise of personal computing and its appearance in the school system, CAI approaches flourished in the public sector. There were as yet no competing educational computing options. Personal computers were in their initial stages, and educational adoption of computers was at its most primitive. Drill and practice, and "electronic page turning," both associated with CAI, were the earliest forms of educational software. These approaches were relatively easy to program on a computer; they required little computer memory and reflected the low level of understanding of educational computing of the time.

The military, however, found CAI approaches to be highly efficient. While the costs of anticipating responses to all learner states and interactions were a problem, a growing body of data indicated success.

Among the findings from comparisons of CAI with standard classroom learning in military, academic and industry sectors were reductions of 24 to 54% in the time taken to learn. Technology costs aside, a 30% reduction in the time needed to learn would save the

[24] FLETCHER, J D. 2009. Education and training in the military. *Science Magazine*. **323**(5910). 72.

[25] FLETCHER, J D. 2009. Education and training in the military. *Science Magazine*. **323**(5910). 72.

Department of Defence 15 to 25% of the $4 to $5 billion it spends annually for specialized skill training (from novice to journeyman).[26]

Today, the military continues to support CAI development and applications, in the form of intelligent tutoring systems (ITS), and also through the development of digital learning objects.

2.3.2. Cognitivist learning theory

The field of *educational technology* emerged during the behaviourist period and gained increased importance and influence for cognitivist researchers and instructional designers. Computers were the key learning technology for cognitivist learning theorists. Key examples include:

2.3.2.1. Intelligent tutoring systems (ITS)

Intelligent tutoring systems (ITS) refer to a didactic, content-specific instructional technology. ITS have been in existence since the 1970s. Precursors of ITS were early mechanical systems such as Charles Babbage's vision of a multipurpose computer which he developed in principle in 1834 as the analytic engine, as well as Pressey's mid-1920s teaching machines or *intelligent machines* which used multiple-choice questions submitted by the instructor. In the 1970s, computer-assisted instruction (CAI) emerged as an instructional method based on a systematic instructional approach administered on a computer. In CAI the computer evaluates whether the student's response is right or wrong, and then branches the student into either moving ahead (with appropriate feedback) or into corrective action such as reviewing the earlier material or presenting a simpler question. Branching is designed (coded) by the instructional designer into the program: if the student's answer is correct, then the student advances to the next question. If the student's response is incorrect, then remediation is invoked. This is the behaviourist instructional design.

Hardware and software have evolved at tremendous rates since the 1970s. As computers developed in sophistication, so too did instructional applications. Increasingly complex branching capabilities in CAI led to what became known as ICAI (or Intelligent CAI) and eventually to ITS. It is a continuum from linear CAI to the more complex branching of ICAI and then ITS, although the authors note that this does not mean that the continuum represents a worst-to-better progression.[27]

Branching is a common and key characteristic of CAI and ITS, and reflects the complexity of knowledge and multiple pathways of curriculum. However, the quality of branching, and its complexity, does distinguish ITS from CAI. Whereas CAI is content-free, ITS are based on specific knowledge domains that are taught to the individual students by the computerized tutor.

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[26] FLETCHER, J D. 2009. Education and training in the military. *Science Magazine*. **323**(5910). 72.

[27] SHUTE, V J and J PSOTKA. 1996. Intelligent tutoring systems: Past, present and future. *In*: *Handbook of research for educational communications and technology*, New York: Simon & Schuster Macmillan. 571.

A student learns from an ITS primarily by solving problems—ones that are appropriately selected or tailormade—that serve as good learning experiences for that student. The system starts by assessing what the student already knows, the student model. The system must concurrently consider what the student needs to know, the curriculum (also known as the domain expert). Finally the system must decide which curriculum element (unit of instruction) ought to be instructed next and how it shall be presented, the tutor or inherent teaching strategy. From all of these considerations, the system selects, or generates, a problem, then either works out a solution to the problem (via the domain expert) or retrieves a prepared solution. The ITS then compares its solution, in real time, to the one the student has prepared and performs a diagnosis based on differences between the two[28].

One reason that ITS may disappear in the future is that, while many researchers agree that intelligence in an ITS is directly a function of the presence of a student model, the student model may, in fact, be the wrong framework around which to build good learning machines[29].

Second, there are problems with the concept of machine intelligence. Intelligence is associated with awareness; the term "intelligent tutoring system" can be viewed as misleading or inappropriate and promising far more than it can or has delivered. ITS may promise too much, deliver too little and constitute too restrictive a construct.

A significant concern with the development of learning theory, pedagogy and technologies by both behaviourists and cognitivists was that the researchers and scholars had little contact with educational practice or practitioners. Pavlov was a medical physiologist who focused on reflexes related to digestive systems while Skinner worked with animals in research laboratories. While behaviourist approaches based on the carrot and the stick dominated (and still do) classrooms at all levels of education, nonetheless, these are very broad interpretations of the stimulus–response activities of classical behaviourism or operative conditioning. Behaviourist learning theorists did not take real classroom learning or educational practice into consideration.

Cognitivist learning theorists were similarly divorced from educational practice, with the exception of Gagné, who spent 50 years working with military training as a psychologist and was subsequently involved with military training research. His instructional design theory and processes have particularly influenced the field of training. Classroom applications in K-12 or higher education were not, however, significantly influenced by Gagné's instructional design model. The technologies developed by cognitivist researchers and developers were similarly isolated from classroom realities. Nor were they ever adopted or considered for

[28] SHUTE, V J and J PSOTKA. 1996. Intelligent tutoring systems: Past, present and future. *In*: *Handbook of research for educational communications and technology*, New York: Simon & Schuster Macmillan. 574.

[29] SHUTE, V J and J PSOTKA. 1996. Intelligent tutoring systems: Past, present and future. *In*: *Handbook of research for educational communications and technology*, New York: Simon & Schuster Macmillan. 591.

classroom applications. There are actually very few ITS in place in schools, yet they exist in abundance in research laboratories. We need to move on.[30]

2.3.2.2. Artificial Intelligence (AI)

The invention of computers after World War II generated anticipation of astounding possibilities for computer programs to be capable of human-like intelligence. In 1950, Alan Turing reflected on the potential of computer programs to simulate the human mind. Turing is known as the inventor of the first computer, in 1936, although his computer was on paper only. The Turing computer was a tape that could store a symbol or simple instructions and a head that could read the instructions and perform very simple operations (read the symbol, select a new symbol, move it left or right). Despite its simple capabilities, Turing argued that his machine could realize anything that can be realized from operations. In 1950, he argued that the mind itself was the result of similar operations (at the neural level). He is thus viewed as the creator of artificial intelligence studies.

The AI movement originated with such scholars as Alan Turing, Marvin Minsky and Allen Newell, who all believed that the development of computers that could "think" like humans was just around the corner. The major constraint, they believed, was the size of current computing power. Bigger and faster computers should be able to solve the problem and achieve human-like cognitive performance. Computers would be able to think, and they would thus be able to instruct.

The AI movement had emerged in the 1950s, in the early post-war period. Thousands of American GIs had returned home from World War II and were going to college on the GI Bill. The impact on educational institutions was unprecedented growth. New ways to meet the demand for education were a high priority. The use of computers for instruction seemed like one obvious solution. Efficient instruction could be met by using computing machines. It could also be facilitated through efficient instructional pedagogies.

During the period of the 1970s and 1980s AI researchers continued to optimistically believe in the imminent viability of computer intelligence. The rapid growth in computing power and capabilities seemed to promise that the goal of thinking computers was nigh. However, the problems began to prove far greater than simply the need for more computer memory or speed. A crisis in the movement was triggered not only by the technological problems but in the very definition and implementation of computer intelligence. As noted earlier in the chapter, there was no universal definition of what constitutes computer intelligence. The AI movement lost its impetus for the moment, although research continued with ITS.

Brent Wilson acknowledged a growing disaffection with theories of AI as well as with instructional design (ID)[31]. As a scholar engaged in ID studies, he found a similar sense of chaos and lack of direction among adherents and researchers. Artificial intelligence right now

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[30] SHUTE, V J and J PSOTKA. 1996. Intelligent tutoring systems: Past, present and future. *In*: *Handbook of research for educational communications and technology*, New York: Simon & Schuster Macmillan. 595.

[31] WILSON, B G. 1997. Reflections on constructuvism and instructional design. *In*: *Instructional development paradigms*, Englewood Cliiffs: Educational Technology Publications. 63 – 80.

is facing some of the same crises we are confronting…. A growing number of AI researchers have lost faith in traditional views of the representability of knowledge.[32] He concludes: "In summary, ID theory, with its prescriptive orientation toward both procedure and product, lies in conceptual limbo"[33].

In the 1960s and 1970s, social reform movements were impacting society and education in the United States. New perspectives on learning based on constructivist epistemology and theory were coming from Europe and began to strongly influence American education. It was a time of change and of changing perceptions on the role of the student and of the citizen. Theories of constructivist learning generated significant researcher as well as teacher interest. Piaget's theories were taking hold and at the same time Bruner was introducing the ideas and writings of Lev Vygotsky, who presented an approach to social constructivism, perspectives related to active learning and student-centered models of learning.

2.3.3. Constructivist Learning Theory

The technologies specifically associated with constructivist learning were often referred to as learning environments or microworlds. The term learning environment was primarily associated with computer-based software that is open-ended to enable and require user input, action and agency. It was primarily related to computer-based software, rather than online or web-based environments.

There are several characteristics that distinguish constructivist learning environments. These can be summarised as[34]:

- provide multiple representations of reality, to avoid oversimplification;
- represent the natural complexity of the real-world;
- emphasize knowledge construction instead of knowledge reproduction;
- emphasize authentic tasks in a meaningful context rather than abstract instruction out of context;
- provide learning environments such as real-world settings or case-based learning instead of predetermined sequences of instruction;
- foster thoughtful reflection on experience;
- enable context- and content-dependent knowledge construction;
- support collaborative construction of knowledge through social negotiation, not competition among learners for recognition.

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[32] WILSON, B G. 1997. Reflections on constructuvism and instructional design. *In*: *Instructional development paradigms*, Englewood Cliiffs: Educational Technology Publications. 77.

[33] WILSON, B G. 1997. Reflections on constructuvism and instructional design. *In*: *Instructional development paradigms*, Englewood Cliiffs: Educational Technology Publications. 70.

[34] JONASSEN, D H, J P CAMPBELL, and M E DAVIDSON. 1994. Learning with media; Restructuring the Debate. *Educational Technology Research & Development*. **42**(2). 35.

This list has been accepted by both social and cognitivist constructivists, albeit with some differences in emphasis.

Computers are viewed as the optimal medium for applying constructivist principles to educational practice, because computer software can support various strategies and approaches more easily and effectively than other media. Computer software can also link to resources necessary in simulations and microworlds. Computer-based constructivist learning environments such as construction kits, microworlds, scaffolded intentional learning environments, learning networks (telecollaboration) and computer-supported collaborative learning environments were developed in the 1980s and 1990s, and are discussed below.

2.3.3.1. Construction Kits and Microworlds

In the late 1980s and 1990s educational computer software development sought to support the variety of ways learners construct their own understanding—both as independent work and in collaboration with other learners. Microworlds were designed to provide students with opportunities to connect prior learning with current experience, and they were often created by learners using computer tools as construction kits.

Papert was an early contributor to the computing and the educational world. In fact, he writes that in the 1960s people laughed at him when he talked about children using computers as instruments for learning and for enhancing creativity: the idea of an inexpensive personal computer seemed like science fiction at the time[35]. But, he notes, it was in his MIT laboratory that children first had the chance to use the computer to write and to make graphics. The Logo programming language was created there, as were the first children's toys with built-in computation. Logo could be used by students of various ages and computer experience to construct and engage in microworlds.

2.3.3.2. Scaffolded Intentional Learning Environments

Computer-based constructivist learning environments were developed during the 1980s and 1990s, and some of these went online using local area networks, mainframe computers or the Internet. CSILE (computer-supported intentional learning environment) was developed by Carl Bereiter and Marlene Scardamalia in 1983, initially at York University, Toronto, and then at the Ontario Institute for Studies in Education, University of Toronto.

There has been a history of attempts in computer-assisted instruction to give students more autonomy or more control over the course of instruction. Usually these attempts presupposed a well-developed repertoire of learning strategies, skills, and goals, without providing means to foster them.[36]

The environment initially envisioned was one in which students could learn and practice these metacognitive skills. Their software, called computer-supported intentional learning environments (CSILE), aimed to foster rather than presuppose a student's metacognitive

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[35] http://www.papert.org

[36] SCARDAMALIA, M, C BEREITER, R S MCCLEAN et al. 1989. Computer supported intentional learning environments. *Journal of Educational Computing Research*. **5**. 51.

abilities. CSILE software was designed to scaffold knowledge-building activities, using a communal database constructed by learners and their teachers. Students would enter text and/or graphic notes into the database on any topic created by the teacher. All students in the project read one another's notes and could contribute to or comment on them, using computers linked together on a local area network. Authors would be notified when comments were made. In 1983, CSILE was prototyped in a university course and in 1986 it was used for the first time in an elementary school, as a full version. In 1995, the software was redesigned in accordance with the World Wide Web and renamed Knowledge Forum.

2.3.3.3. Learning Networks or Telecollaboration

Another category of constructivist learning environments in the 1980s and 1990s is referred to as telecollaboration or online learning networks[37]. Learning network projects began with the use of email running on mainframe computers. The development of the Internet led to a vast number of class–class or school–school network learning activities. One of the earliest examples of online learning networks or telecollaboration was the work by Margaret Riel who created the pedagogical approach of Learning Circles. Learning Circles were student-centered learning projects that began as cross-classroom projects, in which classrooms in different schools and countries communicated by email; by the 1990s, the AT&T telecommunications corporation and then the National Geographic Society offered learners and teachers the opportunity to work with leading scientists. Students also had access to online curriculum units in the sciences in which they collected data and ran and shared their results with others in the network. Riel continues to design, research and direct Learning Circles, a program that brings student/ teacher teams from different counties into project-based learning communities over electronic networks. The Learning Circle network is now part of the International Education and Resource Network (iEARN)[38]. Riel also helped design the model for Passport to Knowledge, a National Science Foundation-funded *electronic travel* socio-technical network.

Another telecollaboration model is the JASON[39] project founded in 1989 by Robert D. Ballard following his discovery of the shipwreck of the RMS Titanic. Given the large interest in this discovery expressed by children, Ballard and his team dedicated themselves to developing ways to enable teachers and students around the world to participate in global interactions using telecommunication technologies like email. Similarly, the MayaQuest[40] project allows students to follow and connect with a team of scientists cycling to remote archaeological sites. Students can ask questions of the scientists and local people as well as engage in scientific activities using the internet.

The online learning environment provides access to learning with context even though the students are far away. Computers are used to assist active experiences; gathering data and

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[37] HARASIM, L M, S R HILTZ, L TELES, and M TUROFF. 1995. *Learning networks: A field guide to teaching and learning online*. Cambridge: MIT Press.

[38] http://www.iearn.org/

[39] http://www.jason.org/public/whatis/start.aspx

[40] http://www.teachervision.fen.com/tv/classroomconnect/maya/index.html

resources, conversing with colleagues, or they assist with reflection. As an example, while an online conversation is an active event, these discussions may lead to reflection. Teachers can also employ computers as authoring tools for such pedagogies as students' journals and portfolios, to encourage learner examination of experience.

The use of real-world tools, relevant experiences and meaningful data seeks to inject a sense of purpose into learning.

The vastness of online information also poses its own challenge though. Internet content is less structured and manageable than say a textbook. It is also more dynamic and the learner needs to learn to question and evaluate the information they find in terms of applicability and authenticity of the data.

2.3.3.4. Online Learning and Course Delivery Platforms

The need for online platforms to support the delivery of online course or educational activities became recognised and by the 1990s, a variety of software packages emerged to address this issue. These platforms were known under various categorisations such as management systems, course management tools, virtual learning environments and computer supported collaborative learning software. Generally, they were not customised to scaffold particular learning strategies, but rather provided generic tools such as discussion forums bundled with quiz tools, grade books and calendars. Examples of these asynchronous learning platforms include Blackboard[41], WebCT[42], Desire2Learn[43] and Moodle[44]. At the time of writing, all these systems are still in existence, but have undergone dramatic changes in order to adapt to enhancements in technology.

These environments are constructivist in that they facilitate user generated content and can be structured by the user to support online discussion, discourse and work projects. Unfortunately, providing the tools does not mean that the teacher will use constructivist pedagogies to engage with the learner. The developer of Construe, a constructivist computer conferencing software, admitted that the software could also be "used to support very traditional instructional strategies"[45].

As mentioned, these platforms are continually maturing to incorporate scaffolds, new pedagogical supports and other features to more explicitly facilitate knowledge building and collaborative learning.

2.4. A learning theory for the 21st century

As with learning theories of the 20th century, online collaborative learning (OCL) theory builds upon previous approaches, but presents a new perspective. OCL emerged with the

[41] http://www.blackboard.com/platforms/learn/overview.aspx

[42] Now owned by Blackboard

[43] http://www.desire2learn.com/

[44] http://moodle.org/

[45] DRISCOLL, M P. 2004. *Psychology of Learning for Instruction*. Allyn & Bacon. 406.

invention of computer networking and the Internet, and the concomitant socio-economic shift from the industrial society to the Knowledge Age. The three major theories of learning that emerged during the 20th century (behaviourism, constructivism and cognitivism) derived from the field of educational psychology. There are four key omissions or problems with 20th-century educational psychology that need to be addressed by theory in the 21st century:[46]

- Educational psychology continues to struggle with the most appropriate relation to practice.
- The position of adults in educational psychology remains a puzzlement
- Neither HBEPI nor HBEPII1 include *Learning* in a chapter title
- A fourth and final set of issues centres around methodology.

Behaviourist, cognitivist and developmental constructivist theories of learning emphasized learning as an individualistic pursuit. Moreover, the epistemological basis of behaviourism and cognitivism was objectivism: objectivist epistemology holds that knowledge is fixed and finite, and ultimately, knowledge is truth. Knowledge is something that the teacher has mastered, and which students must now similarly master by replicating the knowledge of the teacher. The pedagogies emphasized “transmitting information” by the teacher as a way to “acquire knowledge” by the student, reflected in such didactic approaches as lectures or their mechanized versions in the form of teaching machines, computer-assisted instruction (CAI), intelligent tutoring systems (ITS) and courseware. This was the ethos of the Industrial Age, an era that emphasized the learner’s ability to acquire and retain information and associated skills. An implicit educational goal was that the student learns to follow instructions accurately to achieve the desired result.

The 21st-century Knowledge Age has introduced a very new mind set in society. Whereas the Industrial Revolution extended and leveraged our physical capabilities to manipulate objects far beyond muscle power alone, the Internet Revolution and ensuing Knowledge Age emphasizes, extends and leverages our mental capabilities. OCL is proposed as a framework to guide understanding and practice of education in the Knowledge Age. Unlike the behaviourist and cognitivist emphasis on instructions for replicating a textbook answer, OCL focuses on knowledge-building processes. OCL theory differs from constructivist learning theory, by locating active learning within a process of social and conceptual development based on knowledge discourse.

One important advantage of knowledge building as an educational approach is that it provides a straightforward way to address the contemporary emphasis on knowledge creation

[46] CALFEE, R C. 2006. Educational psychology in the 21st century. *In*: *Handbook of educational psychology*, Mahwah: Lawrence Erlbaum Associates. 30–31.

and innovation. These lie outside the scope of most constructivist approaches, whereas they are at the heart of knowledge building.[47]

[47] BEREITER, C and M SCARDAMALIA. 2006. Education for the knowledge age: Design-centred models of teaching and instruction. *In*: *Handbook of educational psychology*, Mahwah, NJ: Lawrence Erlbaum Associates. 99.

Chapter 3
Online Collaborative Learning (OCL) Theory

Online learning has emerged with the development of computer networking and an emphasis on collaboration and knowledge building in the knowledge economy. We introduce online collaborative learning as a framework to guide learning theory and practice within this context. As already discussed in chapter 2, learning theories of the 20th and 21st centuries have primarily been focused on didactic pedagogies and the use of mechanical and computational technologies of the time. These learning methods are based on right and wrong answers and emphasise student repetition and replication of course content.

Later reform in the 20th century shifted from passive didactic learning approaches towards more active learning techniques. But the real facilitators for learning reform were yet to come with computer networking and the internet. The widespread adoption of the internet introduced a paradigm shift, a major socio-economic leap in learning development and the basis for the 21st century knowledge economy.

The knowledge age has brought with it technologies to assist with learning, but also challenges and opportunities that impact on how we view and practice learning. These changes have set the stage for a new theory of learning that can take into account the ubiquity of the internet and the societal shift towards collaborative learning, emphasising the building rather than the transmission of knowledge.

To create knowledge, people need free exchange of information and ideas through communication and collaboration, and access to accumulated knowledge. Together with the transformation of the working environment through the digitalisation of labour, the internet has given rise to a new economy, one based on knowledge work. A new learning theory with relevant pedagogies and technologies is needed to respond to this reality.

Ours is a knowledge-creating civilization…. Sustained knowledge advancement is seen as essential for social progress of all kinds and for the solution of societal problems. From this standpoint the fundamental task of education is to enculturate youth into this knowledge-creating civilization and to help them find a place in it.[48]

While learning is often seen as something affecting youth, it is important to emphasis the education of adults, to emphasise professional development and lifelong learning as part of 21st century educational change.

[48] BEREITER, C and M SCARDAMALIA. 2006. Education for the knowledge age: Design-centred models of teaching and instruction. *In*: *Handbook of educational psychology*, Mahwah, NJ: Lawrence Erlbaum Associates. 98.

Active learning as it is defined and practiced has fallen short in addressing social issues and real problems. *In light of this challenge, traditional educational practice—with its emphasis on knowledge transmission—as well as the newer constructivist methods both appear to be limited in scope if not entirely missing the point.*[49]

OCL is proposed as a new theory of learning that focuses on collaboration, knowledge building and internet use as a means to reshape formal and informal education for the knowledge age. It will provide a theoretical framework to guide the transformation in instructional design.

3.1. The Need for a New Learning Theory

The knowledge age requires and enables knowledge advancement as a process and a product at a global level. Economic transformation now requires innovation over repetition, collaboration over individual approaches and knowledge creation over information transmission in how we work, and by implication, how we learn.

The current generation of youth has grown up collaborating and using online technologies. This is the first generation to grow up in the digital age. Rather than being passive recipients of mass consumer culture, the Net Generation (Net Gen) spends time searching, reading, scrutinising, authenticating, collaborating and organising[50].

The 21st century knowledge age signals the need for a theory of learning that emphasises knowledge work, knowledge creation and knowledge community. The challenge is how to engage learners in creative work with intrinsic rewards within the context of the internet and knowledge age. New educational designs and pedagogies based on new theories such as OCL provide a basis for addressing Knowledge-Age realities that educators can apply in their work. We begin by considering the history of online learning, in the next section.

The importance of e-learning in the 21st century has been repeatedly highlighted by Drucker[51]. He argues that the essence of e-learning relies on the tools and knowledge needed to perform work being moved to the workers, wherever and whoever they are. This *just-in-time education* becomes therefore strictly integrated with the high velocity value chains that characterize nowadays commerce, and basically moves the focus of education from the institution to the individual. The focus on the primary resources is moved as well: not anymore material goods or machines, but intellectual assets and human capital are the key factors that guarantee survival in this fast economy. The two fundamental benefits of e-

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[49] BEREITER, C and M SCARDAMALIA. 2006. Education for the knowledge age: Design-centred models of teaching and instruction. *In*: *Handbook of educational psychology*, Mahwah, NJ: Lawrence Erlbaum Associates. 98.

[50] TAPSCOTT, D and WILLIAMS, A D. 2006. *Wikinomics: How Mass Collaboration Changes Everything*. Portfolio Trade.

[51] DRUCKER, P. 2000. *Need to Know - Integrating e-Learning with High Velocity Value Chains*. [online]. [Accessed 21 July 2010]. Available from World Wide Web: <http://www.delphigroup.com/whitepapers/pdf/20001213-e-learning-wp.pdf >

learning, he continues, are the eliminations of the barriers of time and distance and personalisation of the user's experience.

3.2. History of Online Learning

Distance learning was in evidence at least 100 years before the creation of the first computer. Modern distance education has been around at least since Isaac Pitman taught shorthand in Great Britain via correspondence in the 1840s. The first catalogue of instruction films appeared in 1910[52] and in 1913, Thomas Edison proclaimed that, due to the invention of film, "Our school system will be completely changed in the next ten years"[53]. While this revolution did not take place, the statement highlights the link between technological development and learning. This link is apparent too in the development of online learning.

The introduction of the first personal computer (the Altair 880 in 1975) was quickly followed by the Apple II and the IBM PC. With the Apple and the IBM the computer was reliable enough and was used for didactical purposes. The usability was improving and the computer was not only meant for scientists anymore.

As early as 1993, an online computer-delivered lecture, tutorial and assessment project using electronic Mail, two VAX Notes conferences and Gopher/Lynx together with several software programs that allowed students and instructor to create a Virtual Instructional Classroom Environment in Science (VICES) in Research, Education, Service & Teaching (REST) [54]. The late 1990s represented a dramatic shift in public recognition and perception of online education, online learning began to be viewed as valid and beneficial and became increasingly accepted and adopted in mainstream education.

3.3. Definitions of Online Learning

The relative immaturity of online learning theory has led to a variety of contradictory definitions surrounding it. The term has been applied to almost learning activity that uses email or web access. Different online learning models lead to different results, so understanding the theoretical frameworks will help in designing pedagogical approaches and to select the most appropriate technologies to implement effective online courses and activities. We now discuss the most common models subsumed under the title of online learning. Each uses the internet for education, but in significantly different ways and with major differences in learning theory, learning pedagogies and learning technologies.

3.3.1. Online Collaborative Learning (OCL)

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[52] REISER, R A. 1987. Instructional technology: A history. *In*: *Instructional technology: Foundations*, Lawrence Erlbaum Associates. 11 – 48.

[53] SAETTLER, P. 1968. *History of Instructional Technology*. McGraw-Hill. 68.

[54] GRAZIADEI, W D. 1993. *Virtual Instructional Classroom Environment in Science (VICES)*. [online]. [Accessed 3 March 2010]. Available from World Wide Web: <http://www.cni.org/projects/netteach/1993/prop01.html >

OCL refers to educational applications that emphasise collaborative discourse and knowledge building mediated by the internet. Learners work together online to identify and advance issues of understanding and to apply their new understanding to solving problems or developing explanations for phenomena. OCL emphasises processes that lead to both conceptual understanding and knowledge products. OCL is based on peer discourse that is informed by the processes and resources of the knowledge community and facilitated by the instructor as a representative of that community.

Most commonly, the discourse is text-based and asynchronous, taking place in a web-based discussion forum or computer conferencing system. OCL also uses multimedia technologies such as graphics or video to enhance the discourse. Educational applications may be offered synchronously instead of or in addition to asynchronous communication. The role of the instructor is key: the instructor structures the discussions into small or large groups around knowledge problems. The instructor is not merely a facilitator of the group discourse but acts as a mediator between the learner and the larger knowledge community that he or she represents, and helps to induct the learners into the debates and research processes of that knowledge community.

3.3.2. Online Distance Education (ODE)

In discussing online learning, there is an important distinction between the *conversational paradigm* (which we can identify as OCL) and the *instructional paradigm* (termed here as ODE):

It may help to compare and contrast two alternative paradigms, or maybe philosophies, which can be seen in the real-world practice of education—we shall refer to them as the "instructional" and the "conversational" paradigms…. The "instructional" paradigm is the one that has driven much (though by no means all) of the research and development of the past 30 years that has been performed under the label of educational (or instructional) technology. The "conversational" paradigm may be seen as much of the work done on small group study, group dynamics, experiential learning and so on. In relation to distance teaching specifically, one may notice … that the self-instructional "study module" or typical correspondence course may serve as a good example of the instructional paradigm.[55]

Many institutions that employ ODE are beginning to incorporate OCL into their course design, thereby moving toward what may be described as a blended pedagogical model (OCL + ODE). This shift from ODE to increasingly OCL pedagogy is, more importantly, moving online learning into the conversational paradigm. A significant component of the course becomes the group discourse, while the instructional aspect is an informational self-study component.

3.3.3. Online Courseware (OC)

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[55] ROMISZOWSKI, A J and J RAVITZ. Computer-mediated communications. *In*: C R DILLS and A J ROMISZOWSKI, (eds). *Instructional development paradigms*, Englewood Cliffs: Educational Technology Publications. 438 – 456.

OC, also known as online computer-based training, refers to the use of courseware that a learner accesses online. This method is completely learner-centric and each learner works at their own pace in completing each module. Assessment of learning is often done using a multiple choice test at the end of each module. This may be graded by an instructor, or may only be for the learner's own use in order to gauge his or her understanding of the module.

OC, like ODE, is an example of instructional technology based on cognitive learning theory. OC is based on a prescriptive model of instructional design emphasizing individualized learning pedagogies. There is no discourse among peers, or with a tutor or instructor. OC is most commonly employed in the training sector, where it represents a major investment by large corporations, governments and the military. However, some OC providers are beginning to supplement this training approach with OCL and peer interaction in order to reduce high drop-out rates, to better motivate and engage learners and to emphasize understanding over retention of facts. Researchers and trainers in the field of courseware are expressing the need to shift "away from stand-alone instructional devices and toward using tools to aid in the more collaborative learning process"[56].

3.4. Online Collaborative Learning Theory

Having briefly introduced and distinguished the three major categories within the umbrella term *online education*, the remainder of the chapter discusses OCL theory, pedagogy and technologies.

Online collaborative learning (OCL) theory addresses the needs and opportunities of the Knowledge Age. Ours is a knowledge-creating age and our theories and practice of learning are challenged to move beyond didactic and even active learning approaches to enable learners to become knowledge builders. Knowledge building is a term now widely used. Knowledge building is distinct in important ways from such terms as *active learning*, *self-regulated learning* and *learning by doing*[57].

OCL theory provides a model of learning in which students are encouraged and supported to work together to create knowledge: to invent, to explore ways to innovate and, by so doing, to seek the conceptual knowledge needed to solve problems rather than recite what they think is the right answer. While OCL theory does encourage the learner to be active and engaged, this is not considered to be sufficient for learning or knowledge construction.

Learning activity needs to be informed and guided by the norms of the discipline and a discourse process that emphasizes conceptual learning and builds knowledge. There is a need for learners to have a relationship to the knowledge community, mediated by a teacher or mentor who represents that community. In OCL, the mediator has a very important role to

[56] SHUTE, V J and J PSOTKA. 1996. Intelligent tutoring systems: Past, present and future. *In*: *Handbook of research for educational communications and technology*, New York: Simon & Schuster Macmillan. 595.

[57] BEREITER, C and M SCARDAMALIA. 2006. Education for the knowledge age: Design-centred models of teaching and instruction. *In*: *Handbook of educational psychology*, Mahwah, NJ: Lawrence Erlbaum Associates. 113.

play. Moreover, learning and knowledge building should be viewed as meaningful to society and not driven only by personal interest or done to fulfil a class assignment.

3.5. Online Collaborative Learning Processes

The OCL process includes discourse, collaborative learning and knowledge building and sharing. Key components of building knowledge is innovation and creativity; and are also aspects of divergent thinking. Divergent thinking is and important process which generates questions, ideas or solutions. This is often associated with brainstorming and creative thought, drawing on ideas from different perspectives. The process of choosing from the multitude of divergent ideas is called convergent thinking. This involves narrowing down the options based on analysis of existing information and selecting the best or more precisely, the option or options with the best fit for the particular problem or situation.

The OCL theory has been characterised as being made up of three processes or phases, describing a path from divergent to convergent thinking[58]. The phases feed into each other via feedback loops or spirals so that ideas can be constantly refined.

- *Idea generating (IG)* refers to divergent thinking within a group; sharing of ideas and opinions on a problem or subject. Members engage in democratic participation and contribute towards building a large set of perspectives.
- *Idea organising (IO)* is the beginning of the process of convergence, where the mass of ideas are clustered based on similarity and weak ideas are discarded.
- *Intellectual convergence (IC)* is the final stage where the group has reached a shared understanding. The shared understanding does not necessarily mean that everyone agrees on a single point of view and disagreement may in fact be the consensus.

Intellectual convergence through collaborative discourse is key in creating knowledge[59], as collaboration can lead to convergence of meaning i.e. creating a shared context. Convergence should be explored as a complement to Piagetian and Vygoyskian thinking as democratic participation, intellectual progress and gradual convergence are base attributes of social inquiry practices that enable individuals to undergo conceptual change. In contrast, Vygostkian theory lends itself to the reproduction of existing scientific knowledge and Piaget suggests development through static levels through maturation.

3.6. Online Collaborative Learning Pedagogy

The main challenge to online or technology assisted learning is the need for a theory of learning and associated pedagogies that accommodate the realities of the knowledge age. Teaching approaches and techniques for online education do exist, as is evident from the

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[58] HARASIM, L M. 2002. What makes online learning communities successful? The role of collaborative learning in social and intellectual development. *In*: C VRASIDAS and V GLASS, (eds). *Distance education and distributed learning*, Charlotte: Information Age Publishers. 181-200.

[59] BRUFFEE, K A. 1999. *Collaborative learning: Higher education, interdependence, and the authority of knowledge*. Baltimore, MD: Johns Hopkins University Press.

growth of the field and the many courseware suppliers. Literature on design and moderation of online content is also widely available[60].

OCL can contribute to the above pedagogical activities by providing a theoretical framework to help design and inform activities with processes of conceptual change and intellectual convergence. OCL pedagogy emphasises conceptual change and learning through advancing from the idea generating stage, to idea organising and finally to intellectual convergence. The pedagogical activities linked with the conceptual process that encourage change and improvement over time.

In OCL theory and pedagogy, the role of the teacher is to engage the learners in the language and activities associated with building the particular discipline – acclimatising the learners to the language and processes of the knowledge community. The concept of a common language is what defines the community and decides membership[61].

3.7. Online Collaborative Learning Technology

Another key in understanding and engaging in effective online learning is the understanding of online technologies. Some online technologies facilitate learning tasks (online tools) while other facilitate the learning process (online environments). The need for tools and environments customised specifically for online learning was first expressed in the late 1980s, for group-discussion forums that went beyond generic design to those intentionally designed to support collaborative learning and knowledge building discourse. The need was for online education discourse environments customised by pedagogical principles and learning theory.

3.7.1. Learning Tools

Online learning tools refers to web tools that can facilitate or enable particular tasks in a learning activity. These may be generic web tools, or adapted specifically for the purpose of education. Generic tools include search engines such as Google or Bing, web browsers for accessing the web, email clients, productivity tools such as online calendars, document authoring tools and graphic presentation tools. Generic tools associated with Web 2.0 (an overused term broadly describing the social or collaborative nature of the web) include blogs, wikis, podcast authoring tools, web authoring tools, social networking tools and tools that enable social networking through user-generated content.

Education specific tools are usually just extensions of the generic tools available and as such do not make full use to facilitate collaborative learning. While they are excellent for their purpose of diaries, collaborative authoring or social spaces, they were not designed for, nor are they appropriate as learning environments which can support group discussion that deepens and progress over time. Unfortunately, merely combining all of the available tools

[60] See bibliography for books by Palloff and Pratt, 2001, 2005, 2007; Salmon, 2000; Collison et al., 2000

[61] BRUFFEE, K A. 1999. *Collaborative learning: Higher education, interdependence, and the authority of knowledge*. Baltimore, MD: Johns Hopkins University Press. 153 – 154.

has proved inadequate for producing an effective learning environment. Central to collaborative learning and knowledge building is the need for a shared space for discourse and interactions.

3.7.2. Online Learning Environments

Online learning environments refers to web-based software that is designed to house the learning activities. This could be thought of as the equivalent of a classroom or university. Online learning environments should not just be thought of as transmitters of information and data. They should be environments where users can construct knowledge and negotiate meaning through conversation and collaboration. The educational ecology of media are lived environmental, whereby users exercise their powers of perception, mobility and agency within the constraints imposed upon them by the various technologies and learning theories and pedagogies.[62]

Online learning environments in the OCL context are usually content free. Unlike courseware applications, the content in OCL is discourse generated primarily by the learners. To drive this behaviour, OCL applications typically use software such as forums, bulletin boards or computer conferencing systems.

Online learning environments have the potential to support highly effective learning and knowledge-creation processes. Tools embedded within the environment could provide relevant information, suggestions or scaffolds for particular learning processes.

3.7.3. Attributes of Online Collaborative Learning Environments

The environments in which we live, learn, work and socialise are all characterised by attributes that enable certain kinds of activities and communications, and limit or negate others. Face-to-face environments would have attributes very different to those in an OCL environment. What follows are five attributes which characterise the discourse within an OCL environment.

3.7.3.1. Place-Independent Discourse

This is probably the most obvious and powerful attribute of the internet, the ability to communicate and collaborate beyond the confines of a classroom or office. The primary implication of place-independent discourse is access to information. Online education has a global reach and enables educational access for learners no matter where they are located or whether subject matter is available in their area.

Place-independent discourse not only provides enhanced access to learning, but also improves the quality of learning and knowledge building. It enables student participation, and hence the quality and nature of ideas generated and debated are potentially enriched. Discourse in OCL environments benefits from access to new cultures, perspectives and inputs.

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[62] ALLEN, B S and R G OTTO. 1996. Media as lived environments: The ecological psychology of educational technology. *In*: D H JONASSEN, (ed). *Handbook of research for educational communications and technology*, New York: Macmillan. 199.

There are also however challenges that arise because of place-independent discourse. Cross-cultural discourse creates the need for participants to become sensitised to cultural differences and nuances. Also, since learning can now take place anywhere, it becomes the responsibility of the learner to create a space conducive to learning in their home, office, etc.

3.7.3.2. Time-Independent Discourse

The next attribute is time-independence or asynchronicity. Although OCL is predominantly asynchronous, synchronous course delivery and group interactions is possible through video or audio conferencing.

Being asynchronous means that the learning environment is available at any time. Participation in the online conversations is ongoing and the expanded access enables online discussions to be highly active and interactive. There is no limit to the time the learner can take to grasp a concept or make contributions. Feedback on ideas posted online may be instantaneous, but discussion and refinement can advance the idea over time.

The main challenge to time-independent discourse is the possibility of lag between points in the discussion. This may lead to learner frustration or distraction.

3.7.3.3. Group Discourse

This is the basis for collaboration and knowledge building. Group input enables multiple perspectives to enrich and idea or topic. Online forums or conferencing systems were developed to enable group conversations, and hence allow participants to input their own ideas and thereby create a diversity of ideas, reactions and feedback on the discussion topic.

Current online forum systems are not well designed to facilitate convergent thinking unfortunately. This necessitates the role of an instructor or teacher to guide the group discussions into intellectual processes that lead to intellectual convergence. This requires moderating and facilitating frameworks and techniques to organise the diverse and potentially voluminous input into something manageable.

3.7.3.4. Text-Based Discourse

Although multimedia tools such as audio, video and animation may be incorporated into OCL, discourse remains primarily text based. While it may be contrary to modern thinking, text remains the most important medium of conversation in knowledge[63] (in contrast to audio, video or animation). The reason is that the articulation of thoughts into written text requires analytical deliberation[64].

Writing is thinking made tangible, thinking that can be examined because it is on the page and not in the head invisibly floating around. Writing is thinking that can be stopped and tinkered with. It is a way of holding thought still enough to examine its structure, its flaws. The road to clearer understanding of one's thoughts is travelled on paper. It is through an

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[63] BRUFFEE, K A. 1999. *Collaborative learning: Higher education, interdependence, and the authority of knowledge*. Baltimore, MD: Johns Hopkins University Press. 53.

[64] VYGOTSKY, L S. 1962. *Thought and language*. Cambridge: MIT Press. 99 – 100.

attempt to find words for ourselves in which to express related ideas that we often discover what we think.[65]

This concept is further enhanced by online discourse. Forums for example create an accurate transcript of thought that learners can access at any point in time, in the exact form it was first envisaged. Furthermore, in a society where communication has been broken down into 160 character texts, or 140 character tweets, it is clear that text is valued as a medium of communication above voice or video[66].

3.7.3.5. Internet-Mediated Discourse

The final attribute is perhaps the most important given the vastness of information and its range of impact. The capacity of the internet, already unparalleled by anything before it, is constantly increasing. Some estimate that the global storage capacity doubles every 18 months[67].

We have, in the internet, easy access to a global knowledge network where one can learn from all types of people and resources. With this comes new information and perspectives. Equally important to the volume of information, is the development of new tools which create new methods of discourse, collaboration and knowledge construction.

Data analysis and visualisation tools allow the user to graphically represent data. A simple example is a bar chart representing company sales figures. It is a simplification of the data in order for one to consume at a glance. This is what is required when the quantity of data becomes too vast for a user to consume and interpret.

In the next chapter we discuss the Semantic Web which although not new, provides an evolution to the way we search for and access information on the web. It provides structure to the mostly unstructured information available on the Web.

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[65] MCGINLEY, W and R J TIERNEY. 1989. Traversing the topical landscape: Reading and writing as ways of knowing. *Written Communication*. **6**. 243 – 269.

[66] There have been numerous surveys and polls done on this topic. An example of such a report can be found at http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr12/ - [Accessed 23 August 2012].

[67] KANELLOS, M. 2003. *Moore's Law to roll on for another decade*. [online]. [Accessed 6 June 2012]. Available from World Wide Web: < http://news.cnet.com/2100-1001-984051.html >

Chapter 4
Semantics Overview

4.1. What are semantics?

The word *semantics* can denote different phenomena under different levels of analysis. This ranges from popular, dictionary definitions, to the highly technical and industry restricted view developed further in section 2. Semantics also spans a broad range of disciplines, but the underlying theme remains the same.

4.1.1. Linguistics

At the one end of the scale a popular understanding of semantics would define it as a problem of word selection and portrayed meaning in the use of language. It is basically the problem of communication and understanding. While it may sound simplistic, this is indeed the basic tenet of the highly technical application of semantics we will discuss.

The study of semantics is a subfield of linguistics, which studies the meanings of texts. Texts are broken down into sentences, phrases and words in descending levels of complexity. These units are combined in certain ways in order to convey meaning in the overall text.

While this paper will not delve into the history of linguistics or the development of linguistic theory, it is worth noting the contribution of Richard Montague who pioneered a logical approach to natural language semantics. The study of semantics for linguistic purposes has often been closely tied to what some may view as more technical fields. In the late 1960's, Montague proposed a system for defining semantic entries in the lexicon in terms of lambda calculus. Although this approach was later proven to be limiting, it provided a starting point for semantic analysis in the 1970's and 1980's and the methodology became known as Montague grammar.[68]

4.1.2. Psychology

In psychology, the term semantic memory is used to describe the aspect of memory that preserves only the general significance of an experience, not the specifics. Semantic memory hones in on common features of various episodes and extracts them from their context. A gradual transition takes place from episodic to semantic memory. In this process, episodic memory reduces its sensitivity to particular events so that the information about them can be generalized.

One of the models of semantic knowledge is the semantic network. In a semantic network, each node is to be interpreted as representing a specific concept, word, or feature. That is, each node is a symbol. Semantic networks generally do not employ distributed

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[68] PARTEE, B H. 2006. Richard Montague (1930 - 1971). *In*: *Encyclopedia of Language and Linguistics (2nd ed.)*, Oxford. 255 – 257.

representations for concepts, as may be found in a neural network. The defining feature of a semantic network is that its links are almost always directed (that is, they only point in one direction, from a base to a target) and the links come in many different types, each one standing for a particular relationship that can hold between any two nodes.[69]

Semantic networks see the most use in models of discourse and logical comprehension, as well as in Artificial Intelligence.[70] In these models, the nodes correspond to words or word stems and the links represent syntactic relations between them. For an example of a computational implementation of semantic networks in knowledge representation, see Cravo and Martins[71].

Once again it is interesting to notice the cross-over between two apparently unrelated fields of study.

4.1.3. Computer Science

In computer science semantics is considered as an application of mathematical logic and reflects the meaning of programs or functions.

In this regard, semantics permits programs to be separated into their syntactical part (grammatical structure) and their semantic part (meaning). It is not by chance that computer applications are written in a particular *language*, and the meaning attributed to semantics in computer science, is very close to the meaning in linguistics.

Semantics for computer applications falls into three categories[72]:

- *Operational semantics* – The meaning of a construct is specified by the computation it induces when it is executed on a machine. In particular, it is of interest how the effect of a computation is produced.
- *Denotational semantics* – Meanings are modelled by mathematical objects that represent the effect of executing the constructs. Thus only the effect is of interest, not how it is obtained.
- *Axiomatic semantics* – Specific properties of the effect of executing the constructs as expressed as assertions. Thus there may be aspects of the executions that are ignored.

4.2. The semantic web

The semantic web is a vision pioneered by Sir Tim Berners-Lee and was expressed in a paper in 2001[73]. In essence, it is a layer on top of the current World Wide Web that describes

[69] ARBIB, M A. 2002. Semantic networks. *In*: *The Handbook of Brain Theory and Neural Networks (2nd ed.)*, MIT Press.

[70] BARR, A and E A FEIGENBAUM. 1982. *The handbook of artificial intelligence*. William Kaufman.

[71] CRAYO, M R and J P MARTINS. 1993. SNePSwD: A newcomer to the SNePS family. *Journal of Experimental & Theoretical Artificial Intelligence*. **5**. 135 – 148.

[72] WANG, J Z; LI, J; CHAN, D, and WIEDERHOLD, G. 2011. Semantics-sensitive Retrieval for Digital Picture Libraries. *D-Lib Magazine*. **5**(11).

concepts and relationships, following strict rules of logic. It is seen as the next logical evolution of the current Web, “The Web will reach its full potential when it becomes an environment where data can be shared and processed by automated tools as well as by people”[74]. At its core, the purpose of the semantic web is to enable computers to understand semantics the way that humans do. A prerequisite of this functionality is that the information on the web needs to be annotated with descriptions and relationships. Basic examples of semantics consist of categorising an object and its attributes. This argument has a flaw though, since not all humans would understand the same annotations to mean the same thing. As a result, a common context is also a requirement.

4.2.1. Enabling technologies

The technologies used for the semantic web are nothing new and have been used successfully for other applications. These are things like web technology, knowledge representation technology and digital libraries[75]. The realisation of the semantic web vision is dependent on five core technologies which we now discuss.

4.2.1.1. Extensible Markup Language (XML)

XML is a set of rules for encoding documents in machine-readable form. It is defined in the XML 1.0 Specification[76] produced by the W3C, and several other related specifications. XML's design goals emphasize simplicity, generality, and usability over the Internet[77]. It is a textual data format with strong support via Unicode for the languages of the world. Although the design of XML focuses on documents, it is widely used for the representation of arbitrary data structures, for example in web services.

XML allows for the addition of new tags to the hypertext mark-up language (HTML) standard currently used for most web resources. It allows for the addition of the meta-data fields spoken about previously. While HTML is only concerned with the display and formatting of information on the web, XML acts as a data transfer medium across the internet allowing sharing of structured text and information. The advantage of XML is that software programs can read the specialised tags and perform operations such as extracting bibliographic information[78].

It is possible to create any number of arbitrary tags within XML, so it becomes important to define the shared meaning around an XML document. This is done using Document Type Definition (DTD) file or XML Schema. Their purpose is to define the structure, content of

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[73] BERNERS-LEE, T, J HENDLER, and O LASSILIA. 2001. The Semantic Web. *Scientific American*. **284**(5). 34 – 43.

[74] BERNERS-LEE, T and E MILLER. 2002. The Semantic Web lifts off. *Special issue of ERCIM New*. **51**. 9.

[75] MILLER, E. 2002. Feature interview: Eric Miller on the Semantic Web. *NewBreed Librarian*. **2**(4).

[76] *XML 1.0 Specification*. 2008. [online]. [Accessed 7 April 2011]. Available from World Wide Web: <http://www.w3.org/TR/REC-xml/ >

[77] *XML 1.0 Origin and Goals*. 2008. [online]. [Accessed 7 April 2011]. Available from World Wide Web: <http://www.w3.org/TR/REC-xml/#sec-origin-goals >

[78] ADAMS, K. 2002. The Semantic Web adds logic to web services. *KM World*. **11**(3).

XML documents and facilitate the sharing of information about communities of users[79]. This is the layer that also allows computer software to interpret documents and provides the base for information gathering automation[80].

XML namespaces are responsible for the separation of contexts within a single XML document. It may be necessary to combine several XML documents which necessitate the need to separate original contexts. This overcomes what some refer to as the blending problem of the semantic web[81] where elements from separate documents clash when the documents are combines. There is a further problem which XML namespaces are not able to handle though and this is the problem that stems from the implied meaning of words within documents.

4.2.1.2. Extensible Hypertext Mark-up Language (XHTML)

It is important to note how XML has contributed to web page display though XHTML. An inherent problem of HTML is its inability to enforce a well formed structure. Well-formed HTML becomes of particular concern when documents need to be viewed across different browsers and operating systems. These may interpret the mal-formed HTML documents in different ways and the page display may not be what the creator intended. XHTML combines all the features of HTML with the syntax of XML. This forces pages to be written in a way that all browsers will understand and thus plays a large role in the semantic web.

4.2.1.3. Uniform Resource Identifiers (URIs)

URIs and Uniform Resource Locators (URLs) have a shared history. Tim Berners-Lee's proposals for HyperText[82] implicitly introduced the idea of a URL as a short string representing a resource that is the target of a hyperlink. As the World Wide Web's core technologies developed, a need to distinguish a string that provided an address for a resource from a string that merely named a resource emerged. Although not yet formally defined, the term Uniform Resource Locator came to represent the former, and the more contentious Uniform Resource Name (URN) came to represent the latter.

During the debate over defining URLs and URNs it became evident that the two concepts embodied by the terms were merely aspects of the fundamental, overarching notion of resource identification. In June 1994, the IETF published Berners-Lee's RFC 1630: the first RFC that (in its non-normative text) acknowledged the existence of URLs and URNs, and, more importantly, defined a formal syntax for Universal Resource Identifiers — URL-like strings whose precise syntaxes and semantics depended on their schemes. In addition, this RFC attempted to summarize the syntaxes of URL schemes in use at the time. It also

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[79] BROOKS, T A. 2002. The Semantic Web, Universalist ambition and some lessons from librarianship. *Information Research*. **7**(4).

[80] SINGH, R, L LYER, and A F SALAM. 2005. Semantic eBusiness. *International Journal on Semantic Web & Information Systems*. **1**(1). 19 – 35.

[81] BROOKS, T A. 2002. The Semantic Web, Universalist ambition and some lessons from librarianship. *Information Research*. **7**(4).

[82] PALMER, S B. *The Early History of HTML*. [online]. [Accessed 16 April 2011]. Available from World Wide Web: <http://infomesh.net/html/history/early/>

acknowledged, but did not standardize, the existence of relative URLs and fragment identifiers.

Web document mark-up languages frequently use URI references to point to other resources, such as external documents or specific portions of the same logical document.

4.2.1.4. Resource Definition Framework (RDF)

RDF is an XML-based language which enables description of relationships via predicates[83]. The subject denotes the resource, and the predicate denotes traits or aspects of the resource and expresses a relationship between the subject and the object. For example, one way to represent the notion "The sky has the colour blue" in RDF is as a trio of specially formatted strings: a subject denoting "the sky", a predicate denoting "has the colour", and an object denoting "blue".

RDF is a data model. It offers a consistent framework for metadata and can be written using XML tags. RDF provides a structure that, in functional terms, expresses the meaning of Web documents in a way computers can understand. RDF technology results in rich descriptions of digital information. An RDF description can include all kinds of metadata such as the authors of the document, the date of its creation, the name of the sponsoring organization, intended audience, subject headings, etc.

4.2.1.5. Ontologies

Ontologies sit on top of the RDF framework and are a critical part of making the Semantic Web *intelligent*. Ontologies allow computers to communicate with each other by providing a common set of terms or vocabularies and rules that govern how those terms work together and what they mean[84]. Ontologies define terms and then lay out the relationships among those terms[85]. The aim of web based ontologies is to provide richer integration and interoperability of data among descriptive communities. Ontologies extend RDF’s simple syntax with constructs such as data types, valid data ranges, unique keys and enumerations in order to give the software the linkages needed to infer connections between data, which has not been previously stated.

The usefulness of ontologies can be seen when analysing their possible applications. Ontologies are capable of[86]:

- Retrieving the appropriate information from documents by providing a structure to annotate the contents of a document with semantic information.

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[83] *RDF - Semantic Web Standards*. 2004. [online]. [Accessed 7 April 2011]. Available from World Wide Web: < http://www.w3.org/RDF/ >

[84] HENDLER, J. 2001. Agents and the Sematic Web. *IEEE Intelligent Systems*. **16**(2). 30.

[85] ADAMS, K. 2002. The Semantic Web adds logic to web services. *KM World*. **11**(3).

[86] ALDEA, A, R BAÑARES-ALCÁNTARA, J BOCIO et al. 2003. *An Ontology-Based Knowledge Management Platform*. [online]. [Accessed 2 May 2011]. Available from World Wide Web: <http://www.isi.edu/info-agents/workshops/ijcai03/papers/DIsern-article-ijcai.pdf >

- Integrating the information from various sources by providing a structure for its organisation and facilitating the exchange of data, knowledge and models.
- Ensuring consistency and correctness by formulating constraints on the content of information.
- Creating libraries of interchangeable and reusable models.
- Supporting inference to derive additional knowledge from a set of facts.

4.2.1.6. Intelligent Agents

Combining descriptions from Jennings[87] and Russell and Norvig (2003)[88], you can understand that an agent is an encapsulated computer system made up of an architecture and a program. This computer system should:

- Be situated in some environment
- Be able to perceive its environment
- Be capable of autonomous action within that environment
- Have some kind of design objectives

An agent system is made up of four essential parts:

- A performance measure
- An environment
- Actuators
- Sensors

There are four generic types of reactive agents that are traditionally discussed in texts:

- Simple reflex agents, which act based on their current perceptions
- Model-based reflex agents, which act based on their current perceptions and partial histories
- Goal-based agents, which use their current perceptions in addition to their desires (goals) to act
- Utility-based agents, which try to maximize their status to achieve higher efficiency of acting

However, some modern books about artificial intelligence expand their discussions on other types of agents that aren't specifically reactive agents as defined above. These include:

- Interface agents
- Mobile agents
- Information agents
- Learning agents

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[87] WOOLDRIDGE, M, N R JENNINGS, and D KINNY. 2000. *The Gaia Methodology for Agent-Oriented Analysis and Design*. [online]. [Accessed 2 May 2011]. Available from World Wide Web: <http://www.csc.liv.ac.uk/~mjw/pubs/jaamas2000b.pdf >

[88] RUSSEL, S and P NORVIG. 2009. *Artificial Intelligence: A Modern Approach (3rd Edition)*. Prentice Hall.

- Robotic agents

The Semantic Web has clear business benefits, but only with the additional rules defined by Berners-Lee, which we have already discussed. By exposing public business data as Linked Data, businesses not only make their products or services more findable in an objective fashion, but they also open it up for machine reading, which is ideal for the multi-agent systems. Exposing data as Linked Data becomes an exciting marketing technique.

The refocus from semantics through formal ontologies to semantics through interlinking will not stop the grandiose vision of Berners-Lee and others. However, the way that it progresses may not be exactly how they envisaged in 2001. Agents are now able to follow one node to another across the global giant graph thanks to Linked Data. This change led to the Semantic Web being "revisited" in 2006 by Shadbolt and others[89].

There are numerous areas of application for semantic web technologies and we will return to the idea of intelligent agents in chapter 6 when we look at an example of implementation.

4.2.2. The classic approach to semantic web implementation

There are billions of fairly unstructured HTML pages which contain no annotations and meta-data. The fundamental engineering question is how can we go from today's unstructured web to one rich with semantic information? The W3C authored specifications for RDF (Resource Description Framework) and OWL (Web Ontology Languages) in an attempt to enable the collective capture and description of information, along with the ontology and the relationships with other pieces of information, in a rigorous, mathematical way.

The RDF/OWL framework is comprehensive, but is difficult for people without a background in mathematics or computer science to understand. Given that this is a bottom up approach, it is clear that in order for it to succeed, there is a need for automated mechanism that takes existing HTML content and turns it into RDF and OWL meta data. The irony though is that if we could already do this, the problem would not be there to begin with. Still we can envision the tools required which would do 80% of the work automatically and then interact with the user to complete the other 20% of the work.

Recognising the complexity of RDF and OWL, a group of people are trying a different approach called Microformats. Designed for humans first and machines second, microformats are a set of simple, open data formats built upon existing and widely adopted standards[90]. The goal of microformats is to embed the basic semantics right into HTML pages. It is not as expressive as RDF and OWL, but it is very compact and uses available XHTML facilities to add semantics to the pages. For example, there is a microformat for describing contact information called hCard. Using hCard it is possible to annotate the HTML so that a microformat-aware browser or a search engine can deduce the information about a person

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[89] SHADBOLT, T, T BERNERS-LEE, and W HALL. 2006. *The Semantic Web Revisited*. IEEE Computer Society.

[90] *What are microformats?* [online]. [Accessed 4 March 2010]. Available from World Wide Web: <http://microformats.org >

such as first and last name, a company or a phone number. Another mature microformat called hCalendar enables page authors to describe events. Many popular event sites, such as Facebook and Yahoo! Local use this format to annotate events in their HTML pages.

The microformats approach is clearly simpler than RDF and OWL. And even though it is less powerful, it is becoming very popular. Many site authors are starting to embed microformats into their HTML pages. We are also seeing some early examples of search engines based on microformats[91]. The simple gain in using microformats and doing search is removing ambiguity. In a way, it is similar to a vertical search engine, which knows which vertical you are searching. With microformats inside the pages, the data is also no longer ambiguous, so the search results are more precise.

Still, there are some issues with microformats. The first one is the same as with the previous bottom up approach - people have to do the work to annotate the pages. The good news is that since the format is simpler, more can be done via reverse engineering and automation. The second issue is that the current set of microformats does not cover many things that we encounter online. For example, the researcher was unable to find any microformats that would assist in a library book search. Many more formats need to be created before they can really have a broad impact.

The problem of annotating data is very complex and is far from being solved completely. But let's leave it aside for a moment and think of what we can be doing once all the data becomes annotated. The promise is that we will be doing less of what we are doing now, namely sifting through piles of irrelevant information. Given that the amount of information is growing exponentially and our tolerance is shrinking, this is a very intriguing proposition. If the computer can return relevant results instantly, we can potentially save a ton of time.

But having semantics and knowing all relationships between the data is not enough to do that. Take the simple example of a travel agency. When you arrive there for the first time, the agent does not know what to offer you, even though she knows the semantics of travel, the relationships between things and the prices of everything. In order to be effective, she needs to know where you've been already and what kind of destinations you like. That's why she asks you questions. All services that we receive work this way and the results are better and more refined over time, because service people have time to learn what you like.

So the second important ingredient of the Semantic Web, the one that will facilitate productivity, is a set of persistent personal preferences. Once the computer knows your preferences and has a semantic representation of it online, it can then run an algorithm to deliver you precise, personalised results. To put it differently, your personal preferences is the filter that needs to be applied to the results that the computer returns.

[91] An example is this one from Technorati: <http://kitchen.technorati.com/contact/search/> [Accessed 27 April 2009].

4.2.3. The top down approach to semantic web implementation

One of the technical difficulties that we outlined was the bottom-up nature of the classic semantic web approach. Specifically, each web site needs to annotate information in RDF, OWL, etc. in order for computers to be able to understand it.

As things stand today, there is little reason for web site owners to do that. The tools that would leverage the annotated information do not exist and there has not been any clearly articulated business and consumer value, which means that there is no incentive for the sites to invest money into being compatible with the semantic web of the future.

But there are alternative approaches. We will argue that a more pragmatic, top-down approach to the semantic web not only makes sense, but is already well on the way toward becoming a reality. Many companies have been leveraging existing, unstructured information to build vertical, semantic services. Unlike the original vision, which is rather academic, these emergent solutions are driven by business and market potential.

We will look at the solution that is called the top-down approach to the semantic web, because instead of requiring developers to change or augment the web, this approach leverages and builds on top of current web as-is.

The essence of a top-down semantic web service is simple – leverage existing web information, apply specific, vertical semantic knowledge and then redeliver the results via a consumer-centric application. Consider the vertical search engine iSearch[92], which scans the web for information about people. It knows how to recognize names in HTML pages and it also looks for common information about people that all people have - birthdays, locations, marital status, etc.

In other words, Spock takes simple, everyday semantics about people and applies it to the information that already exists online. The result is a unique and useful vertical search engine for people. Further, note that Spock does not require the information to be re-annotated in RDF and OWL. Instead, the company builds adapters that use heuristics to get the data. The engine does not actually have full understanding of semantics about people, however. For example, it does not know that people like different kinds of ice cream, but it doesn't need to. The point is that by focusing on a simple semantics, Spock is able to deliver a useful end-user service.

Another, much simpler, example is the Map This[93] add-on for Firefox. This application recognizes addresses and provides a map popup using Google Maps[94]. It is the simplicity of this application that precisely conveys the power of simple semantics. The add-on "knows" what addresses look like. Yes, sometimes it makes mistakes, but most of the time it tags addresses in online documents properly. So it leverages existing information and then

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[92] http://www.isearch.com - [Accessed 4 March 2010].

[93] https://addons.mozilla.org/en-US/firefox/addon/map-this/ - [Accessed 4 March 2010].

[94] http://maps.google.com/ - [Accessed 4 March 2010].

provides direct end user utility by meshing it up with Google Maps. Skype[95] has already released tool bars which map telephone numbers so that clicking on one can immediately make a call using Skype.

Despite being effective, the somewhat simplistic top-down approach has several problems. First, it is not really the semantic web as it is defined; instead it is a group of semantic web services and applications that create utility by leveraging simple semantics. So the proponents of the classic approach would protest and they would be right. Another issue is that these services do not always get semantics right because of ambiguities. Because the recognition is algorithmic and not based on an underlying RDF representation, it is not perfect.

It seems to me that it is better to have simpler solutions that work 90% of the time than complex ones that never arrive. The key questions here are: How exactly are mistakes handled? And, is there a way for the user to correct the problem? The answers will be left up to the individual application. In life we are used to other people being unpredictable, but with computers, at least in theory, we expect things to work the same every time.

Yet another issue is that these simple solutions may not scale well. If the underlying unstructured data changes can the algorithms be changed quickly enough? This is always an issue with things that sit on top of other things without an API. Of course, if more web sites had APIs, as we have previously suggested, the top-down semantic web would be much easier and more certain.

4.3. Criticism of the semantic web

4.3.1. Feasibility

In a humorous take on the problems of the semantic web, Cory Doctorow takes a sobering and somewhat pessimistic view of metadata creation. He highlights seven factors which he says limits the feasibility of metadata creation, and hence the semantic web; people lie, people are lazy, people are stupid, mission Impossible: know thyself, schemas aren't neutral, metrics influence results, and there's more than one way to describe something[96].

This argument however, assumes that the semantic web should be completely open and that all data will be invalidated similar to the current state of the web (As an example, take a look at WikiPedia[97]. While being a wonderful community project for sharing information, it is open for abuse[98]). The research however aims to show how these technologies can be applied in a closed or mediated environment where checks and balances are in place in order to

[95] http://www.skype.com/intl/en/home

[96] DOCTOROW, C. 2001. *Metacrap: Putting the torch to seven straw-men of the meta-utopia.* [online]. [Accessed 7 March 2010]. Available from World Wide Web: <http://www.well.com/~doctorow/metacrap.htm >

[97] http://en.wikipedia.org

[98] TIMMER, J. 2009. *Wikipedia hoax points to limits of journalists' research*. [online]. [Accessed 7 March 2010]. Available from World Wide Web: <http://arstechnica.com/media/news/2009/05/wikipedia-hoax-reveals-limits-of-journalists-research.ars >

ensure that data and information is valuable in creating knowledge. The final statement in the article sums it up nicely, "Taken more broadly, this kind of metadata can be thought of as a pedigree: who thinks that this document is valuable? How closely correlated have this person's value judgments been with mine in times gone by? This kind of implicit endorsement of information is a far better candidate for an information-retrieval panacea than all the world's schema combined."

4.3.2. Potential vs. reality

The original goal of the semantic web was described in 2001, but we are yet to see the revolution which was described. In a world where the half-life of knowledge is decreasing, expectations are that the semantic web should be further along in its evolutionary process. In 2006, Berners-Lee and colleagues stated that: "This simple idea, however, remains largely unrealized."[99] While the idea is still in the making, it seems to evolve quickly and inspire many. Between 2007 and 2010 several scholars have already explored first applications and the social potential of the semantic web in the business and health sectors, and for social networking[100].

4.3.3. Privacy

Enthusiasm about the semantic web could be tempered by concerns regarding censorship and privacy. For instance, text-analysing techniques can now be easily bypassed by using other words, metaphors for instance, or by using images in place of words. An advanced implementation of the semantic web would make it much easier for governments to control the viewing and creation of online information, as this information would be much easier for an automated content-blocking machine to understand. In addition, the issue has also been raised that, with the use of friend-of-a-friend (FOAF) files and geo location meta-data, there would be very little anonymity associated with the authorship of articles on things such as a personal blog.

4.3.4. Standards

The distributed nature of the Internet, of course, is one of the central features of the semantic web, and actually, at the same time, its biggest problem. Treating the semantic web as an enormous decentralized database, in fact, highlights the problem of the potentially infinite ways people could adopt in order to describe the meaning of their published data, leading to an unavoidable lack of understanding communication between programs and resources. Decentralization, therefore, requires compromises: the idea of total consistency between the World Wide Web's interconnections has to be left aside[101]. Nevertheless, a semantic web has a lot of potentials since the need to organize semantically the data on the Web does exist, and the vision of letting the machines operate with them intelligently, relieving humans from a constantly growing burden of work, can be realised.

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[99] SHADBOLT, T, T BERNERS-LEE, and W HALL. 2006. *The Semantic Web Revisited*. IEEE Computer Society.

[100] FEIGENBAUM, L, I HERMAN, T HONGSERMEIER et al. 2007. The Semantic Web in Action. *Scientific American*. **297**. 90 – 97.

[101] See the focused discussion on semantic learning standards in chapter 5

4.4. Industry applications of semantic web technologies

At this point, it may be easy to think that semantic web technologies are far too young to be useful in current applications. The choice of examples described below sets out to show that even in this early stage of development, industry applications are indeed being created and getting proven results.

4.4.1. Rolls Royce

Rolls Royce had a need for organising vast amounts of data in a useful way and being able to extract knowledge from it[102]. The key advantages of a semantic web system, drawn from this study of Rolls Royce, were the ability to transfer knowledge between different levels on the production line, the ease of integration across a distributed system and the ability to extract relevant documents based on implied instead of hard coded relationships.

4.4.2. DBpedia

DBpedia[103] is an effort to publish structured data extracted from Wikipedia: the data is published in RDF and made available on the Web for use under the GNU Free Documentation License[104], thus allowing Semantic Web agents to provide inferencing and advanced querying over the Wikipedia-derived dataset and facilitating interlinking, re-use and extension in other data-sources.

4.4.3. FoaF

A popular application of the semantic web is Friend of a Friend (FoaF)[105], which uses RDF to describe the relationships people have to other people and the things around them. FoaF permits intelligent agents to make sense of the thousands of connections people have with each other, their jobs and the items important to their lives; connections that may or may not be enumerated in searches using traditional web search engines. Because the connections are so vast in number, human interpretation of the information may not be the best way of analysing them. FoaF is an example of how the Semantic Web attempts to make use of the relationships within a social context.

The image below[106] shows how FoaF is used in order to make relationships. The actual markup expressed in this image will be discussed in more detail later.

[102] WONG, S C, R M CROWDER, G B WILLIS, and N R SHADBOLT. 2007. Lesson learnt from a large-scale industrial semantic web application. *In*: *Proceedings of the eighteenth conference on Hypertext and hypermedia*. New York. 21 – 30.

[103] http://dbpedia.org/About - [Accessed 7 March 2010].

[104] http://www.gnu.org/licenses/fdl.html

[105] http://www.foaf-project.org/

[106] http://www.w3.org/TR/2005/WD-swbp-skos-core-guide-20051102/

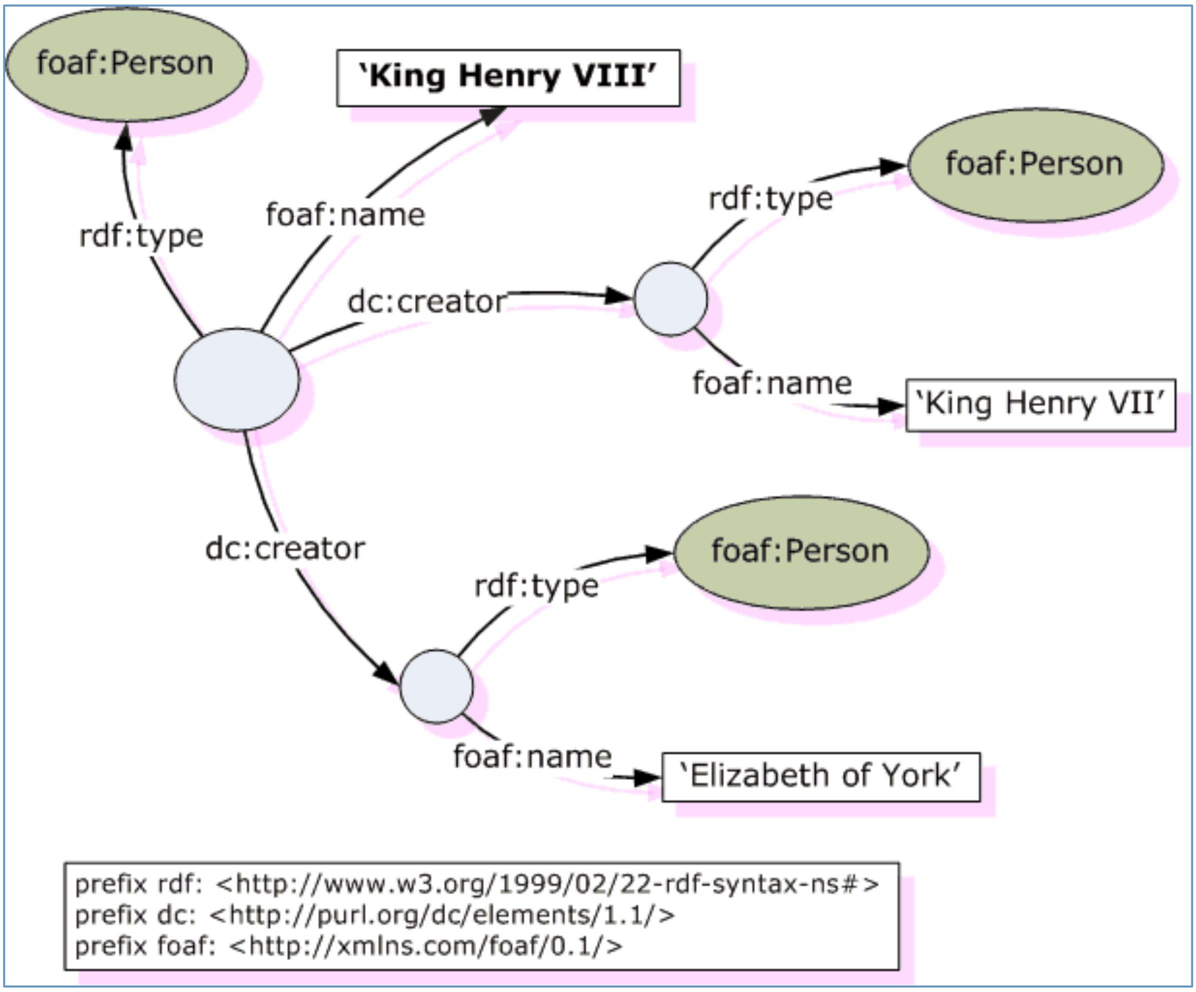

Figure 1 – Relationships defined in Friend of a Friend (FoaF) structure

4.4.4. GoodRelations

A huge potential for Semantic Web technologies lies in adding data structure and typed links to the vast amount of offer data, product model features, and tendering or request for quotation data. GoodRelations[107] is a language that can be used to describe very precisely what a business is offering. Some people call GoodRelations a *data dictionary*, others prefer *schema* or *ontology*. GoodRelations is a lightweight ontology for annotating offerings and other aspects of e-commerce on the Web. GoodRelations has been adopted by BestBuy, Yahoo, OpenLink Software, O'Reilly Media, the Book Mashup, and many others.

4.4.5. NextBio

NextBio[108] is a database, consolidating high-throughput life sciences experimental data tagged and connected via biomedical ontologies. It is accessible via a search engine interface. Researchers can contribute their findings for incorporation to the database. The database currently supports gene or protein expression data and is steadily expanding to support other biological data types.

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[107] http://www.heppnetz.de/projects/goodrelations/

[108] http://www.nextbio.com/b/nextbio.nb

Chapter 5
Applying semantic technologies to learning

The importance of the research is in its application to learning within organisations. The first section of this chapter provides an overview of the possible benefits of the semantic web and specifically its application to learning within the organisation.

5.1. Potential of the semantic web within organisations

5.1.1. The learning environment

No matter what industry the organisation is situated in, learning would most often take place to support the goals of the organisation i.e. we learn in order to do our jobs, which were created to support the organisation in fulfilling its goals. Semantic web technologies can assist in three ways:

- By linking the goals of the organisation to the learning requirements. The linking of the learning plans with the goals of the organization can be mediated through ontologies of competency[109 110].
- Competency ontologies including assessment and evidence gathering[111] can be used to manage evaluation.
- Learning object selection can be done through semantic agents considering organizational needs[112]. Future job roles can be determined through ontologies connected to competencies[113].

Team work is widely accepted as an integral part of an organisation thriving and there are many studies done in areas where high performance is of utmost importance[114 115 116]. Sun

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[109] SICILIA, M A, M LYTRAS, E RODRı´GUEZ, and E GARCı´A-BARRIOCANAL. 2005. Integrating descriptions of knowledge management learning activities into large ontological structures: a case study. *Data and Knowledge Angineering*.

[110] VASCONCELOS, J, C KIMBLE, and A ROCHA. 2003. Organisational memory information systems: an example of a group memory system for the management of group competencies. *Journal of Universal Computer Science*. **9**(12).

[111] SICILIA, M A, E GARCı´A, and R ALCALDE. 2003. Fuzzy specializations and aggregation operator design in competence-based human resource selection. *In*: *Proceedings of the 8th World Federation on Soft Computing Conference*. New York: Springer.

[112] SIMON, B. 2003. Learning object brokerage: how to make it happen. *In*: *Proceedings of Ed-Media 2003*. 681 – 688.

[113] SICILIA, M A, E GARCı´A, and R ALCALDE. 2003. Fuzzy specializations and aggregation operator design in competence-based human resource selection. *In*: *Proceedings of the 8th World Federation on Soft Computing Conference*. New York: Springer.

Tzu wrote over 2000 years ago, "He will win whose army is animated by the same spirit throughout all its ranks". Teamwork can be augmented by semantic web technologies using semantic peer-to-peer technologies[117].

5.1.2. Identifying learning and development needs

Semantic web technologies can also be used to do a sort of gap analysis. The costs and benefits of learning can be evaluated from the calculation of the knowledge gap covered, defined in terms of domain ontology concepts or competencies mastered. Feedback can be automated through assessment agents that are able to explain the divergence between expected and actual outcomes. Knowledge gap analysis can be automated through competencies and learning objects connected through ontologies[118].

An important part of ascertaining the developmental needs of staff is by getting their thoughts on areas they are struggling with, or would like to get more experience in. Semantic negotiation tools[119] can be used as discussion mechanisms between supervisors and employees.

5.1.3. Meeting learning and developmental needs

The scheduling and calendar restrictions to deliver activities can be controlled by agents[120].

Semantically related simultaneous activities can be identified with the purpose of joining the employees engaged in them in informal groups Semantic tools can be used to locate activities that are relevant to the needs of an employee[121].

Automated workload assessment can be used to prevent disadvantages or situation of stress for employees.

Mentors and coaches can be semantically selected by matching the profiles of people inside the company.

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[114] KNOX, G E and K R SIMPSON. 2004. Teamwork: The Fundamental Building Block of High-Reliability Organizations and Patient Safety. *In*: *Patient Safety Handbook*, Jones and Bartlett. 379 – 415.

[115] BAKER, D P, S GUSTAFSON, J M BEAUBIEN et al. 2003. *Medical Teamwork and Patient Safety: The Evidence-Based Relation*. Washington: American Institutes for Research.

[116] SALAS, E, D ROZELL, B MULLEN, and J E DRISKELL. 1999. The Effect of Team Building on Performance: An Integration. *Small Group Research*. **30**. 309 – 339.

[117] NILSSON, M., PALME´R, M. AND NAEVE, A. 2002. *Semantic Web meta-data for e-learning – some architectural guidelines*, Proceedings of the 11th World Wide Web Conference. 7 – 11.

[118] SICILIA, M A. 2005. Ontology-based competency management: infrastructures for the knowledge-intensive learning organization. *In*: *Intelligent Learning Infrastructures in Knowledge Intensive Organizations: A Semantic Web Perspective*, IDEA, Hershey.

[119] TRASTOUR, D, C BARTOLINI, and C PREIST. 2003. Semantic Web support for the business-to-business e-commerce pre-contractual lifecycle. *Computer Networks*. **42**(5). 661 – 673.

[120] PAYNE, T R, R SINGH, and K SYCARA. 2002. Calendar agents on the Semantic Web. *IEEE Intelligent Systems*. **17**(3). 84 – 86.

[121] GARCı´A, E and M A SICILIA. 2003. User interface tactics in ontology-based information seeking. *Psychology e-Journal*. **1**(3). 243 – 256.

Learning styles can be represented as part of the ontologies, so that the selection of learning experiences takes them into account[122].

5.1.4. Applying learning in the workplace

Learning application suitability – Sharing of knowledge and experiences of learning can be mediated by semantic software tools. Employees can inspect their own record of learning.

Learning application effectiveness – Comparisons of products and services can be provided.

Learning application immediate supervisor support and feedback – The ontology representation of job situations and episodes enables the checking that the learning outcomes are actually put into practice.

5.2. The issue of standardisation

The distributed nature of the Web, and consequently the lack or central organized repositories for digital resources, has led to the creation of descriptors in order to foster exchange and re-use between these resources. In the case of educational resources, the notion of a *learning object* has been developed in order to frame the basic independent units usable in a learning activity. A learning object is defined as any entity (digital or non-digital) that may be used for learning, education or training, composed by content and a set of descriptors. These last ones, usually called *metadata*, should apply to learning objects in order to describe their salient features, and facilitate their exchange.

In an example provided by Devedzic[123], metadata is used to bridge the gap between repositories of educational content and the learner. In his scenario, *pedagogical agents* are web services that are able to reason on the metadata of the resources, collect them in a variety of ways (for example following pedagogical, personalised or collaborative schemas) and present them to the user within a final formatting.

[122] MCCALLA, G. 2004. The ecological approach to the design of e-learning environments: purpose-based capture and use of information about learners. *Journal of Interactive Media in Education*. **7**.

[123] DEVEDžIć, V. 2003. Think ahead: evaluation and standardisation issues for elearning applications. *International Journal of Continuing Engineering Education and Lifelong Learning*. **13**(5/6). 556 – 566.

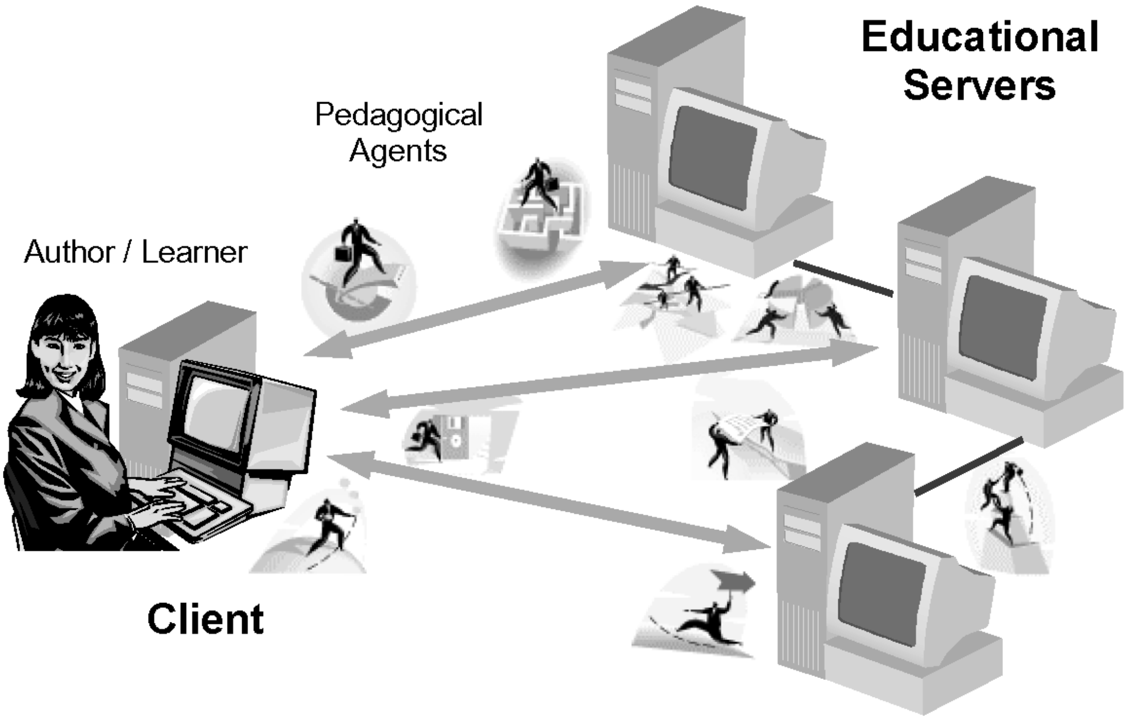

Figure 2 – Human computer interaction using pedagogical agents

It is crucial for the agents (human or digital) that metadata are defined using the same semantic structure, or that at least different metadata schemas are compatible between themselves. This is in fact the core problem of learning resources' exchange, and in general of any communicative activity on the Web: the sharing of a language, i.e., of a formal protocol that also machines can interpret. From the chapter on semantics, it is clear to see that the protocols being developed by organisations are divergent. The same can be said for the protocols being developed for educational semantics.

What follows is a brief synopsis of a few of the protocols being developed for education:

- The IEEE Learning Technology Standards Committee (LTSC) is chartered by the IEEE Computer Society Standards Activity Board to develop accredited technical standards, recommended practices, and guides for learning technology. A part of the LTSC is the WG12 Learning Object Metadata (LOM)[124] working group that develops Draft Standards for Learning Object Metadata. These standards specify the syntax and semantics of Learning Object Metadata, defined as the attributes required to adequately describe a Learning Object. The Learning Object Metadata standards focus on the minimal set of attributes needed to allow these Learning Objects to be managed, located, and evaluated. Relevant attributes of Learning Objects to be described include *type* of object, *author*, *owner*, *terms of distribution*, and *format*. Where applicable, Learning Object Metadata may also include pedagogical attributes such as; *teaching* or *interaction style*, *grade level*, *mastery level*, and *prerequisites*.

[124] *Draft Standard for Learning Object Metadata*. 2002. [online]. [Accessed 4 March 2010]. Available from World Wide Web: <http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf >

- The ARIADNE Foundation[125] is a European project that develops tools and methodologies for producing, managing and reusing computer-based pedagogical elements and telematics supported training curricula. Its Educational Metadata Recommendation is an application profile and implementation of the LOM specification that takes into account the specific needs and requirements of a community, highly representative of European Higher Education and Continuing Professional Training.
- The CID group (Center for user-oriented IT Design) of the Royal Institute of Technology, Stockholm, Sweden, has developed RDF binding of LOM metadata[126]. This specification provides a representation of IEEE LOM in RDF (a Semantic Web language, described in chapter 4), in order to facilitate introduction of educational metadata into the Semantic Web. It is specified as a table defining the RDF property to use for each element in the draft LOM standard. This is very important for future web-based intelligent educational applications, since such a binding enables the RDF-based exchange of LOM instances between applications that implement the LOM data model.
- More recently, the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), which constitute together the specialized agency for worldwide standardization, have formed a joint technical committee, ISO/IEC JTC1[127], in the field of information technology. A working group of this is focused on Information Technology for Learning, Education and Training and is publishing standard data models to describe collaborate learning activities, like workplace and group information, objectives of collaborative learning, expected outcome, name and role of participants, etc. This initiative has been welcomed as a possible conclusive attempt to map learning resources' usages and semantics, however, the drafts published are not stable yet and there seems to be much more work to do.

These are just a selection of the most important protocols being used, but it is already clear that to have a single standard is virtually impossible. This is due to the nature of the web and its extreme openness. Just looking at the battle of the browsers and their own set of standards, it is clear to see that this is indeed an attribute of the web in general. Specifications then that allow some sort of interoperability are the safest bet. Another point is that even if these protocols are useful in the exchange of learning objects, the metadata they expose are semantically poor. This means that only simple data is being transferred. This does not bode

[125] ARIADNE, *ARIADNE Foundation for the European Knowledge Pool*. 2004 [Accessed 4 March 2010]. Available from World Wide Web: <http://www.ariadne-eu.org/index.php?option=com_content&task=view&id=32&Itemid=48>

[126] The *LOM RDF* binding - principles and implementation - [Accessed 4 March 2010]. Available from World Wide Web: <http://kmr.nada.kth.se/papers/SemanticWeb/LOMRDFBinding-ARIADNE.pdf>

[127] ISO/IEC-JTC1, *Standards for Information Technology for Learning, Education and Training (ITLET)*. 2004,. [Accessed 4 March 2010]. Available from World Wide Web: <http://ltsc.ieee.org/wg12/par1484-12-2.html>

well for advanced semantic browsing facilities i.e. linking bits of information non-sequentially in order to create a body of knowledge.

5.3. The semantic learning organisation

The *semantic learning organization* (SLO) is a concept that extends the notion of learning organization in the technological dimension, so that a SLO can be considered as a learning organization in which learning activities are mediated and enhanced through a kind of technology that provides a shared knowledge representation about the domain and context of the organization. Although Semantic Web technology cannot be considered as a requirement for every possible approach to a learning organization, at least in knowledge-intensive organizations, shared semantics provide a competitive advantage when oriented to value inside organizational processes[128].

What follows now is a discussion on solutions that could make up components of an SLO. This is not an exhaustive discussion, but merely a selection of what the researcher suggests are the most powerful usages of semantic web technology within the organisational learning sphere.

5.3.1. Enterprise knowledge portals

For many people, the idea of enterprise knowledge portals is the key for realising the potential benefits of semantic web technologies for business. The challenge for information systems is to provide the user with the right information at the time it is needed and in the right format. Enterprise knowledge portals are an emerging approach to doing just that. They provide a single point of access to various types of information and applications. The problem with many of these portal systems is that their components have very little or no intercommunication, meaning that each source has to be searched individually for relevant information[129]. We have already discussed the goal of the semantic web as described by Berners-Lee. The goal then is to apply semantic web technologies to knowledge portals in order to overcome this problem.

Many different types of portals can be distinguished, mostly based on the fact that there are so many environments where they have been deployed. The first classification criterion is the degree of specialisation and we distinguish between horizontal and vertical portals. Horizontal portals cover a wide variety of topic areas while vertical portals address specific topics which are covered in more detail. Web portals are horizontal in nature and provide an entry point to the World Wide Web. They provide a broad editorial of managed information together with selected linked lists. The main characteristic of web portals is that they have an open access policy. Business portals are the inverse as they target a select audience with a

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[128] LYTRAS, M, A POULOUDI, and A POULYMENAKOU. 2002. Dynamic e-learning setting through advanced semantics: the value justification of a knowledge management oriented metadata schema. *International Journal of e-Learning*. **1**(4). 49 – 61.

[129] PRIEBE, T and G PERMUL. 2003. Towards integrative enterprise knowledge portals. *In*: *Proceedings of the Twelfth International Conferene on Information and Knowledge Management*.

particular interest in a certain business. They provide a vertical focus on a specific topic as well as a number of services around these topics.

Business portals can be subdivided further according by the type of users that they address. *B2C (business to consumer)* portals address multiple customer groups. They most often expose product information and specific services. *B2B (business to business)* portals assist in the sharing of information and transaction processing between enterprises. They are often known as partner or supplier portals. A major concern here is ensuring the security of the information between provider and consumer. *B2E (business to enterprise)* portals provide employees with the information they require to fulfil their individual day-to-day business tasks. As such, they need to allow for personalisation of portal views in order to be most useful to the individual.

Finally, there are three types of enterprise portals that are distinguished based on the functionality that they provide. *Enterprise information portals* are used to publish unstructured information and allow for structuring, authoring and searching (much like a standard intranet based on a content management system). It is by adding personalisation features that the intranet becomes a portal. *Enterprise application portals* provide access to operational systems through a central access point. They incorporate structured i.e. database sources with unstructured sources by integrating external applications into the portal interface. *Enterprise knowledge portals* are equipped with the ability to collect and manage knowledge and distribute it among employees. This might seem like a synonym for information portals, but the focus is on user managed and created knowledge rather than centrally published content. The key is providing the tools for employees to create their own understanding based on the information that is available. Tools include features for collaboration and bulletin boards.

I trust that it is clearly visible that the ideal portal within an organisation will not have to conform to a single classification. Portals should be a combination of these classifications in whatever combination best serves the needs of the enterprise and employees. This then is the most attractive feature of portals, their ability to centralise the entire business process without the need to re-write it. Sub processes remain unchanged while the portal provides a unified access point to them.

Because portals are built to accommodate enterprise needs, different portals will differ substantially in terms of architecture. A common architecture among web applications (portals are a sub set) is the Model View Controller (MVC) architecture. The *model* manages the behaviour and data of the application domain, responds to requests for information about its state (usually from the view), and responds to instructions to change state (usually from the controller). In event-driven systems, the model notifies observers (usually views) when the information changes so that they can react.

The *view* renders the model into a form suitable for interaction, typically a user interface element. Multiple views can exist for a single model for different purposes. A viewport typically has a one to one correspondence with a display surface and knows how to render to it. The *controller* receives input and initiates a response by making calls on model objects. A controller accepts input from the user and instructs the model and viewport to perform actions based on that input. This architecture is the key in allowing the flexibility of personalised interfaces for users as well as ensuring the security of enterprise applications and information.

The image below[130] shows the flow of information between the different components.

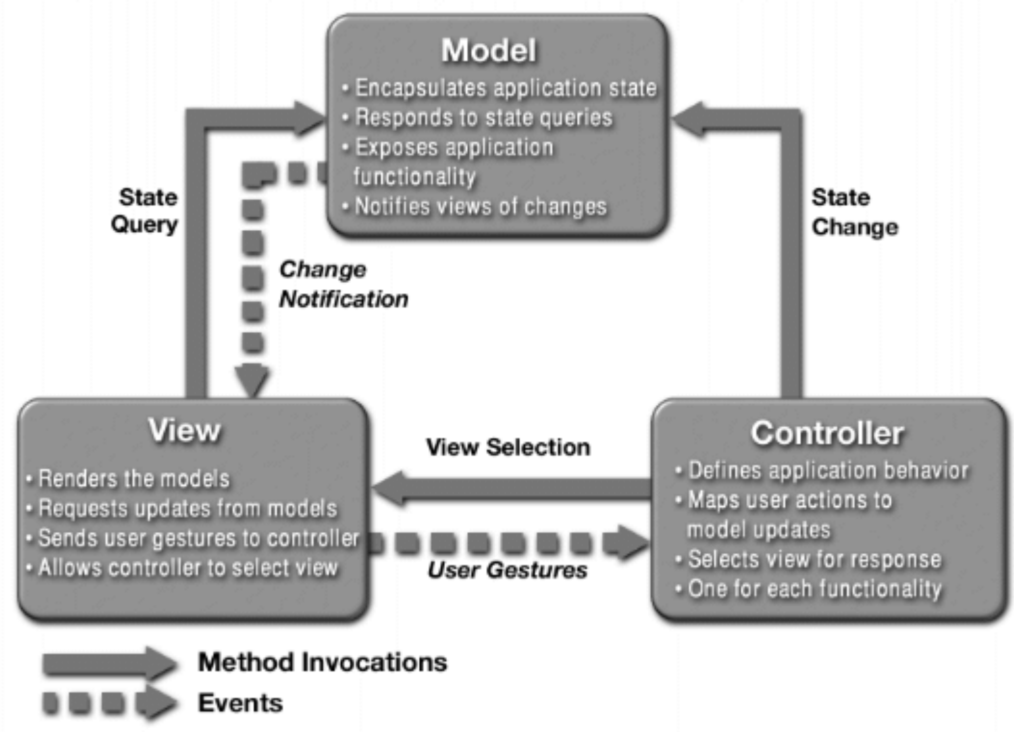

Figure 3 – Flow of information in the Model View Controller architecture

The discussion on the improvement of knowledge portals is split up into three main areas: content management and metadata, global searching, and the integration of external content and applications.

5.3.1.1. Content management and metadata

Web-based systems have become a key technology for distributing information within an organisation. Intranets have replaced the need for paper newsletters and the like as they provide enterprise-wide access to information. Information now has the opportunity to become more and more dynamic. Web content creation used to be the responsibility of a few specialised individuals, so content was limited in volume. Today, content creation tools make it possible for someone with absolutely no HTML knowledge to create web-based content.

Content Management can be defined as a framework to generate, to administrate (organise and prepare), to distribute and to create possibilities of using and processing electronic content, whether it is located on the internet, intranet or corporation-wide systems. Attention is drawn on actuality, consistence and accessibility of the content. Content management has

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[130] *Model-View-Controller*. 2002. [online]. [Accessed 14 May 2011]. Available from World Wide Web: <http://java.sun.com/blueprints/patterns/MVC-detailed.html >

been defined in a web context, but many of the principles have been used on non web-based resources such as textual documents or diagrams.

In order to allow for better structuring of resources and for better search capabilities, the use of metadata is a common approach. Metadata can be described as being data about data. It adds an extra level of definition about the data which is readable by both humans and machines. It represents a mark-up or classification about the resources. This is particularly useful for resources which are not textual to begin with, like technical drawings, but the extra describing information may also benefit textual documents.

Chapter 4 discussed in some detail the concept of metadata and the Resource Description Framework[131].

Where possible, a controlled vocabulary should be used as the set of possible values instead of free text. The element *dc:subject* is usually specified using a pre-defined number of keywords or a taxonomy. The element *dc:coverage* designates the extent of the resource; Dublin Core names geographic coordinates and temporal periods as examples. In an enterprise context, however, different possible "objects" can also be found e.g. products or clients. The use of an ontology as controlled vocabulary seems logical.

A taxonomy consists of a hierarchically ordered number of categories. A document is assigned to one or more of these categories. Using Dublin Core, this may be done using the category *dc:subject*. A category can thus be seen as a kind of virtually directory that contains all the documents on a certain topic. In enterprise knowledge portals, taxonomies are usually used for navigation purposes to guide menu structure. As such, simplicity and comprehensibility of the taxonomy are of vital importance. So to completely describe the resource, a more complex structure is required. This is the role of an ontology. Ontologies are used to formally describe a certain part of reality. It is difficult to clearly distinguish the terms taxonomy and ontology. A taxonomy is sometimes seen as a simplification of an ontology or as a subset of it[132]. For our purpose, an ontology will be more complex and contain a larger number of instances. While resources will be assigned to one or a few taxonomy categories, there extent can cover a much larger number of ontology instances.

There are numerous interoperability tools for the management and querying of metadata such as Sesame[133] or Jena[134], a major problem is the creation remains the creation. Creating or uploading a document to a document or information management system requires the user to manually create the associated metadata as well. You can see that with time constraints, these metadata elements may not be well thought out, or may be absent completely especially since a certain amount of metadata is required before the benefits to searching and information

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[131] *RDF vocabulary description language 1.0: RDF schema*. 2004. [online]. [Accessed 4 January 2011]. Available from World Wide Web: <http://www.w3.org/TR/rdf-schema/ >

[132] MCGUINESS, D L. 2002. Ontologies come of age. *In*: *Spinning the Semantic Web: Bringing the World Wide Web to its full Potential*, MIT Press.

[133] [Accessed 4 January 2011]. Available from World Wide Web: <http://www.openrdf.org/>

[134] [Accessed 4 January 2011]. Available from World Wide Web: <http://jena.sourceforge.net/>

retrieval is clearly visible. This remains an unresolved problem. The remainder of this section will discuss suitable text mining and information extraction techniques that can support the annotation of text documents with semantic metadata. Since the quality of metadata is as important as the volume, a semi-automatic solution is proposed where the system will only suggest metadata to the user, allowing them to improve it manually. The rest of this section deals with finding suitable text mining and information extraction techniques that can support the annotation of text documents with semantic metadata.

Text-mining deals with finding patterns and extracting knowledge from unstructured text documents. Data mining deals with extraction of patterns from structured data, so text-mining can be seen as a special application of data mining[135]. Text mining also draws on elements from other fields such as information retrieval, information extraction and machine learning. In order to apply data mining algorithms to text mining, the unstructured text documents need to be converted into structured data. The initial phase is knows as text refining and has a "document-based intermediate form" as the result[136]. After finishing the pre-processing steps the document is represented as a t-dimensional vector, where t corresponds to the number of terms of the used vocabulary. A document vector consists of the frequencies of the vocabulary terms in the document[137].

Text categorisation is the assignment of one or more predefined categories to a text document[138]. If the document is already represented by a document vector, we can use well-known data mining categorisation algorithms, e.g. induction decision trees (ID3), classification and regression trees (CART) and Bayesian classification[139], for this purpose. We differentiate between single-label and multi-label classifications according to whether exactly one or several categories are to be assigned to an instance. Classification is a supervised learning scheme that predicts the discrete class of an instance using a classifier, which is learned using a pre-classified training data set[140]. To choose an appropriate algorithm, the specific characteristics of document vectors have to be considered. Sebastiani comes to the conclusion that the support vector machines deliver the best mining results for document classification.

The goal of *clustering* is the allocation of input data into dynamically formed groups, such that the instances within a group are very similar and those within different groups are

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[135] TAN, A. 1999. *Text Mining: The state of the art and the challenges*. Kent Ridge Digital Labs.

[136] TAN, A. 1999. *Text Mining: The state of the art and the challenges*. Kent Ridge Digital Labs.

[137] BAEZA-YATES, R and B RIBERIO-NETO. 1999. *Modern information retrieval*. Addison Wesley Longman Limited.

[138] SEBASTIANI, F. 2002. Machine learning in automated text categorization. *ACM Computing Surveys*. **34**(1).

[139] WU, X, V KUMAR, J R QUINLAN et al. 2008. Top 10 algorithms in data mining. *Knowledge Information Systems*. **14**, pp.1-37.

[140] WITTEN, I and E FRANK. 2000. *Data mining: Practical machine learning tools and techniques with Java implementations*. Morgan Kaufmann Publishers.

possible[141]. Clustering algorithms are unsupervised learning schemes as no classes are given in advance. They can be applied for text mining in order to divide documents into similar groups. Clustering algorithms, like instance-based classification algorithms, are based on a similarity or distance function. For this purpose, measures like the cosine similarity can be borrowed from information retrieval[142].

Term-based association analysis identifies dependencies between attributes. A classic example of an association analysis in data mining is a market basket analysis i.e. finding products which are frequently bought together. For text mining, it means that words or terms are found which frequently appear together in documents. More interesting than the association of words or phrases often, is the association of physical entities such as people. These must first be extracted by information extraction techniques.

Information extraction aims to extract certain text segments from a single document. Linguistic techniques such as speech tagging (to recognise word types) and syntactic parsing (to recognise sentence structure) have to be applied as a pre-processing step for information extraction. We distinguish between entity, attribute, fact, and event extraction. An entity is an object such as a person or organisation and usually carries a name; hence we also speak of named entity extraction. The process entity extraction is complex, but are handled acceptably well. The techniques for the other elements are still rather limited.

Automatic text summarisation serves to create a kind of abstract of the text which contains all the important information from the original document, yet is substantially shorter. We distinguish between statistic and linguistic methods. Statistic approaches are based on structured representations of the documents. The example we've already given is the vector space model. One possible approach is the gradual search for expressive words on the basis of the weighted term frequency. For each section in the document, the total weighted term frequency of all occurring words is determined. The sections with the highest value are extracted as the text summary. Linguistic approaches not only look for the occurrence of individual terms, but also their meaning and interdependencies. Statistic approaches have the limitation that semantically related sentences are removed from each other and the summary becomes incomprehensible. The advantage over linguistic methods, which require pre-processing steps, is their speed.

What follows in the next 3 paragraphs is a discussion on how text mining and information extraction techniques can be applied for automatically generating metadata elements. We will use the Dublin Core standard elements dc:title, dc:creator, dc:date, dc:format, dc:description, dc:subject, and dc:coverage to explain the concepts. The first 4 elements are relatively easy to detect programmatically from the document being processed and the dc:description element can be extracted using automated text extraction already discussed. The values of dc:subject

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[141] WITTEN, I and E FRANK. 2000. *Data mining: Practical machine learning tools and techniques with Java implementations*. Morgan Kaufmann Publishers.

[142] BAEZA-YATES, R and B RIBERIO-NETO. 1999. *Modern information retrieval*. Addison Wesley Longman Limited.

and dc:coverage use a controlled vocabulary, so a taxonomy or ontology can be used for coding this.

Taxonomy-based categorisation involves using a taxonomy, created either manually or using the clustering methods already discussed, in order to populate the dc:subject element (determines the topic of a document). Many commercial systems (e.g. SAP) use single-label classification based on the Naive Bayes algorithm to assign the most probable taxonomy category to a new document. Better the classification results can be achieved with more complex algorithms[143].

The final element is dc:coverage, which is the extent of the document and is determined by a set of objects or entities which occur in the document text. Either the set of entities need to exist in the form of an ontology, or information extraction techniques can be used to extract these entities. It is important to note though that the approaches to achieve this are complex and error-prone, so it is advisable to use an enterprise ontology as a controlled vocabulary for dc:coverage. With an ontology as a controlled vocabulary, the automatic linking of a document to related ontology elements is similar to taxonomy-based categorisation. The only difference is the substantially more elements present in the ontology and the fact that dc:coverage can have multiple elements from the ontology assigned to the document.

5.3.1.2. Searching

A major requirement for an enterprise knowledge portal is to be able to globally search for information, no matter where this information is stored or which piece of software manages it. As long as the user has permission to view the resource, they should be able to search for it.

Information retrieval (IR) is a technique used to retrieve information from a source or environment[144]. Classical IR systems search for text documents on that basis of keywords appearing in the document. The most pervasive examples are web search engines like Google[145] which searches on an indexed document base (HTML pages on the internet). The approach used most often is known as the *vector space model*. It compares the query and document and calculates the "distance" between them. This is the extent to which the document contains the query. It allows for ordering because of the distance weighting as well as fuzzy matching as subsets of the query are matched as well.

Repository integration involves merging various data sources (possibly virtually). This makes it easier for a search to look at multiple data sources, without having to compile and order the results across multiple data sources. The integration can happen either up front where each system uses a central repository, or run as a batch where individual data sources are committed to a repository at a set interval. Indexing improves the speed at which a repository

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[143] SEBASTIANI, F. 2002. Machine learning in automated text categorization. *ACM Computing Surveys*. **34**(1).

[144] BAEZA-YATES, R and B RIBERIO-NETO. 1999. *Modern information retrieval*. Addison Wesley Longman Limited.

[145] http://www.google.co.za

can be searched as the indexes (in the form of document vectors) are stored in the repository instead of the entire document.

Meta searching extends these concepts further by searching the metadata content as well as the actual textual content of the document. This approach allows for semantic searches especially if an enterprise ontology exists and is used as a controlled vocabulary. This means that the search has a context. The ideal situation for a meta search would be that the entire enterprise uses a consolidated metadata store. Unfortunately this can't always be the case when different systems are independent of each other. Luckily, the semantic web provides ontology languages such as OWL which provides constructs for ontological mapping (see chapter 2.1 for a further description of OWL). It allows for individual systems storing their metadata in their own ways and then mapping this data to a central repository. An online example of this is MetaCrawler[146], a search engine which indexes and returns results from multiple search engines.

5.3.1.3. Integration of external content and applications

Not only is information required from multiple sources, but often the applications need to be part of the portal as well. This provides a central entry point for an employee to all the tools they require to perform their business function. Web applications provide the best chance of complete integration using syndication for information and portlets to nest the application in the portal.

An integration technique which is usable on any type of application is *content syndication*. It is suitable for integrating static information and messages based on information feeds. The first effort at standardising content syndication on the web, was done by Netscape in an effort to present content from other sites on its portal. They defined the RDF Site Summary (RSS) standard which initially only requested the site headlines to be included in feeds[147]. RSS has undergone multiple changes since then, and went on to be called Really Simple Syndication and finally Rich Site Summary. RSS is simply an XML-based format for exchanging messages and other content between web sites. It allows a portal (or any website) to include content from other sites made available through RSS.

The simplest integration approach for web applications is the *IFRAME*. The IFRAME is an HTML element that allows nesting of web pages, and thus web applications directly into the portal. The browser renders the IFRAME and its contents when the portal page is requested. While this method is very simple to implement, it has some inherent problems which make it a last choice in integration. The portal has no way of controlling or checking the status of the application running within the IFRAME. This means that the possibility exists that the IFRAME content doesn't load because of security settings on the firewall or IFRAME application.

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[146] http://www.metacrawler.com/

[147] HAMMERSLEY, B. 2003. *Content syndication with RSS*. O'Reilly & Associates.

Similar to IFRAMEs are web *clippings*. The difference here is that the server requests the content from the source application via HTTP and merges it with the portal page directly. This does however mean that there are requirements for the pages that the portal will be requesting. This requires more work to be done on the source application, but does allow for a tighter nesting of the application within the portal. Unfortunately, the same limitations exist for clippings as they do for IFRAMEs in terms of portal communication and integration.

In order to fully integrate web applications into the portal (allowing for inter-application communication) the applications need to expose an application programming interface (API). An API is a particular set of rules and specifications that the portal can follow to access and make use of the services and resources provided by another particular software program[148].

5.3.2. Communities of practice and knowledge agents

In order to capture knowledge and even create it, many organisations implement the concept of knowledge management. It uses numerous tools so as to accomplish its duty of collecting precious information and product knowledge. One of the tools used to capture and diffuse a company's knowledge is known as a software agent. A software agent is a complex but flexible computer system with artificial intelligence principles, which acts autonomously on behalf of humans using its context as consideration. An agent carries out activities in an intelligent manner that is adaptable and responsive to environmental stimuli[149].

5.3.2.1. Defining agents

In order to appreciate the value of software agents to knowledge management, we should first explore how they differ to other types of software. The following characteristics can be considered as the differentiating factors between agents and other types of software[150]:

- *Delegation*: Each agent is delegated the responsibility of performing a task; it tackles the user problem without requiring any further input from the user
- *Acting within constraints*: In order for the user to completely trust the agent, their needs to be some boundaries or guidelines which the agent follows in fulfilling their task (these are usually variables which can be adjusted by the user). In this way, the user affects the effectiveness of the agent.
- *Skills/domain of expertise*: An agent should only be defined to have a single purpose referred to as its domain of use. This ensures that the agent will always act in accordance with the user's needs and expectations.
- *Personalisation*: The main differentiating factor is an agent's ability to learn by interacting with the user and thus dynamically adapting to the users' needs. The agent

[148] *Definition of: API*. [online]. [Accessed 5 January 2011]. Available from World Wide Web: <http://www.pcmag.com/encyclopedia_term/0,2542,t=application+programming+interface&i=37856,00.asp >

[149] NWANA, H S. 1996. Software Agents: An Overview. *Knowledge Engineering Review*. **11**. 205 – 244.

[150] ANAGNOSTOPOULOS, A, N LAMPROPOULOS, and S MICHALAKOS. 2005. Knowledge Agents: Exploiting the Community Paradigm for Collective Intelligence. *In*: *Intelligent learning infrasructures for knowledge intensive organisations: A semantic web perspective*.195 – 197.

has the ability to store a user's actions and reuse them when interacting with the same user at a later stage.

- *Predictability*: Since an agent's actions are governed by built-in logic, its actions can be predicted by the end user. That means that each user can have a realistic expectation of the results.
- *Mobility/flexibility*: The agent must be flexible enough to adapt to new data sources not necessarily on its native machine. This is not always the case though, but a lack of mobility and flexibility may decrease its use for the user.
- *Social behaviour*: The agent has the ability to interact with other agents in order to fulfil its delegated task. As the complexity of user requests increase, it becomes increasingly unlikely that a single agent will have access to all the information it needs to complete the delegated task. Thus the need for agents to be able to relate to each other in order to address problems in a more collaborative and this effective and efficient way.
- *Cost effectiveness and efficiency*: The goal of any agent is to benefit the user by seeking required information, gathering it concisely, elaborating on it, filtering out redundant sources and returning the knowledge that the user really wants and needs. The agent must do all this with less effort than is required to enable it to do it.

5.3.2.2. Agent domains

There are many ways in which agent classification is possible. As an example, we may classify them according to their autonomy, learning behaviour and pro-activity, or according to the context in which they operate. Instead of listing all of these, I propose that we instead show examples of domains in which agents are useful to learning.

Whether the agent is simply a tool for disseminating knowledge to users or as a mediator for connecting users looking for the same type of information, smart agents are the key component of any *e-learning* platform. The function of e-learning is reinforced and facilitated by the utilisation of agent infrastructure in aspects such as customising the process of learning to each user's individual specifications and facilitating the search of items with greater importance to the user.

An extension of the e-learning principle is *business intelligence*. We have already discussed how organisations have become environments where knowledge is generated, assimilated, maintained, and consumed at an ever increasing rate. Organisational knowledge mainly consists of all the small elements of tacit knowledge stored in the organisation's employees. One of the most important question, especially to this paper, is how smart agent systems are designed to resolve the issue of knowledge maintenance. Organisational knowledge is difficult to produce and even more so to reproduce. For this reason, if we were to be able to retain this knowledge even when employees leave, it may prove to be a source of a sustainable competitive advantage. A typical use of business knowledge is for decision making. The more useful information at the decision-maker's disposal, the better the decision will be in general. Consequently, it is important that the decision-maker has access to detailed, pertinent, up-to-date, and cross-referenced information. The agent's role then is to only consider the relevant information to the decision in question.

Telecommunication technologies and the ever increasing speed of data transfer, has led to the exponential growth of the internet as a medium for information transfer. The main problem with the internet in terms of its usefulness for knowledge transfer is the sheer volume of information available. How does the user find the information that is useful to that context? As we've already spoken about, *semantic web technologies* such as RDF and OWL have enabled machines to make deductions and organise information in a more effective way.

A novel concept is the presence of agents in a virtual infrastructure in which they operate. Agent societies are coalitions of agents which are utilised in different tasks and functions in a context of collaboration and synchronisation with remarkably high diversity[151]. Therefore, the agent society is the community that makes the interoperability of agents to perform a single task possible. A knowledge management system may be comprised of one or more societies which in turn include several different types of agents.

5.3.2.3. Designing and implementing knowledge management systems using agents

Before designing a knowledge management system, it is important to take the end user into account. The user determines the selection of the types of agents as well as the effort required to deploy the "agent society" once it has been completed (this includes training the user to use the system). No matter how technically savvy the user is though, designers should aim for a clean, simple, and user-friendly interface that allow the user a painless integration into their current workflow (systems should be as unobtrusive as possible).

After the initial design phase, it is important to immediately start thinking about a deployment plan. This may be counter-intuitive, but an unobstructed integration of a system is one of the most important aspects. With the pace of organisational life, it is impossible to set any length of time or personnel aside for an integration process. What follows are three of the most significant elements to take into account when deploying new agent systems.

Every organisation has a number of *legacy systems* that need to be integrated in order to make the new agent system usable. These are often business critical systems supporting decision making and the general workflow process. The older the legacy system is, the more chance of it being a closed system. Closed systems are those that are built as an isolated unit i.e. no ability has been built into the system to allow integration with other systems. The developers of new systems should be cautioned against attempting a rewrite of legacy systems. At first this may seem like the logical choice, but often these systems have hidden nuances which increase the cost of development exponentially. The only viable option for organisations where legacy systems are large and an integral part of operations is to create agents designed to work as proxies between the legacy system and the new agent society.

When any new system is developed, especially one where information transfer and retrieval is as important as it is in agent systems, the problem of *information security* becomes

[151] ANAGNOSTOPOULOS, A, N LAMPROPOULOS, and S MICHALAKOS. 2005. Knowledge Agents: Exploiting the Community Paradigm for Collective Intelligence. *In*: *Intelligent learning infrasructures for knowledge intensive organisations: A semantic web perspective*. 189 – 224.

apparent. Agent systems reach their full potential through personalisation to the user. This however means that the agents have access to sensitive user information and must prevent unauthorised access to this. The first step is to ensure that that network on which the agent society exists is secure, but using firewalls and encrypting data transfer. Secondly, accidental user access to sensitive information should be controlled using access control lists (ACL). These are simply lists matching a user to particular resources.

User training is the final step in the development cycle (this assumes a single phase development process which is almost never the case) and the agent system can't be thought of as deployed until users are trained to use the system effectively. Users need to be trained to use the new agent society, but also to integrate it into their current use of legacy systems.

5.3.3. Tutoring systems for a semantic learning infrastructure

Intelligent tutoring systems (ITS) are computer systems which provide students with learning and teaching environments adapted to their knowledge and learning capabilities as well as being adaptive to their time constraints. The ultimate goal of an ITS, is to provide a learning environment equal to a one-on-one learning environment with a human teacher. As with other systems already discussed, this involves personalising the system based on the user requirements in terms on learning content and teaching method. Several authors have identified the three main interconnected modules of the ITS structure based on three main players in the conceptual model (domain knowledge, teacher and student)[152]:

- Domain knowledge module with the domain knowledge base
- Teacher module, which guides the teaching and learning process
- Student module with information specific to each individual student

More recent research has identified and added a fourth component to the list:

- User interface module, which enables interaction among student, teacher and domain knowledge

ITSs have their origin in CBI (computer based instruction), CBL (computer based learning) and CBT (computer based training). In the past, the technical basis of these systems migrated from running on mainframe computers to personal desktops to thin clients. All of this required substantial investments of time in terms of research and development as well as funding. This resulted in an almost prohibitive cost for training courses based on these systems. From the educational standpoint, these systems were inflexible and could not adapt to the different needs of students. The best known example of a system that started its life like this is Plato[153]. It is worthwhile noting that the current trend in both implementation and research is the application of multimedia, hypermedia and other web based technologies to

[152] NWANA, H S. 1990. Intelligent Tutoring Systems: an overview. *Artificial Intelligence Review*. **4**. 251 – 277.

[153] http://www.plato.com/

improve traditional CBI systems. ITSs aim to be a more advanced form of computer aided education with support from artificial intelligence methods and techniques[154].

5.3.3.1. The use of agents for the implementation of ITSs

Within e-learning systems, agents can be applied in almost all activities requiring adaptation to students. This type of agent fulfils the role that a human educator would usually fill by adjusting to student needs. It is possible to consider each module of the ITS as an agent. Chan (1995) in fact defined ITSs as systems based on the interactions between two agents: a human learner agent and an artificial teacher agent[155]. The teacher agent needs to possess the knowledge that will enable it to act as a human teacher would and respond to the student as if it were. It needs to bridge the gap between the student and the expert knowledge the student would need to embrace. Some of the more important roles that the teacher agent needs to perform is the ability to adjust to the ability of a student or student group, the time available to educate the student and the method to attain the teaching goals. The teacher needs to not only provide the knowledge, but also test the student's grasp of the knowledge matter once the learning session is complete. Testing may include agent assistance to the student, depending on how well the student is doing on the test.

Agents in ITSs can also be linked to activities that are not usually linked to direct one-to-one teaching. The application of these tasks can be classified as follows:

- *Cooperative study* enables student-to-student interactions, guiding them toward the goal of solving some common problem. ITS implementations on a web environment further expand the possibility of cooperative study even when students are not physically closely located. Students also don't have to be present at the same time to benefit from cooperative study due to the creation of a shared, persistent information space for learning. In order to accomplish this, the agent should learn the content of interest to the group, keep this information available for all users and discard information not conforming to the area of interest. Besides searching and storing information, the agent should also make the reporting of each student to the group a painless and seamless process.
- Learning within a cooperative framework can be initiated by *enabling competition*. Competition is an important part of standard test taking allowing a student to assess their ability. Agents can assist by connecting students in the cooperative environment, but can also act as the adversary for students that require direct competition.
- *Information space search*, touched on briefly in cooperative study, is important in connecting the student to distributed, and often disparate information sources while reducing the effects of information overload. Existing information infrastructure enables access to vast amounts of information, however filtering the information for what is useful is a time consuming task. ITS agents should limit the amount of

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[154] PSOTKA, J J, L D MASSEY, and S A MUTTER. 1988. *Intelligent tutoring systems: Lesson learned*. Lawrence Erlbaum Associates.

[155] CHAN, T W. 1995. Artificial agents in distance learning. *International Journal of Educational Telecommunications*. **2**(3). 236 – 282.

routine, time consuming tasks the user has to do in order to get the desired information and to understand the semantics of the desired data.

- *Student-advising* adds value to the learning activities of standard as well as agent based learning systems. Agents should be able to use the student's unique combination of knowledge, age and the desired outcomes to suggest areas of study. Modern agents go as far as factoring in non-measurable aspects of student learning like lack of motivation and suggesting possible remedies.
- The user interface is the entry point of the student into the learning environment and is thus of utmost importance to the quality of education. The *adaptation of the user interface* to the desires, needs, habits and wishes to the needs of the student is this extremely important. User interface agents acquire the student's habits in using the system e.g. storing the common interactions or the path users take to get to a desired sub section of the system, and subsequent executions of similar actions are "auto-completed''.

5.3.3.2. Distributed semantic networks tutor (DiSNet)

This section discusses an application of agents enabling ITSs. DiSNeT is a distance learning system based on the intelligent tutoring paradigm, on knowledge presentation using distributed semantic networks and on using agents in the learning and teaching process. The system aims to enable personal agents to access the knowledge distributed in an information space of an information infrastructure. System users are both the learners and teachers in that the users create and consume the expert knowledge. By annotating the expert knowledge users create sharable teaching elements intended for the tutoring of other users.

DiSNet encompasses the following four modules:

- The *knowledge module* is the fundamental module of DiSNeT and contains the knowledge used by all other modules of the system. The module comprises expert knowledge bases along with educational knowledge bases that are created using the authoring module or gained using the support collaboration module. Knowledge stored in the knowledge module uses the teaching module that enables the learning and teaching process by publishing both stored knowledge and student profile data.
- The *authoring module* supports the creation of both expert knowledge elements and educational knowledge elements. Expert knowledge contains domain knowledge, which is represented by distributed semantic networks. Here every node can contain the following elements: (i) expert knowledge node identifier, (ii) expert knowledge node name, (iii) table containing node properties and respective values, (iv) node description, (v) paths for files describing node hypermedia, (vi) list of expert knowledge node identifiers, which are linked to a certain node as well as the names of the respective links. DiSNeT can use expert knowledge created using the intelligent hypermedia authoring shell Tutor Expert System (TEx-Sys). The authoring module also incorporates the Web Service used by author agents to add or change the knowledge.

- The *teaching module* is implemented using the Web Service used by teaching agents assigned to students. This Web Service enables the access to the knowledge being taught and to the knowledge about students. Using the published knowledge, teaching agents guide the learning and teaching process of a distant student. The implementation of teaching agents and the details of their teaching paradigm are left to agent developers, which enables the design of different ITSs on the services of a single teaching module. Developing different ITSs on teaching and authoring module's Web Services ensures ITS interoperability. By doing this, the DiSNeT server becomes the information space for interchanging knowledge belonging to different ITSs, which is the basis for their tutoring activity. Another way to achieve ITS interoperability is the use of the Web as a whole as the common information space.
- This kind of interoperability is enabled by the support collaboration module, whose functions can be subdivided into two groups. The first group comprises functions for declaring expert and educational knowledge while the second comprises functions for searching and unifying knowledge in the common information space. Educational and expert knowledge are published on the Web using ontologies previously developed according to the SHOE model. Publishing expert and educational knowledge using appropriate ontologies enables knowledge interchange not only with distance learning systems based on DiSNeT, but also with other distance learning systems that adopt the ontologies so far defined. The search part of the support collaboration module contains the search agent, the requests table (RT) and root documents address register (RDAR) pointing to expert and educational knowledge. The root documents address register contains addresses of those documents that represents the root of the tree of networked documents, while addresses of other documents are reached after analysing the content of previously browsed documents, which stored in the requests table. The content of the root documents address register is regularly checked to discover documents that are no longer available thus enabling the removal of the respective addresses from the register. If the search agent finds a new document in the root documents address register, it requests its distribution, analyses its content and stores within the knowledge module the knowledge elements thus found. A new document can be connected to other documents and the search agent analyses their content as well, adding new data to the expert and educational knowledge. Multimedia elements that describe teaching matter are not stored on the DiSNeT server but only their addresses. The search agent completes its task after analysed both all new root documents and all documents from the requests table. Additionally, search agent also analyses the syntax correctness of the published documents.

5.3.4. Redefining the concept of the classroom

Throughout the paper, there have been discussions on how technologies have changed the way that we learn and teach. This section discusses how the semantic web has changed learning and the classroom paradigm and how semantic technologies can enhance learning particularly with regard to providing adaptive learning within the organisation. There are two main groups of adaptive education systems that are frequently used on the web, Adaptive hypermedia (AH) and intelligent tutoring systems (ITSs).

In contrast to traditional e-learning/electronic learning, e-business, and e-government systems, whereby all users are offered or even directed a standard series of hyperlinks, AH tailors what the user sees to the learner's goals, abilities, interests, knowledge, etc. [156] It thus offers a selection of links or content most appropriate to the current user. Moreover, adaptive hypermedia can also offer the most appropriate links or content for the context of the current user, for the device the current user is accessing the information from (e.g. hand-held device versus desktop, etc.). Adaptive hypermedia is thus closely related to web personalization.

An intelligent tutoring system (ITS) is any computer system that provides direct customised instruction or feedback to students, i.e. without the intervention of human beings, whilst performing a task[157]. Thus, ITS implements the theory of learning by doing. An ITS may employ a range of different technologies. However, usually such systems are more narrowly conceived of as artificial intelligence systems, more specifically expert systems made to simulate aspects of a human tutor.

While AH systems have compact system design with high coupled components, ITSs have high-level modularity, meaning that they can provide much more user-oriented design. Both AH and ITSs are often expensive to implement as they require the time of knowledge experts to insert and update learning material within an isolated system.

Learning management systems (LMSs) have been much more successful in web-enhanced education and were discussed at length in chapter 5. We now return to LMSs and extend them further using semantic web technologies.

5.3.4.1. Intelligent learning management system (ILMS)

The greatest task for LMSs is unifying systems, particularly legacy ones, to use standards for data representation and interfaces. The ILMS structure is based on the structures of both the ITSs and LMSs. As with ITSs, ILMSs model and represent the relevant aspects of knowledge. This means that it contains the knowledge about the student, domain of learning, pedagogy ad the communication that is involved.

ILMSs inherit the design of learning materials and management abilities from LMSs. While ITSs are concerned with the adaptation to learning requirements of a single student, LMSs are mainly focused on reusability of learning objects, and execution of collaborative and administrative tasks. They provide a complete platform in the areas of logging, assessing, planning, delivering content, managing records and reporting. They improve both the student-

[156] BRUSILOVSKY, P. 2000. Adaptive Hypermedia: From Intelligent Tutoring Systems to Web-Based Education. *In*: *Proceedings of Intelligent Tutoring Systems*. 1 – 7.

[157] PSOTKA, J J, L D MASSEY, and S A MUTTER. 1988. *Intelligent tutoring systems: Lesson learned*. Lawrence Erlbaum Associates.

led (self-paced) and instructor-led learning processes[158]. ILMSs use web services to expose these features to the end user. Using web services allows for greater transparency and increased security mechanisms.

5.3.4.2. The Multitutor ILMS

The Multitutor system enables the teachers to develop tutoring systems for any course. The teacher has to define the metadata of the course: chapters, the lessons and the tests, the references of the learning materials. It is built on the Java platform, meaning that it can be run on virtually any operating system[159]. This is attractive for the purpose of learning management, as the software does not have to be rewritten depending on what computer environment the organisation has, or decides to implement in the future.

The purpose of this section is not to review the technical aspects of the system but rather to explore some aspects of ILMSs by exploring an actual example of structure and implementation. The aim is to show that a system such as this is a viable replacement for the current classroom/training paradigm.

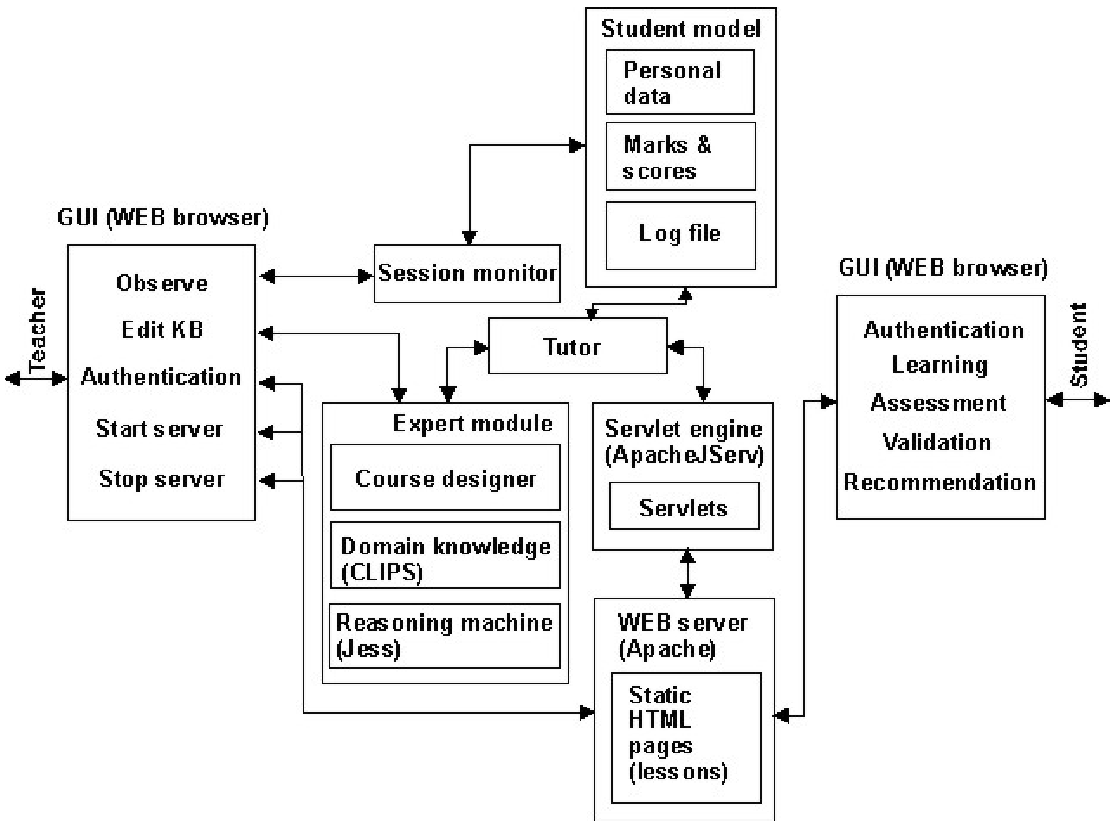

Figure 4 – Multitutor Intelligent Learning Management System

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158 *Learning Management Systems (LMS) Architecture*. 2004. [online]. [Accessed 2 May 2011]. Available from World Wide Web: < http://www.icmgworld.com/corp/ces/ces.lms.asp >

159 Java is often referred to as the write once, run everywhere programming language. This is because of the underlying framework (Java Virtual Machine) which is supported by every major operating system. See *Java Technology*. [online]. [Accessed 14 May 2011]. Available from World Wide Web: <http://www.sun.com/software/learnabout/java/ >

The diagram above[160] depicts the structure of the Multitutor ILMS. The entry point for the setup of the system is the definition of *start-up data*. As an example, each teacher has to be registered on the system. The teacher then defines their areas of expertise (or subjects) and lessons (or courses) they are offering using a web based interface. Students are then registered and access the learning material. The basic building block in this application is the course ontology. It defines the learning material, references and the assessment content. The system uses the concept of learning objects[161], so that there is reuse of learning material between lessons and courses.

This may appear to be exactly the same as the classical classroom learning approach, but remember that learning can take place independent of location or time and students are able to learn in groups or as individuals, as the learning material is always available.

5.3.4.3. Improving ILMSs with the Semantic Web

Multitutor, and many other ILMSs, use XML schemas to define the different parts of the system i.e. teacher, student, courses, etc. The XML schema however has several weaknesses regarding the ontology description[162]. A logical improvement would be to use Semantic Web ontology languages such as RDF and OWL to improve the ontology description process. The main challenge for the e-learning community will be to adopt standards that will be guidelines for developers of ILMSs[163].

5.3.5. E-collaboration/collaborative learning

The major problem with distributed learning systems such as ILMSs, is the removal of interaction from the learning environment. This may be instructor-learning or learner-learner interaction. A means to enable collaboration is thus an important requirement for any learning environment so that communities are developed and maintained. E-collaboration involves a variety of both communication and cooperation issues in that it leverages the connective powers of a computer network to coordinate the efforts of a group of people. By using e-collaborative capabilities in a learning environment, people can operate as a single entity, thus enabling team work and making joint decision making possible.

Issues to be addressed in the establishment of an e-collaboration environment should have a strong organizational focus. These include work structuring in order to improve coordination, use of communication technology to make collaboration more efficient and effective, enforcing of rules and procedures for achieving consistency, and automating data processing in data intensive situations. One should further consider the conceptual, methodological, and application-oriented aspects of the problem. Conceptual focus is associated with the

[160] ŠIMIć, G, D GAšEVIć, and V DEVEDžIć.. *Semantic Web and Intelligent Learning Management Systems*. [online]. [Accessed 14 May 2011]. Available from World Wide Web: < http://www.win.tue.nl/SW-EL/2004/ITS-SWEL-Camera-ready/SWEL04-ITS-PDF/%231-Simic-Gasevic-Devedzic-ITS04.pdf >

[161] Discussed in chapter 5 in section on standardisation.

[162] KLEIN, M. 2001. XML, RDF and Relatives. *IEEE Intelligent Systems*. **16**(2). 26 – 28.

[163] DEVEDžIć, V. 2003. Think ahead: evaluation and standardisation issues for elearning applications. *International Journal of Continuing Engineering Education and Lifelong Learning*. **13**(5/6). 556 – 566.

consideration of the nature of individual and organisational processes, methodological focus with the integration of existing computer-based tools, techniques and systems into the human decision making context, and application-oriented focus with the consideration of the real organizational needs by extending decision support to business teams[164].

There are several factors to be aware of when defining an e-collaboration environment:

- Face-to-face communication is possible when participants are located in the same building or even city. However, this needs to be accommodated for by the e-collaboration framework if participants are geographically dispersed.
- For collaboration of remote participants, time also plays an important role. The question to note is whether participants will be able to set aside the same time period to *connect*, or whether communication will occur at random times through mechanisms such as emails or bulletin boards.
- The collaboration environment can be based either on point-to-point communications or on broadcasting of messages, similar to a teacher teaching a class.
- There will need to be a mechanism for mediation and dispute resolution as the goals of the individuals in the group may not be the same.

The development of an integrated e-collaboration framework will significantly facilitate the tasks performed by a learning community of practice. In the course of their often limited life cycle, learning communities of practice are characterised by asynchronous communication, which takes place at the discretion of the individual participants. The description of the three main services required for an e-collaboration framework based on the above factors will show how e-collaboration can assist in this regard. These services should all work together to provide an e-collaboration framework for learning purposes.

5.3.5.1. Information services

Information systems should handle the problem if drawing media from various sources. As all sources of information will have different structures and follow different standards, the main concern here is interoperability and making diverse sources look as though they are native to the application environment. The main way to do this is by taking these diverse sources and converting them to the standards imposed by the current application. An ideal situation would have a single standard for information sharing, but unfortunately this is not the case so the information services layer is of utmost importance if the collaborative learning environment is to be successful. Subsystems of the information services system include which allow control of remote servers, general purpose electronic communication like email, conferencing systems and hypermedia systems such as the World Wide Web.

Another major concern for this class of service is the provision of personalisation for each team member. The system should adapt to the varying preferences and abilities of the team

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[164] ANGEHRN, A., AND JELASSI, T. 1994, DSS Research and Practice in Perspective. *Decision Support Systems* 12, 267 – 275 in KARACAPILIDIS, N I and C P PAPPIS. *A framework for Group Decision Support Systems: Combining AI tools and OR techniques*. [online]. [Accessed 14 May 2011]. Available from World Wide Web: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.47.5072&rep=rep1&type=pdf >

member, but also to the environment which the team member is using. The environment entails things like operating system and other applications being used by the team member. The system should be asking questions like, "What is the current environment capable of displaying?" and "What is the status of the network connection in terms of accessing dispersed information sources?"

Such systems need to remove the barriers imposed by non-interoperable collaboration tools and environments, inadequate infrastructure, undefined data sharing policies and standards for presentation formats. What follows is a break-down of the various problems which need to be addressed:

- *Adaptation of the quality of services offered* according to the available network infrastructure. This is of particular importance to situations where broadband internet access is not ubiquitous. A video which downloads in a minute in one location may take an hour to download in another. This means that two team members may not be able to access the same information at the same time, and thus a divide is caused.
- *Device independency* to handle the myriad of emerging devices and operating systems. Instead of becoming more unified as technology improves, different providers are moving further apart in order to differentiate themselves in a tough market. While there are standards organisations who aim to unify these parties, there is no impetus from the providers themselves to adopt these standards.
- *Generation of customised content* through document transformation, dynamic document generation and adaptive hypermedia. These partially circumvent the need for documents to all use the same standard. As long as the underlying data is readable and understandable by the system, it should be able to generate a document display for the end user in the format that they require.
- Provision of personalised collaboration tools that track a learner's activity and interactions during usage of the system. It should analyse the feedback and accordingly identify what the user's needs and interests are using adaptive learning techniques.

5.3.5.2. Documentation services

Documentation services should provide the means to create a shared document workspace for storing, retrieving and modifying shared documents and messages. This is only possible when using the appropriate document formats which allow for interoperability such as XML. The only advantage in today's business environment is its ability to quickly leverage and utilise the available knowledge before it becomes redundant[165]. The image below is an adaptation of Boisot's i-Space model, showing how knowledge progresses from personal, tacit knowledge, to public, explicit knowledge. It is clear that once tacit knowledge is incorporated into the organisation and becomes proprietary knowledge (in the form of a product or service), the next step is for it to become public knowledge.

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[165] PRAHALAD, C K and G HAMEL. 1990. The core competence of the corporation. *Harvard Business Review*. **68**(3). 79 – 91.

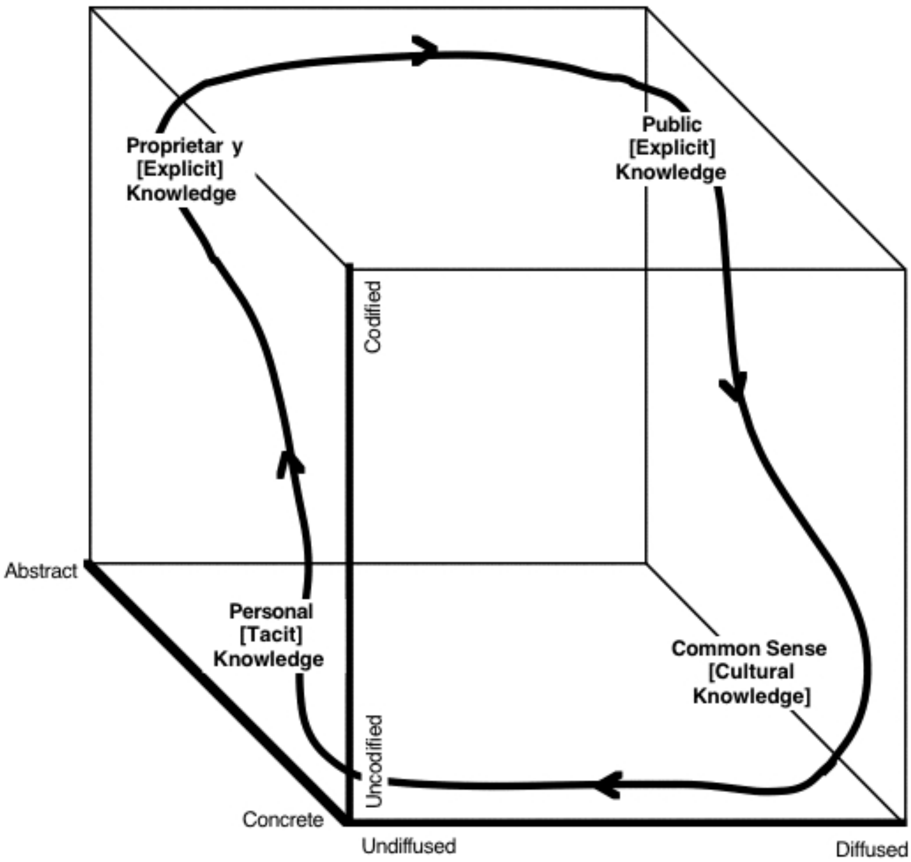

Figure 5 – Adaptation of Boisot's i-Space Model

The dissemination of information is so rapid due to new technologies that a business cannot hope to sit on an idea for any length of time before acting on it. Competitive advantage is also gained from getting things right. If the knowledge can be analysed from different perspectives the possibility of addressing the wrong problem or reaching an inadequate solution is minimised.

It is logical then that any web-based learning environment needs to incorporate knowledge management as well. Issues such as knowledge acquisition, representation, diffusion and maintenance need to be addressed. The thing to note is that this knowledge is resides in various types of assets such as people and the structure and culture of an organisation. Within an organisation, it is arguable that human knowledge is the most important source and as such, needs to be exploited fully[166].

The facilitation of knowledge transfer from one individual to another is dependent on a common language in terms of representation of the issue, assessment of the current situation and the objectives to be attained. It has been shown that ontologies are useful in representing these[167], which makes the semantic web a useful tool for e-collaboration.

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[166] NONAKA, I. 1994. A dynamic theory of organizational knowledge creation. *Organisation Science*. **5**(1). 14 – 37.

[167] CHANDRASEKARAN, B, J R JOSEPHSON, and V R BENJAMINS. 1999. Ontologies: What Are Ontologies, and Why Do We Need Them? *IEEE Intelligent Systems*. **14**(1). 20 – 26.

5.3.5.3. Mediation services

Mediation services aim to facilitate the group's activities and support any decision making processes. Workflow systems are often used to guide a decision through the logical steps in the process. As an example, a document may have to go through as sign-off process within the team before it is accepted. Decisions are pieces of descriptive or procedural knowledge referring to an action commitment. The decision making process is thus able to produce new knowledge by justifying or challenging the practice or action proposed. Knowledge management activities such as knowledge elicitation, representation and distribution influence the creation of the decision models to be adopted, thus enhancing the decision making process[168].

Decision making and knowledge management can be further enhanced by the mediation service allowing group members to engage in discussion and discourse around issues raised. Many problems are too complex to be solved by an individual, so collaboration through debate and negotiation among several people may be the solution. It is unavoidable that there will be conflict of interest among group members, but this may even stimulate participation from all group members and encourage constructive criticism.

Mediation services should consist of the following four levels[169]:

- The *logic level* specifies the notions of argumentation theory that will be used and provides the appropriate inference relations.
- The *argumentation framework level* defines the concepts of positions, supporting arguments, counter-arguments and the prioritising of relationships among competing arguments.
- The *speech act level* defines the space of possible types of actions a participant may perform during a discussion. Participants may alter the structure of the argumentation framework by adding or deleting claims or arguments.
- The *protocol level* specifies the norms and rules about the duties and rights of the participants to perform actions defined at the speech act level. The need for this protocol level arises mainly because of conflicts of interest and goals that each participant has during a debate. Protocols provide a structured way for participants to act during a debate and should promote fairness, rationality and efficiency.

5.3.5.4. Intelligent agents

The next evolution of e-collaboration systems should make use of intelligent agents already discussed in chapter 4. Here, the software entity should perform operations on behalf of the user and similarly to a personal assistant. They are customised and personalised according to the users' profiles, perceived conditions and dynamic environment. Their main use is

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[168] BOLLOJU, N, M KHALIFA, and E TURBAN. 2002. Integrating knowledge management into enterprise environments for the next generation decision support. *Decision Support Systems*. **33**. 163 – 176.

[169] KARACAPILIDIS, N. 2005. Toward an Integrated E-Collaboration Framework for Learning Purposes. In Lytras, M. D. and NAEVE, A (Eds) *Intelligent Learning Infrastructures in Knowledge Intensive Organizations: A Semantic Web Perspective*, IDEA, Hershey. 284 – 297.

information seeking, filtering and retrieval, monitoring of the learning context, comparison and evaluation of alternative solutions and negotiation among group members of differing interest.

5.3.6. Ontologies as competency management tool

Competences are described as reusable domain knowledge. Any model representing competences describes what a competence is and how it is composed of sub-competences. These competences are general descriptions, independent of specific learners or job descriptions. A company may define required, relevant or desirable competences for their business, which are included in job offers or projects descriptions. The exact meaning of these competences is provided by a company-wide competence model. Using this approach, the explanation of a competence needs not to be explicitly included every time it is used, as with the description of ontologies.

Learning can be considered as an outcome of the need to acquire new competencies. The paper has already alluded to the usefulness of ontologies in knowledge management and this section describes the use of ontologies as the enabling semantic infrastructure of competency management, describing the main aspects and scenarios of the knowledge creation life cycle from the perspective of its connection with competency definitions.

A competency can be defined as a specific, identifiable, definable, and measurable knowledge, skill, ability and/or other deployment-related characteristic (e.g. attitude, behaviour, physical ability) which a human resource may possess and which is necessary for, or material to, the performance of an activity within a specific business context. The process of competency acquisition usually stems from a business need, or from strategic intent[170]. The process of assessing whether the organisation is capable of dealing with these business goals is referred to as knowledge gap analysis[171] and involves matching the competencies needed for goals with what is available.

The correct design of competency ontology is a crucial step in the development of an effective competency management system, which possibly has to collaborate with other similar systems or e-learning and human resources applications. Effort has been made in analysing the competencies, their definitions and the corresponding proficiency levels through available dictionaries or after careful consideration. Moreover, ontology design included the correlations between all the entities of the ontology, namely competencies, employees, jobs, learning objects etc.

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[170] RAINER, F and C KAZEM. 1995. Strategy formulation: a learning methodology. *Benchmarking: An International Journal*. **2**(1). 38 – 55.

[171] SPANGLER, S and J KREULEN. 2000. Knowledge Base Maintenance Using Knowledge Gap Analysis. *In*: *Proceedings of the seventh ACM SIGKDD international conference on Knowledge discovery and data mining*. 462 – 466.

5.3.6.1. Ontologies and schemas for competency description

Using ontologies for the purpose of competency description is not a new field. The HrXML consortium[172] and IMS consortium[173] have defined *competency formats* which provide standards for competency definition[174]. While these formats have been developed in isolation of each other, they can be broken down into several main characteristics:

- The competency is defined and a textual description is provided.
- External taxonomies of competencies can be referenced.
- Weights and importance levels for the competency can be stated.
- Competency definitions can be nested by embedding one competency element inside another, so competencies can build on each other.
- Evidence for competencies having being gained can be stored in some sort of standardised way, such as standardised tests, licensing or qualifications.

Unfortunately, both formats lack certain characteristics which would allow for automation of competency handling within an organisation. These areas are not necessarily flaws in their design, as their specifications clearly state that automation is beyond the scope of the projects.

CommOn[175] is based on two models which guide firstly the building of competency reference systems related to particular domains such as Healthcare or Information and Telecommunication, secondly the identification and the formal representation of competency profiles and thirdly the matching of competency profiles. The CommOn framework allows one to build shareable ontologies and knowledge bases represented with Semantic Web Languages and to develop Competency-Based Web Services dedicated to Human Resource Management.

5.3.6.2. Competency gap analysis

The goal is to provide the basis for allowing advanced automatic competence matching and gap analysis. The Simple Reusable Competency Map (SRCM, 2006) tries to model relationships between competencies. A map can contain information about dependencies/ equivalences among competencies, including the composition of complex competencies from simpler ones. In SRCM, relationships are modelled using a directed acyclic graph. However, the semantics of the model proposed in SRCM is confusing. Relationships among different nodes may have different meanings: composition, equivalence or order dependency. This leads to confusion when modelling tasks as well as when creating algorithms to use such information. Furthermore, combination and weighting of competencies is not clearly defined,

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[172] http://www.hr-xml.org

[173] http://www.imsglobal.org/

[174] ALLEN, C. 2003. *Competencies (measurable characteristics)*. [online]. [Accessed 22 May 2011]. Available from World Wide Web: < http://ns.hr-xml.org/2_0/HR-XML-2_0/CPO/Competencies.pdf >

[175] TRICHET, F and M LECLÈRE. 2003. A Framework for Building Competency-Based Systems Dedicated to Human Resource Management. *Lecture Notes in Computer Science*. **2871/2003**. 633 – 639.

and external references to the maps (e.g., from profiles) must point to the root (and not to any node), therefore requiring the traversal of the graph until the appropriate node is found.

It is not possible to model relationships among competencies, because proficiency level and context have to be considered as well. For example, statistics knowledge may be a requisite for becoming a computer scientist or a sociologist. However, the proficiency level required and the context in which the competency is applied is completely different, hence making impossible to create relationships directly among competencies.

5.3.6.3. Bridging Competencies and Modern E-Learning

Modern e-learning technology in the last years has been influenced by the paradigm of learning objects. The concept of learning object is at the centre of the new paradigm for instructional design of Web-based learning that emphasizes reuse as a quality characteristic of learning contents and activities. For example, Polsani[176] includes reuse in his definition of learning object as "an independent and self-standing unit of learning content that is predisposed to reuse in multiple instructional contexts". A number of specifications and standards that describe or make use of the learning object concept have evolved in the last years.

The basic metadata elements associated with learning objects have been described in the IEEE LOM standard[177], which organizes its conceptual metadata schema in nine categories: general, lifecycle, meta-metadata, technical, educational, rights, relation, annotation and classification. Learning objects are considered as reusable elements that can be used as part of learning designs. In the experience and view of the authors, there are two important directions in learning technologies that are especially relevant for the competency approach described above. These are activity-orientation and the use of Semantic Web technologies.

5.3.7. Knowledge repositories

An *Organizational Memory* or *Knowledge Repository* is a computer system that continuously captures and analyses the knowledge assets of an organization. It is a collaborative system where people can query and browse both structured and unstructured information in order to retrieve and preserve organizational knowledge assets and facilitate collaborative working.

The focus of such systems tends to be on storing unstructured, but nonetheless still explicit, forms of knowledge such as unwritten local rules and procedures. The aim is to be able to retrieve data in a context sensitive way rather than just through the use of simple keyword-based retrieval. Such systems might use techniques such as Social Network Analysis or collaborative filtering in order to provide the required "context" for the data.

By providing context sensitive retrieval of data these systems claim to move beyond simple information retrieval and to act like a true Knowledge Management System (KMS). The term KMS is also justified by the capacity of such systems to use inference mechanisms to (semi-

[176] POLSANI, P R. 2003. Use and Abuse of Reusable Learning Objects. *Journal of Digital Information*. **3**(4).

[177] http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf

automatically) generate new information by, for example, filling sections of a document, proposing hints or showing reasons "why" and "why not" a certain outcome should happen.

Some potential application areas for such systems are:

- to identify relevant experts
- to identify potential areas for collaboration
- to identify Networks of Practice
- to uncover hidden knowledge.

5.3.7.1. Knowledge repositories using ontologies

Ontology-driven information systems is a trend in current research that envisions the development of information systems where domain experts, knowledge and software engineers, and ontology experts work together in the definition of domain and general ontologies to support organisational processes[178]. Ontological tasks, such as mapping among ontologies, merging ontologies, creating domain taxonomies, and classification systems should be co-ordinated to define and maintain a high-level representation of the organisational knowledge[179].

Organisational memories should comprise the knowledge of an organisation collected over the time[180]. It includes a model to describe information sources and the context in which these sources are created. It also includes factual, declarative, and procedural knowledge in the form of personal memories of employees: e.g. their knowledge, heuristics, experiences and related expertise.

The information stored in an OM should be useful, addressing important needs in the organisation, where its members retrieve relevant knowledge about on-going activities. This organisational memory itself should be accessible to all members. To make an OM effective, its building, development, and maintenance need to be closely integrated with the existing business tasks and related daily work steps, and consequently with the overall organisation culture.

Organisational knowledge may consist of problem-solving expertise, experiences of human resources, process experiences, technical aspects, and related lessons learned. The coherent integration of this dispersed organisational knowledge in a single computer system is called an OM information system, or OM for short, and it is regarded as a central prerequisite for

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[178] GUARINO, N. 1998. Formal Ontology and Information Systems. *In*: *Proceedings of Formal Ontologies in Information Systems*.

[179] NOY, N, R FERGERSON, and M MUSEN. 2000. The knowledge model of Protégé -2000: combining interoperability and flexibility. *In*: *Proceedings of the 12th International Conference on Knowledge Engineering and Knowledge Management*.

[180] KLEMKE, R. 2000. Context Framework – an Open Approach to Enhance Organisational Memory Systems with Context Modelling Techniques. *In*: *Proceedings of the 3rd International Conference on Practical Aspects of Knowledge Management*. 11 – 14.

effective corporate KM[181]. An OM Information System (OMIS) should be seen as a natural evolution of an organisational IS, wherein tangible information (such as administrative data) is integrated with less tangible knowledge (such as people's competencies[182]).

The integration of ontologies (formal knowledge) with data models (semi-formal knowledge) can have major benefits for the definition of precise and concise domain models. The goal is to develop ontologies at the knowledge and formal levels to assist in effective data model design. This OM architecture should also include an automatic or semi-automatic tool, based on exhaustive mapping criteria, to translate ontological constructs and instances into the proper data model elements whenever possible. The creation of this meta-model is a key requirement for the effective maintenance of an OM.

In our current development environment, ontologies are translated and stored in a relational database, as tables. A set of functions was written as an Application Programming Interface that hides the relational/object conversion from the programmer. By modifying the meta-model it is possible to tailor the development environment to different needs, such as, for example, having two meta-class class types: one where instances are created locally (local classes), and another which refers to remote instances (remote classes), which could be located in legacy systems.

5.3.7.2. Organisational memory specification and architecture

The preservation and integration of different but related organisational knowledge is a key requirement for an effective development of organisational memories. Different knowledge areas within the organisation should be properly classified and integrated. An OM should provide means to preserve and integrate organisational information from different organisational sources. The OM design and development should be prepared to handle different types of information and related levels of information representation[183].

Therefore, semi-structured information, structured information, and formal information need to be integrated in a coherent way. Examples of semi-structured information are file documents in the form of notes, suggestions, and hints. Examples of structured information are file documents in the form of manuals and technical reports. Additionally, the existing data stored in databases and data warehouses can be viewed as a particular type of structured information. Examples of formal information are business rules, design and process

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[181] ABECKER, A, A BERNARDI, K HINKELMANN et al. 1997. Towards a Well-Founded Technology for Organisational Memories. *In*: *Proceedings of AAAI Spring Symposium on Artificial Intelligence in Knowledge Management*.

[182] LIAO, M, K HINKELMANN, A ABECKER, and M SINTEK. 1999. *A Competence Knowledge Base System for the Organizational Memory*. Springer Verlag.

[183] ABECKER, A, A BERNARDI, K HINKELMANN et al. 1998. Towards a Technology for Organisational Memories. *IEEE Intelligent Systems*. **13**(3). 30 – 34.

guidelines, and corporate information that represent internal (organisation) rules and procedures concerning business processes and organisational behaviour[184].

In addition to the integration level of organisational information, an OM should be engineered in order to be integrated with the existing organisational environment. An OM system should have an architecture suitable to be integrated with the existing IS infrastructure, i.e., it has to fit into the flow of information that is already happening in the organisation[185]. This requirement is crucial for the acceptance of the users of the OM system.

[184] VASCONCELOS, J, C KIMBLE, F GOUVEIA, and D KUDENKO. 2001. Reasoning on Corporate Memory Systems: a Case Study of Group Competencies. *In*: *Proceedings of the 8th International Symposium on the Management of Industrial and Corporate Knowledge*.

[185] CONKLIN, J. 1996. Capturing Organisational Memory. *In*: *Groupware and Computer-Supported Cooperative Work*, Morgan Kaufman. 561 – 565.

Chapter 6 An application of semantic e-learning

6.1. Problems to overcome

6.1.1. Creation and maintenance of shared representations

The creation and maintenance of large, shared conceptualizations is a problem in itself, which should be approached both from the perspective of ontology engineering and also from the viewpoint of standardization. Since ontologies are socially constructed artefacts, they evolve with time, entailing significant maintenance costs[186]. To add to this, we have shown that a central problem to organisational learning is the fact that members of staff are fluid, particularly in software development teams. How then are we to create shared representation when those that began the creation may not be around for the maintenance?

6.1.2. Availability and evolution of advanced tools

Semantic tools for learning, collaboration and communication require an extra effort of development than normal web tools, since they use underlying languages like description logics[187] that are often arcane for the average practitioners. The selection of development libraries and frameworks thus become a critical point.

6.1.3. Increase in the workload due to increasing needs for metadata

We've discussed at length the need for metadata as well as the problem with annotation causing increased workloads. We have proposed automation techniques in order to speed up the creation of metadata, but most of these still require some human intervention to be satisfactory and trustworthy.

6.1.4. Alignment of organizational and individual needs

The coherence between organizational and individual needs and priorities is a problem that is difficult to address, since it encompasses the continuing measure of employee satisfaction, and the fit of learning activities taking into account such satisfaction. This could result in conflicts if not carefully addressed and may result in employees abandoning the goals of the organisation in terms of learning.

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[186] VAN ELST, A and A ABECKER. 2002. Ontologies for information management: balancing formality, stability, and sharing scope. *Expert Systems with Applications*. **23**(4). 357 – 366.

[187] BAADER, F, D CALVANESE, D MCGUINNESS et al. 2003. *The Description Logic Handbook. Theory, Implementation and Applications*. Cambridge University Press.

6.1.5. Information security

Security is one of the most important quality attributes in Semantic Web. Semantic Web proposes new security requirements; therefore, previous security mechanisms provide insufficient support for an in-depth treatment of security in Semantic Web. As the demand for data and information management increases, there is also a critical need for maintaining the security of the databases, applications, and information systems. Data and information have to be protected from unauthorized access as well as from malicious corruption. With the advent of the Web, it is even more important to protect the data and information as numerous individuals now have access to this data and information. It is not only important that sensitive information is only exposed to agents who have the correct credentials to be able to view it. It is as important that the information is "correct". The focus is on confidentiality, privacy, trust, and integrity management for the semantic Web. This is what some have termed the *trustworthy semantic web*. We now discuss some security considerations in more detail.

6.1.5.1. XML and RDF

Consider the XML layer of the semantic web. One needs secure XML. That is, access must be controlled to various portions of the document for reading, browsing and modifications. There is research on securing XML and XML schemas. The next step is securing RDF. Now with RDF not only do we need secure XML, we also need security for the interpretations and semantics. For example, under certain contexts, portions of a document may be unclassified while under certain other contexts the document may be classified. As an example, one could declassify an RDF document describing a product, once the product is no longer produced.

6.1.5.2. Ontologies

Once XML and RDF have been secured, the next step is to examine security for ontologies. That is, ontologies may have security levels attached to them. Certain parts of the ontologies could be secret while certain other parts may be unclassified. The challenge is, how does one use these ontologies for applications such as secure information integration? Researchers have done some work on the secure interoperability of databases and the use of ontologies is being explored.

6.1.5.3. Inference

We also need to examine the inference problem for the semantic Web. Inference is the process of posing queries and deducing new information. It becomes a problem when the deduced information is something the user is unauthorized to know. With the semantic Web, and especially with data mining tools, one can make all kinds of inferences. Recently there has been some research on controlling unauthorized inferences on the semantic Web.

6.1.5.4. Flexible security policies

Security should not be an afterthought. We have often heard that one needs to insert security into the system right from the beginning. Similarly security cannot be an afterthought for the semantic Web. However, we cannot also make the system inefficient if we must guarantee one hundred percent security at all times. What is needed is a flexible security policy. During some situations, we may need one hundred percent security while during some other situations some security; e.g., sixty percent, may be sufficient.

6.1.5.5. Privacy

Closely related to security is privacy. The challenge here is protecting sensitive information about the individuals. Other challenges include trust management and negotiation. How do we determine the trust that agents place on one another? Is it based on the reputation of the agents?

6.1.5.6. Integrity

Another challenge is maintaining integrity. For example, when XML documents are published by third parties, we need to ensure that the documents are authentic and are of high quality. As more progress is made on investigating these various issues, we hope that appropriate standards would be developed for securing the semantic web. Note that while security is essentially about confidentiality, we use the term trustworthiness to include not only confidentiality, but also privacy, trust and integrity.

6.2. So many problems, what's the solution?

Given the actual state of Semantic Web technology, the recommended path for organizations that are committed to the view of a SLO is that of first addressing infrastructural elements. Such infrastructures can be considered as the study and provision of the ontologies for each aspect of the SLO, and beginning the construction of prototypes as drivers for the seamless adoption of the semantic view. Concretely, competencies and their ontological representation can be considered as a critical point in any semantic approach to a learning organization.

6.2.1. Mash-ups

In web development, a mash-up is a web page or application that uses or combines data or functionality from two or many more external sources to create a new service.

There are many types of mash-ups, such as data mash-ups, consumer mash-ups, and enterprise mash-ups[188].

- Data butt mash-ups combine similar types of media and information from multiple sources into a single representation. The combination of all these resources creates a new and distinct web service that was not originally provided by either source.
- Consumer mash-ups, opposite to the data mash-up, combine different data types. Generally visual elements and data from multiple sources. *e.g. Wikipediavision combines Google Map and a Wikipedia API*[189].
- Business mash-ups generally define applications that combine their own resources, application and data, with other external web services[190]. They focus data into a single

[188] PEENIKAL, S. 2009. *Mashups and the enterprise*. [online]. [Accessed 25 April 2010]. Available from World Wide Web: < http://www.mphasis.com/pdfs/Mashups_and_the_Enterprise.pdf >

[189] http://www.lkozma.net/wpv/

presentation and allow for collaborative action among businesses and developers. This works well for an Agile Development project, which requires collaboration between the Developers and Customer (or Customer proxy, typically a product manager) for defining and implementing the business requirements. Enterprise Mash-ups are secure, visually rich web applications that expose actionable information from diverse internal and external information sources.

6.3. Components of an organisational learning mash-up

As we have already seen, document gathering and storage are an integral part of organisational learning. However, on their own, documents would not provide any value. It is only through making them available to individuals and teams in order to create knowledge, that they become truly useful. In chapter 5 we discussed at length the various bits of technology that can support this goal, but on their own they have limited use (spheres of influence).

The researcher proposes that by combining several of these technologies into a cohesive framework i.e. a mash-up, a far more useful application could be created. The term *knowledge portal* will be used to describe this mash-up example. The knowledge portal will provide a single point of access to various sources of information (from within the organisation or externally) and provide users an interface for a collaborative community where users share coming goals. This makes the location, navigation and retrieval of information easier. The user does not have to be concerned with the origin of the information unless this is of importance to the task at hand.

Mack, Ravin and Byrd[191] propose eight areas which a knowledge portal should provide; information security, an intuitive user interface, a search engine, indexing/cataloguing, document management, business intelligence tools, personalisation and customisation and application and data integration. We now take a look at the flow of a typical knowledge portal.

6.3.1. Capturing and gathering documents

Knowledge portals should capture and gather internal and external documents and enable the storage of the relevant documents in a central location and in a standardised format. Doing this ensures that relevant information found by one user can be made available to a team or the entire organisation. This is just one of the methods the knowledge portal should use though. Documents that are useful to the organisation are often already part of systems within the organisation. It thus makes no sense to duplicate these within another system i.e. the knowledge portal. The knowledge portal should thus identify these resources, but only store a representation of it (meta-data) with a link to the actual document.

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[190] CLARKIN, L and J HOLMES. *Enterprise Mashups*. [online]. [Accessed 25 April 2010]. Available from World Wide Web: < http://msdn.microsoft.com/en-us/architecture/bb906060 >

[191] MACK, R, Y RAVIN, and R J BYRD. 2001. Knowledge portals and the emergin digital knowledge workplace. *IBM Systems Journal*. **40**(4). 925 – 955.

6.3.2. Document analysis

Once the documents are gathered and have been made available within the knowledge portal, it should do analysis in order to identify textual features which are used in order to categorise the document so that its content is available for subsequent organisation, retrieval and use. At this stage, the meta-data or extrinsic features of the document become important. These are details such as author, date written or category. If these details are stored in a standard format (as discussed in chapter 5), it can be searched without analysing the document each time.

TextWise[192] developed the first scalable, automated, semantic similarity search technology enabling the web to move from matching keywords to a meaning-based foundation. TextWise's semantic technology would enable major search/content players to index, match and retrieve disparate content and enable other applications that leverage the meaning of content. Indexing content with semantic descriptions enables any application to both discern what the content is about and to provide highly relevant matching, concept tagging and categorization. The applications of the technology available on the site provide an insight into the value and broad spectrum of rapid document analysis.

- *Media* - Automatically provide links to highly-relevant related site content using semantics, not keywords. Automated categorization lets visitors choose a category of interest and retrieve related content. Customised media widget publishes your site content via tech savvy fans to share on their own sites/blogs.
- *Call centres* – Whether a question comes through a ticket or direct call, TextWise provides agents with a tool layered over an internal CRM system to assist in finding answers to customers' questions.
- *Self-service CRM (forums and communities)* – Link user-generated content (forums, blogs, etc.) on your site to your customer knowledgebase: Increase visitor satisfaction and drive repeat visits as customers find the information they are looking for, Decrease expensive customer service contacts, Provide a more content-rich experience for community members.
- *Contextual merchandising* – Contextual Merchandising is the process of converting retail or auction product images and descriptions into individual product ads. TextWise can create thousands of ads and place them contextually on millions of website pages, automatically.

6.3.3. Document organisation

Once documents have been gathered and analysed, they must be categorised into categories or clusters. These may form a hierarchy or tree of categories/clusters in which documents are placed. No one technique of document classification is perfect and all the methods need domain expertise and some degree of administrative skill.

6.3.4. Document search

Only after the information is categorised, can users now search for it. The knowledge portal should allow for at least basic querying functionality. The more powerful the search

[192] http://textwise.com/

functionality, the easier it should be for the user to find useful documents that have been indexed by the knowledge portal. The following are more advanced search function.

6.3.5. Prompted query refinement (PQR)

This technique assists the user in refining their initial query until a focused set of information is the result. This may take multiple iterations of prompts or suggestions by the system before getting the appropriately focused result. A simple example of this is Google's "did you mean" search helper. This tool not only corrects spelling in queries, but also uses previous queries by other users to refine your current search by making suggestions.

6.3.6. Relevance feedback

In this technique, the user chooses a document which matches there search and the system then returns documents which are similar in nature. A well-known e-commerce store which does this is Amazon[193]. The suggestions made are based not only on your current selection, but also the choices made by other users that have chosen your current product.

6.3.7. Automatic question answering

This technique is very useful for applications where the user is not particularly technically savvy. The system accepts natural language question and attempts to determine the focus by using natural language analysis. This can be further extended by allowing the system to use stored information on the user in order to suggest documents. This is done without any input from the user. We return to Amazon again for an application of this. Once you have made a purchase on Amazon, the system now has some basic information about what you like to purchase. This information is built up and becomes more detailed as more purchases are made. When returning to Amazon, the system now makes suggestions of new or interesting products that match your previous purchases.

6.3.8. Summarisation

This is an important part of knowledge portals which are often overlooked because they it isn't a knowledge or information resource. However, with the large volumes of information often encapsulated by a knowledge portal, navigating around them becomes tricky and often time consuming. For this reason, knowledge portals should have intuitive and user friendly with built in automatic summarisation tools that extract key pieces of information from documents and display them to users. This allows a user to get an idea of the subject matter without having to read through an entire document. There are four types of summarisation tools that exist:

- *Long informative summaries* – these are often 20 to 25% of the original document length
- *Indicative summaries* – these are much shorter and only one to three sentences long
- *Query based summaries* – based on a search phrase and often only include the sentence in which the search phrase is found
- *Keyword summaries* – present a list of technical terms

[193] http://www.amazon.com

Studies have shown that an indicative summary is sufficient for a human to complete a task without having to read the entire document, saving considerable time and effort[194].

6.3.9. Application integration and relationship mapping

Finding the information is only the first step of the process of using the knowledge portal. The information needs to be utilised for the purpose of a task before it can be considered useful by the user. Two of the primary methods available are application integration and relationship mapping.

Some systems embed other useful applications so that the user does not have to go very far to start using the information that they have found.

The goal of relationship mapping is to provide an assorted and open-ended workplace for representing entities and relationships which may help the user to discover other linked entities and relationships. These are often represented visually as networks in order to allow for better comprehension.

6.3.10. Project collaboration

While there are many collaborative tools available to the user, embedding this within the knowledge portal makes it a complete system. Collaboration may be as simple as allowing the user to send a found resource to a team of people via email or instant message. The knowledge portal may also allow for real-time document authoring collaboration or discussion.

6.3.11. Forming communities

Knowledge portals are beginning to help organisations capture and leverage their intellectual assets by facilitating assembly of communities of interest (similar to communities of practice discussed in chapter 3), best practice and expert systems with a single, intuitive, web-based user interface.

6.4. Extending the knowledge portal

To be an effective solution, the following characteristics are essential[195]:

- Ability to integrate with any business application from any vendor. This may be by using an exposed set of hooks or an API (application programming interface) or simply an import export relationship between the two systems.
- Ability to integrate with enterprise applications such as CRM (customer relationship management) and ERP (enterprise resource planning) systems. The integration should always be both ways so that wherever the user updates information, it is globally

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[194] HAND, T F. 1997. *A Proposal for Task-based Evaluation of Text Summarization Systems*. [online]. [Accessed 20 February 2011]. Available from World Wide Web: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.11.3653&rep=rep1&type=pdf >

[195] KAO, C. 2001. Enterprise application portals. *In*: *A Practical Guide to Planning for E-Business Success: How to E-enable Your Enterprise*, Strategic Computing Directions.

available. This may be particularly difficult in legacy systems which are closed or where nobody within the organisation has the knowledge to amend the system.

- It should facilitate complex workflows across multiple applications in order to streamline the business processes. Applications should work together seamlessly.
- It should not be operating system or hardware specific, allowing a broad range of integration choices.
- It should be a secure environment where only authorised users are able to access the relevant information.

6.5. A simple knowledge portal application

As a practical exercise, the researcher has designed a knowledge portal to suite the environment described in the introduction. While this is a work in progress, there have been a few learning points which would add value to this paper. First, a look at the elements incorporated into this knowledge portal application. Below is a mind-map which resulted from a series of participlan[196] sessions held with the team who would theoretically be using this system.

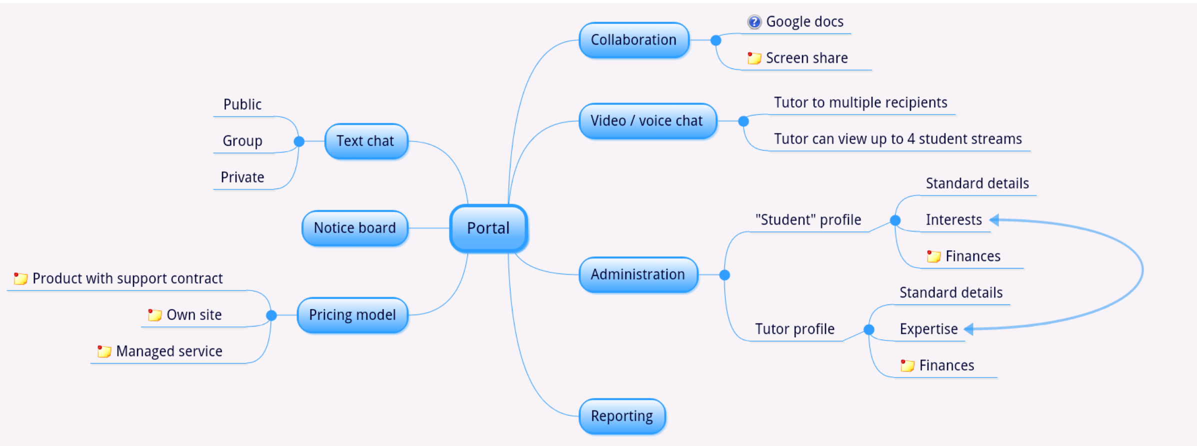

Figure 6 – Structure of a simple knowledge management portal

The purpose of the system quickly expanded to becoming a sellable product when senior level management became involved, but this is not the purpose of the paper and is not explored any further.

The most salient message received from these sessions was that team members required a tool that would connect them real-time to team members even when they were not in a position to have face-to-face meetings. This is clearly visible from the mind-map as almost every main branch has some reference to communication and a way to accomplish that. We now explore the implementation of each of these branches.

[196] This is a tool used by the organisation and is defined as a facilitation method that promotes group involvement, accelerates decision-making and encourages positive interaction through its visual mapping tools and opportunity to contribute without judgment.

Since this project has been planned and implemented while still performing normal organisational functions, it was decided that each of the branches/modules would be implemented as and when there was time available in the work schedule. For this reason, they were ordered as follows, in order to derive the most value in the shortest period of time.

6.5.1. Components

6.5.1.1. Notice board

The first module to be implemented was the notice board. As with a pen and paper notice board, the electronic version allows team members to post problems, experiences and even humour to a central location. Other team members can learn from or contribute to any of these notices. It provided an initial entry point for the application into the area of connecting team members.

The implementation of notice board is an example of how resources already existing within the company can be repurposed for another use. The decision was made to use an existing SharePoint implementation for the notice board and this meant that we could be up and running with the first module of our application in just a few days. We have since moved away from the SharePoint implementation, but the initial time saving was invaluable and allowed more time to be devoted to other areas of the system.

6.5.1.2. Text Chat

Text chat is used to describe real-time brief text messages exchanged between two or more participants. These can be very useful for brief exchanges. It provides instant check that the other person has read the message and responded and works best if team members have access to a directory of chat addresses for all project participants. If something important or relevant to others comes up, it is useful to have a history of chats for documentation at a later date.

The implementation of the text chat was done from scratch first and for mostly so that we could ensure that the module contained all requirements for the team and that security of communications were ensured. The technology chosen for implementation was the Extensible Messaging and Presence Protocol (XMPP). It is an open technology for real-time communication, which powers a wide range of applications including instant messaging, presence, multi-party chat, voice and video calls, collaboration, lightweight middleware, content syndication, and generalized routing of XML data.[197]

Semantic web technologies have played a large role in this module of the application. Since chat histories may be substantial, text analysis is used to glean useful themes from the mass of communications available. A full discussion of the methods used is continued further in the section on collaboration below.

6.5.1.3. Voice/video chat

[197] For further information on XMPP and for resources on creation of XMPP powered applications, see http://professionalxmpp.com/.

The next logical iteration was adding voice and video to the text chat. While the team in which this application has been deployed is technically savvy, there are still times when text based communication lacks the nuances which make face-to-face discussion so important. When getting together in a meeting room is impossible due to different geographic locations, voice and video chat becomes the next best thing.

For the implementation of this module, an open source video chat application called Red5Chat[198] was extended to fit in with the text chat already developed. While Red5Chat already includes a text chat module, it was decided to strip this part out and use it only for video streaming. The decision was based on the need to make the final application as light as possible so that certain modules could be used irrespective of team member computer resources. Red5Chat is a full Flash implementation and as such, doesn't work across all platforms[199].

6.5.1.4. Collaboration

For document collaboration, we chose to implement a system using Google Docs[200]. Google Docs enables multiple people in different locations to collaborate simultaneously on the same document from any computer with internet access. For example, *team member A* and *team member B* are working on a project together, and they need to write a document, keep track of their work in a spreadsheet, and create a presentation and a drawing to share with other people involved in the project. When team member A makes changes to the document, spreadsheet, presentation, or drawing, team member B can see them in real time and respond to them immediately. Both of them work on the same docs, so there's no need to go back and forth, comparing and consolidating individual files.

While Google Docs has provided an excellent starting point for document collaboration in terms of storage, categorisation and group access, there is something missing. Once the group of documents reaches a certain volume, it becomes almost impossible to find useful information within these documents timeously. This is not an indictment on the product as this limitation is found across almost all document creation software suites. The way the application has circumvented this problem is by applying semantic based search to these documents.

We have used the API from TextWise to implement post document parsing. What happens after any textual document is created is that the API is applied to it and the result is stored together with the document. The resulting representation of the original is much easier for both human and machine to read as it is shorter and only contains the most salient themes of the original.

6.5.1.5. Administration and Reporting

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[198] http://www.red5chat.com/

[199] Apple is the most popular provider not to include Flash support natively. This article describes some of the reasoning: [online]. [Accessed 29 May 2011]. Available from World Wide Web: <http://www.reuters.com/article/2010/10/22/us-apple-adobe-idUSTRE69L4ZX20101022>

[200] http://docs.google.com/

An often overlooked role within applications is the administration and reporting module. When trying to manage a remote team, reporting becomes of even more importance to management, but also team members. As an example, knowing who is online and available makes resource management far easier. In the example context, it is also a way to keep track of contractual labour in terms of time spent on projects for billing purposes.

6.5.2. Observations

The time available for observation of the system in use was short due to the long planning and design phase. The researcher believes that this was a necessary step as without it, there would be an increased risk that the system would not meet departmental requirements. With this in mind the observations may be considered superficial, but there is still value to be gained from them.

- Getting department/organisation approval and consensus

  One of the most taxing parts of the project was getting the department and organisation to recognise that the project had merit and to approve the time that would be spent on design and implementation. The researcher is not completely convinced that senior management had enough of an understanding of the concepts and purpose of the system, which made the argument extremely difficult.

- Implementation and initial use

  Getting team members to use the system immediately after the initial release was difficult even with their input during the design phase. Since the only initial content was that already available within the organisation, there was no need to use the new system to access it. This problem was overcome by adding semantic search to the documentation, which was not available using the current infrastructure i.e. making existing content easier to access and personalise.

- Content

  Keeping team members engaged in the system is a possible problem not experienced with the test implementation. This may have to do with the short period of observation and the fact that team members were still seeing the system as a novelty. The researcher however feels that by keeping content fresh and constantly updating the knowledge pool, team members will have a reason to keep coming back to the system.

- Maintaining intended purpose

  It soon became apparent that without an administrator, system content could easily divert from the intended use. The researcher did not expect this with such a small team and such a narrow focus area. Implementing acceptable usage policies and enforcing these was at first manual. Using the text parsing techniques described above, the researcher was able to automate some of the work in identifying content which did not fit in the learning system.

Chapter 7
Conclusion and Future Outlook

The thesis set out to show that the semantic web could be used as an enabling tool to expedite the learning process within an organisation. The premise was that current learning methodologies should be adapted to work with semantic web technologies in order to make learning more accessible and adaptable to the individual or team.

7.1. Conclusions drawn from the research

The original aim of the paper was to show that a purely technical implementation of the semantic web would enable the organisation to equip individuals and teams to learn more effectively. It soon became clear that the most significant benefit of semantic web technologies were in fact its social applications.

The most widely used and top of mind social network in use today has to be Facebook[201]. According to Facebook's statistics page[202] there are more than 500 million registered users. Each Facebook user is connected, on average, with 130 other users, giving your message real potential for broad reach with each Facebook user you engage with. Also remember that 50% of Facebook users login every day, making this a very active community, one that must be considered by any organization today. However, it is very difficult to control what exactly employees are using Facebook for during work hours. For this reason, many organisations block social services by default.

It does however show how important the social aspect of learning is within the organisation. People want to be social, and the researcher believes that people want to learn socially and in fact do learn socially. Employees may not be learning what the organisation requires on their chosen social network, but they are discovering and incorporating the views of others whenever they access it. Why then shouldn't the organisation use employee's social nature in order to promote organisational learning?

The researcher is not suggesting that employees be given free reign over time spent on social networks, as organisations have implemented their access policies based on their own security and productivity requirements. It is however important for the organisation to harness the apparent innate need of employees to be social, by adapting systems themselves to be more social.

7.2. Summary of contributions

The biggest problem that the researcher encountered during the test implementation was the resistance to the implementation of something new. The most common question was why the

[201] http://www.facebook.com/

[202] http://www.facebook.com/press/info.php?statistics

organisation should pay for something which may take years to show return on investment. Conversely, once the application was accepted, senior management wanted something implemented as soon as possible. This seemed initially like two disparate requests that could never be fulfilled.

This however is the most important revelation of the research. Time and money do not have to be barriers to entry for a semantic web learning infrastructure. The research has shown that by using either the infrastructure that is already available, or open source applications which only need some minor modification, a full-fledged semantic learning application can be implemented without massive capital outlays or long project timeframes. There are however some important guidelines when using this approach.

- Know the organisation

  Far too often, software systems are implemented without first taking into account organisational requirements or readiness. It is suggested that the organisation do a full audit of current learning and learning structures in order to establish the platform from which systems can be implemented. Failure to plan is planning to fail[203].

- Get buy-in

  Equally important it ensuring that those implementing and using the system have a vested interest in its success. With any social or group learning system, the true worth is dependent on those who use and contribute to the information within the system.

- Thoroughly research application components

  The solution proposed leverages components that are either open source or already exist within the organisation. While this solution reduces cost to the organisation, it also adds significant risk. It is important that the components are researched thoroughly to avoid any implementation issues.

- Make sure that interoperability is possible

  An element of the research conducted should be ensuring interoperability of the components. It will not benefit the organisation if components are unable to leverage information and resources from each other. Since the idea is to form a network of these components, communication is essential.

- Ensure that information security is not compromised

  An important risk to factor in when using open source applications is data security. Those involved in implementation should ensure that no communication is made by the component without their knowledge and that no outside access to the system is allowed without express permission.

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[203] Attributed to Winston Churchill who said "He who fails to plan is planning to fail" during World War II

7.3. Prospects for future research

The simple application proposed and implemented in chapter 6 should be used, either in its present form or extended, in order to study the long-term impact semantic learning could have on the organisation. Since the application was an end result of the research paper, there was not much time to judge how successful it would be in improving learning in the long term and across multiple teams within the organisation.

Possible areas of further study include:

- What does it take to encourage employees to be social in a way which benefits the organisation?

  Sure, employees want to interact with people that they know on a social level online, but it is not guaranteed that this will logically follow within the organisation as well. The researcher believes that the test implementation of the learning system only has a possibility of success because the individuals who use it find it beneficial. The question must be asked, what drives employees to use learning systems and how does the organisation ensure that employees adopt these systems.

- How do non-technical teams react to such systems in comparison to technical teams?

  The test implementation has a very narrow audience to satisfy. The team is made up of like-minded individuals, all possessing the technical knowledge required to use the system. Further research could be done into the comparative uptake of semantic web learning systems in non-technical teams and what changes need to be made in order to have a broader impact within the organisation.

- What impact does the size of the team have on its usefulness?

  While Facebook has shown us that it is possible to manage a group of friends in their hundreds, the researcher believes that the same cannot be accomplished when there are discrete learning goals such as within the organisation. The social aspects of the learning infrastructure could cause information overload and filtering information becomes even more important. Study should be done on the threshold of when the social aspects go from being useful to being noise which distracts the employee, and what can be done to mitigate this distraction.

- Should there be monitoring of learning systems to ensure that only the organisation goals are pursued?

  Privacy is of major concern to many employees. If you are using a social learning infrastructure, should your employer know exactly what you are discussing with other employees? The researcher asserts that this is the only way that the employer/organisation can keep track of learning and whether goals are being met, but further study needs to be conducted as to the adverse effects of monitoring employee interactions.

- What would it take to extend semantic web learning networks outside of the organisation and what would the risks and benefits be?

  Extending the learning network to encompass suppliers and clients may add new dimensions to the learning system. Everybody using the system would be able to easily gain an understanding of any point of the supply chain. There are numerous risks involved in terms of information security and exposing the user to too much information and these should be explored in depth.

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