Ubiquity of Information and Context: Activity Theoretical Perspective on the Claims and Promises of Semantic Web

Samuli Pekkola[1] and Kimmo Wideroos[2]
[1]Department of Business Information Management and Logistics
Tampere University of Technology, PO Box 541, 33101 Tampere, Finland
[2]Department of Computer Science and Information Systems
University of Jyväskylä, PO Box 35, 40014 University of Jyväskylä, Finland
samuli.pekkola@tut.fi, wikikr@jyu.fi

Abstract. In ubiquitous environments the transition from data to knowledge is becoming significant as more and more data is captured by numerous, usually separated technologies. These technologies are labeled as automated agents, semantic web or ubiquitous computing. As information is data with a certain meaning and knowledge is information with understanding how to apply it in a certain situation, the notion of context is emphasized. In this paper, we use activity theory to analyze this transition of data to knowledge in the context of ubiquitous computing and semantic web. We ground our argument to several examples where human activities are needed in applying information in the everyday life. As a result, we discuss the claims and promises of semantic web and ubiquitous technologies and to what extent they can be achieved. We argue that the role of these technologies is in assisting, mediating or supporting the users' activities and decision making, not making knowledgeable decisions for their behalf.

Keywords: Activity theory, information management, knowledge management, human computer interaction, ubiquitous computing, context, critique to semantic web

Introduction

In their seminal article, Berners-Lee, Hendler and Lassila (2001) illustrated the benefits of semantic web through a fictitious example:

> “The entertainment system was belting out the Beatles' "We Can Work It Out" when the phone rang. When Pete answered, his phone turned the sound down by sending a message to all the other local devices that had a volume control. His sister, Lucy, was on the line from the doctor's office: "Mom needs to see a specialist and then has to have a series of physical therapy sessions. Biweekly or something. I'm going to have my agent set up the appointments." Pete immediately agreed to share the chauffeuring.
>
> At the doctor's office, Lucy instructed her Semantic Web agent through her handheld Web browser. The agent promptly retrieved information about Mom's prescribed treatment from the doctor's agent, looked up several lists of providers, and checked for the ones in-plan for Mom's insurance within a 20-mile radius of her home and with a rating of excellent or very good on trusted rating services. It then began trying to find a match between available appointment times (supplied by the agents of individual providers through their Web sites) and Pete's and Lucy's busy schedules. […]
>
> In a few minutes the agent presented them with a plan. Pete didn't like it – University Hospital was all the way across town from Mom's place, and he'd be driving back in the middle of rush hour. He set his own agent to redo the search with stricter preferences about location and time. Lucy's agent, having complete trust in Pete's agent in the context of the present task, automatically assisted by supplying access certificates and shortcuts to the data it had already sorted through.
>
> Almost instantly the new plan was presented: a much closer clinic and earlier times-but there were two warning notes. First, Pete would have to reschedule a couple of his less important appointments. He checked what they were-not a problem. The other was something about the insurance company's list failing to include this provider under physical therapists: "Service type and insurance plan status securely verified by other means," the agent reassured him." (ibid. p. 34)

In this paper, we critically examine the claims and promises of semantic web and related technologies from the viewpoints of context, information and knowledge. Particularly we want to investigate up to which extent semantic web can be applied in different situations and context. We aim at developing a complementary view to the transition of data to knowledge so that correspondences, contradictories, and/or missing elements and views of context in terms of data and knowledge can be elucidated. This kind of analysis will reveal opportunities and challenges in developing applications that exploit contextual information. These include ubiquitous computing applications, devices and artifacts, automated agents, semantic web-applications and data mining applications.

Lieberman and Selker (2000) studied trends in hardware and software that put demands on contextual issues in computing. First, embedded systems are getting common in everyday artifacts, allowing them to interact with the environment, and second, proactive software agents are reducing the users' burden by taking over their tasks. In other words, the artifacts are monitoring and gathering information from their surroundings and appropriating their activities according to the events in that context. The idea of proactive software agents also leads to the issue of context. The agents perform tasks once done by the user, as depicted in the quote above. Agents collect contents (from the web), process information and exchange the results with other programs. These trends emphasize the information about the context.

A special functionality of agent services is their ability to trace the history of inference back to the origins of the result and translate this chain of evidence in such a form that an inference machine on one's computer can verify the results and present them to the user for their evaluation of the validity. Under these circumstances, both the automated agent and the user need to understand the context in which the inquiry was targeted. This is important as the technology, especially in the context of information systems, is considered as a mediating technology (Thompson 1967; Hirschheim et al. 1995). That is, technology does not reproduce exactly data, information and knowledge, but assists human actors in their interactions favoring the creation, development and sharing of data, information and knowledge, and decision making.

This inference chain becomes meaningful once its relation to the concepts of data and knowledge is considered. Data can be understood as the basic unit of knowledge. Data, as such, does not contain any meaning being just a collection of numbers or other forms of signs. On the other hand, once some meaning is attached to data, it becomes information and further knowledge. This meaning is usually constituted from contextual understanding. That is to say, data becomes meaningful knowledge once the context, in which the data was created and/or interpreted, is appreciated.

The paper is organized as follows. First, the concept of data, information and knowledge is briefly discussed. Second, the meaning of context and context-aware applications are presented. Third, activity theory as a framework to analyze the concept is summarized, and applied in analyzing three different examples; a group of concomitant activities, a set of consecutive activities, and a group of conflicting activities. The article ends with discussion, implications and summary sections.

Transition from data to information and knowledge

Data can be perceived as the basic unit of a collection of signs. The data is thus just a collection of facts or definitions and therefore meaningless. For example, the statement “tomorrow is Saturday” *per se* contains no meaning for a person trying to interpret it. Once a meaning is given to data, it can be referred to as information. Information can also be defined as a difference that makes a difference to somebody (Bateson, 1972). Consequently, information ceases to exist without a particular subject to whom the information makes sense. The statement “tomorrow is Saturday” becomes information once it is perceived as a day off the work, and further, it becomes knowledge when an understanding of the context is incorporated. In other words, Saturday is the day to meet the grand-parents because it is the day off the work, and because of that one has time to visit them.

Knowledge differs from information in that it is about beliefs and commitments. It is a function of a particular stance, perspective or intention emerging in a specific context. One of the cornerstones of Nonaka and Takeuchi’s (1995) epistemology of knowledge is the distinction between tacit and explicit knowledge. Explicit knowledge refers to the conceptually well organized and articulated knowledge that can be easily shared. The level of the exactness of the explicit knowledge determines the level of context dependability. The more exact the knowledge is, the more difficult it is to link to a certain situation or context. Yet, in such a case it is easier to distribute it outside that context as the level of abstraction is higher. On the other hand, tacit knowledge is embedded with people’s activities, it being subjective in contrast to objective explicit knowledge. Tacit knowledge refers to knowledge which can be confidently used by a person in his or her activities, but at the same time cannot be satisfactory articulated. For these reasons, tacit knowledge is always person-bound know-how of how to handle some particular situation, or to act in some context, making it very difficult to share. Tacit and explicit modes of knowledge differ radically also in spatial and temporal aspects. Tacit knowledge is here and now while explicit knowledge is about objective world – there and then. Tacit knowledge appears in human practices in an analog form, in contrast to explicit, theory driven digital knowledge.

The transition from data to information and knowledge thus includes understanding about the applicability of the data and its context. Data, by definition, has no meaning. Once it gains some, it becomes information. Further, once one can understand the consequences and connections of the information, i.e. its context, it becomes knowledge. For instance, a price of an air ticket (100€) becomes information when the currency is understood (100€ and not 100Yen), and knowledge when put in to a certain context (it is valued cheap by *somebody* after comparing it to other airfares). To do this analysis, one has to do several activities: define the type of data (airfare for a certain route), understand the currency, compare the prices, and evaluate the appropriateness of the overall results (so that the ticket is for appropriate day and connection).

The concept of context and context-aware applications

The context-concept is defined implicitly in research literature. It is often taken for granted without explicitly pointing out the standpoint, or explained through examples or, worse, through a circular argument, making the definition vague. Merriam-Webster Online Dictionary gives two distinctive definitions for the concept of context. First, it refers to the parts of a discourse that surround a word or passage and can throw light on its meaning. Second, the word context is used to refer to the interrelated conditions in which something exists or occurs. So, beside the problem of generality of the definition, there is also a problem of ambiguity in the English word.

Based on several definitions of the concept of context, Dey et al (2001) suggested two categories: enumerations of examples of context information, and categorizations. The former definition approaches context as a box of “information bricks” (e.g. time, location) to build upon. Yet it does not help in deciding whether “a brick” should be included. With the latter category (basically “is-a” –type of definitions), there is a substantial risk of ending up to circular definitions. Sowa (2000, p. 288) has pointed out an example of circular definition of context and situation: how the concept of context has been defined in terms of situation, and vice versa, by different writers.

Dourish (2004) encapsulated a group of underlying assumptions of the notion of context in software systems. The context is a form of information, delineable, and stable, and is separable from an activity. In software systems, the problems in handling the context are related to encoding and representation. The consideration of the context as a representational issue misinterprets its role in everyday human activity. Svanaes (2001) argued against this kind of technology driven approach where the context is seen as a property of the physical world to be modeled. Instead, the context should be perceived as an overall frame, or a horizon, within which a user makes sense of the world. Technology driven approach to context also scrutinizes context-aware application designers’ assumptions about the concept of context. In addition, the low penetration of context-aware applications to “real contexts” obviously leads to scarcity of studies about the implications of long-term use of ubiquitous applications. As an alternative, Dourish (2004) has suggested an interactional view to context. There contextuality becomes a relational property between objects or activities, dynamically defining the scope of its features. Furthermore, the context is seen as activity-based, occasioned property.

Context-aware applications take advantages of the predictability of people's actions in certain situations and places. For example, in a library context, people usually borrow books, read them there or order an inter-library loan. However, one may also have a cup of coffee in the library cafeteria, arrange a meeting there or seek bathroom. All these activities are simple for human beings, the first three being highly probable, the last three being not so rare either. Nonetheless, designing a context-aware application to the library environment is quite problematic. For example, automating "mute" ring tone of a mobile phone, according to the location (i.e. library) is appropriate if one is reading the book, but inappropriate if one is waiting for another for a meeting. Hence, in order to be able to make a selection about the ring tone, a simple location-based evaluation is not enough. The data contains information about the location not the purpose of a visit, and consequently cannot be replaced by location-based data. On the other hand, when a relevant part of the context is definable, context-aware applications can be successful. For example, in an organization with many computers and printers in different places, a context-aware application may suggest the nearest printer capable for the printing job. In this example, the context is framed so that the selection of an appropriate printer is easy – assuming the information about the IT infrastructure (that is, the distances between all the computer terminals and printers) is provided. The difference between the aforementioned examples is the level of activity. For example in the first one it is possible to list probable activities (borrowing a book, reading newspaper etc.). However, the context there does not restrict other activities to happen: using the bathroom, having a cup of coffee, meeting people. These can be described as affordances of the specific context: resource for unanticipated use!

Activity theory in brief

Activity Theory[1], founded by Vygotsky, Leontiev and Lurija, is an approach for studying different forms of human practices as constantly evolving processes. The unit of analysis is an activity. It is defined as a human or collective endeavor directed to some kind of object. Each activity has its own history, consequently making a historical analysis essential in order to understand the current situation. Activity is mediated by artifacts, either technical instruments (tools) or psychological instruments (signs). Leontiev further developed the theory and categorized mediation-component to include also social mediation. Different forms of mediation thus include tools, instruments, signs, procedures, machines, methods, laws, or forms of work organization.

[1] For examples about activity theory and information systems research, see e.g. Syrjänen & Kuutti (2006), Korpela et al. (2002), Nardi (1995) and Karlsson and Wistrand (2006)..

Activities are distinguished by their objects. An object can be anything that can be shared for manipulation and transformation by the performer of the activity. This transformation of the object into an outcome gives fundamental motives to the existence of an activity. The tool, which is utilized in the transformation, is at the same time enabling and constricting the activity. The tool empowers the subject in the transformation process with the historically collected experience while simultaneously limiting the interaction to the perspective of that particular tool (Kuutti 1997). This limitation hides other potential features of the object from the subject. To this Leontiev added a community-component, which, *per se* has features similar to the tool. It enables and limits the activity by rules and division of labor. Rules cover both explicit and implicit norms, conventions, and social relations between the subject and the community. Division of labor refers to the explicit and implicit organization of community as related to the transformation process of the object into the outcome/goal. Figure 1 illustrates Leontievs's approach to the theory of human activity as depicted by Engeström (1987).

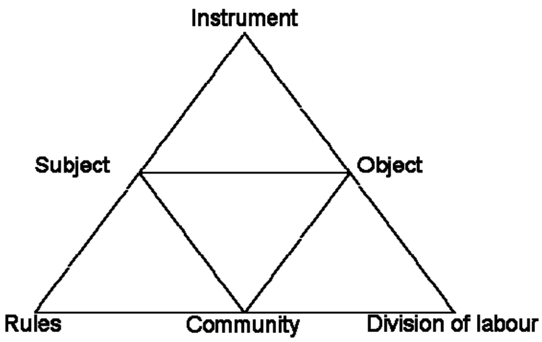

Figure 1. Components of activity theory (Engeström 1987).

Activities are carried out through actions or chains of actions, which in turn consist of operations. Activity is directed to satisfy a need through a material or ideal object, whose perception is the motivation for the activity. Actions are governed by the conscious goals of the subject. These goals reflect the objective results of action. Actions are concretized through operations that are started by the condition and structure of action. To clarify the difference between these concepts, activities answer to an analytical question "why", actions to "what" and operations to "how" (Bertelsen & Bødker 2003). Thus, activities are not necessarily conscious (but may become conscious) while actions are always conscious. Operations provide conditions of actions. Activities are also longer-term formations in relation to actions and operations.

However, these levels of activity are not fixed; an action may become an operation through automation/internationalization, and an operation can become an action through conceptualization′, e.g. in breakdown situations (Bødker 1991). Also, an activity in one context can be an operation in another.

> "An activity can lose its motive and become an action, and an action can become an operation when the goal changes. The motive of some activity may

> become the goal of an activity, as a result of which the latter is transformed into some integral activity […] The mobility of the constituents of activity is also manifested in the fact that each of them may become a part of a unit or conversely come to embrace previously relatively independent units (for example, some acts may be broken down into a series of successive acts, and, correspondingly, a goal may be broken down into subgoals).” (Davydov et al, 1983, cited in Kuutti 1997, p. 32).

According to Bertelsen and Bødker (2003), activity system is fundamentally marked by contradictions. These contradictions are regarded within and between activity systems as driving forces in human learning and development (Engeström, 1987). Contradiction indicates a misfit within elements, between them, between different activities or between different developmental phases of a single activity. Problems, ruptures, breakdowns, clashes are manifestations of contradiction. For instance, so called primary contradiction is the contradiction of a commodity between use and exchange value, e.g. between the best possible solution and a solution that can be implemented with the resources available (Bertelsen and Bødker 2003).

Example 1: Parallel activities

The first example is about co-authoring process, for instance writing a joint conference paper. From a technocratic perspective, the object of a writing activity is text – a sequence of characters, or data. The authors (subjects) input (write) and edit some text document by using a tool (word processor, typewriter). From a technology driven viewpoint, the text can be considered as a tangible object. The problem of co-authoring is thus conceptualized as resolving conflicts of several actors processing the same data at the same time. For example, there is a document consisting of three sections: S1, S2 and S3. The author A edits the text in the section S3 and, at the same time, another author (B) cuts the section S2 off and pastes it at the end of the document. An automated co-authoring system could resolve this conflict by locking the section S3 once its editing has started (thus withholding the author B’s access to S3), and later by making an assumption that the conflict has been resolved as the section S2 has been pasted to the document (see Figure 2).

	Author A’s changes: → S1 – S2 – $S3_{\textit{edited by A}}$	
Original document: S1 – S2 – S3		*Conflict resolution:* → S1 – $S3_{\textit{edited by A}}$ – S2
	Author B’s changes: → S1 – S3 – S2	

Figure 2. Example of individual authors’ changes to document and conflict resolution.

This example illustrates a technological data processing perspective. This kind of operation-level resolution is not unproblematic and could introduce new conflicting intra-documental references. Clearly, for the author A, the *context* for editing the text in section S3 is the original version of the document, namely S1 - S2 - S3 consequently allowing him to refer to the section S2 and assuming the reader is already familiar with it.

From the author's perspective, *tangible text* approach is not appropriate for an object of writing activity, since initially there is no actual text but *a text to be written* (i.e. an idea of the text). Hence, at some point of the process, the object of writing is not text, but its idea. In this phase, the idea can be formalized, for example, in terms of lists of ideas, drafts and schedule (a plan). This shift from an idea to a formal representation is knowledge work that is inherently human, although each formal representation captures some relevant aspects of the text.

Not only is the text shared among the participants in the writing process. The process includes also knowledge about roles; who is in charge of coordinating the writing, who will write on which sections/themes, and what language and style is used, for instance. In the words of activity theory, division of labor and rules are agreed within the community. In co-authoring the object of activity and, as a consequence, the activity itself evolves. The object and motive undergo changes during the activity process, emphasizing the process of *doing* through which the object and motive are revealed. White and Arndt's (1991) process writing model captures the intertwined nature of writing process; ideas, texts, structures etc. are continuously reviewed, reflected and elaborated throughout the process. In this case, although the tool and tangible part of the object remain the same, the object and the activity change. The same human initiated action may be related to a group of activities – which may change during the process. Deleting a sentence from the text may indicate that the author wants the text to meet some word limit, make the text easier to read, move the sentence to some other part of the document, or even write the same idea by using different terminology.

Example 2: Consecutive activities

The second example illustrates a business administration process. It is simplified, having only an accountant making entries and a manager making interpretations of the entries, i.e. about the data. As usual the accountant uses some tool, bookkeeping software or ERP, to input the numbers according to some predefined rules and classifications. For instance, an invoice from a hotel can be classified as a travel cost (accommodation for a company employee), as a representational expense (accommodation for a customer), or even as a personal cost (company credit card used for personal costs that need to be reimbursed later). To decide which category is appropriate, the accountant uses his/her contextual knowledge on acceptable costs. Entries and the budget situation are followed by a manager. He/she examines the costs on general level, evaluating only the categories. Thus the company's balance sheet is based on the accountants' contextual knowledge, and how the manager interprets it. Figure 3 illustrates activity theoretical triangles in this information flow.

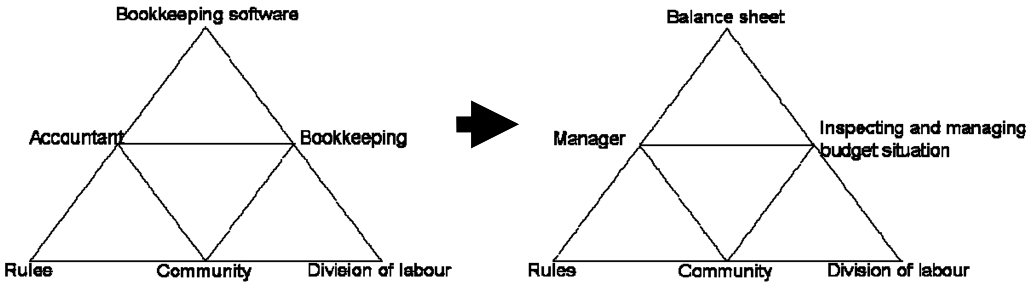

Figure 3. *Activity theoretical illustration of consecutive activities in an administration process.*

Often there are no problems in interpreting individual invoices as the appropriate category is evident and straightforward. However, Saastamoinen (1995; 2005) stated that even up to 40% of incoming invoices could be considered as exceptions. In those situations, accountants, many in big organizations, have to use their knowledge in decided the "appropriate" category. To make these decisions and information flow transparent, several methods and rules have been developed, latest being Sarbanes-Oxley act (Damianides, 2005; Kaarst-Brown, 2005). However, in terms of activity theory, the rules, divisions of labor and tools still provide an interpretation frame for both accountants and managers. In other words, the human's role as an interpreter remains.

Example 3: Conflicting activities

There are many situations in which the knowledge about the context of the activity necessitates understanding and knowledge about the other actors' interests – those interests being coherent or conflicting. In the co-authoring, the actors shared the same goal. In the second example, the actors' goals were on different levels but not conflicting either. However, conflicting situation are common as several actors are trying to achieve resources that are limitedly available. In such situations, other actors' activities need to be predicted.

An agent-based support for car drivers was provided by Keever and Pol (2002). They concluded that drivers just need data about incidents and events, situational analysis of those incidents and events (i.e. information); and the prediction of the impact of the reported situations (i.e. knowledge). The first two types; "raw" data and its situational analysis information are relatively easy to provide. However, the predictions of the impact are very problematic. Even if the situation is correctly described in the agent system, the agent would still need to know to what extent other drivers are aware of the situations (for example, do they have access to information from same kind of navigation agent) and how the other drivers will react to it. The prediction ability of the traffic incident is based on other human actors' reactions, and statistical analysis and predictions from earlier incidents. Figure 4 illustrates activity theoretical triangle for agent-based route planning.

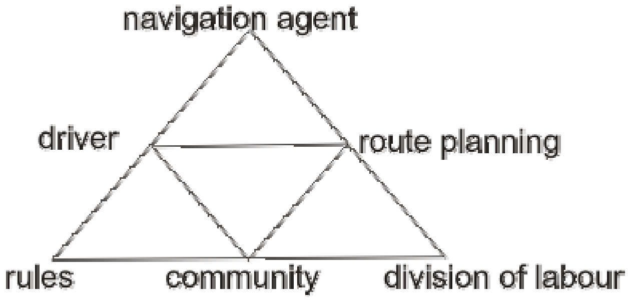

Figure 4. Activity theoretical illustration of agent-based route planning.

From activity theoretical point of view, the drivers form different kinds of communities. The types vary; sometimes they are people driving after another having to be able to react to others actions, sometimes they are people on a same route, sometimes people with the same technology-agent. In other words, the communities are formed dynamically, sub-consciously, and continuously. This becomes significant if it is determined by the common technology. Especially if there are early-adopters and late-comers in the same community, the system's perceived effectiveness and ability to correctly predict the consequences of the incident are very different. If an agent makes a suggestion for hundreds of drivers to take the same detour, it might have been better not to get that suggestion at all. An early-adopter may have learned to trust (or not to trust) the suggestion and act accordingly. The rules and division of labor are based on traffic regulations and conventions of the situation.

Discussion and implications

Previously several examples about situations where the meaning of context and contextual information are emphasized were presented. In the cases; library, administrative process, co-authoring and route-planning, the automation of operations is problematic. In the library, the phone cannot automatically switch to silent-mode as there might be conditions when it must be heard. Administrative process cannot be automated as all invoices cannot be processed in a standardized manner because of numerous exceptions, and in co-authoring, the deletion of a written sentence may have dissimilar implications. Yet there are conditions when the automation of operations can be done. A mobile phone may cross-check location-based data with a calendar and suggests itself to be silenced under certain conditions. Invoices are standard most of the cases. Co-authoring and route-planning may learn from previous activities and propose something. In other words, something can be done. The questions remain: up to what extend the operations can be automated? To which extend the data can be handled automatically, and when some information, or knowledge, is needed to process it correctly? To what extend the transformation of data to knowledge can be automated, or can it even be possible?

These questions were already identified by Berners-Lee et al. (2001) in their seminal article. Until now, they have not been fully answered. We believe it is due to several reasons. First, semantic web and its spin-off technologies deal mainly with data and information. Knowledge is approached only as explicit knowledge leaving tacit knowledge intact. Second, creating the "sets of interference rules" and "structured collections of information" is not evident as illustrated by the co-authoring and route-planning examples. Bowker and Star (1999) discussed that classifying things, i.e. creating rules for collections of information, is all about compromises. Thus, strictly defining and even naming automatically a number of knowledge-intensive activities is nearly impossible. In these situations, human intervention is needed. Third, even if one would be able to create such rules and collection, the shifts and changes of foci between activities, actions and operations complicate the case. As the administrative process example points out, exceptions are common, so if a set of rules for some operation is created, the exception forces the system to abandon them. If it does not do it, the exception is dealt in an inappropriate manner. Fourth, human activity is needed in coding the meta-text for the information. In other words, once some content is created, it needs to be entered twice: once as the actual content, again as its meta-data. Grudin (1994) discussed the disparity of work and its benefits in the context of groupware applications. He argued that the extra work done for a task, for instance voice annotating a document, is something that does not get done regularly unless one sees its benefits. This, in the context of semantic web, means that the meta-data does not get entered regularly as it is extra work for someone. This lack of activities decays the base for semantic web.

Although these obstacles are severe for developing semantic web, something can and has been done. However, the question: "up to what extend" remains. If knowledge, information and data are bound together with activity theory, i.e. the terms of activity, action and operation, their relationship can be discussed. From the human-machine asymmetry point of view, machine operates on data and information levels. Human endeavor has no such limitations. From activity theory point of view, activities are directed to satisfy a need through a material or ideal object. Thus, answering "why"-questions requires thorough understanding, or knowledge, about the situation. As shown in the earlier examples, this cannot be automated. Meanwhile actions are governed by the conscious goals of the subjects. These "what"-questions are more difficult as *sometimes* a machine can make correct suggestions by guessing the subject's conscious goal (e.g. in route planning). Yet this will raise new problems as we will discuss later. However, as long as the processing does not require human processing capabilities or intervention, it can be given to computers. According to activity theory all operations, as long as they remain operations, can be automated while activities and actions remain human capabilities.

Computerized multi-agent systems try to adapt the idea of modeling beliefs, desires, and intentions of other actors. For example, an agent may monitor stock exchange rate and make recommendations to buy/sell, or even buy/sell directly without human intervention, by using some rules in making predictions. The system should be able to evaluate the other stakeholders' operations, activities and intentions, and learn to understand their behavior, beliefs, desires and intentions, in order to be successful. However, although the system may work as wanted (i.e. make money) for a limited number of people, a myriad of agents doing the same produce different outcome: they all operate by using a more or less similar set of rules, leading the same outcome (i.e. not making the money). Minsky (Riecken 1994) discussed multi-agent systems and referred beliefs, desires and intentions to as "common sense", which are crucial in all knowledge work. The idea of a rational agent having beliefs (informational state), desires (motivational state) and intentions (deliberative state) implies that agents act on activity level. Lenat (1995) attempted to model common sense in a large knowledge base by using some propositions. However, it is still questionable if his endeavor will be successful and if it is, to what extent.

However, automated agents are not embodied. Their interface towards reality is limited and artificial, initiated by human beings. Therefore their epistemology is limited as well as is their ability to change the ontological presuppositions (beliefs as information structure). In contrast, the idea of embodied mind emphasizes the importance of human sensor-motor system in reasoning. As Lakoff and Johnson (1999, p. 43) stated, "it is a crucial part of the explanation of why it is possible for our concepts to fit so well with the way we function in the world." Human actors' beliefs about the division of labor and community-memberships are important in decision making as route-planning example illustrated. These make the idea of automated agents taking part in knowledge creation process science fiction, unfortunately.

Semantic web is "based on the idea of having data on the Web defined and linked such that it can be used for more effective discovery, automation, integration, and reuse across various applications" (Hendler et al. 2002). The idea of semantic web, exploiting the vast amount of data of the web for a knowledge base, is no doubt interesting. However, in Nonaka and Takeuchi's (1995) knowledge creation process, semantic web focuses on combining explicit, digital knowledge. It does not consider internalizing, socializing or externalizing the knowledge. From the activity theoretical point of view, i.e. when the data could be used, semantic web focuses on execution of data, doing some pre-defined operations on it as we have discussed earlier. Therefore, the idea of discovering, integrating and reusing data from the web is great, but it needs a human actor to extrapolate and use it in some context.

In ubiquitous computing, the computers are everywhere. They are usable and used in every situation, every context. However, again the automation of technologies is not straightforward. The examples of problems in co-authoring, mobile phone in a library and route-planning illustrate the problems faced in ubiquitous computing. Considering these issues with ISD paradigms (Hirschheim et al. 1995; Iivari et al. 2001) provides an interesting viewpoint. It seems that automated agents, semantic web and ubiquitous computing inherit epistemological and ontological foundations from functionalism. First two examples stretch towards social relativism as actors' subjective issues are emphasized meanwhile route-planning presents a conflict in the world-order. One can thus consider when this foundation is appropriate, up to what extent the "chosen paradigm" is appropriate and suitable. For example, at night the route suggested by the agent might be right as there is less traffic, while at day-time the result is less suitable. Should this evaluation be done by the technology or by a human actor? Following our earlier argument, we suggest that the scope of ubiquitous computing should be on providing information for human decision making. Thus, instead of focusing on a system or systems evaluating and deciding an appropriate activity for humans, it could be more productive to consider how could ubiquitous computing technologies (tools) help best individuals (subjects) in achieving their goals (objects).

Summary and conclusion

In this paper we have discussed the potentialities and shortcomings of ubiquitous technologies in taking different contexts and situations into consideration. As seen, the role of current technologies and applications seem to be more on providing data and information rather than knowledge and decision making. At least this is how the users should consider the output. Also, an endeavor of attempting to design systems that would provide "knowledge" would be currently doomed. There are simply too many factors (including other humans) affecting the human activities and decisions that cannot be currently considered. Appropriate "knowledgeable" agent would also require understanding about the context where the activity is taking place.

Activity theory perceives different forms of human practices as constantly evolving processes and provides a frame for understanding human practices. An activity can be seen as the minimal meaningful context for understanding individual actions. Real-life situations always involve some intertwined and connected web of activities that can be distinguished by their objects. In connected activities, with very different objects, participation can cause tensions and distortions. These tensions and distortions are contradiction points where the participants need to intervene, where their interpretation of a situation, their knowledge is needed. This is a point which cannot be resolved automatically. Contextual knowledge is needed and the problem remains: how to acquire it?

Ubiquitous computing aims at the ubiquity of information and context. As we have argued, the problem there is the technology, a tool, which cannot comprehend the context in a manner that is sufficient for subjects to achieve their objectives. No matter whether there are automated software agents, semantic web applications, or context-aware applications, they are still technologies. Although we like them, we need new ways of approaching their utilization.

References

Bateson, G. (1972). *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. University Of Chicago Press.

Berners-Lee, T. Hendler, J. and Lassila, O. (2001). The Semantic Web, *Scientific American*, May 2001, pp. 28-37.

Bødker, S. (1991). *Through the interface: a human activity approach to user interface design*. Hillsdale, NJ, Erlbaum.

Bowker, G. and Star, S.L. (1999). *Sorting Things Out: Classification and Its Consequences*. MIT Press.

Bertelsen, O.W. & Bødger, S. (2003). Activity theory. In: J.M.Carroll (ed.) *HCI Models, theories and frameworks: Towards multidisciplinary science*. Morgan Kaufmann Publishers. pp. 291-324.

Damianides, M. (2005). Sarbanes-Oxley and IT Governance: New Guidance on IT Control and Compliance. *Information Systems Management*. 22. 77-85.

Dey, A. K., Abowd, G. D., and Salber, D. (2001). A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications, *Human-Computer Interaction*, vol. 16(2-4), pp. 97–166.

Dourish, Paul (2004). What we talk about when we talk about context, *Personal and Ubiquitous Computer*, vol. 8(1), pp. 19 – 30.

Engeström, Y. (1987). *Learning by expanding*. Helsinki: Orienta-Konsultit.

Grudin, J. (1994). Groupware and social dynamics: eight challenges for developers. *Communications of the ACM* 37(1), pp. 92-105.

Hirschheim, R., Klein, H.K., and Lyytinen, K (1995). *Information Systems Development and Data Modeling: Conceptual and philosophical foundations*. Cambridge University Press.

Hendler, J., Berners-Lee, T. and Miller, E. (2002). Integrating Applications on the Semantic Web. *Journal of the Institute of Electrical Engineers of Japan*, Vol 122(10), October, 2002, p. 676-680.

Iivari, J., R. Hirschheim, and H. K. Klein. (2001). A Dynamic Framework for Classifying Information Systems Development Methodologies and Approaches, *Journal of Management Information Systems*, (17)3, pp. 179-218.

Kaarst-Brown, M. L. and Kelly, S. 2005. IT Governance and Sarbanes-Oxley: The Latest Sales Pitch or Real Challenges for the IT Function? *In Proceedings of the 38th Annual Hawaii international Conference on System Sciences, HICSS*. IEEE Computer Society

Karlsson, F. and Wistrand, K. (2006). Combining method engineering with activity theory: theoretical grounding of the method component concept. *European Journal of Information Systems* 15, 82–90

Keever, D. and Pol, J. (2002). Data Fusion to Support Information Needs For Surface Transportation Operators. *9th World Congress on Intelligent Transport Systems*. Chicago, USA: ITS USA.

Korpela, M. et al. (2002). Information systems development as an activity. *Computer Supported Cooperative Work* 11(1-2), 111-128.

Kuutti, K. (1997). A Framework for HCI Research, In Nardi, B.A. (ed.) *Context and Consciousness: Activity Theory and Human-Computer Interaction*. MIT Press, Cambridge MA, 17-44.

Lakoff, G. and Johnson, M. (1999). *Philosophy in the Flesh*. Basic Books.

Lenat, D. B. (1995). CYC: a large-scale investment in knowledge infrastructure. *Communications of the ACM,* 38(11), pp. 33-38.

Lieberman, H. and Selker, T. (2000). Out of context: computer systems that adapt to, and learn from, context. *IBM Systems Journal* 39, 3-4, 617-632.

Nardi, B. (ed.) (1995). *Context and consciousness: activity theory and human-computer interaction*. MIT Press.

Nonaka, I. and Takeuchi, H. (1995). *The Knowledge Creating Company: How Japanese Create the Dynamics of Innovation*. New York: Oxford University Press.

Riecken, D. (1994). A conversation with Marvin Minsky about agents. *Communications of the ACM*, 37(7), 23–29.

Saastamoinen, H.T. (1995). *Exception Handling in Information Systems*, Ph.D. Thesis, University of Jyväskylä Press, 1995

Saastamoinen, H.T. (2005) Exception-Based Approach for Information Systems Evaluation: The Method and its Benefits to Information Systems Management. *Electronic Journal of Information Systems Evaluation* 8 (1) pp. 51-60

Sowa, J. F. (2000). *Knowledge Representations: Logical, Philosophical and Computational Foundations*, Brooks/Cole.

Svanaes, D. (2001). "Context-Aware Technology: A Phenomenological Perspective", *Human-Computer Interaction*, vol . 16(2-4), pp. 379–400.

Syrjänen A.-L. & Kuutti K. (2006). Analysing IT and Communities of Practice. *14th European Conference on Information Systems, 'Grand Challenges'*, June 12-14, Göteborg, Sweden, 12 p.

Thompson, J.D., (1967). *Organizations in Action: Social Science Bases of Administrative Theory*, McGraw-Hill, New York.

White, R. and Arndt, V. (1991). *Process Writing*. London: Longman.