Notion, theories and models of Context: Engineering, Cognitive and Social Perspectives
Technical Report

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Chapter 1

Introduction

Although the notion of context has been studied by several disciplines such as pragmatics, natural language semantics, linguistics, cognitive psychology, and artificial intelligence, there is no standard concept, theory or model. This overview describes engineering, cognitive and sociological approaches to context. It encompasses theories, models and applications of this notion.

In computer engineering , one of the first uses of the concept of context can be found in the Operating Systems field. Nonetheless, the engineering perspective of context has mostly been developed in the Artificial Intelligence field. More recently, other fields such as knowledge management and ubiquitous computing are strongly based on some particular notion of context. Works under this perspective typically regards context as an environment i.e., it is delineable and separable entity related to other entities such as tasks or domains. Under this perspective, context has been employed mainly as a means for partitioning or grouping, as well as for making explicit assumptions, interpretations or concepts, to resolve interoperability problems derived from heterogeneous data sources.

Human and Social Sciences have addressed and developed rather different notions of context, theories and models. The psychological approaches aim at studying the context effects on cognitive processes and have shown that they intervene in virtually all cognitive processes. Cognitive approaches aim at dealing with the notion of context for cognitive modeling purposes i.e., to model how human cognitive processes are influenced by context and how this could e modeled in computer simulations. Central concerns of sociological approaches are issues such as understanding (1) how successive interactions among individuals shape the context of these interactions, (2) in which ways interaction contexts define individual and collective behavior or (3) how and why, in the course of their interactions, do people achieve and maintain a mutual understanding of the context for their actions.

Sociological approaches typically regard context as networks of interacting entities (people, agents or actors and artifacts). These approaches focus on the structural properties of contexts, resulting from recurrent interactions among entities. Whereas some focus on the network itself, others focus on its emergent properties. In the latter case, the context itself is regarded as an entity which both supports and regulates interactions among its members [19]. Activity Theory [30] and Actor-Network Theory (ANT) [21] have been widely used in modeling social contexts. Both theories approach contexts as networks. Thus, whereas the engineering perspective regards context as a discrete entity related to other entities, cognitive and social perspectives regard it as a fuzzy notion that emerges from the interactions among entities.

The remaining of this document is structured as follows; chapters 2 to 4 describe the notion, theories and models of context from engineering, cognitive and sociological perspectives. Chapter 5 covers issues related to the dynamical aspect of context. Chapter 6 describes some relevant applications using the notion of context from three application areas; (1) context-aware applications, (2) distributed knowledge management and (3)process oriented knowledge management.

Chapter 2

Engineering perspective

One of the first uses of the concept of context can be found in the Operating Systems field. In the operating systems jargon, it refers to the context of processes [33]. Process contexts describe the state variables of a process and are implemented with tables maintained by the operating system that have an entry for each process 2.1. This entry contains information about the process' state (running, blocked or waiting), its program counter, stack pointer, memory allocation, the status of its open files, its accounting and scheduling information and everything that must be saved when the process is switched back from running to ready or blocked state so it can be restarted later as if it had never been stopped.

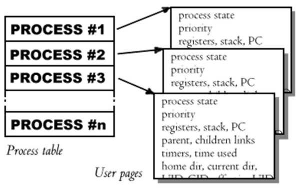

Figure 2.1: Context as a Table

Nonetheless, the engineering perspective of context has been mostly developed in the Artificial Intelligence field. In a literature survey on Context, P. [25] presents a view of how context is considered in knowledge acquisition, machine learning, communication, and databases and ontologies. Despite the existence of some important differences, there are some consensual ideas around the notion of context. First, its relational natural i.e., context is not an autonomous entity. Rather, it is always related to some other entity. Second, context is viewed as a collection of things (sentences, propositions, assumptions, properties, procedures, rules, facts, concepts, constraints, sentences, etc) associated to some specific situation (environment, domain, task, agents, interactions, conversations, etc).

2.1 The box metaphor

This common view is reflected by the *metaphor of the box* introduced in [9]. This metaphor is illustrated in figure 2.2).

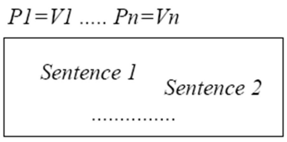

Figure 2.2: Context as a Box [9]

A context dependent representation can be split into three parts: inside the box, a collection of linguistic expressions (be it a single sentence or an entire theory) that describe a state of affairs or a domain; outside the box, a collection of parameters P1, P2,..Pn and a value V1, V2,..Vn for each parameter. The intuition is that the content of what is inside the box is determined (at least partially, and in a sense to be defined) by the values of the parameters associated with that box. For example, in a context in which the speaker is John (i.e. the value of the parameter speaker is set to John), any occurrence of I will refer to John (we should add a lot of qualifications, but for the moment we will ignore them).

In [18], the authors use the box metaphor to discuss questions such as: What features of context should be included among the parameters? Is it possible to specify all the relevant parameters, or the collection is always incomplete? How is the representation affected when the collection of parameters or their values changes? Can we get rid of parameters and get a context independent representation of the contents of a box? What is the relationship between the parameters of different boxes? How does this relationship affect the relationship between the contents of different boxes?

In any case, the specific set of parameters varies according to the areas of application. In pragmatics, indexical expressions are defined as expressions dependent on indexes such as place, time, agent and world, which are a subset of context parameters [9]. In Artificial Intelligence, McCarthy's work, [14] proposed to explicit context models as a means to overcome the generality problem in commom sense reasoning. Based on McCarthy's work, Lenat proposed a set of parameters (called dimensions) such as time, location, culture, topic, granularity and modality among others, as defining elements of a context space [17]. A proposal for a workflow context space in [11]includes the following parameters: function, behavior, causality, organization, information, operation and history. In the area of context aware applications localization, user identity, activity and time have been identified parameters of context [3].

2.2 Contextual Reasoning

The box metaphor is also used in [18] to propose three basic forms of contextual reasoning according to the element of the box that they affect. The authors argue that these three forms encompass all contextual reasoning mechanisms discussed in the literature. Moreover, the general patterns of contextual reasoning propose are meant to hold no matter what the solutions adopted to resolve the fundamental questions previously posed.

- *Expand/contract:* A first general form of contextual reasoning is based on the intuition that the explicit representation associated with a specific context does not contain all the facts potentially available to a reasoner, but only a subset of them. As a consequence, depending on the circumstances, the subset which is explicitly taken into account can be expanded (typically because some new input from the external environment makes it necessary to consider a larger collection of facts), or contracted (typically because the reasoner realizes that some facts are not relevant on a given occasion). Expansion can be illustrated with the following example: when reasoning about traveling from Glasgow to Moscow via London, we normally do not include in the problem solving context the precondition that one must be dressed to get on a plane; however, if one's clothes are stolen at London airport, being clothed becomes a relevant precondition for the success of the travel plan, and therefore the original problem solving context must be expanded with facts about social conventions and buying clothes.

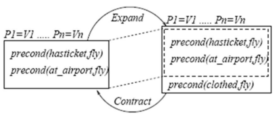

Figure 2.3: Expand/Contract [18]

- *Push/pop:*The content of a context dependent representation is partly encoded in the parameters outside the box, and partly in the sentences inside the box. Some authors propose reasoning mechanisms for altering the balance between what is explicitly encoded inside the box and what is left implicit (i.e. encoded in the parameters). Intuitively, the idea is that we can move information from the collection of parameters outside the box to the representation inside the box, and vice versa.We call these two mechanisms push and pop to suggest a partial analogy with the operations of adding (pushing) and extracting (popping) elements from a stack. For instance, the fact that block x is on block y in a situation s is represented as on(x; y; s) in a context c with no parameter for situations. This is because in some cases we want to leave implicit the dependence on the situation s (typically, when we don't want to take situations into account in reasoning). This means that the situation can be encoded as a parameter, and the representation can be simplified to on(x; y). Push is the reasoning mechanism which allows us to move from on(x; y; s) to on(x; y) (left-to-right arrow in figure 3), whereas pop is the reasoning mechanism which allows us to move back to on(x; y; s)

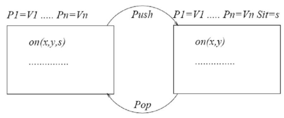

Figure 2.4: Push/Pop [18]

- *Shifting*: Shifting changes the value of one or more contextual parameter, without changing the collection of parameters. The intuition is that changing the value of the parameters shifts the interpretation of what is represented inside the box. The simplest illustration of shifting is again indexical expressions. The fact that on January 1st it is raining is represented as 'Today is raining' in a context in which time is set to January 1st, but it is represented as 'Yesterday it was raining' if the value of time changes to January 2nd. As it is shown in figure 2.5, shifting is the reasoning mechanism which allows us to move from one representation to the other by changing the value of the parameter time, provided we know the relationship between the two parameter's values.

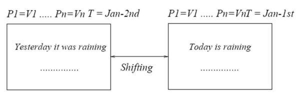

Figure 2.5: Shifting [18]

In summary, the AI approach to contextual reasoning may be characterized as navigation between and within the context-boxes [8]. Crucial issues are how to represent the individual boxes, how to recognize that we have to change the box and how to choose a new box. In most cases the boxes are predefined, e.g. the logical theory or the frame representation describing the box should be defined in advance by the user or programmer. The issue of how to construct a new context on the fly is not addressed. The main issue being addressed is when and how the reasoner decides to change the context either because the goal has been changed or because an external event has happened which should trigger a new context.

2.3 Dimensions of Context Dependence

The three forms of contextual reasoning described actually operate each on a fundamental dimensions of a context dependent representation: *partiality, approximation*, and *perspective*.

Partiality: We say that a representation is partial when it describes only a subset of a more comprehensive state of affairs. Perhaps the more intuitive example of partial theories are domain specific theories. For instance, a theory about the theory about the Italian cuisine is partial because it does not provide information about Indian or French cuisine, about soccer, about quantum mechanics. A different usage of partial theories is in problem solving. Given a problem, people seem to be capable of circum- scribing what knowledge is relevant to solve it, and disregard the rest. In this case, assumptions on what is relevant act as contextual parameters. Partial theories are also used in theories of linguistic communication. When a speaker says something to a hearer, it is assumed that the latter interprets what the speaker said in some context. *Expand/Contract* is the reasoning mechanism that allows us to vary the degree of partiality by varying the amount of knowledge which is used in the representations of the world.

Approximation. We say that a a representation is approximate when it abstracts away some aspects of a given state of affairs. A representation of the blocks world in terms of the binary predicates on(x; y) e above(x; y) is approximate, because the time (situation) is abstracted away. The representation on(x; y) and above(x; y) is more approximate than the representation on(x; y; s) and above(x; y; s) because the first abstracts away the dependence on the situation. *Push/Pop* is the reasoning mechanism that allows us to vary the degree of approximation by regulating the interplay between the collection of parameters outside and the explicit representation inside a box.

Perspective: We say that a representation is perspectival when it encodes a spatio–temporal, logical, or cognitive point of view on a state of affairs. The paradigmatic case of spatio-temporal perspective is a given by indexical languages. A sentences such as 'It's raining (here)(now)' is a perspectival representation because it encodes a spatial perspective (i.e. the location at which the sentences are used, the speaker's current 'here') and a temporal perspective (i.e. the time at which the sentences are used, the speaker's current 'now'). A subtler form of perspective is what we call cognitive perspective. It has to do with the fact that many representation encode a point of view which includes a collection of beliefs, intentions, goals, and so on. *Shifting* is the reasoning mechanism that allows us to change the perspective by taking into account the 'translation' of a representation into another when the value of some contextual parameter is changed.

2.4 Context and Knowledge

P. Brzillon has made an extensive research on context, both on theoretical and practical grounds. This author has related the notions of knowledge and context and has developed the latter in terms of the first. In [29], he first distinguishes between *data*, *information* and *knowledge*. From *data* emerges *information*. Information is structured data with a semantic content expressible by natural language. Information is generally framed by a subject but it is sharable and is immediately usable by human begins on the basis of their previous knowledge. The next transformation is the passage from *information* to *knowledge*. This process also relies on prior knowledge and is made consistent with the values and beliefs of a subject (figure 2.6). Thus, knowledge has several roles: (1) the transformation of data to information, (2) the derivation of new information from the existing ones, and (3) the acquisition of new knowledge. Knowledge is thus simultaneously a result and a process [26]. A difficult question here is that some knowledge is also necessary to structure the unorganized stimuli emerging from the 'primordial symbolic soup' and to shape rough stimuli into data.

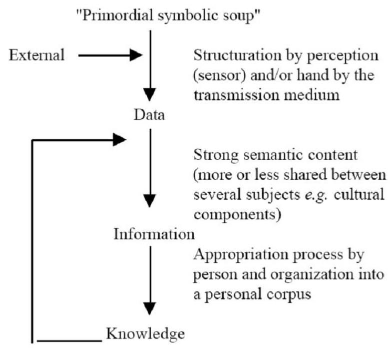

Figure 2.6: From "the Primordial Symbolic Soup" to Knowledge [29]

2.4.1 Different Types of Knowledge

Brzillon describes different types of knowledge . First he distinguishes between *know how* versus *know that*. The term know how refers to the knowledge that people use to operate or behave as opposed to theoretical knowledge which is related to the profound, ultimate and often hidden causes of the ongoing phenomenon. Second, he says that the previous distinction is intertwined with the discussion about *deep* and *surface* knowledge. It is commonly admitted in AI that *deep* knowledge refers to models and causal explanations that goes back to nature laws, whereas the *surface* knowledge is represented by practical rules that can be acquired from people performing efficiently a given task. Thus, the *deep* knowledge is very similar to *know that.* On the other hand, it is not so clear that *surface* knowledge is equivalent to *know how.*

The notion of practical knowledge entails a type of knowledge that needs apprenticeship i.e. practice to be learnt whereas some other does not necessitate such practice. The study of practical knowledge has been renewed by the "communities of practice".

The discussion *deep* vs. *surface* is contemporary to the distinction between *procedural* and *declarative* knowledge which was introduced early in artificial intelligence. Roughly speaking, *procedural* knowledge is knowledge which is expressed in expert systems by rules or, in organizational life, by procedures. *Declarative* knowledge refers to more descriptive knowledge represented by objects or agents in new programming languages.

The question of the practical nature of knowledge opens another discussion: *tacitness* versus *explicitness.* This discussion enlightened by Nonaka [12], who distinguishes explicit and tacit knowledge and the movements between them. *Explicit* knowledge is easily shared whereas *implicit* knowledge is highly personal. The discussion about *tacit* versus explicit knowledge is not far from *knowing how* versus knowing that while it stresses the appropriation components. The *tacit* knowledge implicitly belongs to somebody whereas explicit knowledge can be shared and is generally public. We would also distinguish between *tacit* knowledge which can be *explicited* and *non explicitable* tacit knowledge, even if this latter can be shared in a community of practice. This is the case of many handling skills in a lot of craft jobs. The notions of *procedural* and *declarative* knowledge have been brought into contact with the *implicit-explicit* distinction by several authors.

Between tacit and explicit knowledge, Nonaka describes four types of exchange: *socialization, externalization, combination and internalization*, as represented on the Figure 2.7. Knowledge *socialization* refers to the creation of new tacit knowledge from shared tacit knowledge. Knowledge *externalization* refers to the conversion of tacit knowledge into explicit knowledge. Knowledge *combination* refers to the creation of new knowledge through the exchange and combination of explicit knowledge held by individuals in the organization. Knowledge *internalization* takes place when explicit knowledge becomes tacit, in a way similar to learning.

2.4.2 Context: the Brzillon standpoint

From an engineering point of view, *context is the collection of relevant conditions and surrounding influences that make a situation unique and comprehensible.* For example, in the control of a subway line, where a large amount of knowledge about trains, electricity, people reaction, etc., contributes to make the situation unique, while some more particular conditions about the time, the day, the weather and so on, influence specifically many decisions. In other words, there is a common background context which is then specified by some conjecture and contingent influences. The general context

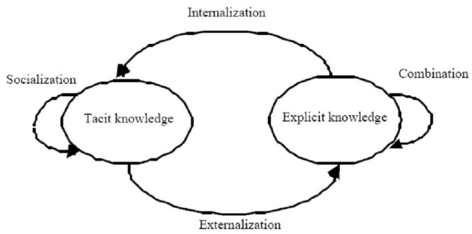

Figure 2.7: Movement between tacit and explicit knowledge [29]

is subway control which differs from train or bicycle control although they share some mechanical laws and the particular context is specific to a line, a day, an hour, etc.

Thus, the general, relatively fixed primary characteristics of a situation are defined as the *primary context*, and the *secondary context* are the characteristics which are more mobile. If we think about primary context, it is difficult to avoid the word knowledge about this general background used by the operators to carry out their task. This is the reason why the *primary context* is called *contextual knowledge* . Therefore, at a given step of a decision process or of a task performing, the part of the context which is relevant at this step of the decision making or task performing is called *contextual knowledge* and the part which is not relevant is called *external knowledge.* The *contextual knowledge* depends on the agent and on the decision (or task) at hand.

At a given step of the decision making (or task performing), a part of the contextual knowledge is *proceduralized.* We call it the *proceduralized context.* The *proceduralized context* is a part of the *contextual knowledge* which is invoked, structured and situated according to a given *focus.* According to Brzillon's field studies about the task of incident solving, it was observed that a part of the *contextual knowledge* is known a posteriori, since some elements appear to be important to understand, explain or solve the incident only during the incident solving, not beforehand. For a given incident, the frontier between *contextual knowledge* and *external knowledge* is fixed, but unknown before the incident.

The *contextual knowledge* is a backstage knowledge whereas *proceduralized context* is immediately useful for the task at hand. The *contextual knowledge* is largely *tacit*, mainly because it is the context that everybody knows without expressing it. The *contextual knowledge* is useful to identify the *activity* whereas the *proceduralized context* is relevant to characterize the task. The *contextual knowledge* can encompass both theoretical (knowing that) or practical (knowing how) knowledge. Figure 2.8 illustrates the three types of context.

An important issue is the passage from *contextual knowledge*to *proceduralized context.*

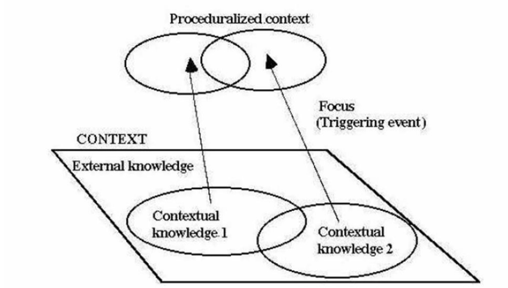

Figure 2.8: The three types of contexts [29]

This *proceduralization* results from the *focus on a task*. Thus, it is task-oriented just as knowing how; it is often triggered by an event or primed by the recognition of a pattern. A second aspect of *proceduralization* is that the operators transform *contextual knowledge* into some *functional knowledge* or causal and consequential reasoning in order to anticipate the result of their own action. This *functionalization* obeys to the necessity of having a consistent explicative framework to anticipate the results of a decision or an action, obtained by reasoning about causes and consequences in a given situation. A third as aspect of proceduralization is that it is a kind of instantiation. This means that the *contextual knowledge* needs some further specifications to perfectly fit the task at hand.

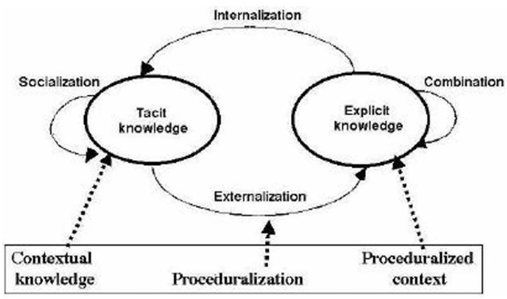

Figure 2.9: Context and movements between tacit and explicit knowledge [26]

Figure 2.9illustrates the relationship of the types of context described and the movements between tacit and explicit knowledge. The process of externalization is especially interesting as regards context for it anticipates on the process of proceduralization leading to the proceduralized context. This rises the question of why and when people decide to externalize. This question is particularly important in process control because the development of automatic control systems supposes that knowing how has been previously captured.

2.4.3 Role of Context in Knowledge Acquisition

Context is argued to be one of the elements used both to transform data into information or/and to acquire knowledge (fig. 2.10.

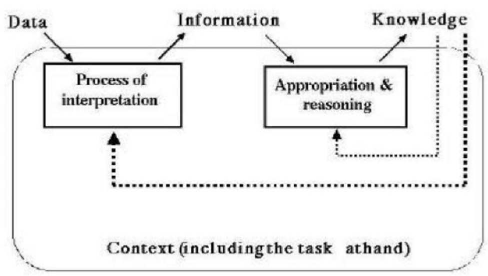

Figure 2.10: Context and Knowledge Acquisition [26]

Even if the context is necessary to "situate" knowledge and if knowledge must be reused in the context of acquisition, there is an important part of knowledge is either non-contextual or de-contextualized in the mind. These authors believe that the subjective and task-oriented nature of context (explained in next section) make it this notion more appropriate than the notion of knowledge for systems design.

2.4.4 Context in Decision and Action

Context is task-oriented or is, at least, related to an activity. For example, the fact that we know that the nearest star after the sun is Proxima Centauri at 4.22 light-years will never be contextual knowledge except for an astronomer or people engaged in star trek! Whether it is *backstage contextual knowledge* or *immediately usable knowledge*, depends on what a subject intends to do. So, the context is also primarily subjective, even it is shared among a community. These two characteristics (1) task oriented and (2) subjective are also two components of *know how*. This does not mean that the two concepts are similar, since the *contextual knowledge* can contain some theoretical knowledge. For example, in many tasks, a contextual element which is taken into account is the gravity. Context is task oriented or more precisely, the *proceduralization process* is task-oriented even task-focused. During this passage from back to front stage some information are instantiated, this is like new information that is provided about the events in a uncertain setting. At a given moment, we do not know the true nature state, then after a while, some events are known which give more information on the true nature state. This means that the *contextual knowledge* has many variables and that the *proceduralization process* is partly an instantiation process. One can say that *knowing how* is instantiated in *doing*. The *proceduralized context* is an instantiation of a part of the *contextual knowledge*. This instantiation gives the keys for decision making or action. *proceduralized context* is sufficient for action but only people with the adequate *knowing how* can bridge the gap between *proceduralized context* and action. The *proceduralized context* triggers some entailment links for people *knowing how*. As such it can be regarded either as a part of know how or as a signal triggering adapted answers to a situation. The relationships between the *proceduralized context* and decision making or action are not necessarily explicit. A kind of compilation can occur that establishes some routine links between a *proceduralized context* and the subsequent action or anticipation. This is the functional side of the *proceduralization*.

2.4.5 Context versus knowledge

Context and knowledge have many similarities and links, but they nevertheless differ [29]. Context is different from *knowing how*, but is similarly subjective and task-oriented. Context is mainly *declarative knowledge* more or less used to describe nature states but can contains a part of *deep knowledge*.

Contextual knowledge obeys to a dynamics of instantiation and functionalization during action. At a given moment, there are *external knowledge* and *contextual knowledge*, and a part of the contextual knowledge is compiled in the focus of attention (through the proceduralized context). Context is relative to a *focus of attention* (e.g. the context of knowledge use) with an organization of the contextual knowledge around this focus. The *contextual knowledge*, which is organized around the *focus of attention*, also has a granularity that depends on the distance to the focus. Moreover, the movement of the focus of attention implies a change in the *proceduralized context*, and explain the dynamics of context.

Knowledge is a too vague concept to be really operant in the analysis of decision making and of task undertaking [29]. On the contrary, the notion of context which is entirely task oriented offers a shrewder concept to model the relationships between knowledge and action.

2.5 Context Models and Representations

There are several theoretical approaches (other than those described before) that consider explicitly or not context[25]. There is a difference between a *context model* and a *context representation* . A model is endowed in a theory and a representation lies on the representation formalism chosen. The goal of a model is to give a coherent picture of context that can be used for explaining and predicting by simulation. The goal of a representation of context is only to account for what is observed whatever the way is. Context has been modeled on the basis of theories such as Situation Theory and Activity Theory and Distributed Cognition. Context has been represented using logic, rules and contextual graphs among others.

As an example of a logic–based representation, McCarthy defined a context as a generalization of a collection of assumptions. Contexts are formalized as first class objects and the basic relation is ist(c,p) that asserts that the proposition p is true in the context c, where c is meant to capture all that is not explicit in p that is required to make p a meaningful statement. A logic context-based system requires building a logic machinery. Nevertheless, the bigger effort lies in in writing the axioms describing and interrelating contexts.

In a rule-based representation, context may be expressed on the basis of either the knowledge structures or the functionalities of the chosen representation formalism. In a rule-based formalism, knowledge structures are rule packets represented either at the level of the rules or at the level of the knowledge base. The former is managed by screening clauses, which are controlled by special rules and the latter organizes the knowledge base in a set of distinct small knowledge bases managed either directly by rules that call rule packets in their THEN part or by interactions among rule packets for exchanging information.

Contextual graphs are tree representations made of two types of elements; (1) actions and (2) contextual nodes. They are similar to decision trees but they do not have chance nodes but contextual nodes and there are no probabilities. This representation was specifically designed for the task of incident troubleshooting in the Paris subway. Other related notions such as scenarios, schemas an even UML Use Cases are forms of context representation [modeling and using context].

2.6 Context Main Uses

In terms of its use, context is employed mainly in two broad different ways. On one hand, context has been used as a partitioning or grouping means. This kind of context use has two different purposes: (1) enable filtering, classification or customization mechanisms and (2) achieve an efficient representation or reasoning. On the other hand, it has been employed as a means for making explicit assumptions, interpretations or concepts, to resolve interoperability problems derived from heterogeneous information or data interchange.

Chapter 3

Cognitive Perspective

The notion of context is dependent of its interpretation on a cognitive science versus an engineering (or system building) point of view, the practice viewpoint versus the theory one [25]. The engineering view is that context is useful in representing and reasoning about a restricted state space within which a problem can be solved. The cognitive science view is that context is used to model interactions and situations in a world of infinite breadth, and human behavior is key in extracting a model.

3.1 Psychological Approaches

The psychological approaches aim at studying the context effects on cognitive processes and have shown that they intervene in virtually all cognitive processes [8]. When psychologists study context effects they do not even think of changing the goals or beliefs of the subject, or the task or instruction to see whether a different perspective imposed on the subject would influence human reasoning. The automaticity of cognitive process is reflected through four different and more or less independent aspects: *intentionality*, *controllability*, *awareness* and *efficiency*. *Intentionality* is related to the presence or lack of control on the start-up of the process by the individual. While *problem solving is typically an intentional process* since it starts when we decide to do so, *categorization and evaluation are typically unintentional ones* since these processes occur automatically when a stimulus is noticed and do not require a deliberate goal or intention. *Controllability* is related to the ability of the individual to stop a cognitive process once started or at least to override its influence if so desired. Examples of uncontrollable cognitive processes would be some strong visual illusions which occur even if one knows they are illusions. *Efficiency* refers to the extent to which the cognitive process requires attentional resources. With respect to *awareness* a cognitive process may be automatic at several different levels. A person may not be aware of the presence of the stimulus event and still be influenced by it as in subliminal perception. A person may be aware of the stimulus but not be aware of the way it has been interpreted. Finally, a person may be aware of the interpretation of the stimulus but not aware of the way it influences his or her further behavior.

The conclusion drawn by psychological studies is that context has often an unconscious and unintended influence on peoples behavior and that this happens continuously and is triggered by all sorts of incidental elements of the environment but also by the previous memory states. On the other hand, this influence has its own internal dynamics and decreases and disappears in a short period of time. It seems very important that the previous memory state produces context effects since this maintains the continuity of the cognitive processes and prevents human thought from continuously running in leaps. It also ensures efficiency since it restricts the set of all possible interpretations, inferences, searches, etc. to the set of relevant ones. On the other hand, context effects produced by the perceptual processes are also important since they ensure that the cognitive system will be flexible and adaptive to changes in the environment.

These effects cannot be explained by postulating pre-existing and static contexts (boxes) and intentional decisions to switch between these contexts taken by the individuals. These effects require context to be considered as a continuously changing (evolving) state of the cognitive system which is not completely under its control. The fact that changes in context can take place automatically and without subjects intention and awareness is very important. If changes in context were taking place only under conscious human control, this would have raised a number of issues. For example, reasoning about contexts must also be context-sensitive and we would run into an endless meta-meta-meta-... explanation. This mechanism would also be very ineffective since the space of possible contexts is unlimited and the limited reasoning resources would have to be distributed among all these levels of reasoning about contexts.

3.2 A Dynamic Theory of Context: A cognitive approach

B. Kokinov [7, 8] developed a dynamic approach to context modeling aiming at dealing with the notion of context from the perspective of cognitive modeling i.e., how human cognitive processes are influenced by context and how this could e modeled in computer simulations. In this work, he introduced an operational definition of context, consistent with psychological studies on context effects: *Context is the set of all entities that influence human (or system's) behavior on a particular occasion i.e. the the set of all elements that produce context effects.*

The main principles of the dynamic theory of context are:

- *Context is a state of the mind*
- *Context has no clear-cut boundaries*
- *Context consists of all associatively relevant elements*
- *Context is dynamic*

All the entities in the environment which do influence human behavior are internally represented and it is the representations which actually influence the behavior. That is why context is considered as a *state of the mind* of the cognitive system. The mental representation involved in the current context are being formed by the interaction between at least three processes; *perception* of the environment that builds new representations and activates old ones; accessing and reconstructing *memory* traces that reactivates or builds representations of old experiences and *reasoning* that constructs representations of generated goals, inferred facts, induced, rules etc. It is also assumed that *context* in turn influences *perception, memory,* and *reasoning* processes (Figure 3.1).

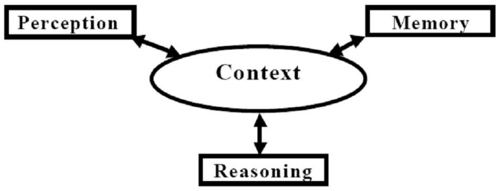

Figure 3.1: Interaction between context and cognitive processes [8]

When performing experiments on context effects on letter recognition or problem solving, specifying which objects belong to the context i.e., have some influence in the corresponding cognitive process has proved to be very difficult. This has lead to the conclusion that rather than defining clear-cut boundaries between the problem representation and its context and between context elements and neutral elements (elements that do not affect behavior), it would be better to consider that context has no clear-cut boundaries i.e., *to consider context as a fuzzy set.*

In a realistic problem solving situation it is impossible for the reasoner to test the causal relevance of all the possibilities since explicit knowledge about most (or all) possibilities will be unavailable a priori. People, however, have an intuitive idea (and approximate) of the relevance of the elements of a situation even before there is any possibility of formal analysis of the situation and sometimes even before the goals are defined or made explicit. In this way associative relevance can be considered as a preliminary and approximate estimation of the relevance of all representations (all memory elements) to the whole context. Associative relevance is defined with respect to the whole context and is measured by the degree of connectivity of the element in question with all other elements of that context. Associative relevance is by definition graded because it is clear that all elements are somehow related to each other, so it is the degree of connectivity that matters.

Associative relevance guides the problem solving process and the higher the associative relevance of an element is the deeper is its influence on the reasoning process. Thus, *associative relevance of the context elements* is an appropriate measure for their membership to the context. The causal relevance, which is defined with respect to goal, plays a secondary role in problem solving, mainly for explicit reasoning about a particular, picked out possibility and in a posteriori explanation of the reasoning process.

Context changes when the reasoning mechanism changes the goal or produces a subgoal. These changes are however, relatively rare and occur in discrete steps. The perceived and memorized contexts are much more dynamic. The environment changes continuously as well as the active perception allows for discovering new elements in it. The memorized context is also dynamic: typically, the influence of an element from the "previous" context on the behavior of the cognitive system in the "current" context decreases with the course of time. Thus, from a cognitive standpoint, *context is dynamic and continuously evolving.*

The context model described in this section was implemented through a cognitive architecture DUAL, consisting of many agents whose collective behavior produces the global behavior of the system. Each agent is a hybrid (symbolic/connectionist) processing device. Its symbolic part takes part in an emergent global symbolic computation processes, while its connectionist part takes part in an emergent global process of spreading activation. All agents work in parallel. The symbolic part of each agent perform its task at a speed proportional to the activation level computed by its connectionist part. Agents with an activation level below some specific threshold, do not perform any symbolic computation.

Chapter 4

Sociological perspectives

The notion of context has also been studied by disciplines of social sciences. Sociological research on context has produced several theories that have become increasingly relevant for other research areas such as Human Computer Interaction (HCI) and Computer Supported Collaborative Work (CSCW). These areas are paying more attention to the context of social interactions. This section describes the notion of context as approached from *Phenomenology*, *Structuration Theory* and *Activity Theory*.

4.1 Phenomenology

Seeking to improve system sensitivity to specific settings, research in context-aware computing is focusing on a view of context inspired by sociological investigations of real-world practice [31]. This work contrasts the objective account of positivism that characterizes engineering and the subjective account of phenomenology and discusses the implications of approaching context from the latter perspective.

Positivist theories derive from the rational, empirical, scientific tradition. Positivist theories seek to reduce social phenomena to essences or simplified models that capture underlying patterns. Accordingly, positivist theories seek objective, independent descriptions of social phenomena, abstracting from the detail of particular occasions or settings, often in favor of broad statistical trends and idealized models. Positivist theories are often (although not always) quantitative or mathematical in nature.

In contrast, phenomenological theories are subjective and qualitative in orientation. By subjective I mean that they regard social facts as having no objective reality beyond the ability of individuals and groups to recognize and orient towards them; in this view, social facts are emergent properties of interactions, not pre-given or absolute but negotiated, contested and subject to continual processes of interpretation and reinterpretation.

4.1.1 Positivist view of context

When regarded from a positivist point of view, the concern is how to model, represent and encode context. This perspective relies on four assumptions; (1) Context is a form of information. Thus, It is something that can be known, (2) Context is delineable. It can be defined what counts as context elements of an activity, (3) Context is stable. Although the precise elements of a context representation may vary among different activities, they do not vary among instances of the same activity and (4) Context and Activity are separable. The activity happens "within" a context. The context describes features of the environment where the activity takes place.

4.1.2 Phenomenological view of context

In phenomenology, context is regarded as an interactional problem. The phenomenological perspective argues that (1) Context is a relational property among objects or activities. The issue is not that something is part or not of the context, the issue is that it may be or not contextually relevant to some particular (2) Rather than delineating or defining context in advance, this view arques that the scope of contextual features are defined dynamically, (3) Context is relevant to particular settings, instances of action and particular parties of that action and (4) context and activity are not separable i.e. context is embedded in activity and arises from it.

This view of context leads the author to the proposal of an interactional model of where the central concern is to answer the questions of how and why, in the course of their interactions, do people achieve and maintain a mutual understanding of the context for their actions? Under this perspective, the focus moves from context representation to context support.

4.1.3 Implications for systems design

The author also illustrates three examples that embody aspects of the phenomenological approach to context:

Systems that display their context. The phenomenological approach draws attention to the way users of computer systems need to interpret the state of the machine in order to determine appropriate courses of action. This leads to consider how a system can display aspects of its own context i.e., its activity and the resources related to that activity. The goal is to allow the system to reveal a richer picture of activities, and so provide users with a more nuanced interpretation of the meaning of the system's action. An example application domain is the security of networking systems. Current work is researching on visualization techniques that can provide users a dynamic understanding the security configuration of their systems.

Architectures for adaptation. One of the consequences of information systems incorporated into different settings is that they are adapted to the different setting in which they are used. Using the phenomenological approach, the systems's own structure and action become available as context for making decisions about adaptation and configuration of device resources.

Structures in information spaces. In information work, the meaningfulness of information for people's work is often encoded in the structures by which that information is organized. The phenomenological view draws attention to the ways to provide information workers with interfaces that give them a direct experience of the structures by which information is organized. This style of interaction has three benefits. First, users interact directly with the information objects rather than with abstract structures under which those objects are organized. There is no separation between two levels of control. Second, structure emerges in the course of a users' interaction. Third, in a collaborative setting, users negotiate the information's organization, incrementally building on each other's work, enabling the creation of a collective organisation for information reflecting their immediate needs, concerns and understandings.

4.2 Structuration Theory

The apparent contradiction between objectivism and subjectivism positions is denied by Structuration Theory [4]), which seeks a balance between both positions. According to the author, those influenced by phenomenology found several shortcomings on objectivism, but they in turn veered too sharply towards subjectivism, putting the conceptual divide between subject and social object yawned as widely as ever. Structuration theory is based on the premise that this dualism has to be reconceptualized as a duality and aims to formulate a coherent account of human agency and of structure. A essential theme is time-space: the structural properties of social systems exist only when particular forms of social conduct are reproduced chronically across time and space.

This theory acknowledges that society is not created only by individual subjects. Human agents or actors have the capacity to understand what they do. This reflexive capacities are (1) largely carried tacitly and (2) involved continuously with the flow of day-to-day conduct in the contexts of social activity. The routine is a basic element of day-to-day social activity. It produces conventions and positioning of actors and contexts of social interaction relative to one another. Since social interactions are situated in time and space, they can be examined in relation to the locales through which these interactions take place. Locales are settings of interaction (interaction contexts) that are used chronically -and largely in a tacit way-by social actors to sustain meaning in communicative acts. The repetitive nature of day-to-day life, the routinization of activities and the situated nature of actions and interactions leads to the patterning of social relations in time-space involving the reproduction of social practices.

For Giddens, social relations have two dimensions; (1) action i.e. the *observable* patterns of behavior in time-space that involve the reproduction of social of situated practices and (2) structure i.e. the *unobservable* rules and resources recursively implicated in such reproduction [5]. [1]. Structuration is the process of producing and reproducing social structures through the daily activity of social actors.

Structure is regarded as *rules* and *resources* recursively implicated in social reproduction. Structure is out of time and space and marked by the absence of the subject. But it is not external to the subject since it is saved as memory traces. The social systems in which structure is recursively implicated, comprise the situated activities of human agents, reproduced across time and space. Social systems do not have structure, rather they exhibit 'structural properties' only in its instantiations in such practices. Thus, structure is visible through discernibly similar social practices to exist to varying spans of time-space.

There are several types of rule usage; to describe habits or routines, constitutive i.e. for the constitution of meaning and regulative. The latter are closely related to sanctions. Resources refer to the modes whereby transformative relations are incorporated into the production and reproduction of social practices. Resources can be of three types; signification, domination and legitimation [5]. Signification resources allow the formation of meaning during an interaction. Domination resources are deployed to bring power into the interaction and to influence its outcome. Legitimation resources are brought into play in order to bring authority and to sanction. All three elements are present in communication in a totally interwined manner. (Figure).

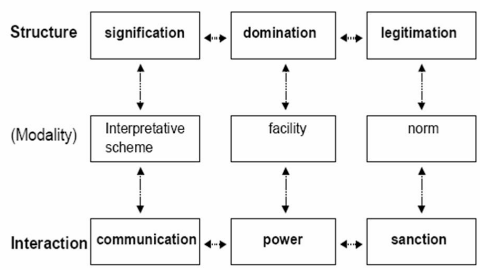

Figure 4.1: Structuration Theory [4]

One of the main propositions of Structuration Theory is that the rules and resources drawn upon in the production and reproduction of social action are at the same time the means of system reproduction. For, example to explain the rule defining checkmate, is to say something about what goes into the very making of chess as a game. On the other side a rule defining at what time workers must clock in, says nothing about what the work is, just how is carried on.

[1] Unobservable means comprising underlying codes that have to be inferred from surface manifestations [4]

Action and Structure are linked by Modalities (fig. 4.1). Modalities link particular types of interaction with particular structural elements. The three key types of modality are *interpretative schemes*, *facilities* and *norms*. To expand upon this scheme, the structure element relating to interpretation is signification [13]. Signification has the ability through the modality of an interpretative scheme to affect the way in which communication interactions are performed. Also, communicative actions can through interpretative schemes, change the form of signification. A simple example of this might be the way in which an email message is interpreted by the receiver and sender, leading, over time, to development of a protocol for use.

Applying the action/structure duality to organizations, actors by virtue of interaction with the organization are both constrained by it and, in a sense, creating the structure(s) of the organization. The value of structuration theory in considering information systems in organizations can be observed in the contextualist approach, which emphasizes the linkage between context and process.

4.3 Activity Theory

Activity theory (AT) was originated with the ideas of the Russian psychologist Vygotsky and further developed by Leontev [16, 22]. This theory examines collective mediated behavior directed towards an outcome, by taking activities as its units of analysis rather than individual actions. Investigating individual actions, or just two individuals sharing knowledge is only useful when it is studied within the context of an activity. Activity theory provides a way to analyze the relationship of practical activities to the broader cultural, social and physical contexts of whom they are part.

AT is a general conceptual approach, rather than a highly predictive theory. Engeström's interpretation of AT provides a model for describing and analyzing activities. The unit of analysis in AT is the *activity*, consisting of a *subject* (an individual or group), an *object or motive*, *mediating artifacts*, *actors*and *sociocultural rules*. Figure 4.2 illustrates an adapted version of Engeström's model of an activity system.

The *object* refers to the 'raw material' or 'problem space' at which the activity is directed and which is molded and transformed into an outcome with the help of mediating artifacts (e.g., a patient who is being treated or a software program that is being developed). The *subject* refers to the individual or sub-group whose agency is chosen as the point of view in the analysis. *Mediating artifacts* refer to physical and symbolic, external and internal instruments, including both tools and signs, which are used to transform the object. They can have many manifestations, like language, visual representations, cultural means, procedures, tools, machines and so forth. The *actors* involved comprise multiple individuals and/or sub-groups who share the same general object of activity and who construct themselves as distinct from other groups.

Sociocultural rules refer to the *explicit* and *implicit regulations*, *norms* and *conventions* that constrain actions and interactions within the activity system. They 'organize' the

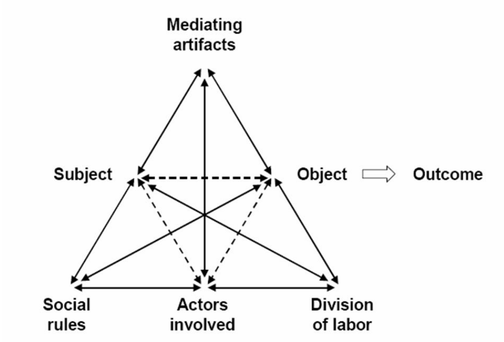

Figure 4.2: Activity Theory [22]

relation between the *subject* and the other *actors* involved in the activity, by *collective traditions, rituals, norms and values.* The *division of labor* refers to both the horizontal division of tasks between the actors involved and to the vertical division of power and status.

Two basic ideas animate AT: (1) the human mind emerges, exists, and can only be understood within the context of human interaction with the world; and (2) this interaction, that is, activity, is *socially* and *culturally* determined. These ideas are elaborated in activity theory into a set of five principles as follows:

Object-Orientedness: The principle of object-orientedness states that every activity is directed toward something that objectively exists in the world, that is, an object. The notion of an object is not limited to the physical, chemical, and biological properties of entities. Socially and culturally determined properties are also objective properties that can be studied with objective methods. For example, the intended purposes and ways of using artifacts can be objectively studied.

Hierarchical Structure of Activity: Interaction between human beings and the world is organized into functionally subordinated hierarchical levels. Leontév differentiated among three levels: *activities*, *actions*, and *operations*. *Activities* are undertaken in order to fulfill *motives*. *Motives* can be considered top-level objectives that are not subordinated to any other objectives. People may or may not be consciously aware of their motives. *Actions* are goal-directed processes that must be carried out to fulfill a motive. *Actions* are conscious; people are aware of their *goals*. *Goals* can be broken into lower level goals, which, in turn, can have lower level goals, much like the concept of goals and subgoals in artificial intelligence (AI) and other traditions. *Actions* are similar to what are often referred to in the human-computer interaction literature as *tasks*. Moving down the hierarchy of actions we cross the border between conscious and automatic processes. Functional subunits of actions, which are carried out automatically, are operations. Operations do not have their own goals; rather they adjust actions to current situations. Actions transform into operations when they become routinized and unconscious with practice.

It must be also considered that an activity system does not exist in a vacuum, it interacts with a network of other activity systems. For example, a project team (activity system) receives rules and instruments from the management activity.

Internalization and Externalization: AT differentiates between internal and external activities. The traditional notion of mental processes (such as in cognitive science) corresponds to internal activities. AT emphasizes that internal activities cannot be understood if they are analyzed separately, in isolation from external activities, because it is the constant transformation between external and internal that is the very basis of human cognition and activity.

Internalization is the transformation of external activities into internal ones. Internalization provides a means for people to try potential interactions with reality without performing actual manipulation with real objects (mental simulations, imaginings, considering alternative plans, and so forth). Therefore, internalization can help identify optimal actions before actually performing an action externally. *Externalization* transforms internal activities into external ones. Externalization is often necessary when an internalized action needs to be repaired, or scaled, such as when a calculation is not coming out right when done mentally or is too large to perform without pencil and paper or calculator.

Mediation: The emphasis of AT on social factors and on the interaction between people and their environments explains why the principle of tool mediation plays a central role. First, tools shape the way human beings interact with reality. Shaping external activities results in shaping internal ones. Second, tools usually reflect the experience of other people who tried to solve similar problems before and invented or modified the tool to make it more efficient and useful. Activity theory emphasizes that a tool comes fully into being when it is used and that knowing how to use it is a crucial part of the tool. The concept of tool in activity theory is broad and embraces both technical tools, which are intended to manipulate physical objects (e.g., a hammer), and psychological tools, which are used by human beings to influence other people or themselves (e.g., the multiplication table or a calendar).

Development: Finally, activity theory requires that human interaction with reality be analyzed in the context of development. Activity theory sees all practice as being reformed and shaped by historical development. Besides the fact that an activity is situated in a network of influencing activity systems, an activity is also situated in time, in order to understand the activity system under investigation, one therefore has to reveal its temporal interconnectedness.

Chapter 5

The dynamical dimension of context

Beyond the contrasted views on it, context possesses a time dimension that poses some problems in modeling [24]. This temporal dimension of context arises from the interactions among agents, as opposed to context as a fixed concept relative to a particular problem or application domain. That is, without interacting agents, there would be no context. In communication, the context is considered as the history of all that occurred over a period of time, the overall state of knowledge of the participating agents at a given moment, and the small set of things they are expecting at that particular moment. Context appears as a shared knowledge space. However, each entity involved in an interaction has its own context, which may or may not be consistent with some parts of the contexts of the others. It is not only important to understand the dynamics of planning and action but also the dynamics of knowledge management.

One must account for both the static aspect (knowledge that remains constant throughout the interaction) and the dynamic aspect (knowledge that changes throughout the interaction) of context. [25]. The changing knowledge of a context and the movement between contexts would be managed by independent but related mechanisms. According to the engineering viewpoint, the context is static and considered at the level of the knowledge representation. As a consequence, there is a discrete number of contexts and the interest is on the management of contexts (e.g., see the lifting and bridging rules, and the algebra on contexts above). Static contextual knowledge is attached to the domain knowledge, and thus may be described in knowledge bases. The static part of the context is what may be coded at the design time or at the beginning of a session (e.g., the file '.profile' under UNIX). With its dynamic aspect, part of the problem is linked to the changing nature of context in time. For example, the context of a problem-solving evolves from one step of the problem solving to the following one when new elements enter the context. If it is (relatively) easy to represent the static aspect of context, the dynamic aspects of context must be considered during its use, say, a problem solving. Similar results were found by Kokinov (section 3.2 for the cognitive science viewpoint.

Chapter 6

Context Applications

There are several application areas based on the notion of context. Depending on their purposes, these applications use an engineering, cognitive or sociological approach to context with varying degrees of success. This section describes some of these application areas and their current challenges. Once again, the applications were selected based on their potential contributions to this research.

6.1 Context Aware Applications

In parallel to the Artificial Intelligence community, mainly interested by computational aspects of context, another community emerges since few years [24] within the HCI research area. One goal of this community is to develop devices and systems that support person mobility and the different ways to support it. Called as Context Aware Applications, includes mobile, ubiquitous and pervasive computing. This community was originally more oriented towards the practical use of context through data such as location and time. Applications in domains such as tourism and e-maintenance were developed. For example, in tourism, the idea was to provide tourists with real time-information, context being here mainly tourist's location and request time. Means for interaction were mobile phones, PDA, fixed, information dispenser of FM radio. Weakneasses of this kind of orientation were threefold (1) context limited to time and location without tourist information (e.g. from a tourist model), (2) no consideration for the dynamic dimension of context and (3) only equipment-based.

These limitations suggest a deeper role for context in interaction. The sociological perspective of context argues that facts and actions acquire meaning in the context where they take place [30]. Context, not only physical but also the organizational and cultural context plays a critical role in shaping action and also in providing people with the means to interpret and understand action.

6.1.1 Challenges

Users' needs are often intangible, affected by habit, self-image, and even issues of motivation (i.e. a person might be more efficient in the morning than the the evening) [27]. The design of a system should analyze what can be know about a user and how to support that information with task, user, and system models. The user must play an active role in the definition of the context about which the system must be aware of.

In order to save time, organizations specify procedures beforehand. Users either conform to procedure or deviate from it for several reasons, even if the process is mandatory. Practices encompass what users do with procedures. When procedures and practices tend to differ as in medicine, the notion of context is very important.

For these reasons, context must be made explicit. This entails a richer context providing more information than time and location. In the example of tourism, the objective is to provide information with real-time information encompassing environmental, temporal, external factors (weather, on-going events) and above all, tourist's interests. One important issue is related to context identification. due to the context dynamic dimension.

Making context explicit allows data, information and knowledge to be structured in order to facilitate the user's navigation (e.g., at each time, present the minimum number of relevant items). However, a computer system can do more by dealing with individual contexts and interaction contexts among users: the system can "learn by interacting". For example, when a tourist is in a street, the system can warn and propose alternatives, by recall of memo with respect to the location (buy bread before to go home). Moreover, having support the operator in the accomplishment of a task may help the system to support the user in the accomplishment of other tasks. Here a system will have to make compatible the context of the task and the context of the user. A goal could be to present an ordered list of alternatives with explanations to the user.

Beyond the support that the system can bring to a user by managing his personal context in relationship to the working context, a system can also reuse its experience with a user when it interacts with other users taken individually or in a collaborative work. An important point by making context explicit is the adjustment of all users' contexts to make compatible their interpretations and understandings on a given problem even with radically different viewpoints such as a family of tourists in a city with different objectives.

6.2 Business Process Oriented Knowledge Management

Business Process Oriented Knowledge Management encompasses a set of applications aiming to integrate Knowledge Management and Business Process applications. Several motivations have been found to seek this integration, both KM and BP aim at similar economic targets like quality or efficiency improvements; both initiatives require a clear organisational take-up and strategic planning at the begin; KM and BPR require an integrated suite of motivational, organizational and technological tools; technological support for both approaches builds upon comprehensive enterprise models (organizational structure, business processes, information systems structure, etc.) [2]. Many of these applications are based on the notion of context, which comes from the engineering approach. In this section we describe some of these applications, developed by the DFKI research center.

In [11], two projects show different approaches for retrieving workflow context as a means for providing intelligent information support. After that, a comprehensive classification scheme for workflow context is be presented.

The VirtualOffice project had the goal to enhance document analysis and understanding (DAU) by using context information from business processes in which the documents to be analysed occur. The definition for workflow context for DAU purposes used in VirtualOffice: Workflow context includes all data related to a document with relevance to DAU and data required for the integration into the WfMS. The retrieval of workflow context is split into two major steps, namely context collection within workflows and context transformation into context units and storage in the context set.

The KnowMore Project aimed at the support of workflow participants dealing with knowledge-intensive tasks (kiT). With the help of workflow context, KnowMore retrieves relevant knowledge from an organizational memory (OM). This OM combines a companys information sources. The contents of these sources are modelled using formal ontologies describing conceptual knowledge. In order to provide a pro-active information support, KnowMore extend the conventional workflow context with kiT-descriptions that specify the information need as generic queries together with the responsible information agent.

The classification scheme for a comprehensive workflow context presented identifies a set of dimensions of the workflow context space that includes the basic process perspectives: function, behaviour, organization, information, and operation. Furthermore, but not assumed basic, history and causality. Additionally, several perspectives concerning more technical issues such as security or integrity. Fig. 6.1 illustrates the dimensions of the workflow context space.

The follow-up project FRODO also pursues a business process oriented knowledge management. The FRODO project is based on the premise that the context of a knowledge workers information needs is determined by three main factors: 1) the individual person, 2) his/her position in the organizational structure, 3) the task at hand. Thus, its approach is to combine user and task modeling. This project uses distributed Organizational Memories and the generic and extensible approach for classifying workflow context illustrated in fig 6.1. The FRODO architecture for business process oriented Knowledge Management amalgamates task, role and user models into a specific context for information supply.

In the research project EPOS a pro-active, context-sensitive support system to aid the user with his knowledge work, which is mostly about searching, reading, creating, and archiving of documents. In order to avoid the extra work –typical of KM initiatives–

Figure 6.1: The Dimensions of the Workflow Context Space [11]

without immediate benefit to the users,the context gathering is realized by installable user observation plugins. EPOS is based on a user's context model comprising a variety of aspects (see figure). Each aspect containing specific contextual elements.

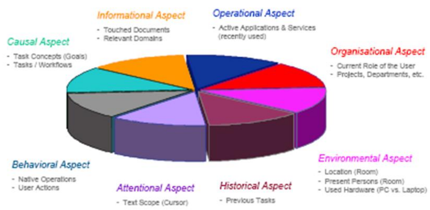

Figure 6.2: The user context in EPOS [32]

6.2.1 Challenges

According to Riss et al.[34], the current state of the art of business process oriented knowledge management is facing two main challenges:

First, although the workflow paradigm is very attractive in terms of (1) provided functionalities such as modelling and coordinating processes (in teams), (2) supporting environments for executing activities, (3) monitoring activities' state, (4) providing rich workflow context and logging mechanisms to process history for later access, classical WfMS are too restrictive for weakly-structured processes that characterize knowledge-intensive work [32]. This has motivated research for more flexible approaches for a couple of years. However, these more flexible model-based workflows require explicit and costly model adaptations.

An alternative approach, which is pursued by Computer-Supported Cooperative Work (CSCW) and their supporting applications (groupware) are mainly unstructured with respect to processes and focuses on information exchange. Neverthelesss, groupware often fails for lack of an explicit task control [10]. Therefore, they do not solve the fundamental problem.

A tool meeting the needs of business process oriented knowledge work must support structured and unstructured process parts in a integrated and uniform way. An appropriate approach is through the recognition of task patterns. Regarding tasks as actions motivated by external triggers suggests concentrating on the constituents of action like agent, goal, context, and execution as well as hypothetical and operational knowledge. The central idea is to completely record these aspects of tasks, in contrast to classical WfMS that take a good deal of this information as constant and treat it implicitly. This allows for the fact that knowledge-intensive work is characterized by high variability of all constituents. However, some of these constituents can be replaced without changing the main character of the process. An extended task management must enable effectual reuse of existing cases even if these are not identical. The first main challenge consists then, in the development of appropriate pattern identification and retrieval algorithms. Here the application of KM methods will be decisive.

A second central challenge concerns the the avoidance of additional work for KM initiatives without immediate benefit to users. The topic has been recently addressed in the project EPOS. The EPOS approach allows to learn more about a single (workflow) task fulfilment. So far, a main drawback of agile workflow approaches, such as the weakly-structured workflows is the demand of modelling efforts of users during their work. Capturing domain and process know–how does not only aim at immediate user support but also at later reuse in similar cases.

A third challenge, is a seamless integration into a personal work environment becomes especially important since a task management has to compete with email as todays most favorite structuring tool for collaborative tasks. However, mails can get lost, stay (unawarely) unanswered, or the relation between different emails and their topic can get lost. Email is also inappropriate to structure personal work since it is designed as communication tool and if it is mixed up with task management it definitely looses its lightweight character.

A successful task management that shall compete with email must decisively reduce effort and complexity of task handling to convince users. Simplicity is one of the major causes for the success of email. On the other hand, it will be complex enough to reflect real work situations including supporting multi-tasking -since handling several concurrent but unrelated tasks is mandatory- and interaction rules defined by the organization, [15]. In this regard, research on personal task management is an important complement to task pattern management. It helps to understand how knowledge workers manage their personal work in order to design user-centric applications that keep users within their electronic personal knowledge workspaces instead of using, e.g., paper notes to manage their tasks that are out of the reach of automatic analysis.

Overcoming these three challenges entails the development of rich context models to reflect. Context information can help users to recall tasks and related information, allowing smooth task switches. A comprehensive context model including the users information space, activities and related interactions is the basis for an efficient individual assistance. Context information makes task specific information retrieval more precise and improves the discovery of task patterns and other task related information. Since most tasks entail interactions among users, considering these interactions is essential to yield context information. Moreover, task activation patterns and even task-independent interaction patterns can be captured for reuse.

Issues such as context identification and exploitation must also be addressed. Environmental information (e.g. skill or resource databases, related business processes or rules, etc.) that can be provided to support users must also be specified. Users should also have the opportunity provide feedback i.e., to change or improve implicitly determined information for control purposes.

6.3 Distributed Knowledge Management

The failure of initial Knowledge Management systems, frequently deserted by users [20] led to research projects [1] that by acknowledging the subjective, social, and contextual nature of knowledge, started promoting a distributed approach to knowledge management.

This research area recognized the discrepancy between social form and technological architecture. They learned that on the one hand, most organizational and sociological studies show that the social form of most modern organizations is similar to a constellation of communities with its own languages, processes, tools, practices, while most KM systems exhibited a centralized architecture, in which knowledge was "alienated" from its original locus (the community), and stored in centralized knowledge bases (KB), used to feed an Enterprise Knowledge Portal. (right hand side of Figure 1). This led to an organizational view composed of several interrelated contexts.

Based on this theoretical framework, a distributed architecture for KM systems was designed aiming to provide a more appropriate support of knowledge-related processes (figure 2) [19]. The ideas behind this architectures were: (1) that knowledge should be autonomously managed where it is created and used, namely within each community and (2) mechanisms for inter-context coordination and matching should be provided.

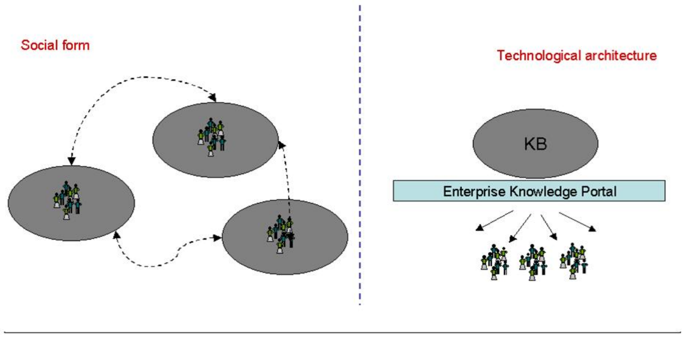

Figure 6.3: Social form of organization vs. traditional KM approach [20]

This architecture was organized in semantic contexts, implemented with ontologies. Languages for context description, classification mechanisms and tools for support of inter-context coordination and matching were developed [21, 23]. However, these developments are not business process-oriented and do not focus the context-changing dynamics of individuals at work.

6.4 Context-based Organizational Models

Based on his previous research on context, Brzillon has recently applied his theoretical framework to organizational analysis and modeling activities. In a first application case, he studies the role of context in Social Networks [28]. In this work he proposes a context-based approach of social networks and virtual communities in the enterprise area. According to the author, by making context explicit, it is possible to study the main aspects of social networks and virtual communities.

The realization of a case study showed that information circulates across contexts at different levels of granularity. Three context levels were identified; group, individual and the context of a focus of attention corresponding to the interaction context in which actors are working collaboratively (Figure 6.5). Actors share contextual elements coming their individual contexts to build collaboratively a proceduralized context for the solution in the interaction context. The group shares a contextual knowledge that is interpreted by the individuals in a proceduralized context. The focus of attention leads to the construction of a proceduralized contet at each step of its evolution. The shared context is developed along actors' interactions in or virtual community.

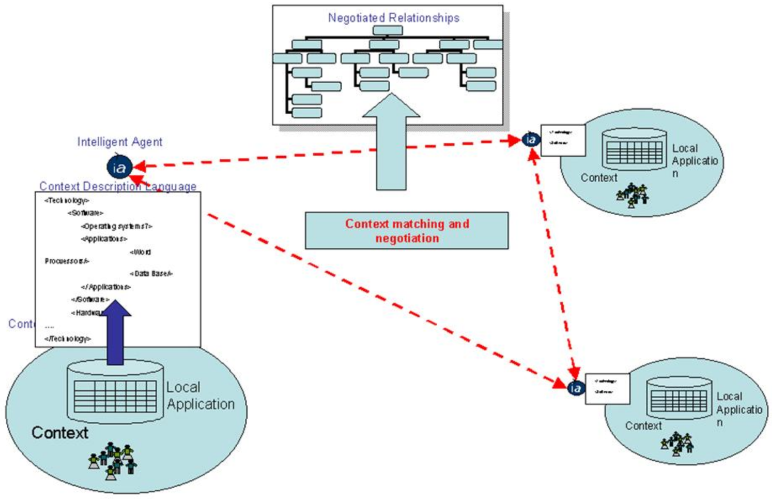

Figure 6.4: Distributed KM architecture [19]

A first result of the case study is that the explicit consideration of context could improve the collaborative-work processes in an enterprise. A second result show the interest of simultaneously considering the paradigms of context and social network when IT is at the core of the enterprise. A third result is to point out that different types of context account for the flux of information between groupss as well as inside each group. Finally, a virtual community can be considered as the contextualization of a social network. In a virtual community the focus of attention affects actors as a glue force that influence ties between actors.

A second application case presents a four-level model representing organizational structures in a decision process, including social networks, enterprises, comunities of practice, virtual communities and task forces [6]. Then it discusses how context intervenes in this four-level model and the role of context at each level. The model is illustrated in a scenario inspired by a real world application.

The four levels of the model are the *human, organization, community* and *adhocracy* level. The human level supports and encompasses the other levels at the same time. It supports the other levels because individuals are the elementary constituents of the entire model. It also encompasses the other levels, because actors in an organization, a community or an adhocracy still belong to their grass root human level. Thus, an individual simultaneously belongs to several levels but in varying degrees. A social network is a structure of the human level. It is comprised of individuals and ties of different natures. It has a flexible structure, lack of hierarchy and a socialization around individual goals.

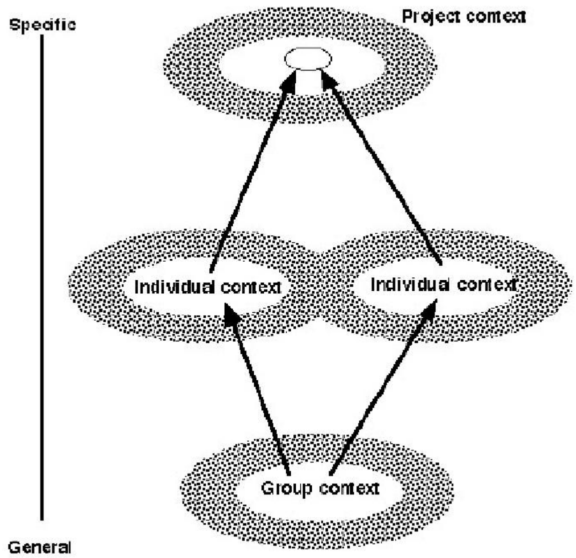

Figure 6.5: Context Granularity [28]

The *Organization* level is closely related to social perspectives. An organization is a combination of human effort in a relatively stable network of social relations. But an organization is structured around a concern related to the organization itself. Thus, it is also related to bureaucratic concepts. A *Community* level can be defined in a bottom-up fashion as a unified body of individuals emerging from an existing social network. Examples are communities of practice, virtual communities, communities of interests, etc. A community emerges when a focus on a specific domain arises among the individuals of an existing social network. The *Adhocracy* level is often used in opposition to the term bureaucracy. It describes a structural configuration that is able to fuse experts drawn from different disciplines into ad hoc project teams. Since they are a response to environmental pressure, an adhocracy is not organized around formal rules or regulations, and it does not provide standard procedures. Task forces are an example of adhocracies.

Each level is associated with a *shared context* that can be *external* or *internal.* The *external context* contains information about underlying levels and environmental information. The *internal context* is interwined with the generation factor of the corresponding level. (discriminating factor, vision, focus, or mission). At the *human level*, individuals retrieve information explaining how to behave in the social network. However, this shared context contains very general pieces of contextual knowledge that individuals cannot transform directly in a proceduralized context for their individual contexts. For example, a piece of contextual knowledge in a society could be any individual must pay taxes, but the relationships for the individuals between the taxes they pay and the actual administration of funds is not immediately perceived. Moreover, all individuals are not equal with respect to the amount they are taxed.

At the *organization level*, the *internal shared context* grows continually during the lifetime of the organization, building what is called the organization memory. Its contents are very varied and include all the knowledge related to the organization. At the *community level*, the internal shared context allows a strong interaction that facilitates information retrieval by any actor of the community and speeds up the briefing of new members. *Contextual knowledge in a community represents specialized knowledge.* As a consequence, actors in a community frequently use a highly technical language, knowing that other actors will understand it immediately. This specialized language (or shared context) allows the maximization of the communication bandwidth between actors of the community. Moreover, its understanding can be seen as a kind of barrier to entry for new members. Finally, at the *adhocracy level*, the *internal context* is created and developed on the fly during the setting-up of the adhocracy. The social pressure within the enterprise on the adhocracy makes this internal context rich (large access of the adhocracy to the resources of the enterprise, for example) and gives a strong cohesiveness to the group.

6.4.1 Challenges

The view presented on the first application case is a challenge. First, the view of a virtual community as a contextualization of a social network to address a given focus of attention is not usual in the literature. Second, the evolution of a focus of attention is described as a series of contextualizations of a social network for dealing with different steps of the global focus of attention. Three, a large project (e.g. an European project) can lead simultaneously to the birth of several virtual communities acting in parallel on parts of the problem to solve (e.g. the work packages). Indeed, it seems that it is not good to concentrate on virtual communities for a comparison with social networks.

The model presented in the second application case intends to overcome the limitations found on the previous case. However, the proposed paradigm still suffers from a number of limitations. In particular, it does not consider the sociological aspects related to the dynamic reshaping of organizational structures inside the company. It is obvious that a dynamic model of organization is socially transformative and its impact on the relationship between workers and work organization should be analyzed from the perspective of the sociology of work.

Another goal of research seeks to leverage the proposed model in order to infer a framework of technology support adapted to the different organizational structures. We believe that each level of the proposed model can benefit from a different kind of support technology (for example, decision support systems (DSS) at the ad–hocracy level, computer supported collaborative work (CSCW) at the community level, management information systems at the organization level and office automation tools at the human level). Bringing these different categories of systems into a coherent framework could be a valuable contribution to the field of systems integration.

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