# Context Framework - an Open Approach to Enhance Organisational Memory Systems with Context Modelling Techniques

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## Abstract

Researchers from various fields (among which are Artificial Intelligence, Computer Supported Co-operative Work, Information Retrieval, Software Engineering, and Knowledge Engineering) try to address issues in Organisational Memories (OM). Many of these approaches also identify the meaning of context for information captured inside an OM. Up to now context has not been modelled explicitly as part of an OM. This paper gives an overview of different approaches in OM research and proposes research for recognising, modelling, and retrieving contextual information as part of the OM. The main question behind the presented approach is whether knowledge about the creation or usage context of any piece of information within the organisational memory and knowledge about the current context of any organisational member may be used to effectively enhance the individual's access to organisational information.

## 1 Introduction

Context has been recognised by a wide range of researchers as being an important concept to consider when looking at the meaning of information. Psychologists perform memory tests to analyse the effect of context for the remembrance of words [Sri 1997], Researchers in the machine learning area investigate the effects of context on the automatic learning of concepts and deliver promising results [MK 1996], Organisational Research people use communication models to investigate the role of context in information product evaluation [Mur 1996], and cognitive scientists stress the importance of context for human expertise (and consequently machine expertise) [Rac 1997]. Some philosophers even deny the existence of a context-independent meaning of concepts [Hei 1962].

Even though context is recognised as being very important, research concerning context (especially in the area of organisational memories) is in its very early stages. It is not yet agreed in the scientific community what context is and which elements of context are important within organisational settings. It is still an open field how to represent contextual information and how to use contextual information for reasoning purposes.

This paper gives an overview on the state of the art in organisational memory research with a special focus on the concept of context and develops a framework on how to recognise, represent and use contextual information within an organisational memory application.

The main question behind the presented approach is whether knowledge about the creation or usage context of any piece of information within the organisational memory and knowledge about the current context of any organisational member may be used to effectively enhance the individual's access to organisational information. Gathered contextual knowledge may be used to automatically offer information related to the current context (by identifying similar contexts and information created within). Retrieval techniques may be enhanced by extending queries with explicit information on past contexts.

## 2 State of the Art in Organisational Memory & Context Research

Generally, an organisational memory (OM) comprises the complete knowledge of an organisation collected over the time of its existence. It consists of personal memories of people working in the organisation (i. e. their knowledge, experiences, expertise), document archives (both electronic and paper-based), and all further relevant pieces of knowledge that are important for organisational success. In this paper we will use the term organisational memory in a more restricted form: OM is seen synonymously to computerised organisational memory applications. The goal of such applications is to capture knowledge or information within an organisation and distribute it to the workers who need it. It is the overall goal of organisational memory systems to *improve the competitiveness of an organisation by improving the way in which it manages its knowledge* [HSK 1996].

In the following sections we will review several



**Proc. of the Third Int. Conf. on Practical Aspects of Knowledge Management (PAKM2000)**
**Basel, Switzerland, 30-31 Oct. 2000,** (U. Reimer, ed.)

http://sunsite.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-34/

approaches to OM stemming from very different research directions and following different goals. We review these approaches with respect to their notion of context. Table 1 summarises these reviews defining the underlying contextual features and models.

### 2.1 Help Systems

One of the first published OM systems was Answer Garden (Ackermann, [Ack 1994a], [Ack 1994b], [AM 1990], [AM 1996]) which aimed to provide a continuously growing repository of hierarchically structured questions and answers including communication means to route unanswered questions to domain experts. Goals of this approach were to *make recorded knowledge retrievable and to make people with knowledge accessible* . Later versions of Answer Garden were expanded with regard to the use of different means to get questions answered: browse through previously answered questions, chat, news groups, help desk, etc. The external communication means were used only to put questions there, they were not used to retrieve or archive previously answered similar questions.

Ackermann identifies contextual problems within OM by showing a trade-off between too much (non generalisable) and too little (non understandable) context information. His idea is to ”strip away” contextual information from documents stored within the OM to identify the general (= reusable) part of it and to provide explicit contextual information in a simple form (such as submission date and author).

The use of one (dynamically growing) categorisation hierarchy (i.e. a question hierarchy) classifying questions and answers makes retrieval using Answer Garden difficult as it does not allow different views on the categorised information. Every user, regardless of his/her context, expertise, interest, etc. viewed the same answers to the same questions using the same hierarchy (that, needless to say, grows a bit unmanageable in time). The question & answer based approach makes Answer Garden a tool to be used in helpdesk applications rather than in general OM applications.

### 2.2 Computer Supported Co-operative Work

Some approaches to OM have been reported from CSCW research. OM in these areas often is called *group memory* underlining the informal character of supported user groups. One approach that archives e-mail communications (Knowledge Depot) is reported in [KZR 1997] and [ZS 1997]. This work identifies the concept of ”Project Awareness” which comprises the awareness of discussions, decisions, and changes during project work. Knowledge Depot organises the group memory into dynamically refinable hierarchical sections (just like Answer Garden) and classifies incoming e-mails based on subject-line keywords. Users may now browse through the archive or trigger selected sections to be automatically informed about incoming mails or search the archive using keywords. If the user community agrees on a subject naming policy, these subject lines may contain contextual information describing the message content, thus allowing contextual organisation of messages.

A second approach (Project Compendium, also reported in [ZS 1997]) is aimed to capture formal documents (e.g. project reports). Project Compendium creates/maintains a hypertext space of documents of different formats/origins allowing to associate documents with each other. This hypertext space serves as a basis for ”Conversational Modelling”, a technique that is motivated by the observation that modelling tasks performed by teams consist to a great extent of discussion, argument, brainstorming, etc. From a different perspective these hyperlinks may also be seen as document context, as all links pointing to a single document can be seen as the context in which this document is embedded.

An approach that introduces explicitly contextualised information to the CSCW domain is described in [Pri 1993] (TOSCA). Here, an organisational information server that models organisational entities (people, projects, departments, tasks, ...) as interrelated objects is described. Different views may be generated on organisational information and relations between organisational objects may be followed. Presented information is always contextualised (creation context, e.g. department or project) and communication means allow contextualised discussion about & annotation of objects. As weak point of this approach one may see that explicit organisational modelling is required a priori which may lead to outdated organisational structures and context models. Another problem is that the contextualised information can only be found by users who move to the appropriate context. Thus only retrieval by ”matching context” (as opposed to the explicit retrieval of documents in a certain context) is supported.

### 2.3 Artificial Intelligence, Knowledge Engineering, Knowledge Management

An approach to an OM for knowledge workers that tries to *capture the history of decision processes* is presented in [Buc 1997]. The author characterises knowledge work using a definition of tame and wicked problems and offers an approach for argumentation visualisation. The history leading to a decision provides the context in which this decision is made. A drawback of this approach is that the visualisation of even a simple decision may look quite complex. This problem increases with complex decisions, where many people are involved. It also requires discussions (and consequently decisions) to be explicitly documented using the presented approach, which leads to additional effort and cognitive load.

Van Heijst, van der Spek, & Kruizinga [HSK 1996] define corporate memories as *an explicit, disembodied, persistent representation of the knowledge and information in an organisation* that should support the basic knowledge processes (develop new knowledge, secure new and existing knowledge, distribute knowledge, combine available knowledge). They aim to develop a *knowledge pump* , i.e. a corporate memory that allows active collection and distribution of knowledge. They propose the use of knowledge profiles for every user as to

identify relevant knowledge objects within the memory. These profiles which can be seen as simple context models are manually constructed and maintained by the users themselves (which may be seen as the weak point of this approach: the maintenance effort may be eschewed by the users).

In [ABHKS 1998], [AAST 1998] & [BHS 1998] OM is seen as an *enterprise-internal application-independent information and assistant system that integrates various techniques and tools to support knowledge management* . The presented approach is based on enterprise-, domain-, and information-ontologies used to classify the archived information where the enterprise-ontology classifies contextual information, the domain-ontology classifies information content and the information-ontology classifies structure. The enterprise ontology may be used to generate a context model for classified information that describes the organisational context in which the information has been created. As context modelling is not the main focus of this research only organisational context is regarded here, which itself is reduced to a process oriented context view.

[Schwa 1998] proposes the use of user centric meta knowledge in organisational memories by enhancing plain text e-mails with links to appropriate concepts within the OM. In this approach the OM is considered to comprise two parts: a knowledge base containing organisational knowledge and meta-knowledge used to process the knowledge. Meta-knowledge is considered to be user centric and is used to identify relevant concept descriptions in the form of user-profiles and shared semantics. User-profiles are used as more or less static user information (regarding e.g. position, current & past projects, ...) while shared semantics are concept descriptions that a user can ascribe to or not. All users who ascribe to the same description of a concept are believed to share the same view of that concept. In this approach users are required to actively ascribe to concepts which have to be defined a priori. Thus it is questionable whether in an environment of ever increasing amounts of concepts users are willed to keep their concept views up to date.

In [MSPK 2000] a knowledge management approach is described that uses ontology-based domain modelling techniques. The used ontology allows inheritance and instance-of relations to be modelled. It is built on concepts and instances and allows attribute-based, concept-based and text-based queries. Documents are manually enriched (contextualised) with concepts from the domain model. In the presented modelling approach only instance-of and inheritance relations are supported. Especially containment and general association relations are missing. Furthermore the underlying definition of context is not clearly stated. The enrichment of documents with domain concepts is simply called contextualisation.

A comprehensive survey of knowledge engineering approaches may be found in [SBF 1998].

### 2.4 Information Retrieval, Text Filtering

The information retrieval community has also been grappling with problems of OM. [KO 1997] offers a matrix-based information retrieval approach to OM document retrieval and resource allocation using relevance ranking and associative retrieval. The idea behind this approach is to identify all relevant concepts (terms) in a domain and set up a concept vector. Every document is then represented by a relevance vector d with |d| = #concepts resulting in a matrix. A single entry in this matrix denotes the occurrence of concept i in document j. Matrix operations allow the calculation of ”similarity measures” between documents and the ranking of documents with respect to certain concepts. An interesting aspect of this approach is that the ”document similarity measures” allows the ranking of documents as relevant even when they don't contain the queried terms. The calculated matrix implicitly relates all concepts and thus provides a context for each possible search term. The a priori definition of relevant concepts may be seen as shortcoming of this approach which may lead to maintenance problems in dynamic environments.

A further approach from IR research focusing on the use of context is described in [Gök 1999]. The proposed research utilises Machine Learning techniques to learn user context by observing subsequent queries. An existing ”ContextLearner” component (of which no further details are provided) shall be used in this project. A major difference between context approaches in OM and IR is that IR systems (as the nature of things demands it) only regard the user context at retrieval time, while OM offers the possibility to enhance the contained information with context. Another issue is that an IR system cannot make any assumptions about the users work environment while an OM will usually be embedded into an organisation's work environment which may provide rich context information.

### 2.5 Organisational Learning

An approach that covers personalisation issues in OM research is presented in a research proposal [FOS 1997]. The authors try to investigate three main OM issues: *how to capture knowledge; how to sustain timeliness & utility; and how to deliver actively and adaptively* . Their research aims to support software development groups and is based on results of a previous project [Lin 1996] where complexity in design is analysed (concerning the synthesis of different perspectives, the increasing amount of information relevant to a design task and the understanding of previous design decisions). A framework for a group memory feedback loop is presented that tries to tackle two disparate goals: support for the current design work at hand & support to record information for future reuse. GIMMe (Group Interactive Memory Manager), an e-mail-based tool to capture, store, organise, share and retrieve conversations is presented. Similar to [KZR 1997] GIMMe organises e-mails according to their subject lines.

### 2.6 Software Engineering

The Software Engineering community also offers

approaches to KM and OM problems. Maurer & Dellen [MD 1998] present an approach for process oriented knowledge management where information need and knowledge provision are dependent on the process context. Their approach is related to the ”experience factory” approach [BCR 1994] that tries to package software development experience. Maurer & Dellen present a process modelling approach that connects documents to processes instead of using formal classification & retrieval methods. While the connection of documents with process states offers interesting retrieval capabilities it is also the weak point of this approach: only the exactly matching process context will provide the right information, no explicit context model is maintained that might allow similarity measures and no context-free retrieval (e.g. using keywords) is supported. The idea behind this approach is quite similar to the already discussed approach in [Pri 1993], where organisational structures are used instead of software engineering process models to identify context.

### 2.7 Workflow

[Wol 1997] offers an approach to use explicit enterprise models to circumvent the drawbacks of standard information filtering methods in the distribution of corporate information. This quite interesting approach to precise information distribution based on enterprise models (thus providing some usage context) is limited to organisations with explicitly modelled, stable and reliable communication structures and responsibilities. In this approach information items get distributed within an organisation based on the organisational roles that people have and their relations to the organisational process that created the information.

Another work focused on highly structured application domains (here: insurance companies) is [Rei 1998], where the author tries to combine (integrate) several knowledge bases using knowledge formalisms. Their understanding of OM is based on the perception of two roles: *(1) OM acts as a passive container for relevant organisational knowledge; (2) OM acts as an active distributor for information needed in the task at hand.* To reach the second role the author states, that the OM needs to know what the user is currently doing. He thus proposes the integration of OM with a WMS which provides process context.

An approach that tries to put dynamics into the context based information distribution of OM is presented in [WWT 1998]. The authors try to integrate OM with an evolutionary workflow management system. The WMS stores completed processes in a case base providing access to best (and worst) practices and lessons learned (inner feedback loop: learning how to optimise process execution) and providing the possibility to reflect on process models and modify them (outer feedback loop: learning how to improve process models). During execution of processes and tasks the WMS gives access to task specific documents and information items. An ”out of context” information need, that exists outside a modelled process is not supported by this approach. Also, it limits context to the notion of ”current workflow task”-context and ”reflection on workflow”-context.

Another approach of integrating OM and WMS is presented in [KS 2000]. The central idea is the explicit representation of *mnemonic processes* (i.e. processes to create, use and maintain knowledge) as business processes. The underlying hypothesis is that business processes involving people and technology form that part of the OM promising best utilisation of resources. Consequently, capturing and accessing OM should concentrate on these processes. The presented work adopts Takeuchi and Nonaka's modes of knowledge conversion (socialisation, externalisation, combination, and internalisation) and outlines the following process: identify core business processes; identify corresponding people and agents; get descriptions for processes by process members; use mnemonic process knowledge creation to externalise process, agent, and tool representations; empower people in training sessions to use the system; and finally run the system to build knowledge. The modelling approach in this work is based on the identification of business process models as primary objects and the identification of knowledge creator, knowledge user, expert, and knowledge administrator as knowledge agents. Context is not explicitly mentioned here but as business process models can be seen as context models for business process execution it seems clear, that explicitly but manually created context models are maintained by this approach.

### 2.8 Virtual Enterprise

A virtual enterprise (VE) is an organisation comprising different people of different (physical) organisations to reach a dedicated goal in a limited period of time. As such a VE is comparable to a project consortium. After the goal is reached, a VE stops to exist. Approaches that try to support VE and research communities with OM technology can e found in [DCGR 1998], [RM 1998], & [GS 1997].

Based on a corporate memory typology offered in [DCGR 1998], [RM 1998] offers an analysis of the CM need of a VE exemplified for the domain of concurrent engineering (CE). Two levels of tasks in concurrent engineering are identified: individual design and co-operative evaluation. To support these tasks a corporate memory designed for a VE should be composed of a profession memory (capturing knowledge about people, expertise, professions), a project definition memory (capturing requirements & results), and a project design rationale memory (keeping components, conflicts, problems, solving methods, arguments).

Some open issues remain unanswered (and even unidentified) by the authors: Why should one set up an OM for a limited period VE when the effort of creating and maintaining an OM only pays off in the long run? Which members of the VE own the OM? The members of a VE may have the same strategic goal but do they share the same interest? Do they want their expertise to be shared with other VE members?

An approach that is oriented towards the support of

research communities is presented in [GS 1997]. Though research communities are no virtual enterprises they share some commonalties: distributed over the whole world, working in closely related areas, interested in fast and efficient knowledge exchange. [GS 1997] proposes knowledge management through capturing of live events (such as conferences) in hypermedia (WWW, CD-ROM, ...). Papers presented should be enriched by video captures of presentations. Electronic conference proceedings could then benefit from the technological advantages of linking text documents with picture, sound, and video material.

### 2.9 Our Previous Work - Information Brokering and Organisational Memories

In a previous project (COBRA - Common Open Brokerage Architecture, [KK 1999], [SMDP 1998]) we aimed to support the work of professional information brokers with specific information systems. We built an organisational memory system (called bizzyB) supporting them in their daily work by integrating customer, case and profile management with automatic information retrieval from various heterogeneous information sources.

The information objects a broker has to deal with (namely customer data, case data, profile data, and dossiers built from retrieved information) were organised along their context of use. A broker working with a customer's profile could then for instance easily access all automatically delivered information for this profile. During the evaluation phase of the COBRA project this context-based information organisation proved to be a useful concept. The underlying model of context used in this approach was a priori modelled and based on our analysis of the working situation of an information broker.

In bizzyB we did not use automatic context observation techniques. Rather the user had to explicitly „move“ to the desired context instead of the system recognising it. This again proved to be useful for our application domain, as the set of different contexts the user community covers is reasonably small.

One of the disadvantages of not using explicit context models was that the system could not perform any kind of reasoning on context similarity. The user had to remember herself, that she has already been in a similar context and move to it in order to reuse information already created. Another problem was that the approach was not very flexible: a change in the work environment had to be reflected in software changes. Furthermore in this approach we only regarded process-oriented context information, while ignoring other probably important contextual dimensions.

In a previous paper [Kle 1999] we already presented first ideas towards the design of a context enhanced organisational memory. In the following we will build on these ideas and present latest results.

In an other paper (see [JKN 2001] ) we offer an information brokering centred view on knowledge management. There we identify contextualisation as an important task that annotates information with contextual information (domain knowledge and situational characteristics) in order to evaluate its relevance in a given situation.

## 3 Context Modelling

In this section we will show some theoretical backgrounds of our context modelling work and motivate the underlying goals. We will then use the results from the state of the art review to derive context modelling requirements.

### 3.1 Background and Goals

Knowledge management is concerned with *data*, *information* and *knowledge*. Following Alavi and Leidner [AL 1999], we define *data* as raw unstructured symbols (such as text and numbers). *Information* is defined as processed, *conceptualised* and *categorised* data. *Knowledge* is information that is made actionable by being *contextualised* and *personalised*. The three levels and their transitions are shown in fig. 1.

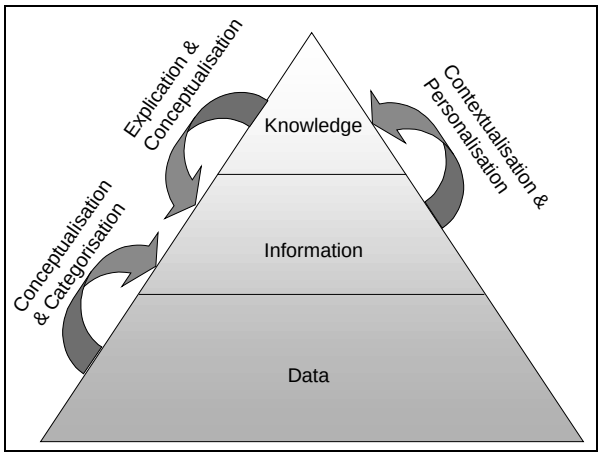


Figure 1. Data, information, and knowledge

An organisational memory aims to support the efficient and effective sharing of organisational information and knowledge. To address issues like information overload, it is necessary to condense any information given to a certain person by personalising and contextualising it. This paper covers the problem of supporting contextualisation and personalisation through explicit and comprehensive context modelling techniques. We strongly believe that context modelling techniques help to decrease an individuals information overload by delivering a decreased amount of information of higher quality (where we define the quality of information as its usefulness within the current context).

### 3.2 Requirements

Table 1 summarises the reviews from the previous sections with respect to the identified contextual features and the underlying (implicit or explicit) model of context. Many approaches recognise context as being a concept of major importance. But as no consensus on what context is exists in the research community we can observe that

Table 1. Context Features and Context Modelling.

| ***Work*** | ***Feature taken as context*** | ***How context is modelled*** |
|---|---|---|
| [Ack 1994a] | Simple features like submission date or author | Manually provide simple meta-information |
| [KZR 1997], [ZS 1997] | Content descriptors provide context | E-mail classification & hypertext for "conversational modelling" |
| [Pri 1993] | Creation context of entities (department, project) based on organisational structure | Annotation as contextualisation |
| [Buc 1997] | History of decision processes | Argumentation visualisation |
| [HSK 1996] | Employees knowledge descriptors | Manually constructed knowledge profiles |
| [ABHKS 1998] | Organisational structure | Enterprise ontology |
| [Schwa 1998] | User centric meta-knowledge | User profiles & shared semantics |
| [MSPK 2000] | Domain concepts from domain ontology | Domain ontology; manual concept selection |
| [KO 1997] | Concept relations | Matrix-based relation calculation |
| [Gök 1999] | History of IR system usage | Learned through machine learning |
| [FOS 1997] | Conceptualised e-mails | Conversation modelling |
| [MD 1998] | Processes to which documents are linked | Process modelling |
| [Wol 1997] | Organisational roles and process relations | Enterprise modelling |
| [Rei 1998] | Workflow process context | Integration of OM and WMS |
| [WWT 1998] | Workflow process context | Evolutionary WMS |
| [KS 2000] | Knowledge creation & use processes | Business process models |
| [GS 1997] | Captured live events related to papers | Association of papers and multimedia data |
| [KK 1999] | Information Brokering Process | Process Modelling and Process Context Visualisation |

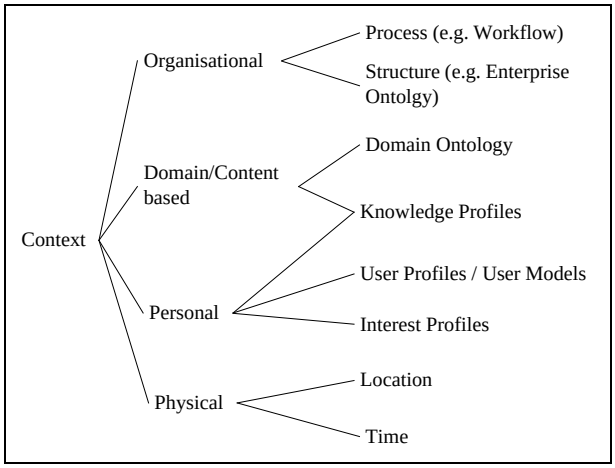


Figure 2. Context Typology

every approach focuses on a special aspect of context.

Based on the different aspects of context being modelled by different approaches we found in the literature and based on our own experience, we have defined a context typology for working contexts as depicted in figure 2. Most of the reviewed works concentrate on one or two of the contextual aspects presented there. We feel a strong need to look at context more comprehensively, which leads us to:

> *Requirement 1:* A context modelling framework has to identify all *relevant* contextual dimensions.

What does requirement 1 mean? Context may be defined as "*any information that can be used to characterise the situation of an entity; an entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves"* [DA 1999]. The amount of information that could possibly characterise a given situation is obviously far too big to be handled. Additionally, some potentially relevant contextual dimensions are hard to identify automatically or even hard to be explicated at all (e.g. the current personal mood or the intention behind a certain action).

Therefore we require a set of relevant contextual dimensions which:

- are of relevance to characterise a situation (i.e. it successfully allows to distinguish different situations)
- can be explicated
- can be (semi-) automatically identified

- are sufficiently small in number to allow efficient storage and retrieval
- allow the definition of a set or range of possible values of sufficient accuracy
- allow the measurement of the similarity of each pair of values for a given dimension.

While in [AMGPS 1996] organisational context is defined along three dimensions ( *organisation dimension, process dimension, space dimension* ) each of which is further hierarchically refined in [Len 1998] twelve dimensions for describing contexts are identified in the background of modelling and reasoning within real world knowledge.

We define a dimension as *relevant* if it allows to separate information into groups that literally "make sense". Consequently, "outside temperature" is probably not a relevant organisational dimension while "time" and "process" are. Additionally, a relevant dimension needs to be easily explicable to be included in the set of represented dimensions. This strongly relates to the notion of explicit and tacit knowledge [Non 1994], where externalisation (i.e. the transformation of tacit knowledge into explicit knowledge) is an essential part in the process of corporate knowledge creation. We believe, that only some parts of existing tacit knowledge can easily be explicated.

Approaches in the IR community that try to make use of context knowledge to improve retrieval results have been discussed above. They vary from long term user interest profiles (created explicitly by the user) to regarding the users retrieval history (observed automatically by the retrieval system) and similar approaches. All of these have in common that they only look at the consumption side of the information retrieval process to make use of context. The production / provision side is not considered in these approaches. For general purpose IR systems an approach to contextualisation of information at provision time would not be appropriate as producers and consumers of information are separated groups which presumably makes their context incomparable. This situation changes when we look at OM, which can be seen as special kind of IR systems. OM contain information produced and consumed by the same group of people: the members of the organisation. Thus they share the same range of possible contexts. This leads us to the next requirement:

> *Requirement 2:* In a context-enhanced organisational memory system, context knowledge has to be associated to information at production and consumption time and has to be used during information retrieval.

This requirement is based on the idea that knowledge about the current context of a user may be used for at least two purposes:

- to enhance any information currently created, modified, published, or used by the current user and
- to offer possibly useful information created, modified, or published in contexts similar to the current user's one.

Some approaches that associate information with organisational models, software engineering process models or general workflow process models have already been discussed above (see [MD 1998], [Pri 1993], [WWT 1998], & [Wol 1997]). These approaches have shown that information may be retrieved context-based (i.e. a user who is in a similar context can view, browse or retrieve the contextualised information). None of these approaches however, maintains an explicit context model that would allow additional retrieval strategies (e.g. match query & similar context, match query & complementary context, match query only, or match context only). This leads us to:

> *Requirement 3:* Context-based and content-based retrieval of information have to be possible independent of each other as well as in combination.

While the a priori modelling of contexts (and the corresponding implementation mechanisms to exploit context information in an information system) is the right approach for a domain with clearly structured work processes that remain stable over a long period of time (like information brokering), we now feel a strong need towards more flexible approaches for other domains. Also, we think that a useful system should automatically recognise the users current context, to be able to provide possibly needed information created in similar contexts immediately. Thus the fourth requirement is:

> *Requirement 4:* Automatic recognition of context should be done as well as giving users the possibility to explicitly provide context information (thus simulating a certain context).

# 4 Architecture

Based on the requirements defined above we now describe our architectural approach in more detail. Therefore we outline possible contents of organisational context models, followed by a description of our architecture giving an overview over the ContextService and ContextAgent components (see figure 3).

## 4.1 Content of context models

Based on requirement 1 and our definition of relevance of a context dimension we will now identify basic dimensions of context that we think are important for organisational context:

- A *person* is uniquely identified by an ID and/or a name. A person's context is further characterised by her position within the organisation, her roles, her skills, her interests and experience.
- A *location* a person works at is not only characterised by its co-ordinates ( *absolute location* ) but also by further characteristics as name (e.g. Room number) and function ( *type of location,* e.g. Office vs. Meeting room)
- A point in *time* may simply be described as *absolute time* but further characteristics are important for its

contextual description: e.g. something happened on a Monday morning ( *type of time* ), or something happened two hours before something else ( *relative time*)

- An *activity* describes what someone is currently doing. This is defined by the task a person has to fulfil (e.g. embedded in a workflow process), by the tools used to fulfil the task, by files opened and further characteristics

Through ontological refinement and association these basic dimensions cover all identified contextual aspects from the identified context typology in figure 1. Each of the attributes that further define the basic context dimensions can be of different types: they either are represented by primitive values (like a timestamp, an ID, or a name) or they may be represented using complex values (e.g. a categorisation hierarchy to classify organisational roles or interests). We use a fully implemented ontology-based knowledge modelling tool (Broker's Lounge, see [JKN 2001] for a detailed discussion) that offers a flexible and user friendly approach to model complex knowledge structures. The main benefit of using Broker's Lounge is, that it offers a type-based ontology-modelling approach that allows to create multi-dimensional knowledge models. We use this approach to model the relevant contextual dimensions we identified. Additionally, Broker's Lounge offers a separate knowledge structuring level (categorisation level) which we use to express similarities among different elements of the ontology. It is out of the scope of this paper to provide further detail about the underlying approaches of the Broker's Lounge environment.

### 4.2 The Context Framework Architecture

It is our aim to provide a component-based system that can be easily integrated with existing intranet-based information systems. Therefore we impose only simple requirements to the existing environment: documents have to be identifiable using URLs and these URLs have to remain stable throughout the document lifetime. A URL does not necessarily point to a pure HTML document, any other kind of document format is supported as well (as well as dynamic query URLs).

In the following we will describe two central components of the Context Framework: ContextService and ContextAgent. ContextService is a background component that manages all existing context models within the organisation and offers an API for retrieval and storage of context models while ContextAgent is the main component for handling user interaction, automatic context observation and interaction with the user's environment.

#### 4.2.1 ContextService

The ContextService component stores all known context models in a database. It is responsible for maintaining the history of context models for every user within the organisation. Furthermore it offers the possibility to

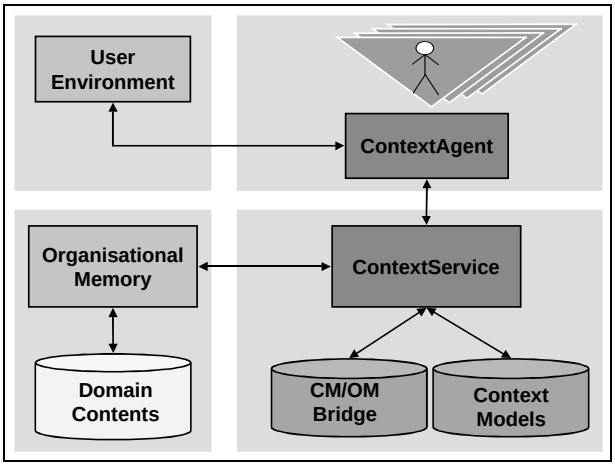


Figure 3. Context Framework Architecture

associate document identifiers (URLs) with context models.

ContextService offers an API which can be used to store new context models, retrieve stored ones, associate new document identifiers with contexts and perform context-based document retrieval. In particular, the following API functions are offered:

- similar: ContextModel -> {ContextModel $_1$, ..., ContextModel$_n$}, delivers a set of ContextModels that are similar to the given one
- getDoc: ContextModel -> {DocID $_1$, ..., DocID $_n$}, delivers the set of document identifiers being associated with the given ContextModel
- getContext: DocID -> {ContextModel $_1$, ..., ContextModel$_n$}, delivers the set of ContextModels being associated with the given document identifier
- addDoc: ContextModel, DocID -> Ø, associates a ContextModel with a document identifier, i.e. stores the ContextModel and creates an association of ContextModel and DocID in the CM/OM Bridge. The CM/OM Bridge is required to maintain the independence of ContextService from the chosen OM.

Especially the API function "similar" is of importance: it must be possible to retrieve similar context models from the potentially huge collection in an efficient way. The retrieval of similar context models is complicated by the complex nature of the models. As we have seen in the previous section, context models are multi-dimensional and each dimension may have a hierarchic (topological) structure, that makes the design of similarity measures a non-trivial task. In our current implementation we use a combination of a weighted distance measure for the final distance calculation and separate distance measures for each dimension.

The similarity measure for the time dimension is a combination of an absolute distance measure and a *type of time* similarity measure. The type of time measure tries to find structural commonalties within two points in time (e.g. both values represent a Monday morning but within different weeks). Location similarity is calculated as combination of absolute spatial distance and *type of place*

similarity. Type of place similarity calculates the semantic distance of two places (assuming that a location's semantic is its role e.g. as office or meeting room). The type of place similarity measure is based on a taxonomic description of all available types of places within an organisation. Similarity measures for persons and activities are based on semantic distance calculation of their respective taxonomic description.

While the time and activity similarity measures are independent of other dimensions, similarity measures for location and person have a temporal aspect (e.g. a meeting room becomes an office as an organisation grows and new members arrive or the position of an organisational member changes during time). This requires to take the history of persons and locations into account when measuring their similarity.

To improve the retrieval performance of our current implementation we evaluate several techniques from the case-based reasoning community (e.g. [DLTBP 1996], [RS 1998], [Scha 1996]).

By combining the API functions it is possible to create complex retrieval scenarios as e.g. document-based retrieval of documents created in similar contexts as the given one. To allow a greater retrieval flexibility further API functions are defined, that allow the manipulation of threshold values and similarity weights.

#### 4.2.2 ContextAgent

The ContextAgent component is the main point of user interaction with ContextService. It serves as intermediary between the user and ContextService, offering the following kinds of interaction:

ContextAgent may automatically observe the user's current context and recognise context shifts. To recognise the user's context ContextAgent observes the set of tools used by the user, interacts with a set of specifically designed tools like workflow management tools, information management systems, organisational memory systems, information retrieval systems, and observes names and locations of files currently worked with. Instead of relying on the automatic context recognition a user may also explicitly provide information on his current context (or any other virtual context).

When ContextAgent recognises a context shift it interacts with ContextService to retrieve relevant information from contexts similar to the current one. Results of this operation are proposed to the user in a none-disruptive manner. The user may look at the information proposed or ignore it and simply continue her daily work. On user demand ContextAgent performs the retrieval operation explicitly, either using the automatically recognised context or the explicitly user defined one.

ContextAgent makes use of different information sources to build the complete model of the user's context. By using location aware components (e.g. the ContextToolkit, [DA 1999]) and time observation precise data about the user's temporal and geographical context is gathered. Knowledge about location types (e.g. office or meeting room) may be further inferred from organisational models. Further organisational information sources (e.g. organisational people database) offer more or less stable data about the user, e.g. information about her position & roles may be collected. Information about the highly dynamic current context is more difficult to extract, as reliable, quality controlled entries in databases are no useful sources here. Sources of information are the user herself (explicitly providing contextual information), the set of tools currently used (e.g. gathered through interaction with the task manager) and additional information from some organisational database about the purpose of each tool used within the organisation, or information gathered through interaction with a set of specially designed tools (e.g. workflow management systems, information systems, organisational memory, IR systems, or even the query history of ContextAgent itself).

#### 4.2.3 Integration

The ContextService component is designed to be integrated with our Broker's Lounge knowledge management environment [JKN 2001]. This allows to combine context-based retrieval with all retrieval techniques offered by Broker's Lounge (full-text, concept-based, category-based, domain-relevance-based) to reach a flexible and comprehensive set of retrieval capabilities. Additionally, it is also possible to integrate ContextService with any kind of intranet-based information management solution, as long as it allows the identification of documents with URLs. The integration with these tools will be twofold:

Firstly, when documents get submitted to the traditional KM tool ContextService needs to know their identifier and the valid ContextModel. The process of adding a document has to be changed slightly therefore. Rather than adding a document to the KM tool directly it will be "added" to ContextService. ContextService in turn forwards the add operation to the KM tool and simply stores the identifier and the associated ContextModel. This does not require an changes to the API of the KM tool, just the corresponding ContextService wrapper has to be provided.

Secondly, queries to the traditional KM tool will also be handled by the ContextService, in order to extend or reduce the number of hits given by the KM engine. Therefore queries will have to be send to both systems and the results will have to be combined. The only thing that has to be done to provide this, is to write a query wrapper, that forwards queries to ContextService and the existing KM tool and combine the results. This integration is straightforward.

## 5 Conclusion & Future Work

We have shown the state of the art in organisational memory systems with a special focus on the notion of context. Based on our previous experience on context-based information access in the domain of information brokering we presented our requirements towards context-based organisational memories. Our approach is based on ontological context modelling, automatic context

observation and similarity measurement of different context models. We have presented the Context Framework architecture, which realises the presented ideas.

By offering a completely new range of information retrieval & information filtering methods that take the working situation of employees into account ContextService aims to significantly improve the access of individuals to organisational memory systems and through extending information with context-based meta-information it improves the way organisational information is organised.

The aim of the presented approach is to provide help to workers by providing needed information at the right time and at the right place. It is not our aim to control or supervise workers within an organisation. As this approach depends on the motivation of people to participate in knowledge sharing processes, it is important that users trust in the system. Therefore means of security have to be offered to users. It has to be assured that information is only published to others if the user explicitly agrees and is kept private otherwise. Furthermore organisational agreements are important that guarantee the privacy of automatically gathered information and that clearly define the possible range of uses of this information.

We believe that if the security and privacy concerns of individuals are respected sufficiently the approach presented can efficiently improve the information distribution within organisations.

By providing a service oriented open framework, the ContextService can be integrated with any kind of KM tool, that allows the external identification of documents with identifiers (URLs). This allows to integrate ContextService with a wide range of Intranet-based information management systems.

Currently, the implementation of ContextService and ContextAgent is in a prototypical stage. A first ContextService prototype exists that offers the defined API functionality as described above. However, the range of context models (i.e. the set of values for each of the defined dimensions) is limited in the current version. The retrieval of similar context models is not very efficiently done within the current version. We expect major improvements for the retrieval efficiency from case-based reasoning approaches.

The Broker's Lounge system, which is the basic ontology-based knowledge management toolkit [JKN 2001] for developing ContextService and ContextAgent exists as a fully implemented prototype that has already successfully been used for further applications [NKS 1998].

The implementation of ContextAgent is in a preliminary stage. Currently, the automatic context observation is restricted to the time and person dimensions of the user's context. We experiment with two components to observe location (Context Toolkit, [DA 1999]) and activity (Envoy) and plan to integrate these within our Context Framework, but for now, the user has to define the values for these dimensions of her current context.

Despite the limited implementation we have encouraging experiences from first system uses. In the near future we mainly plan to extend the current version in two directions: firstly, we want to improve the ContextService performance and context model complexity. Secondly, we want to extend ContextAgent with further automatic observation functionality which will then also offer the possibility of active context-based information provision by ContextAgent.

## 6 Acknowledgements

Special thanks go to Dawit Yimam and Achim Nick for helpful comments on earlier versions of this paper. I would also like to thank the research group at GMD.FIT for fruitful discussions and insights. Parts of this work have been funded by the EU project COBRA.

## References

[ABHKS 1998] A. Abecker, A. Bernardi, K. Hinkelmann, O. Kühn, M. Sintek . *"Toward a Technology for Organisational Memories"*, IEEE Intelligent Systems & Their Applications, May/June 1998.

[AAST 1998] A. Abecker, S. Aitken, F. Schmalhofer, B. Taitschian. " *KARATEKIT: Tools for the knowledge-creating company* ", 11 th Workshop on Knowledge Acquisition, Modelling and Management KAW'98, Banff, 1998

[Ack 1994a] M. S. Ackermann. " *Definitional and Contextual Issues in Organizational and Group Memories*", Proc. of 27 th Hawaii Int'l Conf. on System Sciences (HICSS'94), 1994

[Ack 1994b] M.S. Ackermann. " *Augmenting the Organizational Memory: A Field Study in Answer Garden*", Proc. of ACM Conf. on Computer Supported Cooperative Work (CSCW'94), 1994

[AM 1990] M. S. Ackermann, T. W. Malone. " *Answer Garden: A Tool for Growing Organizational Memory*", Proc. of ACM Conf. on Office Information Systems, Cambridge, 1990

[AM 1996] M.S. Ackermann, D.W. McDonald. " *Answer Garden 2: Merging Organizational Memory with Collaborative Help*", Proc. of ACM Conf. on Computer supported Cooperative Work (CSCW'96), 1996

[AMGPS 1996] A. Agostini, G. de Michelis, M.A. Grasso, W. Prinz, A. Syri: "*Contexts, Work Processes, and Workspaces* ", Computer Supported Cooperative Work: J. of Collaborative Computing 5: 223-250, 1996

[AL 1999] M. Alavi, D. Leidner. " *Knowledge Management Systems: Emerging Views and Practices from the Field*", Proc. of 32 nd Hawaii Int'l Conf. on System Sciences, Hawaii, 1999.

[BCR 1994] V.R. Basili, G. Caldiera, H.D. Rombach. "*Experience Factory*", J. J. Marciniak: Encyclopedia of Software Engineering, vol. 1, John Wiley Sons, 1994.

[BHS 1998] A. Bernardi, K. Hinkelmann, M. Sintek: "*Information Systems in Knowledge Management - An Application Example* ", Proc. of 1st Int'l Conf. on Practical Applications in Knowledge Management (PAKeM'98), London, 1998

[Buc 1997] S. Buckingham Shum. " *Negotiating the Construction and Reconstruction of Organisational Memories*", Universal Computer Science, 3(8), Springer, 1997

[DLTBP 1996] J. Daengdej, D. Lukose, E. Tsui, P. Beinat, L. Prophet. " *Dynamically Creating Indices for Two Million Cases: A Real World Problem* ", Advances in Case-Based Reasoning, LNAI 1168, Springer, 1996

[DA 1999] A. K. Dey, G. D. Abowd. "*Towards a Better Understanding of Context and Context-Awareness* ", Technical Report GIT-GVU-99-32, College of Computing, Georgia Institute of Technology, 1999

[DCGR 1998] R. Dieng, O. Corby, A. Giboin, M. Ribière: "*Methods and Tools for Corporate Knowledge Management*", 11th Workshop on Knowledge Acquisition, Modelling and Management KAW'98, Banff, 1998

[FOS 1997] G. Fischer, J. Ostwald, G. Stahl: "*Conceptual Frameworks and Computational Support for Organizational Memories and Organizational Learning*", Project Proposal, 1997

[GS 1997] B.R. Gaines, M.L.G. Shaw. " *Knowledge Management for Research Communities* ", Proc. of AAAI Spring Symp. Artificial Intelligence in Knowledge Management, Stanford, 1997

[Gök 1999] A. Göker. " *User Context Learning for Intelligent Information Retrieval* ", project proposal at http://www.scms.rgu.ac.uk/staff/asga, Robert Gordon University, Aberdeen, 1999.

[Hei 1962] M. Heidegger. " *Being and Time* ", Harper & Row, New York, 1962.

[HSK 1996] G. van Heijst, R. van der Spek, E. Kruizinga. "*Organising Corporate Memories* ", Proc. of 10th Knowledge Acquisition for Knowledge-Based Systems Workshop, 1996.

[JKN 2001] M. Jarke, R. Klemke, A. Nick. " *Broker's Lounge - An Environment for Multi-Dimensional User-Adaptive Knowledge Management* ", accepted for 34th Hawaii Int'l Conf. on System Sciences, Hawaii, 2001.

[KO 1997] S. O. Kimbrough, J. R. Oliver. " *On Relevance and Two Aspects of the Organizational Memory Problem*", Proc. of the 4th Workshop on Information Technology and Systems, 1994

[KS 2000] R. Klamma, S. Schlaphof (2000). " *Rapid Knowledge Deployment in an Organizational-Memory-Based Workflow Environment* ", 8th Europ. Conf. on Information Systems, ECIS 2000, Vienna, July 2000.

[KK 1999] R. Klemke, J. Koenemann. " *Supporting Information Brokers with an Organisational Memory* ", in: XPS-99, 5th German Conf. on Knowledge-Based Systems, Workshop on Knowledge Management, Organizational Memory and Reuse, Internal Report, Würzburg University, March 1999

[Kle 1999] R. Klemke. " *The Notion of Context in Organisational Memories* ", CONTEXT'99, Modeling and Using Context, LNAI 1688, Trento, Italy, September 1999, Springer

[KZR 1997] M. Kantor, B. Zimmermann, D. Redmiles. "*From Group Memory to Project Awareness through use of the Knowledge Depot* ", Proc. of the California Software Symposium (CSS'97), California, 1997

[Len 1998] D. Lenat: " *The Dimensions of Context-Space*", at: http://www.cyc.com/publications.html, 1998

[Lin 1996] S.N. Lindstaedt. " *Towards Organizational Learning: Growing Memories in the Workplace* ", Proc. of Int'l Conf. on Computer Human Interaction (CHI'96), ACM, 1996

[MSPK 2000] M. Mach, T. Sabol, J. Paralic, R. Kende. "*Knowledge Modelling in Support of Knowledge Management*", Proc. of Conf. on Research Information Systems, CRIS 2000

[MD 1998] F. Maurer, B. Dellen: " *A Concept for an Internet-based Process-oriented Knowledge Management Environment* ", 11th Workshop on Knowledge Acquisition, Modelling and Management KAW'98, Banff, 1998

[MK 1996] S. Matwin, M. Kubat. "*The role of Context in Concept Learning* ", proc. of the 13th int'l conf. on machine learning, Bari, Italy, 1996.

[Mur 1996] L. D. Murphy. " *Information Product Evaluation as Asynchronous Communication in Context: A Model for Organizational Research* ", Proc. of the 1st ACM int'l conf. on Digital Libraries, 1996.

[NKS 1998] A. Nick, J. Koenemann, E. Schalueck. "*ELFI: Information Brokering for the domain of research fundingt*", Int'l Journal of Computer Networks and ISDN systems, Oct. 1998, pp. 1491-1500

[Non 1994] I. Nonaka. *"A dynamic theory of organizational knowledge creation "*, Organizational Science, Vol. 5, No. 1.

[Oar 1997] D.W. Oard. *" State of the Art in Text Filtering*", in User Modeling and User-Adapted Interaction 7: 1997

[Pri 1993] W. Prinz. "TOSCA – Providing organisational information to CSCW Applications", in: Proceedings of Int'l Conference on Computer supported Cooperative Work (ECSCW'93) Kluwer Press, 1993

[Rac 1997] P. Y. Raccah. *" Science, Language, and Situation*", in: proc. of the 2nd Europ. conf. on Cognitive Science, workshop on context, Manchester, UK, 1997.

[Rei 1998] U. Reimer: *" Knowledge Integration for Building Organizational Memories "*, Proc. of 11th Workshop on Knowledge Acquisition, Modelling and Management KAW'98, Banff, 1998

[RM 1998] M. Ribière, N. Matta. *"Virtual Enterprise and Corporate Memory*", Proc. of Europ. Conf. on Artificial Intelligence (ECAI'98), Workshop on Building, Maintaining and Using Organizational Memories, 1998

[RS 1998] F. Ricci, L. Senter. *"Structured Cases, Trees and Efficient Retrieval "*, Proc. of the 4th Europ. Workshop of Case-Based Reasoning [EWCBR-98], Dublin, Ireland, Sep. 1998.

[Scha 1996] J.W. Schaaf. *"Fish and Shrink: A Next Step Towards Efficient Case Retrieval in Large-Scale Case Bases*", Advances in Case-Based Reasoning, LNAI 1168, Springer, 1996

[Schwa 1998] D.G. Schwartz. *" Towards the use of user-centric meta-knowledge in applying organizational memory to email communications "*, Proc. of Europ. Conf. on Artificial Intelligence (ECAI'98), Interdisciplinary Workshop on Building, Maintaining and Using Organizational Memories (OM-98), 1998

[SMDP 1998] R. M. Strens, M. Martin, J. E. Dobson, S. Plagemann. *"Business and Market Models of Brokerage in Network-Based Commerce "*, Proc. 5th Int. Conf. on Intelligence in Services and Networks (IS&N'98), May 1998, Antwerp, Belgium. LNCS, Springer, 1998.

[SBF 1998] R. Studer, V.R. Benjamins, D. Fensel: *"Knowledge Engineering - Principles and Methods "*, Data & Knowledge Engineering 25 (1-2), March 1998

[Sri 1997] K. Srinivas: *" How is context represented in implicit and explicit memory"*, Proc. of the Europ. Conf. on Cognitive Science, Workshop on Context, 1997.

[WWT 1998] C. Wargitsch, T. Wewers, F. Theisinger. *"An Organisational-Memory-Based Approach for an Evolutionary Workflow Management System – Concepts and Implementation"*, Proc. of the 31st Annual Conf. on System Sciences, Vol.1, Los Alamitos 1998.

[Wol 1997] M. Wolverton: *"Exploiting Enterprise Models for the Automatic Distribution of Corporate Information*", Proc. 6th Int'l Conf. on Information and Knowledge Management (CIKM'97), Las Vegas, 1997

[ZS 1997] B. Zimmermann, A.M. Selvin. *"A Framework for Assessing Group Memory Approaches for Software Design Projects*", Proc. of DIS'97