# Business Context Information Manager: application to Information Retrieval

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***Abstract*—Taking into account the context is important to improve the way systems provide relevant information to users. For this purpose, we introduce a *business context information manager* based on a novel and generic interpretation of the context. This manager takes into account various contextual dimensions and acts as an intermediary between information retrieval system and contextual information. The approach presented in this paper is suitable to any business context but in the paper we particularly illustrate it in Information Retrieval (IR) field. This approach relies on an original process (MES) that manages the various contextual dimensions to create a unique situation at a moment *t*. To this end, MES uses rules set which is the knowledge of the context manager. The situations will be used by a third part application (i.e., IR systems) for activity adaptation. Furthermore, an extracting process is also proposed to improve the context manager reliability over time and to facilitate its knowledge evolution. Finally, the proposed BCIM have been implemented to demonstrate the feasibility of our approach.**

***Keywords-Context information management, Contextual Dimension, Situation, Contextual Information Retrieval, Business tasks, Information-related tasks.***

## I. INTRODUCTION

The aim of any Information Retrieval System (IRS) is to meet the needs of the user by providing relevant information. For this, the current trend is focusing on the user in order to serve him in the best way. This allows the systems to take into account the heterogeneity of users and the diversity of their needs. Therefore, the system maintains a representation of the user in what is commonly called a user profile. However, considering only the user profile to meet the user needs is not an answer. Indeed, every user's tasks of Information Retrieval (IR) may be performed quite differently depending on the context in which it was carried out. As a solution, the IRS gradually become "context-aware". This motivation is especially important in corporate settings (aeronautical, automotive, etc.) where tasks are critical and should be performed from specific information. In this context, the professional users (operators) require from IRS to provide them with accurate information necessary to perform their business task (defined and formalized as part of a business activity).

In this direction, we propose an approach to manage business context information enabling any IRS relying on it to have a realistic snapshot of the past and present context in order to perform finer adaptation of the information returned to the user.

The proposed Business Context Information Manager (BCIM) is based on an original interpretation of the context which assumes that the contextual information is dependent on each other. That is to say, the BCIM particularly focuses on the analysis of the interactions between contextual dimensions. This approach is intuitive and takes into account all kinds of contextual dimensions that can be modelled and valuated.

To model context and generate various situations, our approach is based on a set of rules and a specific process called MES. This process aims at contextualizing the various context dimensions on which the adjustment is desired. MES handles the adaptation of the different dimensions using these rules and creates a unique situation at a moment *t*. This situation is a stable interpretation of the context and all the past situations compose the context history. Another process introduced in this paper gains knowledge over time and then improves the context manager reliability. Indeed, the rules extraction process extracts new rules from past situations allowing MES to achieve a finer contextualization.

In this paper, we motivate our approach by giving the four main objectives of the BCIM towards the IRS before presenting the BCIM with a particular emphasis on MES process and the rule extracting process. The proposed BCIM is intended to the IR field. Specifically, the dimensions considered are the user, the business task and the environment (location, equipment, etc.). These business tasks need information to be performed by users.

Hereafter, the paper is organized as following. Section 2 presents background on context definitions and their use in the field of computer science and especially in IR field. Section 3 introduces the three contextual components of the IRS business context. Section 4 discusses the main purposes of the BCIM as well as its overall architecture. In this latter section, we also present the two main BCIM processes: the MES process and the rules extraction process after giving the various types of rules used in our approach.

## II. RELATED WORK

Since we focus on IRS in this paper and since the general concept of context is broad, we concentrate in this section on the field of IR after giving some definitions of the context in the literature. We also discuss some limits of the IRS in

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previous work. In the end of this section we give our interpretation of the notion of "context".

### A. Context in the literature

The existence of numerous definitions comes from the multidisciplinary and rich nature of this notion. One of the broadest definitions of the context was proposed by Schilit and his colleagues. They claim that the important aspects of context are: where you are, who you are with and what resources are nearby [1]. The physical location of the operator situation is the central part of context proposed by Schilit and his collaborators. Pascoe [2] defines context as the subset of physical and conceptual states of interest to a particular entity.

One of the most accurate definitions is given by Dey [3] "Any information that can be used to characterize 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". From this definition, the context is a set of situations and actions. Such situations change over time, it depends on the behaviours of users, on the applications and finally on environmental states at the moment when actions are performed.

Among the multitude of context definitions, it is important to introduce the work of Dourish [4] to have a clear vision on it. The author introduces taxonomy of contexts, according to which contexts can be classified into the representational and the interactional views. In the representational view, context is defined with a predefined set of observable attributes which does not change significantly over time. Thus, the representational view assumes that the contextual attributes are identifiable and known a priori. In contrast, the interactional view assumes that the user behaviour is induced by an underlying context, but that context itself is not necessarily observable. More interesting, Dourish [4] assumes that different types of actions may give rise to different types of relevant contexts. Thus for Dourish, there is a bidirectional relationship between activities and underlying contexts. In other words, contexts influence activities and also different activities giving rise to different contexts.

### B. Context in IR

The issue of integrating the context in the IRS lies in the simple fact that a system cannot display the same result for two users retrieving information in two different contexts only because they have expressed the same query [5].

First, IRS can be improved by (1) modelling, (2) integrating, (3) using the context. Thus, the context can be used for example to improve the way people formulate their needs to the IRS and explore the returned information [6]. Traditionally, important contextual variables are included: user contexts (for example, its fields of interest in the short and long term, its habits, etc.); object contexts; tasks and social contexts where information needs arise.

There are several types of dimensions that can be integrated to a context in an IRS. The most important dimension is the user's profile, or more precisely the user's area of interest [7]. Context-aware IRS can take many other dimensions such as the nature of the task or the environment of the search to adapt the retrieval process [8]. Cool and Spink [9] distinguish four dimensions for the contextualization in the field of IR: information environment level, information seeking level, IR interaction level and query level.

At the present time, almost all work in this area are dependent on the explicit specification of the search goals, information related tasks and user intentions [10].

We go further to introduce information tasks and their relation with the business tasks. These tasks received particular attention in recent work to improve context-aware IRS. These studies concentrate on the users behaviour searching information and on the tasks that motivate his search process.

The relationship between business tasks and the information related tasks has been underlined by Byström and Hansen [11]. They consider the information related tasks carried via the IRS (information-seeking, information searching) as sub-tasks of business tasks. A relationship between the various information-related tasks has been also available. Recent work as those of Li and Belkin [12] offers a faceted approach to conceptualizing information related tasks in information seeking to explore the relationship between business tasks and the interactive behaviour of information access. Ingwersen and Järvelin [13] have another view of the context in the field of information retrieval. Their decomposition of the context is centred on the user achieving his business task related to information task(s). The information related task is always included in a business task which is itself the motivation of information search.

### C. Limits of context-aware IRS

Before discussing the limits of previous work, it is important to point out that most of previous approaches agree on a common core that includes environment and human dimensions, but differs on the elements that must be included in the context [14].

One of the current IRS limits is that they do not have access to the business tasks and the possible conjunctions between all parts of the overall context [10, 11]. In addition, the specificity of IR in business context is to use the IRS to find the (missing) information necessary for business task achievement, i.e., the business task belongs to a tasks hierarchy; which is linked to other business tasks that have pre-conditions achievements, which make the classic IRS inadequate. Thus one of the current IRS limits is that they do not have access to this business tasks modelling.

Furthermore, previous work tried to understand how the user is doing his information task in his work environment. For these approaches, a better knowledge of the user allows adapting the search process to meet his needs [15]. However, the scope of previous work is limited because they do not converge: they are interested only in partial aspects of the user tasks or in specific business context.

Thus, the main objective of the business context information manager is to provide the IRS with realistic

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situations. These saved situations from the context history can be used by IRS in two ways:

- *Present use*: context history used if it is relevant to current user need.
- *Future use*: context history used to predict user need or contextual element values.

### D. Definitions

According to the interactional view of Dourish [4], as described at the end of the section II.A, the context influences activities and similarly different activities give rise to different contexts. In addition, some relevant work underlines the fact that the context is relative to something in particular: the context of an action, background interactions, etc. [16]. Thus, in respect of these views and the definition of context given by Dey [3], we define a situation as:

**Definition** *A situation is a stable interpretation (snapshot) of the context of an object at a specific time t.*

Every situation is characterized by a set of information (cf. Dey definition) which is organized in contextual dimensions to describe the various complex elements (i.e., user, system, task, environment, etc.) implied in the context. So, we define a contextual dimension as:

**Definition** *A contextual dimension composing the context of an object describes an external element that may have an impact on this object.*

This definition highlights that we limit the situation to elements which eventually have an impact on the object which we want to model the context. This has been decided to avoid information overload issue in the context representation. The choice of contextual dimensions is predefined and can vary from one application to another. We note that for our approach the contextual dimensions are not predefined a priori by the system. With regards to the user applications, the contextual dimensions and their contextual elements are selected in each situation.

**Definition** *Contextual elements are the leaf nodes composing the contextual dimensions trees.*

A contextual element is characterized by their name, their value, a Boolean that indicates if the element can evolve (i.e., for the contextual dimension "User", an element "name" could be considered as constant unlike to an element "tiredness" that can evolve through situations). The belief value (real number) allows the context manager to gradually measure the accuracy of the value. Indeed, some changes can be done due to the interactions between contextual dimensions. So it is important to give to the IRS the belief value relatively to the contextual element values.

In this paper we particularly focus on the dynamics of the interactions between the contextual information as underlined by Dourish [4]. Indeed, interactions exist between various contextual dimensions. For example, consider the following context for a specific information system composed of two contextual dimensions: user and task. The task dimension may have an interaction with the user dimension because this latter becomes stressed when he is performing it. That is to say, we cannot consider contextual dimensions independently within a situation. This makes reference to the **stability** property in the situation definition. Consequently to generate a new situation BCIM have to take into account all the interactions between contextual elements to ensure the situation stability. That is to say, no more interactions exist between contextual dimensions in this situation.

## III. WHAT IS THE CONTEXT OF IRS?

We present in the following the three interdependent dimensions that compose the business context of an IRS. This triptych includes: users modelling, task modelling and environment modelling. As described in section II.B, these three dimensions are considered in IR field as the most important contextual dimensions.

### A. The user

The *user dimension* corresponds to all contextual (long-term) factors related to users. It is based on a user model. Several elements can be considered as essential for our business context and thus include in the model of the user. These elements come from most of personalized information access work. This model has to be as general as possible in order to be used in different applications as proposed in [15].

### B. The business task

The original dimension integrated to context-aware IRS concerns *business tasks*. It includes business task and its relations to information related tasks.

We show (Fig 1) an example of relation between one business task (and its sub-tasks), requiring information and two information processes allowing supplying the missing data necessary for its processing. The information process is not unique for a given task (i.e., T1.1). Actually the IRS has to select the most adapted information related task for the user in his environment.

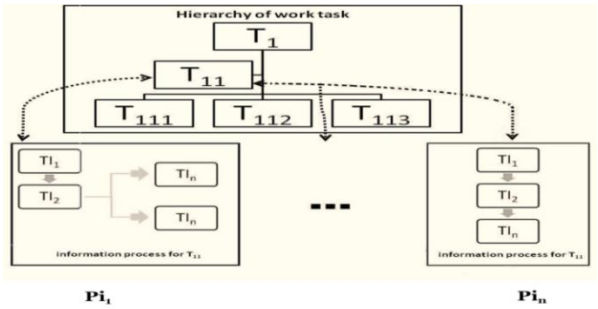


Figure 1. - Example of a hierarchical business task and its relation with information processes.

### C. The environment

The *environment* is the dimension that aims at modelling all the environmental factors. The context can be interpreted as the environmental information in which the exploitations of the information take place.

## IV. BUSINESS CONTEXT INFORMATION MANAGER

We propose a BCIM in order to reach main goals of context management for IRS. To achieve these goals, IRS

and BCIM exchange information like contextual information, actions done by end-user, etc.

In the following, we introduce the BCIM main purposes.

### A. Purposes of the proposed BCIM

We identified four main purposes related to context information management that are important for business context-aware IRS.

*1) Providing the contextual elements to IR*

This first purpose is the most common one. Indeed, context-aware IRS should have access to contextual information (e.g., for systems adaptation). For this purpose, the BCIM enables the IRS to query contextual dimensions of the current situation. As contextual information can be "fuzzy" or approximated, every value given by the BCIM is associated to its belief level.

*2) Checking situations validity*

The second objective of our BCIM concerns the checking of the validity of any situation. A valid situation is a situation that actually satisfies the constraints and rules. Invalid situations are identified and the system alerted.

*3) Anticipating actions*

The third objective of BCIM is to anticipate actions and to recommend them automatically to the IRS for adaptation purpose for instance. When generating a situation, the BCIM identifies similar situations in order to identify actions that have been the most used in such situation. As a consequence, for a given situation, BCIM can recommend to IRS as well as to end-users a specific way to achieve their goals (through recommended actions).

*4) Addressing the lack of information in the context*

The fourth objective of the BCIM is the completion or the adaptation of situation content according to the knowledge related to interactions between contextual dimensions. Indeed, sometimes some contextual information is missing or lacks of accuracy. As a solution, the BCIM exploits the knowledge it can extract from past situations to complete such contextual information.

### B. The knowledge exploited to achieve the BCIM goals

In this paper, we present three types of rules used by our BCIM. Note that the two first kinds of rules are provided a priori by domain experts.

- **Legal business rules**: they correspond to rules whose violation is strictly prohibited by legislation (e.g., law of the company). It is necessary to comply with these rules.
- **Business rules:** they are provided by experts of the domain to enhance activities performance or to establish procedures or processes. It is not required to comply with these rules. These rules can evolve according to users' real activity.
- **Inferred rules:** such rules are extracted via a rules extraction process which is detailed in the section IV.C.2.

Every rule is given as an implication "X implies Y", noted **X => Y**, where X is a conjunction of some contextual elements from user, task or environment. Y is a single contextual element that is not present in X. Every rule in rules set has also a priority which is computed by the BCIM or given by the domain experts. A rule is applied if and only if every contextual element in X is satisfied.

### C. Overall architecture of BCIM

Thanks to these elements, now we introduce the overall architecture of our context manager with particular regard on MES and the extracting rules process (Fig 2).

The manager we propose contextualizes IRS. Indeed, the situations proposed by our context manager are the entry point of IRS. In other words, our approach allows the IRS to obtain the most realistic picture of contextual information in order to better satisfy / match the needs of the user.

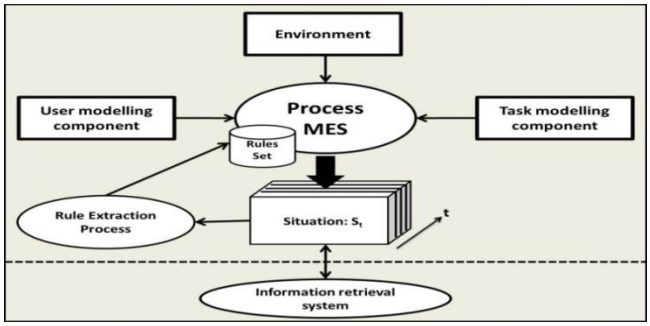


Figure 2. The overall architecture of the BCIM

*1) MES process*

During initialization stage, when BCIM is creating the first situation of a particular activity, the IRS relying on our manager provides MES with values of all the contextual elements of each dimension. Then MES checks the validity of the situation (according to the second purpose of the BCIM) and alerts the IRS in case of an invalid one. This may happen in two cases:

- The contextual elements from various contextual dimensions cannot interact into the situation because of the breach of one or more legal business rules. We can give the example of the aircraft maintenance field: technician with "class A" skills cannot perform intensive tasks or work on the tarmac.
- In addition to contextual elements, actions sent by the IRS may also violate such rules. We can give the example of the access to an electronic document that can be read only by specific categories of users.

We notice that the BCIM (through the MES process) stores the invalid situations to send feedback to the system experts. This can be helpful to improve the BCIM by updating the set of legal business rules.

Thereafter, when the IRS modifies one or more initial contextual dimensions (change in contextual element value), MES uses the rules set to adapt all other contextual elements to build an up-to-date situation. In other words, the goal of MES in this case is to assess the impact of the changed element value on the rest of the context and above all the missing contextual elements values. Thus, MES keeps the

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given values and it predicts missing ones using the rules set (refresh the other values in the new situation).

We note that MES does not perform any adaptation when the situation is the most realistic interpretation of the context, i.e., all the values are correct and given by the system sensors.

Furthermore, it is important to give some clarification regarding the fourth goal of the manager. The lack of contextual information can occur in two cases:

- Upon initialization stage, there may be missing contextual information caused, for instance, by a failure in one sensor. To infer this missing information and to create the situation, MES applies the different rules in the following order: business rules and then inferred rules.
- Between two linked situations (situation at a moment *t* and situation at a moment *t-1*). To create a new situation (at a moment *t*), MES gets contextual information from the previous situation (at a moment *t-1*) in addition to new contextual element values supplied by the IRS. MES therefore can use all illegal rules types to adapt the contextual elements.

*a) The adaptation cycle of contextual dimensions*

For the effectiveness of any IRS based on our context manager, it is essential for all contextual dimensions to be adapted and confronted to each other (i.e., contextualized). The goal is to characterize the best possible situation. To achieve the adaptation of one dimension, depending on the others, the MES process uses the three types of rules to describe the various transformations to be applied. As detailed in the previous section, the specific type of rules used by MES widely depends on the precise purpose to be achieved.

Hereafter we present a simplified example of the three contextual dimensions in IR field (Fig 3). We note that these contextual elements are provided by the IRS to the BCIM. Thus to generate a new situation, the BCIM (thanks to the MES process) performs a new adaptation cycle.

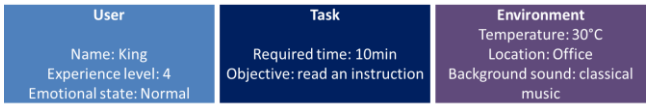


Figure 3. Example of the three contextual dimensions

Suppose the following set of five rules: R2, R3 and R4 are business rules provided by the domain expert, R1 and R5 are inferred rules given by the extracting process. We remind that these rules are sorted according to their own priorities and they are applied if and only if their conditions are satisfied.

R1: User.Experience level≤4 AND Environment.Location=Office
➔ Task.required time=50min (priority = 0.9).
R2: Task.required time>40min AND Environment.Temperature>25°C
➔ User.Emotional state=stressed (priority = 0.8).
R3: User.Emotional state=stressed AND Task.Objective=read an instruction
➔ Environment.Background sound=OFF (priority = 0.6).
R4: User.Experience level>8 AND Environment.Location=Home
➔ Task.required time=5min (priority = 0.5).
R5: User.Emotional state=stressed AND Environment.Background sound=OFF
➔ Task.required time=70min (priority = 0.5).

By taking this example, we want to explain the adaptation cycle and how MES could adapt the various contextual dimensions. In our case, at the beginning of the adaptation cycle only rule R1 can be applied because it is the only rule whose condition is satisfied. As a consequence of this adaptation, the time required in the adapted task dimension (*Task'*) evolves; the value becomes 50 minutes instead of 10 min (see Fig 4).


Figure 4. The adaptation of the Task dimension

*b) Situation stability*

The adaptation cycle respects our context definition and its originality. Indeed, the situation stability gives rise to the dynamic interaction between contextual elements we wanted to reach. Every dimension is adapted by the use of all other dimensions. We therefore emphasize that the construction of a situation is a recursive process. Indeed, we cannot consider each dimension of a context separately. Thus, these rules are applied successively on the dimensions until a stability point of the context at a moment *t* is found; that is what we call situation. A stable situation can arise from large number of iterations (the stability process).

Taking the previous example (Fig 3), only R1 was applied at the end of the first iteration of the adaptation cycle. Therefore, to obtain situation stability, MES performs a second iteration and the new task (*task':* the adapted one) substitutes the initial task in the context dimensions set. As a consequence of *task'* elements values, R2 condition is satisfied. Thus, MES continues the stability process and adapts the user dimension using R2. Therefore, this adaptation infers knowledge on the emotional state contextual element of the user by altering the initial model and the emotional state of the user becomes stressed. In the same way, the new adapted contextual dimension (*user')* will impact on the environment since this change satisfies the R3 condition. In other words, R3 will be applied by our stability process and a new environment dimension feature is inferred by the MES process. It is important to note that R2 and R3 could not have been applied if only the initial contextual dimensions (Fig 3) had been considered without incorporating the adapted ones in the adaptation cycle.

As presented before, the three contextual dimensions are adapted at the end of the third iteration of the adaptation cycle. At this point MES will not stop the adaptation cycle and a fourth iteration is performed. Consequently, R5 can be applied and the task dimension is adapted again (time required becomes 70 minutes). Finally, at the end of the adaptation cycle a stability point is reached (no more rules can be applied). MES provides the IRS with the three

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adapted contextual dimensions (see Fig 5) which are considered as the realistic situation.


Figure 5. The adapted contextual dimensions composing the situation

*2) Rules Extraction Process*

The BCIM must be able to evolve over time. In other words, the set of rules used by the MES process should grow to enhance contextual information accuracy. For this purpose, we propose a novel rules extraction process based on past situations. This process concentrates only on valid situations because they contain information about what happens in practice. Furthermore, the impact of the dynamic interaction of various contextual elements during the adaptation itself can cause a change in activity or in the initial models. Learning from past situations can give to our BCIM a realistic view of what actually happens during an activity. The system becomes then more and more efficient and the information more and more relevant as well.

For the BCIM, the rules extraction process is based on the classical association rules extraction methods [17]. These methods aim at finding interesting associations and/or correlation relationships among large sets of data items. Association rules show the value of items that occur frequently together in a given dataset. In our case, these items are the contextual elements and our dataset is the set of past situations. Thus, via this process, the context manager will enrich its rules set. Consequently, this will improve the quality of the adaptation of the contextual dimensions. We note that inferred rules are subsequently ranked by the BCIM according to their priority which is computed by rules extraction process using, for example, confidence or support.

*3) Implementation*

The proposed BCIM have been implemented as a Java server. The different contextual dimensions are stored in XML format. This choice is motivated to improve the possibility to describe various contextual dimensions (e.g., CTT approach: "ConcurTaskTrees" for hierarchical task modelling can generate XML document [18]). To extract and manage association rules, the prototype uses Weka API [19] and specifically its *a priori* algorithm.

## V. CONCLUSION

In this paper, we present a BCIM for IRS business context based on three contextual dimensions: business task, user and environment. The manager is based on a novel interpretation of the context. This interpretation is original because it focuses on the dynamics between all these contextual dimensions rather than how information is represented. We introduced the MES process that manages the three contextual dimensions using the context manager knowledge related to interactions between contextual dimensions. The BCIM provides the IRS with realistic snapshot of the user activity. This snapshot is the current situation that will be used for any purpose by IRS. We have also shown that the three kinds of rules are useful to model knowledge necessary to manage IRS context. Finally, we presented the rules extraction process that improves the BCIM over time by making it gain new knowledge from past situations. As a matter of future work we plan to evaluate the BCIM using real situations in concrete business context. Then, we can compare other rules extraction methods.

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