Understanding Context-Aware Business Applications in the Future Internet Environment*

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Abstract. The obvious move towards a Future Internet environment that is strongly distributed, mobile, cloud-based, semantically rich has raised and emphasized the need for a different type of applications. The focus of this new type of applications can no longer be on the software itself but directly on the relevant needs and goals of end-users. We argue that because these applications are strongly end-user oriented, context and context-awareness play an important role in their design and development. Hence in this paper we discuss context-aware business applications towards a better understanding of their specific features. We emphasize two major directions related to context oriented applications, their importance, and the order in which they should be followed and interlinked.

Keywords: context-aware systems, business applications, user centric approach

1 Introduction

We are witnessing an obvious trend towards the Future Internet environment which is essentially cloud-based and which comes with a new set of characteristics and challenges. In this new environment that is generative and fosters innovation business models and customer relationships are changing, it is about software on demand, simple to use, software that takes into account users’ needs, it is mobile, runs everywhere, including web browsers.

A series of new challenges emerge from this new environment. To name just a few:

– how to design software that is highly end-user oriented and social;
– how to involve the end-user in the development process;

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how to take advantage of the end-user’s knowledge;
how can this knowledge be acquired and then shared;
how to design software that can be easily adapted either automatically or by other end-users;

We believe and assert that in this environment which is fundamentally oriented towards end-users, context will play an important role as context greatly influences the way humans or machines act, the way they report themselves to situations and things; furthermore any change in context, causes a transformation in the experience that is going to be lived and sensed [4]. Gartner has identified context, and context-awareness alongside cloud computing, business impact of social computing, and pattern based strategy, as being one of the broad trends that will change IT and the economy in the next 10 years [33]. However, context is a vague notion.

Context, as defined in [11] is 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. Similarly for Coutaz et al. [8] the context is a structured and unified view of the world in which the system operates and is part of a process interacting with an ever changing environment.

Although many have tried to give a definition for the concept "context", it is still a vague notion. Hence in this paper our objective and original contribution is first to discuss and see how context has been used in the relationship with business applications and business related approaches. We further support our initial discussion with a Future Internet specific example. We then later, based on our results, come with a proposal on how context aware business applications should be understood.

The rest of the paper is organized as follows. Section 2 presents directions and approaches related to business applications. Section 3 depicts Slice.com a motivating use case, end-user oriented. We discuss context in relationships with business applications research directions in section 4. Our proposal on how context-aware business applications should be understood is presented in section 5. We conclude in section 6.

2 Trends and Approaches for Tackling Business Applications

Although not explicitly stated, a business application or business software is any set or combination of tools, programs, paradigms that are used by business users to perform various business tasks to innovate, to increase productivity, to measure productivity, to monitor, perform business functions accurately and so forth. If we look for instance at Google’s business apps web site [1] we have an immediate confirmation of our statement. Moreover we see that even email is considered a business application, and even an important one, since for some

business activities, receiving an email is a triggering event for starting a business process (see for instance [5]).

The move to the Internet as a platform and the shift from transaction-based Web pages to interaction-based ones opened the way to a whole new environment. Future Internet is a generative environment that fosters innovation, through an advance of technologies and a shift in how people perceive, use and interact with it [36]. Future Internet is by and for the people: it is about services and things, it is about knowledge and contents. This process included both consumers, businesses as well as governments around the world.

According to a survey by the Economist [30] from 2007, 31% of companies participating in the survey think that the usage of the web as platform will affect all parts of their business and 38% of companies expect to use Web 2.0 tools and methods to boost revenue through customer acquisition. Corporate winners and losers will be designated simply by who figures out how to use the network [30].

Unlike traditional technologies such as ERP and CRM where users mostly process information in the form of reports or execute transactions, Web 2.0 technologies are interactive and require users to generate new information and content or to edit the work of other participants [7].

This new ecosystem requires more intelligent tools and means to tackle: huge amount of information; data coming from different sources; users with a low level of technological background but who have a lot of ideas, and who have to resolve by themselves different business tasks, see [32], [17]. Business Intelligence (BI) for the new economy requires people to take active part and do by themselves BI development tasks from within their browsers [17]. In terms of research the main directions dealt with business rules, business processes, web services, semantic web services and service oriented architectures (SOA) [14]. In the last 15 years business rules were employed to declaratively describe policies, business processes and practices of an enterprise. Applications in domains such as insurance, financial services, government, telecom, and e-commerce benefit greatly from using rule engines. Moreover, rules are becoming increasingly important in business modeling and requirements engineering, as well as in Semantic Web applications. Over time several rule languages have been defined as well as techniques to perform interchange between these different languages [12].

A lot of work and effort has been put also in the topic of workflows, workflow management, business processes and business process management (BPM). As stated in [34] a “business process consists of a set of activities that are performed in coordination in an organizational and technical environment”. Their all together scope is the fulfillment of a business goal. BPMN [20] is the de facto standard for modeling business processes. Some of the most important directions of research in terms of business processes comprise management of process variants [13] and workflow mining with the purpose of discovering

\[\text{https://www.oasis-open.org/committees/soa-rm/}\]
process models from event logs [31]. There are also approaches that tackle the
natural combination between business rules and business processes, e.g. [16].

**Service Oriented Architecture (SOA)** is a flexible, standardized archi-
tecture that facilitates the combination of various applications into inter-
operable services. Sommerville [28] defines a **Web service** as a loosely coupled,
reusable software component that encapsulates discrete functionality, which may
be distributed and programmatically accessed. A web service is a service that is
accessed using standard Internet and XML-based protocols. A more general def-
inition given by Lovelock [18] “a service is an act or performance offered by one
party to another”. Although the process may be tied to a physical product, the
performance is essentially intangible and does not normally result in ownership
of any of the factors of production.

However, in reality Web services have hardly been adopted beyond the bound-
aries of enterprises [9]. Hence companies and institutions started to realize that
allowing people to use the data they hold could unveil additional value with very
little investment. Therefore companies started to open and allow usage of their
data by mere customers which gave birth to what is called the Web of Data or
Linked Data [3]. Linked Data as stated in [3] refers to a set of best practices for
publishing and connecting structured data on the Web. Nowadays the Web has
evolved from a global space of linked documents to one where both documents
and data are linked together. The **Semantic Web** [2] or the web of Linked
Data adds formal knowledge representation such that intelligent software could
reason with the information.

To sum up, what we find out is that enterprise software is the glue that
ties together teams and business processes [19], and that enterprise systems are
simplifying, webifying, mobilizing, and getting a lot more social. These changes
bring in, both, challenges and benefits. For the context-aware community users
have been the fundamental motivation (see for instance [8], [33], [10] etc). **Con-
text** greatly influences the way humans or machines act, the way they report
themselves to situations and things; furthermore any change in context, causes a
transformation in the experience that is going to be lived, sensed [4]. As argued
in the previous paragraphs the future business applications are also changing
into being strongly user-centric. Therefore the binding link, the gluing agent,
between business applications on one side and context-awareness on the other
side, are the users and a switch to a more social business environment.

In addition the concept of a business user changes. The massive adoption of
**cloud computing** as a platform for business applications, that fosters on-line
**collaboration**, **crowd sourcing**, **wisdom of the crowds** and other social
aspects of using business apps, has absorbed in the business processes also the
customers and simple users. They are part of the processes and their knowledge
and input is important. In addition web-based business apps become accessible
to a ever growing user base of entrepreneurs, startups companies. These require
flexibility and a rapid adaptation of applications to user’s needs. As such the
step towards context-aware business applications is a natural one.
3 Motivating Example

Forbes enumerates in "10 Brilliant Apps Small Businesses Should Use" a list of ten applications that have emerged from the Future Internet generative environment. The fundamental characteristic of this applications is that they are user-centric. In the sense that they focus on resolving a particular problem that is of interest for the end users.

Slice.com is such a Future Internet specific project that uses emails to tackle a very specific end-user related problem. Slice is an online purchase management tool that gets hooked into user email account. When ever a new email is received Slice automatically analyzes the content of the email. If the email contains order information from one of user’s online shops, then Slice via pattern-based recognition techniques extracts order related contextual information and organizes this information for the user. Hence all of user purchases will be gathered in one place, the user will be able to keep track of his shopping history, amount of money that he spents, type of products, time related information i.e. when a shipment is about to arrive and so forth.

As we have already argued in [24] applications tackling similar use case, and which are user-centric are required to provide at least the following capabilities:

– provide the means and allow the end-user to model and represent context;
– allow the modeling of relationships between context elements;
– allow the modeling of interactions between different contexts, this implies both in the form of conditions and sequences of events and actions (more precise business rules and business processes)
– based on the provided models have the capabilities to discover in the environment the modeled context(s)
– sense events and actions that are performed in the system
– perform actions according to models defined.

We believe that this example supports our statements from Section 1 and that it underlines the challenges and characteristics of business applications for the Future Internet environment. Moreover, it also emphasizes the need for context and context-awareness. On the other hand it also confirms that the notion of context is a vague notion and that the context notion is actually strongly connected to each user and to a specific problem.

In the next sections we want to examine how context has been studied in relationship with business application related directions and then we will argue about how context-aware business applications should be understood.

4 Perspective on Context Related Research

The notion of context has been important in conceptualization of systems for many years and hence over the years a large number of papers have been writ-
ten addressing the topic of context and context-awareness from different perspectives. A series of surveys addressing different aspects (i.e. context modeling and context-based reasoning, context-aware frameworks and applications, context-aware web services) of development of context-aware systems and their applications have been developed. However to be able to get a holistic view and to get a better understanding about the role of context and context-awareness in relationship with business applications we have employed a new research methodology that has been introduced and discussed in further details in [25]. The proposed research methodology is based on existing techniques for text clustering and text mining. The motivation for using such an approach is supported by the very large number of papers that need to be analyzed. A manual approach would make the task almost impossible to fulfill. Moreover such an approach will provide an automatic way to extract related terms, topics, directions of research, and relationships between directions of research.

We have compiled a bibliography file which so far contains 100 entries, carefully selected, that spans over a period of more than 20 years, ranging between 1991-2013. To compile this bibliography file we have used as a starting point Google, to search for papers using terms such as context, context-awareness, context-aware surveys. A survey is a better entry point as it provides a wider view on the subject. These were just initial search terms.

We have used JabRef to organize our bibliography file and Carrot2 to do the clustering. Carrot2 as stated on the project website is an "Open Source Search Results Clustering Engine. It can automatically organize small collections of documents (search results but not only) into thematic categories". The reason for using Carrot2 over other tools (such as Lemur and Terrier) is its simplicity. It

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http://jabref.sourceforge.net/
http://project.carrot2.org/
http://www.lemurproject.org/
http://terrier.org/
was very simple to write an export layout from JabRef to Carrot2 XML input format.

The results depicted in Figures 1 and 2 have been computed using the Lingo clustering algorithm. The results are based on the abstracts, and were present, also the keywords of the bibliographic entries in our collection of context-related research papers. Lingo [21] as described by the authors is able to capture thematic threads in a search result, that is discover groups of related documents and describe the subject of these groups in a way meaningful to a human.

Figure 1 enumerates the thematic threads as they were computed by Carrot2. Figure 2 on the other hand depicts the relationships between these topics. We can easily infer just by looking at Figure 2 that context has been taken into account in many of the business applications related directions that we haveunderline din Section 2. On the other hand we also observe that there is no unified approach that could tackle most of the directions enumerated in Section 2 under the same conceptual model.
5 Understanding Context-Aware Business Applications

So far we have discussed and underlined aspects, research directions and technologies related to business applications. We have further addressed a Future Internet specific example and later presented how context related research has interfered with business related research trends. This section is dedicated to analyzing previous results towards a better understanding on how context should be seen and its implications from the perspective of business applications.

In [4] it is argued that the word context is derived from the Latin con which means with or together and texere\(^8\) which means to weave. As a result it describes context not just as a profile but as an active process dealing with the way humans weave their experience within their whole environment, to give it meaning. Context-awareness on the other hand is the ability of an application or system to use the current contextual information in order to improve user experience or to achieve a user goal [33].

As depicted in Section 4 there has been done a huge amount of work that addresses the problem of context. And although this work has tackled different aspects and research directions, i.e. modeling, reasoning, data-bases etc., we argue that all this work, from the focus point of view, follows two major directions: context-aware applications that are system-centric (most part of the work, see for instance [29], [1], [6], [15]) context-aware applications that are user-centric (i.e. [26], [35], [22]). These two directions act as an analysis framework for us and our further assertions revolve around these directions.

Let us take for instance [29] which is an example of a system-centric context-aware application. The underlying problem that is addressed is about how to improve the behavior of a service in a particular situation. Furthermore [29] states that context information is dependent on the individual system. Web services as discussed in Section 2 are part of the components used in the business applications environment.

Context and context-awareness has been used also in relationship with business processes mainly to tackle process adaptability at the execution time (see for instance [27], [13]). However these approaches fall also in the system-centric group because their focus is also on the system (here process).

On the other hand [35] proposes VINCA-cc which is a user-centric, business level service composition language. This approach employs Context Business Objects (CBOs), and all context information are abstracted to standardized CBOs registered in the context middleware layer. Therefore here we deal with layers: the business level and the system level. Business level deals directly with the business concepts that are understood by the user. The system layer makes the connection between the business layer and the underlying system. A similar approach is introduced also in [23], [22]. However while [35] imposes restriction based on CBOs that are define in the system, the approach introduced in [23], [22] does not imposes any such restrictions.

\(^8\) [http://latin-dictionary.net/search/latin/texere](http://latin-dictionary.net/search/latin/texere)
Future mobile applications frameworks are context-aware and in a mobile business environment the context is often dynamic and the user interacts differently with the applications on his mobile device. Context is not limited to the physical world around the user but it also incorporates user’s behavior or user behavior is a strong relationship with the context as argued in.

Petrelli et al. state that the main objective of context should be to make technology invisible for the user, hence the focus will not be anymore on how to use the technology in a proper way but the focus will be once again on resolving our activities and achieving our goals in daily business activities and not only. To achieve this goal will require a completely and reliable world representation; a shared understanding of concepts. Moreover such a system would need to deal with a partial and approximate theory of the world in the sense that the representation is from an individual’s perspective. Thus an individual representation of the world needs to be a subset of the entire world that a system can understand. There are a series of fundamental differences between these two perspectives which are depicted in Table 1.

Table 1. System-centric vs. User-centric - differences

<table>
<thead>
<tr>
<th></th>
<th>system-centric</th>
<th>user-centric</th>
</tr>
</thead>
<tbody>
<tr>
<td>type of context</td>
<td>static</td>
<td>dynamic</td>
</tr>
<tr>
<td>focus</td>
<td>system</td>
<td>user</td>
</tr>
<tr>
<td>technology visible</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>context design</td>
<td>system or domain dependent</td>
<td>basically unbounded</td>
</tr>
</tbody>
</table>

Figure 3 depicts a mind map with the context related concepts for the user-centric perspective. These concepts have been extracted from the assertions emphasized throughout this paper. We argue that the combination of these concepts together with proper techniques for modeling, reasoning and system specific execution facts can address the challenges we have enumerated in Section 1. We believe that the set of concepts depicted in Figure 3 comprises the minimal elements required to tackle the issues emphasized by the Slice.com example. Thus context and relationship between context elements can be modeled, interactions between different context as well as any actions or events that would be of interest could be modeled as well. Furthermore these elements address the issue of context being strongly related to the user and the user’s goal.

We assert the followings about context-aware business applications for the Future Internet environment:

- end-users should be part of modeling and design process and this process should be goal and end-user oriented;
- context is also end-user oriented and becomes unambiguous in relationship with an end-user problem;
- context subsumes a description of the environment in which the user behaves; environment’s definition should comprise space and time attributes as well as any other entities that are of interest to the user;
– moreover context description comprises user’s behavior and the other way around, where behavior is modeled by means of business rules and business processes that comprise actions and events;
– the model of such applications should be understood both by the system and end-users in the same way;
– such models should allow adaptation by other users through inheritance and/or direct modifications.

Fig. 3. Mind Map of Context Related Concepts for the User-centric perspective

6 Conclusion

In the Future Internet environment business applications are different and they need to comply with different challenges than legacy systems. For this new type of applications an end-user orientation is an essential characteristics. Most of the challenges new in this environment arise from the strong end-user orientation, i.e. (1) end-users need to be involved in the design process; (2) end-users’ know how needs to be taken into account; (3) the models representing such applications need to adaptable and so forth.

For these applications context is fundamental. But context by itself, although studied extensively, has proven to be an ambiguous concept. Hence we have analyzed via a text mining and text clustering based approach researched context related directions. Thus we are able to assert that business applications research directions have been studied in relationship with context and context-awareness. However these approaches have focused on specific aspects and have not offered a unified and holistic view.

Based on these results and a motivating use case that is specific to Future Internet environment we have extracted a proposal about the elements that make out context in a context-aware business application. Moreover most of the current approaches with respect to context and context-awareness are system-centric. We have argued that this perspective it is important but for context-aware business applications a user-centric perspective is mandatory, and that such a perspective is required on top of the system-centric layer in order to hide technology specific issues towards making such apps user friendly.

This paper presents results of research that is work in progress towards achieving a unified modeling and methodological approach for context aware business applications, and (2) a unified execution framework of context aware business applications.
References