Towards a Better Understanding of Context-Aware Applications

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Abstract—**With the new technological advances and strong move towards Future Internet and Internet as a Platform a new environment is emerging. This environment is generative, social, strongly interactive and collaborative, so users play a fundamental role in it. Business applications are simplifying, webifying and getting more user-centric. In this environment, context and context-awareness plays a fundamental role, as context gives meaning and accurately describes the situation of an user. This paper introduces the basis for a new research methodology that aims to address and visualize the topic of context and context-awareness from a holistic point of view, by means of text mining and text clustering.**

I. Introduction

THE concepts of context and context awareness have been studied for more than 20 years in the field of artificial intelligence, computer and cognitive science. However, it has been still identified by Gartner, 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 [1].

Moreover these IT and economical changes are reflecting themselves also onto business applications. Applications are simplifying, are becoming mobile, are moving to the cloud, are getting more social and user focused [2].

For instance smart phones although almost anywhere present nowadays, they present also a lot of downsides, i.e. they ring in movie theaters, conferences, meetings, air flights, they are the cause of car accidents. Theaters and even restaurants in some places have employed cell-phone jamming to limit cell-phone disruptions. This could be considered partly a social problem, but is also a technological problem. Through better applications, people can be helped to make better and safer use of their smart phones.

Hence we are faced with a series of new challenges in the context of developing future business apps. They need to:
- be highly adaptive;
- provide UIs that are user specific;
- provide means for users to modify them by themselves according to their needs, goals, context, while still keeping the underlying infrastructure in place;
- be interactive;
- be distributed, at the same time cloud computing ready;
- support both desktop and mobile environments, while providing a similar experience, finally

- developed with business users, and vendors and for customers, while hiding as much as possible all technical requirements.

To understand what is required to tackle these challenges a holistic and unified approach is needed. In this setting, the purpose of this paper is to introduces the basis of a new research methodology that aims to address and visualize the topic of context and context awareness from a holistic point of view, by means of text mining and text clustering.

It is worth emphasizing, that in this paper we do not explicitly introduce the term *"context"*. In fact, we aim at identifying and categorizing different uses of this term according to the existing literature.

II. Context and Context Awareness – Related Work in General

Over time, there have been written a large number of surveys on the topic of context and context-awareness addressing different directions of research. By far the most known and most cited (according to Google Scholar[1]: 3213 times) survey is the work by Dey and Abowd [3]. They argue that context is important for interactive applications and for applications where the context of users is changing rapidly. They discuss what a context-aware application means and give a definition for the term *context*.

Context and context-awareness in mobile computing is one of the oldest directions [4] of research when it comes to context-aware applications. This is because information such as user's location, nearby people and devices, time of day and user activity can be used to improve, for instance, latency time or boost up communication signal by using bandwidth from nearby devices and so forth.

Context modeling is part of any endeavor that tackles context-aware systems. Strang and Popien [5] address the problem of modeling of *context* in the context of ubiquitous computing paradigm (paradigm for which context is a driver). Several approaches are studied and discussed. Bolchini et al. [6] deal also with the problem of context modeling from a data-oriented perspective. A general framework for classifying context modeling approaches has been defined.

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[1]http://scholar.google.com/scholar?cites=7671228831233541198&as_sdt=2005&sciodt=0,5&hl=en

Context-awareness has become lately of importance also for the development of web service-based systems [7]. These systems are more and more knowledge-based [8], e.g. using business rules and processes for a specification [9]–[11].

Although the issue of context has been well studied in the field of mobile systems and pervasive computing, the interest in the business-oriented community has been only recently growing. In fact with business applications becoming more social and user focused, cloud-based, massively distributed and mobile, both of these areas seem to finally meet. Therefore, studying the impact of context in business applications is of great conceptual and practical importance.

III. RESEARCH METHODOLOGY

To be able to investigate and to get a better understanding about the role of context and context awareness in relationship with business applications we used a particular research method which we are going to present in this section.

We are going to emphasize through out this section, that there is a huge amount of work that tackles the problem of context and context awareness in different fields and from different aspects. However, there is no unified view on the matter, nor – to the best of our knowledge – there is any approach that provides a holistic view on the subject. Therefore we propose a research methodology which takes advantage of the existing techniques for text clustering and text mining to get a broader view on the research that has been done on the side of context and context awareness.

The motivation to use text mining and clustering techniques is very simple. Too many papers that need to be organized, make the task almost impossible to fulfill. Moreover such an approach will provide an automatic way to extract related terms, topics and directions of research.

We present our methodology in a form of a simple workflow, modeled as a business process model, designed using the BPMN [12] notation and depicted in Figure 1. The model presents the steps that we took in our research approach and the ordering of those steps.

We have compiled a bibliography file which so far contains 94 carefully selected bibliographic entries that spans over a period of more than 20 years, starting 1991-2013. The quality of the papers is also an important factor. There are two ways to weight and asses the quality of the papers. One way is objective as it is given by the number of citation a paper has. We have extracted the number of citation, where this number existed, for a paper from digital libraries websites: CiteSeer[2], Google Scholar[3], ACM Digital Library[4], IEEE Xplore Digital library[5]. In the cases where there is no available citation number, we can not know for sure if a paper has been cited or not, therefore it is up to the researcher to read and asses the quality of a paper. This approach one could say that is rather subjective. Table I depicts only a small excerpt of this bibliography file, due to space limitation. However the entire file is available to download as a bibtex file or consult online at the following address: `http://geist.agh.edu.pl/ pub:research:context_aware`.

The steps for compiling this bibliographic collections are depicted in Figure 1. We start by searching via Google for context related keywords i.e. *context*, *context-awareness*, *context-aware surveys*. A survey is a better entry point as it provides a wider view on a subject. These are just entry search terms. The more you search and read, the more terms can be further used. Besides the "random" search, we followed (searched) also concrete references that were indicated in the initial papers that we retrieved and read.

The next step in the process (See Figure 1) is to add bibliographic entries. We used for the clustering algorithms the abstract of each paper, if there was one. In consequence a bibliographic entry, if there is one, needs to have an abstract. Some of the papers also contained keywords. We have also used when available the keywords associated. These were combined with the abstract.

We used JabRef[6] to compile our bibliography. JabRef offers the functionality of an export layout, which we are using to export the bibliographic information into Carrot2[7] input format. 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[8], Terrier[9]) is its *simplicity*. It was very simple to write an export layout from JabRef to Carrot2 XML input format. The export layout is also available online at the previosly given address. And also the results are by default given also in several visual formats.

Although Carrot2 provides several search algorithms we used Lingo and K-Means algorithms as they provided the best results. Unfortunately the free version of Carrot2 does not provide options to addresses issues such as synonyms in order to improve the results. Arthur and Vassilvitskii state in [13] that the K-Means method is a well known geometric clustering algorithm based on work by Lloyd [14]. Though the K-Means term has been first used by MacQueen [15]. According to [13] given a set of n data points, the algorithm uses a local search approach to partition the points into k clusters. Lingo [16] 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.

Figures 2 and 3 depict the results of running the K-Means and respectively Lingo algorithms over our bibliographic collection. The results are visualized in a Foam representation. Results are similar but not the same. We can easily visualize directions of research and words related with the context concept. Having similar results it helps to verify the output of

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[2]http://citeseerx.ist.psu.edu/

[3]http://scholar.google.com/

[4]http://dl.acm.org/

[5]http://ieeexplore.ieee.org/Xplore/home.jsp

[6]http://jabref.sourceforge.net/

[7]http://project.carrot2.org/

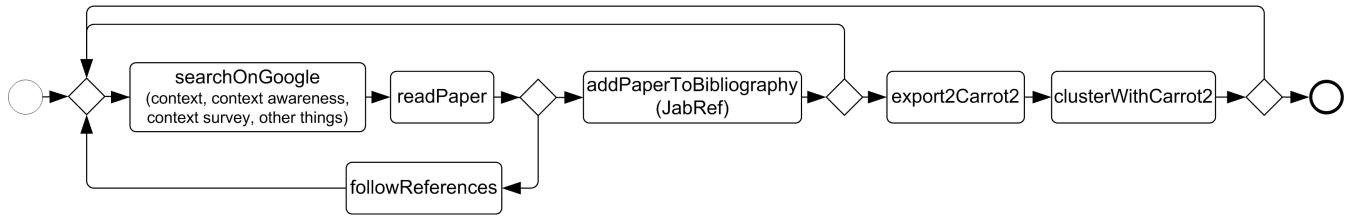[8]http://www.lemurproject.org/

[9]http://terrier.org/

Fig. 1. Research Methodology - Business Process Model (BPMN notation)

TABLE I
EXCERPT OF CONTEXT RELATED BIBLIOGRAPHY

No.	Title	Year	Citations
1	Contextualization as an Independent Abstraction Mechanism for Conceptual Modeling	2007	25
2	A Survey on Context-aware Web Service Systems	2009	83
3	A data-oriented survey of context models	2007	181
4	Towards a better understanding of context and context-awareness	1999	3213

the clustering algorithms. Having differences helps to identify what each algorithm has missed with respect to the other.

The authors of [17] already identified that context is of fundamental importance for cognitive psychology, and computer science. Furthermore it states that in computer science the notion of context has been addressed in several areas such as: artificial intelligence, software development, databases, data integration, machine learning and knowledge representation. Since all these directions have been also identified by our research approach we argue that results are satisfactory in terms of how adequately the mining and clustering algorithms have performed.

In addition based on the information depicted in Figures 2 and 3, context has been used to address many of the future business apps challenges we have enumerated in Section I: adaptation, mobile computing, flexibility, user, modeling, task management, distributed systems, business process models.

IV. CONCLUSION

Context, context-awareness studied for a long time already, it still part of future development trends. Now, because of the changes (i.e. move to the cloud, social computing and so forth), that both IT and economy are witnessing, context is required to tackle the challenges that these changes bring in.

We propose a new research methodology in order to tackle the large number of publications that have been published over time, starting 1991 to present in order to get a more holistic view on the subject of context and context-awareness, by employing text mining and text clustering techniques.

This paper presents results of research that is work in progress. In our future work we will continue to investigate the results and ideas that can be extracted from using the text mining and text clustering based research methodology that we have introduced here. We will investigate semantic wikis, e.g. [18], [19], as systems that can be made context-aware and user-centric [20].

However, our ultimate goal is to provide a holistic design and deployment approach for context-aware user-centric business applications through a (1) unified modeling and methodological approach for context aware applications, and (2) unified execution framework of context aware applications.

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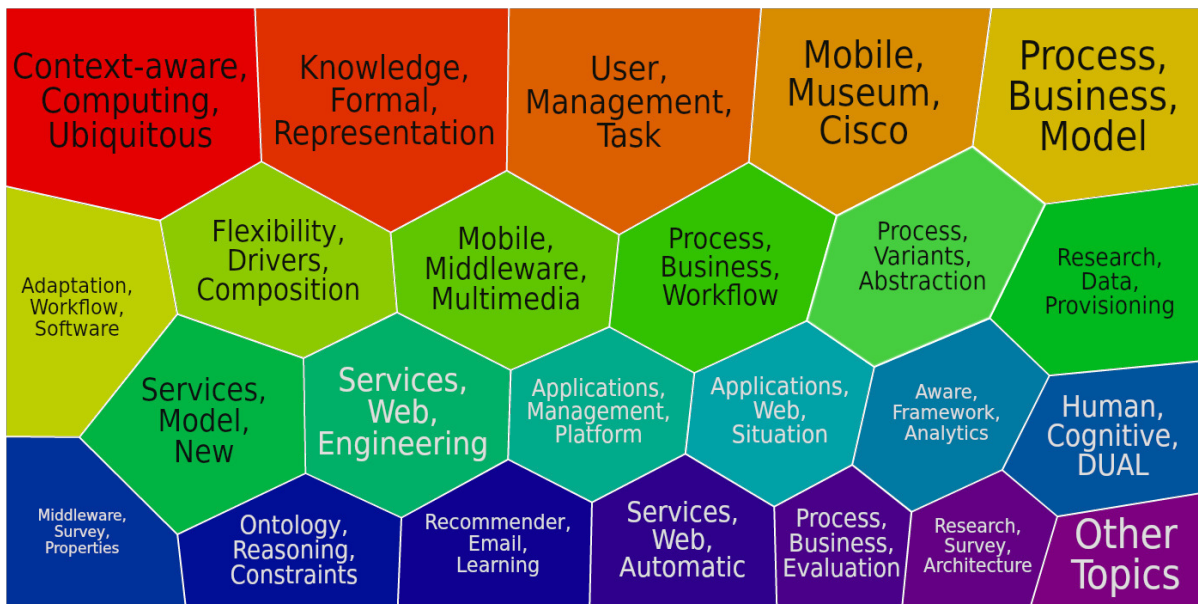[12] OMG, "Business process model and notation (bpmn)," OMG, Tech. Rep. formal/2011-01-03, November 2011.

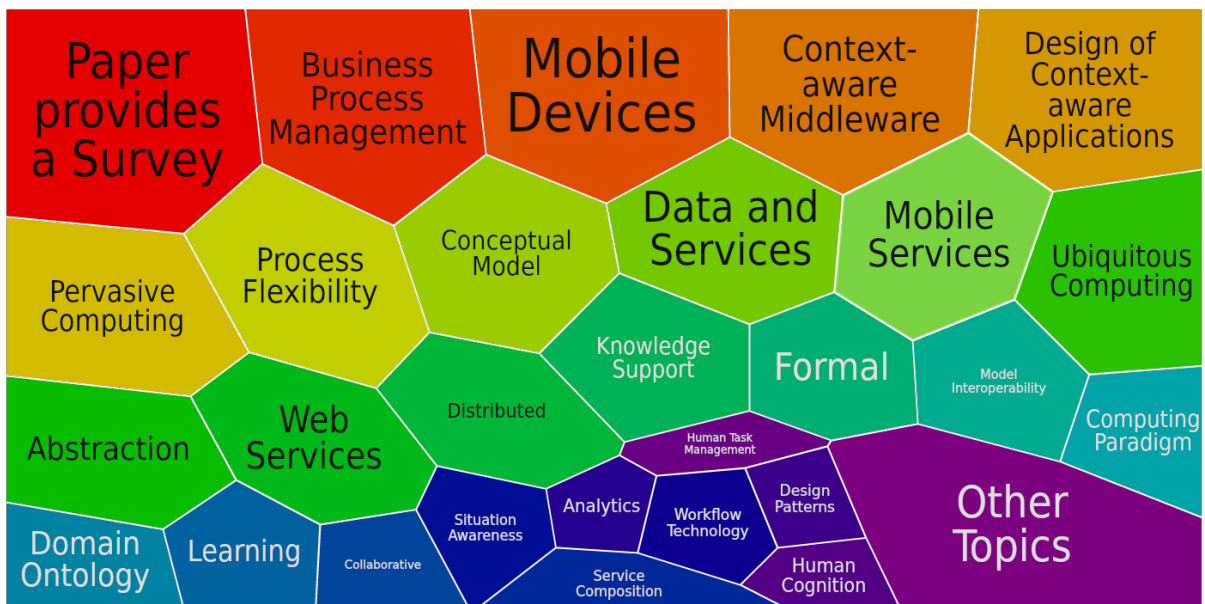Fig. 2. K-Means – Foam Visual Representation

Fig. 3. Lingo – Foam Visual Representation

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