Application-based Context–Awareness in Collaborative Workspaces: A Review

N. A. A. Fadzillah, N. Omar, and S. Z. Z. Abidin

***Abstract*--In this paper, we investigate the existing research based on context-awareness elements in various collaborative applications. The investigation is based on seven context awareness entities; application, media, method, tool, platform, framework and device. This work focuses on the application which involves eight context elements; domain, activity of user, context object, locations, type of communication, type of context, digital elements and models. In order to define the attributes for each of the context element, various domains of applications are selected that include education, business, mobile, multimedia and virtual reality. Based on the attributes, a context awareness structure in collaborative workspaces is proposed. The structure visualizes a general relationship between the clustered elements in handling context awareness. Thus, the relationship enables context-awareness to be used in a broader perspective of context-aware applications as opposed to the current practice that is limited for specific circumstances.**

***Index Terms*-- Context awareness, context element, collaborative application, collaborative workspace, networked collaborative virtual environment.**

I. INTRODUCTION

Networked Collaborative Virtual Environment (NCVE) is a system that allows geographically distant users to interact in a shared workspace. In NCVEs, the corresponding users are invisible; however, their visibilities are represented only in graphical forms [1]. Basically, creating virtual workspaces involves designing user interactions in which people and information are glued together. In order to support their collaborative and cooperative activities, it is important that the workspaces offer the means to access appropriate information and communication tools [2].

The ways in which people identify the colleagues whom they need to be aware of is a necessary and integral aspect in collaborative works. In addition, context is all about the whole situation relevant to an application and its set of users [3]. The fundamental objective of context-awareness is to provide services not only to people at anytime, anywhere, with any media but specifically to communicate the right thing at the right time in the right way [4]. Today, most researchers have been enhanced their perspectives into context-awareness but most of the context-awareness has been discussed as an independent domain. The work usually focuses only on a certain situation. In this paper, we examine various application domains in order to determine the most constructive elements used in collaborative workspaces. Within the elements, details of attributes are inspected to construct relationships of context-awareness in collaborative workspaces.

N. A. A. Fadzillah is a PhD (Computer Science) student in Universiti Teknologi MARA, 40450 Shah Alam, (e-mail:norazlina@perlis.uitm.edu.my)

N. Omar is with the Computer Science Department, Faculty Computer and Mathematical Sciences, Universiti Teknologi MARA, 40450 Shah Alam, (e-mail:nasiroh@tmsk.uitm.edu.my)

S. Z. Z. Abidin is also with the Computer Science Department, Faculty Computer and Mathematical Sciences, Universiti Teknologi MARA, 40450 Shah Alam, (e-mail:sitizaleha533@salam.uitm.edu.my)

II. CONTEXT-AWARENESS

Context-awareness is an area of computer science which deals with the adaptation of computing systems to the user's current situation and a multidimensional context within the ubiquitous environment. It was first introduced by Schilit and Theimer in1994 [3],[5]. Context can be seen as "*any information that can be used to characterize the situation of an entity*", where an entity can lay within a large range of things such as a person, a place or an object, that relevant to the interaction between a user and application [6]. It refers to the ability for a class of systems to use contextual information to supply better services to users, in a flexible and manageable way [7].

In the early systems, context-aware uses specific kinds of context such as location in domain-specific application systems. Later, such systems are enhanced to general purpose context-aware that can support various types of context [5]. Most awareness research investigates on synchronous phenomena; who is participating in an ongoing activity, what activities that each person is currently doing, and how the team as a whole is performing [8].

Context-awareness in networked collaborative virtual systems has been an active area of research for several years. The contexts are suitable for numerous collaborative applications ranging from business to medicine. For example, in Text-Based Conferencing System (TCS), context is used to recognize the conversational situation and facilitate socially oriented communication [9] while it supports group conversation [10]. In addition, it also provides supporting evidence in suggesting gross communication and behavioral patterns for passively distinguishing between humans and their representations [11]. It is also used to add awareness and collaboration features to web sites or notes-based systems with little or no programming [12].

In some domain of research, context awareness is used as a way of sharing reflection and collaboration. Currently, it gains its popularity in e-learning environment. For example, [13] used the intelligent tutor in virtual classroom to improve the educational function of e-learning. Whereas, [14] design and implement teacher training model in a cyber face-to-face

language learning context by using Synchronous Learning Management System (SLMS). It is also used to test interdisciplinary collaborative venture in the NCVE between four university teams to enable students use the tools of dynamic social network analysis [15]. Reference [16] applies the web-based context learning to guide students to learn in a very large learning area, such as the national park and the palace museum. It embeds Heuristic-based navigation algorithms in these applications. Basically, it has been proved that context-aware in collaborative learning is vital in designing and supporting e-learning community [14].

In another domain, instant messaging (IM) becomes an important communication tool that is used by millions of worldwide users. The primary and most essential feature of IM is to provide context-awareness in the form of its users' presence information (about the availability of each of its users). For example, [17] use Conversation Dock (ConDock) to provide more awareness for a group chat. On the other hand, [18] use Bluetooth-based and GPRS to increase opportunities for situated chat in public spaces. Both technologies are used to improve group awareness between peers and people who facilitate the conversations.

Instead of e-learning and instant messaging, context awareness is also used to improve quality of experience (QoE) in video on demand through web and dynamic services [19],[20]. Furthermore, [21] states that the successful of physical collaboration (e.g. to repair bicycle) depends on the context, conversation and action that relate the target objects, people and location in the collaboration.

As innovations and technology progressing, context awareness is also evolving in the style of conveying the information. Reference [9] suggests that context awareness should include four elements; presence, relationship, activity and contents. The four elements are essential in providing cues to users in order to recognize the situations and relationship among collaborators. Furthermore, context awareness becomes a new approach in bridging the gap between the actual needs of collaborating end-users and the functionality provided by their collaborative environments [22]. The environment involves elements such as necessary actions, events or signals in order to function as a context awareness application [23].

III. CONTEXT-ELEMENTS

In context-aware computing environment, *context element* is defined as *anything relevant to the interaction between user and application* [3]. The context will assist the system developer to select appropriate contexts to use along with their structures. Based on the reviewed literature, eight pertinent context elements can be embedded in the context-aware application; context, domain, user activity, context-object, location, type of communication, digital elements used and model of context awareness.

Reference [7] defines *context* as a concept that is intimately related with reasoning and cognition in humans. It is possible to categorize context in various ways by considering different characteristics of the context [24]. These categorizations are useful for developing application, understanding the context, managing the quality of context and managing the context adaptively [24], [25]. The types of context categorization include user, system, computing, and historical context.

The categorization of the context depends on its domain. *Domain* is defined as *any area of application* that include education, business, games, mobile, engineering, health and multimedia. Different domain has different types of *user activities*. User requires *context object* in the activities, which it can be anything, either as hardware or tools. Examples of context objects are people (e.g. students, teachers, managers), peripherals (e.g. personal digital assistant (PDA), tablet PC and mobile phones, mobile eye-tracker) and actions (e.g. speech, speaker, fingerprint).

The mostly used context element is *location* [24]. Location is applied to places. Places can be located in a frame of reference such as geographical coordinates or relative spatial relations [26]. Location determines *type of communication*. The type of communication refers to how the communication is carried out; face-to-face, one-to-one, interview, or a multi-touch interaction communication.

Digital elements play an important role for presenting the context objects in collaborative space. A comparison is made on how and to what extent four digital elements, namely text, 2D graphic, 3D avatar and audio-video support the awareness models [27], [28]. According to [28], digital elements cannot stand alone on its own as a mean of communication unless they are combined with other elements to promote effective communication.

Lastly, a context element depends on its underlying *model*. According to [5] in the earlier days, context-aware systems tend to use simple context-data models. Later, more complex context models are used (e.g. object-oriented model, graph model). Reference [23] states that there are six context aware models; key-values, mark-up-scheme, graphical, object oriented, logic-based and ontology-based. The important feature of models in context-aware application is that it eases designers to translate real world concepts into its modeling constructs. Furthermore, it enables applications to use and manipulate the context information at runtime [29].

IV. THEORETICAL STUDY

This work employs extensive literature reviews on current context-aware research dated from 2008 to 2012. The review focuses on seven entities in various collaborative works that include application, media, method, tool, platform, framework and device. Based on the review, the application entity is chosen for further analysis. The analysis is performed in relation of the eight context elements (as discussed in the previous section); domain, user activities, context object, location, type of communication, type of context, digital elements and model. In addition, the analysis involves extracting attributes for each of the context element in various application domains that include education, business, mobile, multimedia and virtual reality. Table 1 presents summary of the selected samples of application domains versus eight context elements.

TABLE 1
SUMMARY OF SELECTED SAMPLES OF APPLICATION DOMAIN VERSUS CONTEXT ELEMENTS

DOMAIN	ACTIVITY OF USER	CONTEXT OBJECT	LOCATION	TYPE OF COMMUNICATION	TYPE OF CONTEXT	DIGITAL ELEMENTS	MODELS
Education [12]	Virtual classroom	Speech, text	Virtual Environment	Face-to-face	Computing Context	3D	Graphic Model
Education [15]	Web-based learning	Student, Mobile device	Butterfly Museum	Live scene	System Context	Text	Object Oriented Models
Education [13]	Cyber face-to-face Chinese language	Teacher, Student,	Cyber classroom	Face-to-face	Computing Context	Text	Object Oriented Models
Communication [30]	Chat instant messaging	Users, AI Developers, Admin	Chat room	One-to-one	User Context	Text	Object Oriented Models
Business [31]	Group-decision making	Participants agent,	Simulation of a group decision meeting	Group discussion	Historical context	Text	Object oriented models
Business [32]	Predict the buyers' need	Product image, buyers	External environment	One-to-one	User context	Text	Graphical model
Mobile [33]	Mobile learning	iPod, users,	Central Pennsylvania Festival of the Arts	One-to-one	User context	Text	Object oriented models
Mobile [34]	Mobile health counseling agents	PDA, users	Exercise – walk on a treadmill	One-to-one	System context	Text , 2D	Object oriented models
Multimedia [27]	Multitouch	People, Fingerprints,	Virtual space: Remote collaborative environment (RCE)	Multitouch interaction	Computing context	2D, 3D	Graphical model
Virtual Reality [35]	Video-mediated communication (VMC)	Mobile eye-trackers, speakers, students	Immersive CVE	Informal interview, Avatar gaze mimic	User context	2D, Audio-video	Logic-Based Models

Based on information in Table 1, attributes for each of the context elements are identified. Table 2 shows some attributes of the eight context elements.

TABLE 2
SAMPLE OF ATTRIBUTES IN CONTEXT ELEMENTS

Context Elements	**Attributes**
Domain	Education, Multimedia, Games, Virtual Reality, Communication, Mobile, Business, Management, Engineering, Health , Counselling
Activity of user	Virtual classroom, Text-based Conferencing, Group chat, Health counselling agent, Animated virtual human, Multi-touch interaction, Mobile messaging
Context object	Speech, Text, Teacher, student, user, buyer, Product image, iPod, PC, Mobile, PDA
Locations	Simulation of a group decision meeting, Exercise – walk on a treadmill, External environment
Type of communication	One-to-one, Face-to-face, Live scene, Group discussion
Type of context	User context, System context, Domain context, Computing context, Physical context, Time context, Social context, Internal context, Infrastructure context
Digital elements	Text, 2D graphic, 3D avatar, audio-video
Models	Key-values models, Mark-up-scheme models, Graphical models, Object oriented models, Logic-based models, Ontology-based models

V. RESULTS AND ANALYSES

Based on the information in Section 4, in context-aware applications, the relationship between users and technology is vital. The technology should support users to collaborate among each other with various digital elements. In addition, context-aware applications provide task-relevant information with services to a user [3]. Users are allowed to determine their activities and tasks. A *task* is defined as a unit of work. Fulfillment of a task may require capabilities from environments in which the task is carried out [36]. Such capabilities include the ways in which people identify their colleagues. The colleagues that they need to be aware of are necessary and they are the integral aspect of a collaborative work. This aspect is still being researched by software developers and needs to be properly studied and supported by software tools [37].

Beside user and task, a context-aware application should be supported by necessary resources in order to achieve the goal of doing collaborative work. These resources consist of communication media (e.g. mobile device, PDA, iPad), location and the structured context (e.g. type of context, type of digital elements and models). If the resources are sufficient, the task can be completely achieved and fulfilled user requirements.

Derived from Table 1, the eight elements can be clustered into three main context elements namely user (people), resource (peripherals) and task (activities). Figure 1 presents the clustered context elements.

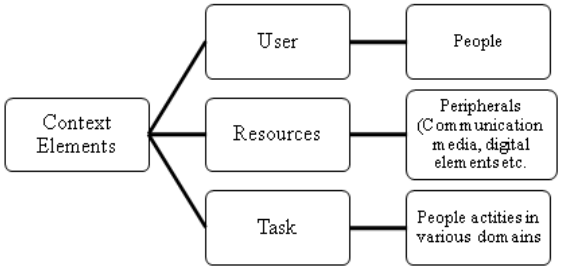

Figure 1: Clustered Context Elements

Based on this investigation, the results show that most context-aware applications involves users, resources and tasks. Basically, users are connected with all of activities in which they need resources in order to achieve their goal of the particular events. It has been found that contextual information is relevant, useful, and can be used during collaboration. In order to understand the process of collaborative communication, the user should be aware of who is online, what they are doing, and what their plans are. However, people who are sharing their tasks require details information of what others exactly do and what are their task progressions or work in the collaborative workspaces. Based on the requirements, a general relationship of context awareness structure in collaborative workspaces is proposed. Figure 2 visualizes the structure of task that implicitly represents user in such workspace.

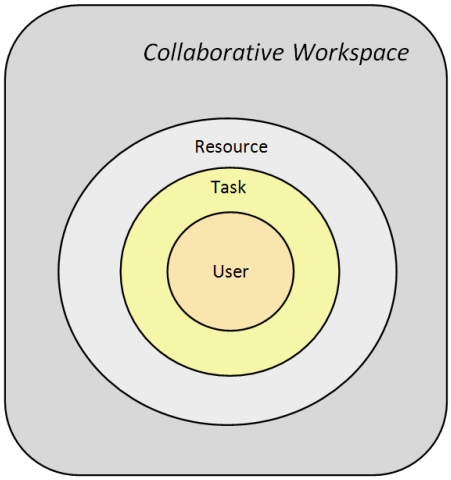

Figure 2: The General relationships of context-aware elements in Collaborative Workspace

VI. Conclusion

This paper investigates various applications from various domains. The investigation has revealed eight elements that mostly associated with context-awareness research. The elements are clustered into three: user, resources and task. The clustered element is generalized in order to form and define the meaning of context-aware collaborative workspace.

Based on this study, the evaluation of context-aware systems and application is enormously challenging and still developing in order to improve effective communication among users [38], [39]. Usually, the places where user actions and interactions occur in collaborative workspace are invisible and in remote areas. The user does not know what others are doing and their work progression. The lack of awareness in the collaboration causes delay in decision making and consumes extra time, which in turn will increase the cost and produce inaccurate outcome. Thus, by improving the computer's access to its context-aware elements, the richness of communication can be increased in human-computer interaction and make it possible to produce more useful computational services. Nevertheless, there is still lack of research in relation to contextual information which is deficient in the aspect of human-human interaction. Therefore, our future work will study appropriate mechanisms that are needed especially in visualizing tasks progression for widely-distributed virtual collaborative workspace.

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VIII. BIOGRAPHIES

Nor Azlina Aziz Fadzillah received her honorary degrees and master from Northern University of Malaysia. She is currently a PhD student in Universiti Teknologi MARA, Shah Alam, Malaysia. Her employment experience included teaching at Cosmopoint College and University Technology MARA, Perlis. Her special fields of interest included computer programming and collaborative application.

After earning a computer science degree from Binghamton University, USA and her masters from Universiti Kebangsaan Malaysia and later earned a PhD from the University of Nottingham, UK. She is a senior lecturer at the Faculty of Computer and Mathematical Sciences at the Universiti Teknologi MARA, Malaysia. Currently, she has special interests in research that involves quantification of virtual users' behaviour in task-based events.

Siti Zaleha received her bachelor degree from Michigan State Univesity, USA and Master of Science in Computer Science from Illinois, USA. During her studies in the USA, she was awarded lifetime membership to two distinct American honor societies, Pi Mu Epsilon (Mathematics) and Upsilon Pi Epsilon (Science Computing). She received her PhD in Computer Science in 2007 from the University of Wales Swansea, United Kingdom. She is an associate professor in the department of Computer Science at the Universiti Teknologi MARA, Shah Alam (Malaysia) and acts as a fellow of Information Warfare Technology Unit, Centre for Media and Information Warfare Studies. Her research interest includes interactive computing, language construction, visual and virtual computing, geographical information system (GIS) and metaheuristics algorithms.