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Human Computer Interaction (HCI) in Ubiquitous Computing

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ABSTRACT: Ubiquitous Computing is new computer paradigm with seamless integration of hundreds and thousands of self-communicating small scale computers and intelligent devices into the user environment and daily life activities. Ubiquitous computing has high prospects for human life along with certain challenges across computer science, system design, system engineering, system modeling and in Human Computer Interactions (HCI) design. In case of Human Computer Interactions (HCI) there are certain requirements and challenges for ubiquitous computing like minimum user attention in order to enable them to focus on tasks rather than technology. Traditional Human computer Interaction models in the form command line, menu driven or Graphical User Interface (GUI) are inadequate and insufficient to meet the unique requirements of the ubiquitous computing environment. The spirit of Ubiquitous Computing requires specialized natural, implicit and embedded interaction paradigm in order to support the unique requirements of interaction patterns in ubiquitous computing. In order to promote implicit Human Computer Interactions (iHCI) the context aware system, natural multimodal interfaces are the prerequisite. With the help of context aware and multimodal natural interfaces user would have the opportunity to pay less time to interact with technology that is the agenda of the implicit Human Computer Interactions (iHCI) and ultimately achieve the objective of Ubiquitous computing of minimum user involvement into technology and to enable them to focus on their tasks.

KEYWORDS: Ubiquitous Computing, Human Computer Interactions (HCI), explicit Human Computer Interactions (eHCI), implicit Human Computer Interactions (iHCI), Context aware Systems, Natural interfaces, Multimodal interfaces.

1 BACKGROUND

Technology had changed our lives to a large extent and still has the potential to change it in a new and dramatic way. Due proliferation of technology into our lives to a large extent we spent our lives in a different way as compared to our fore fathers. Technology has embedded into our daily life activities from working to recreational activities. We are now busy in interactions with different types of gadgets, devices and appliances. In fact it intruded into our life in such a way that it is very difficult to distinguish it apart from our environment.

Ubiquitous Computing is a new and exciting paradigm characterized by hundreds and thousands of self-communicating smart devices, taking active role in every realm of daily activities of human life, in every location and context. The essence of this vision of Ubiquitous computing was first described by Mark Weiser in 1991 in his seminal paper as; *"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life, until they are indistinguishable from it"* [1].

The above statement of the Mark Weiser is actually a motivation to think about computers beyond the desktop model. Ubiquitous computing has many dimensions for understandings and implementations. It also refers to calm technologies. Calm technologies would recede into background of our daily life activities. This paradigm suggest that computing resources would present in such a manner that user would not aware of their presence. Another aspect of calm computing is that these embedded devices provide services with little interactions with users so that user do not distract from their task in a technology overwhelming environment [2].

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Mark Weiser put the idea of invisible computing and predicted that in very near future we observe the shift in computer systems. His vision the tremendous change in the computing environment and said that in very near future we observe the phenomenon of “many computer to one user” from “one man to one computer”. He believes that desktop computers would be replaced by hundreds of scattered computers in our environments. These scattered computers in our environments would be enabled to sense our environment and communicate with each other to provide different services to human in a variety of way. The idea of Ubiquitous computing is invisible computers everywhere, embedded into the environment, with dozens of hundreds of computer available to each person, each one operating without much human intervention [3].

Weiser vision is more than the infrastructure; it poses certain new dimension of interaction with the system. The ubiquitous computing goes beyond the integration of hardware and technology into the physical user space. Its main theme is the way we interact with the computational resources. Ubiquitous computing is much more than mere embedded technology into our daily lives, it is about changing our perception about their presence into the physical world. The agenda of Ubiquitous computing interaction demands different themes of interactions as continuous interaction and implicit human computer interactions. There were a lot of efforts along these lines but still a huge prospect to work on these lines is still available [4].

The terms calm computing, invisible computing, embedded interactions and disappearing computers does not imply the size of the computers or seamless integration of the hardware into the user environment. Therese terms tend to describe the aspect of interaction with the computers. They reflect the need to understand the difference between the traditional user computer interaction relationships to the user computer relation in augmented environment, and how the user perceives the computers. In order to make the computer invisible to the user, it means interaction of the user with the computers is in a seamless way integrated into the user’s tasks. Focus of the user is on the task rather than explicit interaction with the system in contrast to traditional user computer interaction relationship where focus is on computer rather than the task [5].

Ubiquitous computing is also considered as post desktop model of interactions in which information processing and smart capabilities would integrate into every realm of life. The core of the vision of the Weiser was that smart phones and appliances would also communicate with each other to provide services in a seamless way through coordination with each other and provide different services to user in a synergetic way through enhanced user experience. Weiser believes that computing resources would present into daily life artifacts rather than a separate computing entity. According to Weiser if this integration and coordination is done on reasonable basis it would be very difficult to distinguish computer as a separate entity for user activities [6].

2 MATERIAL AND METHOD

Ubiquitous applications interfaces should be adaptable to their environment and behave according to the situation. They should adapt according to context and do not require explicit interaction from the user. The main objective of the Ubiquitous computing is to allow user to focus on their tasks rather than on technology. In last few years we observe many applications that gather user context through sensors in order to do right things at right time. Most profound among these applications are CyberGuide, UbiCicero and GoogleAdSense [7].

2.1 HUMAN COMPUTER INTERACTIONS (HCI) REQUIREMENTS FOR UBIQUITOUS COMPUTING

HCI should not only consider ease of use but also focus on assisting user tasks, proving access to information in best way and concentrate on more powerful form of interactions. After considering its perspective HCI has taken new dimension especially in Ubiquitous computing. All the fantasy and novelty of ubiquitous systems based on the novel way of user interaction with the systems. Some core characteristics of Human Computer Interaction (HCI) in Ubiquitous system are given below [4], [8];

- HCI in ubiquitous system would be hidden and implicit rather than traditional explicit interactions of user with the system.
- Ubiquitous system environment should allow the user to focus on the tasks rather than on the technology.
- HCI in ubiquitous computing involves adaptive to situation and support for multimodal of interaction with the user. This requires some sort of intelligence work integrated with interaction paradigm.
- Human interaction pattern in Ubiquitous environment would multimodal of interaction support.
- With advance in technology the interaction in ubiquitous computing tends to be supported with natural interactions like interaction of human to human.

2.2 HUMAN COMPUTER INTERACTION FRAMEWORK FOR UBIQUITOUS COMPUTING

All these requirements of HCI in ubiquitous computing require an enhanced model of interaction with clear defined goals [9]. The agenda of ubiquitous computing require implicit Human Computer Interactions (iHCI) with the help of context aware interactions and natural, intelligent multimodal interfaces. Traditional interactions theme can also be utilized when they can prove to be useful in ubiquitous computing environment.

2.3 IMPLICIT HUMAN COMPUTER INTERACTIONS

The ubiquitous computing had the agenda of implicit Human Computer Interactions (iHCI) with minimum distraction of user from their core activities. The main goal is to focus on the user task rather than user focus on technology. Weiser vision of calm, disappearing computers is manifold and multidimensional. Important context of calm and disappearing computers is their working without much interaction with the user [10]. The system should support the user tasks without much intervention and with minimal distraction of user from their core activities. The system tends to disappear and become calm because human interactions with this system tend to implicit rather than explicit. Due to effective use of implicit mode of interaction the calm or disappearing computers would be reality in very near future. The basic purpose of calm and disappearing computer is that system should proactive rather than user involve in explicit interaction with the system. Clam computing removes user from the system and hope that system work proactive rather than reactive to the user.

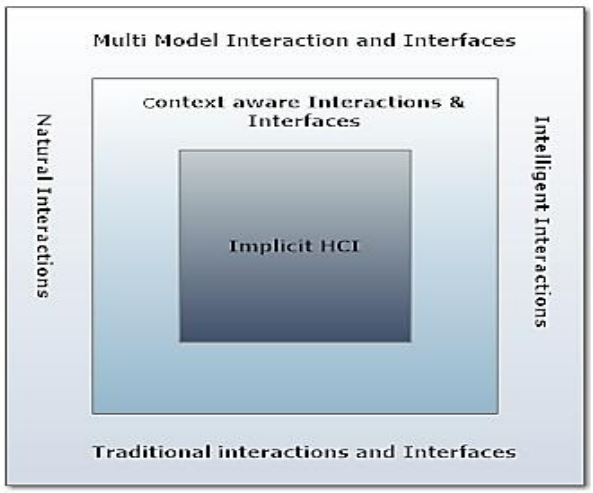

Fig. 1. Human Computer Interaction in Ubiquitous Computing

2.4 CONTEXT AWARE INTERACTIONS

Ubiquitous application has to be context ware system. Previous research on the issue of HCI in Ubiquitous computing has posed the agenda of context ware applications in order to be proactive. The context would play an integral part in ubiquitous application that help to achieve the implicit interaction but there are still unresolved issues relating to representation of context, acquisition of context and its distribution.

Context aware systems are system that are aware of their situation and adopt accordingly. Context aware systems are aware of their environment, situation or context so that system can adapt to the situation and provide services according to the changed situation or context. According to Dey, “a system is said to be context aware if it exploit relevant context to provide services”. Dey and Abowd define context as information that used to characterize the situation of an entity that is relevant to the interaction between the user and application [4].

Context information’s depends upon the type of services and application like location, temperature, light etc. For example many smart phones turned automatically to silent mode for some location without explicit interaction with the user. Context information can be very helpful in proactively of the interactions but it may cause problem if desired level of accuracy not achieved. In order to be successful in ubiquitous environment interactions, different context information and accuracy of this context information is very crucial. Context of use and adaption of application and user interfaces according to the context of use help to create applications that are easy to use especially in ubiquitous computing environment. For

application in ubiquitous computing we have to consider context of use not only in design process but also for different usage scenarios of application and its services in order to adapt according to the situation and environment [10].

For traditional application HCI we design around single context of use and user. Most of our efforts in design spent around the single anticipated use context. For application in ubiquitous computing environment that have to change and provide services according to the situation and environment the traditional approach of HCI may fail. If we attempt to support multiple contexts with single design it also turn to complex one as the number of context and users may increase to a large extent. In order to provide support for a range of context support of Context aware system is necessary for HCI in ubiquitous applications [11].

Context aware system has strong relationship with ubiquitous computing and can play important role in realization of Mark Weiser vision about Ubiquitous computing. When computer would be part of everyday life it would be necessary that such system are easy to use and do not overwhelm the user with explicitly interaction with the system. User environment saturated with thousands of computers may distract user from their tasks and involve user in explicit interaction with the system rather than allow them to focus on their tasks and activities. This is against the vision and spirit of the Ubiquitous computing or clam computing.

For the realization of Ubiquitous computing context aware systems are very important for optimal use and performance of different system in ubiquitous computing environment. Computers with different shapes and sized had already integrated into our life and activities. Different home usage devices and appliances had acquired the smart capabilities due to installations of microprocessors and memories capabilities. These smart integrated devices also have the capabilities for interconnections with available network high capacity bandwidth. What remain is to judge the user situations and environment and provide services according to the environment. In order to provide services by adapting to the user environment it is necessary for the system to have the capabilities of context aware system. Context aware system enables to sense the environment and help the ubiquitous system to adopt and provide services according to changing situation [10].

2.5 INTELLIGENT, NATURAL AND MULTIMODAL INTERFACES

Intelligent user interfaces aim to enhance the efficiency, naturalness, and effectiveness of HCI by using artificial intelligence techniques. If we look into history, user note taking capabilities evaluation starts with typewriter. From type writer it shifted to keyboard and from key board to touch and voice input capabilities suggest that interactions pattern in modern days shifting towards natural paradigm. Intelligent user interfaces enhance user experience by content support for input and output of data and navigational support for navigation between applications. One type of such support is that highlight important information and reduces the user effort to find desired information. Intelligent interfaces can also adapt to provide access to most relevant functionality and information [12].

Single independent channel of interaction is called modality. This is the channel through which information transferred between system and user. A system that is based on single channel is called uni-model whereas system with multiple channels is called multi-model. The most common system based on different modalities is visual, audio and sensors based. With the help of context aware system different input and output modalities can be included in order to increase user experience according to specific context. With help of context user interface can be tailored to specific context and adapt behavior according to context, situation or user requirement. But it is not as simple as it seems to be. User has to learn how to use the system and how to cope with change behavior with change of context. When the user interfaces are adaptive and change their behavior dynamically it becomes very difficult for the user to learn and adjust with the system. It is necessary that user also aware of cause of change of interface. Otherwise user feels very difficult in remember of navigations and interaction with a dynamic changing context of the system. User interface adaptation to context should be designed in careful way so that user can understand it easily. Good design should focus in stability and help the user in memorizing and causes of adaptation of user interface with each change of context. A carful design should avoid user from complexity [13].

Fig. 2. Canasta Key board [14]

Due to multiple focus of HCI research there is also trend in multimodality interfaces from traditional interfaces. Along with shift from traditional to multimodality there is also trend of intelligent, context aware, adaptive interface with implicit human computer interactions rather than explicit interaction pattern through command line and GUI interfaces. Multimodal interaction should be focus of HCI in future. Multimodal interfaces offer additional models like dialogue, gesture and context of use. Challenge is to identify what task fit to what modality. Human to human communication is an ideal standard for future multimodal interactions in Ubiquitous computing [5].

The ubiquitous applications would be different from the desktop model of computing therefore it is known as off the desktop or post desktop interaction paradigm. The interaction pattern in this paradigm would be quite different from desktop computing environment and should be in natural style. It would much like the way human interact with their physical environment. Human exploit speech, gesture and pen based interactions to communicate with the physical artifacts and human being. These natural actions of the human would be source of implicit or explicit interaction with the system. This theme poses an agenda of implicit interaction from the user environment, from user activities and even from user expression. Ideally it should be like man to man communication. Though a lot of research along the lines of pen and gesture input introduced but the inherent error rate still very high and need to be lowered in future. These natural interfaces would be easy to use and have the capability to learn from their environment. They also have the ability to support user task rather than distracting the user from their task to focus on technological issues [15], [16].

3 RESULTS

In order to determine the role of contextual information in implicit Human Computer Interactions (HCI) we design experiment for three activities listed below.

- A user determines his/her locations.
- Find a restaurant in nearby.
- Send an E-mail

We conduct experiment with two different types of handheld devices. One of the devices provides static user interface named device 'A' and second provide context aware adaptable interface named device 'B'. For context aware adaptation we used android context Aviate screen [17]. We repeat the same experiment with both types of devices.

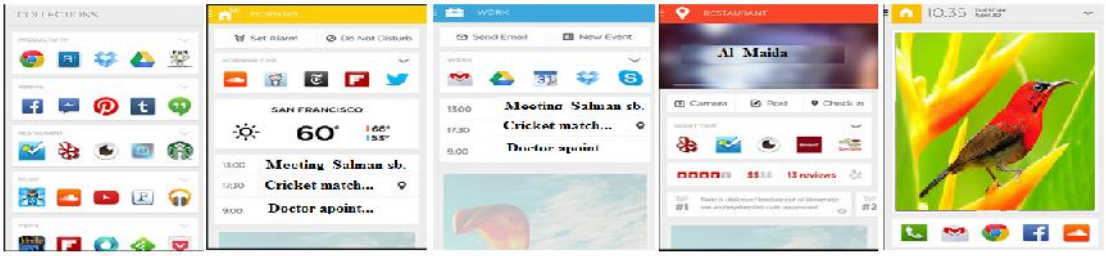

Fig. 3. Device a contextual based interface adaptation capabilities

Experiment was repeated with ten people with each user operates from three different locations. From each location each user repeats the same experiment at least three times with one device. User session recorded for time, accuracy and efficiency to complete each task. About sixteen volunteers are selected randomly who have experience in operating of two

different set of mobile. Each participant was allocated phone sets in a random way at different time. Initially ten minutes are used for the explanation of the task required from the user and then each user time recorded for completion of overall task, the number of moves user made to complete task. A log file is used to record time and number of moves (menu, icons clicks) for each interaction to complete the activities of our experiment. We want to evaluate the interaction usability of different interactions style with these two types of devices. We also want to know how the intelligent, context aware, multimodal and natural interface promote implicit HCI that is the core of our recommended framework. In first experiment prototype we want to test the usability of different interaction style with implementation of context aware User interfaces and using natural multimodal interaction style.

Time and number of moves are the dependent variables for each interaction. Based on the time of activities completion and number of moves we can compare total and average completion time of the activities. Data collected from these experiments would be used to test the fallowing hypothesis.

Hypothesis 1: Context aware interaction improves usability.

Hypothesis 2: Context aware interactions is enabling technology for implicit Human Computer Interactions (iHCI)

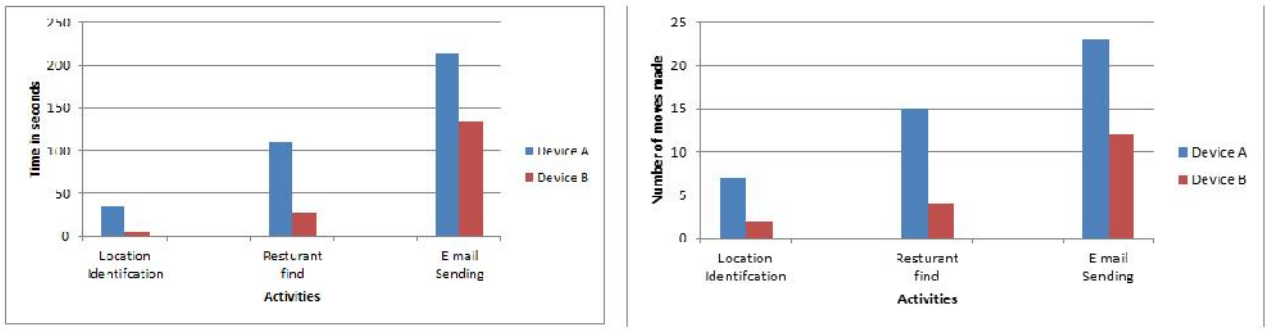

Fig. 4. Time taken and No of moves a user made with device 'A' and Device 'B'

4 DISCUSSIONS

Now we like to discuss some finding from the prototype experiment. We proved our first hypothesis that context aware user interfaces increase usability. From the above results we can infer that context aware interaction improves usability and efficiency, reduce number of moves in term of number of menus, buttons accessed for task completion and net result is that context aware interaction provide basis of implicit Human Computer Interactions (iHCI). These results suggest for accepting our first hypothesis that context aware information improve usability.

Designing such system there should be balance between complexity, usability and proactively or implicit interactions. Contextual information should be accurate enough to take actions otherwise it may lead to strange behavior of application with different context leads to lose of trust of user. Multimodal interactions, natural interactions and intelligent user interface help to adapt to context in an accurate way. We already mention that Implicit Human Computer Interactions (iHCI) is the basic requirement for interaction pattern in Ubiquitous computing and contextual information is useful for developing Implicit Human Computer Interactions (iHCI). This suggests for accepting our second hypothesis that "Context aware interactions are enabling technology for implicit Human Computer Interactions (iHCI)".

5 CONCLUSIONS

Ubiquitous computing has certain requirements and challenges in context of Human Computer Interactions (HCI). The spirit of Ubiquitous computing demands that there should be implicit Human Computer Interactions (HCI) in order to allow user to focus on their task with minimum distractions. Implicit Human Computer Interactions (iHCI) can be successfully achieved through use of contextual information based interactions. Context based interactions improves usability to improve Implicit Human Computer Interactions (iHCI). In this study we identify four themes of interactions named context based interactions, intelligent, natural and multimodal interactions suggested as a framework of Human Computer Interactions (HCI) that contribute towards development of implicit Human Computer Interactions (iHCI) in ubiquitous computing environment.

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