CHAPTER ONE

1.0 INTRODUCTION

The concept of smart environments evolves from the definition of ubiquitous computing that, according to Mark Weiser, promotes the ideas of "a physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives, and connected through a continuous network. “Smart environments are envisioned as the byproduct of pervasive computing and the availability of cheap computing power, making human interaction with the system a pleasant experience. In the influential article “The Computer for the 21st Century”, Mark Weiser created a vision of omnipresent computers that would serve people in their everyday lives at home and work, functioning invisibly and unobtrusively in the background and freeing them from tedious routine tasks. While Weiser’s basic principles – augmenting everyday artifacts with computation, sensing, and communication abilities; and using context to anticipate the user’s goals and intentions have been the subject of much research in the past years, the implications of comprehensively deploying such technology in society are much less understood. With its orientation towards the public as well as the private, the personal as well as the commercial, ubiquitous computing aspires to create technology that will accompany us throughout our whole lives, day in and day out. While developments in information technology never had the explicit goal of changing society, but rather did so as a side effect, the visions associated with ubiquitous computing expressly propose to transform the world and our society by fully computerizing it. In an ideal pervasive computing environment, a large number of connected smart devices are deployed to collaboratively provision seamless services to users. Pervasive computing is enabled by various advanced technologies, particularly wireless technologies and the Internet. It has become a trend for our future lives. A pervasive computing environment can be extremely heterogeneous. We can imagine how many different devices are involved in a smart home: TVs, phones, cameras, coffee makers, or even books and bookshelves. Since these devices are smart and communicate with each other mainly via wireless links, security must be ensured. Otherwise, the smart devices deployed around us would come back to haunt us and the result would be catastrophic. In this abstract we briefly discuss some important security issues in pervasive computing. A Smart Environment is a world where all kinds of smart devices are continuously working to make users' lives more comfortable (Cook, 2005). The context of the occupants is detected. In this way contextual information can be used to support and enhance the ability to execute application specific actions by providing information and services tailored to user's immediate needs (Ryan, 2005). The smart devices which work together are interconnected with each other. These smart devices have to provide contextual information. For this reason they have to be equipped with sensors which provide low level data. If the contextual information is the users' one, the smart devices are mobile devices carried by the user.

Smart Environments are currently considered a key factor to connect the physical world with the information world. A Smart Environment can be defined as the combination of a physical environment, an infrastructure for data management (called Smart Space), a collection of embedded systems gathering heterogeneous data from the environment and a connectivity solution to convey these data to the Smart Space. With this vision, any application which takes advantages from the environment could be devised, without the need to directly access to it, since all information are stored in the Smart Space in a interoperable format.

Moreover, according to this vision, for each entity populating the physical environment, i.e. users, objects, devices, environments, the following questions can be arise: "Who?, i.e. which are the entities that should be identified? "Where?" i.e. where are such entities located in physical space? and "What?" i.e. which attributes and properties of the entities should be stored in the Smart Space in machine understandable format, in the sense that its meaning has to be explicitly defined and all the data should be linked together in order to be automatically retrieved by interoperable applications. Starting from this the location detection is a necessary step in the creation of Smart Environments. If the addressed entity is a user and the environment a generic environment, a meaningful way to assign the position, is through a Pedestrian Tracking System. In this work two solutions for this type of system are proposed and compared. One of the two solutions has been studied and developed in all its aspects during the doctoral period. The work also investigates the problem to create and manage the Smart Environment. The proposed solution is to create, by means of natural interactions, links between objects and between objects and their environment, through the use of specific devices, i.e. Smart Objects.

1.1 SMART ENVIRONMENTS APPLICATIONS

In the last years, several Smart Environments applications has been developed in different domains. These applications utilize different Context Management systems and different data scheme. Particularly active is the smart housing research field. The Smart Home concept is presented in (Ricquebourg, 2006). In this paper a smart home can be described as a house which is equipped with smart objects. Smart Objects make possible the interaction between the residential gateway and the inhabitants.

The Georgia Tech Aware Home (Georgia Tech Institute, 1998) is one of the most complete of these projects. The Aware Home Research is devoted to the multidisciplinary exploration of emerging technologies and services in the home. For this reason the initiative follow different research areas: services for aging people, for example utilizing support for family communication (Digital Family Portrait), providing a medication management (Memory Mirror) and using computer vision to estimate senior's risk for falling in natural situations (Get Up and Go); several tools for family are proposed, for example Audio Notes which is a message center for the family, applications to aid caregivers for children with developmental disabilities, Baby Steps, an application for helping parents track their child's developmental progress or Pervasive Dietary Advisor (PDA) which monitor the health of individuals with type 2 diabetes after they leave the hospital. The Aware Home try to satisfy the need of householders with respect to the energy consumption of various appliances. For this purpose a Smart Energy monitor that reuses existing infrastructure in the home has been developed.

The Adaptive House developed by the University of Colorado (University Colorado, 2010) is a prototype system in an actual residence. The home laboratory is equipped with an array of over 75 sensors which provide information about the environmental conditions. Temperature, ambient light levels, sound, motion, door and window openings are monitored. Actuators to control the furnace, space heaters, water heater, lighting units, and ceiling fans are present. Control systems in the residence are based on neural network reinforcement learning and prediction techniques. Some examples of what the system can or do are: predicting when the occupants will return home and determining when to start heating the house so that a comfortable temperature is reached by the time the occupants arrive; inferring where the occupant is and what activities the occupant is engaged in.

Another nice example of Smart Environment research focused on smart housing is the Massachusetts Institute of Technology House_n (Massachusetts Institute Technology, 2010). In this project new technologies, materials, and strategies for design are explored in order to make possible dynamic and evolving places that respond to the complexities of life. Major House_n initiatives are The Place Lab and the Open Source Building Alliance. The Place Lab (Intille, 2006) initiative is a "living laboratory" residential home. The interior of the Place Lab is formed by 15 prefabricated cabinetry interior components that can be rapidly reconfigured. Each of the interior components contains: a network of 30 sensors, an array of environmental sensors, including CO, CO_2, temperature, and humidity, sensors to detect the on-off, open-closed, and object movement events, radio frequency devices to identity and detect the position approximate of people within the Place Lab, microphones, a sophisticated video capture system processes images. Advanced features are provided, such as: context specific feedback from people captured with standard Pocket PC devices, using sensors to trigger and acquire information, activity recognition in order to trigger an action or intervention utilizing installed sensors or biometric and accelerometer devices worn by the user, dynamic control of the lighting system, environmental control. The project Easy Living (Brumitt, 2000), is a project of Microsoft Research. In this project researchers developed prototype architectures and technologies for builbing intelligent environments. The system works utilizing three models: the world model, which inputs are the sensors data, the User Interface service model, which inputs are the User Interface devices and the application model which is connected with the above twos. The features provided by the system are the tracking of users' movements and the room control to perform light and eating management.

The MavHome project developed at the University of Texas, (Das, 2002) is a home environment which detects home environmental states through sensors and acts upon the environment through controller. The major goal of the MavHome project is to create a home that acts as a rational agent. The agent seeks to maximize inhabitant comfort and minimize operation cost. To achieve these goals, the agent must be able to predict the mobility patterns and device usages of the inhabitants.

The Ubiquitous Home (Yamazaki, 2007) is a real-life test bed for context aware service experiments. The Ubiquitous Home has a living room, dining-kitchen, study, bedroom, washroom and bathroom, these rooms comprising an apartment. The Ubiquitous Home is equipped with various types of sensors to monitor living human activities. Each room has cameras and microphones in the ceiling to gather video and audio information. Floor pressure sensors installed throughout the flooring track residents or detect furniture positions. Infra-red sensors installed are used to detect human movement. Two RFID systems are installed in the

Ubiquitous Home. Four accelerometers or vibration sensors are attached to the bedroom floor in four corners. To provide a service to users, the user context is considered. In the Ubiquitous Home, personal identification can be obtained from the active-type RFID tag worn by the resident or the face recognition by the visible-type robot camera.

One of Smart Home application are the Welfare Techno House (Tamura, 1995). The concepts of this experimental house is to promote the independence for the elderly and disabled people and improve their quality life.

CHAPTER TWO

2.0 LITERATURE REVIEW

“The traditional computer is a glass box. All you can do is press buttons and see the effects. Ubiquitous computing and augmented reality systems break this glass box linking the real world with the electronics worlds”. These are words of Alan Dix, deriving from his book Human-Computer Interaction (Dix, 2004). In this book, Dix shows how computer has broken out of its plastic and glass bounds providing us with networked societies where personal computing devices from mobile phones to smart cards fill our pockets and electronic devices surround us at home and work. As the distinctions between the physical and the digital, and between work and leisure start to break down, Human-Computer interaction is also changing radically.

As Dix suggests, the way on which we are moving from an “Information Society” to a “Knowledge Society” involves research regarding various sectors. To summarize this migration a word has been introduced: Ubiquitous Computing. This term was born with the visionary work of Mark Weiser in mind (Weiser, 1991) (Weiser, 1996):

“*The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it*.” Consider a scenario like this: it’s night and you are awake. So you get up and go in the kitchen. Then you open the freezer and catch the chocolate ice cream box. “No” says the fridge, “it’s the two o’clock in the morning and you have the cholesterol level high”. This scenario has shades of Minority Report, the Steven Spielberg movie based upon the great futurist Philip K. Dick’s short story by that name. In fact, in the film, when the hero, John Anderton flees from the authorities, he passes through the crowded shopping malls. The advertising signs recognize him by name, tempting him with offers of clothes and special sale prices just for him. Minority Report was a fiction but the technology depicted in that movie was designed considering the Ubiquitous Computing idea. For example advertising sign are already close to becoming a reality. Billboards in multiple cities recognize owners of Mini Cooper automobile by the RFID tags they carry. This is only an example and a lot of work must be done to arrive at the Minority Report scenario. This jump in science fiction introduces the concept of technology “Anytime, anywhere, any device”. This concept means the transition from a device-centered world to a new type of interconnected society, where information is spread around the environment and a large set of different technologies and devices are used at the same time with seamless transition of information from one to another.

2.1 SCENARIO

As mentioned, the Ubiquitous Computing is about research regarding various sectors. In fact, the above mentioned anytime, anywhere, any device technology can be seen as the interaction between physical environment, people, sensors, devices (Fig. 1. 1).

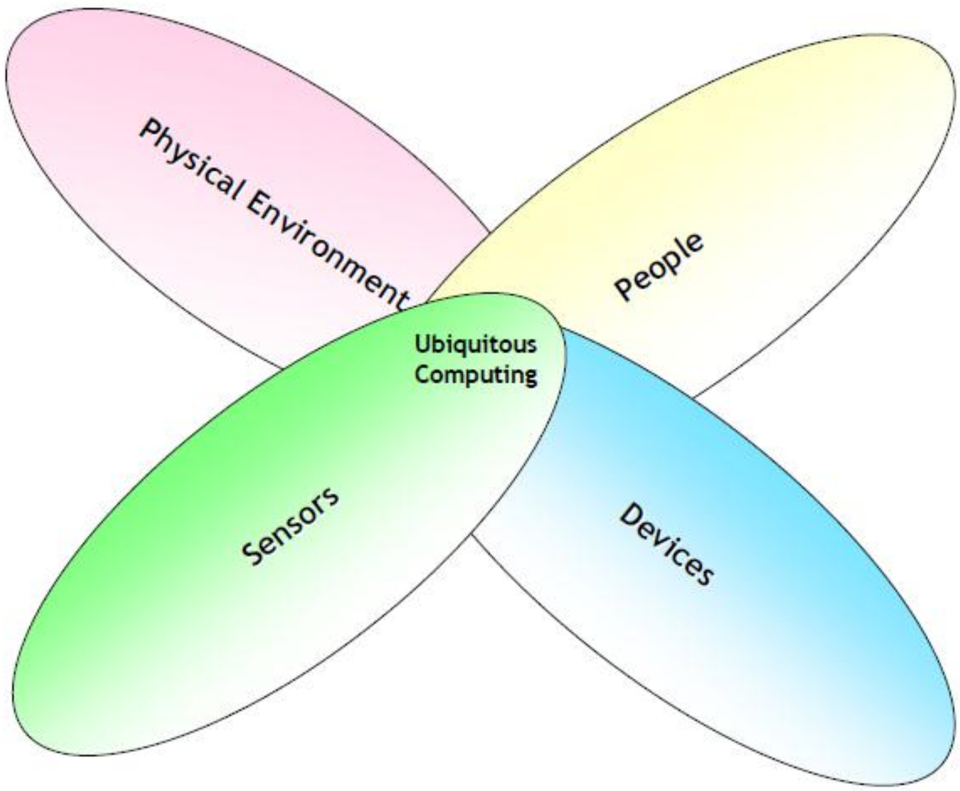

Fig. 2.1 Ubiquitous computing interaction

The physical environment surrounds people which live in it. People wear or carry mobile devices. Physical environment is composed by objects which can be equipped of sensors. Sensors can be installed in the physical environment. One of the visions of the Ubiquitous Computing is from the environment point of view. The research field in which the principles and the methodology necessary to the creation of intelligent environment are studied, is called ambient computing. Starting from physical environment, the ambient computing allows to create environments in which heterogeneous devices interact with each other, with people and with the physical environment itself, allowing the identification of contextual relevant services and adapting them to the situation and to the user profile and preferences. These type of environments are called Smart Environments (SE) (Fig. 1. 2).

Fig. 2.1.1 Smart Environments

A Smart Environment is a world where "all kinds of smart devices are continuously working to make users' lives more comfortable" (Cook, 2005). Smart Environments aim to satisfy the experience of individuals from every environment, by replacing the hazardous work, physical labor, and repetitive tasks with automated agents. Another definition of Smart Environments derives from Mark Weiser: "a physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives, and connected through a continuous network".

In Smart Environment the context of the occupants is detected. In this way contextual information can be used to support and enhance the ability to execute application specific actions by providing information and services tailored to user's immediate needs (Ryan, 2005). The smart devices which work together are interconnected with each other. These smart devices has to provide contextual information. For this reason they have to be equipped by sensors which provide low level data. If the contextual information is the users' one, the smart devices are mobile devices carried from the user. Devices that are able to connect people and environment within the Smart Environment are called Smart Objects (SO). A Smart Environment can be defined as the combination of a physical environment, an infrastructure for data management (called Smart Space SS), a collection of embedded systems gathering heterogeneous data from the environment and a connectivity solution to convey these data to the Smart Space (Fig. 1. 3).

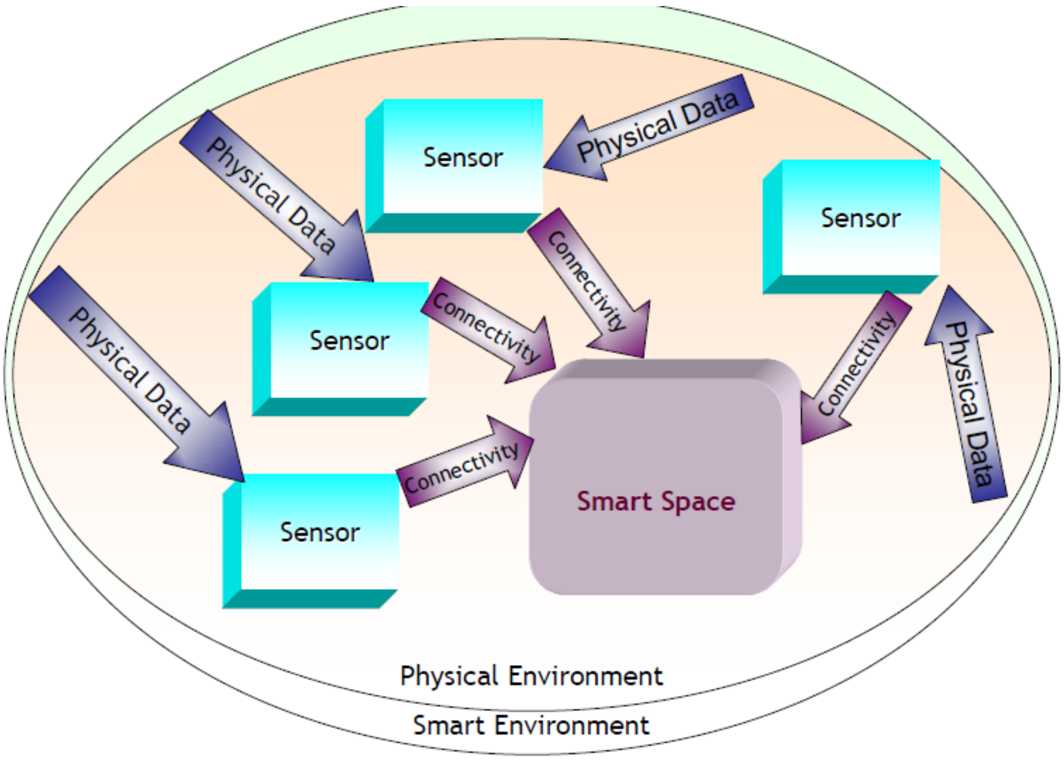

Fig. 2.1.3 Smart Environment Components

To realize Smart Environments numerous amount of technical challenges must be overcome. The technical challenges may be summarized as how to create a consistent architecture for a Smart Environment characterized by three equally important trends: Multi-Part, Multi-Device, and Multi-Vendor interoperability (MMM interoperability), dynamic device configurations and extreme scalability. Interoperability is defined from IEEE (IEEE, 1990) as the ability of two or more systems or components to exchange information and to use the information that has been exchanged. A more accurate definition is: Interoperability is the capability of a product or system to interact and function with other products or systems, without any access or implementation restrictions.

The interoperability is the requirement to provide to the users seamless connectivity and seamless services supplying (Salmon, 2008):

1. platform interoperability: same services run on different platforms, e.g. devices, Smart Phones;
2. data interoperability: services work on a common representation of data, and are independent from their data sources;
3. Network interoperability: the connection takes place to the best available network. Focusing on interoperability, the aim of a Smart Environment is to provide cross-domain interoperability and cross-industry interoperability. The cross-domain interoperability is about the interconnection and communication between different technological platforms, possibly developed within different application domains. The cross-industry interoperability deals with technical interoperability issues, such as commercial strategies, licenses, and regulations. This type of interoperability can be called Multi-Part, Multi-Device, and Multi-Vendor interoperability (MMM interoperability).

The Smart Environment problem could be decomposed in several problems, each of them open research issues:

1. the context-aware computing problem
2. the mobile computing problem
3. the problem of creating and interfacing context providing sensors
4. the problem of creating usable and friendly interfaces between devices and people.

2.2 CONTEXT AWARE COMPUTING

People have always used the context of the situation to get things done. We use our understanding of current circumstances to structure activities, to navigate the world around us, to organize information, and to adapt to external conditions. Context awareness has become a integral part of computing. Context awareness computing aims to adapt the service to the current situation. To provide the fittest service, the system has to observe the inhabitant and the environment to collect information. The context is “all information which can be used to characterize an entity. 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 application themselves” (Dey, 2001). This broad definition allows to define in every scenario the most suitable specialized definition of context, which is needed for every practical implementation of Context awareness.

Several different definitions are proposed in literature. A survey of the most relevant current approaches to modeling context for Ubiquitous Computing is proposed in (Strang, 2004). A review of the context-aware systems from 2000 to 2007 is proposed in (Hong, 2009).

(Schilit, 1994) refers to context as location, identities of nearby people and objects and changes to those objects. Also (Brown, 1997a) defines context as location, identities of the people around the user, the time of day, season, temperature, etc. (Coutaz, 2005) points out that context is not merely a collection of elements (a state) but it is a part of the entire Human-Computer Interaction (HCI discussed further on) process or interaction within an ever-changing environment, made by a set of entities, a set of roles (of entities) and relations (between entities) and a set of situation.

The requirements for an infrastructure that supports Context Aware application are (Dey, 1999):

1. To allow applications to access context information from distributed machines in the same way they access user input information from the local machine;
2. To support execution on different platforms and the use of different programming languages;
3. To support for the interpretation of context information;
4. To support for the aggregation of context information;
5. To support independence and persistence of context widgets;
6. To support the storing of context history.

2.3 MOBILE COMPUTING

Today's trends see the introduction of a new figure of users: the nomadic user. In the context of Smart Environments, the trend in this case introduces high-capabilities devices spread in the environment and mobile devices, wearable devices and in general high computational capacity computers which move together with the user. As a consequence, the devices need increased capabilities. Internet-capable smart cell phones, wireless-enabled PDAs, tiny mobile devices which utilize last generation CPUs, high storage memories, several communication capabilities, has been introduced. In this case the cooperation between the user and the Smart Environment is explicit, in that the user has to interact with the mobile device to perform a task.

If the mobile device is worn from the user, if it is created for a specific task, or if the cooperation from the user and the Smart Environment is implicit, the mobile computing flows into the field of wearable computing. The aims of wearable computing is to connect the user to an adaptive personal intelligent environment. Research on tiny embedded devices, small sensors, high capacity in situation adapting, affect this implicit cooperation between users and Smart Environment. If we define Smart Objects as devices that are able to connect people and the Smart Environment, it is easy to see that all the issues considered in the creation of mobile devices and wearable devices have to be taken into consideration also in the case of Smart Objects.

2.4 CONTEXT PROVIDING SENSORS

Sensors are the link between digital and physical world. In fact, the automatic context acquisition is a prerequisite in order to capture real world situations. This phase is characterized by the usage of a multitude of sensors. Sensors are used to capture the characteristics of the physical world. As seen in (Goertz, 2004): “A sensor is a device that perceives a physical property and transmits the result to a measurement. A sensor maps the value of some environmental attribute to a quantitative measurement.” Then sensors provide the intelligence to the physical environment.

The conceptual flow from physical data to extracting contextual data is exposed in Fig. 1. 4: physical data are spread in the world; Smart Environment contains sensors; data are captured from the sensors; the combination and fusion of multiple sensor output can be used; the transformation of this data into relevant contextual data requires the knowledge of the situation in which these data has to be utilized. The problem of sensor fusion is particularly important in the extraction of contextual data: a sensor might not produce sufficient information due to uncertainty and unreliability of the sensor itself. Two types of sensor fusion are present: the competitive and the complementary. The competitive sensor fusion is based on sensors which detect equivalent physical data, trying to diminish the errors in the measurements of every sensor. The complementary sensor fusion utilizes different typologies of sensors to extract high level data.

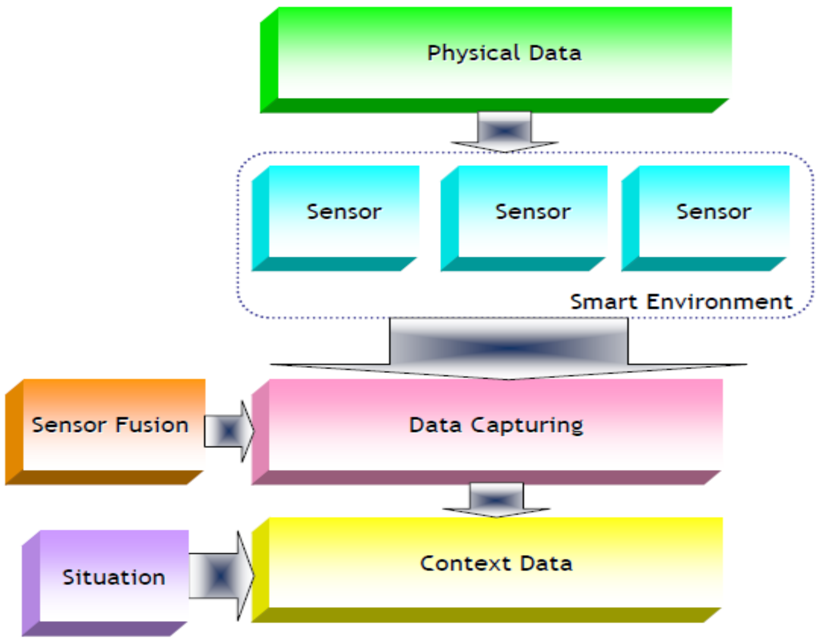

Fig. 2.4 From Physical to Context Data

2.5 HUMAN-MACHINE INTERFACES

The Design of future things (Norman, 2007), the relevant problem of interaction between human and machine occurs because we are two different species which work, think and act in different manner and utilizing different mechanisms. Devices are "stupid" and the management is always a major problem of the user because human have greater adaptation capabilities. Then, the entire research and commercial community is trying to solve the problem called Human-Computer Interaction (HCI). When considering Smart Environments, the problem of interaction as a support of the communication from the Smart Environment and the user is a crucial point. The goals of interaction are: supporting adaptative interfaces of devices on user's preferences, supporting self-configuration of devices to collection of interaction devices, providing a loop for interaction with the environment and feedback loops for information gathering from the environment. Interaction in the context of Smart Environments can be either active (explicit) interaction or passive (implicit) interaction by means of ambient sensors and contextual data tracking. In every cases the successful of the interaction between human and machine trying to avoid the lack of common ground. "The lack of common ground precludes many conversation-like interactions" (Norman, 2007), freezing the communication channel form people to devices.

CHAPTER THREE

3.0 CHALLENGES FACING THE IMPLEMENTATION OF SMART ENVIRONMENT IN NIGERIA.

A. POWER

In May of this year, the Ministry of Power released figures that showed power output nosedived from a peak 4,500 MW to 2,500MW; which is nearly half of the original figure.

According to an official statement by the Ministry which coincidentally is headed by the immediate past governor of Lagos, the drop in power production was caused by vandalism of gas pipelines. There is no respite to this plight in sight, instead, it looks to be getting worse as we have seen an increase in the activities of these vandals recently. And this has reflected in daily electricity allowance in homes. If the electricity will not stay on long enough for me to iron two shirts, how will a smart city be powered? I suggest off-grid energy. Solar energy as a source of power should be explored to its full potential. Wind and water energy can also be harnessed along with biodiesel and other renewable energy sources. It makes complete sense for a futuristic project like a smart city to tap into alternative sources of energy to power it.

B. DATA AND RESEARCH

A smart environment has all its workings interwoven and this is only possible with the collation and application of data gathered way over time from the citizens. Systems cannot be efficient and fluid as intended in a Smart Environment if basic data of the citizens are not on record. This problem is only peculiar to a smart environment in an area where data is not readily available or non-existent.

The data culture in Nigeria is not very alive, even though it is picking up slowly albeit rather slowly. Too slow for a rapidly growing economy. To get answers and data across various platforms and really understand how its systems work, Federal Government has to tap into sourcing from the citizens themselves with surveys, reliable computing systems in places where public data us collated.

C. SECURITY

1. A smart environment must provide the facilities for a user, device and application to authenticate with different security means, e.g. ID, password, public key exchange, biometrics, etc. Authentication is required before different kinds of interactions and actions can be performed.
2. A smart environment has to keep controlling the accesses of appliances and related authorizations. Thus, when a user or application tries to access to a smart space, the space has to check that the requester has access to information or an appliance in question. This also regards any software update, which should not breach access control.
3. A smart environment is to guarantee integrity and privacy of (shared) information. First, information about the entities connected to the smart space has to be protected while transmitted from an information provider to an information consumer.

   Second, the environment should provide solutions that prevent unauthorized corruption of transmitted information. Thirdly, privacy is the must; information related to persons and their preferences/behaviours in the smart space is to be secured.
4. A space might have to support non-repudiation of performed operations and requests. Thus every action performed by a user or an application must be logged and associated to the source of the action. For example, the action performed by a building maintenance staff has to be associated to the person who completed the task.

5. Users and smart environment should protect themselves from infections. Moreover, use and forwarding of harmful content to users and applications are to be prevented.

D. ILLITERACY

In Nigeria today, the lack of illiteracy has caused a lot of damage to the society because of the non adaptation to smart environment.Some electronic technologies needs experts and also it is only educated people that can be able to adapt to the environment. Education is very importance in this computer age, therefore being educated is very good so that, in every environment a person finds him or herself, adaptation will be guarantee.

E. INADEQUATE FACILITIES

In developed countries, like U.S.A, government ensure that there is enough storage facilities in their countries, this makes life easier and convenient for the to live because of living in a smart environment, makes life more easier and convenient to live. But this is not effective in Nigeria. Nigeria is a corrupt country govern by selfish people, but it can be better if the government can provide and supply the basic facilities and equipments the country needs to make the environment a smart environment.

F. DUMB ADMINISTRATION

The politicians of Nigeria have picked up the term “smart Environment” to woo the youngsters. In the past few months, we have witnessed the real face of the corrupt ministers who rule our country. Corruption has become a part of our country's identity. Talking about a smart environment and creating a plan under the corrupt ministers is a waste of time and resources. Smart Environment is not possible with a set of dumb administrators and politicians.

G. LACK OF FINANCES

In a smart Environment, most people have to build their own houses according to their financial capacity. A lot of people would not be able to afford a place in smart city as it would be very costly. Thus, people from Middle class and poor section of the society won't be able to enjoy the benefits of a smart Environment.

H. BETTER UTILIZATION OF PLACES

A large acre of land would be wasted for the construction of a smart Environment. If properly utilized, this area can be turned into a biodiversity park later on.

I. PROPER USE OF FUND

Nigeria is a country which is better known for its increasing poverty rate. Only a certain part of the Environment would be utilized for constructing a smart Environment whereas, the other part of the Environment would be still under the shadow of poverty. We should understand that smart Environment won't be able to solve the basic issues of an entire state or Environment. If the fund which is planned to be spent for a smart Environment is utilized for decreasing the poverty rate, Nigeria would be much ahead of other countries.

3.1 TECHNOLOGIES INVOLVE IN BUILDING SMART ENVIRONMENT

1. Wireless communication

2. Algorithm design, signal prediction & classification, information theory

3. Multilayered software architecture, Corba, middleware

4. Speech recognition

5. Image processing, image recognition

6. Sensors design, calibration, motion detection, temperature, pressure sensors,

7. Semantic Web and knowledge graphs

8. Adaptive control, Kalman filters

9. Computer networking

10. Parallel processing

11. Operating systems

3.2 FEATURES OF SMART ENVIRONMENTS

Smart environments are broadly classified to have the following features

1. Remote control of devices, like power line communication systems to control devices.
2. Device Communication, using middleware, and Wireless communication to form a picture of connected environments.
3. Information Acquisition/Dissemination from sensor networks
4. Enhanced Services by Intelligent Devices
5. Predictive and Decision-Making capabilities Technologies

Important features of smart environments are that they possess a degree of autonomy, adapt themselves to changing environments, and communicate with humans in a natural way. Intelligent automation can reduce the amount of interaction required by the inhabitants, as well as reducing utility consumption and other potential wastages. These capabilities can also provide important features such as detection of unusual or anomalous behaviors for health monitoring and home security, for example.

The benefits of automation can influence every environment we interact with in daily lives. As an example, consider operations in a smart home and illustrate with the help of the following scenario. To minimize energy consumption, the home keeps the temperature cool throughout the night. At 6:45am, the home turns up the heat because it has learned that it needs 15 minutes to warm to the inhabitant's favorite waking temperature. The alarm sounds at 7:00, which signals the bedroom light to go on as well as the coffee maker in the kitchen. The inhabitant, Bob, steps into the bathroom and turns on the light. The home records this manual interaction, displays the morning news on the bathroom video screen, and turns on the shower. While Bob is shaving, the home senses that Bob is four pounds over his ideal weight and adjusts his suggested daily menu and displays in the kitchen. When Bob finishes grooming, the bathroom light turns off while the kitchen light and display turn on. During breakfast, Bob requests the janitor robot to clean the house. When Bob leaves for work, the home secures all doors behind him and starts the lawn sprinklers despite knowing the 30% predicted chance of rain. To reduce energy costs, the house turns down the heat until 15 minutes before Bob is due home. Because the refrigerator is low on milk and cheese, the home places a grocery order. When Bob arrives home, his grocery order has arrived, the house is back at Bob's desired temperature, and the hot tub is waiting for him.
This scenario highlights a number of desired features in a smart environment such as a home. In the following, let us look at some of these features in more detail.

3.3 REMOTE CONTROL OF DEVICES

The most basic feature of smart environments is the ability to control devices remotely or automatically. Powerline control systems have been available for decades and basic controls offered by X10 can be easily installed. By plugging devices into such a controller, inhabitants of an environment can turn lights, coffee makers, and other appliances on or off in much the same way as couch potatoes switch television stations with a remote control. Computer software can additionally be employed to program sequences of device activities and to capture device events executed by the powerline controllers.

With this capability, inhabitants are free from the requirement of physical access to devices. Individuals with disabilities can control devices from a distance, as can the person who realized when he got to work that he left the sprinklers on. Automated lighting sequences can give the impression that an environment is occupied while the inhabitants are gone, thus handling basic routine procedures by the environment with almost no human intervention

Figure 3.3 Device Control in Smart Environments

3.4 DEVICE COMMUNICATIONS

With the maturity of wireless mobile communications and middleware technology, smart environment designers and inhabitants have been able to raise their standards and expectations. In particular, devices use these technologies to communicate with each other, share data to build a more informed model of the state of the environment and/or inhabitants, and retrieve information from outside sources over the Internet or wireless communication infrastructure. This allows better response to the current state and needs.

As mentioned earlier, such “connected environments” have become the focus of many industry developed smart homes and offices. With these capabilities, for example, the environment can access the weather page to determine the forecast and query the moisture sensor in the lawn to determine how long the sprinklers should run. Devices can access information from the Internet such as menus, operational manuals, or software upgrades, and can post information such as a grocery store list generated from monitoring inventory with an intelligent refrigerator or trash bin.

3.5 ENHANCED SERVICES BY INTELLIGENT DEVICES

Smart environments are usually equipped with numerous smart devices/appliances that provide varied and impressive capabilities. Networked together and tied to intelligent sensors and the outside world, the impact of these devices becomes even more powerful. Such devices are becoming the focus of a number of manufacturers including Electrolux, Whirlpool, and a collection of startup companies.

As examples of such devices, Frigidaire and Whirlpool offer intelligent refrigerators with features that include web cameras to monitor inventory, bar code scanners, and Internet-ready interactive screens. Through interactive cameras, inhabitants away from home can view the location of security or fire alerts and remote caregivers can check on the status of their patients or family. Merloni's Margherita 2000 washing machine is similarly Internet controlled, and uses sensor information to determine appropriate cycle times. Other devices such as microwaves, coffee makers, and toasters are quickly joining the collection.

CHAPTER FOUR
SUMMARY AND CONCLUSION

4.0 SUMMARY

The concept of smart environments evolves from the definition of ubiquitous computing that, according to Mark Weiser, promotes the ideas of "a physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives, and connected through a continuous network. "Smart environments are envisioned as the byproduct of pervasive computing and the availability of cheap computing power, making human interaction with the system a pleasant experience. A smart environment takes the notion of interactive architecture a bit further. With the use of sensing devices and actuators it will be possible to coordinate different objects and materials in a built environment to make buildings more functional and better able meet occupant needs in real-time. One trend is to make smart environments "goal-based" (thus, occupant-centered).

4.1 CONCLUSION

This chapter demonstrated the effectiveness of learning and prediction based paradigm in a smart home environment. Efficient prediction algorithms provide information useful for future locations and activities, automating activities, optimizing design and control methods for devices and tasks within the environment, and identifying anomalies. These technologies reduce the work to maintain a home, lessen energy utilization, and provide special benefits for elderly and people with disabilities. In the future, these abilities will be generalized to conglomeration of environments, including smart offices, smart roads, smart hospitals, smart automobiles, and smart airports, through which a user may pass through in daily life. Another research challenge is how to characterize mobility and activity profiles of multiple inhabitants (e.g., living in the same home) in the same dictionary and predict or trigger events to meet the common goals of the house under conflicting requirements of individual inhabitants

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