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An Ambient Assisted Living for Smart Home to Wealthy Life: A Short Review

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ABSTRACT

Establishing and sustaining smart environments for specific as well as generic purposes is the chief challenge today for IT professionals, professors and pundits. The attributes such as self, situation and surroundings-awareness have become an obligatory necessity and the key differentiators for next-generation IT, for dynamically producing and unobtrusively providing context-aware and cognitive applications to people everywhere all the time. This short review has discussed in detail a variety of Ambient Assisted Living (AAL) applications that are getting prominent and dominant in smart homes across the world. The idea is to gain a significant knowledge base on the role and responsibility of future IT in energizing and ensuring smart healthcare services for the total humanity.

Key words: Sensors, actuators, connectivity mechanisms, service-based integration middleware, ambient healthcare, smart environments

INTRODUCTION

Ambient Intelligence (AmI) is the long-term vision for IT (Kung *et al*., 2011). That is, the much-discussed computational, communication, sensing, perception, decision-enabling and actuation intelligence is readily made available for all everywhere and every time (Zhou *et al*., 2011; Aztiria *et al*., 2010; Cook *et al*., 2009; Ramos *et al*., 2008; Thomas *et al*., 2007). Our daily environments and all the elements and entities over there are increasingly made intelligent. Digitalization, commoditization, distribution, decentralization and other age-old IT-enablement activities are zooming ahead. The prevalence and penetration of IT into our public as well as private zones is gaining momentum in order to accomplish more precise and perfect automation.

Each and every common and casual article, asset and artifact in our daily working, walking and wandering environments is going to be digitalized towards compact cognition-enablement. Our everyday spaces are mesmerizingly stuffed and saturated with a cornucopia of smart sensors and actuators. Further on, the deeper connectivity and seamless integration among the physical world constituents (appliances, devices, instruments, machines, personal gadgets and gizmos, consumer electronics, kitchen items, displays, controllers, robots, medicine cabinets, coffee makers, wardrobes, cots, chairs, windows, media players, meters, etc.) and the cloud-based Cyber world applications goes a long way in realizing scores of next-generation sophisticated and smart physical and people-centric services (Alam *et al*., 2011).

This phenomenal transformation is not an easy or rosy task to be established in days or months. It is estimated that this strategic goal is to take years to fructify. However, the brewing and booming trends in the hot IT space are really encouraging and exciting. A number of competent technologies and methodologies have arrived onto the IT space and are grandly and gladly assuring the AmI realization sooner than later. The device space is really mind-boggling and our personal digital assistants are getting slimmer, sleeker and trendier. The versatility and vivacity of the varied and vast embedded world is really fascinating and fabulous. This study has considered home environments as the key domain of the present research investigation and AAL is the problem of choice for sprouting and springing forth a stream of new functionalities, facilities and features for those aged, bed-ridden and debilitated people.

AMBIENT INTELLIGENCE (AMI)

AmI (Ambient Intelligence), is context awareness (Venkatesh *et al.*, 2012a; Zhou *et al.*, 2011; Meyer and Rakotonirainy, 2003; Baldauf *et al.*, 2007). i.e., to enable systems to understand user needs and situational contexts so as to provide personalized services by tailoring its reaction upon the environment and user needs proactively. The human interactions are associated with the entire environment and its each single physical object, in this plan of approach. A protractile and more intuitive interaction is anticipated to yield better efficiency, increased creativity and greater personal well-being.

There are a wider variety of digital devices emerging and evolving in order to assist knowledge workers by facilitating ubiquitous information and service access. These personal gadgets and gizmos empower people to take timely, well-informed and insightful decisions in their daily walks and works by precisely and perfectly pulling and aggregating information from different and distributed sources using any available network. These devices are capable of multicasting messages in their environments in order to locate compatible devices and do an increasing number of situation-aware actions for device owners. For example, a presenter could make use of projectors, displays and other equipments in order to provide a smart presentation to his audience.

Whenever, we use sensors of different kind together, we are in need of a mediator or a technique which can help us in proper communication and help in accurate transfer of required information in the right time. This becomes a major issue because if the information is not received as it must be or is garbled, lost then the entire concept of employing these sensors has been diminished. For this purpose, a lot of work is being done to develop various middleware architectures. The outcomes of smarter homes (Venkatesh and Sundaram, 2012) are many including making consumers' lives more productive, healthier and happier. The four service areas are:

- **Entertainment and convenience:** Today, we can provide all the content of internet through entertainment systems such as a TV. Many consumer electronics companies are creating open platforms for their products such as flat panel televisions. These devices are featuring a portal which personalises the various entertainment content provided by broadcasters and movie studios
- **Energy management:** In the future, automatic savings in the electricity usage will be provided to the users based on the demands of the main electricity grid which is accomplished by doing an instantaneous home appliance management prioritizing energy services. Adding the smart technology would minimize the energy consumption based on the environment

conditions and the changes to them. Some of the places where this can be done is in lighting, home appliances, environmental and climate sensors, to name a few

- **Safety and security:** Home security is being enhanced by the use of home sensors that would instantly notify the home owner, neighbours, police and anyone else in case of a violation of security. Many insurers are offering discounts if centralised alarm services using sensors and IP surveillance cameras already exist. It is also possible today those family members can keep a check on the safety of their children or elderly remotely by employing these services (Xu *et al.*, 2012)
- **Health and wellness:** Without the need for hospitalisation, it is possible today to provide state of the art health care at the house of a patient. We can monitor for disease management and prevention of an individual by collecting information about current health conditions to track the fitness and well being and thus provide a holistic prognosis

ENVISIONING THE SENSOR WORLD

An Embedded Wireless Sensor Network (EWSN) (Ming-Hui *et al.*, 2005; Alemdar and Ersoy, 2010; Zhang *et al.*, 2007) in health care domain consists of heterogeneous components and is used to monitor the physical as well as present situation of temperature, humidity, pressure, oxygen, carbon dioxide etc. The EWSN was more helpful in social care, for the benefit of aged people in order to run their daily life with highly independent secured and safety. EWSN collects information from each sensor which is needed by smart environment across the globe like smart home, smart office, smart hospital (Venkatesh *et al.*, 2012b), smart railway station and many other environments. In smart environment if it is implemented with wired one it is practically not suitable one. A (EWSN) is quite required to solve the problem and also mush faster than any other network. Sensors and Actuators-Sensors are like the sensory organs of a human body. They are used to observe certain changes in the environment. He *et al.* (2001) discusses about a theory based on the finite element formulation based on the classical laminated plate theory and vibration control of the Functionally Graded Material (FGM) plates with integrated piezoelectric sensors and actuators. The influence of feedback control gain on responses, both static and dynamic are examined. The effects of the constituent volume fractions were also examined. He also says that use of piezoelectric sensor and actuator systems for the active vibration suppression and shape control is fast becoming an essential tool in the design of smart structures and systems. Issues regarding the use of sensors made of the materials that are discussed in the paper are also addressed.

Luo *et al.* (2010) has given a brief and a concise description about piezoelectric actuators. A new multi-objective topology optimization method is proposed in his study for systematic design of multi-phase piezoelectric actuators. The actuator under consideration is composed of a compliant host structure equipped with piezoelectric elements, where the host structure functions as a compliant amplifier to enlarge the small stroke output generated via the actuation force of piezoelectric materials. In the context of optimal design of smart actuators however, most up-to-date approaches are either to optimize only the host passive structure with pre-determined piezoelectric stacks or to optimize the piezoelectric actuator with pre-known structure, both of which restricts the overall performance of multi-material actuators. This article presented a new design method for compliant piezoelectric actuators of multi-phase materials. A multi-objective topology optimization method based on the physical programming is proposed to measure practical multi-criterion requirements. The placements and topological layouts of the non-piezoelectric and piezoelectric materials are optimized by simultaneously distributing the multiple materials in the design domain.

The non-piezoelectric component actually acts as a compliant assembly which will enlarge the small displacement output generated by the embedded piezoelectric material elements. The introduction of a second elastic material phase as a host structure can greatly improve the overall performance of the smart actuation system.

Schneider *et al*. (2011) describes actuators as those which execute commands of smart control systems like alarm systems, for security systems or ambient assisted living, home automation (Yilmaz, 2010), healthcare etc. Each actuator establishes an interface for connecting systems without bus/network capabilities. Actuators can execute commands upon request. Schneider also says that 2 different classes of commands are possible. One is the action command such as those which trigger an alarm and the other one a control command, those actuators that receive a control command and replies with its current actuator status or an error message. An action command triggers an event on the connection port of the actuator. Usually, these ports are connected to other entities like alarm generator, roller blinds, etc.

Smart sensors: Sammarco *et al*. (2007) describe a smart sensor as one having in-built intelligence on partially or fully integrated on a single chip, whether apparent to the user or not. They along with the primary function of producing an output which represents a sensed quantity, provide added functionality. A thorough discussion on how sensors are characterized, how they are used in various environments is provided by the author and his colleagues.

Smart sensors that are capable of sensing various dimensions in a smart environment are used today together to get a larger picture of the entire scenario. This information can then be used for making developing a smart home, a smart hospital or any other environment that when altered by employing these sensors would surely improve the lifestyle of humans to a great extent. We are only beginning to employ these sensors and there are so many other possible use for these sensors. Some of the places where these sensors are used today are mentioned here:

- Heating, Ventilation and Air Conditioning Systems (HVAC)
- Security and safety (access control)
- Lighting fixtures
- Sun control and shading devices
- Indoor air quality
- Window controls
- Systems switching off devices
- Metering (covered in the section on smart grids)
- Standard household applications (e.g. televisions, washing machines)

These sensors are today used to create an ambient environment. Called by names such as ambient assisted living, ambient intelligence, this phenomenon aims to help humans in making their day to day activities in lesser intensive and giving them time to perform activities of greater importance. Ambient Intelligence (AmI) is about creating environments that respond to the actions of persons and objects and catering to their needs depending on the sensitivity, adaptability.

EXPLAINING THE LEADING COMMUNICATION PROTOCOLS

For the sensor world, ZigBee, is the communication protocol standard (Xiao *et al*., 2011). There are a growing array of sensors and actuators with low data rate, low power consumption wireless networking protocol which would also be energy efficient and in variegating capacities and capabilities. ZigBee technology is used for various remote control applications and automation.

The initial work on a low data rate standard was started by the IEEE 802.15.4 committee which later combined its work with the ZigBee alliance; named their products ZigBee, for commercial purposes. These products are estimated to provide low power for equipments but require a battery life as long as several months and cost connectivity but which may need a low data rate when compared to Bluetooth. The other major advantage is the fact that the mesh networks that can be created in ZigBee are way larger and can be more complex when compared to Bluetooth. Depending on the RF environment and the consumption of power by the device for a given application the devices are expected to transmit to up to a range of 75 meters, where the worldwide unlicensed RF would be used for communication.

ZigBee technology has impetus for building next-generation sensor-based applications as it is more power efficient when compared to similar wireless networks such as Bluetooth. ZigBee may rather look like Bluetooth in many ways but actually is simpler, has a lower data rate and snoozes most of the time. These characteristics imply that a node on a ZigBee network should be able to run on just two AA batteries for a time span of up to two years. The opportunities and possibilities for creating a ubiquitous environment have widened with arrival of slim and sleek devices (Hussain *et al*., 2008).

SERVICE ORIENTED DEVICE ARCHITECTURE (SODA)

Various sensors being fully compatible with each other are very slim. This makes our task very difficult as we might not be able to retrieve the right information from all the sensors simultaneously as we need to. Else, each sensor may be produced with different specifications. So to be able to tackle these and other problems, we need a middleware. A lot of promising work has been done in this field and today we have technologies such as OSGi, DPWS to name a few.

Device Integration (Chen and Helal, 2009) and Orchestration-the open Service Gateway initiative (OSGi) (Martin *et al*., 2009; Dobrev *et al*., 2002) specifications define a standardized, component-oriented, computing environment for networked services. These services are the ones which lay the foundation of an enhanced SOA. The capabilities are added, to manage life cycles of the software components in the device from anywhere in the network when we use the OSGi service platform. Without disrupting the operation of the device a component can be changed, installed or removed.

Software components consist of libraries or applications which are capable of dynamically discovering and using other components. A software component can be bought off the shelf or developed from scratch.

Many standard component interfaces that are available for common functions namely for HTTP servers, logging, security, configuration, XML and many more have been developed and provided by the OSGi alliance. We can obtain the implementations to these components from various vendors with different optimizations to suit our needs and that of the market. A single JVM is used by the OSGi specifications. Hence, they form a very small layer that allows multiple Java based components cooperate and function efficiently. Extensive array of mechanisms are provided to make the cooperation of components possible and also secure.

The Devices Profile for Web Services (DPWS) is a fast-emerging standard for the device space. This is fully compliant to the SODA concepts and is to result in a series of best-of-breed implementations by different individuals, innovators and institutions. This is primarily for everyday devices in our environments (home, office, manufacturing floor, railway station, hospital, auditorium, etc.). The key differentiator is that DPWS is language-independent. That means, all kinds of device services could be written using any programming language. Microsoft has included a lean implementation of DPWS in operating system software so that Windows can be leveraged for the mesmerizing device space. DPWS focuses on two sets of devices: Clients (controlling devices) and services (controlled devices). The major modules of DPWS include WS-Discovery, WS-Eventing and WS-Metadata Exchange that allow the clients to discover, subscribe to events and get descriptions form services using well- known, standard and open protocols.

The core transport components of DPWS are UDP (User Datagram Protocol), with its multicast messages that are used for discovery and TCP/IP (Transmission Control Protocol/Internet Protocol) for data exchange. The messages are sent between a client and server with the HTTP protocol that sits on top of the TCP/IP. All messages are in the SOAP (Simple Object Access Protocol) format which is based on XML and is used for common Web Services.

ESTABLISHING SMART ENVIRONMENTS

Zhou *et al.* (2011) has written about smart sensors and smart Environment. Rashidi *et al.* (2011) and Abdulrazak *et al.* (2004) have penned that while supporting natural interactions with users, ambient sensors often perform too ambiguously to differentiate detailed information concerning specific users. In this regard, wearable sensors can provide more detailed and user-specific information. These sensors often form a body sensor network and provide a platform to establish a pervasive health monitoring system. Wearable sensors include ECG sensors for measuring heart rhythms, accelerometers for measuring human motion and microphones for recording sounds, etc. While these signals can indicate the trends or symptoms of certain diseases, they can hardly offer information about users' behavior or locations.

THE EMERGING AAL APPLICATIONS

Venkatesh *et al.* (2011a) describes a standards-based ambient healthcare system which was developed and tested. The author further writes that it is a great gift for the debilitated, disabled and elderly. The system can significantly enhance the living conditions of humans rapidly. Their focus was to produce and protract an Ambient Assisted Living (AAL) (Venkatesh *et al.*, 2011b, 2011c; McNaull *et al.*, 2011; Jara *et al.*, 2011) system by using Open Services Gateway Initiative (OSGi) which is impinging as the leading and dominant service integration, composition and collaboration standard. There are several best-in-class implementations of the OSGi specification. Furthermore it also developed a decentralized network of services and devices.

In addition, Venkatesh *et al.* (2011c) has identified a pervasive and persuasive use case. In this paper the author has implemented a smart environment in a hospital ICU. In an ICU, where even a small time difference in treatment can change course of the entire medical procedure a smart environment can be very useful and thus save a lot of lives. The smart environment is implemented using technologies like ZigBee (a wireless communication protocol), OSGi (a middleware) and knopflerfish (a framework for implementing OSGi).

Furthermore, Rashidi *et al.* (2011) has used pattern and activity recognition techniques in a smart environment to recognize and track daily routines that occur in a smart home (Liao and Tu, 2007; Xiaohu and Guangxi, 2006; Xu *et al.*, 2012). This information has been further used to track the occurrence of activities to monitor functional health and to detect changes in an individual's patterns and lifestyle. Several algorithms have been used by the author for this purpose and they have been described in this study.

Jara *et al.* (2011) has considered the seriousness of respiratory problems. To help patients suffering from severe problems, the author has dealt with these issues by employing an ambient assisted living solution. This paper presents an ambient assisted living solution that comprises technological innovations and advanced services to remotely monitor bed-ridden and debilitated patients. The specialized integrated biomedical sensors for monitoring the reduction in breathing capacity of person under care connect and communicate wirelessly to the gateway deployed at the house by a safe, global and secure communication. Thereafter the wide area network transmits the relevant and right message to care givers, clinics, doctors or even spouse in order to quickly contemplate any appropriate counter measures.

A CLOUD-BASED SERVICE DELIVERY PLATFORM (SDP) FRAME WORK

A common SDP based on industry standards supports cooperative interconnection and creation of novelty-packed services. Implementation inside the cloud (Carroll and Wang, 2011; Mohamed *et al.*, 2011) delivers definite advantages such as quick development of services at lower cost. The time-to-market has also been shortened facilitating rapid experimentation for improvisation. Typically an SDP enables the integration and management of large and complex sets of distributed services. The SDP concept got initiated in the telecommunications systems domain and is penetrating into other domains in faster and furious pace. Due to the diversity, distribution and decentralization of services, such kinds of common and centralized managed environments are gaining. An SOA-based framework has been provided by SDP to link modular services, including third-party services. These are used to manage the different types of service exposure and to leverage common back-end components. In addition, the SDP provides service lifecycle management. This begins from the creation of new services and takes care of tasks such as bringing them online in a controlled way for selected customer sets, to actual operations. Other services are also bundled and also, the final termination of services to make way for alternatives is also provided. The Important benefits of SDP are:

- Managing the complexity of service deployments means that third-party service providers can focus on their specific value add, without having the need to acquire the skill or spending capital to build a fully functional service infrastructure
- A more agile service creation is enabled by SDP by using SOA and Web 2.0 technologies
- Common storefront technology gives service providers the ability to integrate their business processes and store fronts for providing their services more efficiently

With the clouds emerge as the most competent, common and compact platform, increasingly the SDP is being migrated to clouds. Thus collectively the business, technical and user benefits are bound to abound. Implementing the SDP in the cloud can very well revolutionize the raging smart home discipline (Xiaohu and Guangxi, 2006; Xu *et al.*, 2012). The SDP is a unified and synchronized platform to easily integrate different services, whether they are implemented with cloud technology or as any of the conventional web services. The balancing of centralized and decentralized services with the use of existing back-end systems for the common functions has been made possible.

A Service Delivery Platform (SDP) in the cloud could support the expansion of the scope the business unit by enabling newer services in existing markets and by expanding existing services into newer markets. By exposing standard service interfaces in the network being employed, it

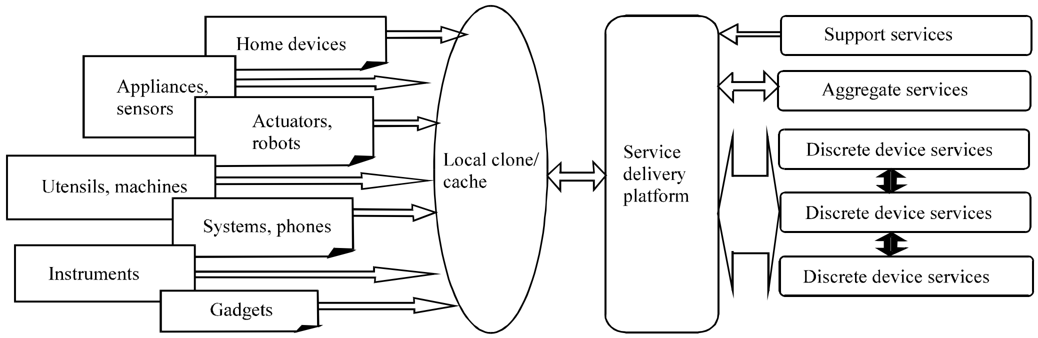

Fig. 1: Reference architecture for SDP

enables third parties to integrate their services quickly or to build novel services based on the service components provided in the SDP. This paves the way for nimbler business models with unbeatable business opportunities. A smarter home SDP is a specific-purpose SDP for contributing for the establishing, operation, management, governance and enhancement of smarter homes. The reference architecture for a cloud-based smarter home SDP comprising the vital components is given in Fig. 1.

CONCLUSION

A Smarter home is a personal and personalized place specifically designed to add life value, comfort, choice, care and convenience, energy-efficiency, safety and security and future expansion. Without an iota of doubt, home is the most lively and lovely place for people in their everyday lives. A growing array of smart environment technologies is being retrofitted to be usable and useful for easily and quickly producing and sustaining smarter homes. Home automation elements in plenty, industry-strength and open standards, trendy electronics, dynamic, virtualized and converged infrastructures and proven processes are being given fresh coat of life and thrust in order to build digital homes.

Wireless broadband communication, ambient, agile and adaptive sensors and actuators, smart heating, lighting, ventilation and air control systems, sophisticated, energy-efficient and connectable edutainment and infotainment electronics, home security appliances, kitchen utensils, etc will be profusely and prominently utilized in futuristic home environments in order to sufficiently enhance the quality of life. Digital electronics, technology-enabled and gripped spaces, the information superhighway, the Internet of services and things and energy all singlehandedly contribute for the goals of smarter homes. Sophistication and smartness are the trends decisively hold the home ICT. The powerful arrival of cloud technology syncs up with the smart home technologies and methodologies to lead to smarter homes.

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