Environmental Sustainability and Improved Quality of Life Through Service Convergence Technologies

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Abstract— This paper proposes the use of a wireless sensor network system as applied in a Smart Mining Camp to remotely control amenity functions and reduce energy consumption / emissions. Furthermore, we investigate such environmental sustainability and improved quality of life aspects through the use of multimedia convergence technologies.

Keywords: Smart home, ZigBee

I. INTRODUCTION

This paper proposes the use of a wireless sensor network system as applied in a Smart Mining Camp to remotely control amenity functions and reduce energy consumption / emissions. Furthermore, we investigate such environmental sustainability and improved quality of life aspects through the use of multimedia convergence technologies.

The aim of this research proposal is to develop a Smart Camp system with a range of initiatives including the goal of reducing environmental impact, operational costs and improving overall amenity. The following aspects are considered;

- **Presence monitoring** – PIR detectors signal if the room is occupied by monitoring the movement of a heated object within its field of view.
- **Access control** – RFID cards provide both security and access control. All locks and entry can be controlled from a central location.
- **Power control** – Lighting, entertainment, climate control, hot water heating etc can be monitored and controlled.

The main purpose of the our solution is to reduce energy consumption at the camp unit level. Energy usage reductions of +30% are anticipated when the Heating, Ventilation and Air Conditioning (HVAC) (including temperature and humidity control) is monitored and intelligently controlled. Cost savings can generally be seen as one of the most important aspects to a homeowner and a business. An internet-controlled system that has timer functions, for example, can both save money and help the environment, by allowing the homeowner to shutdown a unit's electrical systems in a timely fashion remotely.

The following two sections (Sections 2 and 3) provide the background of the technologies and concepts discussed in this paper.

II. HOME AUTOMATION

Smart home and home automation technologies can be seen as an enabling system that provide the resources needed to control the household environment and devices that can also be used for environmental conservation. Home automation depends on products that control the air conditioning, appliances, consumer electronics, and other devices. The goals of such a system may be entertainment, convenience, energy management, security, climate control, etc.

A Smart home network is available in wired and wireless network, sensor networks, and networked appliances. Wireless technologies are becoming increasingly common in home and building automation systems. They are relatively cheap and easy to install and extend, and they offer aesthetic benefits for device connectivity [1, 2]. A generic wireless data transmission system includes transmitters and receivers, and a translator to allow the wireless receiver to communicate with a control network. Repeaters may also be used to increase the range of wireless signals.
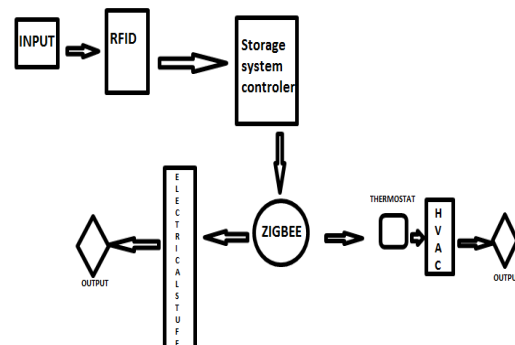

Fig 1. Generic home automation concepts.

Most wireless home automation systems use mesh style of networks, where some or all nodes can serve as transmitters and receivers and as routers that can relay messages from their

neighbours. An effective mesh network provides multiple communication pathways and dynamically identifies the optimum transmission path for each node in response to network traffic and interference. Wireless systems with extended antennae installed as part of a building's infrastructure may enable pervasive low-power systems that are used for home automation.

The IEEE 802.15.4 [6] low rate Wireless Personal Area Network (WPAN) is a protocol suitable for wireless sensor networks. There has been growing interest in the IEEE 802.15.4 protocol for use in home automation networks.

Among the many existing wireless protocols, ZigBee[5] is particularly well suited to home automation. The Zigbee protocol represents an instruction for a suite of high level communication constructs that are intended for small, low-power digital radios that are based on IEEE 802.15.4. ZigBee is intended to enable reliable, cost-effective, low-power, wirelessly networked monitoring and control products based on an open standard [9]. The ZigBee Alliance, with more than 200 member companies has produced a standard for wireless transmission of digital data that address many key needs of wireless building control networks. ZigBee-compliant devices operate at low data rates to reduce energy consumption and prolong device battery life, incorporate data security options, leverage communication technologies to reduce interference, and have a low cost.

Recently, research into the field of home automation has continued to receive much attention in academia. However, the new and exciting opportunities to increase the connectivity of devices within the home and industrial setting for the purpose of automation remain largely unexploited. The following areas of research are well documented:

- **Device Interfacing**
  - **Wireless Sensor Networks (WSN) -** WSNs are targeted to monitoring and operation applications. They are designed to be low cost, extremely power efficient and provide effective communication with low data rates that are needed for most home automation scenarios [2,4,5,6,8]. Popular solutions include 802.15.4, Z-Wave, Zigbee, Insteon, Smart Dust, KNX RF, and En Ocean are available now.
  - **Device Control Lines -** Programmable control systems can use embedded processing boards that are physically connected to devices and power switches. Through integration with a Personal Computer (PC), remote control of such devices is possible [2].

- **Automation Functions -** ICT systems are able to contribute to the efficiency of many solutions through automation services and operation processes. Construction and management of buildings using 'smart technology' from inception to demolition. For example;
  - **Design and Construction** - To better control resource and energy use, emissions, serviceability and durability, and a reduced environmental footprint during design and construction, computer aided analysis, simulation, design of buildings and products

using ICT-based tools can achieve reduced energy consumption, environmental emissions and improved services. If a building undergoes a change of use, ICT can be used to redesign its energy model and measure the impacts of this change.
  - **Demolition** - During decommissioning stages ICT services and plans in the design and construction phases can be used to shutdown, model and monitor demolition efforts.
  - **Energy Generation** - Engine Control Modules (ECM) can perform precise fuel and ignition control functions while greatly improving the energy efficiency of petrol/diesel generators.
  - **Operation** - Once a building is operational, using ICT systems and tools, it is possible to measure and benchmark its performance determine its energy efficiency. Occupants can install a Building Management System (BMS) to automate building functions such as lighting, heating and cooling. With home automation, monitoring, controlling and managing home functions can be performed remotely and automatically. Furthermore, energy usage can be monitored and scheduled throughout the day for optimum efficiency and off-peak usage. The environmental impact is reduced as power plants receive a more stable energy demand and consumers save on energy costs by shifting energy-intensive activities to lower rate periods.

III. CONVERGENCE

The advent of personal computers and the web have provided distributed mechanisms for information sharing [1, 2]. Currently, homes utilize the following ICT mediums and technologies:

- **Devices –** Wireless and wired telephones, computing devices and sensors are used to visualize, vocalize and process enterprise data, applications and services. Networks are used to perform daily telecommunications activities mostly over the Public Switched Telephone Network (PSTN) and Global System for Mobile (GSM) networks.
- **Data Networks -** Internet Protocol (IP) wired and wireless networks provide a data communication medium for access to internet and intranet data services and applications.
- **Internet Services**
  - **Email -** Electronic mail communication among users of computer networks.
  - **Web Sites -** Information, News, Weather and many others.
  - **Social Networking Applications –** Instant Messaging (IM) and Social Networking software applications such as MSN Messanger, Skype, Facebook, MySpace and many others allow users to interact with others.
  - **Online Data Repositories –** Online document and image databases such as Youtube, Flickr, Picasa and

many others provide structured storage and sharing facilities for shared user media.

- **Entertainment -** Free-to-air / Satellite / Pay TV. On demand and DVD/Bluray movies.
- **Electronic Video Games -** An interactive multimedia system designed to entertain the user.

In the IT&T world, convergence refers to the move towards the use of a single united medium and media as opposed to the many that we use today [3]. Convergence enables services that are concurrently coupled and networked. The ability to visualize a concept via images, graphs, tables and procedures using a telephone or a video link greatly enhances interaction. Communication is more pleasing, meaningful, effective and efficient. Data and communications convergence promises a wide range of opportunities that increase quality of life and flexibility.

Media convergence aims to enable distributed virtual collaboration and entertainment environments that provides users with a new integrated and powerful means for collaboration. From an enterprise perspective, converged collaboration and entertainment environments in remote mining, oil and gas locations for its employees amenity and quality of life is essential.

Converged voice, video and data services have rapidly emerged as a popular alternative to existing telephony networks. A Smart Camp media convergence solution must have the following key properties;

- **Telecommunications –** Private Automatic Branch eXchanges (PABX) that facilitate call management and routing.
- **Computing –** Graphical User Interfaces (GUI) help visualize interaction and entertain the user. Features such as user interfaces, images, sounds, animations, videos, graphs and tables may provide more personal access to friends and family as well as enterprise data, applications, services and networks.
- **Functionality –** Current, almost ubiquitous devices such as the TV, have powerful hardware, utilize large graphical interfaces and should offer Internet connectivity. With these features, the demand for media and function rich services and multi-way communication will rise dramatically.
- **Interface -** Desired content must be delivered direct to devices concurrently and interchangeably in a number of formats. Interaction may be performed through the various devices and their interfaces (keyboard / mouse, touchscreen, pen etc) and/or through voice driven commands interchangeably.

Converged services have rapidly emerged as a popular alternative to existing solutions. Many sources [4 – 7] indicate that converged voice, video and data networks of various forms are rapidly growing across industry in the last 5 years.

IV. TECHNOLOGY AND DESIGN

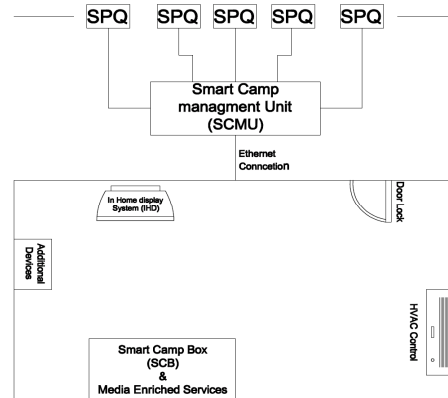Our architecture diagram is illustrated in figure 2.

Fig 2. Architecture diagram of all elements in smart home

A.RFID

Indoor location-aware systems can be classified according to the need for a terminal that should be carried by the resident. Terminal-based methods, such as Active Bats, do not recognize the resident's location directly, but perceive an empty or occupied room, such as an infrared transceiver or radio frequency identification (RFID) tag. Infrared sensors installed above the entrance to each room, at foot positions along the corridor are used to detect residents' movement. Two radio frequency identification (RFID) systems are installed in each room. One is active and the other passive. The former uses 315-MHz waves, the latter the 2.45-GHz band. Active system scanners, located above the ceiling of each room, detect RFID tags when a person wearing them enters the room. Passive system antennas are embedded inside walls around each room entrance. When a person wearing an RFID tag passes through an entrance, an antenna reads information on the tag. To provide a service to users, we should consider their contexts. Although the definition of user context may change based on the situation or service, "who," "where," and "when" are usually the main contexts. In the smart home, The resident's location is detected from the active RFID tag, and time is provided by a computer clock that is adjusted by a Network Time Protocol (NTP) server. With the above contexts the following context aware services are implemented in the smart Home.[10]
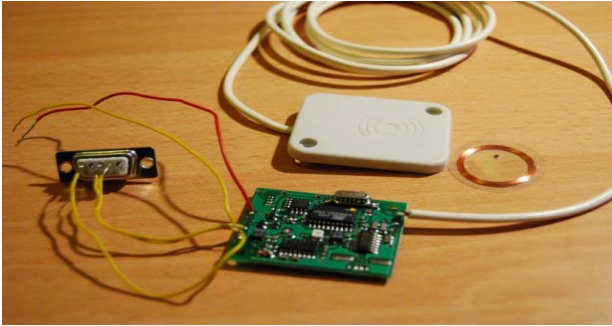
Fig 3. RFID reader and tag

B. Zigbee

ZigBee is a local-area network designed specifically for applications of automation or control systems to replace the proliferation of incompatible proprietary solutions. ZigBee was created to satisfy the market's need for cost-effective, standards based wireless networks that support low data rates, low power consumption, security, robustness and reliability. To address this need, the ZigBee Alliance [5], an industry working group, developed standardized application software on top of the IEEE 802.15.4 wireless standard [6]. The alliance works closely with the IEEE to ensure an integrated, complete, and interoperable network for the market. A result of active standard development in Alliance is new standard ratification in 2004 [4] and new versions in 2006 (ZigBee 2006) [7] and in 2007 (ZigBee PRO) [8].

The ZigBee protocol supports large numbers of mesh nodes and implements AES 128 security and key management. ZigBee can be implemented into low performance 8-bit MCUs such as x51, HCS08, AVR, PIC, etc.[9]
Each Zigbee product consists of zigbee compatible RF chip, microcontroller, sensors, actuators, and power sources [7. 8. 9]
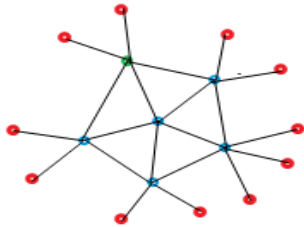

Fig 4. Zigbee mesh network

C. IConnect

The Smart Camp Box (SCB) has two purposes in the connected home - bridging different technologies within the home and providing access from the home to external services and vice versa. The XBee Simple Board has been designed to allow an easy and reliable connection between the Xbee's modules and our core application. The construction and high power voltage regulator ensure reliability and performance.

D. Network

Global warming has yielded increasing public interest in clean or green technologies based on renewable energy sources, and smart technology [11-12].

Home networks enable communication for home automations. Periodic traffic is generated from sensors which sample and send data to controllers. Controllers also send periodic traffic to actuators thus driving them. Periodic traffic involves exchanging control messages or event-driven messages when necessary.

Fig. 5 is a simple example of a network for Smart home to show how to find the suitable frame parameters such as BO and SO. IEEE 802.15.4 provides three different topologies such as star, mesh, and hybrid. We assume that the network topology is of the star type. In star topology, communication is established between a device and a single central controller called a main coordinator. In Fig. 5, the example network has three devices with a Multi-Media monitor sensor A, a HVAC sensor B, Power control sensors C, and a main coordinator that functions as a home automation controller.
The device A is required to send 8000 bits at a period of 4 sec, and device B sends 4000 bits at a period of 2 sec, and device C, 4000 bits, 1 sec.
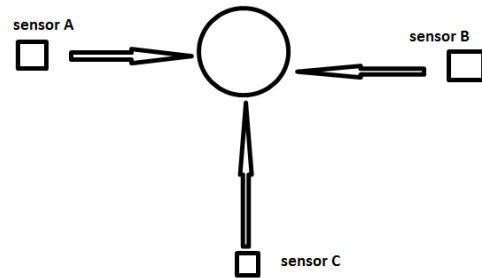

Fig 5. A network for smart home with main coordinator and three devices with sensors.

V. COST EFFICIENCY

A variety of wireless sensors have come to market, both within and outside of the HVAC industry. Wireless temperature sensors, and wireless thermostats, are most common for HVAC. Recently, ZigBee has produced a standard for wireless transmission of digital data that addresses many key needs of wireless building control networks. Wireless sensors and wireless communications are enabling technologies that decrease the cost to implement energy-saving building controls and diagnostic measures in cases that require additional sensors, notably in retrofit applications. In addition, wireless communications and controls can enable Demand Response (DR), i.e., reduction of electric demand and control HVAC system.[13]
The purpose of this project is to reduce energy consumption at the unit level. Subject to verification and conditions, energy usage reductions of +30% are anticipated. Heating, Ventilation

and Air Conditioning (HVAC) solutions include temperature and humidity control. This is generally one of the most important aspects to a homeowner. An Internet-controlled thermostat, for example, can both save money and help the environment, by allowing the homeowner to control the building's heating and air conditioning systems remotely. For this purpose, we use a use a PLC (Programmable Logic Controller) or an actuator (An actuator is a mechanical device for moving or controlling a mechanism or system).

VI. SMART HOME PROGRAMMING

In the following, we outline a solution that addresses the energy efficiency, and environment sustainability.

By dealing with space not only as a physical entity but also as a software data structure we realised the concept of a programmable physical environment. The advantage of this approach is that the application developer can implement applications for the smart home as one logical entity. Rule-Caster software provides the application developer with a high-level language for application development.

As mentioned earlier, dealing with evolutionary changes to the application requirements and the infrastructure is a complex job for application developers, which touches upon several life-cycle phases. We can identify three major classes of changes that a smart home application undergoes throughout its lifecycle. These are changes to the logical structure, physical structure and computing infrastructure [17].

The logical structure describes how functional elements and application states are connected for describing the application logic. Changes to the logical structure refer to changes in the observable behaviour of an application. For example, while an application might initially be defined to open the window when the room is too hot, new application logic might turn on the air conditioning instead [14].

The physical structure describes where computational elements are executed and where application states are stored in the network infrastructure. Changes to the physical structure of an application refer to changes in the distribution of computing tasks to individual nodes. For example, a task initially performed by a central node is distributed over several nodes in order to improve reliability and decrease energy consumption. The infrastructure is the actual smart home that stores and computes the application states. It is the distributed runtime environment. Changes to the infrastructure refer to changes in the underlying hardware and runtime system (e.g. network system). For example, a system might need to be updated when a new generation of hardware devices become available with different processor, memory or radio. Another example is modifying a system by adding or removing nodes.

The application logic is defined in the RuleCaster Application Language (RCAL) - a programming language that provides the application developer with high-level abstractions of the programmable smart home. RuleCaster supports these classes of changes by separating them into models. The core of RuleCaster is a high-level compiler system that takes these three models as input to generate a distributed software system. Changes to any of these three models can be directly propagated to the running application by recompilation and re-deployment [17]. This allows the programmer to change any model individually and therefore simplifies maintenance of applications. The infrastructure is described in terms of a network model which provides the compiler with a list of properties (e.g. location, hardware specification etc.) and available node level services. The infrastructure consists of the actual sensor-actuator node hardware running a middleware that executes the application. This middleware is based around a service-based architecture.

Services give access to the interface between the network and the physical world (i.e. sensors and actuators). Nodes are statically assigned to a space or several spaces. More information about the other models can be found previous work [14,15,16].

The structure of the programming model is reflected in this architecture. The application, which is programmed in the high-level language RCAL is split by the compiler into individual tasks and distributed over the network of sensor nodes. The physical structure is implicitly described by a distribution strategy - a compiler plug-in that influences the generation of the physical structure of an application based on some quality model such as energy consumption.

VII. SAMPLE CONFIGURATION AND OPERATION PLAN

The rooms that we have in one smart home have different spaces we program. The main program performs the following functions; Turn off all the electrical devices if the RFID is active and nobody is in room. It has three sensors' to observe the environment. The sensor is declared with the signature of a term that can be used in a transition rule to access the sensor. This term is TRUE if the RFID is detected to be on and FALSE otherwise. Also we can use this application for audio/visual control, Internet, security and climate control right out of the box.

VIII. CONCLUSION

This paper has proposes the use of a wireless sensor network as applied to the field of smart camps. The purpose of that is to establish cost effective ICT systems for energy and emissions conservation while delivering improved services in a Smart Mining Camp. This research will contribute as a method for home automation companies to mitigate the usage of energy conservation techniques while providing other converged features.

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