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ADVANCES IN WIRELESS TECHNOLOGIES AND IMPACT ON HEALTH-A REVIEW

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Abstract

This paper examines the advances in wireless technologies with case studies. A brief note on the effect of wireless technologies on human health is also discussed in this paper. Typical case studies include (i) wireless Technology in Real-Time Industrial Process Control and (ii) Wireless Technology for Lighting Control and Environmental Sensing. The schematics outline of HART Communication Protocol and Wireless HART Data Link Layer Architecture is explained clearly. Several case studies available in literature related to effect of wireless technology and human health are discussed.

Keywords: wireless technology; lighting control; human health; environmental sensing

1. Introduction

Information is power and many technologies are being invented for in all fields, namely, information technology, agriculture, aerospace, defence, construction sector etc. In all fields, any technology needs that one has understand it, implement it and continuously work on it by adopting the changes for improved benefits and profits. Wireless technologies is one of the emerging areas. To achieve all these, the important things to be focused are; the necessary management, supervision, monitoring in order to make sure the wireless architecture selected maximizes limited resources, while allowing wide range applications to share spectrum within context of importance, time sensitivity, and mission criticality. The mobile communication systems and the wireless communication technologies have been improving fast day by day. Devices generally continue to reduce in size while growing in processing power. Consumers/users are demanding more latest and useful applications. Hence, there is need of capacity improvements in wireless communications. In addition, wireless communications is active areas of technology development of our time.

Several major cellular wireless communication techniques have been proposed in order to meet the user expectations and demand.

Wireless internet technology is also popularly known by its trademark name Wi-Fi which was initially was originated in the 1980. Later, wireless technology has wide spread in mid 2000s and importantly as part of municipal free- internet projects [1,2]. In the present scenario, it can be noted that wireless technology is being widely employed in airports, power sector, construction sector, automotive industries, in the manufacture of many mechanical components. Further, wireless technology is also widely used in telecommunication tower industry and cellular phone. Even though Wi-Fi is a relatively advanced communication technology, use of the radiofrequency (RF) band for communications and other applications is not new or advanced and widespread public exposure to these frequencies has occurred for several decades. The RF band varies at different scales depending on the application. It was found in the literature that the RF band is a band that ranges from 3 kHz – 300,000 MHz [3,4]. It is also known that the RF band is part of the electromagnetic spectrum, with frequencies below those associated with visible light and X-rays and higher than those frequencies associated with power lines. In most countries exposure limits for RF are prescribed at their respective national levels. Radio and TV broadcasting, cell phones, emergency radio communications, weather radar and satellite communications all use different RF energy (Fig. 1)

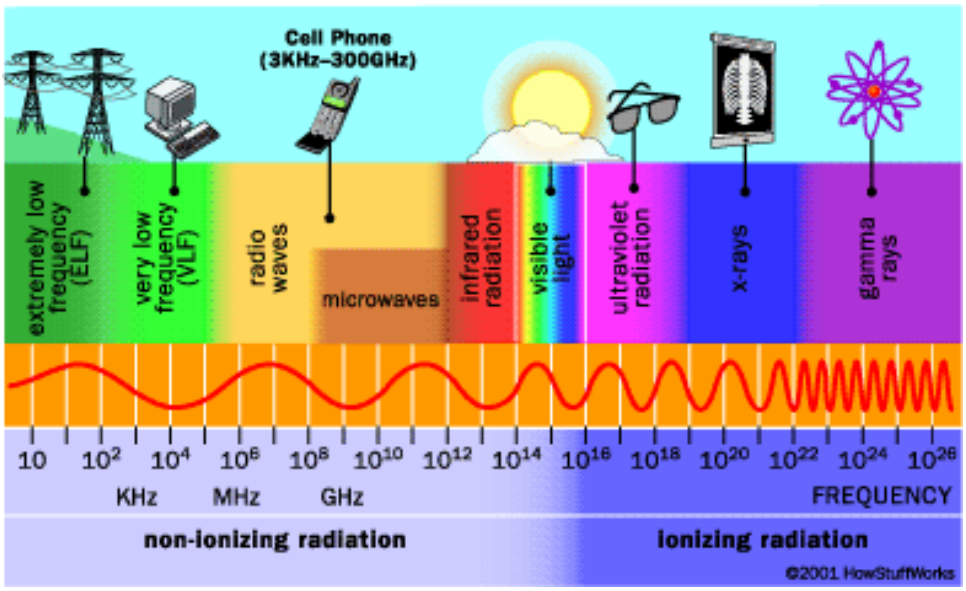

Fig. 1 Typical radio frequencies (RF) for various applications.

Among these technologies, the major focus is on research in radio frequency has been on cellular phones. It is well known that cellular phones have been in use more than Wi-Fi and are associated with higher domain strengths. In view

of this, when considering total radio frequency exposure in terms of power density, duration, distance from source and frequency of exposure [5], it is important to note that Wi-Fi generally represent only a small proportion of an individual's overall RF exposure.

This paper focuses on advanced application of wireless technology and their impact on human health. Typical case studies available in literature have been exemplified in the paper.

2. Applications of wireless technologies

2.1 Application to Wireless Technology in Real Time Industrial Process

It has been observed that wireless process control has become popular recently in the domain of industrial applications [6-8]. Compared to conventional wired process control systems, wireless counterparts have the immense potential towards reduction of costs and make installation easier. Also, wireless technologies brought the new horizons for advanced automated applications. Several industrial organizations, such as ISA [9], HART [10], WINA [11] and ZigBee [12], have been implementing actively the application of wireless technologies in industrial automation control. As a milestone of such several efforts, WirelessHART is ratified by the HART Communication Foundation in September 2007. WirelessHART [10] is generally observed to be the first open wireless communication standard in particularly designed towards process measurement and control applications. Song et al. [13] described their first-hand experience in developing a prototype for this type of specification. It is obvious that for design and implementation, several challenges are to be faced and handled. The issues generally include the timer design, security of communication, synchronization of wide network, interaction of networks, efficient and reliable networking and the core or central network manager. For each task/issue, a detailed analysis and solution was provided by the authors [13]. Based on the prototype implementation, a simple WirelessHART network has been built for the purpose of readymade demonstration. The demonstration network in turn validates their design.

It was reported that to the best of their knowledge, this is the first reported effort to develop a WirelessHART protocol stack.

Conceptually, WirelessHART networks are one special type of wireless sensor network. Although it possesses many similarities with other wireless systems, such as Bluetooth, ZigBee, and Wi-Fi, WirelessHART differentiates itself from them in many other aspects. Wireless sensor network has received extensive study recently.

Figure 2 illustrates the architecture of the WirelessHART protocol stack according to the OSI 7-layer communication model [13]. As shown in this figure, WirelessHART protocol stack includes five layers: physical layer, data link layer 1, network layer, transport layer and application layer. In addition, a central network manager is introduced to manage the routing and arbitrate the communication schedule.

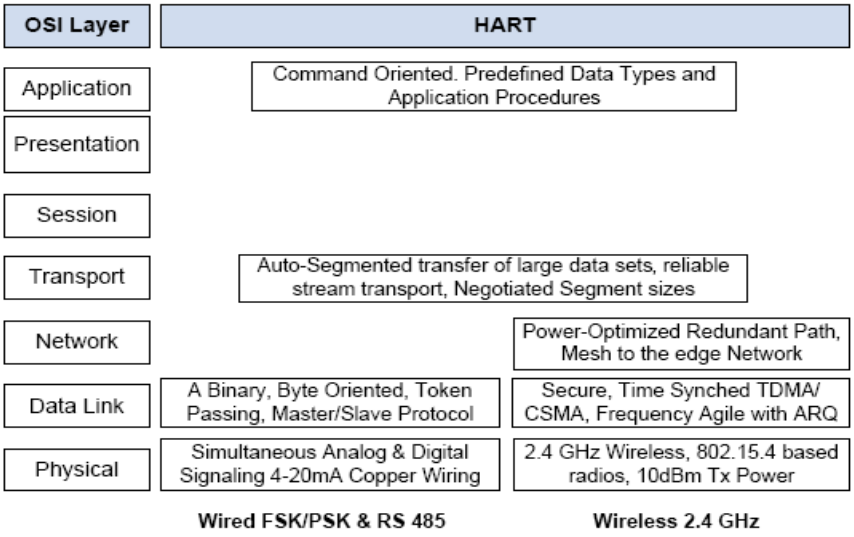

Fig. 2 Architecture of HART Communication Protocol [13]

Figure 3 describes the overall design of the data dink layer which consists of several major modules, namely, interface, timer, communication tables, link scheduler, message handling module, state machine etc.[13].

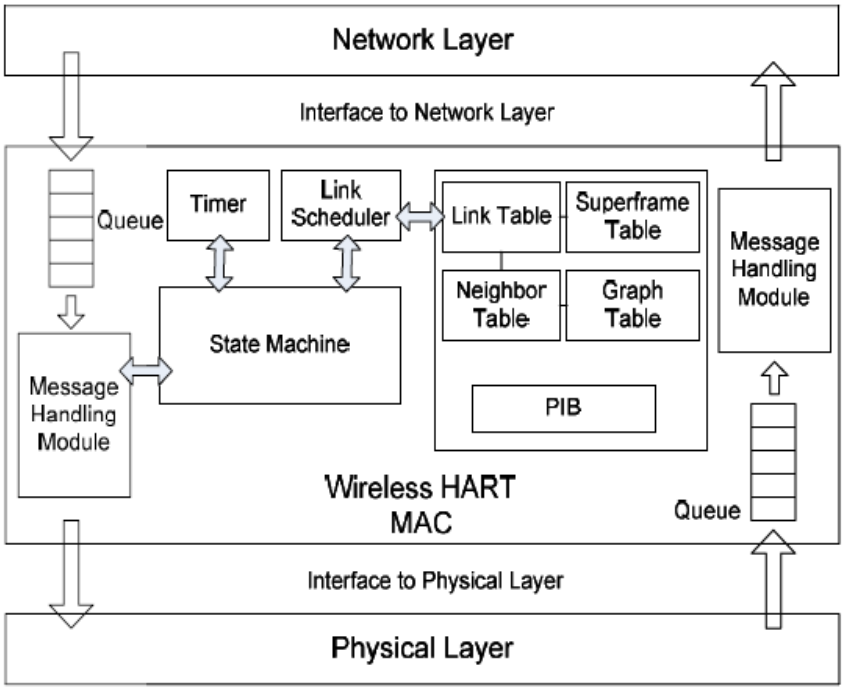

Fig. 3 Wireless HART Data Link Layer Architecture [13]

Preliminary results from their prototype are found to be very significant and encouraging. Further, it was reported that based on their experiments with the hardware, there is a serious requirement for using AES hardware accelerator in order to realize the 10*ms* time slot. WirelessHART is a multi-layered and unique protocol stack. From the above, it can be noted that there is much work to be carried out on the transport layer and application layer.

2.2 Application of Wireless Technology for Lighting Control and Environmental Sensing

The significant cost of retrofitting buildings with advanced lighting control systems is a barrier for adoption and implementation of this energy-saving technology. To overcome this, wireless technology offers a solution to mount installation costs as it requires no additional wiring to adopt and implement. To demonstrate the feasibility of such a system, a prototype wirelessly controlled advanced lighting system was designed and built by Dana et al. [14]. The developed technology includes the following components, namely, a wirelessly-controllable analog circuit module (ACM), a wirelessly-controllable electronic dimmable ballast, an environmental multi-sensor, a T8 3-lamp fixture, a current transducer, and control software. The components such as the ACM, dimmable ballast, multi-sensor, and current transducer are all integrated with SmartMeshTM wireless mesh networking nodes, generally called motes, which can be used for wireless communication, sensor monitoring, and actuator control. Each mote-enabled device generally has a reliable communication path to the SmartMesh Manager, a single board computer that controls network functions. The entire assembly is connected to the wireless network to a PC running lighting control software. The novel feature of ACM is that it has capability of locally driving one or more standard voltage ranging from 0-10Volt electronic dimmable ballasts through relay control and a range from 0-10 Volt controllable output. In order to drive a standard 3-lamp T8 light fixture, the mote-integrated electronic dimmable ballast is designed and to measure occupancy, light level and temperature, the environmental multisensory has been used. The power consumed by the fixture was measured by current transducer. To implement advanced lighting algorithms, including occupancy control, daylight ramping, and demand response, an automotive control software has been developed. Engineering prototypes of each component were fabricated and tested in a bench-scale system. A cost economics analysis was performed based on standard industry practices and estimated that the installation cost of a wireless advanced lighting control system for a retrofit application is minimum 30% lower than a comparable wired system for a typical case of 16,000 square-foot (1986.45 square meter) office building, with a payback period of less than 3 years.

The purpose of their investigation is to apply wireless technology to lighting controls in order to develop a system capable of advanced lighting strategies that is also cost effective for commercial retrofit applications. Occupants will benefit from improved workplace comfort, building owners will also benefit from improved energy efficiency and flexible lighting control, and utilities will benefit from energy savings that are responsive to peak demand periods. The main objective of their investigation [14] is to (i) demonstrate that wireless technology can be cost-effectively applied to the problem of retrofitting integrated lighting controls into existing buildings. The outcome of the program will be an advanced lighting control system capable of implementing all lighting control strategies in existing buildings without the need to run additional wires and (ii) demonstrate that wireless technology can be cost-effectively embedded into controllable fluorescent lamp ballasts allowing independent control of individual ballasts from and intelligent, wireless environmental sensor.

Figure-4: Shows the typical wireless lighting control system adopted by Dana et al. [14].

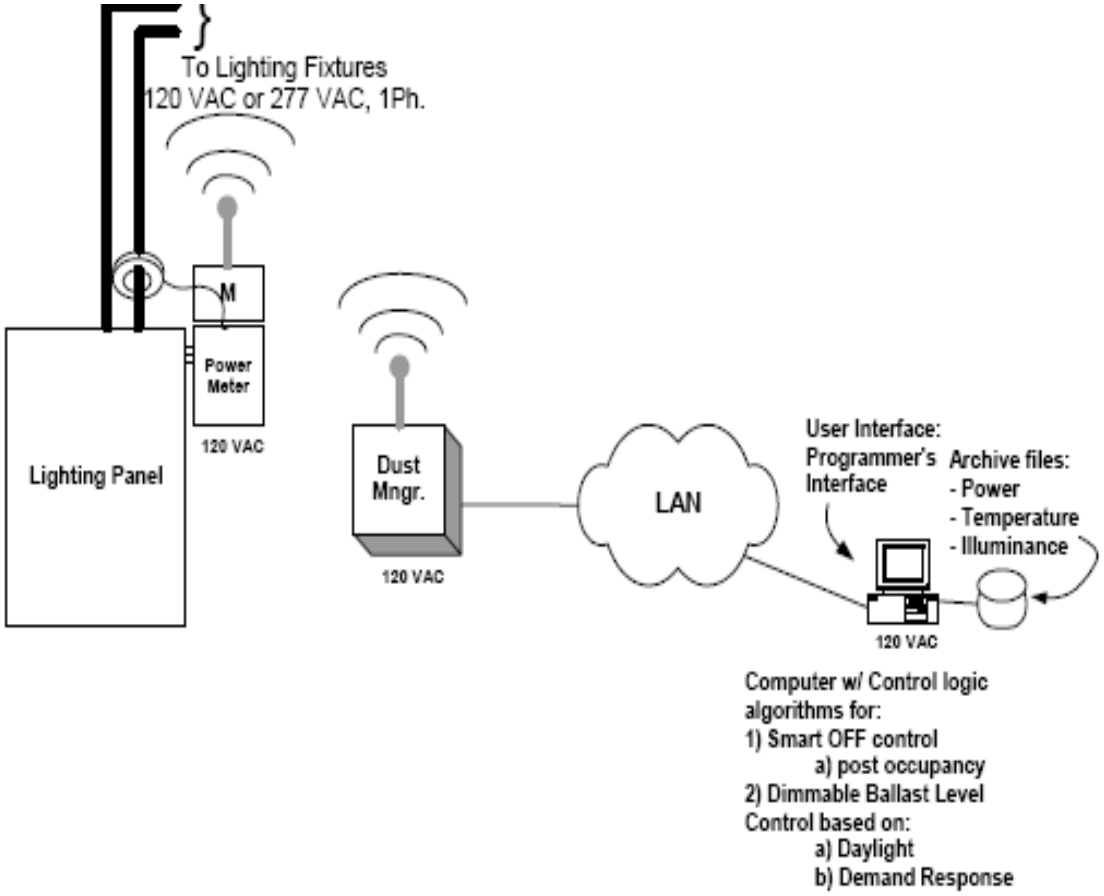

Fig. 4 Schematic illustration of wireless lighting control system.

Wireless vs. Wired

Wireless control offers many benefits compared to wired control, like system flexibility and ease of installation. Reduced wiring translates directly into reduced installation costs. Dana et al. [14] compared the installation cost of a wireless retrofit system with a wired version capable of the same advanced lighting control. The following retrofit cost breakdown was generated (shown in Figure 5) for a 16,000 sq. ft. building area, assuming the same number of ballasts, fixtures and sensors are installed for each [14]:

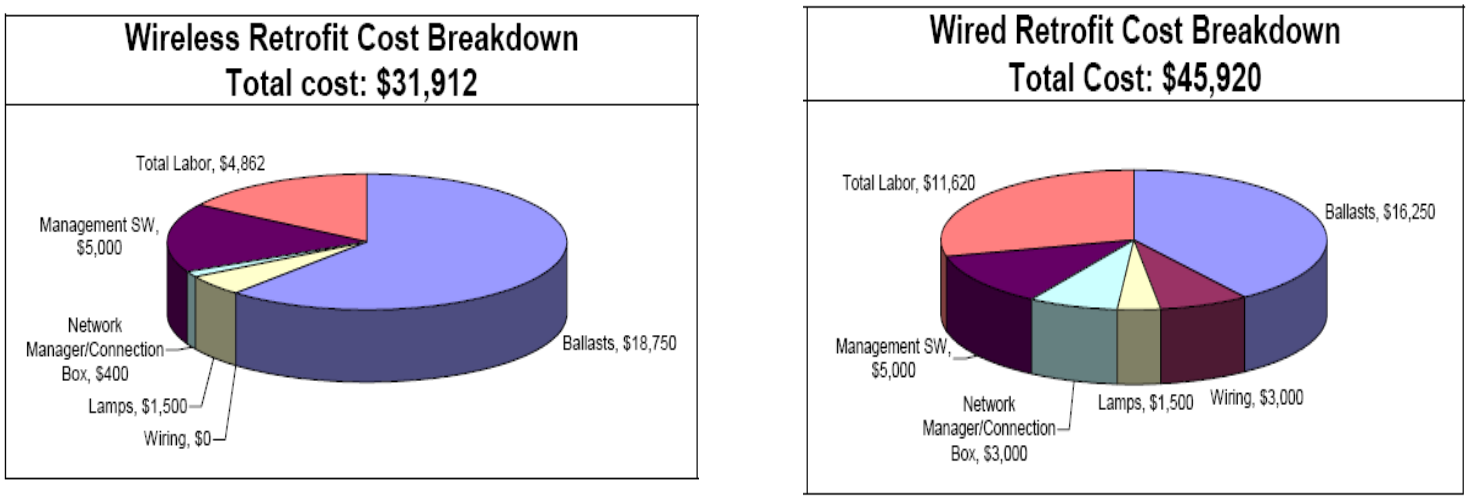

Fig. 5 Cost economics of wireless retrofit and wired retrofit

2.3 Effect of Wireless technology on health

There is general discussion or apprehension that with the advancement in wireless technology, there will be significant effect on health of humans. In the literature, different researchers were carried investigations on the data available in the literature. Some researchers were carried out survey on humans. Investigations were carried out using MeSH terms “Radio Waves”, “Microwaves” and “Electromagnetic Fields” combined with “adverse effects” and “public health”. Free text searches were also carried out using search terms “radiofrequency and health”, “wi-fi and health”, and “cellular phones health”. Many other researchers have performed their studies with title and keywords, abstract and full length paper. Title review identified reviews and key large studies, whose abstracts were then reviewed for relevance. Articles were then selected for review if they had been published in reputable peer-reviewed journals, published within the last two years, or had significant public interest or impact. Reference lists of selected articles were then further hand searched for relevant articles and reports. Foster [15] addressed many issues like source intensity and power density, frequency and duration of exposure, and distance from the source, in measuring potential exposures and health effects.

With respect to source power densities, Foster and others [15] demonstrated that maximum and median Wi- Fi exposures were significantly below the exposure limit set by the ICNIRP (please refer to Table 1 [16]). Another study revealed that cellular base antenna power densities to be 0.05 W/m2 11.

Table 1 Comparison of measured RF fields with Wi-Fi [16].

RF activity being measured or calculated	Maximum time-averaged power density (W/m^2)	Median time-averaged power density (W/m^2)
Laptop not communicating with Wi-Fi, measured directly next to Wi-Fi access point	0.007	0.000012
Laptop uploading/downloading file, measured 1 metre away from laptop Wi-Fi card	0.001	0.000016
Laptop uploading/downloading file, average of measurements taken at different distances from laptop	0.04	0.00006

It is known that Wi-Fi is a more recent application of RF and generally results in much lower levels of exposure to RF, much of the available scientific literature on potential health effects of RF is based on studies of cell phones. Multiple biologic outcomes were explored, including cancer, infertility in animals, behavioural changes, and "electromagnetic hypersensitivity" (EHS), defined as a set of non-specific symptoms such as nausea, headache, and dizziness [17].

In the literature, it was mentioned that the Bio-Initiatives Working team is an ad-hoc group of intellectuals and public policy analysts who produced "The BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields" [18]. This report contains different conclusions and recommendations as compared to the international health and standard setting organizations [18]. Ray Copes [16] mentioned that numerous case-control studies using cancer as an outcome conducted in different countries around the world did not support a clear association between cancer and cellular phone use. The latest study found in the literature is the INTERPHONE study, whose results were published in June 2010. A review by Kundi and Hutter [19] described the research studies conducted in France, Spain and Austria on the effect of cell phone in human health. Many participants were involved in the study and various parameters have been examined. From the study, They rated a list of 18 symptoms (e.g. fatigue, headaches, and sleeping problems) and how frequently they experienced them. None of the studies showed any statistically significant relationship between symptoms and proximity to a base station [19].

Three recent publications revealed at the effects of RF exposures or cellphone use in young people. Abramson et al [20] examined 317 7th graders. It is known that self reported cellphone use is generally associated with more advanced and rapid but less accurate responses on a computerized cognitive test battery. It was found that as the findings were similar for use of text messaging the authors' opinion [20] was that the impressions/behaviours may have been learnt through frequent application and were unlikely due to radio frequency exposure.

3.0 Summary and Conclusions

Information is power and many technologies are being invented for in all fields, namely, information technology, agriculture, aerospace, defence, construction sector etc. In all fields, any technology needs that one has understand it, implement it and continuously work on it by adopting the changes for improved benefits and profits. Wireless technologies is one of the emerging areas. To achieve all these, the important things to be focused are; the necessary management, supervision, monitoring in order to make sure the wireless architecture selected maximizes limited resources, while allowing wide range applications to share spectrum within context of importance, time sensitivity, and mission criticality.

The evolution in wireless technologies has opened new awareness or new avenues to a new class of plant automation architecture which offers adopters a significant strategic advantage. Automation experts and IT professionals expressed that cost savings in engineering, installation, and logistics, as well as dramatic improvements in the frequency and reliability of field data collection are to be performed in reliable and efficient manner.

Another avenue of future work is the network manager. In WirelessHART network, the network manager is the central control unit. In order to derive, the routing table and communication schedules, the network manager has to select optimized several metrics, such as energy consumption, average end-to-end latency. It is generally believed that the scheduling algorithms can be more different depending on the optimization goal and procedure. From the literature, it was noted that the co-existence issues between WirelessHART, ZigBee and Bluetooth are to be solved.

Research investigations on potential health effects which were primarily exposure to radio frequency is an active field of interest. It was noted that there is no substantial information available on various case studies. Only limited data is available, but that is also not consistent. From the investigations carried out on health effects, it was noted that some school of researchers expressed that there is no risk of health effects. On the other hand, some other school of thought

expressed that there is need to reduce exposure limits. Hence, in order to make policy decision, lot more studies are to be carried out by varying the radio frequency levels for different applications.

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