

Assessment of Zigbee Standard

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A wireless sensor network, or WSN, is a computer network consisting of distributed independent self-governing sensor devices that collaborate to monitor certain aspects of the environment [1]. In the past, one of the main driving forces behind research in wireless sensor networks is military application, such as surveillance or espionage. In recent years, there has been a diversification towards the development of non-military applications such as environmental monitoring, habitat monitoring, residential use, structural monitoring, and health care.

In order to effectively assess the Zigbee standard, it is necessary to remain attentive to the environment. A short environmental scan was completed as part of the preparation of the assessment. The purpose of the environmental scan was to identify important issues related to wireless sensor networks, including the Zigbee standard. The scan included detecting trends, defining potential threats, and exploring potential opportunities within the wireless sensor network industry.

Wireless sensor network technology is becoming an ever-present technology tool for monitoring environments and collecting data from areas of interest. The reliability and performance of wireless sensor networks is increasing and promises to be sufficient enough to perform mission critical operations within various environments. As potential advances become reality, components will be more intelligent, networks will become autonomous, and maintenance tasks will decrease substantially. It is expected that Moore's Law will be observed enabling wireless sensor network components to evolve into inexpensive, disposable, plug and play devices.

A crucial element to the success of the technology is the development and support of a wireless sensor network standard or specification. A standard specification would allow interoperability between components manufactured by different companies and would create an opportunity for multi-functional wireless sensor network infrastructure. The basis for platform independence, interoperable applications, and data transmission architecture is the protocol by which devices and applications communicate. Therefore, the specification is an essential ingredient in the future of wireless sensor network technology.

The following technology assessment will provide an overview of the ZigBee standard, along with societal and technological issues related to the technology.

1. WSN Technology Issues

The environmental scan aided in the identification of technology issues, trends, opportunities, and threats to wireless sensor network technology. The bulk of research related to wireless sensor networks concentrates on a few main issues. Deficiencies in the areas of energy, protocols, and congestion dominate current research.

Energy availability and power consumption are major weaknesses of wireless sensor networks [2]. Any possible energy preservation techniques help to extend the operational lifetime of a sensor. Currently, there are rechargeable and non-rechargeable batteries in use with the field. Application of rechargeable batteries often depends on the environment in which the sensor is deployed. The environment may determine that it is impossible or infeasible to replace or recharge a battery. Other current options include solar or motion energy sensors that are able to charge from a renewable energy source.

Along with different battery choices, there are a few major implementation methods used to conserve battery usage. Dynamic Power Management allows unused devices to dynamically shut down and activate [3]. Therefore,

devices are only using battery life when in use. Dynamic Power Management requires operating system support and uses a form of probability analysis to predict the future of the environment [3]. Other approaches to power conservation are based on scheduling the activity of sensors within the network.

Wireless sensor networks require fault tolerance, scalability, and level of predicted reliability. Sensors have a short operation lifespan relative to other electronic equipment [4]. In the past, data transmission loss has been offset by the large amount of sensor distributed in the environment. Although this has help reduce loss, reliable data transmission is essential to any successful network. Therefore, the transport protocol is a vital piece to the wireless sensor network puzzle.

A reliable standard protocol has the ability transform and extend data transmission technology. A standard protocol is essential for wireless sensor networks to support a variety of application across many different industries. A multi-function wireless sensor network could provide infrastructure for a multitude of emerging applications. In addition to standard protocols, the prospect of platform independent application could transform the technology to performing local computations, data aggregation, or other high level computing tasks.

Much like any other network, wireless sensor networks may face issues with congestion and interference. Wireless sensor networks operate with limited resources for processing and storage, therefore, congestion is a very real problem when the network is flooding with information [5]. Interference can occur from several different types of devices, including residential products and rogue radio signals.

In order to combat congestion problems, much of the current research focuses on channel monitoring and efficient routing. By monitoring the load of the channel, the network can route data more efficiently or pause information for being transmitted [5]. Data rates can be adjusted and the sink can control multiple nodes by sending notices after determining congestion [5].

Although there are methods to limiting congestion, there are inherent problems with the current approaches to congestion control. While monitoring channel load can be effective, it also has some downfalls in the routines that route or control data transmission [5]. Sending notices to control data rates can be effective, but in an already stressed network, it could add to the congestion. Monitoring channels, queues, and routing control requires smarter sensors which result in higher per node costs.

2. Assessment Definition

Based on current research effort, key advances in the technology will be needed in energy, reliability, functionality, bandwidth efficiency, and cost. The research and development effort will continue to be substantial, but will require cross disciplinary expertise from several different stakeholders.

ZigBee is a low power, short distance wireless standard used primarily in applications such as home automation, industrial control, and tracking [6]. The technology assessment will attempt to identify relevant technologies, applications, and solutions, as well as determine the current issues with the technology. The ZigBee standard is intended for use with applications with low data rates and low energy requirements. The current focus of the ZigBee movement is general purpose mesh networks that inexpensive and self organizing. The components of a ZigBee solution are limited in intelligence and data transmission capabilities, but require a relatively small amount of energy to operate [7].

3. Assumptions

With the emergence of the 802.15.4 and ZigBee standards, the wireless market is transitioning from proprietary technology toward a standards-based environment. Standardization promises to improve interoperability while decreasing the switching costs from one provider to another [8]. Proprietary platforms would require a complete overhaul of a wireless sensor network when switching solutions. Standardization allows the infrastructure to remain intact and independent of the applications. In addition to the benefits realized by customers, the introduction of standards will allow component manufactures to provide certified devices and realize economies of scale.

While there are benefits to implementation of a standardized wireless sensor network solution, such as ZigBee, there are also societal issues that have very little to do with existing technology. The following includes societal issues relative to the implementation of a wireless sensor network solution. Commercial industries require maximum reliability with minimal error. Manufacturing carries a high cost of downtime; therefore, manufacturers will not invest in wireless sensor networks unless the reliability and cost effectiveness are realistic [4]. Also, wireless sensor networks could be met with cultural opposition in companies, especially when the systems operate autonomously [1]. Workers could fear loss of employment or fret the need for training. Finally, societal attitudes may affect the adoption and implementation of wireless sensor networks due to a perception of invasion of privacy [1].

4. Impact Areas

The ZigBee standard includes multiple facets relative to technology, marketing, business, and society. There are several impact areas that can be defined with regards to each of the aspects of wireless sensor networks. With regard to technology, ZigBee is a combination of two organizational standards, which allows ZigBee devices to be engineered on open platforms. The ZigBee technology provides a simple, cost effective, energy efficient solution.

Within the marketplace, ZigBee applications focus on creating smart environments and wireless sensor networks. In the residential market, ZigBee devices are used to create smart homes, including security solutions, utility meter reading, and remote control devices [9]. Within industrial settings, wireless sensor networks have the potential to drastically affect processes and procedures for the better. Use of wireless sensor networks promises a radical improvement in operational efficiency. Along with residential and commercial impacts, the ZigBee standard has the possibility to affect the society. It is expected that adoption of the technology will increase as early adopters proclaim the overwhelming benefits of the technology. Some of the benefits include cost, flexibility, and ease of use.

5. Preliminary Impact Analysis

Wireless sensor network systems, including ZigBee based solutions, have the potential to reduce industry costs, increase efficiency, and affect continuous improvement in a variety of settings [1]. The flexibility of ZigBee, and other wireless sensor network solutions, is an important advantage to anyone considering implementation of a related technology. Implementation of wireless sensor networks could enable manufacturers to be more attentive to customer, leading to a system of mass customization where production equipment can be reconfigured quickly and easily [4]. In addition to a manufacturing environment, wireless sensors can improve safety by monitoring the environments of food processing and pharmaceutical production facilities.

6. Possible Action Options

Given the advantages of a wireless sensor network solution, ZigBee technology is expected to increase and gain a strong market share within building automation, light industrial applications, and smart homes [10]. The benefits within these areas will provide an opportunity to demonstrate the capabilities of the technology. In order for the technology to realize its potential, there are some possible action options that could be implemented.

The first possible action is the education of the consumer. Participants in the development of the technology must educate the society regarding cost benefits, ease of deployment, and scalability. The wireless sensor network industry must make the public aware of the possibilities as they are being researched and developed. This should decrease cultural resistance.

Another possible action option includes interdisciplinary research efforts. Collaborative research and development efforts would speed the development of the technology and ensure that it is built on open standard that is flexible, robust, and platform independent.

The third action option involves government funding of ZigBee research. The ZigBee solution is an excellent candidate for military applications due to the long battery life. Military research dollars would increase the

ability of ZigBee to extend its capabilities. There appears to be an opportunity for government sponsorship of the ZigBee specification.

7. Impact Analysis

As stated in the preliminary impact analysis, the ZigBee standard has an enormous opportunity to affect industry, military, and residential applications. The ZigBee solution provides a flexible, cost effective, quality product. The ZigBee standard has shown a substantial amount of promise in the areas of industrial wireless, smart homes and offices, and military installations. The wireless sensor network market is developing fast due to the high demand in many branches of industry and high volume of deployment for military application.

The ZigBee standard and other wireless technologies have attracted attention due to the ability to support multiple applications and their cost efficiency. These technologies have become synonymous with home and manufacturing automation as well as with the larger branch or wireless sensor networks. These are relatively new and fast growing technologies covering a multitude of applications.

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