

Information and communication technology issues & challenges for wireless sensor networks

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Abstract:

The aim of this study is to discuss the tracking issues and challenges in Wireless Sensor Networks (WSNs). The objective of this paper is to provide policies on energy efficiency and efficient WSN usage with regards to tracking issues and challenges. The research employs conceptual secondary data using content investigation of theories and observations of the whole scenario. The study found that energy consumption/conservation in the field of WSN poses a threat to the information and communication technology systems. The findings also observed that, sensors are characterized by a small path and nodes that present stringent energy constraints to the facts they are equipped with the finite energy resources. Based on these findings, there are several tracking issues and challenges to the policy makers, stakeholders and government around the globe. Specifically in designing sufficient policies to address the challenges of WSN and stimulate information and communication technology. Result have shown that consumption of energy is the greatest fundamental problem in WSN. On the other hand, is not detected by the researchers where as it can provide for the enhancement of the energy efficiency. The study elaborates the weaknesses of the existing approaches which make them inappropriate for energy efficient routing in WSN. Therefore, it's obvious from the findings that an energy conservation policy is suitable to supplement the energy short comings. In this context stake holders and energy policies makers should invest in research and development in alternative energy sources such as wind, solar, hydroelectric power, biomass and nuclear energy to promote information communication technology.

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1. Introduction

Wireless sensor networks (WSNs) is described as multi-hop network systems. They are formed through distributed, self- organized, and energy-constrained wireless sensor nodes and actuators that collect data needed for a certain application from the monitoring area automatically in order to improve the performance of the monitoring systems and decrease the total costs [1]. Focus for monitoring-oriented applications (e.g., water quality on watersheds, pollution monitoring in cities) [2]. Wireless sensor networks have recently become a major area of research interest. They have great long-term economic potential, the ability to transform lives and cause many challenges for building systems. Wireless sensor networks pose a number of new conceptual and optimization issues, such as implementation, location and tracking. These are fundamental problems because many applications use them to obtain the necessary information. Essentially, coverage answers questions about the quality of service (monitoring) that can be provided by a particular sensor network is highly crucial. The integration of different types

of sensors such as seismic, optical, acoustic sensors is significance in wireless sensor networks etc. In a network platform, there is need to study the overall coverage of the system also presents numerous exciting challenges. With the modification of energy recovery techniques bring the capability of collecting valuable energy from radio energy explosions, vibrations, etc., the self-powered circuit is a real possibility, with networks of millions of nodes, spread by injections, brushes and planes. In addition, the preamble of an additional type of sensor node allows the network to arrange itself by integrating adaptive and intelligent algorithms [3].

Architecture, Data Collection and Transmission (DCT), Fault Tolerance (FT), Quality of Service (QoS), Deployment, Limited Memory and Storage Space, Heterogeneity, Secure Localization, Physical Attacks and Security, MAC Layer Issues, Decentralized Management, Management at a Distance, Energy, are the challenges that reduce efficiency of wireless sensor network to the information and communication technology. However, the objectives of this paper are to have a look at the whole

scenario with regards to issues and challenges so as to strive at bringing policies on energy efficiency and efficient WSNs. Wireless sensors have become an excellent tool for military applications involving intrusion detection, perimeter monitoring, and information gathering and smart logistics support in an unknown deployed area [4].

Other applications comprise sensor-based personal health monitor, location detection with sensor networks and movement detection. A wireless sensor network can be described as a composition of tiny sensor nodes that communicate wirelessly with each other to sense some specific actions in an interested field. Each sensor node consists of main components: processing capability, memory, RF transceiver, power source and in some cases equipped with Global Positioning System (GPS). WSNs have deployed in different fields in order to provide online insights into the conditions, demands and performance of the observed infrastructure. WSN can be deployed in different structure of network topology according to applications used in [5].

Reviewed literatures have shown that consumption of energy is the greatest fundamental problem in WSN. On the other hand, is not detected by the researchers where as it can provide for the enhancement of the energy efficiency. The aim of this study is to discuss the tracking issues and challenges in WSNs. The objective of this paper is to provide policies on energy efficiency and efficient WSN usage with regards to tracking issues and challenges. The current study employs conceptual secondary data using content investigation of theories and observations of the whole scenario.

2. Methodology

The key aim of this article is to present a recent idea of the wireless sensor network structure, applications and challenges of wireless sensor network. This research examines some of the challenges and issues of wireless sensor network by tracking some obstacles that have not been included in some research by reviewing previous

related work. The investigation of the study suggested that researchers should concentrate to ascertain the solution to the challenges disturbing the area of wireless sensor network particularly security issues, design issues, etc.

Furthermore, since security and energy consumption are some of the major challenges in WSN, then security requirements are the basic root, therefore emphasis should be given, to ensure network stability and operations, e.g., confidentiality, integrity and authentication.

Thus, cryptography can be used as a method that can help to secure and protect data over a network. It is not surprising that very small investigative outcome exists for wireless sensor network since development, researchers are curious and engaged to create new protocols and new applications. However, some results are tested and evaluated by some researchers and the actual system has been deployed. The issue of security in WSN requires scientific approach in which system can be designed and analysed before it is deployed, to ensure the performance and efficiency of the system.

3. Architectural design of WSNs

A WSN is a distributed network where autonomous sensors are connected together for various network operations. WSN consists of multiple detection stations called sensor nodes, each of which is small, lightweight and portable. WSNs are bi-directional and its topology differs from each application. WSN has some characteristics such as: mobility and heterogeneity of nodes, large scale of deployment, ease of use, ability to cope with node failures and more. The function of a sensor node in a sensor area is to detect events, perform local data processing, and transmit raw or processed data. Sink node is nothing but a base station which plays a vital role in wireless environment and it acts like a distributed controller. Base station is important for the following reasons: sensor nodes are prone to failure, better collection of data and provides the backup if the master node failed [6].

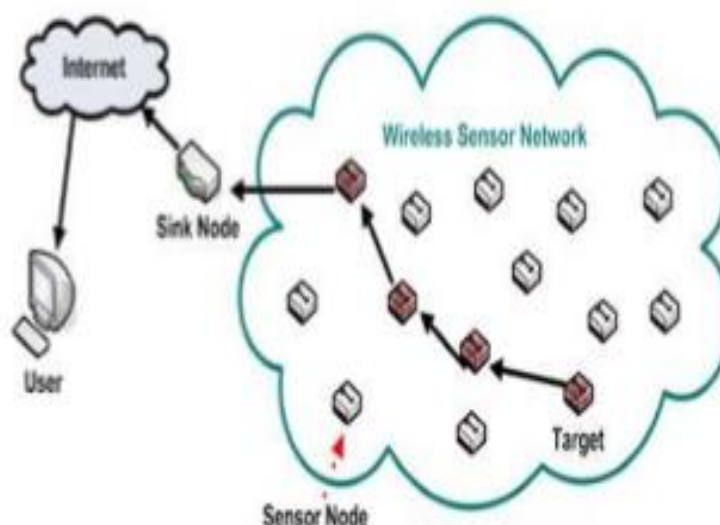


Figure 1: Architectural view of wireless sensor network
Source: Randhawa and Jain [7]

3.1 Research challenges in WSNS

The main problems with design and performance of a wireless sensor network are listed below

3.1.1 Architecture

The architecture can be considered as a set of rules and rules for the implementation of certain functionalities as well as a set of interfaces, functional components, protocols and physical hardware. Lack of sensors the network architecture is a limiting factor that hinders progress in this area. The network architecture of the sensor must be durable and scalable. As if the number of nodes had increased, the quality of service was not decreasing, but had to be flexible to meet the wide range of target application scenarios because wireless sensor networks do not have a fixed set of communication protocols to which they must conform. The architecture must decouple the speed of the data path and the radio transmission rate because the direct coupling between the processing speed and the communication rate can lead to suboptimal energy performance [8].

3.1.2 Data Collection and Transmission:

Data gathering is the primary goal of sensor nodes. Sensors periodically detect environmental data, process it, and transmit it to the base station or sink. Data collection involves collecting data and transmitting data to the collector node. Sometimes the sample of collected data is redundant and it is not necessary to transmit these nodes [9].

3.1.3 Fault Tolerance

The sensor network must remain functional even if a node fails while the network is operational. The network should be able to adapt by changing its connectivity in case of failure. In this case, an efficient routing algorithm is applied to modify the general configuration of the network [10].

3.1.4 Quality of Service (QoS)

Quality of service is the level of service provided by sensor networks to its users [3, 11]. WSNs are used in a variety of real-time and critical applications. It is therefore imperative that the network provide a good quality of service. However, this is difficult because the network topology can change constantly and the state information available for routing is inherently inaccurate. Sensor networks must have the necessary bandwidth to achieve the required minimum quality of service. The traffic is unbalanced in the sensor network because the data is aggregated from several nodes to a receiving node. QoS mechanisms must be designed for unbalanced samples on the collector node because they only consume energy. Care must be taken when collecting and transmitting data [12, 13].

3.1.5 Deployment of node

Deployment means the implementation of the wireless sensor network in the real position. It is a very difficult and cumbersome action that depends on the

demographics of the application and how the network will be implemented. In hard-to-reach places, the sensors are released from the helicopter or, in some positions, the sensors are located according to certain topologies. Energy organization issues such as charging and battery change are challenges in real life scenarios. The use of sensor arrays leads to overcrowding of the network due to frequent simultaneous transmission attempts by different sensor nodes. The low performance of the data is a problem in the real scenario because the network provides insufficient information [14].

3.1.6 Limited Memory and Storage Space

A sensor is a tiny device with only a small amount of memory and storage space for the code. To build an effective security mechanism, it is necessary to limit the code size of the security algorithm. For example, a common sensor type has a 16-bit RISC processor, 8 MHz with only 10,000 RAM, a program memory of 48 K and a flash memory of 1024 K. With such a limitation, the software created for the sensor must also be small enough [15].

3.1.7 Heterogeneity

This consists of a group where all the nodes are not identical and do not have the same functionality, for example some nodes are more powerful than others. The example of a heterogeneous group is the cluster architecture in which the node forms a cluster head and collects data from the least powerful node. Heterogeneity occurs when two completely different network numbers have to communicate. Combined communication interfaces will be needed to enable efficient exchange of information between different systems and nodes [16].

3.1.8 Secure Localization

The utility of a sensor network is often based on its ability to precisely and automatically locate each sensor in the network. A sensor network designed to locate faults will need accurate location information to identify the location of a fault unfortunately, an attacker can easily manipulate unprotected location information by signalling the strength of dummy signals, read signals, etc. [17].

3.1.9 Physical Attacks and Security

Security is one of the first challenge in wireless sensor network in which sensor can be deployed in an environment open to adversaries, weather conditions, etc. The probability that a sensor will undergo a physical attack in such an environment is therefore much greater than that of conventional PCs, which are in a safe place and are mainly confronted with attacks from a network. It is not possible to guarantee the physical titles of the sensor nodes. Attackers can modify the hardware of the node. Replace it with a malicious sensor or dummy sensor [16, 18]. The details about Wireless Sensor Networks, and other aspect like classification, types, topologies, and related issues were discussed in this article. Thus, security is a difficult challenge for any system. The severe constraints and demanding environments of WSN make

computer security for these systems even more challenging [19].

3.1.10 MAC Layer Issues

Medium Access Control (MAC) solutions have a direct impact on power consumption, some of the leading causes of energy wastage in the MAC layer: collisions control packet overload and inactive listening. The technique of controlling energy saving errors is not easy to implement because of its high computing power and the fact that long packets are not normally practical [20].

3.1.11 Decentralized Management

The large-scale and energy constraints of many network storage networks make it impossible to implement centralized algorithms (for example, executed at the base station level) to implement network management solutions such as management. Topology or routing. Instead, the sensor nodes must work with their neighbours to make localized decisions, that is, without global knowledge. As a result, the results of these decentralized (or distributed) algorithms will not be optimal, but could be more energy efficient than centralized solutions. Although decentralization may lead to suboptimal paths, overall management costs can be significantly reduced [21].

3.1.12 Maintenance at a Distance

The sensor nodes will be installed in our doorway, for example a metro station. It is difficult for managers or operators to manage the network directly. Therefore, the structure should provide an indirect remote control or management system [22].

3.1.13 Energy consumption

Sensors need energy for various operations. Energy is consumed in the data collection and processing Communication; moreover, listening continues to average for faithful operation requires a large amount of energy of the node components (CPU, radio, etc.) even if they are inactive. Batteries that provide energy must be changed or reloaded after been consumed. Sometimes it becomes difficult recharge or replaces the batteries due to demographic conditions. The most crucial research the challenge for WSN researchers is to design, develop and implement energy efficient equipment and software protocols for WSN [23, 24].

3.2 Classification of wireless sensor network

3.2.1 Terrestrial WSNs

This wireless network comprises of hundreds or thousands of inexpensive wireless sensor nodes scattered in a given area, both in pre-programmed mode and in ad hoc mode [24]. In the planned implementation, grid positioning, optimal positioning [18] 2-day positioning and 3-day positioning are available. In the ad hoc distribution, the sensor nodes can be released from one stage and randomly positioned in the destination area [24 - 26].

3.2.2 Underground WSN

This entails a number of sensor nodes hide under the ground, in a cave or in a mine, used to monitor underground conditions. Some additional receiver nodes are located above the ground to disseminate information from the sensor nodes to the base station. An underground WSN is generally more costly than a terrestrial WSN in terms of equipment, implementation and maintenance [25, 26].

3.2.3 Multi-media WSNs

This wireless was since proposed to enable monitoring and tracking of events in the form of multimedia. Multi-media WSNs consist of a different low-cost sensor node equipped with cameras and microphones. These sensor nodes usually interconnect with one other over a wireless connection for data retrieval, process, correlation, and compression. Multi-media sensor nodes are typically deployed in a pre-planned manner into the environment to guarantee coverage [25].

3.2.4 Mobile WSNs

This wireless is made up of sensor nodes that can move alone and communicate with the physical environment. Mobile nodes have the ability to detect, calculate and communicate as static nodes. Mobile nodes also have the ability to reposition themselves and organize themselves in the network. A mobile WSN can begin with an initial distribution and the nodes can then spread to collect information. The information collected by one mobile node can be communicated to another when they are in close proximity to each other. Another key distinction is the distribution of data. In a static WSN, data can be distributed using fixed or flood routing, while dynamic routing is used in a mobile WSN. The challenges of this type of network include implementation, location, self-organization, navigation and control, coverage, energy, maintenance and data processing [26].

3.2.5 Underwater WSNs

These consist of a several sensor nodes and vehicles that are deployed underwater. As compared to terrestrial WSNs, underwater sensor nodes are more expensive and fewer number of sensor nodes are deployed. Autonomous underwater vehicles are used for exploration or gathering data from sensor nodes. Compared to a dense deployment of sensor nodes in a TWSN, a sparse deployment of sensor nodes is placed underwater. Typical underwater wireless communications are established through transmission of acoustic waves [26, 27].

3.3 Topology issues for WSN

3.3.1 Geographic Routing

Geographic routing is a routing principle that relies on geographic position information. It is mainly proposed for wireless networks and based on the idea that the source sends a message to the geographic location of the destination instead of using the network address [27].

3.3.2 Sensor Holes

A routing hole consists of a region in the sensor network, where either node is not available or the available nodes cannot participate in the actual routing of the data due to various possible reasons. The task of identifying holes is especially challenging since typical wireless sensor networks consist of lightweight, low-capability nodes that are unaware of their geographic location [27].

3.3.3 Coverage Topology

Coverage problem reflects how well an area is monitored or tracked by sensors. The coverage and connectivity problems in sensor networks have received considerable attention in the research community in recent years. This problem can be formulated as a decision problem, whose goal is to determine whether every point in the service area of the sensor network is covered by at least k sensors, where k is a given parameter [27].

4 Discussions

Energy saving is one of the main concern, since it has been observed that another serious challenge is the energy consumption in the field of WSN, an algorithm should be developed that will reduced the rate of sensor node mortality, like in LEACH protocol, a cluster head is formed to minimize energy consumption, and individual sensor send the information to cluster head onward the sensed information to the base station (BS), However to overcome these challenges an energy efficient hardware and software protocols should be design, develop and implement in WSNs, so that many issues and challenges identified in this paper could be solved, in addition energy routing algorithms can also eliminate many problem, furthermore future direction gives some highlights to overcome some issue and challenges in the field of WSNs. additional issues that affect the design and performance of a wireless sensor network include: Hardware and Operating System for WSN, Synchronization, Network Layer, Transport Layer, and Data Aggregation and Data Dissemination. At the same time, there are many challenges that leads to the short coming of WSN efficiency among which are: majority of the wireless applications uses sensor nodes in the real world for remote applications sensors are embedded. This is unlike traditional Internet, PDA, and mobility applications that interface mainly with human users. Secondly, sensors are characterized by a small path, and as such nodes present stringent energy constraints since they are equipped with small finite, limited, energy source. Thirdly, communications is primary consumer of energy in this surroundings where sending a bit over 20 or 200 meters consumes as much energy as thousands-to-millions of operations since the performance of these protocols is promising in terms of energy adequacy and the constrain energy is a thread to the system, more research would be needed to address issues such as Quality of Service (QoS) posed by real-time applications.

5. Conclusion

In this manuscript, an investigation of some of the vital routing techniques for sensor networks were presented. They have the common purpose of trying to expand the life time of the sensor network, while not compromising data delivery & QoS. Those issues were also highlighted, challenges and pinpointed future research directions in this regard. We also emphasize the design trade-offs among power usage, mobility and communication overhead savings in some of the routing examples, as well as the selection of each routing technique for specific applications. However, Wireless Sensor Networks (WSNs) consist of small nodes with sensing, computation, and wireless communications capabilities. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue.

Recommendations

In this section the limitations of WSNs-based applications have been analysed and provide some recommendations to progress the performance of the sensor networks. Despite recent developments in the area. The wireless sensor nodes have restricted memory and computational capabilities. In addition, the WSNs have been useful in harsh and inaccessible environments for a long period of time. Thus, the resource limitation of the wireless sensor nodes is an additional challenge for WSNs-based applications. Routing algorithms are required to solve challenges like energy efficiency. The further research would be needed to address issues such as(a) Quality of Service (QoS), (b) localization, (c) topology control (d)dependability(e) data aggregation(f) group management (g) query processing, (i) sensor processing and fusion under limited capacities, the issue of physical attack and security is equally important to address etc. Currently, there is very little research that looks at handling QoS requirements in a very energy constrained environment like sensor networks. Another interesting issue for routing protocols is the consideration of the node mobility. Most of the current research assume that the node and the sink are both stationary. Wireless sensor networks are still a young research field, much activity is still ongoing to solve many open issues. Other possible future research for routing protocols includes the integration of sensor networks with wired networks like Internet.

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