Modeling the Traditional Wireless Sensor Network to suit the Modern Wireless Sensor Networks infrastructure.

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Abstract - Wireless Sensor Networks (WSNs) finds a wide range of applications from different spheres of natural applications. One of the major reasons for this diversity is due to the recent advances in miniaturized low-cost, low-powered devices and advances in recent networking techniques. This has enabled the traditional wireless sensor networks to support multiple applications on the same shared wireless sensor networks giving raise to heterogeneous wireless sensor networks. This has also paved way for open challenges and new research issues with respect to deployment techniques and quality of services. This paper addresses the advantages of heterogeneous WSN over traditional WSN, some of the current applications based on heterogeneous WSN, technologies supporting it and some of the open research issues and challenges.

Keywords: Traditional WSNs, Survey, Sensor applications, heterogeneous wireless sensor networks, architecture.

1. INTRODUCTION

Wireless Sensor Networks are a set of tiny individual nodes that are capable of interacting with natural environment by sensing or by controlling the natural physical parameters. Just a single node is not capable of doing bigger task and hence collection of nodes with similar capabilities were grouped together to create a topology that would carry out the specific application. Traditional wireless communication technologies enabled the cooperation of such nodes to fulfill bigger tasks that a single node could not perform.

Hence, the field of Wireless Sensor Networks (WSNs) is experiencing a great interest and a continuous evolution in the scientific and industrial community. The use of this particular type of ad hoc network is becoming increasingly important in many contexts, regardless of geographical position and so, according to a set of possible application. WSNs offer interesting low cost and easily deployable solutions to perform a remote real time monitoring, target tracking and recognition of physical phenomenon. The uses of these sensors organized into a network continue to reveal a set of research questions according to particularities target applications. Despite difficulties introduced by sensor resources constraints, research contributions in this field are growing day by day.

Hence, wireless Sensor Networks have come a long way due to the recent advances in embedded systems and wireless communications. WSNs are envisioned to be the next generation of networks which are forming an integral part of human lives. WSNs consist of low-cost, low-power, multifunctional sensor nodes that are miniature in size and communicate over short distances. This has given way for large variety of applications which in turn has been a research target for many different scientists from different fields of electrical engineering, telecommunications, biology, computer science and other sciences.

Wireless Sensor Networks were traditionally used for single application, but recently these traditional infrastructures is be used or modified to suit the heterogeneous applications. Earlier when Wireless Sensor Networks developed they were used for a single purpose for example for just temperature monitoring or animal sensing. The applications were very specific. This ultimately led to inefficient utilization of resources. Hence many researchers made effort to share the already existing infrastructure to suit the modern needs. Hence a new era of heterogeneous Wireless Sensor Networks bloomed up.

According to Moore’s law “the number of transistors in a dense integrated circuit has doubled approximately every two years” which holds appropriately suitable for growth of current wireless sensor networks. Recent growth in technology and micro-electrical components finds lots of applications built on Wireless Sensor Networks. And the capability of accessing sensor generated data from the Web, fitting WSNs in novel paradigms of Internet of Things (IoT) and Web of Things (WoT). This a lead to development wide range of applications such as i) Smart Video Sensor Platform ii) Wireless video-based sensor networks for surveillance of residential districts iii) Monitoring water quality iv) monitoring of animals in their natural environments and updating data on cloud. This has made the world completely intact.

Some of the applications of Shared Wireless Sensor Networks include recent deployment of integrated environmental monitoring [4] and urban sensing systems [1], [2], building automation [3]. For example, a smart building employs an integrated WSN to support multiple applications including light control, temperature and humidity monitoring, burglar and security alarms, and monitoring the structural health. When compared to a traditional WSN which are dedicated to a single application, a shared WSN or a heterogeneous WSN can significantly reduce the overall system cost by allowing multiple applications to share nodes and the network resources. And some latest technologies imbibed with it can also enhance system flexibility by dynamically allocating nodes to different applications in response to environmental changes and user requirements.

The remainder of this paper is organized as follows: Section II discusses previous work related to this study. The overview of different factors supporting heterogeneous WSNs is introduced in Section III. Section IV opens up some open research issues and QoS challenges in integrating traditional WSNs into Current technology. Section V describes a brief outline of our research focus followed by conclusion in Section VI.

2. RELATED WORKS

2.1 Quality of Monitoring in Shared Sensor Networks

In this paper *Sangeeta Bhattacharya et. al* [5] has discussed about the deployment of multiple applications on the traditional Wireless sensor networks that are evolving from dedicated application-specific platforms to integrated infrastructure shared by multiple applications. Shared sensor networks offer inherent advantages in terms of flexibility and cost since they allow dynamic resource sharing and allocation among multiple applications. Such shared systems face the critical need for allocation of nodes to contending applications to enhance the overall Quality of Monitoring (QoM) under resource constraints.

To address this need, in this paper the authors have presented an *Utility-based Multi-application Allocation and Deployment Environment (UMADE)*, an integrated application deployment system for shared sensor networks. In sharp contrast to traditional approaches that allocate applications based on cyber metrics (e.g., computing resource utilization), UMADE adopts a cyber-physical system approach that dynamically allocates nodes to applications based on their QoM of the physical phenomena. The key novelty of UMADE is that it is designed to deal with the *inter-node QoM dependencies* typical in cyber-physical applications. Furthermore, UMADE provides an integrated system solution that supports the end-to-end process of (1) QoM specification for applications, (2) QoM-aware application allocation, (3) application deployment over multi-hop wireless networks, and (4) adaptive reallocation of applications in response to network dynamics. The authors have implemented UMADE on TinyOS and Agilla virtual machine for Telos motes.

2.2 Integrating QoS for Wireless Sensor Networks with Heterogeneous Data Traffic

Syarifah *et. al* in [6], the QoS requirements for the WSN-Internet integration are investigated by first distinguishing the Internet QoS from the WSN QoS. Next, emphasizes on the study of WSN applications that involve traffic with different levels of importance, thus the way real-time traffic and delay-tolerant traffic are handled to guarantee QoS in the network is studied. Additionally, an overview of the integration strategies has been given, and the delay-tolerant network (DTN) gateway, being one of the desirable approaches for integrating WSNs to the Internet, has been discussed. The service model implementation has been presented, by considering both the prioritization of traffic and differentiation of service. Based on the simulation results in OPNET Modeler, the authors have observed that real-time traffic achieve low bound delay while delay-tolerant traffic experience a lower packet dropped, hence indicating that the needs of real-time and delay-tolerant traffic can be better met by treating both packet types differently. Furthermore, in this work a vehicular network was used as a case study to describe the applicability of the framework in a real IoT application environment to justify and verify the obtained results.

2.3 Efficient way of resource allocation in multiple heterogeneous Wireless Sensor Networks

Wireless Sensor Networks (WSNs) are useful for a wide range of applications, from different domains. Recently, new features and design trends have emerged in the WSN field, making those networks appealing not only to the scientific community but also to the industries. One such trend is the running different applications on heterogeneous sensor nodes deployed in multiple WSNs in order to better exploit the expensive physical network infrastructure. Another trend deals with the capability of accessing sensor generated data from the Web, fitting WSNs in novel paradigms of Internet of Things (IoT) and Web of Things (WoT). Using well-known and broadly accepted Web standards and protocols enables the interoperation of heterogeneous WSNs and the integration of their data with other Web resources, in order to provide the final user with value-added information and applications. Such emergent scenarios where multiple networks and applications interoperate to meet high level requirements of the user will pose several changes in the design and execution of WSN systems. One of these challenges regards to the fact that applications would probably compete for the resources offered by the underlying sensor nodes through the Web. Thus, it is crucial to design mechanisms that effectively and dynamically coordinate the sharing of the available resources to optimize resource utilization while meeting application requirements.

However, it is likely that Quality of Service (QoS) requirements of different applications cannot be simultaneously met, while efficiently sharing the scarce networks resources, thus bringing the need of managing an inherent tradeoff. In this paper [7], the authors urge the need for a middleware platform required to manage heterogeneous WSNs and efficiently share their resources while satisfying user needs in the emergent scenarios of WoT. Such middleware should provide several services to control running application as well as to distribute and coordinate nodes in the execution of submitted sensing tasks in an energy-efficient and QoS-enabled way. The authors have presented an algorithm for resource Allocation in Heterogeneous WSNs named SACHSEN algorithm. SACHSEN is a new resource allocation heuristic for systems composed of heterogeneous WSNs that effectively deals with the tradeoff between possibly conflicting QoS requirements and exploits heterogeneity of multiple WSNs.

2.4 Generalized Data Stack Programming Model in Routing

Generalized Data Stack Programming (GDSP) model describes that any affected activity or varying environment is intelligently self-recorded inside the system in form of stack-based layering types where stack is re-defined to be one of six classes. The multi-stacking network is presented thinking of that any system connects to other system to work properly. This addresses a novel way to investigate and analyze any system. Wireless Sensor Networks (WSNs) monitor the environment and take action accordingly. However, WSN suffers from some weakness due to nodes failure or interference which affects the network topology and the routing table at each node. In this paper [8], the GDSP model is applied on the routing problems in WSNs. A history matrix at the user side is proposed to retrieve and backward the events affected the network. This would help to analyze the reasons for events that affected the network and ultimately improve upon it.

2.5 QoS improvement in Wireless Sensor Networks using Multi-Stack Architecture

The authors of this paper [43] have a interesting study on traditional mono-stack approach on WSN i.e they are operating according to a single combination of one MAC protocol and one network (NWK) protocol. In this paper the authors have proposed a new multi-stack architecture in which several combinations of MAC and NWK protocols are used. This has been achieved by dividing time into time intervals and activating different combinations during each period. It is also proved that QoS achieved is mitigated among the combinations. The dimensioning problem is also formally solved using a queue exchange algorithm that allows frames from a time-interval to be sent during another time-interval are proposed. This algorithm has also significantly improved the global performance of the network. Hence giving way for different types of data to be shared among the traditional network. This study is used in industrial applications and same can be adopted to support other real-time applications using the standards mentioned in that paper.

2.6. OCARI Technology for Industrial Wireless Sensor Networks.

MaCARI [24] (MAC protocol for Ad-hoc Industrial Networks) was a MAC protocol that was specified and implemented in the OCARI1 project [25] as stated by the authors. The main purpose of this project was to implement a protocol stack that increases the lifetime of a wireless sensor network in order to monitor critical applications in an industrial environment. MaCARI is an energy-efficient MAC protocol providing different QoS for many types of applications and traffic which would suit the current shared networks. All the nodes can switch to sleep mode which forms the energy efficient characteristics of this protocol.

In this protocol the QoS warranty has been carried out by applying the mechanism of frame relay or routing packets according to the traffic priority. Moreover, MaCARI is based on the IEEE 802.15.4 physical layer and adopts the same types of devices as the IEEE 802.15.4 MAC layer. In addition, it adopts a similar tree as the cluster-tree of ZigBee. MaCARI divides the time into cycles. This gives a way to allocate different types of traffics in an orderly fashion.

2.7 Cross layer approaches in heterogeneous WSN

Understanding cross-layer approach requires prerequisite knowledge about layered approach. Traditionally, all communications in the network is managed by protocol stack organized in a series of different layers. In WSN a hybrid of OSI and TCP/IP is used. All the layers are individual and communication is allowed only between the adjacent layers as the functions of each layer are predefined. But in contrast to it is the cross-layer approach in which each layer shares information with any other layer in any combination. The literature of WSN protocols that have been surveyed by several authors classifies the protocols in terms of interactions or modularity among physical (PHY), medium access control (MAC), routing, and transport layers.

Major reason for the suitability of cross-layer approach for heterogeneous WSNs is the ability to provide a single communication module for efficient communication among several nodes in WSNs.

3. FACTORRS SUPPORTING SHARED WSNs

There are several factors and technologies that have helped in integrating the traditional Wireless Sensor Networks into modern Wireless Sensor Networks. Major contribution goes to the developers, who have made available efficient, low cost, low power miniature devices. Figure 1 gives an overview of factors supporting the shared wsn. Improvement in the integrated low power devices and the wireless communication technologies have also play a vital role .The combination of these factors has improved the viability of utilizing a sensor network consisting of a large number of intelligent sensors, enabling the collection, processing, analysis and dissemination of valuable information, gathered from the environment has paved way for integrating applications and developing shared heterogeneous WSNs.

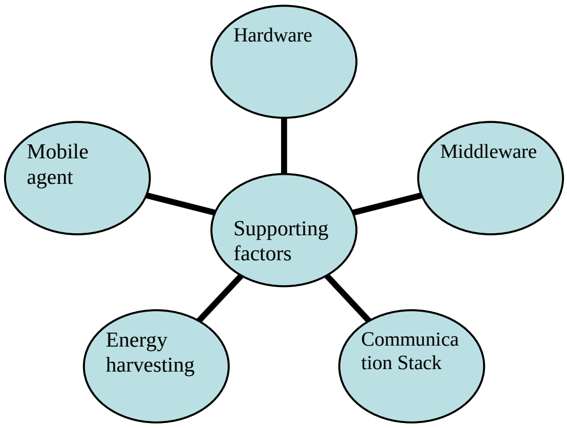

Figure 1 Factors supporting heterogeneous WSN

There are several factors that have developed the growth of these wireless sensor networks. Following are some of the major factors from our knowledge of study:

1) WSN hardware - Micro Electro Mechanical Systems (MEMS) a miniaturization technology for sensor nodes has made a great and remarkable progress in recent years. Realization of combining microelectronics technology, micromachining technology and the packaging technology is the core technology of MEMS According to [26], there are different levels of 2D and 3D micro sensitive structures can be produced based on microelectronics and micro-machining technology, which are the miniature sensing elements. And these miniature sensing elements, associated power supply and signal conditioning circuits can be integrated and packaged as a miniature MEMS sensor that can be used for various applications.

Now a day's wide variety of miniature MEMS sensors are available in the market which can be used to measure environmental components. Author in [27] discuses about variety of physical, chemical and biomass signals, including displacement, velocity, acceleration, pressure, stress, strain, sound, light, electricity, magnetism, heat, pH value, etc. Early in 2000, researchers at the University of California Berkeley [28], have developed a WSN sensor node (mote) with a micro sensor whose actual size of the MEMS sensing module was only 2.8 mm × 2.1 mm.

2) WSN communication stack - The nodes in the wireless sensor networks are generally deployed in an adhoc manner for most applications. Hence designing an appropriate topology, routing and MAC layer is very important for extensibility and life span of the deployed network. Communication has to happen between the nodes in the WSN to transmit data to the sink node or the base station through single hop or multi-hop. This is the basic requirement in any type of wireless sensor network. This requirement is satisfied to extend with the help of several access technologies.

IEEE 802.15.4 wireless technology is used for short range communication systems. The key features of this technology such are low complexity, low data rate transmissions, low cost, low power consumption places itself as the major accessing technology for WSNs. The IEEE 802.15.4 technologies such as IEEE 802.15.4 Physical Layer, IEEE 802.15.4 MAC Layer, Zigbee, 6LowPan etc., has enabled the growth of wide range of WSN applications on industries, biomedical, environment monitoring etc.

Other technologies that are enabling the growth of WSNs are Ultra wide Bandwidth Technology - Impulse Radio-UWB IR-UWB) is widely used by academia, industry, and global standardization.

Bluetooth Technology – These are short-range communication system which replaces the cables in wireless personal area networks. The key features of these technologies are robustness, low power, and low cost.

Z-Wave - a technology developed by the Danish company Zensys; uses a low-power RF radio for low-power remote control applications. Since this is not compatible with 802.15.4, it is not adopted in WSN applications which are purely based on IEEE 802.15.4. Operational speed of Z-Wave is about sub 1 GHz band is main advantage of this technology with respect to 802.15.4.

3) Middleware - A mechanism to combine cyber infrastructure with a Service Oriented Architecture (SOA) and sensor networks to provide access to heterogeneous sensor resources in a deployment independent manner [17]. This is based on the idea to isolate resources that can be used by several applications. A platform independent middleware for developing sensor applications is required, such as an Open Sensor Web Architecture (OSWA) [18]. OSWA is built upon a uniform set of operations and standard data representations as defined in the Sensor Web Enablement Method (SWE) by the Open Geospatial Consortium (OGC).

d) Mobile agent technology – On of the issues is in shared WSNs is the great amount of varied data traffic, Qi. et al [50] proposed the mobile agent based distributed sensor network (MADSN) for scalable and energy efficient data aggregation. By transmitting the software code, called a mobile agent (MA), to sensor nodes, a large amount of sensory data can be reduced or transformed into a small amount of data by eliminating the redundancy.

Abdelhakim Hamzi *et. al* [51] exploits the advantages of Mobile Agent System for modeling WSN services, network topologies and sensor device architectures. This needs a study of agents composing its different modules, a WSN nodes types and agents classification. This would ultimately help the developer to choose the appropriate mobile agent.

This mobile agent technology is used in various spheres such as security, energy efficient routing etc.

4) Energy harvesting technology – One of the major drawbacks of WSN nodes are low power. This has been over come to an extent by using various optimization techniques on MAC layer, Network layer etc. Still energy saving remains a bottleneck for several applications especially on shared or heterogeneous WSNs. Currently, energy harvesting techniques have popped up aiming to lower down this issue on energy. The key difference between energy saving or conservation from energy harvesting is that: In energy saving the actual energy of the node is preserved for prolonging the node life time by using several optimization techniques. But in energy harvesting techniques we try to energize using external sources.

These energy harvesting are realized through miniature piezoelectric crystals, micro oscillators, thermoelectric power generation elements, or electromagnetic wave reception devices [29] [30] apart from those done by conventional optical cell power generation.

The A.S.M. Zahid Kausar et. al [31] has made a detailed study on various means of energy harvesting that are done through Magnetic field, solar energy, thermal, vibration, Steady state mechanical sources, Human and machine motion etc., As the energy harvesting system for WSNs has a great prospect in near future the studied presented in above paper would help and enlighten the researchers to work with eager.

4. OPEN RESEARCH ISSUES

4.1 General issues in traditional (homogeneous) WSN:

a) Hardware constraints

Though advancement in MEMS has enabled the growth of Wireless Sensor Networks, still there are some constraints on the hardware that provides challenges to the researchers and upcoming application developers. One such example is in terms of computation and communication by sensor nodes in terms of security, implementing bio-inspired algorithms etc., which needs more energy for computations.

b) Data gathering/aggregation [41]

Data gathering is the process of collecting or accumulating the sensed data for further processing. And most of the traditional WSN architectures consist of static nodes which were densely deployed over a sensing area. Data gathering is one of the major issues as it would lead to more energy consumption and would ultimately decrease the network life time.

An efficient and secure data aggregation method is required for extending the lifetime of the network as well as ensuring reliable data collected from sensors [19]. Node failure being a common characteristic of WSNs, the network topology should have the capability to heal itself at the time of failure. Ensuring security is critical as the system is automatically linked to actuators and protecting the systems from intruders becomes very important.

c) Fault detection

Since sensor network conditions undergo constant changes, network monitoring alone may be insufficient. Even with fault prevention mechanisms, failures will still occur, so fault detection techniques need to be in place to detect potential faults. Fault detection in sensor networks largely depends on the type of applications and the type of failures. Similar to wired networks, sensor networks can use packet loss as an indication of faults. In data dissemination protocols which deliver large segments of data to the entire (or part of the) network, the destination nodes are responsible for detecting the missing packet or the window of missing packets, and communicating the feedback to the source using NACK messaging such as in PSFQ [24] and GARUDA [25]. The potential disadvantage of NACK messaging is that the packets need to be cached indefinitely at the intermediate nodes in case the of failure detection.

d) Security

In general symmetric key cryptography was preferred in WSN due to the constraints in sensor nodes. Selecting the appropriate cryptography method for sensor nodes is fundamental to providing security services in WSNs. However, the decision depends on the computation and communication capability of the sensor nodes.

Many researchers have made extended study based on hardware design:

• Studies on public key cryptography have demonstrated that public key operations may be practical in sensor networks. However, private key operations are still too expensive in terms of computation and energy cost to accomplish in a sensor node. The application of private key operations to sensor nodes needs to be studied further.

• Symmetric key cryptography is superior to public key cryptography in terms of speed and low energy cost. However, the key distribution schemes based on symmetric key cryptography are not perfect. Efficient and flexible key distribution schemes need to be designed.

• It is also likely that more powerful motes will need to be designed in order to support the increasing requirements for computation and communication in sensor nodes.

Some of the issues in traditional or homogenous wsn are discussed from various sources. In addition to it, the issues in heterogeneous WSNs are discussed below which has given an insight about the QoS challenges and challenges faced in heterogeneous WSN supporting multiple types of sensor nodes and applications.

4.2 .QOS CHALLENGES AND ISSUES IN Heterogeneous WSNS [9]

Wireless Sensor Networks differ from traditional wireless voice or data networks in many ways. Most nodes in a WSN are likely to be battery powered which limits its source of energy. Wireless sensor nodes must organize themselves into a communication network because they are often deployed in an ad hoc fashion rather than being in a fixed position. Many WSNs applications employ large number of sensor nodes and node density may vary in different places and times. Most data traffic in a WSN is triggered by sensing events which can be extremely bursty [12].

There are a number of challenges for dealing with QoS traffic in a WSN:

1) Bandwidth Limitation:

Traffic in a WSN can be both real time such as voice and non-real time, where reserving the available bandwidth only to QoS traffic as in traditional networks can't be acceptable. According to Y.T. Hou et al [13], in order to deal with non-real time traffic a trade off in high quality real time traffic should be used, using at the time a number of independent routes to split the traffic and meet the QoS requirements were energy constraints, limited computational resources and increased collisions in sensor nodes transmission causes the independent routes for the same traffic flow to be very challenging.

Sufficient allocation of bandwidth for any network is essential in order to avoid issues on synchronization, packet loss etc. This issue becomes more complicated if it a wireless network. Moreover in becomes still more complicated with networks with resource constraints like WSNs. In [45], the authors have made an effort to maximize the lifetime of WSN's using TDMA protocol. They have concluded by that aggregating data in the network will increase the super frame length and thus, reduce the reserved bandwidth for each one.

In [46], the knowledge about the network topology and spatial interference is considered as a key to reduce the inherent constraints in wireless communication and increasing the bandwidth utilization and throughput quality in TDMA based heterogeneous WSN networks.

The area of bandwidth management is vast and researches are making efforts to provide solutions to accommodate varied traffic in order to main the stability of the network.

2) *Redundancy Removal:*

WSNs have very high redundancy in the data generated and data aggregation is needed. In data aggregation [14], eliminating redundant data messages is sufficient for unconstrained traffic; on the other hand, aggregating data for QoS traffic is more complex. According to N. Nikaein et al [15] relaying voice traffic and images consume high energy and is not trivial computationally. Thus, combining both system and sensor level rules should be achieved to aggregate computationally feasible QoS data.

3) *Energy and Delay Tradeoff*:

According to Knag and Poovendran in [16], since the use of multi hop routing is standard in WSNs, an increase in the number of hops reduces the energy consumed by the collection nodes as the transmission power of radio and distance squared (or higher) are proportional but in return increases the packet delay and in return complicates the handling of delay constrained traffic. Therefore, to meet the traffic constrained delivery requirement, the QoS routing of data would trade off energy efficiency.

4) Buffer Size Limitation:

*W*ireless sensor nodes have a small buffer size which constrains their storage and processing capabilities. The radio in a sensor node consumes most of the energy due to the transmission needed, so it is trivial to keep it off as long as possible, thus it is an advantage to receive as many packets before sending them [17]. Different architectures and design goals have been considered for WSNs but all depending on the application. In WSNs there are several design issues that would affect the performance of the network such as network dynamics, node deployment, node communication and the data delivery model [18][19][20].

5) *Data Delivery Models*:

Depending on the application of the sensor network, the data delivery model to the sink can be continuous, event-driven, query-driven and hybrid [20]. In the continuous delivery model, each sensor sends data periodically. In event-driven and query-driven models, the transmission of data is triggered when an event occurs or a query is generated by the sink. Some networks apply a hybrid model using a combination of continuous, event driven and query-driven data delivery [21]. The routing and MAC protocols are highly influenced by the data delivery model, especially with regards to the minimization of energy consumption and route stability. For instance, it has been concluded in [22] that for a habitat monitoring application where data is continuously transmitted to the sink, a hierarchical routing protocol is the most efficient alternative. This is due to the fact that such an application generates significant redundant data that can be aggregated on route to the sink, thus reducing traffic and saving energy. In addition, in continuous data delivery model, time-based medium access can achieve significant energy saving since it will enable turning off sensors' radio receivers [23]. CSMA medium access arbitration is a good fit for event based data delivery models since the data is generated sporadically.

6) *Scalability*

Scalability is the method of expanding the existing network topology without affecting the stability of the existing network setup. Scalability depends on the application requirement and moreover number nodes can be added to tens, hundreds, even thousands of sensors depending upon the need. Thus, the scalability of heterogeneous WSNs provides a challenge in the ways the network has to be scaled.

7) *Topology management*

Topology issues have received more and more attentions in Wireless Sensor Networks (WSN). While WSN applications are normally optimized by the given underlying network topology, another trend is to optimize WSN by means of topology control. A number of approaches have been invested in this area, such as topology directed routing, cooperating schemes, sensor coverage based topology control and network connectivity based topology control. Most of the schemes have proven to be able to provide a better network monitoring and communication performance with prolonged system lifetime.

In [48], the authors have specifically dealt with the problem of cluster task assignment to maximize total utilities of nodes for target coverage in Urban-scale Wireless Sensor Networks which is heterogeneous in nature.

In [47], the authors have discussed about various issues related to topology which are as follows: Blanket Coverage, Barrier Coverage, and Sweep Coverage which are to be considered when designing a heterogeneous network which are to be scaled in future. The author has also given insight about network connectivity issues taken from various references which are listed as follows: Power Management Mechanisms, Power Control Mechanisms, Achieving Both Coverage and Connectivity. All of these issues are to be taken care while designing a heterogeneous wireless sensor networks.

8) *Platform Heterogeneity*

Sensors and actuators do not share the same level of resource constraints, as mentioned above. Possibly designed using different technologies and with different goals, they are different from each other in many aspects such as computing / communication capabilities, functionality, and number. In a large-scale system of systems, the hardware and networking technologies used in the underlying WSANs may differ from one subsystem to another. This is true because of the lack of relevant standards dedicated to WSANs and hence commercially available products often have disparate features. This platform heterogeneity makes it very difficult to make full use of the resources available in the integrated system.

A heterogeneous wireless sensor network contains different types of sensor nodes in it serving different applications. The author in the paper [40] has presented an architecture MARWIS (Management Architecture for Wireless Sensor Networks) to operate such a WSN. It uses hierarchical architecture which efficiently manages the several structural elements present in the network. This paper suggests that user can perform task using a management station which in turn can be remotely located on the internet.

Consequently, resource efficiency cannot be maximized in many situations. In addition, the platform heterogeneity also makes it challenging to achieve real-time and reliable communication between different nodes.

9) Mixed Traffic management

In heterogeneous WSN diverse applications are needed to share the same network which may include data that are periodic and non-periodic data. As the WSN's scales this feature becomes more evident and predominant. Some sensors may be used to create the measurements of certain physical variables in a periodic manner for the purpose of monitoring and/or control. Meanwhile, some others may be deployed to detect critical events. For instance, in a smart home, some sensors are used to sense the temperature and lighting, while some others are responsible for reporting events like the entering or leaving of a person. Furthermore, disparate sensors for different kinds of physical variables, e.g., temperature, humidity, location, and speed, generate traffic flows with different characteristics (e.g. message size and sampling rate). This feature of heterogeneous WSNs necessitates the support of service differentiation in QoS management.

10) Localization

The main use to heterogeneous sensor nodes is to gather different types of data from the environment and give it to base station and process it. However, it is an important task to know the location of data from where it is collected. Localization is a mechanism in which such nodes are located. There are many approaches for localization; however, such approaches are desirable which are capable to take care of limited resources of sensor nodes. In [38], the authors have explained different localization techniques in detail and have deeply analyzed Range free, range-based, and TWR techniques. This is one of the major issues and as of no proper localization mechanisms are adopted which might lead to decreased network lifetime also.

It is really very challenging to overcome all the above mentioned issues in designing a heterogeneous WSN. It is real challenge for the application developers and network designers to balance the tradeoff in integrate the traditional WSNs into modern heterogonous WSNs. Some of the challenges and integrating goals are summarized in Table 1.

Table 1. Challenges/issues verses design goals in integrating WSNs

Issues	Design Goals
Bandwidth	Dynamic allocation mechanism without overhead to be considered
Scalability	Should be able to integrate with internet and other technologies
Mixed traffic management	Proper queuing mechanism to manage the varied traffic
Data Redundancy	Looping of same packets to be taken care
Addressing	Internetworking addressing schemes to be adopted
Data delivery models	Adopt proper model to delivery varied types of data
Security	Secure design considering all parameters

5. RESEARCH CONTRIBUTION

Wireless Sensor Networks offer great opportunities for WSNs offer great opportunities from simple sensing applications to diverse applications supporting the latest Internet of Things. As the use of WSN technology (offers of services) and existing applications are constantly growing, the research in this field is very exciting. In this paper, we have presented the overall study we have made in underlying concepts responsible for developing the current wireless sensor networks. The study has been made by highlighting some aspects of particular type of sensor networks which are relevant for our research, and open research directions in this field.

Nevertheless, there are several problems that still require improvements, despite the number of contributions made in this area. In particular, scheduling, cross layer optimization, security, localization, mixed traffic management, energy efficient routing, etc. remains open. And moreover from these study and references made shows that biological inspired algorithms would provide a good solution for management of sensor network [10]. These algorithms would be very useful when mixed traffic has to be managed especially in Wireless

Multimedia Sensor Networks. Our first attempt has been contributed in the paper [49], which aims at increased throughput and decreased delay in mixed traffic heterogeneous wireless sensor networks using priority based packet scheduling algorithm in a multi-stacked queue. Still effort is being made to improve upon it by reducing the energy consumption.

6. CONCLUSION

Hence in this paper, we have briefly addressed most of the recent literature of WSNs along with the traditional approach and outlined some of open research issues in this field.

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