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THEME

Le Fonctionnement Optimal du Réseau de Capteurs Sans Fil sous la Variation de la Température par La Triangulation Deluanay

Préparé et présenté par :

BOURABIA Ahmed

Présenté, devant le Jury Composé de:

A . TEBERKAKE MAA U.Y.F.M President
A.KHELDOUN MAA U.Y.F.M Examinateur
A.GAGUI MAA U.Y.F.M Encadreur

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شكر

اشكر خالقي وبارئي الذي فضل علي بالصحة والعافية والتوفيق لاكمال هذه المذكرة.

واشكر ثانيا استاذي الفاضل قاقي الذي كان سندا لي وعونا وداعما.

كما اشكر الهيئة المناقشة على هذا التشريف.

ولا انسى بالشكر كل استاذ له مكانة في رفع مستوانا التعليمي خلال الخمس سنوات التي قضيناها في الجامعة راجيا من المولى عز وجل ان يجعلها لهم ذخرا وزادا.

واختم بشكر العائلة والاصدقاء في جميع الميادين على دعمهم ومؤازرتهم.

إهداء

لعل اللغة العربية ورغم ثرائها تقف في بعض الاحيان عاجزة عن تقدير الاشخاص ووصف مكانتهم في القلب وبالرغم من هذا لابد من القول

أهدي هذه المذكرة أولاإلى أغلى ماملكت في هذه الدنيا إلى والدي العزيزين الذين ضحيا بالغالي والنفيس من اجل ان أصل انا واخوتي إلى ماوصلنا اليه وأقول طبتما وطاب ممشاكما وتبوئتما من الجنة مقعدا طبتما وطاب ممشاكما وتبوئتما من الجنة منزلا.

وثانيا إلى اخوتي والعائلة الكريمة التي كانت لي سندا وعونا.

ثم لا انسى بالذكر اخي ساسي العربي رحمه الله والذي ترك فراغا رهيبا لا اجد من سلوى في نفسي له الا ان اقول رحمك الله واسكنك فسيح جنانه.

كما اهدي هذه المذكرة الى الاصدقاء سواء في العمل اوالدراسة او الحياة اليومية.

وكما يقال فان الخواتيم مسك فاختم باهداء هذه المذكرة الى من لهم فضل على ماحييت الى كل معلم واستاذ كان له يد في وصولي الى هذه المرحلة واقول جعل الله كل حرف علمتمونيه

في ميزان حسناتكم.

Abstract:

The wireless sensors network has becomes a major research domain because of its uses in many places so that lead to find solutions to some problems that effect on the wireless network such as energy saving which represent a big problem specially when we now that the sensors are subsystem the temperature effecting also can cause sophistications specially on communication part . we integrated two models the first one is to save energy by putting some nodes in hibernate mode as in the SO (Stop-Operate) algorithm, and the second one is Delaunay triangulation algorithm to create communication links which also save energy by minimize unnecessary communication between nodes. All proposed algorithms are fully distributed and use the temperature factor. Our results identify the optimal work of wireless network under temperature effecting .

Key words:

Wireless sensor networks, temperature variations, communication links, deployment, Stop-Operate, Delaunay triangulation.

Résumé :

Le réseau de capteurs sans fil est devenu une recherche majeure de recherche en raison de ses utilisations dans de nombreux endroits afin de trouver des solutions à certains problèmes qui affectent le réseau sans fil, comme l'économie d'énergie, ce qui représente un gros problème spécialement lorsque les capteurs sont un sous-système dont la température peut aussi provoquer des sophistications spécialement en communication. nous avons intégré deux modèles, le premier consiste à économiser de l'énergie en mettant certains noeuds en mode hibernation comme dans l'algorithme SO (Stop-Operate), et le second est l'algorithme de triangulation Delaunay pour créer des liens de communication qui permettent également d'économiser l'énergie en minimisant communication entre les nœuds. Tous les algorithmes proposés sont entièrement distribués et utilisent le facteur de température. Nos résultats identifient le travail optimal du réseau sans fil sous l'effet de la température.

Les mots clés :

Réseau de capteurs sans fil, variations de température, déploiement, Stop-exploitation, triangulation de Delaunay, communication.

ملخص:

كشفت دراسات اقيمت على شبكات الحساسات اللاسلكية ان تغيرات درجات الحرارة في الوسط تأثر بشكل كبير على عمل الحساسات خاصة من جانب الاتصال, وبالخوض في التفاصيل نجد ان ارتفاع درجة الحرارة ياثر بشكل سلبي على مدى الاتصال حيث ان زيادة درجة الحرارة ينقص من مدى الاتصال والعلاقة بينهما هي علاقة عكسية وعليه فان تناقص درجات الحرارة يزيد مدى الاتصال. وعليه وبناءا على هذا المنطلق كان تصميم مخطط يعتمد على درجة الحرارة كعامل في توزيع الحساسات شيئا اساسيا للحفاظ على فعالية الشبكة لذلك تقدمنا بهذا المشروع الي يعتمد على خوارزميتين تساهمان في حل هذا المشكل الاولى هي خوارزمية التوقف عن النشاط والتي تعتمد على اتخاذ القرارات بناءا على موضع الحساس الذي يتحرك بناءا على درجة الحرارة بحيث انه يدخل في وضعية السبات اذا كان خارج المدى المطلوب ويعود الى النشاط اذا دخل المدى المطلوب مايساهم قطعا في الحفاظ على الطاقة في الحساس الامر الذي ينعكس ايجابا على المدى الزمني للشبكة, اما في مايتعلق بالخوارزمية الثانية فهي خورزمية دولوناي التي تعتمد التثليث مبدءا اساسيا لها بحيث تحدد الجيران لكل حساس ماينقص مدى الاتصال المطلوب الشيء الذي يساهم ايضا في الحفاظ على الطاقة وقد حاولنا دمج هاتين الخوارزميتين للخروج بحل يساهم في تفادي تاثير درجة الحرارة على الشبكة.

الكلمات المفتاحية:

شبكة الحساسات اللاسلكية, الحرارة, خوارزمية التوقف عن النشاط, خوارزمية دولوناي, المخطط.

Contents

General Introduction……1
Chapter 1:*General information about wireless sensor networks*……...….3
I. introduction ……...…...3
II. THE SENSOR……...…….....3
II.1 Definition……..…..……3
II.2 Sensor design…….……..……..4
II.3 Nodes history revolution: …….…….……..4
III. Wireless sensor network……..….5
III.1 History…….....….5
III.2 Definition……...….6
III.3 WSN Architect……..…….....….7
III.4 Protocol Stack of WSNs……...7
III.4.1 The physical layer…..……...…....8
III.4.2 The data link layer……...…..…8
III.4.3 The network layer……...……..8
III.4.4 The transportation layer……..8
III.4.5 The application layer……...……8
III.4.6 The power management plane…….9
III.4.7The mobility management plane……...9
III.4.8 The task management plane…….……9
III.4.9 QoS management(Quality Of Service) ……...9
III.5 WSN parameters…….…9
III.5.1 node parameters…….9
III.5.1.1 Node density…….9
III.5.1.2 Transmission range…….…9
III.5.1.3 Sensing range……...9
III.5.2WSN types……...9
III.5.2.1 Homogeneous WSNs…….…..9
III.5.2.2 Heterogeneous WSNs…….….9
III.6 Protocols & algorithms of wireless sensor network……10
III.6.1 Flooding…….....11
III.6.2 Gossiping……12
III.6.3 Protocols for Information via Negotiation(SPIN)..12
III.6.4 Low-Energy Adaptive Clustering Hierarch (LEACH)……13
III.6.5 Threshold-sensitive Energy Efficient Protocols (TEEN and APTEEN) ……14
III.6.6 Power-Efficient Gathering in Sensor Information Systems (PEGASIS) ……..…15
III.6.7 Directed Diffusion……..…16
III.6.8 Geographic Adaptive Fidelity (GAF) …….....16
III.7 WSN characteristics……..…..17

III.7.1 Communication paradigm……....17
III.7.2 Application specific……. .17
III.7.3 Dynamic nature……..17
III.7.4 Scale and density……....17
III.7.5 Resource constraints……..17
III.7.6 Deployment……17
III.7.7 Fault tolerance……17
III.7.8 Lifetime……....17
III.7.9 Scalability……....18
III.7.10 Realtime…...……..18
III.7.11 Security…..……...….....18
III.7.12 Production cost……18
III.8 Applications of Sensor Networks……18
III.8.1 Military applications……...18
III.8.2 Environmental applications……19
III.8.3 Health applications……..19
III.8.4 Home applications……....19
III.8.5 Commercial applications……19
III.9 WSN OPERATING SYSTEM (OS) ……19
III.10 EXAMPLES OF OPERATING SYSTEMS……..20
III.10.1 TinyOS……20
III.10.2 Mate……21
III.10.3 MANTIS……..21
III.10.4 OSPM……...22
III.11 Structure of a wireless sensor network……..23
III.11.1 Star network……23
III.11.2 Mesh network……..23
III.11.3 Hybrid star – Mesh network……24
IV. Challenges and Hurdles……25
IV.1 Hardware Constraints……...25
IV.2 Power Consumption……...26
IV.3 Node Unit Costs……..26
IV.4 Environment……...26
IV.5 Transmission Channels……..27
IV.6 Connectivity and Topology……27
IV.7Standards……28
V. Conclusion……28
Chapter 2:energy consumption and temperature effect on WSN…...29
I. Introduction……...29
II. NETWORK LIFETIME DEFINITION……30
II.1 Network lifetime based on the number of a live nodes.....30
II.2 Network lifetime based on coverage……..…31

II.3 Network lifetime based on connectivity……..…31
II.4 Network lifetime based on application requirements……...31
III. WSN node Power Consumption……..….31
IV. Problems and Energy Issues in Wireless Sensor Networks……...32
IV.1 Broadcasting Issues…….33
IV.2 Virtual backbone…….33
IV.3 Family of Connected Dominating Sets…….34
IV.4 Clustering……34
IV.5 Disjoint Dominating Sets……...35
IV.6 Target Monitoring……...……...35
IV.7 Self-Protecting WSNs……..……...36
IV.8 Topology Control Problems……...37
V. Classification of energy efficient techniques……..38
V.1 Duty cycling…….....38
V.2 data-driven approaches……38
VI. Influence of Temperature on Communication……42
VI.1 Experimental Setup…….……42
VI.2 Packet Error Dependency on Temperature……..……43
VII. RELATED WORKS……44
VIII. Conclusions……...……46
Chapter 3:Deployment issues in Wireless sensor network……..46
I. Introduction……...……46
II. The objective……..46
III. COVERAGE STRATEGIES……..46
III.1 Force Based ……47
III.2 Grid Based ……..47
III.3 Computational Geometry Based……48
III.3.1 Voronoi Diagram……..…49
III.3.2 Delaunay triangulation……49
IV. Delaunay triangulation principle……....49
V. WSN deployment……...51
VI. SYSTEM MODEL……...52
VI.1 Wireless Links……..52
VI.2 Communication Range……53
VII. Effect of temperature on communication power……...…55
VIII. Functions and algorithms……55
VIII.1 Node position: ……..55
VIII.2 Movement coefficient……...…57
VIII.3 Stop-Operate algorithm……...57
VIII.4 Delaunay algorithm ……58
IX. Network working diagram……..59
X. Conclusion……...61
Chapter 4: simulation and results……..62

I.Introduction ……...62
II. The tools……62
III. Temperature daily variation……..…62
IV. Default simulation values…….63
V. Simulation results……..65
IV.1 Deployment ……65
IV.2 Communication……..66
IV.3 Stop-Operate……...67
IV.4 Energy……..68
VI. Conclusion…… ….72
General conclusion……....73

Figures list

Figure1. Sensor design……4
Figure 2. wireless sensors network architect ……..7
Figure 3. Wireless Sensor Network protocol stack……..8
Figure 4. Flooding in data communication networks……12
Figure 5. SPIN basic protocol operation……13
Figure 6. Chain-based data gathering and aggregation scheme……16
Figure 7. A Star network topology…….23
Figure 8. A Mesh network topology……..24
Figure 9. A Hybrid Star – Mesh network topology……...25
Figure 10 Taxonomy of approaches to energy savings insensor networks…...41
Figure 11. Influence of temperature on several key communication metrics…44
Figure 12. Types of grids (a) Triangular lattice (b)Square grid (c) Hexagonal grid……...48
Figure 13. Voronoi Diagram……...49
Figure 14: Every triangle in a Delaunay triangulation has an empty open circle disk……...50
Figure 15:waysto define a Delaunay structure……...50
Figure 16. common spaces between nodes…….51
Figure 17. active and inactive nodes ……..59
Figure 18. deployment work..……60
Figure 19. Eclipse interface……61
Figure 20. NetAnim interface……..62
Figure 21. temperature variation in 24 hours……...63
Figure 22. simulation deployment ……...65
Figure 23. Delaunay triangulation in the simulation……....66
Figure 24. Stop-Operate in simulation……...…….67
Figure 25. normal deployment energy consumption……68
Figure 26. the simulation energy consumption……68
Figure 27. StopOperating energy consumption……69

Tables list:

Table 1: Nodes history revolution……4

Table 2: WSN Node System Specifications……32

Table 3: simulation properties……70

Abbreviations:

WSN : wireless sensor network

dBm : Decibel-mmilliwatts.

IEEE: Electrical and Electronics Engineers

MAC: Medium Access Access Control

mW : milli Watts

General introduction

The wireless sensors network become one of the major domains of research in the last few years because its services are requires more than ever these revolution take the edges of sensor development to high level as a normal result the problems become to the surface.

When we take the sensor as battery operated node that sense and communicate many issues become priority as saving energy to make the network work for the longest time possible because the deployments vary from application to another but generally nodes are unattended and are required to operate over long periods of time without external intervention or assistance. Therefore, nodes need to consume the least amount of energy while ensuring that the sensor network continues to operate correctly. In its basic form, the correct operation of the network can be achieved if both coverage and connectivity are preserved. The coverage ensures that the entire deployment area is monitored so that no event will be missed, and the connectivity means that the network is not fragmented so that data transmitted can reach any node in the network.

Wireless sensors network fond in many domains most of them are outdoor so as a results the temperature factor should be one of the issues that we take in concern when we build any projects.

In matter of fact, sensor generally uses low-cost and low-power transceivers whose performance depends on the temperature in which they operate. Independent research results (see chapter 2) and data taken from the data sheets of popular radio transceivers show that temperature affects both the quality of transmission and reception when temperature increases, both transmission power and reception sensitivity decrease thereby leading to changing in communication range which make deployment useless unless the deployment take the temperature in concern

In this paper we represented some researches about effect of temperature on communication specifically and the work of the network generally.

So we propose a deployment that take the temperature as very important factor in the distribution of the sensors in the field without forgetting to make sensors make the least communication required to save energy by using algorithms based on famous functions as Delaunay triangulation in communication part and stop-operate in deployment part(see chapter 3) by combine this two methods we

create network that adapt with the variation of temperature without effecting on the main function that this network stand for.

The rest of the paper is organized as follows. In chapter 1 we represented general consumptions about wireless sensor network as sensors and network architect. In chapter 2 we presented energy consumption and the effect of temperature on the network. For the 3rd chapter we Deployment issues in our Wireless sensor network and the last chapter we presented the simulation results and analysis them.

Chapter 1

General information about wireless sensor networks

I. INTRODUCTION:

Efficient design and implementation of wireless sensor networks has become a hot area of research in recent years, due to the vast potential of sensor networks to enable applications that connect the physical world to the virtual world. By networking large numbers of tiny sensor nodes, it is possible to obtain data about physical phenomena that was difficult or impossible to obtain in more conventional ways. In the coming years, as advances in micro-fabrication technology allow the cost of manufacturing sensor nodes to continue to drop, increasing deployments of wireless sensor networks are expected, with the networks eventually growing to large numbers of nodes (e.g., thousands). Potential applications for such large-scale wireless sensor networks exist in a variety of fields, including medical monitoring, environmental monitoring, surveillance, home security, military operations, and industrial machine monitoring[1].

In this chapter we are going to have a general look to wireless sensor networks characteristics and its component beside its history and were we generally find it.

II. THE SENSOR

II.1 Definition:

A sensor is an electronic component, module, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor. A sensor is always used with other electronics, whether as simple as a light or as complex as a computer.

Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base, besides innumerable applications of which most people are never aware. With advances in micro machinery and easy-to-use microcontroller platforms, the uses of sensors have expanded beyond the traditional fields of temperature, pressure or flow measurement, for example into MARG sensors. Moreover, analog sensors such as potentiometers and force-sensing resistors are still widely used. Applications include manufacturing and machinery, airplanes and aerospace, cars, medicine, robotics and many other aspects of our day-to-day life[1].

II.2 Sensor design:

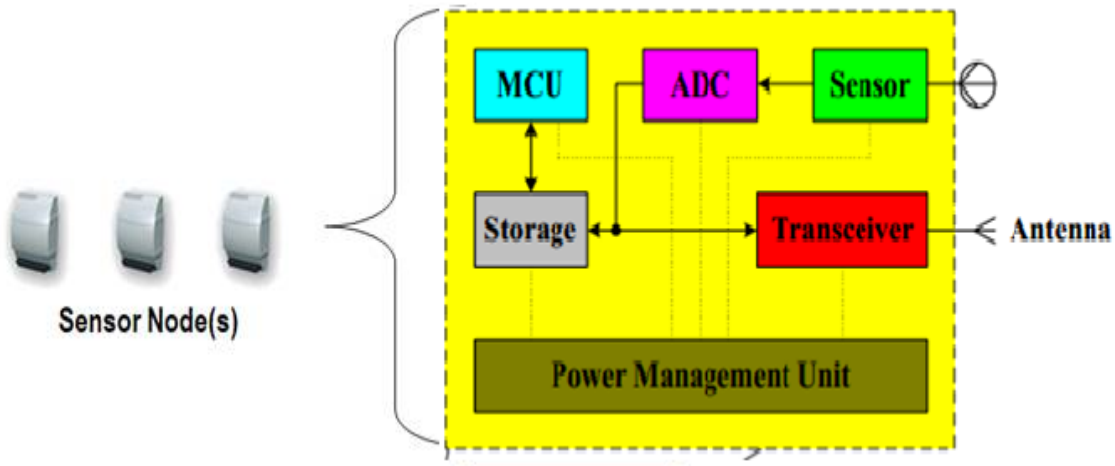


Figure 1. Sensor design

For the sensor design there are four important components:
MCU: Micro Controller Unit which is responsible for the calculation issues.
Antenna: is the receiver or the sender physical part.
Power management unit: witch represent the battery supply.
Storage: witch contain in memory unit.

II.3 Nodes history revolution:

	First Generation (1980s–1990s)	Second Generation(Early 2000s)	Third Generation(Late 2000s)
Size	Attache or larger	Paperback book or smaller	Small, even a dust particle
Weight	Pounds	Ounces	Grams or less
Deploymentmode	Physically installed or air-dropped	Hand-placed	Embedded or ‘‘sprinkled’’ possibly nanotechnology based
Node Architecture	Separate sensing, processing, and communication	Integrated sensing, processing, and communication	Fully integrated sensing, processing, and communication
Protocols	Proprietary	Proprietary	Standard: Wi-Fi, ZigBee, WiMax, etc.

Topology	Point-to-point, star,and multihop	Client–server and peer-to-peer	Fully peer to peer
Power supply	Large batteries or line feed	AA batteries	Solar or possibly nanotechnology-based
Life span	Hours, days	Days to weeks	Months to years

Table 1 . Nodes history revolution

III. Wireless sensor network

III.1 History

The origins of the research on WSNs can be traced back to the Distributed Sensor Networks (DSN) program at the Defense Advanced Research Projects Agency (DARPA) at around 1980.

By this time, the ARPANET (Advanced Research Projects Agency Network) had been operational for a number of years, with about 200 hosts at universities and research institutes [3] DSNs were assumed to have many spatially distributed low-cost sensing nodes that collaborated with each other but operated autonomously, with information being routed to whichever node was best able to use the information. At that time, this was actually an ambitious program. There were no personal computers and workstations; processing was mainly performed on minicomputers and the Ethernet was just becoming popular [4]. Technology components for a DSN were identified in a Distributed Sensor Nets workshop in 1978 (Proceedings of the Distributed Sensor Nets Work-shop, 1978). These included sensors (acoustic), communication and processing modules, and distributed software. Researchers at Carnegie Mellon University (CMU) even developed a communication-oriented operating system called Accent [5],which allowed flexible, transparent access to distributed resources required for a fault-tolerant DSN.

A demonstrative application of DSN was a helicopter tracking system , using a distributed array of acoustic microphones by means of signal abstractions and matching techniques, developed at the Massachusetts Institute of Technology (MIT).

Even though early researchers on sensor networks had in mind the vision of a DSN, the technology was not quite ready. More specifically, the sensors were

rather large (i.e. shoe box and up) which limited the number of potential applications. Further, the earliest DSNs were not tightly associated with wireless connectivity. Recent advances in computing, communication and microelectromechanical technology have caused a significant shift in WSN research and brought it closer to achieving the original vision. The new wave of research in WSNs started in around 1998 and has been attracting more and more attention and international involvement.

In the new wave of sensor network research, networking techniques and networked information processing suitable for highly dynamic ad hoc environments and resource-constrained sensor nodes have been the focus. Further, the sensor nodes have been much smaller in size (i.e. pack of cards to dust particle) and much cheaper in price, and thus many new civilianapplications of sensor networks such as environment monitoring, vehicular sensor network and body sensor network have emerged. Again, DARPA acted as a pioneer in the new wave of sensor network research by launching an initiative research program called SensIT [6] which provided the present sensor networks with new capabilities such as ad hoc networking, dynamic querying and tasking, reprogramming and multi-tasking. At the same time, the IEEE noticed the low expense and high capabilities that sensor networks offer. The organization has defined the IEEE 802.15.4 standard (IEEE 802.15 WPAN Task Group 4)for low data rate wireless personal area networks. Based on IEEE 802.15.4, ZigBee Alliance (ZigBee Alliance, n.d.) has published the ZigBee standard which specifies a suite of high level communication protocols which can be used by WSNs. Currently, WSN has been viewed as one of the most important technologies for the 21st century (21 Ideas for the 21st Century, 1999). Countries such as China have involved WSNs in their national strategic research programs [7]. The commercialization of WSNs is also being accelerated by new formed companies like Crossbow Technology (Crossbow Technology, n.d.) and Dust Networks (Dust Networks, Inc., n.d.)[2].

III.2 Definition:

Wireless sensor networks (WSN) or wireless sensor and actuator networks (WSAN) are spatially distributed autonomous sensors to *monitor* physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling *control* of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial

and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

The WSN is built of "nodes" from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors.

The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding[1].

III.3 WSN Architect:

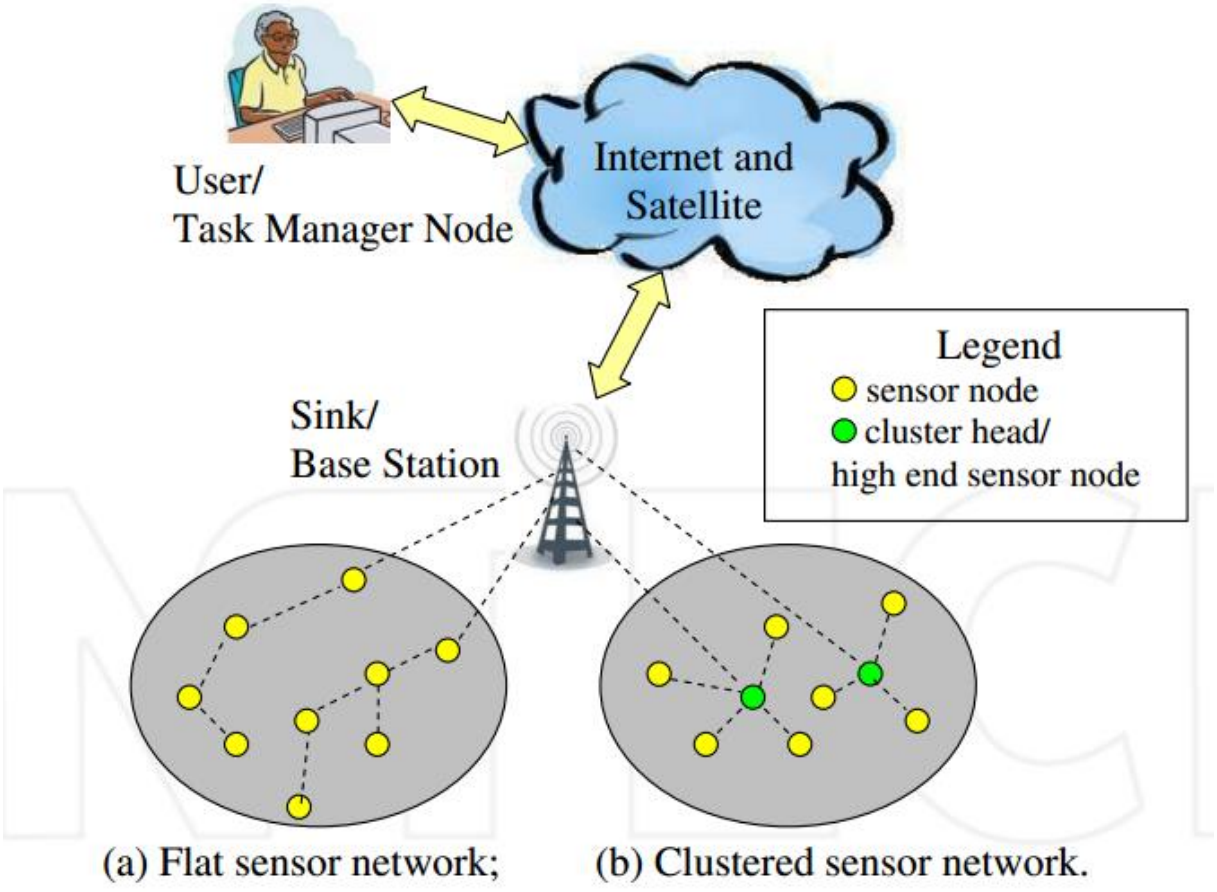


Figure 2.wireless sensors network architect

In this figure we can find two types of deployment the first one figure 2.a is flat sensor network which contain similar sensors each one of them can communicate with the base station and for the second deployment type figure 2.b only the cluster heads (the green nodes) can communicate with the base station.

III.4 Protocol Stack of WSNs

The protocol stack used by the sink, cluster head and sensor nodes are shown in Fig. 2. According to [8], the sensor network protocol stack is much like the traditional protocol stack, with the following layers: application, transport, network, data link, and physical.

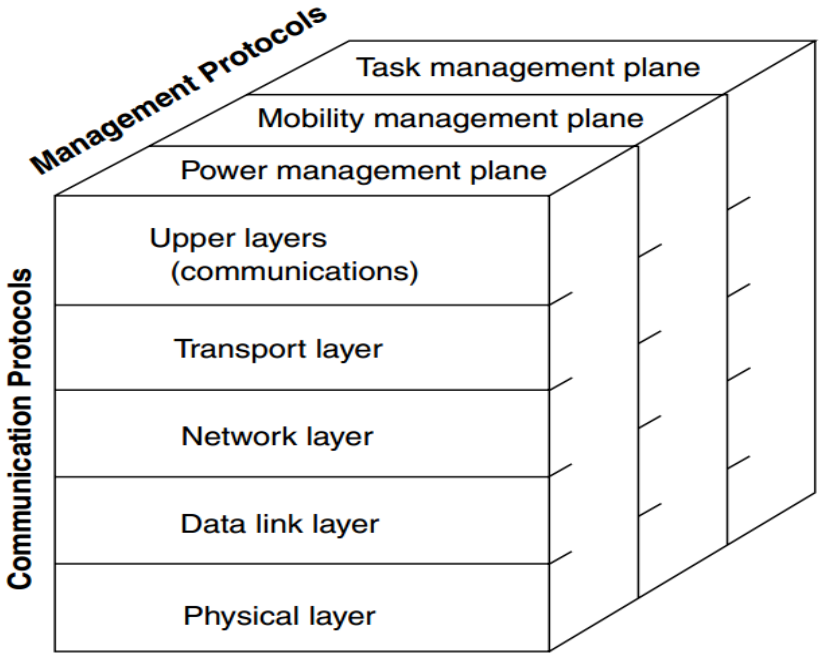


Figure3. Wireless Sensor Network protocol stack

III.4.1 The physical layeris responsible for frequency selection, carrier frequency generation, signal detection, modulation and data encryption.

III.4.2 The data link layeris responsible for the multiplexing of data streams, data frame detection, medium access and error control. It ensures reliable point-to-point and point-to-multipoint connections in a communication net-work.

III.4.3 The network layertakes care of routing the data supplied by the transport layer;the network layer design in WSNs must consider the power efficiency, datacentric communication, data aggregation, etc.

III.4.4 The transportation layerhelps to maintain the data flow and may be important if WSNs are planned to be accessed through the Internet or other external networks.

III.4.5 The application layer :depending on the sensing tasks, different types of application software can be set up and used on the application layer.

WSNs must also be aware of the following management planes in order to function efficiently: mobility, power, task, quality of service (QoS) and security management planes. Among them, the functions of task, mobility and power management planes have been elaborated in[10].

III.4.6 The power management plane: is responsible for minimizing power consumption and may turn off functionality in order to preserve energy.

III.4.7The mobility management plane: detects and registers movement of nodes so a data route to the sink is always maintained.

III.4.8 The task management planebalances and schedules the sensing tasks assigned to the sensing field and thus only the necessary nodes are assigned with sensing tasks and the remainder are able to focus on routing and data aggregation.

III.4.9 QoSmanagement(Quality Of Service)in WSNs [9] can be very important if there is a real-time requirement with regard to.

III.5 WSN parameters

III.5.1 node parameters

Before mention any deployment issues we need to know Some parameters that influence the probability of intrusion detection are:

III.5.1.1 Node density: It is defined as the total number of nodes present in the network.

III.5.1.2 Transmission range: The maximum distance up to which a node can transmit is called transmission range.

III.5.1.3Sensing range: The distance up to which a sensor can detect the presence of intruder is called its sensing range. We consider these three parameters in our model.

III.5.2WSN types:

Depending on sensors capability there are two types of WSNs[11]:

III.5.2.1 Homogeneous WSNs

In homogeneous WSNs all the sensors have same capabilities. They all have same battery energy, hardware complexity sensing range, and transmission

range [12]. Homogeneous WSNs have simple network connectivity because of symmetrical wireless link.

III.5.2.2 Heterogeneous WSNs

A heterogeneous WSNs consists different sensor nodes. In heterogeneous WSNs some sensors have larger capabilities than other sensors. In this network some sensors have larger sensing range, transmission range and have more battery power. Heterogeneous WSNs are most suitable for real life applications as compared to homogeneous. In heterogeneous WSNs a large no. of inexpensive nodes perform sensing, while a few nodes having comparatively more energy perform other tasks as data filtering, transport. Heterogeneous WSNs have comparatively difficult network connectivity because of asymmetrical wireless links. As packets from high capability nodes may reach the low capability nodes but low capability nodes may not be able to transmit information to high capability nodes. In real world the assumption of homogeneous sensors may not be practical because sensing application may require heterogeneous nodes in terms of sensing and communication capabilities in order to enhance network [11].

III.6 Protocols & algorithms of wireless sensor network

In WSN, the main task of a sensor node is to sense data and sends it to the base station in multi hop environment for which routing path isessential. For computing the routing path from the source node to the base station there is huge numbers of proposed routing protocols exist [13]. The design of routing protocols for WSNs must consider the power and resource limitations of the network nodes, the time-varying quality of the wireless channel, and the possibility for packet loss and delay. To address these design requirements, several routing strategiesfor WSNs have been proposed in [10, 14,15,16,17,18].

The first class of routing protocols adopts a flat network architecture in which all nodes are considered peers. Flat network architecture has several advantages, including minimal overhead to maintain the infrastructure and the potential for the discovery of multiple routes between communicating nodes for fault tolerance.

A second class of routing protocols imposes a structure on the network to achieve energy efficiency, stability, and scalability. In this class of protocols, network nodes are organized in clusters in which a node with higher residual energy, for example, assumes the role of a cluster head. The cluster head is

responsible for coordinating activities within the cluster and forwarding information between clusters. Clustering has potential to reduce energy consumption and extend the lifetime of the network.

A third class of routing protocols uses a data-centric approach to disseminate interest within the network. The approach uses attribute-based naming, whereby a source node queries an attribute for the phenomenon rather than an individual sensor node. The interest dissemination is achieved by assigning tasks to sensor nodes and expressing queries to relative to specific attributes. Different strategies can be used to communicate interests to the sensor nodes, including broadcasting, attribute-based multicasting, geo-casting, and any casting.

A fourth class of routing protocols uses location to address a sensor node. Location-based routing is useful in applications where the position of the node within the geographical coverage of the network is relevant to the query issued by the source node. Such a query may specify a specific area where a phenomenon of interest may occur or the vicinity to a specific point in the network environment. Next we discuss some of the major routing protocols and algorithms to deal with the energy conservation issue in the literatures get from [19]:

III.6.1 Flooding: Flooding is a common technique frequently used for path discovery and information dissemination in wired and wireless ad hoc networks which has been discussed in [10]. The routing strategy of flooding is simple and does not rely on costly network topology maintenance and complex route discovery algorithms. Flooding uses a reactive approach whereby each node receiving a data or control packet sends the packet to all its neighbors. After transmission, a packet follows all possible paths. Unless the network is disconnected, the packet will eventually reach its destination. Furthermore, as the network topology changes, the packet transmitted follows the new routes. Figure 4 illustrates the concept of flooding in data communications network. As shown in the figure, flooding in its simplest form may cause packets to be replicated indefinitely by network nodes.

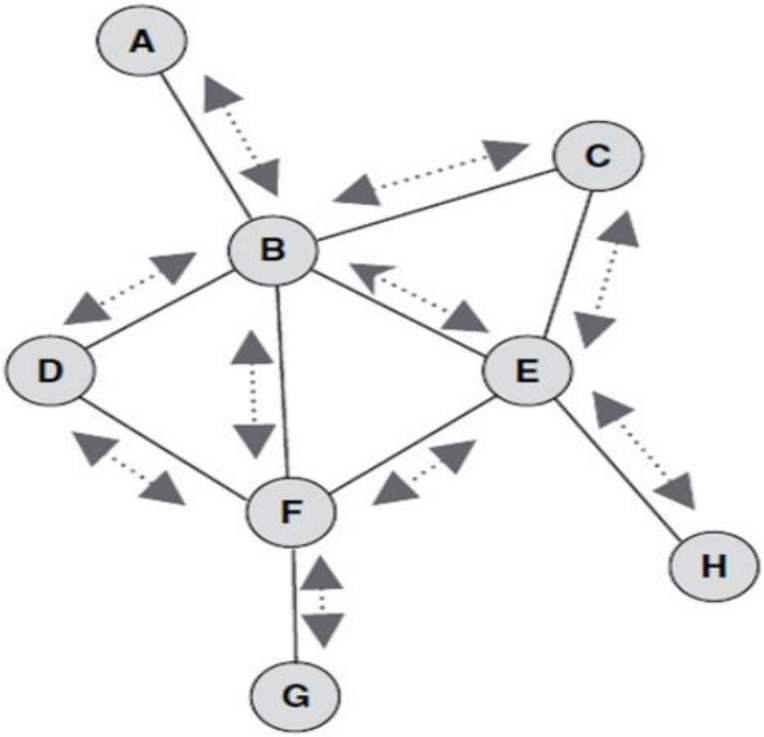


Figure 4. Flooding in data communication networks

III.6.2 Gossiping: To address the shortcomings of flooding, a derivative approach, referred to as gossiping, has been proposed in [20].Similar to flooding, gossiping uses a simple forwarding rule and does not require costly topology maintenance or complex route discovery algorithms. Contrary to flooding, where a data packet is broadcast to all neighbors, gossiping requires that each nodes ends the incoming packet to a randomly selected neighbor. Upon receiving the packet, the neighbor selected randomly chooses one of its own neighbors and forwards the packet to the neighbor chosen. This process continues iteratively until the packet reaches its intended destination or the maximum hop count is exceeded.

III.6.3 Protocols for Information via Negotiation (SPIN):

Sensor protocols for information via negotiation (SPIN), is a data-centric negotiation-based family of information dissemination protocols for WSNs [21]. The main objective of these protocols is to efficiently disseminate observations gathered by individual sensor nodes to all the sensor nodes in the network. Simple protocols such as flooding and gossiping are commonly proposed to achieve information dissemination in WSNs. Flooding requires that each node sends a copy of the data packet to all its neighbors until the information reaches all nodes in the network. Gossiping, on the other hand, uses randomization to

reduce the number of duplicate packets and requires only that a node receiving a data packet forward it to a randomly selected neighbor.

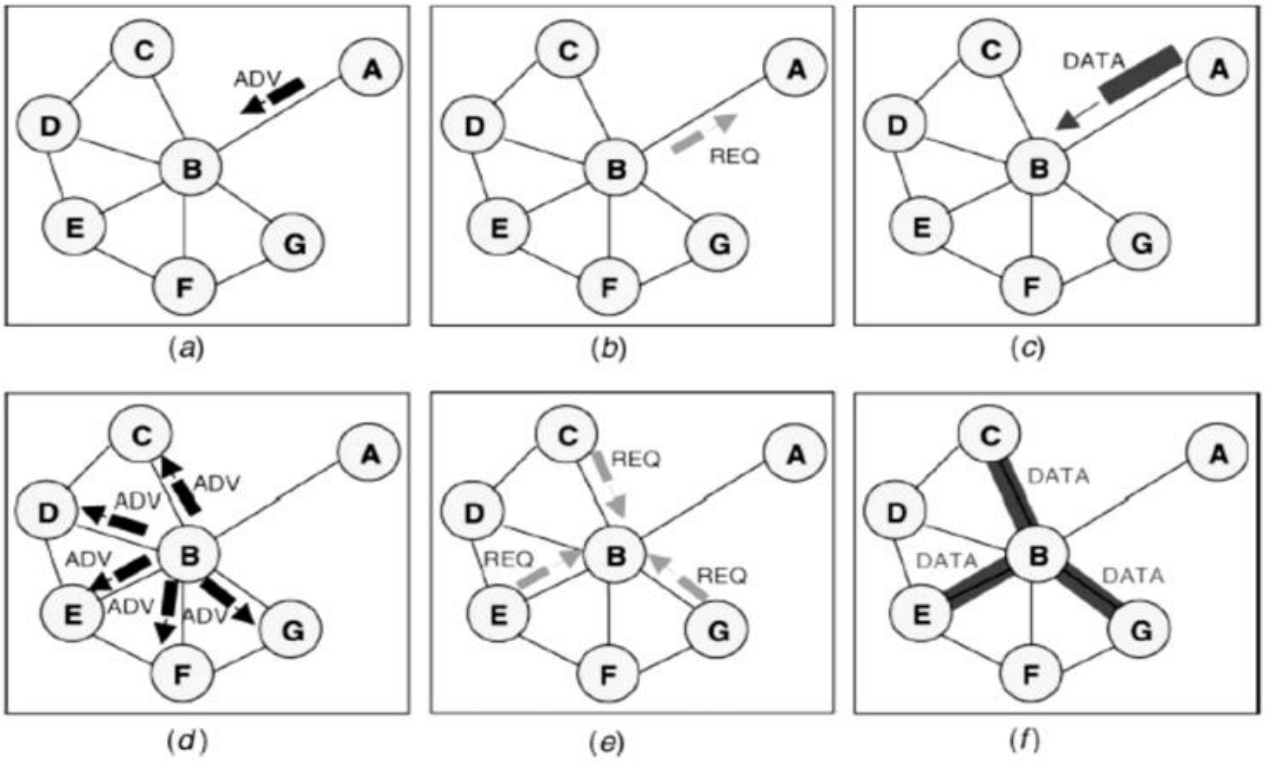


Figure 5. SPIN basic protocol operation

III.6.4 Low-Energy Adaptive Clustering Hierarchy (LEACH)

Low-energy adaptive clustering hierarchy (LEACH) is a routing algorithm designed to collect and deliver data to the data sink, typically a base station [22]. The main objectives of LEACH are:

- Extension of the network lifetime
- Reduced energy consumption by each network sensor node
- Use of data aggregation to reduce the number of communication messages.

To achieve these objectives, LEACH adopts a hierarchical approach to organize the network into a set of clusters. Each cluster is managed by a selected cluster head. The cluster head assumes the responsibility to carry out multiple tasks. The first task consists of periodic collection of data from the members of the cluster. Upon gathering the data, the cluster head aggregates it in an effort to remove redundancy among correlated values. The second main task of a cluster head is to transmit the aggregated data directly to the base station over single hop. The third main task of the cluster head is to create a TDMA-based schedule whereby each node of the cluster is assigned a time slot that it can use for transmission. The cluster head announces the schedule to its cluster members

through broadcasting. To reduce the likelihood of collisions among sensors within and outside the cluster, LEACH nodes use a code-division multiple access–based scheme for communication. The basic operations of LEACH are organized intwo distinct phases. The first phase, the setup phase, consists of two steps, cluster-head selection and cluster formation. The second phase, the steady-state phase, focuses on data collection, aggregation, and delivery to the base station. The duration of the setup is assumed to be relatively shorter than the steady-state phase to minimize the protocol overhead. At the beginning of the setup phase, a round of cluster-head selection starts. To decide whether a node to become cluster head or not a threshold T(s) is addressed in [23] which is as follows:

$$T(s) = \begin{cases} \dfrac{p_{opt}}{1 - p_{opt}.(r.\mathrm{mod}.\dfrac{1}{p_{opt}})}, ifs \in G' \\ 0, otherwise \end{cases}$$

Where r is the current round number and G is the set of nodes that have not become cluster head within the last 1/Poptrounds. At the beginning of each round, each node which belongs to the set G selects a random number 0 or 1. Ifthe random number is less than the threshold T(s) then the node becomes a cluster head in the current round.

III.6.5 Threshold-sensitive Energy Efficient Protocols (TEENand APTEEN):

Two hierarchical routing protocols called TEEN(Threshold-sensitive Energy Efficient sensor Network protocol), and APTEEN (Adaptive Periodic Threshold-sensitive Energy Efficient sensor Network protocol) are proposed in [24] and [25] , respectively. These protocols were proposed for time-critical applications. In TEEN, sensor nodes sense the medium continuously, but the data transmission is done less frequently. A cluster head sensor sends its members a hard threshold, which is the threshold value of the sensed attribute and a soft threshold, which is a small change in the value of the sensed attribute that triggers the node to switch on its transmitter and transmit. Thus the hard threshold tries to reduce the number of transmissions by allowing the nodes to transmit only when the sensed attribute is in the range of interest. The soft threshold further reduces the number of transmissions that might have otherwise occurred when there is little or no change in the sensed attribute. A smaller

value of the soft threshold gives a more accurate picture of the network, at the expense of increased energy consumption. Thus, the user can control the trade-off between energy efficiency and data accuracy. When cluster-heads are to change, new values for the above parameters are broadcast. The main drawback ofthis scheme is that, if the thresholds are not received, the nodes will never communicate, and the user will not get any data from the network at all.

III.6.6 Power-Efficient Gathering in Sensor Information Systems (PEGASIS):

Power-efficient gathering in sensor information systems (PEGASIS) [25] and its extension, hierarchical PEGASIS, are a family of routing and information-gathering protocols for WSNs. The main objectives of PEGASIS are twofold. First, the protocol aims at extending the lifetime of a network by achieving a high level of energy efficiency and uniform energy consumption across all network nodes. Second, the protocol strives to reduce the delay that data incur on their way to the sink.

The network model considered by PEGASIS assumes a homogeneous set of nodes deployed across a geographical area. Nodes are assumed to have global knowledge about other sensors' positions. Furthermore, they have the ability to control their power to cover arbitrary ranges. The nodes may also be equipped with CDMA-capable radio transceivers. The nodes' responsibility is to gather and deliver data to a sink, typically a wireless base station. The goal is to develop a routing structure and an aggregation scheme to reduce energy consumption and deliver the aggregated data to the base station with minimal delay while balancing energy consumption among the sensor nodes. Contrary to other protocols, which rely on a tree structure or a cluster-based hierarchical organization of the network for data gathering and dissemination, PEGASIS uses a chain structure.

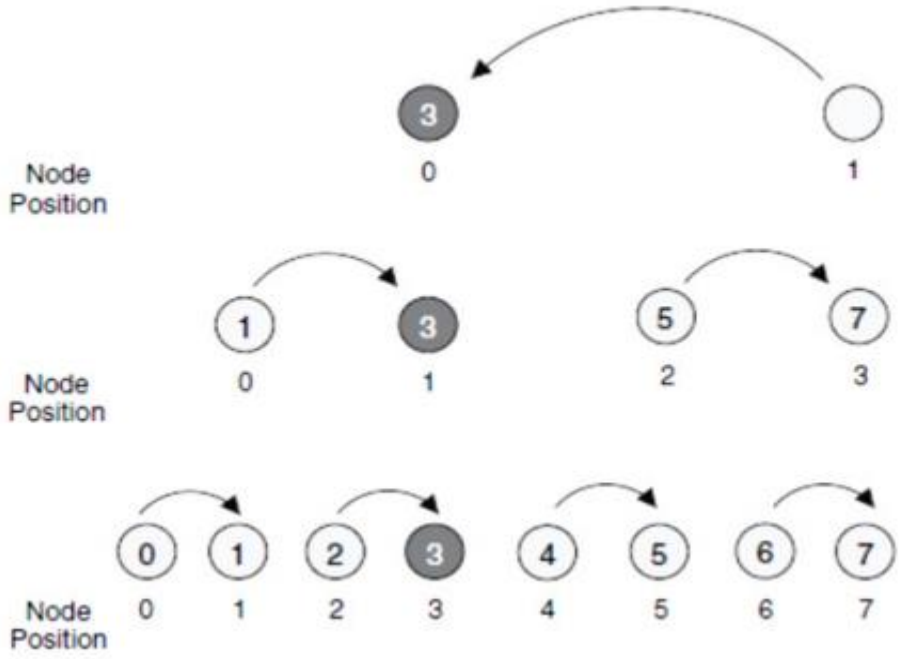


Figure 6.Chain-based data gathering and aggregation scheme.

III.6.7 Directed Diffusion:

Directed diffusion [26] is a data-centric routing protocol for information gathering and dissemination in WSNs. The main objective of the protocol is to achieve substantial energy savings in order to extend the lifetime of the network. To achieve this objective, directed diffusion keeps interactions between nodes, in terms of message exchanges, localized within limited network vicinity. Using localized interaction, direct diffusion can still realize robust multi-path delivery and adapt to a minimal subset of network paths. This unique feature of the protocol, combined with the ability of the nodes to aggregate response to queries, results into significant energy savings.

The main elements of direct diffusion include interests, data messages, gradients, and reinforcements. Directed diffusion uses a publish-and-subscribe information model in which an inquirer expresses an interest using attribute–value pairs. An interest can be viewed as a query or an interrogation that specifies what the inquirer wants.

III.6.8 Geographic Adaptive Fidelity (GAF):

GAF [27] is an energy-aware location-based routing algorithm designed mainly for mobile ad hoc networks, but may be applicable to sensor networks as well. The network area is first divided into fixed zones and forms a virtual grid. Inside each zone, nodes collaborate with each other to play different roles. For

example, nodes will elect one sensor node to stay awake for a certain period of time and then they go to sleep. This node is responsible for monitoring and reporting data to the BS on behalf of the nodes in the zone. Hence, GAF conserves energy by turning off unnecessary nodes in the network without affecting the level of routing fidelity.

III.7WSN characteristics

There are some the unique characteristics that set WSNs apart from other [10]:

III.7.1 Communication paradigm: Compared to traditional communication networks, individual node Identifiers (IDs) are not important. Instead, WSNs are data-centric meaning that the communication should be targeted to nodes in a given location or with a defined data content.

III.7.2 Application specific: WSN is deployed to perform a specific task.

III.7.3 Dynamic nature: In a typical WSNs, node platforms are error-prone due to harsh operating conditions. Communication links between nodes are not stable due to node errors, unreliable and simple modulations, mobility of nodes, and environmental interferences.

III.7.4 Scale and density: Compared to other wireless networks, the number of nodes comprising WSNs may be huge.Further, the density of nodes can be high.

III.7.5 Resource constraints: A typical WSN node is small in physical size and battery powered. This implies that computation, communication, and memory resources in nodes are very limited.

III.7.6 Deployment: In large-scale WSNs, the deployment of nodes is random and their maintenance and replacement is impractical. Still, the requirements and applications of the deployed WSN may alter, which implicate that runtime reconfiguration and reprogramming are needed.

III.7.7 Fault tolerance: The network functionality must be maintained even though the built-in dynamic nature andfailures of nodes due to harsh environment, depletion of batteries, or external interferencemake networks prone to errors.

III.7.8 Lifetime: The nodes are battery powered or the energy is scavenged from the environment and theirmaintenance is difficult. Thus, energy saving and load balancing must be taken into accountin the design and implementation of WSN platforms, protocols, and applications.

III.7.9 Scalability: The number of nodes in WSN is typically high. Thus, the WSN protocols must deal with highdensities and numbers of nodes.

III.7.10 Realtime: WSNs are tightly related to the real world. Therefore, strict timing constraints for sensing, processing, and communication are present in WSNs.

III.7.11 Security: The need for security in WSNs is evident, especially in health care, security, and military applications. Most of the applications relay data that contain private or confidential information.

III.7.12 Production cost: The number of nodes in WSNs is high, and once nodes run out of batteries they are replaced by new ones. Further, WSNs are envisioned to be everywhere. Therefore, to make the deployments possible, the nodes should be extremely low cost.

III.8Applications of Sensor Networks:

Traditionally, sensor networks have been used in the context of high-end applications such as radiation and nuclear-threat detection systems, ‘‘over-the-horizon’’ weapon sensors for ships, biomedical applications, habitat sensing, and seismic monitoring. More recently, interest has focusing on networked biological and chemical sensors for national security applications; furthermore, evolving interest extends to direct consumer applications. Existing and potential applications of sensor networks include, among others, military sensing, physical security, air traffic control, traffic surveillance, video surveillance, industrial and manufacturing automation, process control, inventory management, distributed robotics, weather sensing, environment monitoring, national border monitoring, and building and structures monitoring[3]. A short list of applications follows.

III.8.1Military applications

- Monitoring inimical forces
- Monitoring friendly forces and equipment
- Military-theater or battlefield surveillance

- Targeting
- Battle damage assessment
- Nuclear, biological, and chemical attack detection

and more...

III.8.2Environmental applications

- Microclimates
- Forest fire detection
- Flood detection
- Precision agriculture

and more...

III.8.3Health applications

- Remote monitoring of physiological data
- Tracking and monitoring doctors and patients inside a hospital
- Drug administration
- Elderly assistance

and more...

III.8.4Home applications

- Home automation
- Instrumented environment
- Automated meter reading

and more...

III.8.5Commercial applications

- Environmental control in industrial and office buildings
- Inventory control
- Vehicle tracking and detection
- Traffic flow surveillance

and more...

III.9 WSN OPERATING SYSTEM (OS) :

Sensor operating systems (SOS) should embody the following functions, bearing in mind the limited resource of sensor nodes:

1. Should be compact and small in size since the sensor nodes have very small memory. The sensor nodes often have memories of only tens or hundreds of kilobytes.

2. Should provide real-time support, since there are real-time applications, especially when actuators are involved. The information received may become outdated rather quickly. Therefore, information should be collected and reported as quickly as possible.

3. Should provide efficient resource management mechanisms in order to allocate microprocessor time and limited memory. The CPU time and limited memory must be scheduled and allocated for processes carefully to guarantee fairness (or priority if required).

4. Should support reliable and efficient code distribution since the functionality performed by the sensor nodes may need to be changed after deployment. The code distribution must keep WSNs running normally and use as little wireless bandwidth as possible.

5. Should support power management, which helps to extend the system lifetime and improve its performance. For example, the operating system may schedule the process to sleep when the system is idle, and to wake up with the advent of an incoming event or an interrupt from the hardware.

6. Should provide a generic programming interface up to sensor middleware or application software. This may allow access and control of hardware directly, to optimize system performance.

III.10 EXAMPLES OF OPERATING SYSTEMS

III.10.1 TinyOS

The design of TinyOS [28,29] allows application software to access hardware directly when required. TinyOS is a tiny microthreaded OS that attempts to address two issues: how to guarantee concurrent data flows among hardware devices, and how to provide modularized components with little processing and storage overhead.TinyOS uses an event-based model to support high levels of concurrent application in a very small amount of memory. Compared with a stack-based threaded approach, which would require that stack

space be reserved for each execution context, and because the switching rate of execution context is slower than in an event-based approach, TinyOS achieves higher throughput. It can rapidly create tasks associated with an event, with no blocking or polling. When CPU is idle, the process is maintained in a sleep state to conserve energy.

III.10.2 Mate

Mate [30] is designed to work on the top of TinyOS as one of its components. It is a byte-code interpreter that aims to make TinyOS accessible to non-expert program-mers and to enable quick and efficient programming of an entire sensor network. Mate also provides an execution environment, which is helpful for the UC–Berkeley mote since in this system there is no hardware protection mechanism. In Mate, a program code is made up of capsules. Each capsule has 24 instructions, and the length of each instruction is 1 byte. The capsules contain type and version information, which makes code injection easy. Mate capsules can deploy themselves into the network. Mate implements a beacon-less (BLESS) ad hoc routing protocol as well as the ability to implement new routing protocols. A sensor node that receives a newer version of a capsule installs it. Through hop-by-hop code injection, Mate can program the entire network. Capsules are classified into four categories: message send, message receive, timer, and subroutine. An event can trigger Mate to run. It can be used not only as a virtual machine platform for application development, but also as a tool to manage and control the entire sensor network.

III.10.3 MANTIS

MANTIS [31] is a multithread embedded operating system, which with its general single-board hardware enables flexible and fast deployment of applications. With the key goal of ease for programmers, MANTIS uses classical layered multithreaded structure and standard programming language. The layered structure contains multithreading, preemptive scheduling with time slicing, I/O synchronization via mutual exclusion, a network protocol stack, and device drivers. The current MANTIS kernel realizes these functions in less than 500 bytes of RAM.

MANTIS uses standard C to implement the kernel and API. In the current implementation of MANTIS, the RAM size allocated to each new thread is fixed. The thread table stored in a global data structure has a capacity for of items, each of which is 10 bytes and is used to store thread-related information.

The thread scheduler in MANTIS is priority based and round robin within each priority level. The scheduler is triggered only by timer interrupts from hardware to perform context switching. In MANTIS, other interrupts are handled by device drivers The network protocol stack in MANTIS has four layers: application, network, MAC, and physical. MANTIS implements these as one or more user-level threads, which would allow a trade-off between flexibility and performance. The network stack is realized with a standard API between layers. MANTIS implements flooding as a routing protocol and a simple stop-and-wait protocol for flow and congestion control [32]. The total code size of the kernel, scheduler, and network stack is smaller than 500 bytes and 14 kB flash. MANTIS supports certain advanced features, such as a multimodal prototyping environment for testing sensor networking applications, dynamic binary update-based reprogramming [31], and a remote shell and command server enabling the user to log in and inspect the sensor node's memory and status.

III.10.4 OSPM

OSPM (or dynamic power management, DPM), proposed in [33], is directed at power management techniques. The general dynamic power management is based on a greedy algorithm that will switch the system to a sleep state as soon as it is idle. It considers the following factors [33]:

- Transitioning to a sleep state has the overhead of storing the processor state and shutting off the power supply.
- Waking up takes a finite amount of time.
- The deeper the sleep state, the less the power consumption will be lower and the wake-up time will take longer [33].

Then, based on a given event arrival model, transition time, and power consumption rate, it reduces the energy savings. If the energy savings is positive, it will trigger a state transition; otherwise, the current state is maintained. This adaptive shutdown algorithm is a trade-off between energy savings and the cost of delay and possibly missed events.

III.11Structure of a wireless sensor network

Structure of a Wireless Sensor Network includes different topologies for radio communications networks. A short discussion of the network topologies that apply to wireless sensor networks are outlined below [34]:

III.11.1 Star network(single point-to-multipoint)

A star network is a communications topology where a single base station can send and/or receive a message to a number of remote nodes. The remote nodes are not permitted to send messages to each other. The advantage of this type of network for wireless sensor networks includes simplicity, ability to keep the remote node's power consumption to a minimum. It also allows low latency communications between the remote node and the base station. The disadvantage of such a network is that the base station must be within radio transmission range of all the individual nodes and is not as robust as other networks due to its dependency on a single node to manage the network.

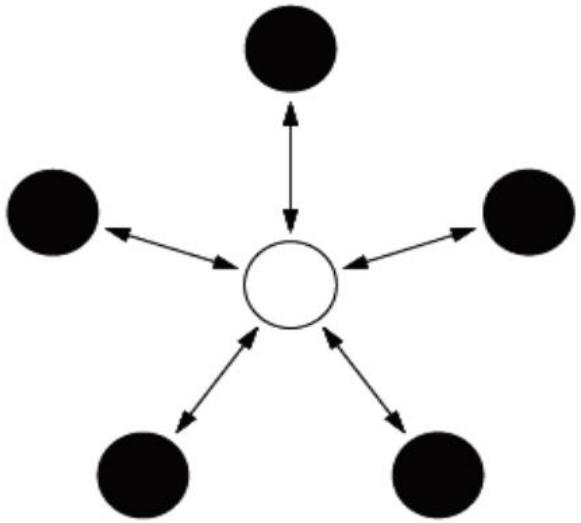


Figure 7. A Star network topology

III.11.2 Mesh network

A mesh network allows transmitting data to one node to other node in the network that is within its radio transmission range. This allows for what is known as multi-hop communications, that is, if a node wants to send a message to another node that is out of radio communications range, it can use an intermediate node to forward the message to the desired node. This network topology has the advantage of redundancy and scalability. If an individual node fails, a remote node still can communicate to any other node in its range, which in turn, can forward the message to the desired location. In addition, the range of the network is not necessarily limited by the range in between single nodes; it can simply be extended by adding more nodes to the system. The disadvantage

of this type of network is in power consumption for the nodes that implement the multi-hop communications are generally higher than for the nodes that don't have this capability, often limiting the battery life. Additionally, as the numberof communication hops to a destination increases, the time to deliver the message also increases, especially if low power operation of the nodes is a requirement.

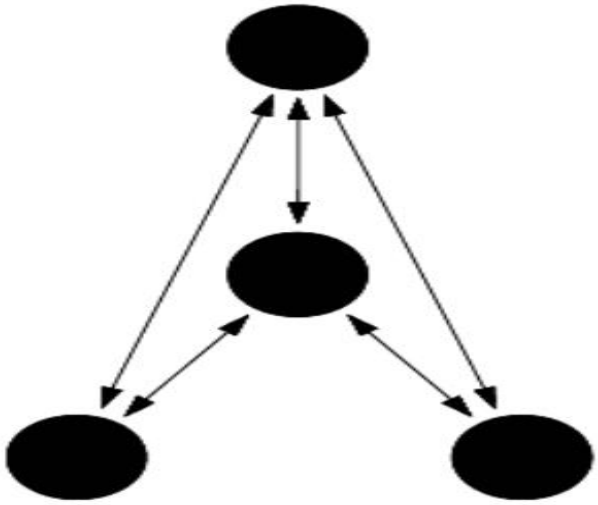


Figure 8. A Mesh network topology

III.11.3 Hybrid star – Mesh network

A hybrid between the star and mesh network provides a robust and versatile communications network, while maintaining the ability to keep the wireless sensor nodes power consumption to a minimum. In this network topology, the sensor nodes with lowest power are not enabled with the ability to forward messages. This allows for minimal power consumption to be maintained. However, other nodes on the network are enabled with multi-hop capability, allowing them to forward messages from the low power nodes to other nodes on the network. Generally, the nodes with the multi-hop capability are higher power, and if possible, are often plugged into the electrical mains line. This is the topology implemented by the up and coming mesh networking standard known as ZigBee.

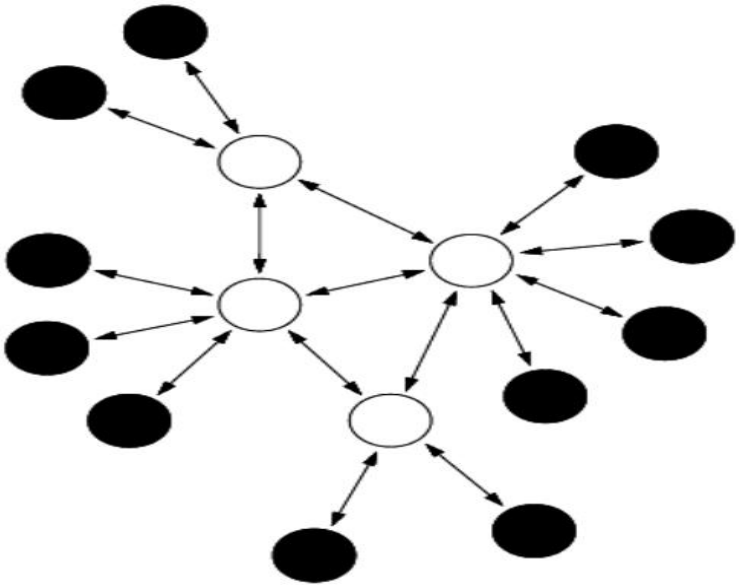


Figure 9. A Hybrid Star – Mesh network topology

IV. Challenges and Hurdles:

For WSNs to become truly ubiquitous, a number of challenges and hurdles must be overcome. Challenges and limitations of wireless sensor networks include, but are not limited to, the following[35]:

- Limited functional capabilities, including problems of size
- Power factors
- Node costs
- Environmental factors
- Transmission channel factors
- Topology management complexity and node distribution
- Standards versus proprietary solutions
- Scalability concerns[36].

IV.1 Hardware Constraints:

A sensor may need to fit into a tight module on the order of 2*5*1 cm or even as small as a 1*1*1 cm. A sensor node is typically comprised of four key components and four optional components. The key components include a power unit (batteries and/or solar cells), a sensing unit (sensors and analog-to-digital converters), a processing unit(along with storage), and a transceiver unit (connects the node to the network). The optional components include a location-finding system, a power generator, a control actuator, and other application-dependent elements. The environmentally-intrinsic analog signals measured by

the sensors are converted to digital signals by analog-to-digital converters and then are supplied to the processing unit. Sensor nodes may also have to be disposable, autonomous, and adaptive to the environment.

IV.2 Power Consumption

The sensor node lifetime typically exhibits a strong dependency on battery life. In many cases, the wireless sensor node has a limited powersource (<500mAh, 1.2 V), and replenishment of power may be limited or impossible altogether. Battery operation for sensors used in commercial applications istypically based on two AA alkaline cells or one Li-AA cell. It follows, as already noted, that power management and power conservation are critical functions for sensor networks, and one needs to design power-aware protocols and algorithms. The function of a sensor node in a sensor field is to detect events, perform local data processing, and transmit raw and/or processed data. Power consumption can therefore be allocated to three functional domains: sensing, communication, and data processing, each of which requires optimization. In the context of communications, in a multihop sensor network a node may play the dual role of data collection and processing and of being a data relay point. As can easily be understood, (excessive) rerouting and/or retransmission will require additional power.

IV.3 Node Unit Costs

Almost by definition, a sensor network consists of a large set of sensor nodes. It follows that the cost of an individual node is critical to the overall financial metric of the sensor network. Clearly, the cost of each sensor node has to be kept low for the global metrics to be acceptable. Current sensor systems based on Bluetooth technology cost about $10; however, Bluetooth is limited as a transmission technology in terms of both bandwidth and distance. However, the cost of a sensor node is generally targeted to be less than $1, which is lower than the current state-of-the-art technology.

IV.4 Environment:

Sensor networks often are expected to operate in an unattended fashion in dispersed and/or remote geographic locations: Nodes may be deployed in harsh, hostile, or widely scattered environments. Such environments give rise to challenging management mechanisms. At the other end of the spectrum, sensor nodes are occasionally deployed densely either in close proximity with or directly inside the environment to be observed.

IV.5 Transmission Channels

Sensor networks often operate in a bandwidth and performance-constrained multihop wireless communications medium. These wireless communications links operate in the radio, infrared, or optical range. Some low-power radio-based sensor devices use a single-channel RF transceiver operating at 916 MHz **[66];** some sensor systems use a Bluetooth-compatible 2.4 GHz transceiver with an integrated frequency synthesizer **[38];** yet other systems use 2.4 GHz (IEEE 802.11b technology), 5.0 GHz (IEEE 802.11a technology), or possibly other bands (for IEEE 802.15.4/IEEE 802.16 and/or for international use). To facilitate global operation of these networks, the transmission channel selected must be available on a worldwide basis.

IV.6 Connectivity and Topology

Deploying and managing a high number of nodes in a relatively bounded environment requires special techniques. Hundreds to thousands of sensors in close proximity (feet) may be deployed in a sensor field. The density of sensors may be as high as 27 nodes/m^3**[38]**.Sensor network applications require ad hoc networking techniques; although many protocols and algorithms have been proposed for traditional wireless ad hoc networks, they are not well suited to the unique features and application requirements of sensor networks **[10,39]**. Nodes could be deployed en mass or be injected in the sensor field individually (e.g., they could be deployed by dropping them from an helicopter, scattered by an artillery shell or rocket, or deployed individually by a human or a robot). Any time after deployment, topology changes may ensue, due to changes in sensor node position; power availability, dropouts, or brownouts; malfunctioning; reachability impairments; jamming; and so on. At some future time, additional sensor nodes may need to be deployed to replace malfunctioning nodes, for example; hence, although some sensor nodes may fail or be blocked due to lack of power or have physical damage or environmental interference, this failure should not affect the overall mission of the sensor network.

IV.7 Standards

As implied by the protocol stack, a suite of protocols and open standards are needed at the physical, link, network, and transport layers; in addition, other management protocols and standards are required (physical layer standards are also known as air interface standards). Historically, sensor networks have used network and application-specific protocols. This has had the effect of slowing cost effective commercial deployment on a wide scale. Standards are now

beginning to be incorporated into sensor networks. The highest degree of standardization has occurred at the lower layers. Within-building WSNs now tend to look to use ZigBee/IEEE802.15.4; WSNs that are in the open (outside buildings and over a broad geography) may find other technologies useful. In particular, IEEE-based wireless LAN standards have been given consideration. IEEE 802.11 supports 1- or 2-Mbps transmission in the 2.4-GHz band using either frequency-hopping spread spectrum or direct-sequence spread spectrum. IEEE 802.11a is an extension of 802.11 that provides up to 54 Mbps in the 5-GHz band and uses orthogonal frequency-division multiplexing encoding. IEEE 802.11b is an extension to 802.11 that provides 11-Mbps transmission in the 2.4-GHz band using DSSS. IEEE 802.11g provides up to 54 Mbps in the 2.4-GHz band. Extensions of these standards were also under way at the time of this writing (e.g., IEEE 802.11n). Another trans-mission method is free-space optics operating in the 1-mm wavelength (infrared). Infrared is license-free line-of-sight technology that operates at short range (300 to 3000 m). The new WiMax standard (IEEE 802.16) may also be useful for metro-Politian environments, as is the application of cellular third-generation technologies. Earlier we also mentioned the Smart Dust mote, which uses the visible optical spectrum to communicate.

V. Conclusion:

In this chapter we introduced the basic concept of WSNs and supportive technologies witch give as an idea about what we should take in concern to make our WSN work fine without any sophistication.

Chapter 2

ENERGY CONSUMPTION AND TEMPERTURE

I. Introduction

A wireless sensor network consists of sensor nodes deployed over a geographical area for monitoring physical phenomena like temperature, humidity, vibrations, seismic events, and so on [42]. Typically, a sensor node is a tiny device that includes three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for local data processing and storage, and a wireless communication subsystem for data transmission. In addition, a power source supplies the energy needed by the device to perform the programmed task. This power source often consists of a battery with a limited energy budget. In addition, it could be impossible or inconvenient to recharge the battery, because nodes may be deployed in a hostile or unpractical environment. On the other hand, the sensor network should have a lifetime long enough to fulfill the application requirements. In many cases a lifetime in the order ofseveral months, or even years, may be required. Therefore, the crucial question is: “how to prolong the network lifetime to such a long time?”[41].

Energy management in WSNs is defined as the set of rules to manage various energy supply mechanisms and then efficient consumption of the provided energy in a sensor node. The overall aim should be to manageenergy in such a way that no node becomes energy deficient and the network is operational perpetually. Itis important for a sensor node to have an efficient energy management scheme for the limited source as wellas the application requirement should be managed in accordance to the available energy source. Energy isconsidered as a scarce resource for a sensor node, specifically when a node is deployed in a remote regionand once it depletes the available energy, it is almost impossible to provide supplant energy [40].

Someone may ask a simple question : we generally use WSN in outdoor missions so do weather condition effect on WSN work specially the heat?. In matter of fact the weather and specially temperature has the biggest effect on WSN work and to be exact in communication quality witch we are going to see in this chapter beside the deployment that we chose to our study and its relation with the health of WSN and its lifetime.

In this chapter we will discuss the consumption and conservation of energy in WSN beside the effect of temperature on WSN and try to find solutions to make our network work fine.

II. NETWORK LIFETIME DEFINITION

The most challenging concern in WSN design is how to savenode energy while maintaining the desirable network behavior.Any WSN can only fulfill its mission as long as it is consideredalive, but not after that. As a consequence, the goal of anyenergy efficient technique is to maximize network lifetime.This latter depends drastically on the lifetime of any singlenode. However, in the literature, there is no consensus for thedefinition of network lifetime. The majority of authors use adefinition suitable for the context of their work. This situationhas driven toward a plethora of coexisting definitions. Basedon the previous works on WSNs [11], [12], we give an overviewof the most common definitions.

III.1 Network lifetime based on the number of alive nodes

The definition found most frequently in the literatureis the time during which all sensors are alive. The sink nodes are excluded from the setof nodes to reflect the assumption that sink nodes aremore sophisticated and powerful devices. This lifetime iseasy to compute since it does not take into account thetopology changes. However, in dense networks whereredundancy is present, this metric does not representactually the lifetime evaluation. Therefore, the only casein which this metric can be reasonably used is if allnodes are of equal of importance and critical to networkapplication.

A variant defines the network lifetime as the time untilthe fraction of alive nodes falls below a predefine threshold β [43]. While this definition takes redundancyinto account unlike the former, it does not accuratelydescribe the correct running of data gathering applications where the failure of at most β % of sensors nearthe sink can prevent the sink to receive collected data.In the context of clustering [44], [45], authors define thenetwork lifetime as the time to failure of the first clusterhead. However, in most works, researchers change cluster head dynamically to balance energy consumption.

III.2 Network lifetime based on coverage

Coverage reflects how well the network can detect anevent in the monitored area. Therefore some worksdefine the lifetime as the time during which the areaof interest is covered by sensor nodes. However, evenan 100% coverage is not sufficient because it does notensure that collected data are delivered to the sink.

III.3 Network lifetime based on connectivity

This definition is based on the ability of the networkto transmit data to a sink. This definition is similar towhat has been proposed in context of ad hoc networks.In [46] authors define the lifetime as the minimum timewhen either the percentage of alive nodes or the size ofthe largest connected component of the network dropsbelow a specific threshold.

III.4 Network lifetime based on application requirements

Some authors consider that network is alive as long asapplication functionalities are ensured. Kumar et al. [47]state ”we define the lifetime of a WSN to be the timeperiod during which the network continually satisfies theapplication requirements”. Tian and Georganas [43] suggest another definition: It is the time until ”the networkno longer provides an acceptable event detection ratio.”However, if no connectivity is guaranteed to report theevent, this definition becomes irrelevant.As a conclusion, network lifetime must take into accountconnectivity and coverage if needed by the application sup-ported by WSN. Knowledge of the application requirementswill enable WSN designers to refine the definition of networklifetime, leading to an evaluation more realistic and morepertinent for the application users[48].

III. WSN node Power Consumption

The following table shows the power consumption by the various components of the WSN Node[49]. Full operation of the sensor requires an average of ~ 15ma of current. AA batteries are about 1800 mA, which means they would last about 120 hours or 5 days. Lithium batteries may also be used, but they are more expensive and decay more rapidly than AA batteries.

Currents		Value (units)
Microprocessor	Current(full operation) Current sleep	6mA 8µA
Radio	Current in receive Current transmit Current sleep	8mA 12mA 2µA
Flash serial memory	write Read Sleep	15mA 4mA 2µA
Sensor board	Current (full operation)	5mA

Table 2.WSN Node System Specifications.

IV. Problems and Energy Issues in Wireless Sensor Networks

As mentioned before, reducing energy consumption on individual sensors (or justnodes, henceforth we use sensors and nodes interchangeably) in the network and obtaining the expected standard of quality in the solutions provided by such networks isa major challenge. In this thesis, we address a number of problems arising from various applications of WSNs with a view to finding efficient polynomial-time solutionswhile emphasizing the energy minimization issue of such networks. The problemsconsidered fall in the broad categories of broadcasting, clustering, monitoring, andtopology control of WSNs.

We mainly focus on devising distributed (and local) algorithms for these problems,where individual nodes execute algorithms on their own to compute solutions to aproblem of a global nature. A distributed algorithm is one where nodes individuallyexecute the same algorithm and make decisions accordingly without knowing theglobal topology of the network. However, in some distributed algorithms, it is allowedthat nodes may know a little global information (e.g., the number of sensors in thenetwork and/or the maximum degree of the underlying graph). A more strict versionof the distributed algorithm is known as the local algorithm. Informally , in a localalgorithm, a node is allowed to communicate only with its neighbors, which are atmost a constant hop away from it, to make decisions during the execution of the algorithm (more about local algorithms is described later in this chapter).

Unlike centralized systems, the distributed and local approaches relieve sensorsfrom sending their information (e.g., ids, geographic positions, neighborhood information, covered areas, and so on) to a central base station which runs the algorithmand returns the results to the sensors. Sending information to a base station is energy-consuming and generally not scalable. However, we consider the following problems in the thesis:[10]

V.1 Broadcasting Issues

Broadcasting is an operation by which a message, generated by a node in the network,is forwarded to all other nodes in the network. Following a simple flooding approach to do this is inefficient. This is because a lot of unnecessary message transmissions (or just transmissions) are generated and relayed in the network, which in turn,causes nodes to dissipate their valuable energy quickly. Thus we need to devise energy efficient algorithms that can avoid or at least reduce the amount of redundanttransmissions.

V.2 Virtual backbone

Establishing a virtual backbone in WSNs, which can be seen as an analogue of the fixed communication infrastructure in wired networks, helps reduce the number ofretransmissions of the energy-constrained sensors. In a virtual backbone, only a\small" number of nodes in the network are engaged in transmissions. Basically ,avirtual backbone consists of a subset of nodes in the network which are responsible forrelaying messages throughout the network. The connected dominating set (CDS) isone of the earliest and most popular structures proposed as a candidate for a virtualbackbone in wireless networks [50]. Since the work of Das et. al. [50], an extensive research effort has been put in to finding small-sized CDSs in WSNs. The smaller the size of a CDS, the fewer the number of transmissions in the network.

V.3 Family of Connected Dominating Sets

We make an important observation regarding finding small-sized or even optimalCDSs in WSNs. Although the general focus of research for broadcasting algorithmsis to obtain small cardinality CDSs, generating a single CDS (even if it is optimal)and using it all the time causes the nodes in the CDS to run out their energy fasterthan other nodes (which are not in the CDS). This is because the nodes in the CDSare responsible for forwarding messages in the network on

behalf of other nodes,whenever any node in the network has some messages to broadcast. Considering this important aspect, we study the problem of computing a family of CDSs in adistributed manner such that only one CDS is active for a certain period of time andother nodes can be put in the energy-efficient sleep mode.

Thus, using the CDSs iteratively , we can expect to substantially reduce the energyconsumption of the individual nodes by repeatedly switching them back and forthfrom the active to the sleep mode and make the lifetime of the network longer. Bythe lifetime of a WSN, we mean the elapsed time between the deployment of the sensors and the time when the first sensor runs out of energy.

V.4 Clustering

Clustering is a heavily studied topic [51,4,52,53,54,55,56] in the WSNs community ,where the goal is to divide the whole network in a number of clusters (not necessarilydisjoint) and select a node as a cluster head (CH) from each of the clusters. Eachsuch CH is supposed to be active and do all the coordination works, e.g., sensing,data gathering, and transmitting data on behalf of the cluster to the base station,while the remaining nodes in the cluster can go in to the sleep mode. One of the basicproblems in clustering is to minimize the number of CHs under the condition that forany node in the network either it is a CH or directly connected to at least one CH. This would leave most of sensors in the energy-efficient sleep mode. This problem isalso known as the minimum dominating set problem.

However, as the set of CHs (even the minimum set of CHs) is busy all the timefor sensing, processing, and transmitting data, they quickly run out of energy , whileother nodes (which are not CHs) are left with considerable amount of energy . Thiscauses a significant imbalance in the energy reserve in the nodes and reduces thenetwork lifetime. One possible way to overcome this situation is

to find a family ofdisjoint sets of CHs and make them active iteratively such that energy consumptionis balanced among the nodes in the network.

V.5 Disjoint Dominating Sets

In the context of WSNs (considering the above circumstance), we address the following problem: Given a WSN, find the maximum number of disjoint dominating sets".A dominating set of a graph is a subset of nodes such any node in the graph eitheris in the subset or a neighbor of some node in the subset. Finding the maximumnumber of disjoint dominating sets in a graph is also known as the Domatic Partition problem. Although the domatic partition problem is NP-hard in general graphs, itis unknown whether the same is true for unit disk graphs.

V.6 Target Monitoring

Monitoring (also called cover age) is one of the important and extensively studiedtopics in sensor networks [57,58,59,60,61,62,63]. In general, the main goal ofresearch in this line is to devise scheduling algorithms such that individual sensors inthe network are assigned time-slots which indicate to them during which time-slotsthey will be active and during which time slots they will sleep. Given a WSN whichmonitors certain targets, it is sometimes possible to find only a subset of the sensorsand engage them to do the same monitoring activity . Thus, instead of making allnodes active for this purpose (which is obviously redundant), we can choose possiblya small subset which can guarantee the same monitoring. This observation leadsresearchers to devise efficient algorithms such that at any time only a small numberof nodes are made active to monitor all the targets in question.

V.7 Self-Protecting WSNs

We study an interesting problem which deals with providing sensors with a level ofprotection by other sensors. Since sensors provide monitoring to targets, it is often necessary to give them a level of protection (by other sensors) such that sensors cantake certain actions when attacks are targeted on them. One natural idea is to monitorsensors by their neighbors such that the neighbors can inform the base station whenother sensors are in danger (or not working due to malfunction). We elaborate on this in the following.Sometimes it may be required to know whether every sensor in the network is ingood health to render its tasks. Since a b ad sensor, i.e., a malfunctioning or dyingout sensor cannot inform the base station of its condition, the targets monitored bythe bad sensor become unprotected and the system has no way to know about thisvulnerability . In that case, we need to find a subset of sensors whose function isto monitor other sensors, such that when any sensor (including themselves) fails orcannot function properly these sensors will notify the base station of the situation.

The base station then takes appropriate actions, such as, deploying additional nodesin replacement of the non-functioning ones to provide continuous protection to thetargets.Keeping this in mind, the p-self-protection subset problem has been formally introduced in [65]. The p-self-protection subset problem is defined to be a subset ofnodes such that for any node in the network there are at least p nodes from the subsetthat monitor it. Chapter 7 studies the problem of p-self-protection . Thatchapter begins by giving a counterexample to the algorithm [64], and then provides afast and distributed algorithm to approximately solve the p-self-protection problem.

V.8 Topology Control Problems

Topology control is one of the pivotal problems which has received a lot of attentiondue to its numerous applications in WSNs such as coverage, connectivity, and routing[66,67,68,69,70,71,72,73,74,75,76,77,78,79]. The main idea is to obtain aSubgraph from the underlying network by removing some (possibly redundant) linksin order to enhance the overall performance of the network in some ways.

Topology control algorithms, in general, deal with finding a suitable structure of the given graph. This resulting graph is expected to have certain features (e.g., connectedness, planarity, sparseness, bounded-degree, and spanner property, etc.) which mainly facilitate routing and other decisions in the network.Finding a topology with the above features has certain advantages. First, a number of routing algorithms including the well-known GPSR routing algorithm [80] canonly be applied if and only if the network topology is planar. Second, by eliminating anumber of links, we can substantially reduce the burden of the nodes by letting themkeep only a subset (possibly small) of their neighbors. The smaller the neighborhood,the faster the information processing of a node. Having a few neighbors also causesa small number of transmissions and helps prolong the lifetime of the network bylimiting the number of retransmissions. Topology algorithms tend to remove longerlinks in the network and keep smaller ones since long links consume more power thanshorter links for transmission (recall that the power spent on a link for a transmissionis directly proportional to at least the square of the length of that link). This savesenergy in the long run for routing and thus helps extend the network's lifetime.

V. Classification of energy efficient techniques

We can identify five main classes of energy efficient techniques, namely, data reduction, protocol overhead reduction,energy efficient routing, duty cycling and topology control [48].

VI.1 Duty cycling

Is mainly focused on the networking subsystem. Themost effective energy-conserving operation is putting the radio transceiver in the (low-power) sleep modewhenever communication is not required. Ideally, the radio should be switched off as soon as there is no more data to send/receive, and should be resumed as soon as a new data packet becomes ready. In this way nodes alternate between active and sleep periods depending on network activity. This behavior is usually referred to as duty cycling, and duty cycleis defined as the fraction of time nodes are active during their lifetime. As sensor nodes perform a cooperative task, they need to coordinate their sleep/wakeup times. A sleep/wakeup scheduling algorithmthus accompanies any duty cycling scheme. It is typically a distributed algorithm based on which sensor nodes decide when to transition from active to sleep, and back. It allows neighboring nodes to be active at the same time, thus making packet exchange feasible even when nodes operate with a low duty cycle (i.e., they sleep for most of the time). Duty-cycling schemes are typically oblivious to data that are sampled by sensor nodes.

VI.2 **data-driven approaches**

can be used to improve the energy efficiency even more. In fact, data sensing impacts on sensor nodes energy consumption in two ways:

• Unneeded samples. Sampled data generally has strong spatial and/or temporal correlation [81], so there is no need to communicate the redundant information to the sink.

• Power consumption of the sensing subsystem. Reducing communication is not enough when the sensor itself is power hungry.

In the first case unneeded samples result in useless energy consumption, even if the cost of sampling is negligible, because they result in unneeded communications. The second issue arises whenever the consumption of the sensing subsystem is not negligible. Data driven techniques presented in thefollowing are designed to reduce the amount of sampled data by keeping the sensing accuracy within an acceptable level forthe application.

In case some of the sensor nodes are mobile, **mobility**can finally be used as a tool for reducing energy consumption (beyond duty cycling and data-driven techniques). In a static sensor network packets coming from sensor nodes follow a multihop path towards the sink(s). Thus, a few paths can be more loaded than others, and nodes closerto the sink have to relay more packets so that they are more subject topremature energy depletion (funneling effect) [20]. If some of the nodes (including, possibly, the sink) are mobile, the traffic flow can be altered if mobile devices are responsible for data collectiondirectly from static nodes. Ordinary nodes wait forthe passage of the mobile device and route messages towards it, so that the communications take place in proximity (directly or at most with a limited multi-hop traversal). As a consequence, ordinary nodes can save energy because path length,contention and forwarding

overheads are reduced aswell. In addition, the mobile device can visit the network in order tospread more uniformly the energy consumption due to communications. When the cost of mobilizing sensor nodes is prohibitive, the usual approach is to “attach” sensor nodes to entities that will be roaming in the sensing field anyway, such as buses or animals.

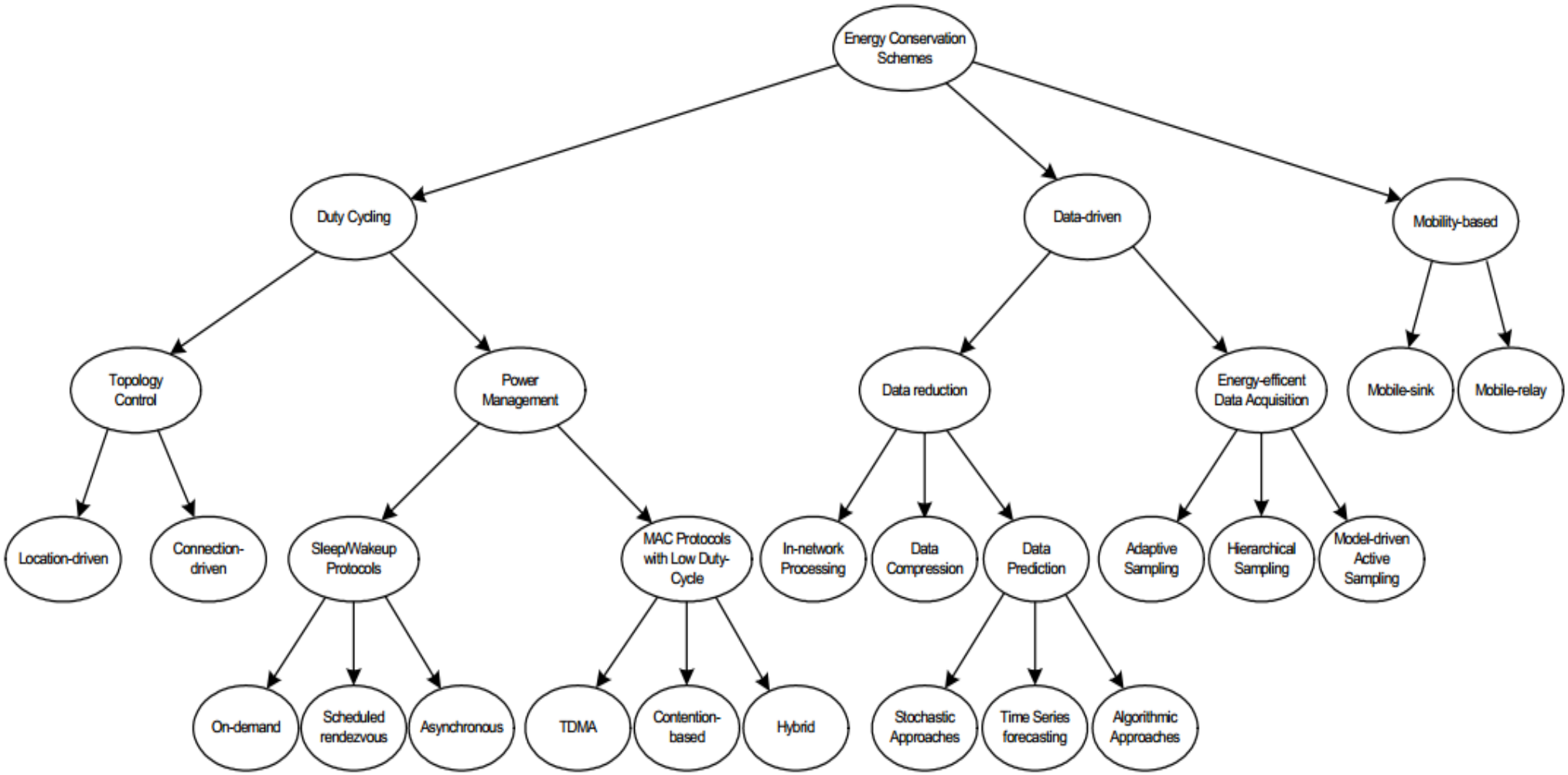


Figure 10: Taxonomy of approaches to energy savings insensor networks.

VI. Influence of Temperature on Communication

In the following, we present [82] experimental results from investigating theInfluence of temperature on the communication quality between sensor nodes.

VII.1 Experimental Setup

For the experiments, TelosB sensor nodes from different manufacturersas well as production runs and ages were used. The TelosB is a widely-used platform thatemploys a CC2420 radio chip for communication which implements the IEEE802.15.4 standard. At the physical layer, the standard defines a DSSS OQPSKmodulation in the 2:4GHz ISM band, with a nominal data rate of 250kbps. Allexperiments were conducted in a room that witnesses little interference fromsurrounding IEEE 802.11 (WiFi) networks; furthermore, they used channel 26 ofthe 802.15.4 standard, which is outside the band allocated to 802.11 in Europe.

For temperature control during the experiments, they designed a system termed “HotBox”. Its design stems from the need to accurately control theinfluence of temperature on sensor motes. One of goals with HotBox wasto design a highly accurate control system (less than 0:5 °C deviation) whichcan be produced relatively quickly and cheaply. Thus, all hardware elements areoff-the-shelf items, while all manufacturing can be done with a soldering iron, aPCB mill, and a laser cutter, which are often available via the rapidly-spreadingFabLab concept.

Experiments used direct (single-hop) connections between links. Each experiment comprised two boxes with one node each. Both nodes were connectedto a PC via USB; the PC created the packets and sent them via USB to onenode (alternating the sender role between the two nodes every packet); the nodewould then send the packet via the CC2420 radio. If the other node received thepacket, it forwarded the received version to the PC via USB, which then compared the original and the received version for bit errors. Otherwise, a timeoutwould be triggered at the PC to identify the missed reception. Each run comprised 180 000 packets, spread out over approximately 3:5hours, during whichwe gradually increased the temperature in one of the boxes from 30°C to 80°C,while keeping the other at 30°C. We exchanged the nodes between experimentalruns to account for potential performance differences between

production runsand different models of the TelosB nodes. However, for the metrics presented inthis paper, we could not find any noticeable performance differences.

VII.2 Packet Error Dependency on Temperature

First, The experiment started with a temperature of 30°C and gradually increased the temperaturein 5 or 10°C increments, spending 20 minutes at each target temperature. Results for each node were saved separately, thereby creating two separate datasetsfrom heating the transmitter and from heating the receiver, respectively. the RSSI was recorded, the Link Quality Indicator (LQI), and bit error rate (BER)as well as packet reception rate (PRR). The experimenters split the latter into three cases: apacket could be received without errors; received, but with errors; or not receivedat all (completely lost). Figure 11 shows a typical result from one of our experiments. All presented results are values as witnessed by the receiving mote. Thus, the temperature shown in Figure 11b shows temperature changes throughout theexperiment. Conversely, Figure 11a does not show any changes in the temperature, because it was the transmitter which was heated, while the receiver, whosevalues are shown, was kept at a constant temperature.Overall, it can be seen that all metrics are negatively influenced by temperature. However, the amount as to which they are influenced differs, and heating the transmitter and the receiver has different magnitudes of effect for mostmetrics. The only metric that is largely independent of this fact is the RSSI. Allother metrics show a much higher negative influence when the receiver is heated.

Heating the transmitter to 80°C still allows communication, albeit with a packeterror rate of more than 20%. In contrast, communication completely breaks ifthat temperature is applied at the receiver's side, and even at 70°C, PER is muchhigher at above 50%. This is reflected in the BER, which explodes at receivertemperature above 70°C. At the same time, LQI significantly decreases.

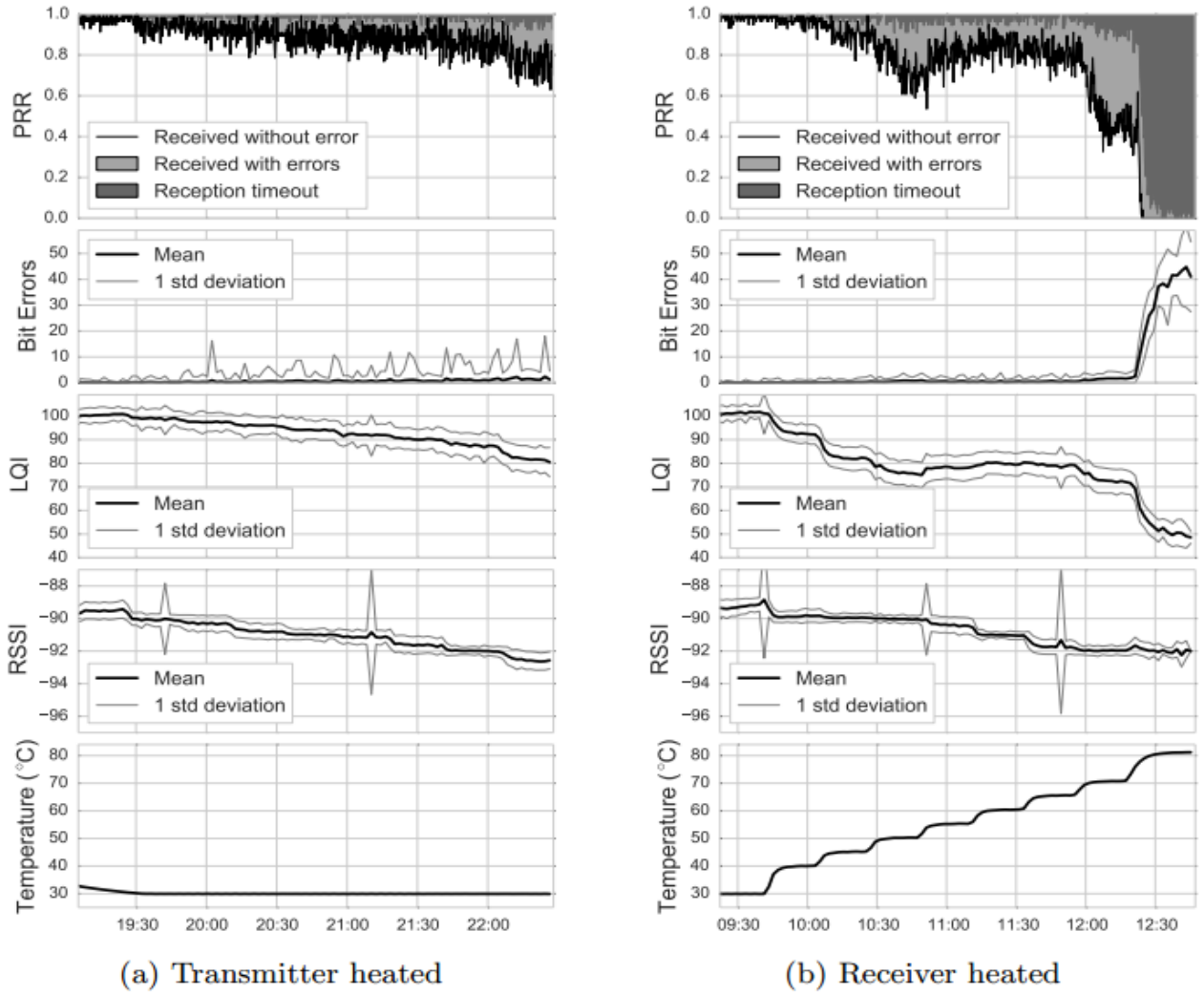


Figure11: Influence of temperature on several key communication metrics.

VII. Conclusions

As we saw there are many things that should be considering in building a WSN especially in energy part, even in energy there are many methods and technics each one has two faces positive and negative. so to build healthy WSN we should be careful in selection.

Chapter 3

Deployment issues in Wireless sensor network

I. Introduction:

The correct operation of the network should be preserved constantly independently of changing conditions. Therefore, a good deployment should take into account the worst case conditions in which the network is also required to continue operating correctly. However, the worst case conditions may only happen in a limited number of occasions from time to time. In the rest of the time, the conditions are more favorable and the network needs to adapt its operating mode to save more energy and resources. The detection of these situations needs to use small resources and be effective so that the advantages of adaptation are not surpassed by its overhead.

II. The objective

Before mention any thing about strategies or technics we should defined our purpose or goals that we trying to rich and for that the main objective for this project is to create WSN minimize the effect of temperature to its minimum without effect the WSN ordinary objectives (sensing and detecting activities).

In this project we will try to create topology work on temperature as an important factor beside make it work for the longest possible time.

and for the temperature part we will make the nodes move and change their positions based on calculations doing by each node to ovoid temperature effect especially on communication rang.

As for the energy part we will create channels between nodes based on Delaunay triangulation by creating a list of neighbors addresses to each node to minimize communications between them besides using stop operating technic to save energy all this will discuss in this chapter.

III. COVERAGE STRATEGIES

This section reviews the strategies used in solving coverage problem in WSN. The strategies are divided into three categories as under [83]

- Force Based
- Grid Based
- Computational Geometry Based.

III.1 Force Based

Force based deployment strategies rely on the sensors mobility, using virtual repulsive and attractive force, the sensors are force to move away or towards each other so that full coverage is achieved. The sensors will keep moving until equilibrium state is achieved [84] where repulsive and attractive forces are equal thus they end up canceling each other. In the sensors and objects in the ROI exert virtual repulsive force that pushes sensors away from the objects and also from each other so that their sensing areas are not overlapping. The sensors will keep moving until static equilibrium state is reached. The static equilibrium state is reached based on the fact that the total energy is reduced with time. However this strategy did not consider the network's connectivity. Thus it was further extends to consider network connectivity, node degree (number of neighbors each sensor can communicate with) is used to provide attractive force so that full connectivity is maintained. The advantages of potential field method are, it does not need any prior information of the localization of nodes, and it is scalable deployment strategy. And disadvantage is it extremely depends on mobility, which is a high power consumption task.

III.2 Grid Based

Grid based deployment strategies used to determine sensors positions. Grid based is the sampling method in which coverage is estimated as ratio of grid pointscovered to total number of grid points in the ROI. There are three types of grids commonly used in networking[85];

- Triangular Lattice
- Square Grid
- Hexagonal Grid

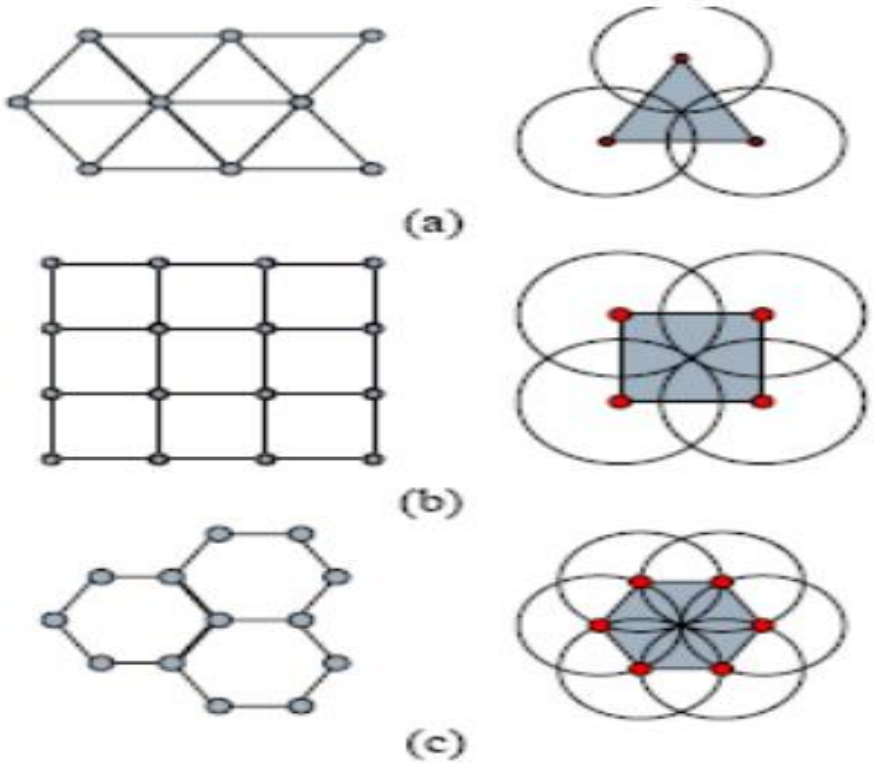


Figure 12: Types of grids (a) Triangular lattice (b)Square grid (c) Hexagonal grid

Triangular lattice is the best among the three kinds of grids as it has the smallest overlapping area hencethis grid requires the least number of sensors. Triangular Lattice is shown in figure 12(a). Square grid is shown in figure 12(b). Square grid provides fairly good performance for any parameters. Hexagonal grid is the worst among all since it has the biggest overlapping area, shown infigure 12(c).

III.3 Computational Geometry Based:

Computational geometry is frequently used in WSN coverage optimization [86], the most commonly used computational geometry approach are:

A. Voronoi diagram.

B. Delaunay triangulation.

III.3.1Voronoi Diagram

Voronoi Diagram [86] is used as one of the sampling method in determining WSN Coverage. Voronoi Diagramis partition of site in form of Polygon. If all polygon vertices are covered then the ROI is fully covered otherwise coverage holes exits. Figure 13 shows voronoi diagram.

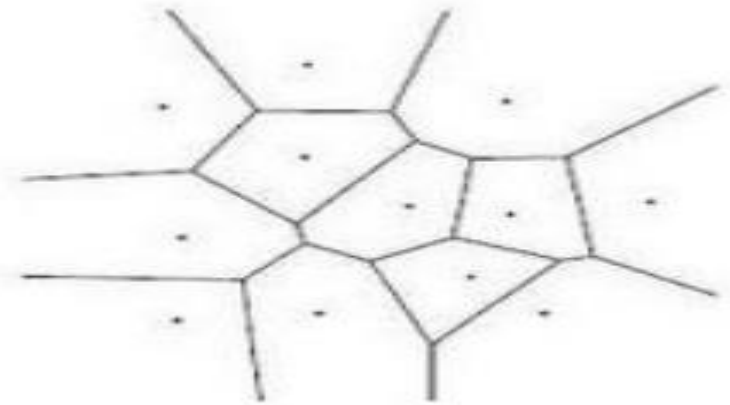


Figure 13.Voronoi Diagram

III.3.2Delaunay triangulation

The Delaunay triangulation is a geometric structure that engineers have used for meshessince mesh generation was in its infancy. In two dimensions, it has a striking advantage:among all possible triangulations of a fixed set of points, the Delaunay triangulation maximizes the minimum angle. It also optimizes several other geometric criteria related tointerpolation accuracy. If it is our goal to create a triangulation without small angles, itseems almost silly to consider atriangulation that is not Delaunay. Delaunay triangulationshave been studied thoroughly, and excellent algorithms are available for constructing andupdating them.

IV. Delaunay triangulation principle:

In the context of a finite point setS,a triangle isDelaunayif its vertices are in S and its open circle disk isempty'i.e.contains nopoint inS.Note that any number of points inS can lie on a Delaunay triangles circle disk. Anedge isDelaunayif its vertices are in Sand it has at least one empty open circle disk. ADelaunay triangulationofS,denoted DelS,is a triangulation ofSin which every triangleis Delaunay, as illustrated in Figure 10.Onemightwonder whether everypoint sethasaDelaunaytriangulation, andhowmanyDelaunay triangulations a point set can have. The answer to the first question is yes every point have at least one

Delaunay triangle. And the second answer is the number of the triangles that can one point participate in is depend on the point position.

The Delaunay triangulation of S is unique if and only if no four points in S lie on a common empty circle. Otherwise, there are Delaunay trianglesand edges whose interiors intersect, illustrated in Figure 15(a). Most applications omitsome of these triangles and edges so that the survivors form a simplicials complex, as in Figure 15(b). Depending on which Delaunay simples one keeps and which one discards, one obtains different Delaunay triangulations.

It is sometimes useful to unite the intersecting triangles into a single polygon, depictedin Figure 15(c). The Delaunay subdivisionobtained this way is a polyhedral complex, rather than a simplifies complex. It has the advantage of being the geometric dual of the famous Voronoidiagram, discussed above.

Clearly, a simplex's being Delaunay does not guarantee that it is in every Delaunay triangulation of a point set. But a slightly stronger property does provide thatguarantee.

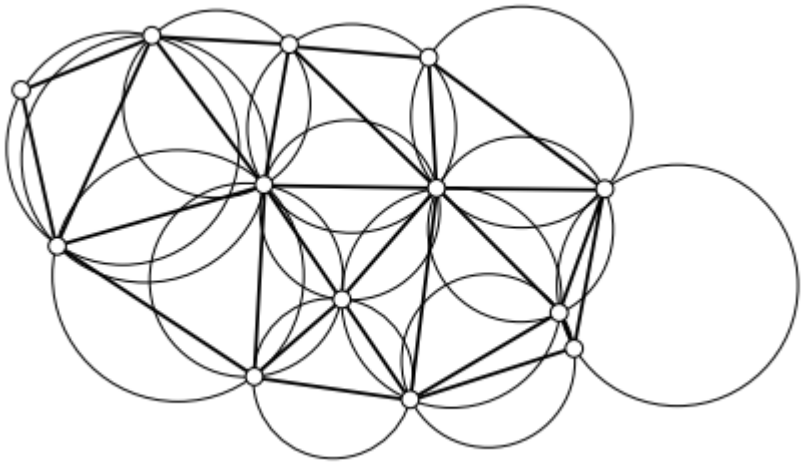


Figure 14: Every triangle in a Delaunay triangulation has an empty open circle disk.

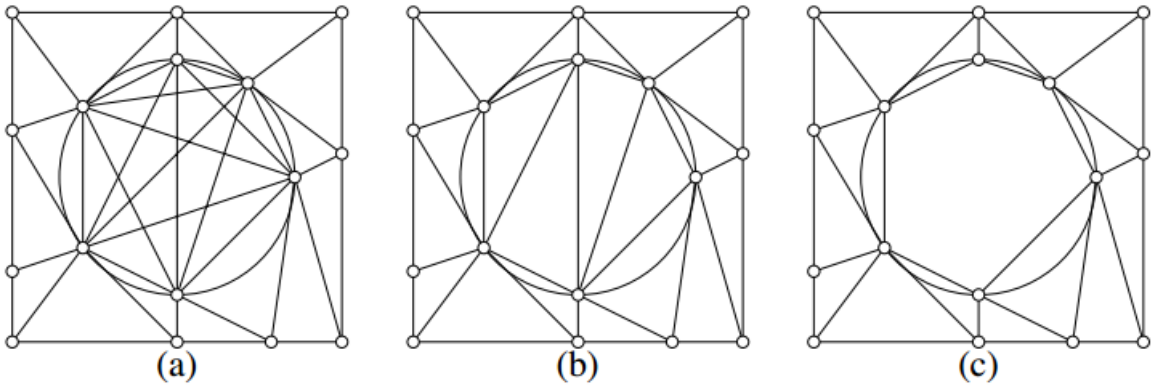


Figure15:waysto define a Delaunay structure

As we see in figure 15 there are Threewaysto defineaDelaunaystructure inthepresence ofco-circular vertices.(a) Include all the Delaunay possibleFormations. (b) Choose a subset of Delaunay Formationsthatconstitutes a triangulation. (c) Exclude all crossing Delaunay edges, and fuse overlappingDelaunay triangles into Delaunay polygons.

V. WSN deployment:

For the deployment we chose triangle deployment because its more reasonable in many ways from square and Hexagonal deployment from logical point the common sensing spaces in triangulation deployment is much less from others as we going to see in figure 16 witch make the cost less because triangulation deployment consume the least number of nodes to cover the same area as other deployments.

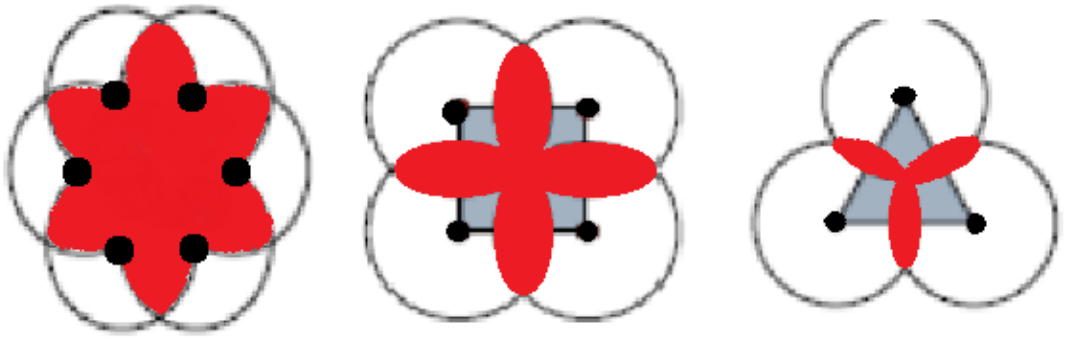


Figure 16.common spaces between nodes

VI. SYSTEM MODEL

VI.1 Wireless Links

The quality of wireless communication link betweentwo nodes, a transmitter and a receiver, is usually ex-pressed by the experienced PER (Packet Error Rate). ThePER mainly depends on the signal strength measured atthe receiver. The minimum signal strength measured atthe receiver required to achieve a PER of less than 1% iscalled sensitivity.

We assume that a link exists if the received power PrPt and Pr (d) are expressed in dBm, the attenuation indB is:

$$\mathcal{A}(d) = P_t - P_r(d) \tag{1}$$

A commonly used model for the attenuation is the log-normal path loss model [10], where the attenuation hasthree components: A0, A1(d) and A2 such that:

$$\mathcal{A}(d) = \mathcal{A}_0 + \mathcal{A}_1(d) + \mathcal{A}_2 \tag{2}$$

where A0is the path loss at reference distance d0, which can be obtained by experimentation, or according to the free space propagation model, A1(d) is the log-distance path loss in function of distance d and reference distanced0, and A2 is a random variable reflecting the attenuation caused by fading. All A0, A1, and A2 are expressed in dB. By taking A0 according to the free space propagationmodel, we obtain:

$$\begin{cases} \mathcal{A}_0 = 20\log d_0 + 20\log f - 27.55 \\ \mathcal{A}_1(d) = \alpha 10\log(d/d_0) \\ \mathcal{A}_2 \sim \mathcal{N}(0,\sigma) \end{cases} \tag{3}$$

Where f is the frequency (in MHz), is the path lossexponent, and N (0;) is a normal random variable (indB). We set the reference distance d0 to be equal to 1m.

VI.2 Communication Range

We define the communication range as the distance atwhich less than 1% of packets are lost (i.e. correspondingto less than 1% of PER). The communication range isa random variable R with the cumulative distributionfunction FR(d) defined as:

$$\begin{aligned} F_{\mathcal{R}}(d) &= \Pr[\mathcal{R} \geq d] = \Pr[P_r(d) \geq P_s] \\ &= \Pr[P_t - P_r(d) \leq P_t - P_s] \\ &= \Pr[\mathcal{A}(d) \leq P_t - P_s] \end{aligned} \quad (4)$$

By replacing A(d) by its value from (2), we obtain:

$$F_{\mathcal{R}}(d) = \Pr[\mathcal{A}_2 \leq P_t - P_s - \mathcal{A}_0 - \mathcal{A}_1(d)] \quad (5)$$

As A2 is a normal random variable, we have:

$$\Pr[\mathcal{A}_2 \leq P_t - P_s - \mathcal{A}_0 - \mathcal{A}_1(d)] = F_{\mathcal{A}_2}(P_t - P_s - \mathcal{A}_0 - \mathcal{A}_1(d)) \quad (6)$$

Where FA2is the CDF of the random variable A2.As A2 ~N (0; δ), we have:

$$F_{\mathcal{A}_2}(P_t - P_s - \mathcal{A}_0 - \mathcal{A}_1(d)) = \frac{1}{2} + \frac{1}{2}\text{erf}\left(\frac{P_t - P_s - \mathcal{A}_0 - \mathcal{A}_1(d)}{\sigma\sqrt{2}}\right) \quad (7)$$

Where erf is the error function defined as:

$$\text{erf}(z) = \frac{2}{\sqrt{\pi}} \int_0^z e^{-t^2} dt \quad (8)$$

By combining (5), (6) and (7), we get:

$$F_{\mathcal{R}}(d) = \frac{1}{2} + \frac{1}{2}\text{erf}\left(\frac{P_t - P_s - \mathcal{A}_0 - \mathcal{A}_1(d)}{\sigma\sqrt{2}}\right) \quad (9)$$

Note that (7) and (9) are only valid when δ±0.when δ=0, A2becomes equal to 0. Therefore, the expressionof FR(d) should be calculated from (5). Thus, we have:

$$F_{\mathcal{R}}(d)_{\sigma=0} = \Pr[0 \leq P_t - P_s - \mathcal{A}_0 - \mathcal{A}_1(d)] \quad (10)$$

$$= \Pr[\mathcal{A}_1(d) \leq P_t - P_s - \mathcal{A}_0] \quad (11)$$

By replacing A1(d) with its value from (3) and takingd0=1 ,(11) becomes:

$$F_{\mathcal{R}}(d)_{\sigma=0} = \Pr[10\alpha \log d \leq P_t - P_s - \mathcal{A}_0] \quad (12)$$

$$= \Pr[d \leq 10^{(P_t - P_s - \mathcal{A}_0)/(10\alpha)}] \quad (13)$$

$$= \begin{cases} 1 & \text{if } d \leq 10^{(P_t - P_s - \mathcal{A}_0)/(10\alpha)}, \\ 0 & \text{elsewhere.} \end{cases} \quad (14)$$

By putting :

$$R = 10^{(P_t - P_s - \mathcal{A}_0)/(10\alpha)} \quad (15)$$

And combining (9) with (14), we obtain:

$$F_{\mathcal{R}}(d) = \begin{cases} \frac{1}{2} + \frac{1}{2}\text{erf}\left(\frac{P_t - P_s - \mathcal{A}_0 - \mathcal{A}_1(d)}{\sigma\sqrt{2}}\right) \\ 1_{(-\infty,R]}(d) \end{cases}$$

Where$1_{(-\infty,R]}$(d) is the indicator function, which is equalto 1 when d≤ R and to 0 elsewhere. Note that Rrepresents the communication range in the absence of shadowing fading (i.e. when δ=0).

VII. Effect of temperature on communication power:

As we prove Previously that the temperature effect on communication now we defined mathematically that effect by calculating Ps and Pt on temperature function, The following equations were obtained by interpolation of degree equal to 2[87]:

$$P_t(T) = -0,0001.T^2 - 0,0676.T + 1,6112 \quad (dBm)$$
$$P_s(T) = 0,0005.T^2 + 0,0407.T - 89,547 \quad (dBm)$$

VIII. Functions and algorithms

VIII.1 Node position:

In sensing field each node has two components X and Y (and Z for three dimensional field) as its shown in figure 16 and for regular deployment each node have to calculate its position and because we are using triangle deployment we need algorithms witch include math calculation as we going to see in algorithm 1

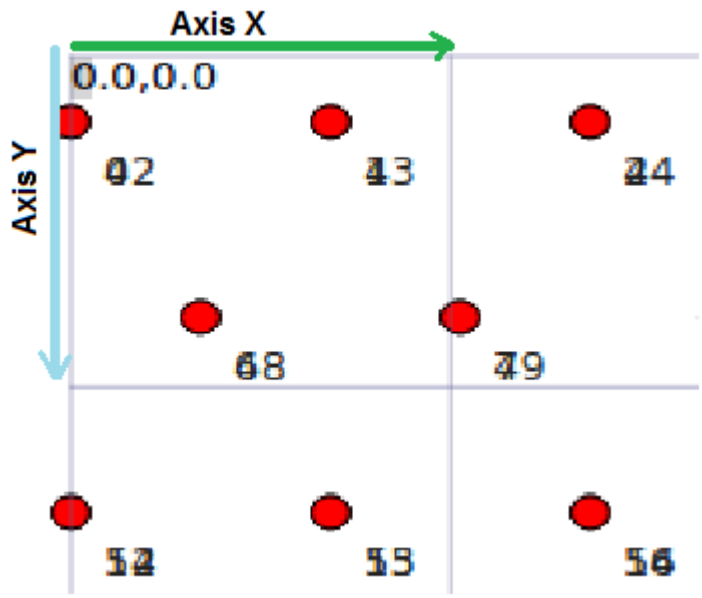


Figure 16.field axis

algorithm 1: triangle deployment

```
int CreateNodes(NodeContainer c,Ptr<ListPositionAllocator> positionAlloc, double R, double AreaWidth,double AreaLength){
    int nbrNode=0; bool Coverage=false;
    double x0=0,y0=R/2 ;
    int k=1;
       while (!Coverage){
           while(y0<= AreaLength){
                while(x0<= AreaWidth){
                    positionAlloc->Add (Vector (x0, y0, 0.0)); //save the coordinations in table of vectors
                    nbrNode++;
                    x0= x0 + sqrt(3)*R;  //add √3*r to x to set next node
                }
              y0=y0+3*R/2;// add 3*r/2 to y to move to the next level in Y axis
              k=k+1;          //the role of k is to make x move alternatively fome one level to another
              if(k %2==0){
                  x0=sqrt(3)*R/2;  // in the new level x start from √3*r/2 if k is a double
              }else{
                   x0=0.0;   // in the new level x start from 0 if k is individual
                 }
           }
           Coverage = true;
         }
  return nbrNode;
}
```

This algorithm is NP hard

The distance between each two nodes is defined as :

$$d(N1,N2)= \sqrt{(N1.X - N2.X)^2 + (N1.Y - N2.Y)^2}$$

To insure both connectivity and sensitivity we defined the default distance between two suit nodes by √3*r were r is the sensing rang.

VIII.2Movement coefficient:

The movement coefficient is math function based on calculating the result of dividing node position on communication rang to decide how much the node will move:

$$Node.CoefX= \frac{node.X}{R}$$

$$Node.CoefY= \frac{node.Y}{R}$$

VIII.3 Stop-Operate algorithm:

Stop-Operate (OS) is algorithm use to make sure that the least number of needed sensor is work by making sensors move in the sensing field , to make that simple we will explain it in few steps:

1/ calculate the new temperature T.

2/calculate the communication rang R by function of the new T.

3/based on new R the sensors will move to new positions (expend/Shrink) or by other said we will reset all sensor position based on new R

4/ the sensors that in borders without position will shut the radio off to save energy until the next temperature change.

In the figure 17 we have both active (red) and inactive sensor(green)

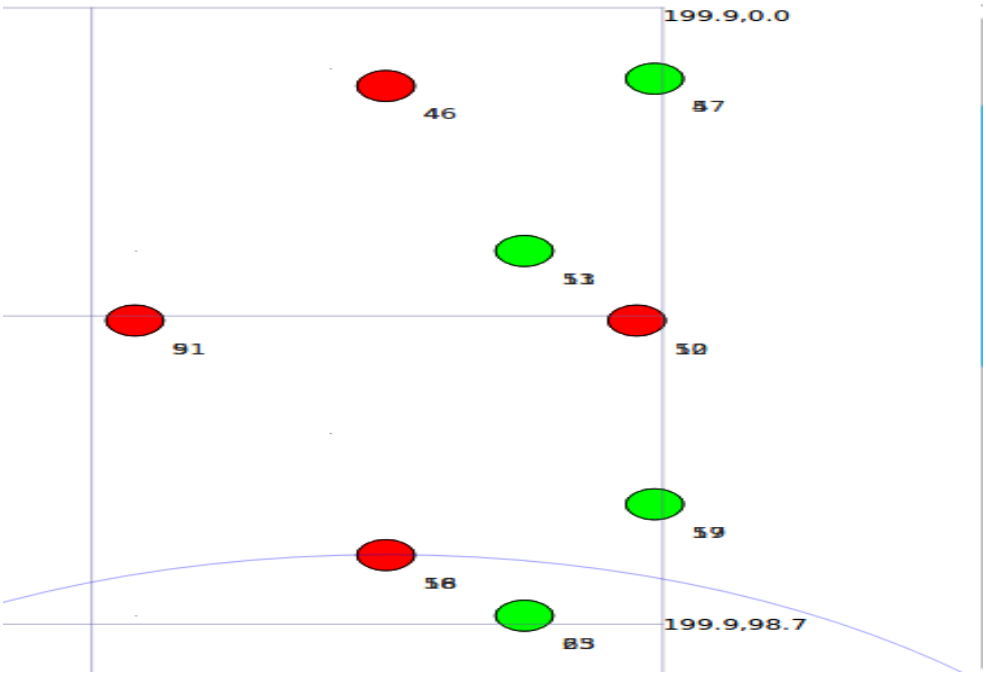


Figure 17.active and inactive nodes

The 3rd algorithm is showing how stop operate work:

Algorithm 3 : StopOperate (excut by each node)

Data: Temperature ,AreaWidth , AreaLength

```
// calculate the new communication range
NewR ← CommunicationRange(Temperature) ;
// calculate the defrence between old and new rang
DiffR ← NewR − OldeR ;
// getting the new position of each node
Node.GetPosition() ;
X ← Node.X + Node.CoefX × DiffR ;
Y ← Node.Y + Node.CoefY × DiffR ;
if X ≤ AreaWidth And Y ≤ AreaLength then
    // after make new positions if the new position still in the sensing
    area the node will continue working
    Node.SetPosition(X, Y) ;
else
    // if new position out of sensing area the radio will close off
    Node.SetRadio(off) ;
end
```

This algorithm is NP hard.

VIII.4 Delaunay algorithm:

We explain earlier the main principle of Delaunay triangulation but to make it work that's the challenge to make it possible we follow the next steps:

1/ take each possible three nodes

2/ calculate the center of the circle witch contain the three nodes

3/ calculate the distance between every other node and the circle center

4/ at this point we have two cases:

1st the distance is less than the rayon(the distance between the center and one form selected point) of the circle in this case that main the three selected points triangle can't be Delaunay triangle.

2nd the distance between all the other nodes and the circle center is more than the rayon witch mean that the three selected point triangle is a Delaunay triangulation.

We did these steps in the following algorithm:

```
void delaunay traingle(NodeContainer c ,uint32_t nbr    ){
     uint32_t i=0;uint32_t z=0;uint32_t j=0;uint32_t k=0;uint32_t l=0;
     float reyan;
     Vector center;
     while ( i < nbr )
        {
            j=0;
            while ( j < nbr ){
                if(i!=j)
                {
                     z=0;
                     while ( z < nbr ){
                        if(z!=j and z!=i){
                            Vector v1 = GetPosition (c.Get(i));
                            Vector v2 = GetPosition (c.Get(j));
                            Vector v3 = GetPosition (c.Get(z));
                            center= circul_center(v1,v2,v3);
                            reyan = destence(center,v1);
                            k=0;
                            while(destence(center,GetPosition (c.Get(K)))>=reyan and k<nbr){
                                k++;
                            }
                            if(k==nbr){
                                triangles[l].A=i;
                                triangles[l].B=j;
                                triangles[l].C=z;
                                l++;
                            }
                        }
                        z++;
                    }
                }
            }
                j++;
        }
}
```

This algorithm is NP hard.

IX. Network working diagram:

And to make all clear we create a diagram that show the simulation steps in Figure 18

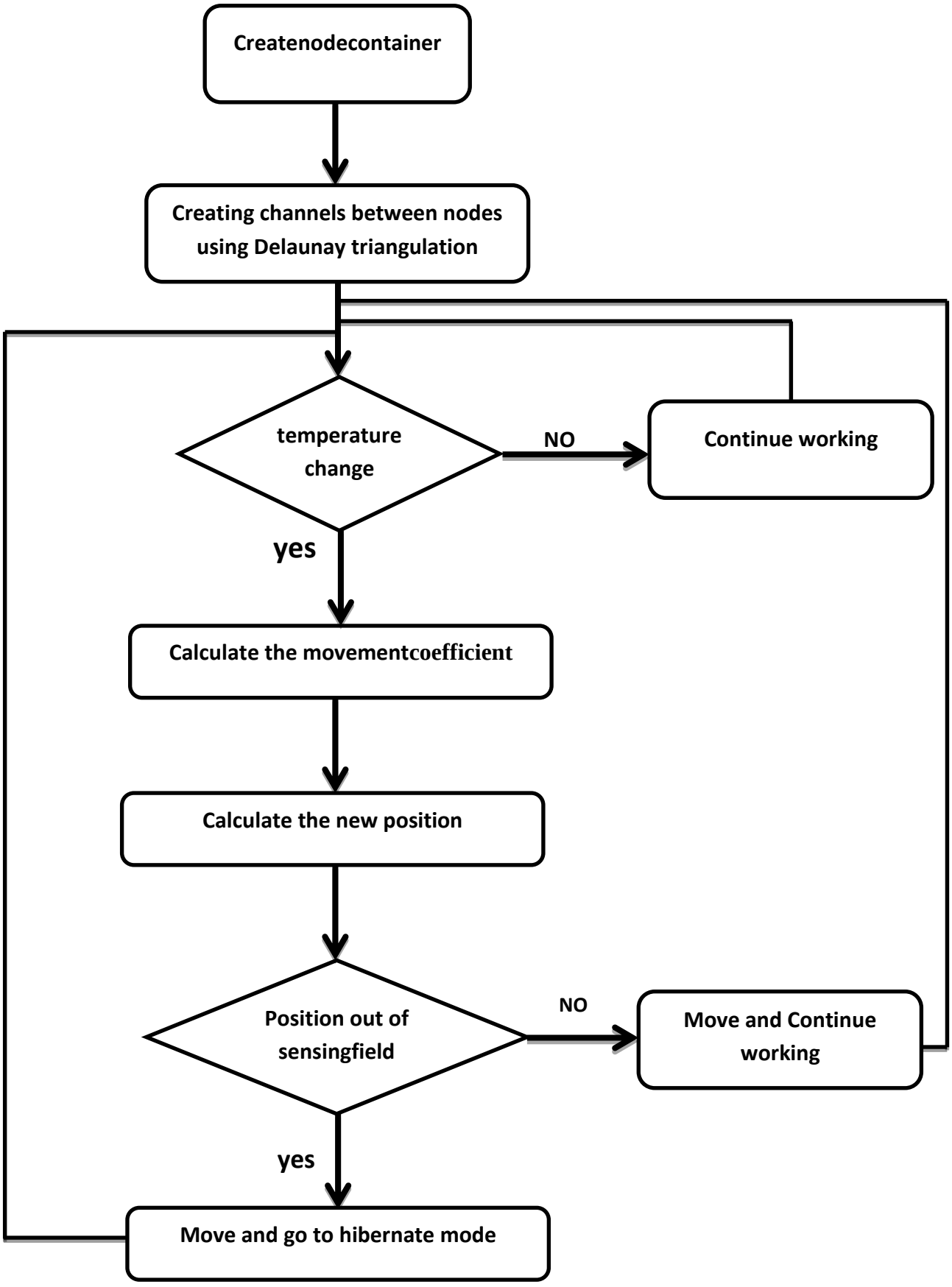


Figure 18.deployment work

X. Conclusion

Deployment issues are a major domain of researches specially in the last years and as we sow in this chapter the good deployment can make the deference between good healthy WSN and a bad miss function one and we also sow the deployment that we are going to use in ours project witch we will see his results in the next chapter.

Chapter 4

SIMULATION AND RESULTS

I. Introduction

In this chapter we will put our project in simulation and discuss the results of the simulation beside after implementing our system, we should put it in a good test to improve the performance of the technics that we used. As a main step, we limit the test on day temperature variation using function that we will see next.

We divided this chapter into two parts the first one we will introduce the tools that we use to make the simulation and in the second part we will see the results of the simulation.

II. The tools:

II.1 C++ language:

C++ is a general-purpose programming language. It has imperative, object-oriented and generic programming features, while also providing facilities for low-level memory manipulation.

It was designed with a bias toward system programming and embedded, resource-constrained and large systems, with performance, efficiency and flexibility of use as its design highlights. C++ has also been found useful in many other contexts, with key strengths being software infrastructure and resource-constrained applications, [92]including desktop applications, servers (e.g. e-commerce, web search or SQL servers), and performance-critical applications (e.g. telephone switches or space probes).[93] C++ is a compiled language, with implementations of it available on many platforms. Many vendors provide C++ compilers, including the Free Software Foundation, Microsoft, Intel, and IBM.

II.2 NS-3 simulator

Ns-3 is a discrete-event network simulator, targeted primarily for research and educational use. ns-3 is free software, licensed under the GNU GPLv2 license, and is publicly available for research, development, and use.

The goal of the ns-3 project is to develop a preferred, open simulation environment for networking research: it should be aligned with the simulation needs of modern networking research and should encourage community contribution, peer review, and validation of the software[97].

II.3 Eclipse:

Eclipse is a platform that has been designed from the ground up for building integrated web and application development tooling. By design, the platform does not provide a great deal of end user functionality by itself. The value of the platform is what it encourages: rapid development of integrated features based on a plug-in model [98].

Eclipse provides a common user interface (UI) model for working with tools. It is designed to run on multiple operating systems while providing robust integration with each underlying OS. Plug-ins can program to the Eclipse portable APIs and run unchanged on any of the supported operating systems [98].

At the core of Eclipse is architecture for dynamic discovery, loading, and running of plug-ins. The platform handles the logistics of finding and running the right code. The platform UI provides a standard user navigation model. Each plug-in can then focus on doing a small number of tasks well. What kinds of tasks? Defining, testing, animating, publishing, compiling, debugging, diagramming…the only limit is your imagination[98].

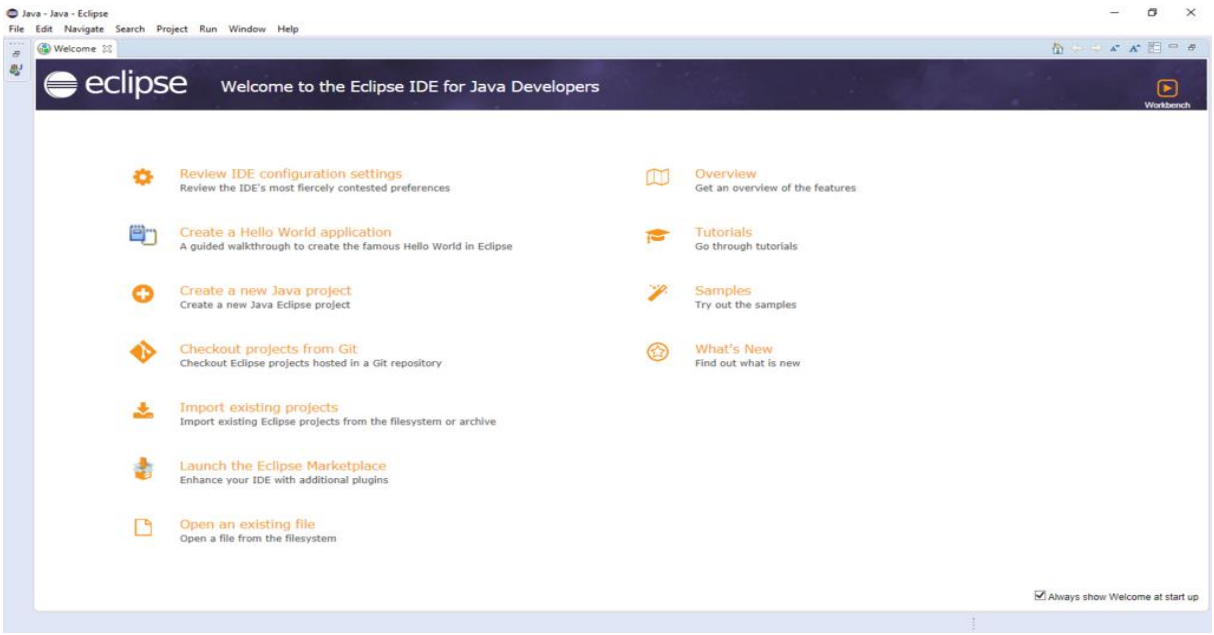
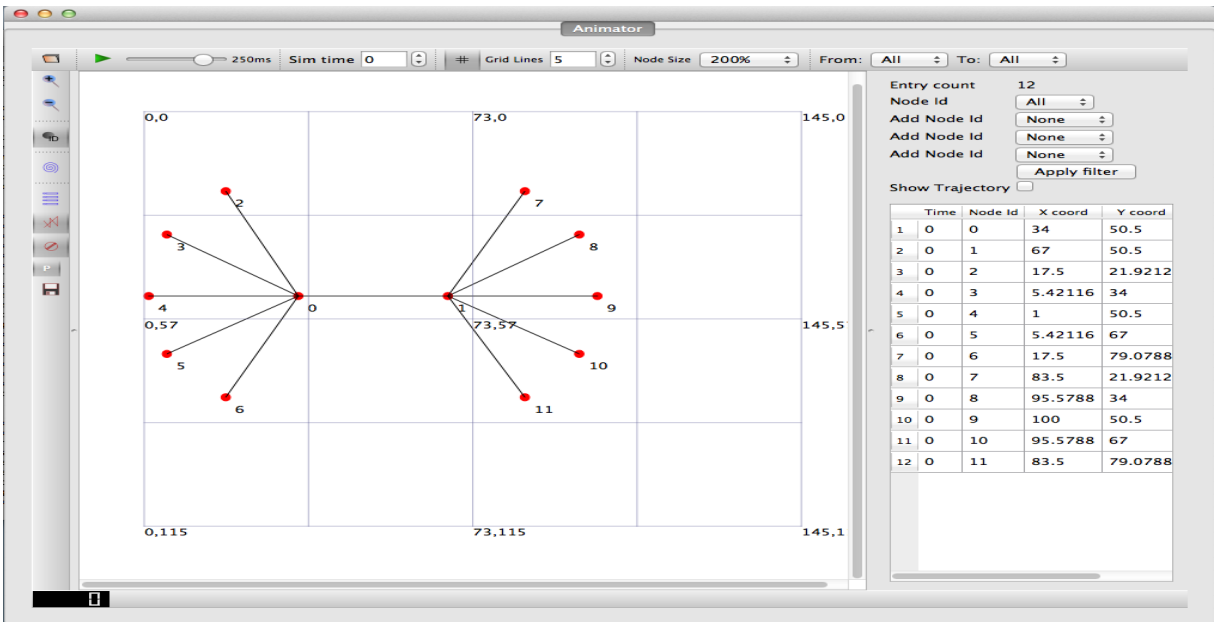


Figure 19. Eclipse interface

II.4 NetAnim:

NetAnim is an offline animator based on the Qt toolkit. It currently animates the simulation using an XML trace file collected during simulation. The first version was developed by George F Riley[99].



	Time	Node Id	X coord	Y coord
1	0	0	34	50.5
2	0	1	67	50.5
3	0	2	17.5	21.9212
4	0	3	5.42116	34
5	0	4	1	50.5
6	0	5	5.42116	67
7	0	6	17.5	79.0788
8	0	7	83.5	21.9212
9	0	8	95.5788	34
10	0	9	100	50.5
11	0	10	95.5788	67
12	0	11	83.5	79.0788

Figure 20. NetAnim interface

III. Temperature daily variation:

We used [81] model for weather statistics of the Mediterranean Sea to simulate temperature variant in one day to make our simulation more real testing to do that we used the next function:

$$\tau(Y,m,t) = \tau(Y,m) + A\tau(Y,m)[0.4632\cos(r(t) - 3.805) + 0.0984\cos(2\gamma(t) - 0.360) + 0.0168\cos(3\gamma(t) - 0.822) + 0.0138\cos(4\gamma(t) - 3.513)]$$

Where:

$\gamma(t) = 2\pi(t-1)/24$, t is the time on hour.

$\tau(Y,m)$ is the monthly temperature of the air.

$A\tau(Y,m)$ Is the monthly thermal amplitude in degrees Celsius.

For our simulation we used:

τ (Y,m)= Aτ(Y,m)=25°

The next figure show the variation of temperature in 24 hours.

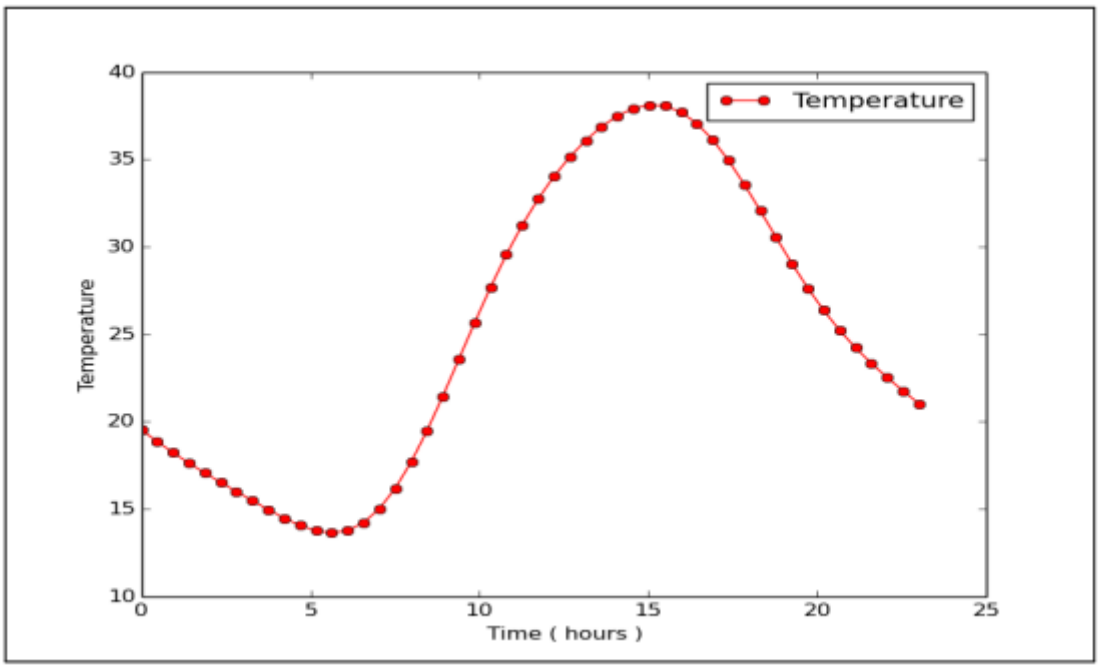


Figure 21. temperature variation in 24 hours

IV. Simulation results:

IV.1 Deployment:

As we mention early we use triangle deployment for many reasons and the next figure show the deployment:

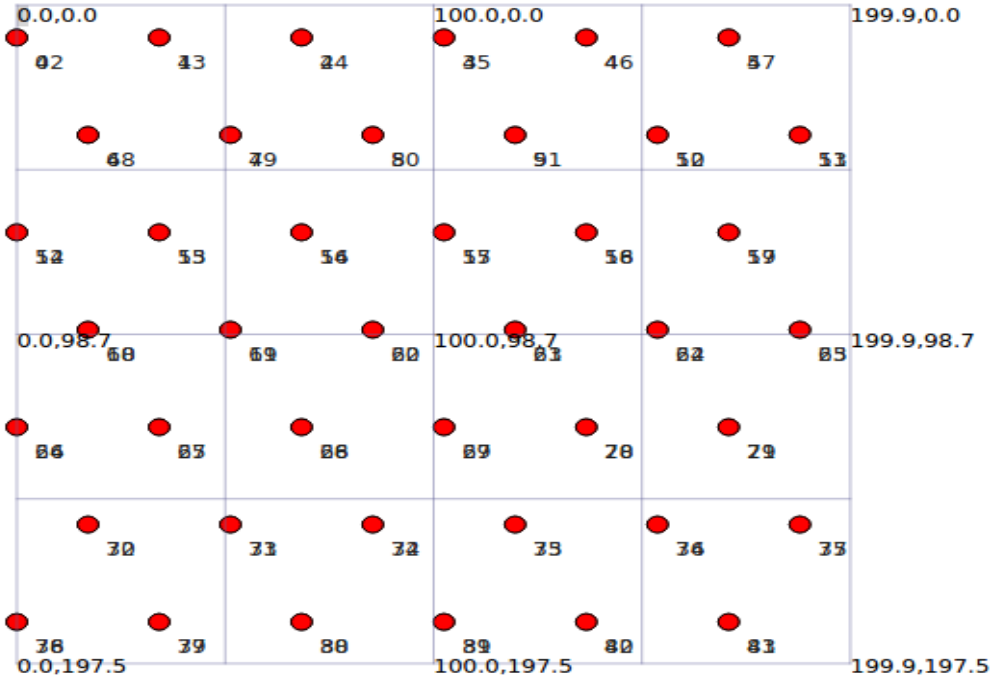


Figure 22. simulation deployment.

IV.2 Communication:

As we explain we used Delaunay triangulation to make channels between nodes to create UDP communication between nodes as it shown in figure 21:

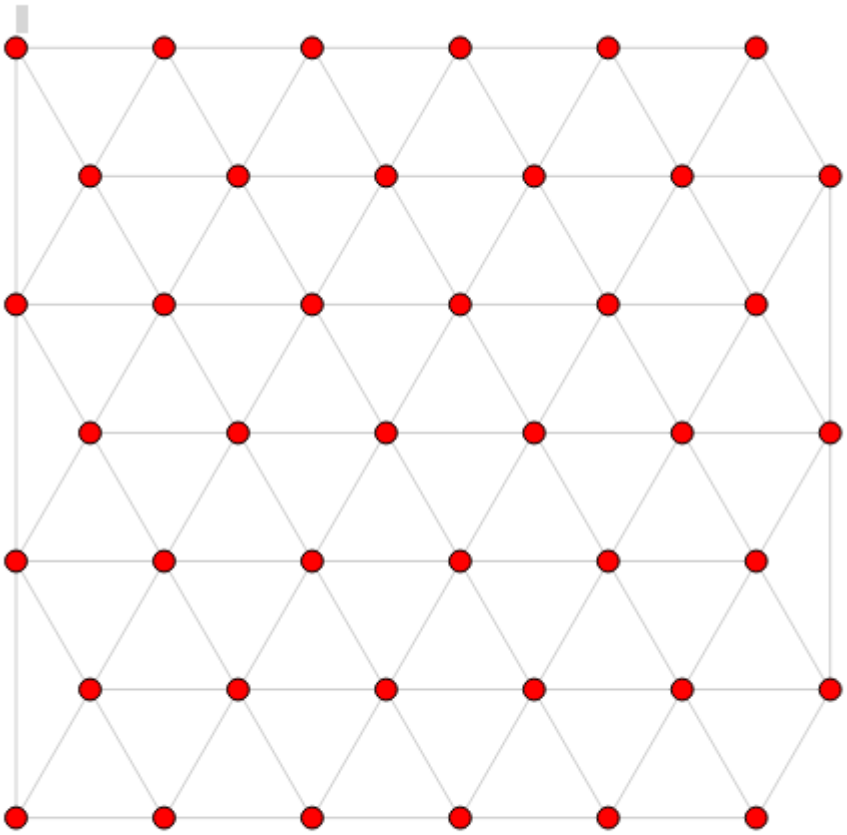


Figure 23. Delaunay triangulation in the simulation

IV.3 Stop-Operate:

Stop-Operate as we sow previously is a technics we used to save energy its based idea is to make nodes move using temperature as factor as it will shown in figure 22.a and 22.b witch shown the simulation in deferent two times

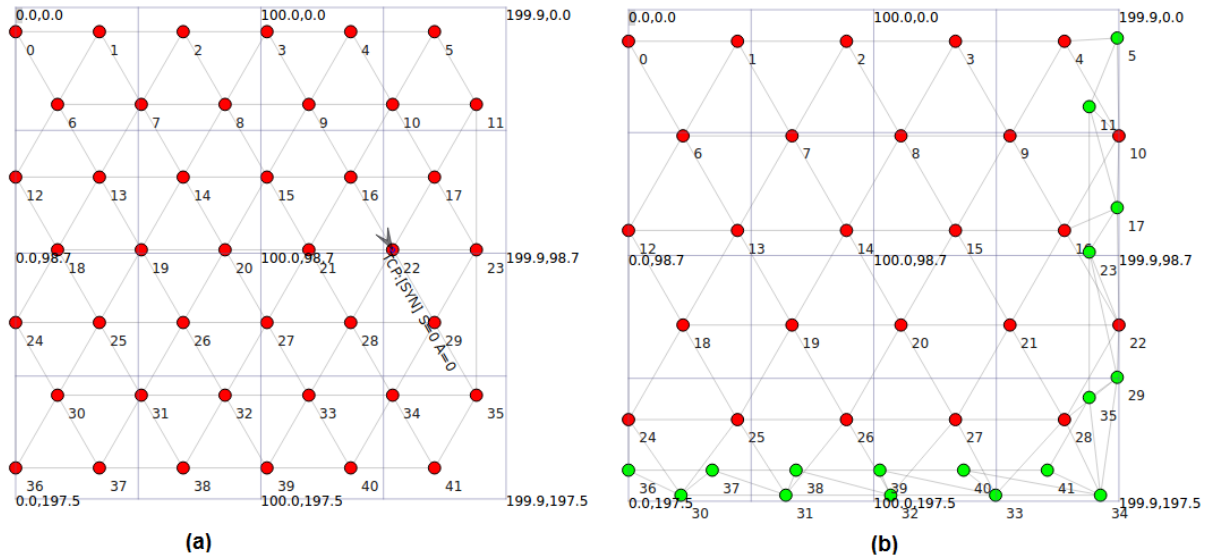


Figure 24. Stop-Operate in simulation

IV.4 Energy

One of the objectives that we design this simulation for is energy saving but did we get to it that's what we will see in the two next figures witch represent a Comparison between normal deployment energy consumption and our deployment energy consumption:

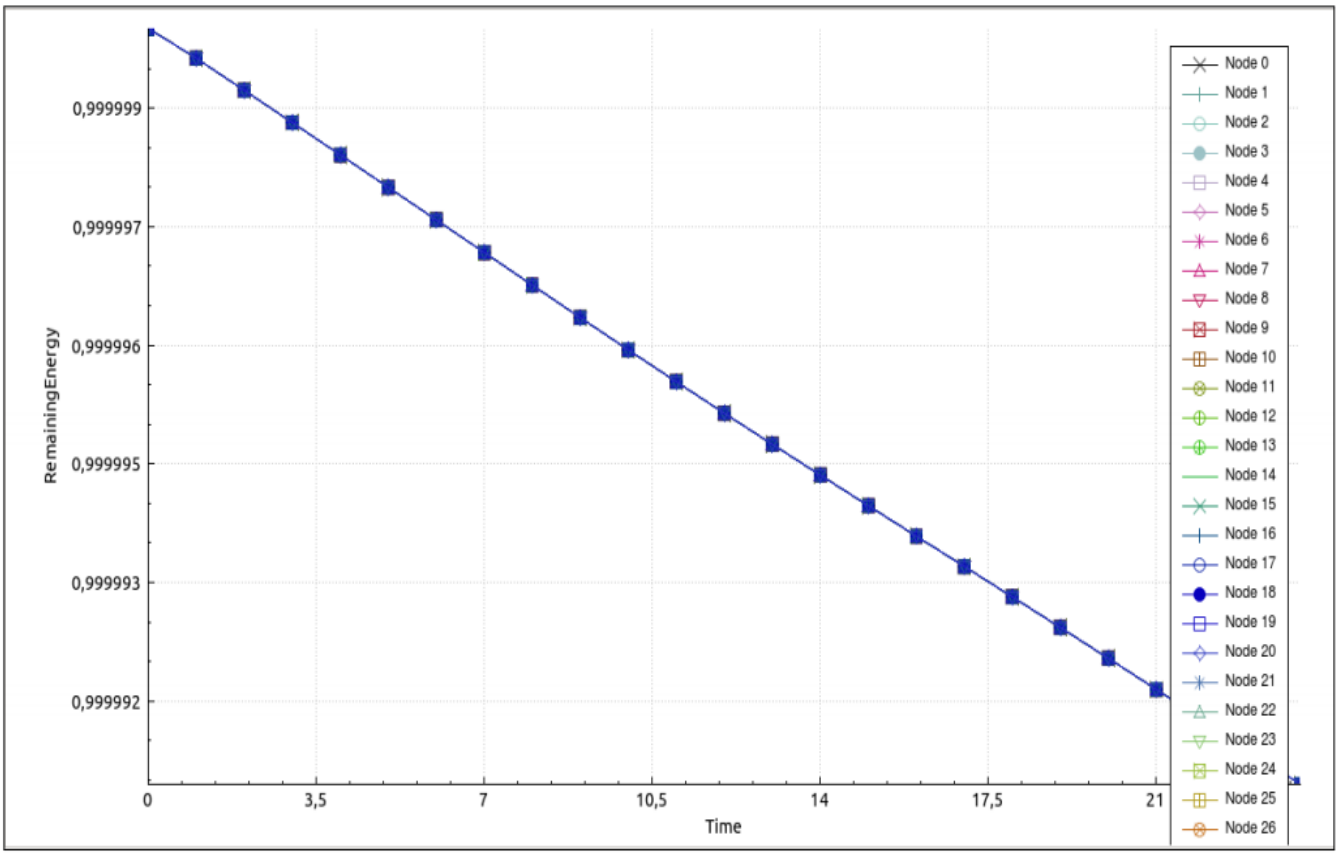


Figure 25. normal deployment energy consumption

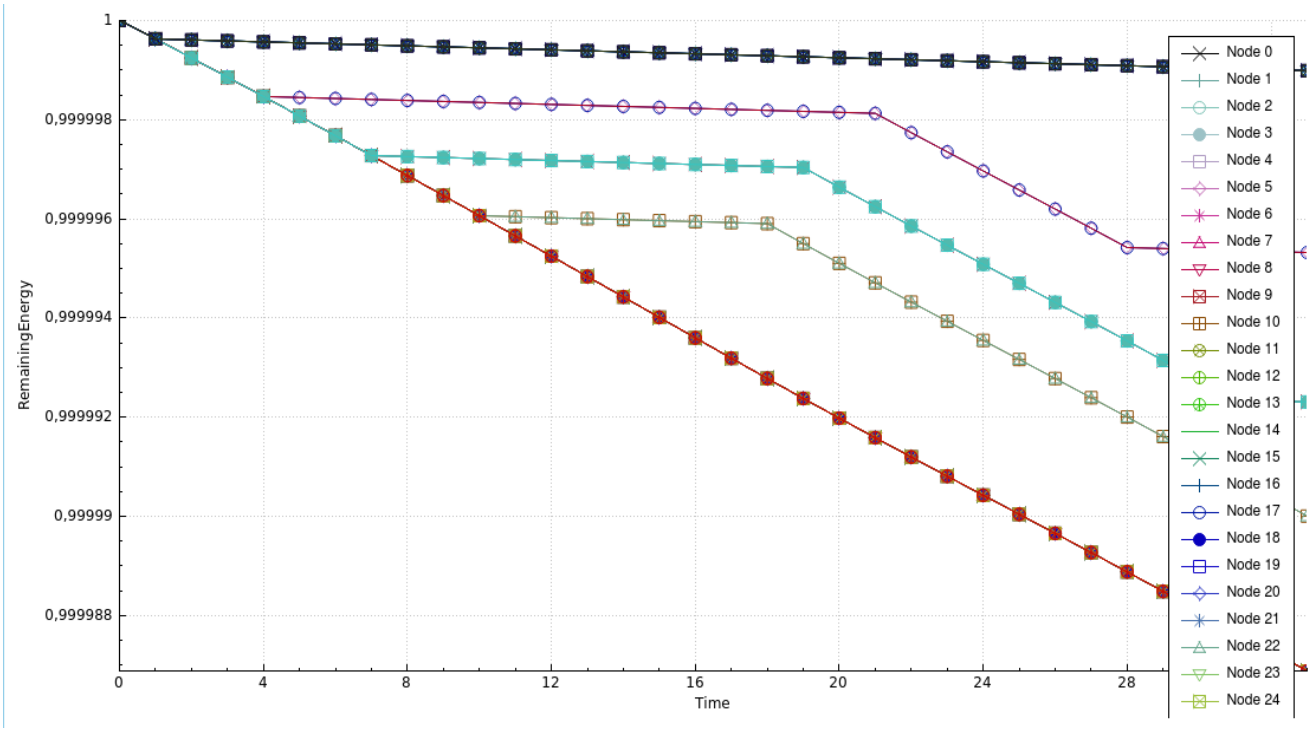


Figure 26. the simulation energy consumption.

And to prove that the Delaunay triangulation have an effect on the energy consumption we take simulation results from [100] witch use only StopOpertaing method as it shown in figure 26.

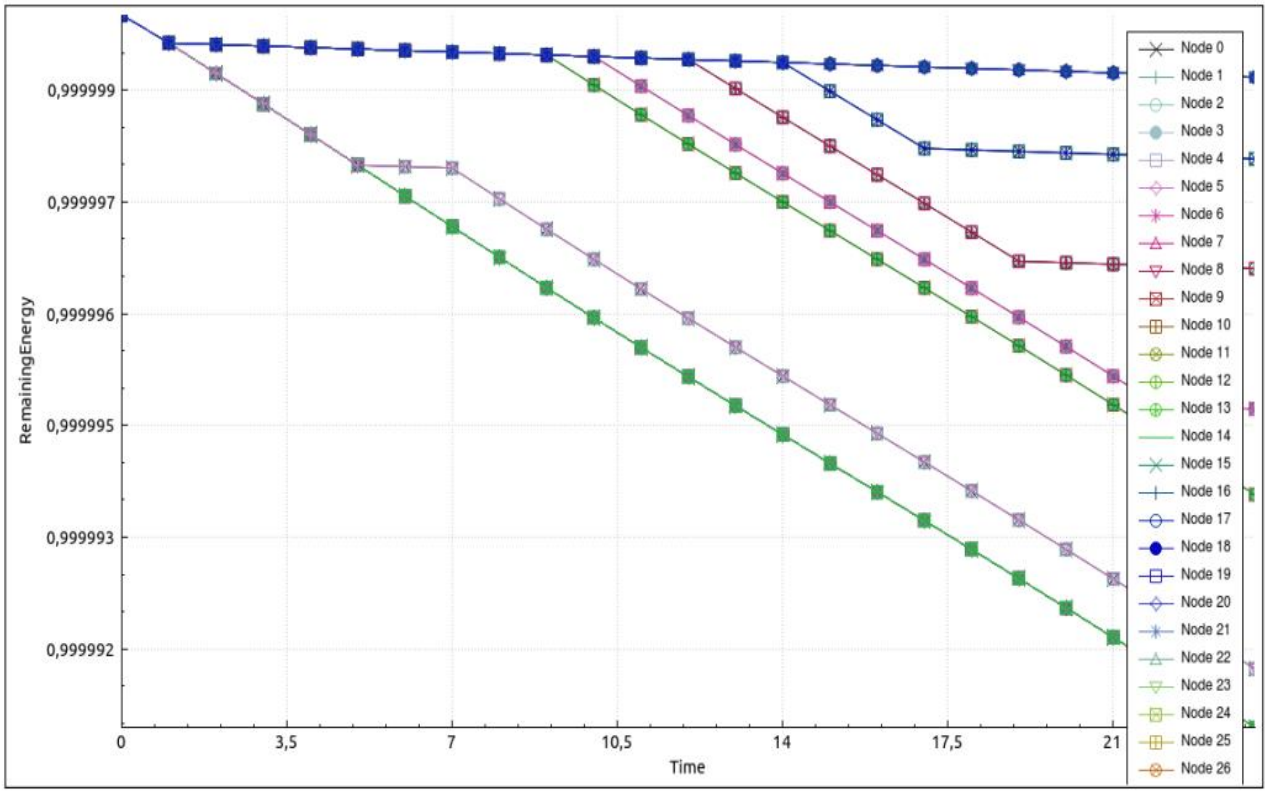


Figure 27. StopOperating energy consumption

V. Default simulation values

Parameters	Values
Sensing area dimensions	Area width*area length= 200*200
Communication rang	$R = 10^{(P_t - P_s - A_0)/(10\alpha)}$
Maximum temperature	Tmax= 47°
Exposing attenuation	α = 4
Frequency	F = 10^3 MHz
Energy source	E=150 J
Receiving current	Irc= 24mA
Voltage	V=3v
Hibernate power consumption	Ph=3µW
Power consumed on the move	Pm=30mW
Transmission speed	DataRate = 1 Mbps
Height of transmitter antenna	Ht = 1.5
Receiver antenna height	Hr=1.5
Gain of the transmitter antenna	Gt=1
Gain of the Receiver antenna	Gr=1
Radio	CC2400
Radio Standard	DLT_IEEE802_11_RADIO
Traffic type	UDP
Mobility model	ns3 : :ConstantPositionMobilityModel
Propagation Model	ns3 : :TwoRayGroundPropagationLossModel

Table 3. simulation properties

VI. Conclusion:

With this simulation results we can say that we achieve our mains objective by using the temperature effect in the deployment as an important factor and also minimize energy consumption by using stop operate technic.

General conclusion:

The WSN is large and new research domain witch make it nearly impossible to cover all problems or sophistication and so to cover the maximum problem is the goal and that what we try to in this project that we focus on two problem the main one is to avoid the effect of temperature on the WSN and the secondary one is to make the WSN work for the longest time possible with the least human handle in.

As a solution we inter the temperature as important factor in the deployment distribution witch reflex positively on the work of the WSN on both energy and communication characteristics.

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