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Concepts for Designing Low Power Wireless Sensor Network

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***Abstract*—**Wireless sensor networks have been used in wide areas of application and become an attractive area for researchers in recent years. Because of the limited energy storage capability of sensor nodes, Energy consumption is one of the most challenging aspects of these networks and different strategies and protocols deals with this area. This paper presents general methods for designing low power wireless sensor network. Different sources of energy consumptions in these networks are discussed here and techniques for alleviating the consumption of energy are presented.

***Keywords*—**Energy consumption, MAC protocol, Routing protocol, Sensor node, Topology control, Wireless sensor network.

I. INTRODUCTION

WIRELESS sensor network (WSN) consists of low cost, low power distributed devices which is called sensor nodes. The role of these nodes is sensing physical and environmental changes such as temperature and pressure and transmitting the data to sink point or base station, through which user accesses the data. Each sensor node has four main components including sensor, processor, transceiver, and an energy supply. Each node has a limited communication range and storage capability.

Applications of these networks seem endless and range from defense and environmental monitoring to health and business. WSN not only enable scientific and medical researchers to collect data in brand new ways, but they also make a rich source of research topics and educational activities in multiple disciplines. Real-world wireless sensing applications are quite diverse, and they impose a wide range of constraints on the system platforms, including the size, cost, power availability, wireless connectivity, performance, memory, storage, and flexibility [1].

In many applications, it is expected that each sensor node last for a long time because in most of the cases these networks are used in remote areas and recharging and replacing power supply units is difficult. For this reason, it is very important to minimize the total power in sensor network.

In this research several techniques that result in to decreasing the consumed power is discussed. These techniques are related to different aspects of senor network, from hardware platform to MAC protocol, routing, and topology control.

II. SOURCE OF ENERGY CONSUMPTION IN WIRELESS SENSOR NETWORKS

In order to design a low power wireless sensor network, first step is to analyze the power dissipation characteristics of wireless senor node. Each node in the network is consists of four components: a sensor which connects the network to physical world, computation part which is consists of microcontroller or in some application microprocessor and is responsible for control of the sensors and communication, a transceiver for communicating between nodes and base station, and a power supply which is usually a battery.

There are wide ranges of choices for each part of the node and choosing a right device will affect the energy consumption.

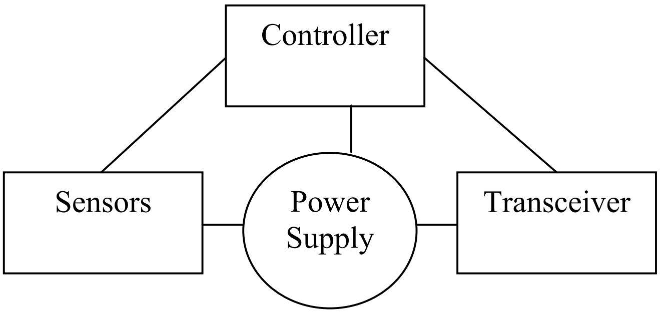

Fig. 1 Overview of sensor node hardware components

Despite the energy efficiency of specific hardware platforms, Sensor network lifetime can be significantly enhanced if the software of the system, including different layers and protocols are designed in a way that lower the consumption of energy [2].

In the following parts, at first the most important points in choosing the hardware for the node will be discussed and then we will go through several techniques which affect different aspects of WSN software, in order to have low power network.

III. HARDWARE CHARACTERISTICS

A. Processing Unit

The computing/processing unit is a microcontroller or microprocessor. In most application microcontroller is used as a computation device and also do some simple processing.

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Microcontroller functions as a core of the system witch do the decision making task in each node. In order to choose the ideal microcontroller for the system the designer must consider the desired performance level. The level of performance varies in different application. Usually, microcontrollers with high power consumptions have better performance [3]. For example, the StrongARM microprocessor from Intel, consumes around 400mW of power while executing instructions, whereas the ATmega103L AVR microcontroller from Atmel consumes only around 16.5mW, but provides much lower performance [2].

Another important point is microcontroller's operational modes. Most of the Microcontrollers support various operational modes and the power consumption in each mode is different. The most common modes in microcontrollers are active, idea, and sleep modes.

For example Texas Instruments MSP 430 features a wide range of operation modes: One fully operational mode, which consumes about 1.2mW and four sleep modes. The deepest sleep mode only consumes 0.3 µW but the controller is only woken up by external interrupts in this mode. In the next higher mode, a clock is also still running, which can be used for scheduled wake ups, and still consumes only about 6 µW [3].

Changing between modes is a power consuming task and in application which involves fast data sampling and frequent data reporting, it is often not a good idea to change between modes but if the interval between sampling or reporting is significant the microcontroller can be put in to sleep mode between the sampling times.

There is also an attractive design option which suggests to split the workload between two low power microcontrollers, in this way one microcontroller is responsible for the sensing control, while the other performs the networking tasks such as controlling the RF interface and running networking algorithms [1].

A more sophisticated possibility than discrete operational modes is to use a continuous notion of functionality/power adaptation by adapting the speed with which a controller operates. The idea is to choose the best possible speed with which to compute a task that has to be completed by a given deadline. One obvious solution is to switch the controller in full operation mode, compute the task at highest speed, and go back to a sleep mode as quickly as possible [3].

The alternative approach is to compute the task only at the speed that is required to finish it before the deadline. The rationale is the fact that a controller running at lower speed, that is, lower clock rates, consumes less power than at full speed. This is due to the fact that the supply voltage can be reduced at lower clock rates while still guaranteeing correct operation. This technique is called Dynamic Voltage Scaling (DVS) [3]. DVS dynamically adapting the processor's supply voltage and operating frequency to just meet the instantaneous processing requirement, thus trading off unutilized performance for energy savings [2].

This technique is actually beneficial for CMOS chips; as the actual power consumption P depends quadratically on the supply voltage VDD [3], reducing the voltage is a very efficient way to reduce power consumption. Power consumption also depends on the frequency f , hence [3]:

$$P \propto f . V_{DD}^{2} \tag{1}$$

Consequently, dynamic voltage scaling also reduces energy consumption.

B. Communication Device

The exchange of data between nodes is done by communication device. There are several choices for communication mediums like radio frequencies, optical communication, and ultrasound but radio frequency based communication is the most relevant one for wireless sensor network applications. For actual communication, both a transmitter and a receiver are required in a sensor node. The essential task is to convert a bit stream coming from a microcontroller and convert them to and from radio waves [3]. For practical purposes, it is usually convenient to use a device that combines these two tasks in a single entity. Such combined devices are called transceiver.

Transceiver is usually the largest power consumer and optimizing its power can result in significant improvement at the system level [1]. There are several factors that affect the power consumption characteristics of a transceiver, including the Type of modulation scheme used, data rate, transmit power (determined by the transmission distance), and the operational duty cycle [2].

The range of commercially available transceivers is vast, with many different characteristics. Transceivers that appear to have excellent energy characteristics might suffer from other shortcomings like poor frequency stability under temperature variations (leading to partitioning of a network when parts of the node are placed in the shade and others in sunlight), high susceptibility to interference on neighboring frequency channels, or undesirable error characteristics; they could also lack features that other transceivers have, like tunability to multiple frequencies [3]. So the designer must aware of the most essential factors which is crucial for the particular application and based on this knowledge he can choose the most appropriate transceiver.

Many transceivers allow the user to set the power level. In general, transceivers can operate in four distinct modes of operation, namely Transmit, Receive, Idle, and Sleep modes. An important observation in the case of most transceivers is that, operating in idle mode results in significantly high power consumption, almost equal to the power consumed in the Receive mode. Thus, it is important to completely shut down the transceiver rather than transitioning to idle mode, when it is not transmitting or receiving data [2]. Some transceivers can support more diverse power level for example the CC1000 has 23 levels of transmission power, from −20 dBm to +10 dBm. Setting the transmission power high will result in higher SNR (signal to noise ratio) and lower BER (bit error rate), but at the same time it could increase interference with farther radios. More importantly, drawing higher current than the rated current of the given battery will decrease the battery efficiency; due to the rate capacity effect [1]. This effect will be discussed in power supply section.

Another important characteristic of the transceiver is its startup energy. A transceiver waking up from the sleep mode to the transmit mode requires some startup time and startup energy, for example, to ramp up phase-locked loops or voltage-controlled oscillators. During this startup time, no transmission or reception of data is possible.

Looking at Table I [3], it's clear that considerable time and energy might be spent to turn on a transceiver. According to some research on this energy, the architectures with short startup times are preferable in low power networks. It is also point out that this start up time has a great impact on choosing the modulation [3].

TABLE I
SOME PARAMETERS OF TRANSCEIVER ENERGY CONSUMPTION

Symbol	Descriptions	Example Transceivers	
		μAMPS-1	WINS
*P*amp	Amplifier Power	174-674 mW	N/A
*P*rxElec	Reception Power	279 mW	368.3 mW
*P*rxIdle	Receive Idle	N/A	344.2 mW
*P*start	Startup Power	58.7 mW	N/A
*P*txElec	Transmit Power	151 mW	≈ 386 mW
R	Transmission Rate	1 Mbps	100 kbps
*T*start	Startup time	466 µs	N/A

Fig. 2 [3] illustrated a commonly used model for sleep state. At time t1 the component decides whether to go in to sleep mode or remain active. If it decides to go to sleep, the power reduces to $Psleep$ but a time $\tau down$ is needed for reaching in to sleep mode. Assume that the average power consumption during this phase is $(Pactive + Psleep)/2$ then the energy in sleep mode is as follows [3]:

$$Esleep = \frac{\tau down(Pactive+Psleep)}{2} + (tevent - t1 - \tau down)Psleep \qquad (2)$$

While the energy when remaining active is equal to [3]:

$$Eactive = (tevent - t1)Pactive \qquad (3)$$

The energy saving is thus [3]:

$$Esaved = (tevent - t1)Pactive - (\frac{\tau down(Pactive+Psleep)}{2} + (tevent - t1 - \tau down)Psleep) \qquad (4)$$

When a new event occurs, an additional overhead is needed for coming back to active mode. During this time no useful activity can be undertaken [3].

$$E\ overhead = \frac{\tau up(Pactive+Psleep)}{2} \qquad (5)$$

Clearly, switching to a sleep mode is only beneficial if $Eoverhead < Esaved$ or, equivalently, if the time to the next event is sufficiently large [3].

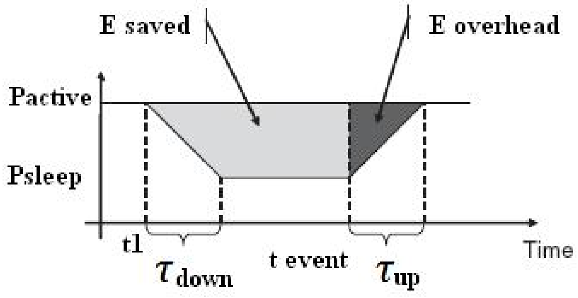

Fig. 2 Energy saving for sleep mode

In general, different measurements showed that communication is a considerably more energy consuming than computation. According to this, usually it is preferable to decrease the transmission time. One of the simplest methods to do this is to use aggregation techniques but it will add some delay to system which might be disastrous for some application [3].

C. *Power Supply Device*

The power supply is a crucial system component for wireless sensor network. In order to have a low power network, besides considering the consumption characteristics of the network the supply side must also be considered. In most of the cases the power source of a sensor node is a battery.

The battery supplies power to the complete sensor node, and hence plays a vital role in determining sensor node lifetime. Batteries are complex devices whose operation depends on many factors including battery dimensions, type of electrode material used, and diffusion rate of the active materials in the electrolyte [2].

One of the most important factors that a designer must consider is rate capacity effect. It is one of the most important factors that affects battery lifetime. This effect is related to the discharge rate or the amount of current drawn from the battery. Every battery has a rated current capacity, specified by the manufacturer. Drawing higher current than the rated value leads to a significant reduction in battery life. This is because, if a high current is drawn from the battery, the rate at which active ingredients diffuse through the electrolyte falls behind the rate at which they are consumed at the electrodes. If the high discharge rate is maintained for a long time, the electrodes run out of active materials, resulting in battery death even though active ingredients are still present in the electrolyte. Hence, to avoid battery life degradation, the amount of current drawn from the battery should be kept under tight check [2].

Because most of the applications of wireless sensor networks involve deploying sensor nodes in harsh and remote environment it is difficult to use ordinary recharging methods for batteries. Some times in particular applications when the nodes are in a situation that they can use other external energy resources like sunlight and wind, these resources can be used to extend the operational time of the node. Some sensor nodes now include multiple power sources to replenish the charge over time. They include solar panels and other energy scavenging mechanisms. For instance, Zebranet, a mobile wireless sensor network, contains a solar array that generates up to 5W, in addition to 14 Sony Li-ion polymer cells [1].

Table II [3] gives an overview of typical values of power and energy densities for different energy sources. These numbers can only serve as a general orientation.

TABLE II
COMPARISON OF ENERGY SOURCES

Energy Source	Energy/ Power Density
Batteries (zinc-air)	1050–1560 mWh/c m^3
Batteries (rechargeable lithium)	300 mWh/c m^3 (at 3–4 V)
Solar (outdoors)	15 mW/cm^2 (direct sun)
	0.15 mW/cm^2 (cloudy day)
Solar (indoors)	0.006 mW/cm^2 (standard office desk)
	0.57 mW/cm^2 (<60 W desk lamp)
Vibrations	0.01–0.1 mW/c m^3
Acoustic noise	$3 \cdot 10^{-6}$ mW/cm^2 at 75 dB
	$9, 6 \cdot 10^{-4}$ mW/cm^2 at 100 dB
Nuclear reaction	80 mW/c m^3, 106 mWh/c m^3

Another solution that slows down battery aging is to place a supercapacitor in parallel with the battery so that transient power is delivered by the capacitor rather than the battery. Fewer and shorter current pulses drawn from the battery allow more efficient use of battery capacity and increase the number of charge cycles possible. Super capacitors have received wide attention recently due to their power density, low equivalent series resistance, and very low leakage current. A typical supercapacitor offers more than half a million charge cycles and a 10-year operational lifetime until the capacitance is reduced by 20%. One could not simply replace a battery with a super capacitor because of the very different electrical characteristics and efficiency considerations [1].

D. *Sensing Device*

Sensors in wireless sensor network translate physical phenomena to electrical signals, and can be classified as either analog or digital devices depending on the type of output they produce. There are several sources of power consumption in a sensor, including: signal sampling and conversion of physical signals to electrical ones, signal conditioning, and analog to digital conversion [2].

Because the wide diversity of the sensors no specific guideline can be provided for choosing them. But In general, passive sensors such as temperature sensors consume less power than active sensors like sonar which need energy to send out a signal to probe the observed object. In addition to this, the sampling rate evidently is quite important and more frequent sampling requires more energy [3].

Effective management of sensor power consumption has lately emerged as an important issue in sensor networks. In order to have a low power network, sensors should acquires a measurement sample only if needed, when needed, where needed, and with the right level of fidelity [4].

Doing this, not only reduces the energy consumed in the subsystem, but in general reduces the processing and communication load as well. The goal is typically achieved using mechanisms such as changing the bit resolution of measurement samples (e.g., number of bits per pixel or number of pixels per frame in an image sensor); changing the sampling rate (e.g., frame rate in an image sensor); adaptive spatiotemporal sampling (as opposed to uniform sampling), which focuses sampling effort in interesting regions of space and intervals of time; exploiting redundancy and correlations models to predict a measurement instead of actually making it; and hierarchical sensing [4].

For example, interval sensing consumes less energy than continuous monitoring; therefore, in addition to designing low-power hardware, interval sensing can be used as a power-saving approach to reduce unnecessary sensing by turning the nodes off in the inactive duty cycles. [5].

Another way to decrease the power in sensor nodes is to use triggered sensing. For example consider the task of detecting a vehicular target. A low-power magnetometer or a simple acoustic energy detector can certainly detect such targets, but likely with a higher error rate and without an ability to identify the type of vehicle or track it. On the other hand, an acoustic beam-former with higher-quality acoustic sensors will consume higher power but will be more accurate in its detection accuracy and also provide the ability to identify and track the vehicle [4]. In order to have a low power network, designer can use low power detectors to trigger the high quality acoustic sensor. In this way when low power detectors detect object they will wake up the acoustic beam former sensors so the high power detectors will be in sleep most of the time.

IV. MAC PROTOCOL

Communication among nodes is the major energy consumer process in wireless sensor network. Significant portion of the node's energy is spent on radio transmissions and on listening to the medium for anticipated packet reception [5]. In addition to this, Nodes in wireless sensor network share a single medium for communication and Network performance largely depends upon how efficiently and fairly the nodes can share this common medium. MAC protocol controls the communication modes in WSNs and regulates access to the shared wireless medium such that the performance requirements of the underlying application are satisfied [6].

Nodes in wireless sensor network have restricted power sources and the node lifetime depends on how energy is conserved during communication so the most serious issue in design of MAC protocol is the need to conserve energy. There are other important attributes include: fairness, latency, throughput, and bandwidth utilization but these issues are considered secondary compared to energy considerations [5].

MAC protocol must be designed in a way that eliminates the source of energy waste. The major sources of energy waste in conventional MAC protocols are packet collisions, idle listening, overhearing, and overhead [6].

Collisions can happen if the MAC protocol allows two or more nodes to send packets at the same time. In this case none of transmitted packets can be received correctly so the nodes must retransmit their packets and that leads to increase in energy consumption. In addition to this, latency will be increases as a result of collision.

The second source of energy waste is idle listening. In order to eliminate or reduce collisions, nodes must sense the channel continuously to obtain scheduling information or wait before sending data until the channel is detected idle. This process is called idle listening. Measurements have shown that energy consumption in idle mode does not differ much from that in Transmit or Receive mode and idle listening consumes 50-100% of the energy, required for receiving [5]. So Long periods of idle listening may also increase energy consumption and decrease network throughput.

Another source of energy waste is overhearing which occurs when a node picks up packets destined to other nodes. Over hearing increases energy consumption and also degrades the network throughput.

Last source of energy waste in wireless sensor network is overhead. This refers to the situation when too much control packet exchange within the network. Control packets are used for signaling, scheduling, routing updates, and collision avoidance and their transmission will consume extra energy [5].

Besides these sources of energy waste, frequent switching between different operation modes also result in significant energy consumption and Limiting the number of transitions between sleep and active modes, leads to considerable energy saving [6].

The effect of these sources of energy waste differs according to the application. For example, under low traffic rates, sensors consume most of their energy in idle listening since the transmission occurs sporadically. However, under high traffic rates, the collisions and protocol overheads cause a significant increase in energy consumption [7].

In general, in order to design an energy-efficient MAC protocol, collisions must be avoided as much as possible. Moreover, energy dissipation due to idle channel sensing, overhearing, and overhead should also be reduced to a minimum [5]. One way to do this is by having the users enter a sleep state when they become idle, i.e. when they are neither transmitting nor receiving. To maintain communication, each user must wake up periodically to listen for a packet intended for it. If, in fact, such a packet is heard during the wake-up period, the sensor will remain awake until the data packet is received [7].

To guarantee that a packet is always heard, each transmitter must emit a preamble at the beginning of each data packet which must be sufficiently long to cover at least one sleep-wake period [7].

While designing a MAC protocol, one must take in to consideration that most of the strategies for reducing the energy waste comes at the cost of reduced fairness, throughput and increased delay so the first step in designing an efficient protocol is to understand the most desirable characteristic of the network for specific application [7].

V. ROUTING PROTOCOL

Wireless sensor network has wide range of application but in all of them the main task of wireless sensor nodes is to sense and collect data, process it, and transmit the information to the site where user can control the parameters. Achieving this task efficiently requires the development of an energy-efficient routing protocol to set up paths between sensor nodes and the data sink [6].

Unlike traditional routing protocols that minimize delay is the most important character of the protocol, many of wireless sensor network's protocols try to minimize the energy required for communication because nodes in a sensor network are energy constrained [5].

The characteristics of the environment within which sensor nodes typically operate, coupled with severe resource and energy limitation, make the routing problem very challenging. The path selection must be such that the lifetime of the network is maximized [6]. There are some general guidelines that one can follow to design a routing protocol which leads to energy conservation.

One simple strategy is to avoid bad-quality routes because unreliability of wireless links has an adverse effect on their performance. Link failures and packet losses leads to many retransmissions and therefore results in higher power consumption [8]. So a careful selection of the links is likely to increasing the performance of a routing protocol. Beside this, it is better to avoid forwarding packets through regions of the network that are running low on energy resources, thus preserving them for future, possibly critical detection and communication tasks [2].

Nodes can also use resource adaption mechanism and put a threshold for their energy level. If the energy level approaches the low threshold node can reduces its participation in the protocol operations and reduce or completely eliminate certain activities, such as forwarding control packets or data packets which is not addressed to that node [6].

Another technique to minimize energy consumption is to avoid links with high communication costs. Congestion always results in an increase in communication cost so congestion control is vital to minimize energy consumption. For example, the designer can use control mechanism in a way that the sink, slow down sources that cause congestion and speed up sources with lower communication costs [9].

In addition to this, the protocol should ensure that connectivity in a network is maintained as long as possible. In order to achieve this, one good method is to avoid forwarding packets via the same path because the nodes on that path will run out of energy in a short time and so the network connectivity will be compromised. Instead of that, the load can be uniformly spread over the network which leads to a more graceful degradation of the network [2].

Additional energy savings can be achieved by doing in-network data aggregation. Data collected by many sensors in WSNs are based on common phenomena; there is a high probability that these data have some redundancy. The concept of data aggregation is to exploit data correlation among the sensor nodes by eliminating redundancy. Consequently, there are fewer transmissions in the network, which results in to energy savings [10].

Partitioning network in to clusters also result in to more energy conservation. In the clustered network each cluster managed by a node which is a Cluster Head and the cluster head has several nodes as its cluster members. The cluster head is responsible for coordinating activities within the cluster and forwarding information between clusters [6].

The clustered topology can reduce energy consumption due to the several reasons. First, a node can communicate with the cluster head closest to it, for the sake of better channel condition and shorter transmission range. Moreover, in a cluster, the data which is sensed by cluster members may have a large similarity due to a small geographical distance between the cluster members. Therefore the cluster head can aggregate the data and remove the redundancy before sending it to the sink, which in turn reduces the size of the relayed packets [11]. Because the node which is selected as a cluster head is active most of the time the task of cluster head is rotating between all the nodes in order to ensure that energy consumption is distributed equally between all nodes. For example in LEACH protocol in order to select a cluster head each node generate random number, ν, between 0 and 1 only the node which its generated value, ν, is less than threshold value,$T(n)$, can become a cluster head. This threshold value is expressed as follow [6]:

$$T(n) = \begin{cases} 0 & If\ n \notin G \\ \dfrac{P}{1-P\left(r\ mod\left(1/_P\right)\right)} & \forall\ n \in G \end{cases} \qquad (6)$$

In this formula the predefined parameter, P, represent cluster head probability and variable G represents the set of nodes that have not been selected to become cluster heads in the last 1/P rounds and r denotes the current round. It is clear that if a node has served as a cluster head in the last 1/P rounds, it will not be elected in this round [6].

Finally, before designing the protocol it is important to note that Sensor nodes have limited computing power and therefore may not be able to run sophisticated network protocols so the routing protocol must be light-weight and has simple processing requirements [5].

VI. TOPOLOGY CONTROL

In the process of designing a wireless sensor network the efficient use of the scarce energy resources is one of the important tasks that a designer should take in to consideration. Having knowledge about topology control, help the designer to present more effective designs.

Topology control is the art of coordinating nodes' decisions regarding their transmitting ranges in order to generate a network with the desired properties (e.g. connectivity) while reducing node energy consumption and/or increasing network capacity [12].

Some researchers considered topology control as transmitter power control and believed that topology control scheme enables each node to set its power level to a minimum value under the constraint that the packet sent by this node could just reach its intended neighboring node. The energy consumption of data communication can thus be reduced [9].

Topology control is a powerful means to change the appearance and properties of network in a way that significantly improve operational aspects of a network, such as lifetime and energy consumption. For example in a densely deployed wireless network, a single node has many neighboring nodes with which direct communication would be possible when using sufficiently large transmission power. This is, however, not necessarily beneficial because high transmission power requires lots of energy. The number of neighboring nodes determines the number of receivers and total power consumption is reduced for topologies with fewer neighbors. To overcome this problem, topology control can be applied and decrease the neighbors node [3].

There are many techniques that can be used to restrict the nodes that are considered as neighbors. This can be done by controlling transmission power, by introducing hierarchies in the network and signaling out some nodes to take over certain coordination tasks, or by simply turning off some nodes for a certain time. So by use of topology control techniques, the topology of the network is deliberately restricted in order to decrease the power consumption [3].

Many different techniques can be classified as topology control mechanisms. One of the simplest types of topology control issues deals with finding the minimum value for transmitting range such that a certain network wide property is satisfied [12].

Topology control also deals with finding routes toward the destination and according to several studies in this area, from the energy-consumption point of view, it is better to forward data packets toward a data sink over many short hops instead of forwarding over a few long hops [13].

Topology control also has an impact on MAC and routing protocols. Topology control protocol, which creates and maintains the list of the immediate neighbors of a node, can trigger a route update phase in case it detects that the neighbor list is considerably changed. So, instead of passively waiting for the routing protocol to update each route separately, a route update phase can be triggered, leading to a faster response time to topology changes and to a reduced packet-loss rate and so eliminate the energy which is need for retransmission. On the other hand, the routing layer can trigger the re-execution of the topology control protocol in case it detects many route breakages in the network [12].

Moreover, topology control can decide on the nod's transmitting range and so this can be used to set the transmit power level at the MAC layer. Beside this, the MAC layer can trigger re-execution of the topology control protocol in case it discovers new neighbor nodes [12].

VII. CONCLUSION

Wireless sensor networks have opened the doors to many applications that require monitoring and control. In a wireless sensor system, the individual nodes are capable of sensing their environments, processing the information locally, and sending it to one or more collection points through a wireless link. In most of wireless sensor network applications, the nodes are hard to reach and it is impossible to replace their batteries so the nodes must operate without battery replacement for a long time. So designing a low power wireless sensor network will have a great benefit for most application areas. In order to design a low power network, designers must pay attention to several parameters like node's hardware and network protocols.

In this paper, different sources of power consumption in wireless sensor networks are discussed and several design concepts is presented which result in to decreasing the consumed power and so enhancing the life time of the network.

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