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An Integrated Survey in Efficient Energy Management for WSN using Architecture Approach

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---ABSTRACT---
Wireless Sensor Network consist of large number of sensing devices, which are equipped with limited radio communication capabilities and limited computing which is used for many purposes in the present and the future. Clustering and routing in wireless sensor networks for the transfer of information from sensor nodes to base station are especially important. Energy is one the most important items to determine the network lifetime due to low power energy nodes included in the network. For improving this major parameter we have to design best network architecture and consider all impact components. In this article, firstly we discuss all important concepts in WSN architecture and the impact factors that effect in performance directly or indirectly, and then we focus to power management to find best design. Finally we propose a power usage model with considering these discussed impact factors.

Keywords – **Wireless Sensor Networks, Energy Consumption, Network Model, Clustering**

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I. Introduction

Wireless sensor networks provide an unexampled opportunity to gather huge volumes of data about the physical world around us. WSN, however, have severe resource constraints, in terms of power, memory, and bandwidth, which make gathering and processing the data an extremely challenging problem. WSN are used in several areas including: military, medical, environmental and household. But in all these fields, energy, data lost, delays have determining role in the performance of wireless sensor networks [3].Since energy consumption during communication is major energy depletion parameters, the number of transmissions must be reduced as much as possible to achieve extended battery life [1, 2].In this paper we will try to offer a optimum architecture with considering all these assumptions. For having a network with a high performance we have to do deep Glimpse in WSN architecture.

1.1 WSN Architecture

Firstly we see the general wireless sensor network architecture as shown in figure 1[2].

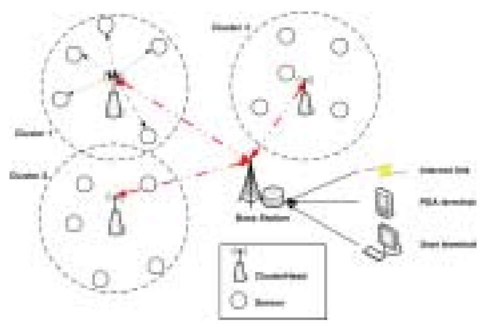

Figure 1: General WSN scheme

Physical factors of nodes that is used in many applications for wireless sensor network, and these factors:

- Light
- Sound
- Humility
- Pressure
- Temperature

The basic unit of the wireless sensor network is a sensor node. Its duty not only senses the environment, the physical world, furthermore it contains other units help processing, and delivering the sensed data [4]. Sensor node, depending on application scenarios and requirements, in addition to units shown in figure 2: sensor unit, communication unit, controller unit, and memory and power unit, maybe include other units like GPS, camera, energy scavenge and locomotive units

1.2 **Hardware components**

When choosing the hardware components for a wireless sensor node, evidently the application's requirements play a decisive factor with regard mostly to size, costs, and energy consumption of the nodes [5]. In some cases, an entire sensor node should be smaller than 1 cc, weigh less than 100 g, cheaper than US$1, and consume less than 100 μW [6]. Sometimes, the nodes are claimed to have to be reduced to the size of grains of dust. In more realistic applications, the mere size of a node is not so important; rather, convenience, simple power supply, and cost are more important [7]. There is certainly not a single standard available, nor would such a standard necessarily be able to support all application types.

A basic sensor node consists of five main components Figure 2:

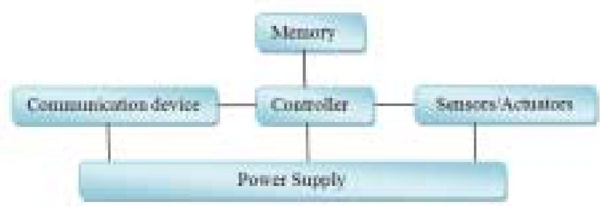

Figure 2: Overview of main sensor node hardware components

Controller A controller to process all the relevant data, capable of executing arbitrary code.

Memory: Some memory to store programs and intermediate data; usually, different types of memory are used for programs and data.

Sensors and actuators: The actual interface to the physical world: devices that can observe or control physical parameters of the environment.

Communication: Turning nodes into a network requires a device for sending and receiving information over a wireless channel.

Power supply: As usually no tethered power supply is available, some forms of batteries are necessary to provide energy. Sometimes, some form of recharging by obtaining energy from the environment is available as well (e.g. solar cells).

Each of these components has to operate balancing the trade-off between as small energy consumption as possible on the one hand and the need to fulfill their tasks on the other hand. For example, both the communication device and the controller should be turned off as long as possible. To wake up again, the controller could, for example, use a preprogrammed timer to be reactivated after some time. Alternatively, the sensors could be programmed to raise an interrupt if a given event occurs – say, a temperature value exceeds a given threshold or the communication device detects an incoming transmission. Supporting such alert functions requires appropriate interconnection between individual components.

1.2.1 Controller (Microcontrollers)

The microcontroller, just like the central processor unit (CPU) of a desktop computer; but consumes less energy than CPU, is the core of a wireless sensor node. Its functions are collecting data from the sensors, processing this sensed data, deciding when and where to send it, receiving data from other sensor nodes, and deciding on the actuator's behavior [4].

1.2.2 Memory

RAM is fast. However, opposite ROM it loses its content if power supply is interrupted. Therefore, in WSN the memory component includes both the on-chip random access memory (RAM) used by the microcontroller to store intermediate sensor readings and packets from other nodes and the on-board read-only memory (ROM) used for storing program codes. Here ROM typically includes Electrically Erasable Programmable ROM (EEPROM) and flash memory, flash memory sometimes serve as intermediate storage of data in case RAM is insufficient or when the power supply of RAM should be shut down for some time. Depending on the application requirements size of memory is ranging from hundreds of KB to hundreds of MB [4].

1.2.3 Communication Device

The communication device is used to exchange data between individual nodes. Since the wired communication is limits the flexibility and scalability of a sensor network, in both industrial and academic domain, wireless communication is of more interests [4]. Radio Frequency (RF)-based communication is best fits the requirements of most WSN applications: It provides relatively long range and high data rates, acceptable error rates at reasonable energy expenditure, and does not require line of sight between sender and receiver.

1.2.4 Transceivers

Transceiver is a device that combines both a transmitter and a receiver that are required in a sensor node. It is to convert a bit stream coming from a microcontroller and convert them to and from radio waves. A range of low-cost transceivers is commercially available that incorporate all the circuitry required for transmitting and receiving–

modulation , demodulation, amplifiers, filters, mixers, and so on.

Transceiver operational states: Many transceivers can distinguish four operational states [8]:

- **Transmit :**In the transmit state, the transmit part of the transceiver is active.
- **Receive :**In the receive state the receive part is active.
- **Idle :**A transceiver is ready to receive but is not currently receiving anything. Means some parts of the circuitry are active and others can be switched off.
- **Sleep :**In this state, significant parts of the transceiver are switched off.

The sensor node's protocol stack and operating software must decide into which state the transceiver is switched, according to the current and anticipated communications needs.

1.2.5 Sensors and actuators

Actual sensors and actuators are constructing the wireless sensor network entirely.

1.2.5.1 Sensors

Sensor is a device that represents an interface between physical and electrical word, a device which senses the physical environment (such as temperature, pressure, light, sound, etc.) and convert this sensed physical signals to an electrical signals that can be treated by digital environment, such as computers, and makes people to easy understand, monitor and control machines and environments [4]. Sensors represent very important part of our life you can see them every day in everywhere in lamp and sensitive buttons. It uses in applications include cars, medicine, machines, airplanes and application most people never aware. Sensors can be roughly categorized into three categories [8]:

i. Passive, omnidirectional sensors

These sensors can measure a physical quantity at the point of the sensor node without actually effect the environment by active probing, they are passive. There is no notion of "direction" involved in these measurements. Typical examples for such sensors include thermometer, light sensors, vibration, microphones, humidity, mechanical stress or tension in materials, chemical sensors sensitive for given substances, smoke detectors, air pressure, and so on.

ii. Passive, narrow-beam sensors

These sensors are passive as well, but have a well-defined notion of direction of measurement. A typical example is a camera, which can "take measurements" in a given direction, but has to be rotated if need be.

iii. Active sensors

These sensors actively probe the environment, for example, a sonar or radar sensor or some types of seismic sensors, which generate shock waves by small explosions. In practice, sensors from all of these types are available in many different forms with many individual peculiarities, include accuracy, dependability, energy consumption, cost, size, and so on – all this would make a detailed discussion of individual sensors quite ineffective.

1.2.5.2 Actuators

Actuators opposite the sensors, convert electrical signals into some action, are mechanical devices for moving or controlling a mechanism or system [9]. Moreover, they are devices that accept electrical signal and make changes in physical domain by generating motion, force, etc. Actuators, for the purposes of designing a WSN, are as diverse as sensors they are a bit simpler to take account of. In principle, all that a sensor node can do is to open or close a switch or a relay or to set a value in some way. Whether this controls a motor, a light bulb, or some other physical object is not really of concern to the way communication protocols are designed.

1.3. Power supply of sensor nodes

Power supply is a crucial system component of the tethered wireless sensor nodes. Storing power is conventionally done using batteries, which is the power source of sensors. For example, a normal AA battery stores about 2.2–2.5 Ah at 1.5 V. Battery design is a science and industry in itself and energy scavenging has attracted a lot of attention in research.

1.3.1 Energy consumption of sensor nodes

Recently wireless sensor networks have emerged as an effective way of monitoring physical environment. The main challenges in these networks are the constrained energy and computational resources of the sensor nodes, and these constrains have to be taken into account at all levels of system hierarchy. As seen, one of the most important requirements is that Wireless sensor architectures and applications must be provided or developed with low energy consumption [10] protocols that make well-use of the limited energy of the sensor nodes are required. Furthermore, sensor nodes must avoid direct communication with a distant destination and it is better to send the messages in multi-hop than sending it in a single hop [11].

In [22] we discussed stable route selection in ODMRP for forwarding data. In basic ODMRP route selection function uses minimum delay. But in proposed approach we consider nodes energy in route selection from source to destination. For presenting PDR improvement in proposed approach, we discussed group size and mobility speed in control overhead and end to end delay.

With a routing algorithm to determine the optimal path of energy consumption viewpoint for information transfer from sensor nodes to base station with the data transmission in other paper [23] we have presented multi skip. In this algorithm, performance region is divided to some sector and there are several relay nodes in the each sector. Relay nodes accumulates data from sensor nodes of their around and they transfer based on the shortest path and minimum skip possible in two-dimensional coordinates (x, y) to the base station.

As mentioned in the previous section, energy supply for a sensor node is at a premium. Because the batteries have small capacity the energy consumption of a sensor node must be tightly controlled. The controller, the memory, and the sensors are the main consumers of energy. To reduce power consumption of these components it is good to start with designing low-power chips for an energy-efficient sensor node. However, this is not enough, the components must operate properly. Where the wireless sensor node most of the time has nothing to do and it is best to turn it off. Completely turning off a node is not possible because it should be able to wake up again. Some modes can be introduced for all components of a sensor node, for a controller, typical states are "active", "idle", and "sleep"; a radio modem could turn transmitter, receiver, or both on or off; sensors and memory could also be turned on or off.

1.3.2 Microcontroller

Embedded controllers commonly implement the concept of multiple operational states as outlined above; it is also fairly easy to control. To understand the idea takes this example:

Intel Strong ARM

The Intel Strong ARM [12] provides three sleep modes:

- In **normal mode**, all parts of the processor are fully powered. Power consumption is up to 400 mW.
- In **idle mode**, clocks to the CPU are stopped; clocks that pertain to peripherals are active. Any interrupt will cause return to normal mode. Power consumption is up to 100 mW.
- In **sleep mode**, only the real-time clock remains active. Wakeup occurs after a timer interrupt and takes up to 160 ms. Power consumption is up to 50 μW.

1.3.3 Memory

The power needed to drive on-chip memory is usually included in the power consumption numbers given for the controllers. Therefore, the most relevant kinds of memory are on-chip memory of a microcontroller. FLASH memory off - chip RAM it is rarely used because it influences node lifetime. For example, consider the energy consumption necessary for reading and writing to the Flash memory used on the Mica nodes [13]. Reading data takes 1.111 nAh, writing requires 83.333 nAh. As shown, writing to FLASH memory can be a time- and energy-consuming task that is best avoided if it possible. For detailed numbers, it is necessary to consult the documentation of the particular wireless sensor node and its FLASH memory under consideration.

1.3.4 Radio Transceivers

Transmitting and receiving data between a pair of nodes are two tasks of a radio transceiver. It, like microcontrollers, can operate in different modes; the simplest ones are being turned on or turned off. To reduce energy consumption, the transceivers should be turned off most of the time and only be activated when necessary.

1.3.5 Sensor and Actuators

Because of the wide diversity of the actual sensors and actuators it is impossible to provide any guidelines about the power consumption. However, as an example, passive light or temperature sensors – the power consumption can perhaps be ignored in comparison to other devices on a wireless node. In contract, active devices like sonar, power consumption can be quite considerable and must be considered in the dimensioning of power sources on the sensor node. It requires a look at the intended application scenarios and the intended sensors to be used in order to derive any meaningful numbers.

II. WSN Scenarios

Wireless sensor network consist of Wireless sensor nodes, which monitor the environment and produce data, and sink/sinks, which collects/collect data from the sensor nodes and does not produce any data. Sink sometimes works as a gateway to another network like internet [4]. Depending on the capabilities of the sensor nodes and sinks and communication paradigm used by the sensor nodes and sink, wireless sensor networks can work in different architectural and operational scenarios. For instant, sometimes wireless sensor node has more advanced units that enable it to take more responsibilities inside the WSN. Bellow, several typical sensor network scenarios are introduced.

2.1 Types of Sources and Sinks

A source is any entity in the network that can provide information, here, typically a sensor node or an actuator node that provides feedback about an operation.
A sink is the entity where information is required. There are three options for a sink:

- A sink could be just another sensor/actuator node that belongs to the sensor network.
- A sink could be an actual device outside this network, for example, it could be a PDA used to interact with sensor network.
- A sink could be a gateway to another larger network such as the Internet.

Figure 3 shows the sources and the main types of sinks.

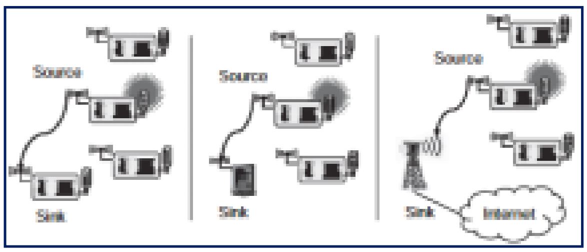

Figure 3 Three types of sinks in a very simple, single-hop sensor network

2.2 Single-Sink ,Single-hop WSN

Scalability is the critical problem of this scenario, where by increasing the number of nodes the amount of data gathered by the sink increases and once its capacity is reached the network size cannot be increased any more. To calculate the maximum number of nodes that a sink can serves:
Let N is number of nodes, R the channel bit rate, α is factor overhead introduced by all protocol stack layers (takes value between 0.5 and 0.1), nodes are requested to send their samples (each sample = D bytes) taken from the monitored space every T seconds. Under such assumptions, the application throughput will be approximately equal to ND8/TR.
Then, we reach the following inequality: $ND8/T \leq R\alpha$; and then

$$N \leq R\alpha T/(8D) \qquad (1)$$

For example, assume R = 250 Kbit/s, T = 1 s, α = 0.1 and D = 3
Then,
$N \leq 250000 \times 0.1 \times 1 * (8 \times 3) = 1041$ approximately

If T is 0.01 then the maximum number of nodes will not exceed 10 [14]. Figure 4 shows the traditional single-sink WSN.

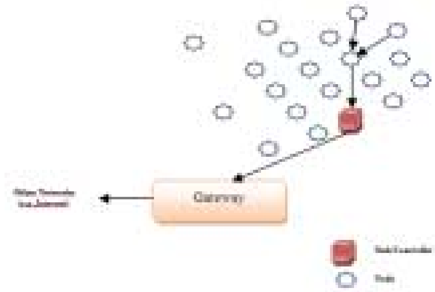

Figure 4 Traditional single - sink WSN

2.3 Single-Sink Multi-hop WSN

In this scenario a node can reach the sink through multiple hops. Let the average number of hops that a node can send a data sample = H then the total number of sensors in a single-sink multi-hop WSN:

$$N \leq R\alpha T/(8DH) \qquad (2)$$

This means that the capacity of the network will be reduced by a factor of H.

2.4 Multi-sink multi-hop WSN

Multiple-sink WSN opposite single-sink WSN can be scalable, means the same performance can be achieved even by increasing the number of nodes. In this scenario (Figure 5) the probability of isolated clusters of nodes that cannot deliver their data owing to unfortunate signal propagation conditions will be decreased. This ensures better performance of network. However, communication protocols are more complex and should be designed according to suitable criteria.
If we assume S is the total number of sinks in the network and by expressions (1) and (2). Each sink can serve up to N nodes:

$$N \leq SR\alpha T/(8DH) \qquad (3)$$

Taking the same example above, where R = 250Kbit/s, T = 10msec, α = 0.1 D = 3 and S = 5

$N \leq 5 \times 250000 \times 0.1 \times 1/(8 \times 3 \times 2) = 26$ approximately

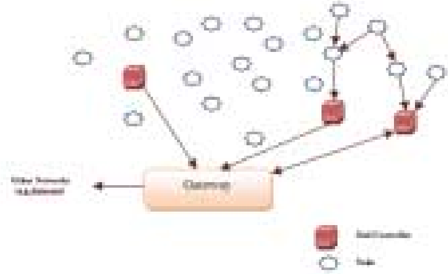

Figure 5 Multi-sink WSN

2.5 Single-Hop versus multi-hop Networks

Because of power limitation of radio communication and a limitation on the feasible distance between a sender and a receiver, in WSN, direct communication between source and sink is not always possible. Because of the huge number of nodes that cover the ground, for instant, in environmental or agriculture applications. This obstacle could overcome by using relay stations, in which the packets take multi hops from the source to the sink. Moreover, to achieve energy efficiency, sensor nodes communicate in multi-hop network to forward messages to the sink because achieving a reliable transmission with a distant destination needs high transmission power [15], [16]. This concept is illustrated in Figure 6 and it is attractive for WSN. Since the sensor nodes themselves can act as such relay without the need to additional device.

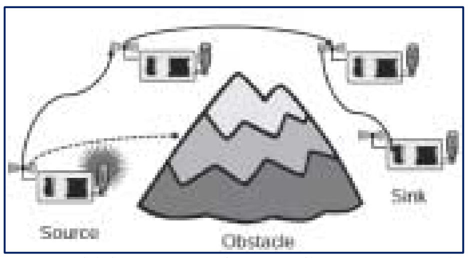

Figure 6 Multi-hop networks: As direct communication is impossible because of distance and/or obstacles, multi-hop communication can circumvent the problem.

2.6 Three types of Mobility

One of the main benefits of wireless communication is its ability to support mobile participants. In wireless sensor networks, mobility can appear in three forms:

2.6.1 Node mobility

Depend on the application of WSN the nodes themselves could be mobile. In this situation, the network has to reorganize itself frequently enough to be able to function correctly. This shows that there are trade-offs between the frequency and speed of node movement on the one hand and the energy required to maintain a desired level of functionality in the network on the other hand. An example for this kind of node mobility is in livestock surveillance, where sensor nodes attached to cattle.

2.6.2 Sink mobility

When a mobile requester requests a data that is not locally available but it must be retrieved from a remote part of the network. And since the requester can communicate only with neighbor nodes, it has to move to that remote part of the network. Here the network, possibly with the assistance of the mobile requester, must make provisions that the requested data actually follows and reaches the requester despite its movements [17]. Information requesting by a human user, by a PDA (mobile sink), where he is not part of sensor network, while walking in an intelligent building, is a good example for this kind of mobile information sink. Figure 7 illustrate the mobile sink.

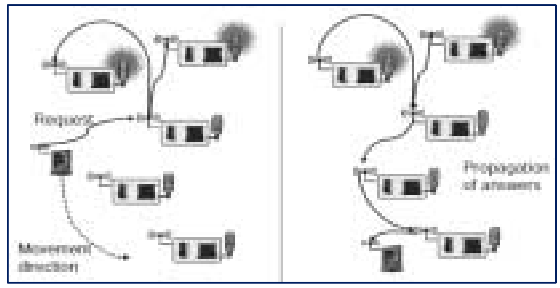

Figure 7 A mobile sink moves through a sensor network as information is being retrieved on its behalf

2.6.3 Event mobility

An example for this kind of mobility is in applications like event detection, the cause of the events or the objects to be tracked can be mobile. Usually the observed events covered by number of sensors at all time. So, sensors will wake up around the object to observe it and then go back to sleep. As the event source moves through the network, it is accompanied by an area of activity within the Network. This notion is described by Figure 8, where the task is to detect a moving elephant and to observe it as it moves around [18].

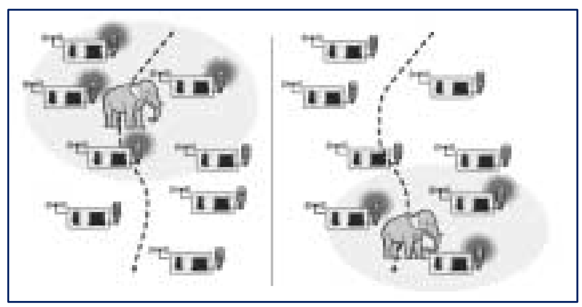

Figure 8 Area of sensor nodes detecting an event – an elephant – that moves through the network along with the event source (dashed line indicate the elephant's trajectory; shaded ellipse the activity area following or even preceding the elephant)

III. OPTIMIZATION GOALS

Although different types of applications and different forms of network solution are found, Questions like how to optimize a network, how to compare these solutions, how to decide which approach better supports a given application, and how to turn relatively imprecise optimization goals into measurable figures of merit? Are impossible to answer that is for the huge number of applications. Below are some aspects:

3.1 Quality of service

High-level QoS attributes in WSN, just like in traditional networks highly, depend on the application. Some generic possibilities are:

- **Event detection/reporting probability:** What is the probability that an event that actually occurred is not detected or, more precisely, not reported to an information sink that is interested in such an event? Simply, this probability can depend on reporting of such an event (e.g. routing tables) or depend on the run-time overhead (e.g. sampling frequencies).
- **Event classification error:** If events are not only to be detected but also to be classified, the error in classification must be small.
- **Event detection delay**: What is the delay between detecting an event and reporting it to any or all interested sinks?
- **Missing reports**: The probability of undelivered reports should be small in applications that require periodic reporting.
- **Approximation accuracy**: For function approximation applications, what is the average/maximum absolute or relative error with respect to the actual function?
- **Tracking accuracy**: Tracking applications must not miss an object to be tracked, the reported position should be as close to the real position as possible, and the error should be small.

3.2 Energy efficiency

The most important issue in WSN is the energy, the limited energy capacity of sensor nodes, usually battery operated, dictates how communications must be performed inside wireless sensor networks (WSNs). To achieve energy efficiency, sensor nodes communicate in multi-hop network to forward messages to the sink because achieving a reliable transmission with a distant destination needs high transmission power. Moreover, a sensor node to reduce the communication burden may process and aggregate incoming data before relaying it to its neighbor node [19]. Two major aspects have to be examined in order to determine the optimal data packet size for communication between neighboring sensor nodes:

1) Using Energy efficiency as optimization metric.
2) Effect of retransmissions, error control parities and encoding/decoding energies on energy efficiency.

Furthermore, the energy efficiency depends on both channel conditions and energy consumption characteristics of a sensor node.

- **Energy Consumption Characteristics**

In WSN the smallest communication entity between adjacent sensor nodes is the link layer data packet.

As shown in figure 9 link later data packet is consists of header field (long **α** bit), payload (size □ bit) and trailer (**τ** bit long).

Figure 9 Link Layer Packet Format

Header identifies event, location or attribute so α is just few bytes. The payload contains information bits and the trailer is composed of parity bits for error control [19].

Based on energy model in [20], the energy required to communicate one bit of information (E_b) through a single hop is [19]:

$$E_b = E_t + E_r + \frac{E_{dec}}{l} \quad (4)$$

Where:

E_{dec} Is the decoding energy per packet

E_t is the transmitter energy consumption

E_r is the receiver energy consumption.

And are given by

$$(5) \quad E_t = \frac{\left((P_{te} + P_0)\frac{(l + \alpha + \tau)}{R} + P_{tst}T_{tst} \right)}{l}$$

$$E_r = \frac{\left((P_{re})\frac{(l + \alpha + \tau)}{R} + P_{rst}T_{rst} \right)}{l}$$

Where:

P_{te}/P_{re} : Power consumed in the transmitter/receiver electronics

P_{tst}/P_{rst} : Start-up power consumed in the transmitter/receiver

T_{tst}/T_{rst} : Transmitter/receiver start-up time

P_0 : Output transmit power

R : Data arte (20 Kbps)

Energy, as discussed, is a precious resource in wireless sensor networks and therefore, that energy efficiency should make an evident optimization goal and should be carefully distinguished to form actual, measurable figures of merit. The most commonly considered aspects are:

- **Energy per correctly received bit**
  Amount of energy spent on average to transport one bit of information from the source to the destination is a useful metric for periodic monitoring applications.
- **Energy per reported (unique) event**
  Similarly, what is the average energy spent to report one event? Since the same event is

sometimes reported from various sources, it is usual to normalize this metric to only the unique events

- **Delay/energy trade-offs**
  Applications that have a notion of "urgent" events can increase energy investment for a speedy reporting of such events. Here, the trade-off between delay and energy overhead is interesting.

3.3 Network Lifetime

Network lifetime is a critical concern in the design of WSNs. In many applications replacing or recharging sensors sometimes is impossible. Therefore, many protocols have been proposed to increase network lifetime. It is difficult to analysis network life time because it depends on many factors like network architecture and protocols, data collection initiation, lifetime definition, channel characteristics, and energy consumption model.

Below are the most important network characteristics that affect the network lifetime.

- **Network Architecture.** Specifies how sensors should report their data to the Access points. For example in flat ad hoc architecture, it is done by multiple hops. In hierarchical WSNs, it is done by cluster heads, where the sensors form clusters and report their data to the cluster heads which in turn send it to Access points and so on.
- **Data Collection Initiation.** Data collections in a WSN can be initiated according to the applications by the event of interest (internal clock of sensor) or by demanding from the end user (request from Access point).
- **Channel and Energy Consumption Model.** Energy consumption in WSN can classify into two main categories:
  1) Continuous energy consumption and
  2) Reporting energy consumption.

The first is the minimum energy that sustain network during its lifetime, and the second is the energy that consumed during data collections, transmission, reception, and possibly channel acquisition.

3.3.1 Lifetime Concepts

Network lifetime is the time span from the deployment to the situation that the network is nonfunctional. And here some other definition of the lifetime:

- **Time to first node death:** When does the first node in the network run out of energy or fail and stop operating?
- **Network half-life:** When have 50% of the nodes run out of energy and stopped operating?
- **Time to partition:** When does the first partition of the network in two (or more) disconnected parts occur? This can be as early as the death of the first node or occur very late if the network topology is robust.
- **Time to loss of coverage:** The first time any spot in the deployment region is no longer covered by any node's observations. In tracking applications, for example, *r* redundant observations are necessary, the corresponding definition of loss of coverage would be the first time any spot in the deployment region is no longer covered by at least *r* different sensor nodes.
- **Time to failure of first event notification:** A network partition can be seen as irrelevant if the unreachable part of the network does not want to report any events in the first place. This can be due to an event not being noticed because the responsible sensor is dead or because a partition between source and sink has occurred.

Obviously, the longer these times are the better does a network performs. However, general formula for network lifetime has been driven in [21] which hold independently of the characteristics that affect the network lifetime mentioned above (network architecture and protocols, data collection initiation, lifetime definitions, channel characteristics, and energy consumption model). This general formula depends on two physical parameters: the channel state and residual energy of sensors. It indicates that channel state information (CSI) and the residual energy information (REI) should be exploited in the lifetime maximizing protocols. By using both CSI and REI, the proposed protocol maximizes the minimum residual energy across the network in each data collection.

The average lifetime of WSN have studied in a general setting no network architecture has specified nor the channel and the energy consumption model. Moreover, the interesting thing is the obtained formula applies to any definition of the network lifetime. The theorem is as below:

"For a WSN with total non-rechargeable initial energy E_0, *the average network lifetime E[L], measured as the average amount of time until the network dies, is given by*

$$\mathbf{E}[\mathbf{L}] = \frac{E_0 - E[E_w]}{P_C + \lambda E[E_r]}$$

Where Pc is the constant continuous power consumption over the whole network, E[Ew] is the expected wasted energy (i.e., the total unused energy in the network when it dies), λ is the average sensor reporting rate defined as the number of data collections per unit time, and E[Er] is the expected reporting energy consumed by all sensors in a randomly chosen data collection."

Finally, lifetime maximizing protocol (max-min protocol) aims to reduce the average wasted energy E[*Ew*] by exploiting the REI of individual sensors and the average reporting energy E[*Er*] by exploiting the CSI to give the priority to the sensors with better channels transmission. Hence, energy consumed in transmission will be reduced [21].

3.4 Scalability

Scalability is the ability to maintain performance characteristics irrespective of the size of the network. Because of the huge number of nodes in WSN, scalability is an indispensable requirement. The need for extreme scalability has direct consequences for the protocol design. Architectures and protocols should implement appropriate scalability support rather than trying to be as scalable as possible.

3.5 Robustness

Wireless sensor networks should not fail just because a limited number of nodes run out of energy, or because their environment changes and severs existing radio links between two nodes. They should exhibit an appropriate robustness and these failures must be solved by finding other route. A precise evaluation of robustness is difficult in practice and depends mostly on failure models for both nodes and communication links.

IV. Conclusion

Because of limitations in energy storage of batteries, the energy management in WSN is one of important parameters. Many methods are presented for energy management on the sensor networks until now but mostly to the study of energy management in the network already designed and presented several routing protocols in this regard while we would like to customize the network architecture. Here firstly, we reviewed the general concepts of computer networks architecture. Then we have discussed topics that have direct relationship with the consumption of energy. We analyzed the all impact parameters in energy consumption.

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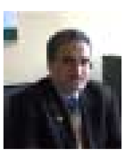

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