Low- Power and Low - cost Wireless Sensor Networks

Dara Sampath Kumar
Associate Professor
Vaageswari college of Engineering, Karimnagar, T.S, India

Dr G.R.K Subrahmanyam
Professor
Vaageswari college of Engineering, Karimnagar, T.S, India

Abstract*: -* The challenging task for the design of wireless sensor networks (WSN) is to maintain long lifetime of network since the sensor nodes are severely energy-constrained. Traditional WSN assumes employment of conventional RF transmitters which consume most of the stored power on the sensor node. The main objective of this project is to investigate the communication coverage. The communication performance of WPSN is directly related to the RF coverage provided over the field the passive sensor nodes are deployed. The required number of RF sources to obtain interference-free communication connectivity with the WPSN nodes is determined and analyzed in terms of output power and the transmission frequency of RF sources, network size, RF source and WPSN node characteristics

I. INTRODUCTION

Wireless Sensor Networks (WSN) are of low-cost, low-power sensor nodes, they are equipped with a limited power source, i.e., a battery. Sensor nodes consume most of the stored power during RF transmission. At this point, modulated backscattering (MB) is a promising communication technique leading to a new sensor network paradigm, Wireless Passive Sensor Networks (WPSN) [1]. WPSN are supplied with energy by external RF power sources. With MB approach, a passive sensor node transmits its data simply by modulating the incident signal from an RF source by switching its antenna impedance. Therefore, the transmitter is basically an antenna impedance switching circuitry, and WPSN is free of the lifetime constraint of conventional WSN.

Sensor networks [2] are an important emerging area of mobile computing that presents novel wireless networking issues because of their unusual application requirements, highly constrained resources and functionality, small packet size, and deep multi hop dynamic topologies. Although many high level architectural and programming aspects of this area are still being resolved, the underlying media access control (MAC) and transmission control protocols are critical enabling technology for many sensor network applications. These problems are well-studied for traditional computer networks, however, the different wireless technologies, application characteristics, and usage scenarios create a complex mix of issues that have led to the existence of many distinct solutions. It is natural to expect the low-level protocols to evolve again for this new era

The literature review is backscatter modulation is frequently used in microwave tagging or sensor systems for interrogating remote devices [3]. The energy consumption in transmitting an information bit, i.e., energy-per-bit, has been known to decrease monotonically as the transmission time increases. However, when considering the power amplifier (PA) characteristics, we learn that the energy-per-bit starts to increase as the transmission time becomes long over a certain threshold [6]. F. Kocer [4] showed that measured results of an experimental tagging system setup operating in the 2.4-GHz ISM band are presented which show the performance of the proposed interrogator. C. A. Balanis [5] represented that the basic concepts of antenna analysis and design.

The main focus of this paper is to investigate the communication coverage problem in WPSN. More specifically, minimum number of RF sources to achieve successful MB based communication in WPSN is investigated. Furthermore, the relation between the numbers of RF sources that are required to obtain interference-free RF communication coverage is analyzed in terms of output power and the transmission frequency of RF sources, network size, RF source and WPSN node characteristics.

Sensor networks are an important emerging area of mobile computing that presents novel wireless networking issues because of their unusual application requirements, highly constrained resources and functionality, small packet size, and deep multi hop dynamic topologies. Although many high level architectural and programming aspects of this area are still being resolved, the underlying Media Access Control [8] (MAC) and transmission control protocols are critical enabling technology for many sensor network applications. These problems are well-studied for traditional computer networks, however, the different wireless technologies, application characteristics, and usage scenarios create a complex mix of issues that have led to the existence of many distinct solutions. It is natural to expect the low-level protocols to evolve again for this new era.

The organization of the document is as follows, Section II will discuss about Wireless sensor networks and Section III will discuss about Wireless system analysis. Simulation results will be discussed in section IV and conclusion is given in Section V

II. WIRELESS SENSOR NETWORKS

In the third Millennium, wireless sensor networks (WSNs) [9] generated an increasing interest from industrial and research perspectives. A WSN can be generally described as a network of nodes that cooperatively sense and may control the environment enabling interaction between persons or computers and the surrounding environment. On one hand, WSNs enable new applications and thus new possible markets, on the other hand, the design is affected by several constraints that call for new paradigms. In fact, the activity of sensing, processing, and communication under limited amount of energy, ignites a cross-layer design approach typically requiring the joint consideration of distributed signal/data processing, medium access control, and communication protocols.

The main features in WSNs design are described later. Specifically, the design of energy efficient communication protocols is a very peculiar issue of WSNs, without significant precedent in wireless network history. Generally, when a node is in transmit mode, the transceiver drains much more current from the battery than the microprocessor in active state or the sensors and the memory chip. The ratio between the energy needed for transmitting and for processing a bit of information is usually assumed to be much larger than one (more than one hundred or one thousand in most commercial platforms). For this reason, the communication protocols need to be designed according to paradigms of energy efficiency, while this constraint is less restrictive for processing tasks. Then, the design of energy efficient communication protocols is a very peculiar issue of WSNs, without significant precedent in wireless network history [7].

We present a model shown in fig.1 which explain both for maximizing the total information gathered subject to energy constraints (on sensing, transmission, and reception), and for minimizing the energy usage subject to information constraints. The process of standardization in the field of WSNs is very active in the last years and an important outcome is represented by IEEE 802.15.4 which is a short-range communication system intended to provide applications with relaxed throughput and latency requirements in Wireless Personal Area Networks (WPAN) . The main features of the 802.15.4 standard are resumed, where examples of performance indexes are illustrated in terms of area throughput and energy efficiency. Others technologies such as Ultra WideBand (UWB), Bluetooth and other custom-defined technologies are reported. We finally conclude the paper by giving our vision on future research directions.

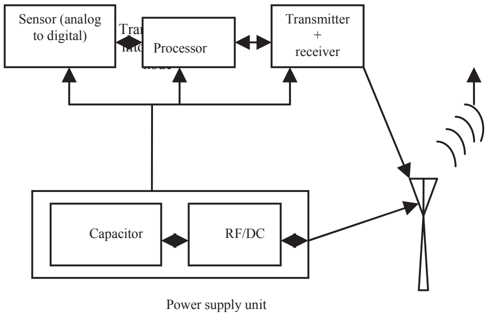

Fig 1 WPSN Sensor node

A two-point source interference pattern shown in fig.2 is always has an alternating pattern of nodal and antinodal lines. There are however some features of the pattern which can be modified. First, a change in wavelength (or frequency) of the source will alter the number of lines in the pattern and alter the proximity or closeness of the lines. An increase in frequency will result in more lines per centimeter and a smaller distance between each consecutive line. And a decrease in frequency will result in fewer lines per centimeter and a greater distance between each consecutive line.

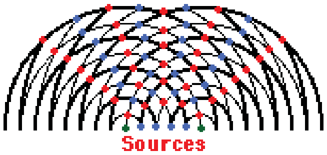

Fig.2 Two-point source interference pattern

III. SYSTEM ANALYSIS

The Path Difference

Two-point source interference occurs when waves from one source meet up with waves from another source. If the source of waves produces circular waves, then the circular wave fronts will meet within the medium to produce a pattern. The pattern is characterized by a collection of nodes and antinodes that lie along nearly straight lines referred to as antinodal lines and nodal lines. If the wave sources have identical frequencies, then there will be an antinodal line in the exact center of the pattern and an alternating series of nodal and antinodal lines to the left and the right of the central antinodal line. Here each line in the pattern is assigned a name (e.g., first antinodal line) and an order number (represented by the symbol m). A representative two-point source interference pattern with accompanying order numbers (m values) is shown in fig.3

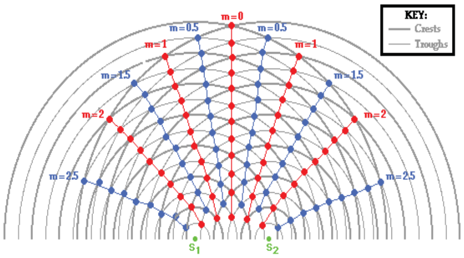

Fig 3. Two point source interference m=0 to 2.5

In this paper, we will investigate the rationale behind the numbering system and develop some mathematical equations that relate the features of the pattern to the wavelength of the waves. This investigation will involve the analysis of several antinodal and nodal locations on a typical two-point source interference pattern. It will be assumed in the discussion that the wave sources are producing waves with identical frequencies (and therefore identical wavelengths).

To begin, consider the pattern shown in fig.4 the Point A is a point located on the first antinodal line. This specific antinode is formed as the result of the interference of a crest from Source 1 (S_1) meeting up with a crest from Source 2 (S_2). The two wave crests are taking two different paths to the same location to constructively interfere to form the antinodal point.

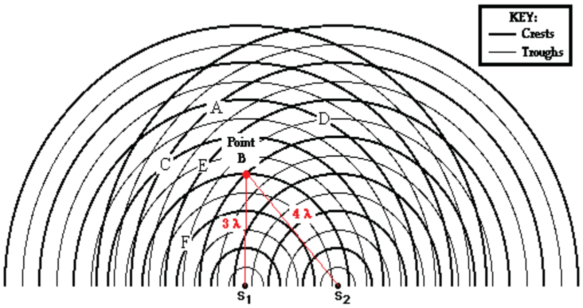

Fig 4. Comparison of distances from two sources (s_1,s_2) to point (A,B,C,D,E,F)

The crest traveling from Source 1 (S_1) travels a distance equivalent to 5 full waves; that is, point A is a distance of 5 wavelengths from Source 1 (S_1). The crest traveling from Source 2 (S_2) travels a distance equivalent to 6 full waves; point A is a distance of 6 wavelengths from Source 2 (S_2). While the two wave crests are traveling a different distance from their sources, they meet at point A in such a way that a crest meets a crest. For this specific location on the pattern, the difference in distance traveled (known as the **path difference** and abbreviated as **PD**) is

$$\mathbf{PD = | S_1A - S_2A | = | 5\lambda - 6\lambda | = 1\,\lambda} \quad \ldots\ldots\ldots(1)$$

Note the path difference or PD is the difference in distance traveled by the two waves from their respective sources to a given point on the pattern.

Table.1 Summary of the Path Difference Analysis

Point	antinode or Node?	Order (m)	Distance from S_1 (in λ)	Distance from S_2 (in λ)	Path Difference (in λ)
A	Antinode	1	5 λ	6 λ	1 λ
B	Antinode	1	3 λ	4 λ	1 λ
C	Antinode	2	4 λ	6 λ	2 λ
D	Node	0.5	5 λ	4.5 λ	0.5 λ
E	Node	1.5	3.5 λ	5 λ	1.5 λ
F	Node	2.5	2 λ	4.5 λ	2.5 λ

The path difference is always the order number multiplied by the wavelength. That is,

$$PD = m \bullet \lambda \quad \ldots\ldots\ldots(2)$$

Furthermore, one might notice that the path difference is a whole number of wavelengths for the antinodal positions and a half number of wavelengths for the nodal positions. That is,

Antinodal Points: $PD = m \bullet \lambda$ where m = 0, 1, 2, 3, 4, ...

Nodal Points: $PD = m \bullet \lambda$ where m = 0.5, 1.5, 2.5, 3.5, ...

IV. RESULT ANALYSIS

For a WPSN node calculate the P_r (Recived power), and next calculate the P_t (Transmitted power) by using Friss transmission equation, then after calculate the value of 'k'. Where $k = \frac{\Delta}{2\pi R_{RF}}$ and

$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi R_{RF}} \right)$, Where G_tG_r = Antenna gains, R_{RF} = communication range of an RF source.

k= required number of RF sources to provide MB based communication coverage, Δ= Event area of size.

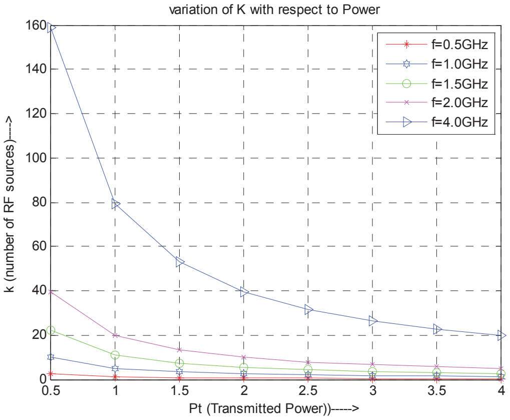

Fig.5 Variation of K with respect to power

From the above graph we can observe the number of Rf sources decreased by increasing the transmitted power. And we can observe, at 1GHz frequency and at 1W power the number of Rf sources are 5. at 2GHz frequency and at 2W power the number of Rf sources are 10, that means if we double the transmitting power and the frequency the number of Rf sources also doubled.

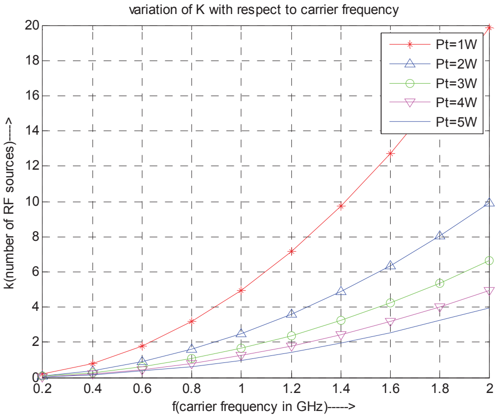

Fig.6 Variation of K with respect to carrier frequency

From the above graph we can observe the number of Rf sources are increased by increasing the carrier frequency. Here we can observe at 1GHz frequency and at 1W power the number of R_f sources 5. At 2GHz frequency and at 2W power the number of R_f sources are 10

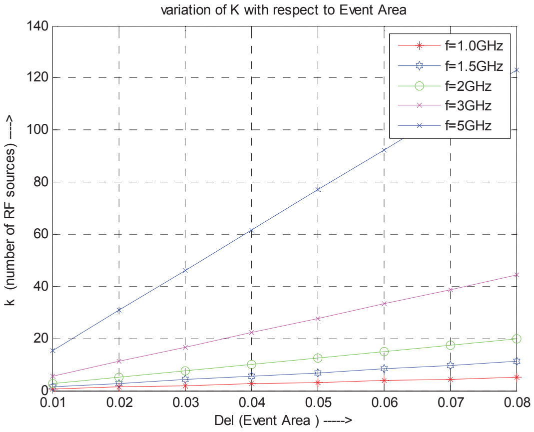

Fig.7 Variation of K with respect to event area

Increasing the size of the event field also increases the required number of RF sources for a given output power, because RF sources with a given output power have a limited range determined by their output power, and more such RF sources are needed to cover a larger area.

V. CONCLUSION

The analysis developed here can be used towards determination of design strategies of battery-free WPSN as well as radio frequency identification (RFID) networks. The communication coverage problem in WPSN was investigated. More specifically, minimum number of RF sources to achieve successful MB based communication in WPSN is investigated. Furthermore, the relation between the numbers of RF sources that are required to obtain interference-free RF communication coverage is analyzed in terms of output power and the transmission frequency of RF sources, network size, RF source and WPSN node characteristics.

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