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# Improving the Lifetime of Wireless Sensor Nodes Batteries by using SEMD (Single Energy Multi Data) and MEMD (Multi Energy Multi Data) Transmission Modes

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## Abstract

The main problem which occur in wireless communication networks is the field nodes are battery resource constrained. Consider a situation of multi-hop wireless communication in a sensor network in which using ad hoc multi hop network the information from a node is transferred to the base station. That is, the sensed information from a field sensor node is forwarded by multiple intermediate nodes until information reaches the base station. If due to low battery power one of the nodes which participate in multi-hop forwarding is switched off, the network is disconnected and the field information could be lost on the way. While energy efficiency of communication protocols tries to ensure extended network lifetime, battery drainage problem still remains. In many applications, it is very difficult or infeasible to replace the exhausted batteries due to the deployment terrain condition or because of the sheer number of field nodes, .The means to recharge the nodes without shutting down the network is very important for uninterrupted operation of the network and also to keep the network maintenance cost at a minimum.

One technology which serves this purpose is energy harvesting - a process by which from an external ambient source energy is derived (e.g., kinetic energy, RF, solar power, thermal energy, or vibration and wind energy). While there have been proposals on tapping the non-network ambient energy sources, such as solar, thermal, wind, etc., they are not universally available. Recharging from RF sources is being investigated by other researchers, which proposes to use very high power external source, such as microwave source, and it involves a significant waste of RF energy. We propose to use the RF energy that is already available in the network due to regular communication among the nodes. Our approach does not depend any specific external energy sources, and thus, if found feasible, it would over a universal solution. In this work, we explore the means of imparting energy to the field nodes by exploiting network topology and communication protocols. The first aim is to achieve a condition that allows equal distribution of energy among all nodes. We test the one-dimensional as well as two-dimensional topologies, antenna radiation patterns, and coordination among nodes in receiving and radiating energy, to achieve the best possible equitable energy distribution. To achieve the equienergy distribution we propose a method in which the field nodes which are power rich not only receive energy from the power they also contribute energy to the weaker nodes. We call it as multi hop charging. In this study, we compared the multi hop charging with the single hop charging method.

**Keywords—** Wireless communication network, energy efficiency RF energy, sensor nodes, multi-hope communication and recharging, Energy harvesting, energy scavenging, wireless sensor networks (WSNs), energy management

## 1. INTRODUCTION

The wireless sensor nodes rely on batteries for the energy needed for their operation. With the energy harvesting technology, the batteries can be recharged. The challenge is developing the technology in which the sensor nodes can be operated battery free saving the maintenance and replacement costs. In this study we describe a novel approach of harvesting RF energy which is already available in the network

The following are the major issues we are addressing

- Sensor nodes are power constrained. So need to be recharged automatically.
- There is need for battery free operation. It also saves opex costs and replacement efforts.
- How the cluster head in a sensor network can act as energy source and data sink.
- How efficiently the RF energy can be used for multi hop communication.

Various energy harvesting approaches were studied. This work is based on the idea of transferring energy to the field nodes not only from the energy source but also from the higher power nodes that is which has more power compared to other nodes in the network. We call it as multi hop energy transfer or multi hop charging.

**Fig 1.** source delivering power to the sensor node

In the WSN, there is a need for sensor nodes to be recharged automatically. One of the ways is RF energy harvesting - a method of receiving electromagnetic energy and converting it to DC power, Which is the input to the battery charging circuit whose output is used for transmitting and receiving the signal. This can be accomplished using antenna, rectifier, charging circuit as shown in fig 2

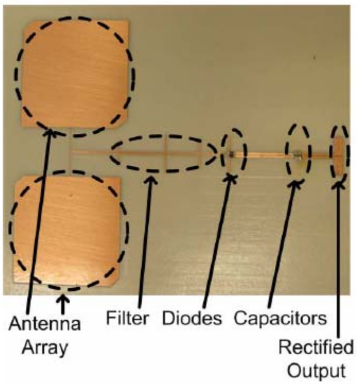


**Fig 2.** Prototype of Antenna Array and Rectification circuit

We propose a system where battery powered wireless sensor nodes can be recharged by harvesting energy from a microwave Radio Frequency (RF) signal source as shown in figure 3. The remote power charging module of the wireless sensor node architecture consisted of an antenna array and a rectification circuit. A prototype of the antenna array and rectification circuit of the remote power charging module for the wireless sensor node was constructed and is presented in this paper.

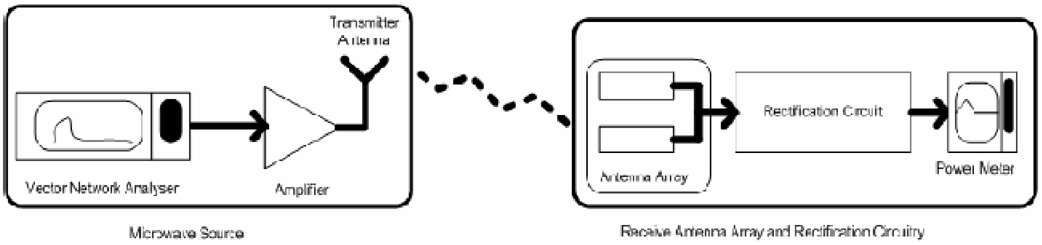


**Fig** 3. RF energy harvesting Process.

Wireless RF power transmission has been investigated as a viable method of power delivery in a wide array of applications, from high-power space solar power satellites to low-power wireless sensors. However, until recently, efficient application at the low sub-milli watt power levels has not been realized due to limitations in available control circuitry. This paper presents RF energy is currently broadcasted from billions of radio transmitters around the world, including mobile telephones, handheld radios, mobile base stations, and television/ radio broadcast stations. The ability to harvest RF energy, from ambient or dedicated sources, enables wireless charging of low-power devices and has resulting benefits to product design, usability, and reliability. Battery-based systems can be trickled charged to eliminate battery replacement or extend the operating life of systems using disposable batteries. Battery-free devices can be designed to operate upon demand or when sufficient charge is accumulated. In both cases, these devices can be free of connectors, cables, and battery access panels, and have freedom of placement and mobility during charging and usage

The obvious appeal of harvesting ambient RF energy is that it is essentially “free” energy. The number of radio transmitters, especially for mobile base stations and handsets, continues to increase. ABI Research and supply estimate the number of mobile phone subscriptions has recently surpassed 5 billion, and the ITU estimates there are over 1 billion subscriptions for mobile broadband. Mobile phones represent a large source of transmitters from which to harvest RF energy, and will potentially enable users to provide power-on-demand for a variety of close range sensing applications. Also, consider the number of Wi-Fi routers and wireless end devices such as laptops. In some urban environments, it is possible to literally detect hundreds of Wi-Fi access points from a single location. At short range, such as within the same room, it is possible to harvest a tiny amount of energy from a typical Wi-Fi router transmitting at a power level of 50 to 100 mW. For longer-range operation, larger antennas with higher gain are needed for practical harvesting of RF energy from mobile base stations and broadcast radio towers. In 2005, Power cast demonstrated ambient RF energy harvesting at 1.5 miles (~2.4 km) from a small, 5-kW AM radio station. RF energy can be broadcasted in unlicensed bands such as 868MHz, 915MHz, 2.4GHz, and 5.8GHz when more power or more predictable energy is needed than what is available from ambient sources. At 915MHz, government regulations limit the output power of radios using unlicensed frequency bands to 4W effective isotropic radiated power (EIRP), as in the case of radio-frequency-identification (RFID) interrogators. As a comparison, earlier generations of mobile phones based on analog technology had maximum transmission power of 3.6W, and Power cast’s TX91501 transmitter that sends power and data is 3W.

## 2. MODEL ASSUMPTION

ATLAS universal patch antenna of 3db is considered for source antenna at node A and nodes 'B’, ’C'. Radiated power delivered by the source node A is 40dbm. e1=0.35 % rectification efficiency according to received power at node 'a' in receiving mode (from the paper umedo) e2=0.12 % rectification efficiency according to received power at node 'b' when it is receiving only from source (from the paper umedo) e3=0.32 %rectification efficiency at node 'b' when it is receiving both from source and the node 'a'

CC 1000[7] is a low power transceiver that can be used in the sensor node for low power applications. It can be operated at 315/433/915 MHz frequency bands. The current consumption while transmitting is 5.3 mA at -20 dbm and 7.4 mA while receiving the signal at a data rate of 76.8 kbps. It has different power transmission levels- -20dbm, -5 dbm, 0dbm, 5dbm, 10 dbm. Different types of antenna datasheets [8], [9], [10], [11] are used for simulation purpose. And last K is the compression factor. Mat lab simulation tool is used for implementing our approach. If an antenna transmits certain amount of power to a farther node, the power received at the receiver will be found as follows.

$$p_r(dbm) = p_t(dbm) - PL(db) \qquad (2.1)$$

where
$p_r$=received power
$p_t$=transmitted power
PL−path loss
path loss is calculated using logarithmic path loss model

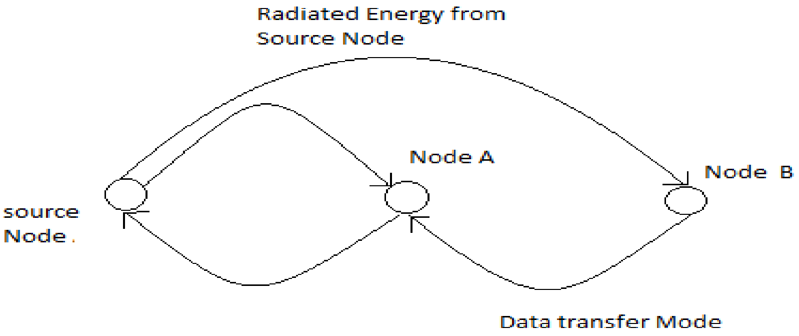
$$PL(d) - PL(d_0) + 10 * n * log(\frac{d}{d_0}) + Fadingloss \qquad (2.2)$$

where
$d_0$=reference distance
$PL(d_0)$=path loss at $d_0$
which is calculated as

$$PL(d_0) = -10 * log(\frac{g_t * g_r * \lambda^2}{(4 * pi * d_0)^2}) \qquad (2.3)$$

where $\lambda$ =wavelength of the signal= $\frac{speedoflight}{frequencyofoperation}$
$g_t$=gain of transmitter antenna
$g_r$=gain of receiver antenna
Fading losses are taken as 6dB [15]

**SEMD (Single energy multi data transmission mode)**



## 3. RELATED WORK

WSNs have received a lot of attention in recent years and this is reflected in the significant interest shown by researchers in its different aspects. Power and energy efficiency have received particular attention because of limiting value they place on the many potentials of WSNs. A brief discussion of some background information from related research is discussed in the sections that follow. Many research efforts geared towards increasing the lifespan of WSN batteries have adopted the approach of lulling the WSNs to sleep at periods when they are neither receiving nor transmitting data. In their work, Li et al [10] identified with the mostly-off approach of Intel's Fab project. As a modification, they presented a low-power listening with flooding, as well as local update with suppression as a means of reducing latency and cost of flooding respectively, while enjoying the benefits of sleeping nodes. Low power listening involves the periodic sampling of a channel by taking one or a few signal strength samples . Some techniques utilize duty cycling to conserve power. In duty cycling, sensor nodes periodically alternate between active and sleeping states. An added synchronization requirement is implicitly imposed since nodes need to be on for data transmission to occur. Sensor MAC (S-MAC), a technique employs message pass into reduces contention latency and uses synchronization between local nodes to account for clock drift.

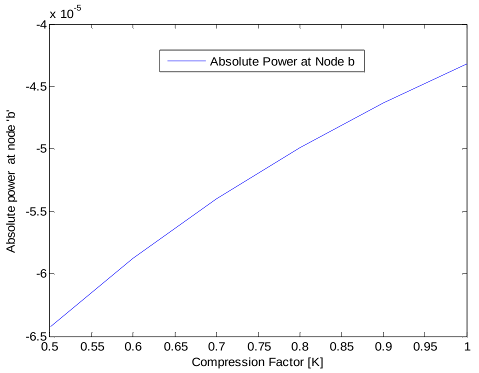
## 4. FINAL RESULT

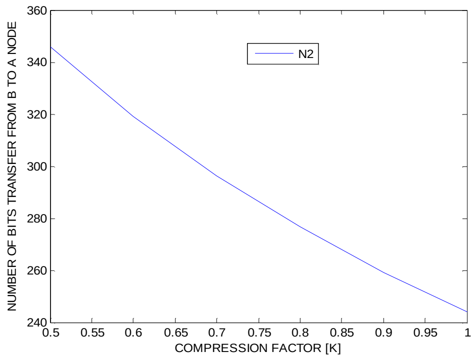
Case 1: Ea= zero (i.e. remaining Energy after transmission and reception become Zero at Node A). Than there is only one equation implies one unknown variable. 'X2' which is fraction of time node 'b' in transmission of data to node 'a' is considered as unknown.

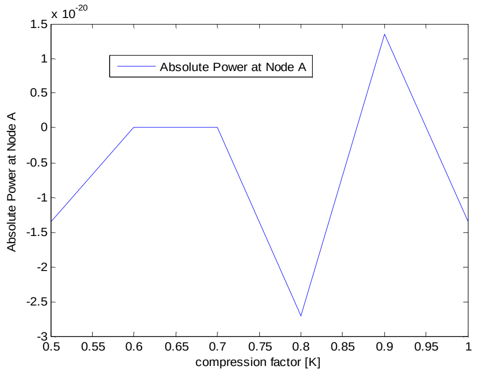
$$E_a = e_1 * p_1 * (T - x_1 - x_2 - x_3) - x_3 * p_d - p_{t_x} * x_1 - p_{r_x} x_2$$

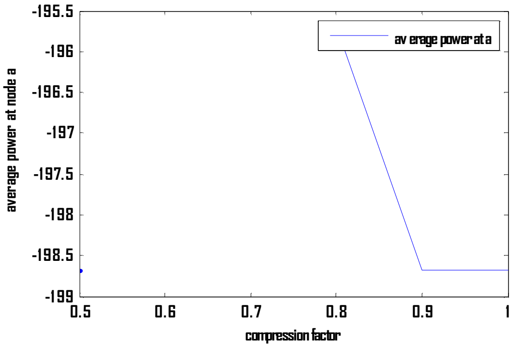
$$E_b = e_2 * p_2 * (T - x_1 - x_2 - x_3) + e_3 * (p_{d1} + p_2) * x_3 - p_{t_x} * x_2$$

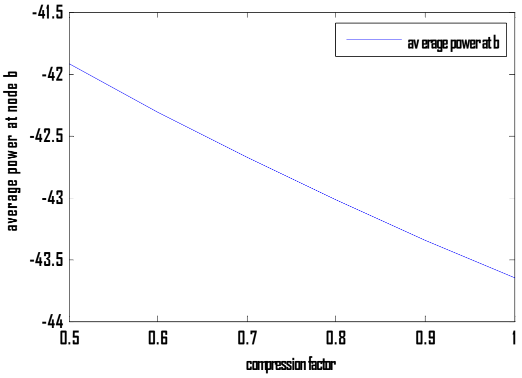
It is clearly show that when Ea put zero than Maximum number of bits transfer from B to A is 346 and minimum is 245. And Maximum number of bits transfer from A to Source node is 490 and minimum is 346. It is clearly find that remaining energy at node B will be negative and no recharge process going on. So finally discard this case and put Eb will be zero.

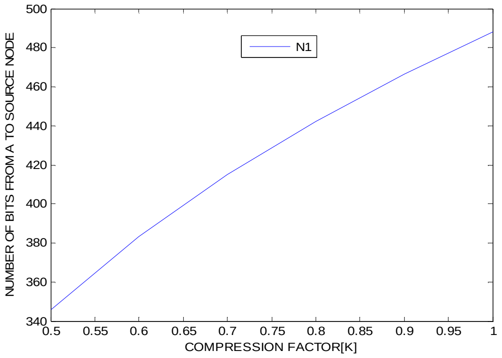

x 10^-5
Absolute Power at Node b
Absolute power at node 'b'
-4
-4.5
-5
-5.5
-6
-6.5
0.5 0.55 0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1
Compression Factor [K]

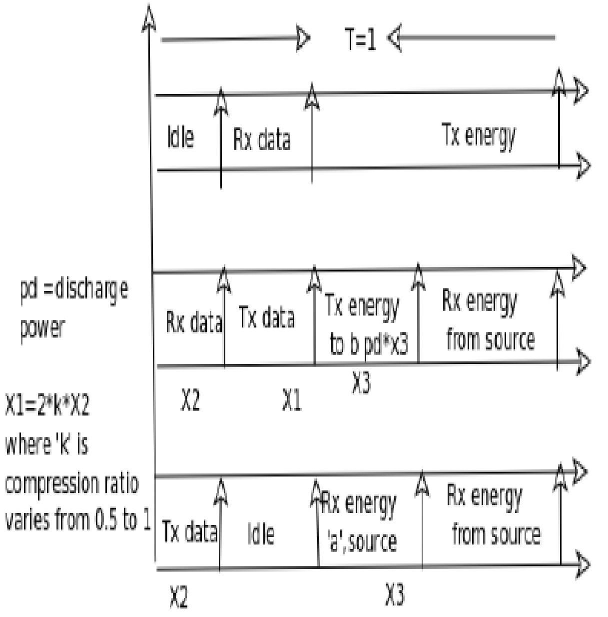

N2
NUMBER OF BITS TRANSFER FROM B TO A NODE
360
340
320
300
280
260
240
0.5 0.55 0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1
COMPRESSION FACTOR [K]


x 10^-20
Absolute Power at Node A
Absolute Power at Node A
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
0.5 0.55 0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1
compression factor [K]


av erage power at a
average power at node a
-195.5
-196
-196.5
-197
-197.5
-198
-198.5
-199
0.5 0.6 0.7 0.8 0.9 1
compression factor


av erage power at b
average power at node b
-41.5
-42
-42.5
-43
-43.5
-44
0.5 0.6 0.7 0.8 0.9 1
compression factor


N1
NUMBER OF BITS FROM A TO SOURCE NODE
500
480
460
440
420
400
380
360
340
0.5 0.55 0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1
COMPRESSION FACTOR[K]

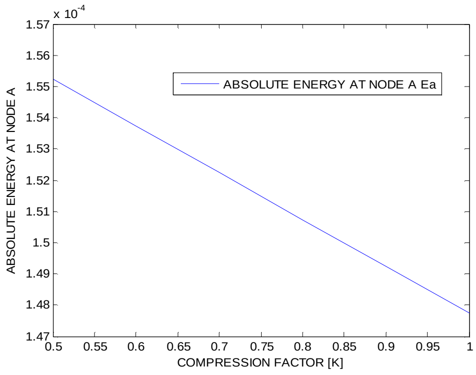


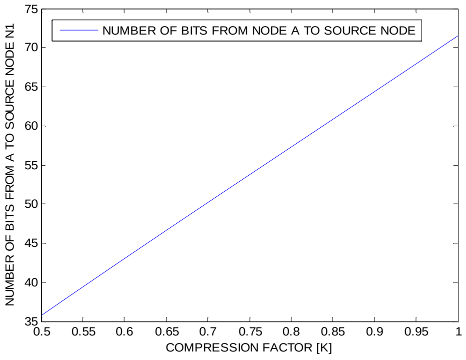
Timing Diagram of Multi hop charging and communication

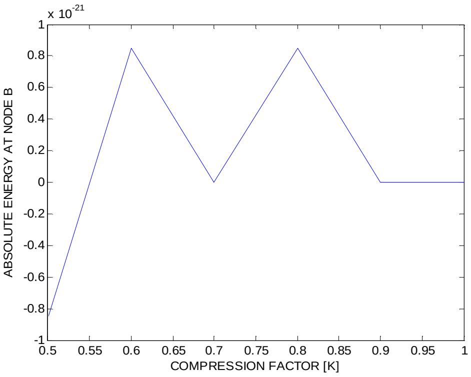
**Case 2: when Eb=0**

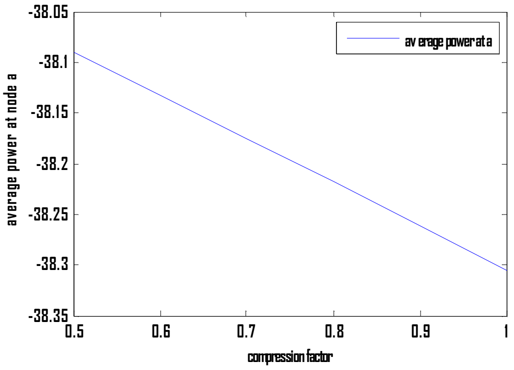
Eb= zero. here there is only one equation implies one unknown variable.'x2' which is fraction of time node 'b' in transmission of data to node 'a' is considered as unknown.

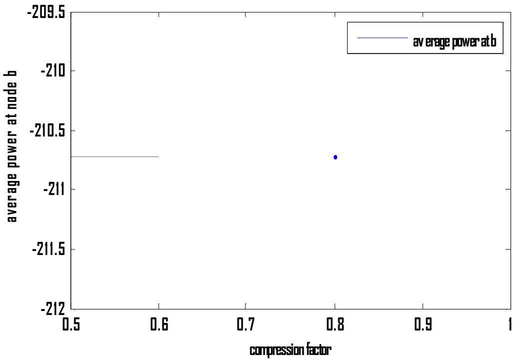
In this case Eb put zero than we find that both Ea and Eb find positive and very effectively and number of bits transfer from Node B to A is approx. 36 and A to source is minimum 36 and maximum 72. In this case we observe that our battery effectively charge and appropriate communication going on from each and every node.

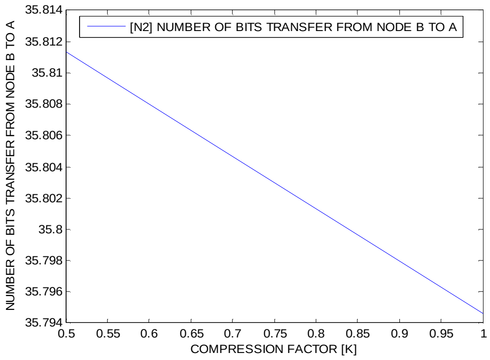












## 5. DISADVANTAGE OF EXISTING TECHNOLOGY

Two kinds of far-field coupling electromagnetic energy sources are usually considered currently: ambient radiation derived from radio and TV broadcasting, and energy deliberately broadcast by RF devices. The former is not reliable while the latter needs a deliberate energy supply.

In addition, people have to face the problem of electromagnetic pollution, and it is considered that overall electromagnetic radiation should be reduced. So it makes sense to make use of existing electromagnetic radiation distributed around rather than adopting additional electromagnetic power supply device.

## 6. Future Work:

The goals achieved are, the power patterns of different one dimensional and two dimensional topologies are simulated and analyzed. Achieved equienergy distribution for a three node case (without data transfer), the multi hop energy transfer and direct energy transfer approaches are compared. The optimum configuration of parameters for multi hop charging is required which is analyzed for a certain configuration of a network.

There can be some improvements in the project. Equienergy distribution case can be analyzed increasing the number of nodes with and without data transfer. This can be extended to the random deployment of nodes.

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