Radio frequency (RF) Energy Harvesting to Recharge Wireless Senor Nodes (WSNs) using Single Hop and Multi Communication

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Abstract— This idea of implementation is to use renewable energy from environment for generating electricity from one of the renewable energy sources. The main problem in wireless senor nodes is to battery resources to main problem due to when one of the node is switch of due to battery resources in multi hope communication than network is fail to connect next node and information have been lost. Recharging the nodes without shutting down the network is very important for uninterrupted operation of the network and also to keep the network maintenance cost to a minimum. In this work we proposed a novel form of recharging of battery resource by using waste RF energy using multi energy, multipath architecture. Here we design multi hope architecture using multi energy multipath of data to achieve the best possible energy harvesting to recharge the network using RF waves. The resultant electrical energy is stored in a battery such that it can be used for charging of wireless sensor node battery resources. 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: Multi Hop Charging, Single Hop Charging, WSN, RF

I. 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[1]. The motivation of the work is to develop an efficient communication protocol which ensures the multi hop communication in a sensor network without any power constraints from the sensor nodes, which recharges the field nodes automatically with the available network energy[1-5]. Energy can be harvested in various ways using solar, wind, vibrations, RF etc. The reason for preferring RF harvesting over others is explained as follows. Consider a situation in which an energy source is delivering power to a sensor node in the network as shown in Fig1. If a node in between receives this energy it will not be a loss to the other node for which 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. The brief overview about the Excusive review are show in table 1.

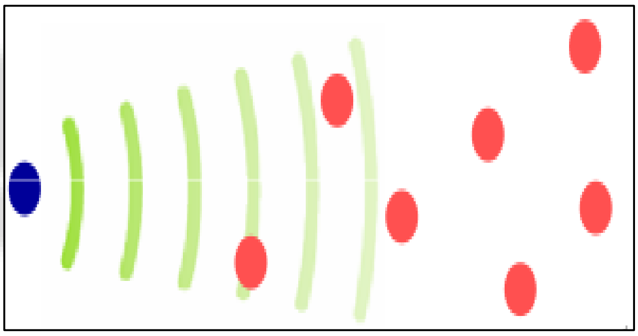


Fig. 1: Source delivering power to sensor nodes

Investigator	Year of Publication	Methodology	Evolution of Criteria
Priya kumara et al [1]	2017	ambient energy from environment through antenna	Output voltage & Efficiency
Sultan. M. Hamid et al [2]	2015	Review paper	Review of exist parameter
AminovParvizso et al [3]	2014	ambient energy from environment through antenna	Output voltage
Warda Saeed et al [4]	2018	RF Energy Harvesting for Ubiquitous	Zero Power utilization in energy Harvesting
PrusayonNintanavongsa et al [5]	2014	Survey paper	RF energy evolution method discuss
AsmaBakkali[6]	2017	Radio frequency energy harvesting	RF frequency energy harvesting
Alex Mouapi[7]	2018	Optimized Radiofrequency Energy Harvesting System	Low-Energy Adaptive Clustering
Prof.SonalHutke et al [8]	2018	RF Energy harvesting	Output Voltage
UfukMuncuk et al [9]	2018	Ambient RF energy harvesting	RF energy evolution method discuss
YunusUzun et al [10]	2016	Radio frequency (RF) energy harvester systems	Efficiency
Hamid Jabbar et al [11]	2010	RF energy harvesting	Efficiency

Action NECHIBVUTE et al [12]	2017	radio frequency (RF) energy harvesting	Efficiency
Xiao Lu et al [13]	2015	RF energy harvesting system	Output Voltage

Table 1: Review of literature

From Table 1, it is concluded that RF energy harvesting is key technology for new energy source [1-13]. It is further concluded that radio frequency generated using antenna and it will be used for further conversion into electrical signal using transducer. In this study we describe a novel approach of harvesting RF energy which is already available in the network.

II. RELATED WORK

Ambient radio waves are universally present over an ever-increasing range of frequencies and power levels, especially in highly populated urban areas. These radio waves represent a unique and widely available source of energy if it can be effectively and efficiently harvested. The growing number of wireless transmitters is naturally resulting in increased RF power density and availability [1-13,16]. Dedicated power transmitters further enable engineered and predictable wireless power solutions. With continued decreases in the power consumption of electronic components, increased sensitivity of passive receivers for RF harvesting, and improved performance of low-leakage energy storage devices, the applications for wire-free charging by means of RF-based wireless power and energy harvesting will continue to grow[17]. The RF energy conversion block diagram using antenna as shown in Fig.2.

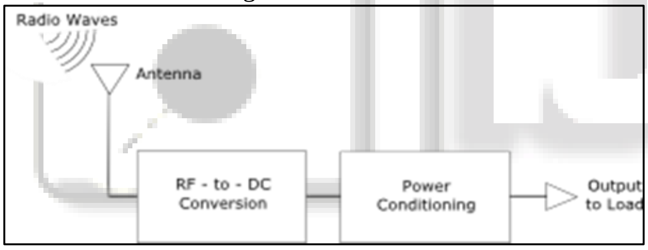


Fig. 2: RF Energy conversion block diagram using antenna

A. *Ecoupled Technology*

Ecoupled technology uses the principle of RF energy harvesting. It uses the concept of near field inductive coupling and combines it with the wireless communication [18]. The primary coil at the power source generates the electromagnetic energy and at the end device (which is to be recharged), the secondary coil converts this energy to electricity[19]. Authentication process is built in the technology so that only the device which has the related signature is only allowed to receive power [21]. So it does not require surface contact between the transmitter and receiver.

B. *Powercasto Technology*

In this technology, dedicated source sends the RF energy to the devices. The receiver which contains the antenna and harvesting circuit receives and stores the energy after converting to DC. The source sends power as needed that is on demand or scheduled or continuously [20]. The rectifier circuit has the conversion efficiency of 50% to 70%.

C. *Other Research Method*

Some Researchers have proposed protocols to harvest RF energy a protocol for RF energy harvesting in ZigBee network. It proposes two methods [21-23]. In the first method, nodes get energy from the communication messages between the nodes. Nodes when asleep enters into harvesting mode. If a node gets message which is not intended for it, it harvests energy from it. But the main problem in this approach is a situation will occur in which all nodes wants to harvest energy and no node participates in communication [22].

III. RF ENERGY HARVESTING METHODOLOGY

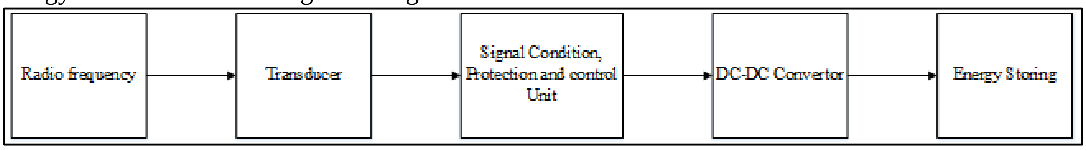


Fig. 3: RF energy Harvesting Methodology Block diagram

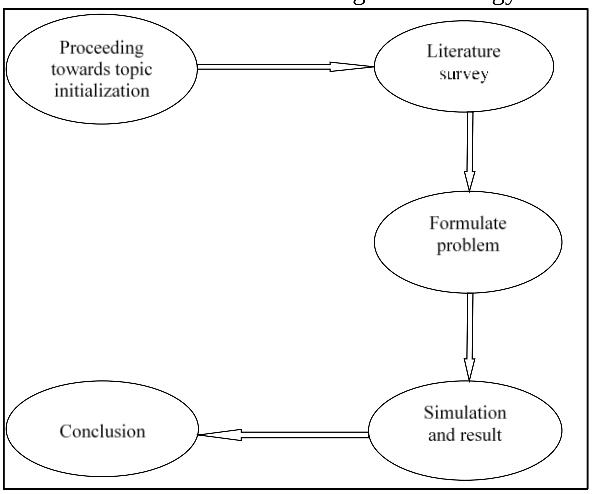


Fig. 4: various steps for research methodology

Matlab 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.

Pr (dbm) = Pt (dbm) - PL (dB.)……………………….. (1)

Where Pr = received power, Pt = transmitted power and PL=path loss path loss is calculated using logarithmic path loss model

$$PL(d) = PL(d_0) + 10*n*\log\left(\frac{d}{d0}\right) + FaddingLoss \ldots\ldots (2)$$

Where d0=reference distance, PL (d0) = path loss at d0
Which is calculated as

$$PL(d0) = -10 * \log\left(\frac{gt*gr*\lambda^2}{(4*pi*d0)^2}\right) \ldots\ldots (3)$$

Where λ=wavelength of the signal, gt = gain of transmitter antenna, gr = gain of receiver antenna and Fading losses are taken as 6dB.

$$k = \frac{e1*p1+pd+2*e2*pd11)}{e2*p3+pd+2*e2*pd11} \ldots\ldots\ldots\ldots\ldots\ldots(4.7)$$

Where p3& p1 is the value of absolute power received only from the power supply and e1 & e2 is the rectification efficiency. Pd11 available power.

The field nodes are assumed to be deployed on a straight line with the nodal antenna pattern having a lobe in each side of the line supplying power to the nodes, as shown in figure 4. It can be observed that, this is a hypothetical case in which the nodes are isolated from other networks. But this is considered to study the pattern of energy received at the nodes [24-27]. Due to the logarithmic path loss, the nodes nearer to the supply antennas receive more power when compared with the nodes far from supply.

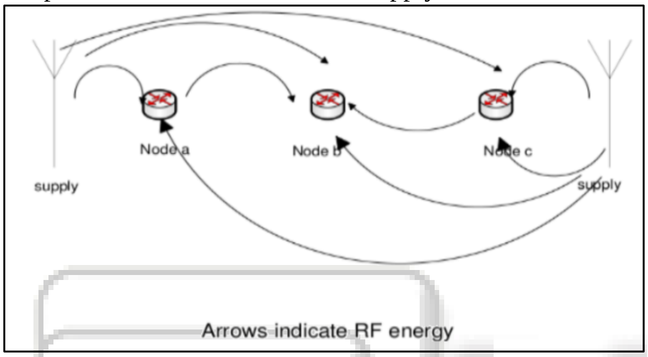


Fig. 5: Multi hop charging

IV. Result and Discussion

A. *Single-Hop Charging*

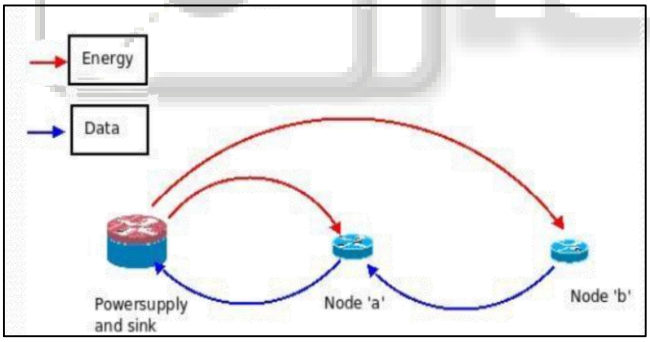


Fig. 6: Single hop charging with multi hop communication with two nodes

In this case, the single Hope charging with multi hop communication shown in Fig 6. The energy transfer is only from source to nodes. When Ea = zeroi.eavailable energy at A.

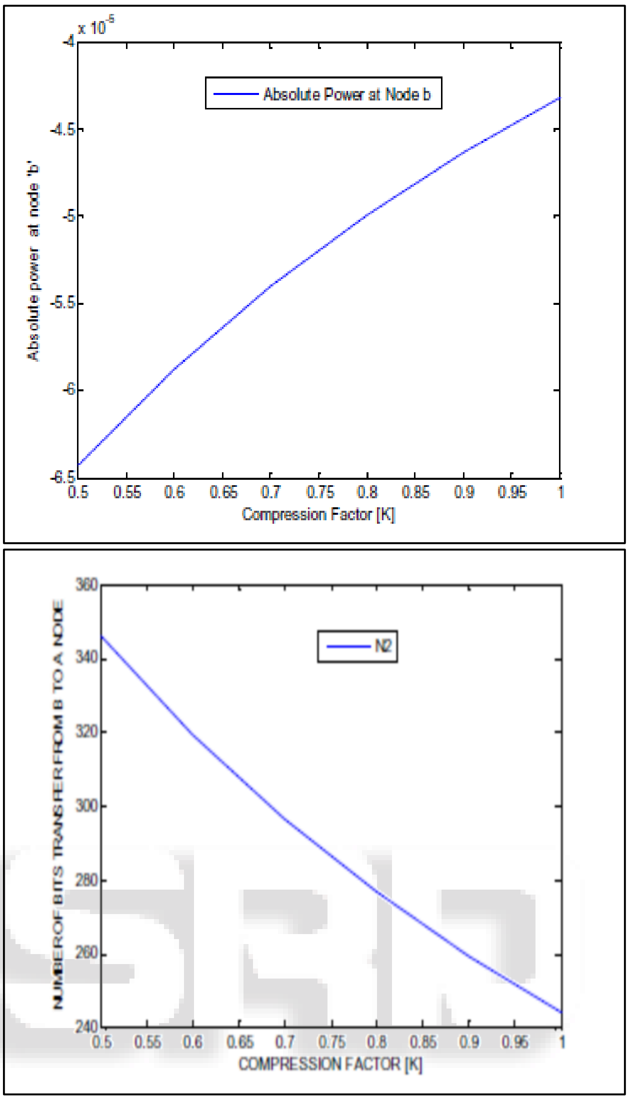
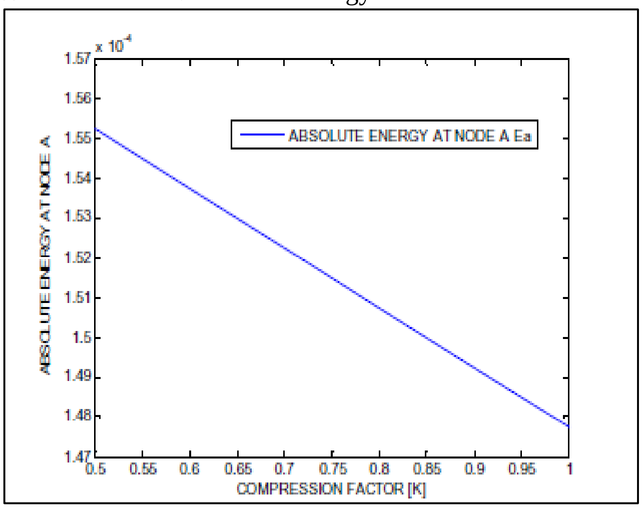


Fig. 7: Graph showing absolute power (single Hop) at node B Number of Bits Transfer)

It is clearly shown that when Ea is put zero, then maximum number of bits transferred from B to A is 346 and minimum is 245. It is clearly found that the remaining energy at node B will be negative and no recharge process is going on. So, finally we discard this case.

When Eb = zeroi.eavailable energy at B



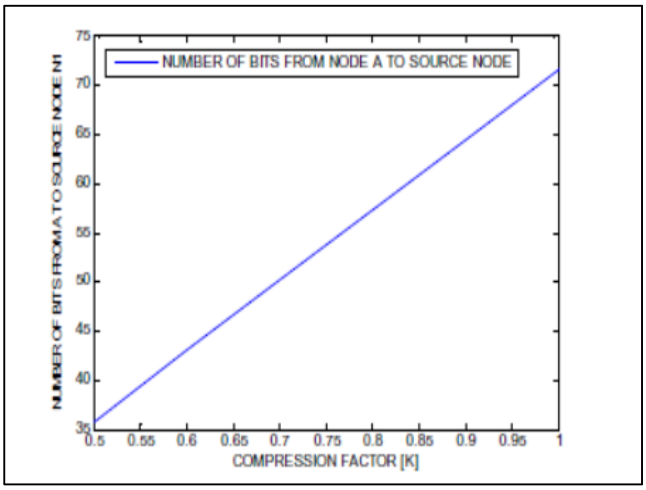


Fig. 8: Absolute energy (single Hop) at node A with Number of bits from A to Source Node.

In this case, we put Eb as zero and found that both Ea are positive and very effective. Number of bits transferred 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 is effectively charged and appropriate communication is going on from each and every node.

B. *Multi Hop Charging*

In this case, the multi Hope charging with multi hop communication shown in Fig 9. The energy transfer is only from source to nodes. When Ea = zeroi.eavailable energy at A

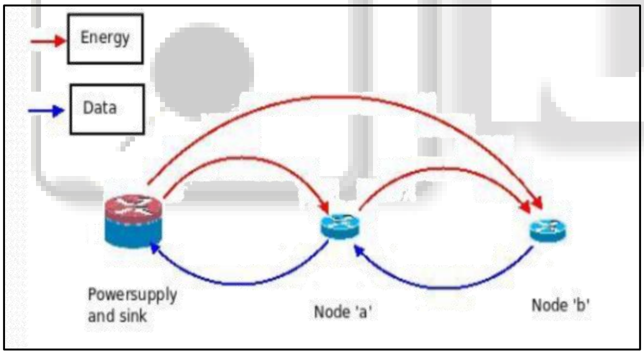
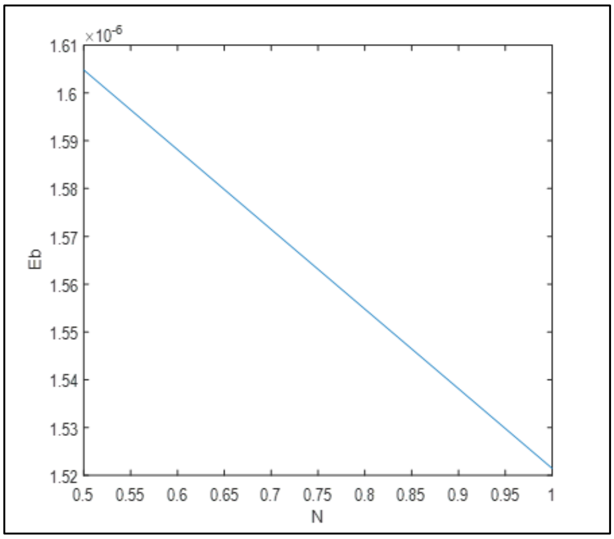


Fig. 9: Multi hop charging with multi hop communication with two nodes.



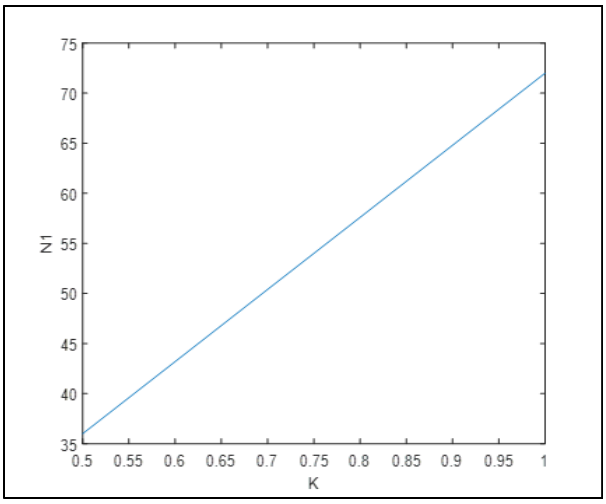
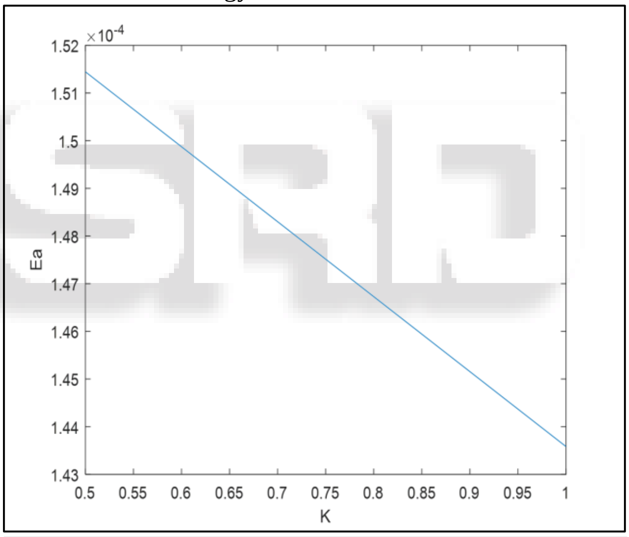


Fig. 10: Absolute power at node B and number of bits transfer B to A.

It is clearly shown that when Ea is put zero, then maximum number of bits transferred from B to A is 75 and minimum is 35. It is clearly found that the remaining energy at node B will be positive and recharge process is going on The energy transfer is only from source to nodes. When Eb = zero i.e.available energy at B



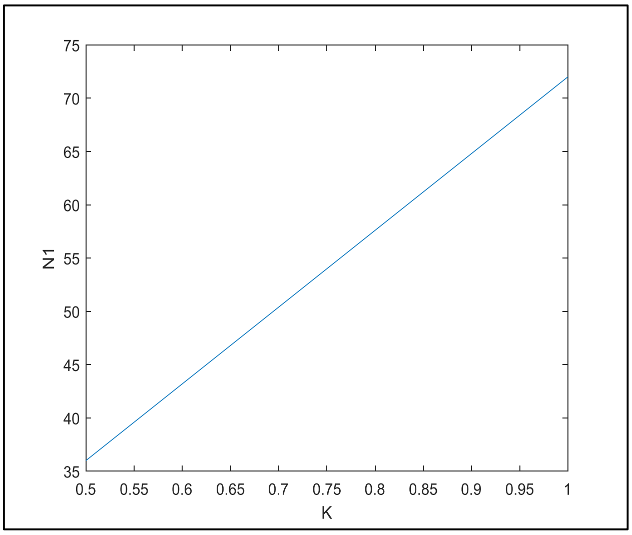


Fig. 11: Absolute power at node A and number of bits transfer A to Source Node.

V. Discussion and Future Direction

The multi hop energy transfer is more useful when the power losses are less. So it can be more advantageous if the WSN is operated at lower frequencies. Also if the distances between the field nodes participating in multi hop communication are less, the multi hop charging gains advantage over the single hop charging approach. In future prospective, Equienergy distribution case can be analyzed with increase the number of nodes with and without data transfer and it can be extended to the random deployment of nodes.

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