ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 5, September 2013

Analysis and Implementation of IEEE 802.11 MAC Protocol for Wireless Sensor Networks

Urmila A. Patil, Smita V. Modi, Suma B.J.
Associate Professor, Student, Student

Abstract: ***Energy Consumption in Wireless sensor networks is one of the main challenges for researchers. Many researchers have been done for extending the overall network lifetime by minimizing the power consumption of sensor nodes. Most of the work is done over the MAC layer of network in which different kinds of MAC protocol used by sensor networks. Most commonly used standard is 802.11.Sensor networks consist of small, inexpensive, resource constrained devicesthat communicate wirelessly in a multihop network. Each device, called asensor node, collaborates with other devices in the network to perform some operation for the end user, such as environmental monitoring or target tracking.End users typically desire to deploy hundreds to thousands of sensor nodes randomly;each sensor node often has a simple processor and limited memory resources. Producing simple, small, and inexpensive devices also limits the energy resourcesavailable for sensor node operation. Replacing or renewing energy resources afterdeployment becomes infeasible or too costly in most cases, so the protocolsand applications must make judicious use of the finite energy resources. As medium accesscontrol (MAC) has a significant effect on the energy consumption, energy efficiency is one of the fundamentalresearch themes in the design of MAC protocols for WSNs.In this paper, we described an energy efficiency of IEEE 802.11 protocol which is a standard MAC protocol. The paper presents simulation results of IEEE 802.11 performance on a sensor node with different scenarios. NS-2 is used for simulation purpose.***

I. INTRODUCTION

Wireless sensor networks have emerged as one of the first real applications of ubiquitous computing. It has become a hot issue in research, and it is regarded as one of the ten influencing technologies in the 21st century [1]. A WSN is defined as being composed of a large number of nodes, which are deployed densely in close proximity to the phenomenon to be monitored. WSNs communicate via a radio interface instead of being wired to a control station. Sensors themselves are normally not equipped with a radio interface. Therefore, a simple signal processor and a radio are packaged together with one or more sensors into what is called a wireless sensor node. This is an emerging technology that has a wide range of potential applications including event tracking, environment monitoring, smart spaces, medical systems, agriculture, robotic exploration, traffic surveillance, military surveillance, fire detection, structure and earthquake monitoring, disaster relief, search and rescue, etc. WSNs can be deployed extensively in the physical world and spread throughout our environment. They can be sited far from the actual occurrence and can still be used for data aggregation and collection from a remote location far away from the phenomenon. The WSNs comprise of a large number of application-specific wireless sensor nodes (typically in hundreds of thousands in number) spread over varying topographies. This kind of random placement of the sensor nodes does not follow any fixed pattern and the density of nodes is not dependent on any factor. Once they are deployed in the environment (under scrutiny where sensing needs to take place), these hundreds and thousands of nodes have to organize themselves in the network by listening to one another. They self-organize themselves by creating multi-hop wireless paths through mutual co-operation. The nodes work collectively and collaborate together on common tasks of sensing/data-collection/communications etc. to provide good network-wide performance in terms of network life-time, latency, and uniform density of available nodes for sensing.

WSNs offer unique benefits and versatility with respect to low-power and low-cost rapid deployment for many applications that do not need human supervision. Some of these applications include disaster recovery, military surveillance, health administration, environmental & habitat monitoring, target-tracking etc. Due to the large numbers of nodes involved in the WSN deployment new benefits to the afore-mentioned sensing applications including:

- Extended range of sensing
- Robustness and fault-tolerance
- Improved accuracy
- Lower cost

However to be able to realize all the discussed specifications we need to design protocols that can provide appropriate support and allow the wide-spread use of WSNs.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 5, September 2013

II. STANDARD MAC 802.11 PROTOCOL

Sensor nodes communicate by forming a multi hop network to forward messages to the destination, which may collect data for later retrieval by the end user or transfer the data over a dedicated communications link. Sensor nodes avoid direct communication with a distant destination due to the high transmission power requirements for reliably sending messages across the deployment area, which may cover a large geographical area. Despite using multi hop communication to reduce energy requirements for communication, the wireless transceiver often consumes the largest amount of energy—per time period of use—within a sensor node and, thus, provides the greatest potential for energy savings. Beyond improving the radio design, an efficient medium access control (MAC) protocol possesses the greatest capability to decrease the energy consumption of the transceiver since it directly controls transceiver operation. A MAC protocol provides slightly different functionality depending on the network, device capability, and upper layer requirements, but several functions exist in most MAC protocols. In general, a MAC protocol provides [2]:

- Framing – Define the frame format and perform data encapsulation and decapsulation for communication between devices.
- Medium Access – Control which devices participate in communication at any time. Medium access becomes a main function of wireless MAC protocols since broadcasts easily cause data corruption through collisions.
- Reliability – Ensure successful transmission between devices. Most commonly accomplished through acknowledgement (ACK) messages and retransmissions when necessary.
- Flow Control – Prevent frame loss through overloaded recipient buffers.
- Error Control – Use error detection or error correction codes to control the amount of errors present in frames delivered to upper layers.

Most work on sensor network MAC protocols has focused on medium access techniques since the transceiver consumes a significant amount of energy and the MAC protocol has the most direct control over its utilization. Limited energy resources provide the primary constraint for sensor network protocol design, so proposed MAC protocols primarily focus on reducing energy losses related to the wireless medium. Other design constraints, such as fairness, latency, and throughput, appear for specific applications and we present MAC protocols designed with these constraints.

Several aspects of sensor networks dibranchiate the MAC protocol design from MAC protocols in other networks. First, sensor nodes conserve energy by turning off unneeded hardware because most hardware, even when not active, consumes a non-negligible amount of energy. Thus, each sensor node must somehow coordinate with its neighbor to ensure both devices remain active and participate in communication. Sensor network MAC protocols most often performer actively participate in this functionality so upper layers have only an abstract concept of viable links or topology information. Several techniques, such as schedule-based clustering and separate wakeup communication, exist and we mention them when used in the discussed protocols. Secondly, sensor networks produce traffic that differs from the communication patterns existing in other networks. Environmental monitoring provides a typical sensor network application. Sensor nodes monitoring a particular environmental characteristic periodically send data to a central entity for collection and analysis. These devices individually produce traffic at periodic rates with small payloads. Both the data characteristics, which may exhibit strong periodic generation and high spatial correlation, and the small payload size, which increases the impact of protocol overhead, differentiate sensor net- works from other networks. Third, the limited resources available to a sensor node prevent the use of common MAC protocol techniques. Many wireless MAC protocols constantly listen to the wireless channel for activity either for reception or before transmitting. However, a transceiver that constantly senses the channel will quickly deplete the sensor node energy resources and shorten the network lifetime to unacceptable levels.

Due to the popularity of the IEEE 802.11 [3] standard in wireless local area networks, we provide a brief introduction, but show that it does not suit sensor network applications for several reasons. IEEE 802.11 provides two modes of operation for wireless devices: an infrastructure mode where devices communicate through a central entity called an access point (AP) using the point coordination function (PCF) and an ad-hoc mode where devices communicate with each other directly using the distributed coordination function (DCF). The PCF extends upon the DCF and provides mechanisms for collision-free transmissions and device synchronization with the AP. Both the PCF and DCF use a channel access mechanism similar to slotted CSMA/CA and use acknowledgments for reliability. In addition to sensing the channel according to the CSMA algorithm, called physical carrier sensing, IEEE 802.11 devices perform virtual carrier sensing by tracking channel utilization with control messages. Each device maintains a counter, called the network allocation vector

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 5, September 2013

(NAV) that indicates the channel has activity on it whenever the NAV has a non-zero value. Devices update the NAV based on the data length present in control messages they receive. Periodically, each device decrements its NAV so that the current transmission ends when the NAV reaches zero. Using the NAV allows a device to quickly check for possible channel activity without having to activate the device's transceiver. For the purpose of determining channel activity, an IEEE 802.11 device considers the channel busy whenever physical channel sensing detects a transmission or when the NAV contains a non-zero value.

The DCF in IEEE 802.11 operates similar to slotted CSMA/CA with the use of virtual carrier sensing and acknowledgments. When first trying to transmit a message, a device senses the channel and, if free for a time period, transmits the message. If the device detects activity on the channel it defers access to the current transmission and performs the back-off algorithm. A device using the DCF considers the wireless channel idle if it detects no activity on it for a time period called the DCF interframe space (DIFS). An IEEE 802.11 device performs the back-off algorithm by randomly selecting a number of time slots to wait and storing this value in a back-off counter. For each time slot where the device senses no activity on the channel, it decrements its back-off counter and transmits a frame when the count reaches zero. If the device

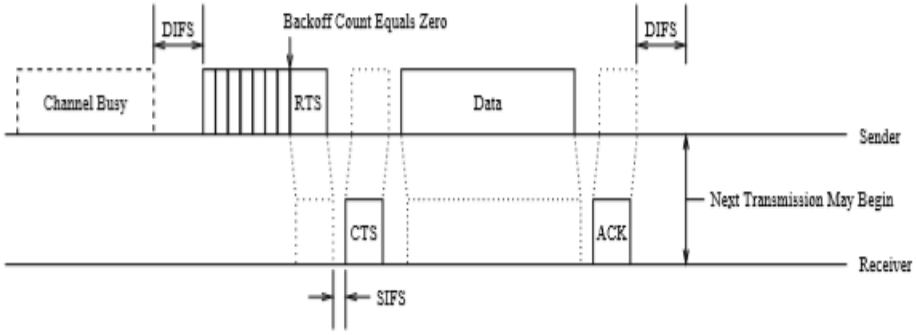

Fig1. IEEE 802.11

DCF Backup Algorithm and Message Transfer detects activity on the channel before the back-off counter reaches zero, it halts the countdown, defers access to the current transmission, and continues the countdown after the channel becomes idle for a DIFS. Devices that successfully receive a data message respond by transmitting an acknowledgment after a short interframe space (SIFS). IEEE 802.11 defines a SIFS shorter than a DIFS so that other devices do not physically sense an idle channel and cause a collision by transmitting over a control message. Fig.1, modified from the IEEE 802.11 standard, shows a message transfer when the sender detects channel activity upon the first carrier sense.

The PCF extends the DCF by having the AP coordinate collision-free time periods within its transmission range. The AP prepares for collision-free trans- missions by broadcasting a beacon message that includes a list of devices to receive data during the next time period and an indication of the contention-free period's length. During the contention-free period the AP transmits messages to the devices listed in the beacon or, optionally, transmits polling messages to devices, which allows the devices to initiate data transfer with the AP. Before transmitting messages the AP waits for the channel to become idle for a PCF interframe space (PIFS) and will timeout after this period when it does not receive any expected response from a device. IEEE 802.11 defines the PIFS between the DIFS and SIFS in length; this allows the AP to have priority over devices operating in its range according to the DCF, but allows devices to transmit replies, such as CTS and ACK messages.

IEEE 802.11 does not suit sensor networks due to the differences of the in- tended applications. Characteristics important to devices operating on a wire- less local area network, such as fairness, mobility support, high throughput, and low latency, influenced the design of the IEEE 802.11 standard, but these do not have as high a priority in sensor networks as energy conservation. As a result, IEEE 802.11 devices consume large amounts of energy due to the high percentage of time spent listening without receiving messages [4]. IEEE 802.11 does provide a simple energy management capability, called a power save mode, to devices operating according to the PCF. Devices that wish to sleep inform the AP using special control messages and enter sleep mode when they do not have messages to receive or transmit. Each device wakes up to receive beacon messages from the AP to determine if it must receive messages during the contention-free period and to remain synchronized with

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 5, September 2013

the AP. The work [4] provides some discussion of the IEEE 802.11 power save mode and notes the following limitations: power save mode only operates in infrastructure mode, so scalability becomes a problem, and the IEEE 802.11 standard does not specify when or for how long devices should sleep. Additionally, the protocol overhead in IEEE 802.11, which local networks can tolerate, becomes very large when used in sensor networks where applications may only generate a few bytes of data per message.

III. DESIGN MODEL DESCRIPTION

We have chosen the ns-2 simulator for this research because it realistically models arbitrary node mobility as well as physical radio propagation effects such as signal strength, interference, capture effect, and wireless propagation delay. The simulator also includes an accurate model of the IEEE 802.11 Distributed Coordination Function (DCF) wireless MAC protocol.

NS2 provides the network simulation environment for both wired, wireless means MANET networks. Provides the modules for the wireless channel such as 802.11, 802.16 etc.Provides the number of routing protocols for choice in which the routing is done along multiple paths. Simulations of the cellular networks possible as the mobile hosts are simulated as well. The analysis is being done on the basis of the results of *.nam file and the *.tr file. We also evaluate the performance of the protocol. In the ns2-allinone package NAM is a build-in program. NAM helps us to see the flow of message between the nodes. It also shows the packets are dropping or reaching to the destination properly. When the TCL file is written, NAM is invoked inside that file. With the help of 2D and 3D graphs we have tried to analyze the simulation with different simulation time. The scripts for the NAM is stored as *.nam and for trace- graph *.tr is used.

A. Energy Consumption

The metric is measured as the percent of energy consumed by a node with respect to its initial energy. The initial energy and the final energy left in the node, at the end of the simulation run are measured. The percent energy consumed by a node is calculated as the energy consumed to the initial energy. And finally the percent energy consumed by all the nodes in a scenario is calculated as the average of their individual energy consumption of the nodes.

Percent Energy consumed = [(Initial Energy – Final Energy) / Initial Energy]*100

Average_Energy_Consumed = Sum_of_Percent_Energy_Consumed_by_All_Nodes / Number_of_NodesResidual_Energy = total_energy_given_to_all_nodes – Sum_of_energy_consumed_by_all_nodes.

B. Scenarios

There number scenario and traffic files needs to generate in order to evaluate the performance of the routing protocols under the different network conditions. In this simulation the main parameter which is varied during the simulation is the number of nodes, number of connections and size of the network.

Following are parameters which are varied for these simulations:

_ Nodes of maximum velocity
_ Maximum number of data connections
_ Number of nodes
_Size network area

1) 10 nodes
2) 20 nodes
3) 30 nodes
4) 40 nodes

Number of Nodes	10
Traffic Patterns	CBR (Constant Bit Rate)
Network Size	500 x 500 (X x Y)
Max Speed	10 m/s
Simulation Time	15s
Transmission Packet Rate Time	10 m/s
Pause Time	2.0s
Routing Protocol	FLOODING

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 5, September 2013

MAC Protocol	802.11
Number of Nodes	20
Traffic Patterns	CBR (Constant Bit Rate)
Network Size	1000 x 1000 (X x Y)
Max Speed	10 m/s
Simulation Time	20s
Transmission Packet Rate Time	10 m/s
Pause Time	2.0s
Routing Protocol	FLOODING
MAC Protocol	802.11

Number of Nodes	30
Traffic Patterns	CBR (Constant Bit Rate)
Network Size	1000 x 1000 (X x Y)
Max Speed	10 m/s
Simulation Time	25s
Transmission Packet Rate Time	10 m/s
Pause Time	2.0s
Routing Protocol	FLOODING
MAC Protocol	802.11

C. Software Requirements

For the simulation of this work we have to need the following setups requirement for the same

1) Cygwin: for the windows XP
2) Ns-allinone-2.31

Following are the steps to for installation of the Cygwin + ns2

1) Computer Requirements
   a. 5 GB free space of HDD
   b. 1 GB of RAM
2) Installation Assumptions
   a. Windows is installed in C drive.
3) Installing Cygwin as following ways:
   a. Download the latest version Cygwin setup.
   b. Execute the Cygwin setup

V. RESULTS AND DISCUSSION

As we observed in previous sections, as per the research objectives the simulation and implementation of proposed approach and methods with NS2 is done. We have implemented IEEE 802.11 protocol for WSN. Here we have simulated different networks according to the varying number of sensor nodes such as 10, 20, 30 & 40. We have got following results to our simulation study; the results are recording in terms of:

Average Energy Consumption
Total Energy Consumption
Residual Energy

Following graphs in fig 2, fig 3 and fig 4 respectively showing above three performances and analysis in order to claim efficiency of IEEE 802.11.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 5, September 2013

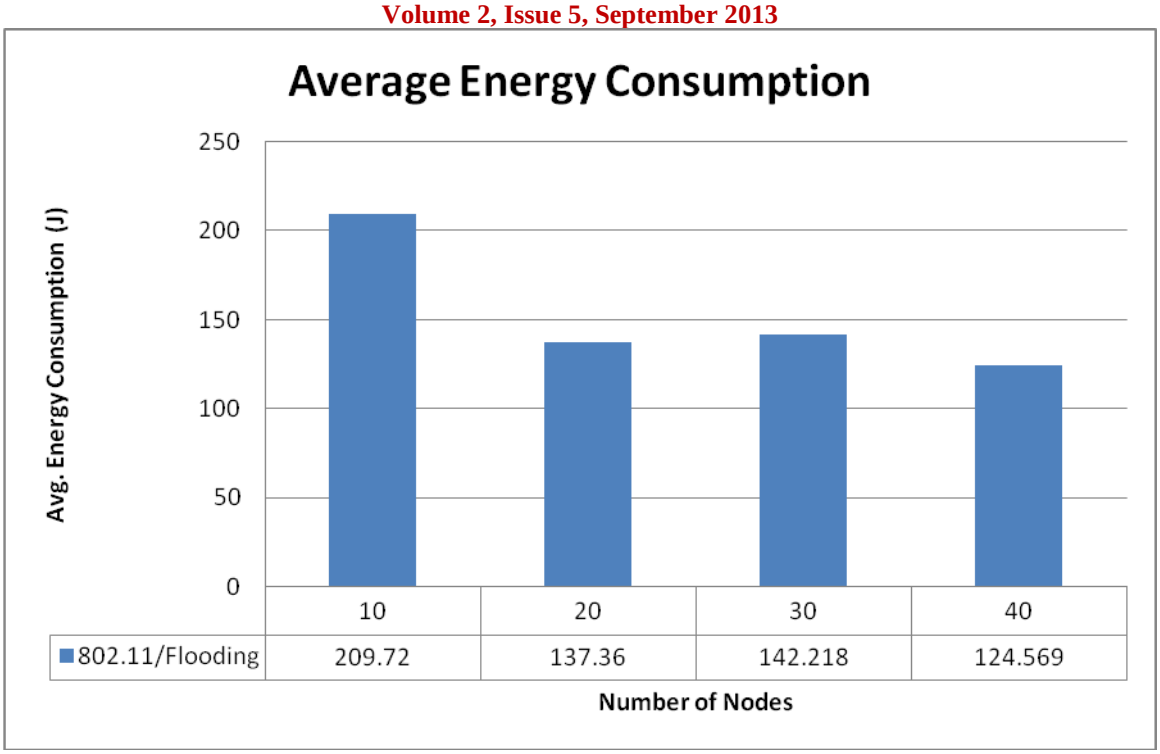

Fig 2: Average Energy Consumption Performance Analysis

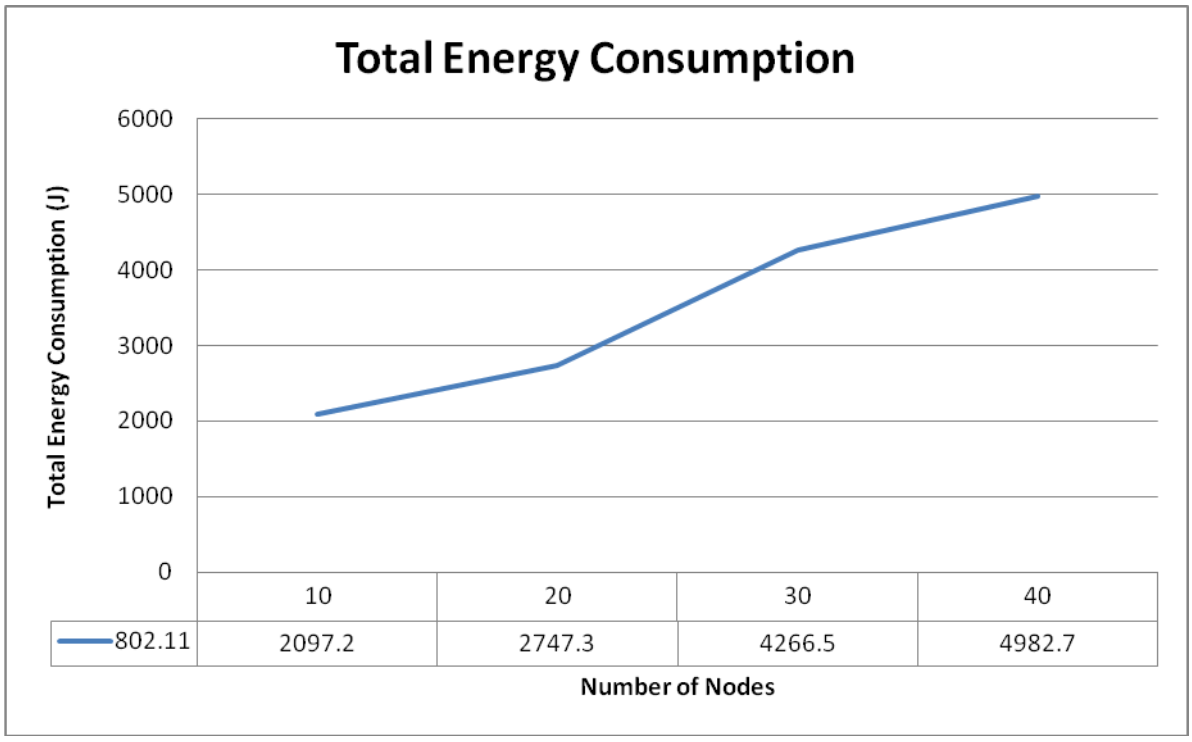

Fig3: Total Energy Consumption Performance Analysis

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 5, September 2013

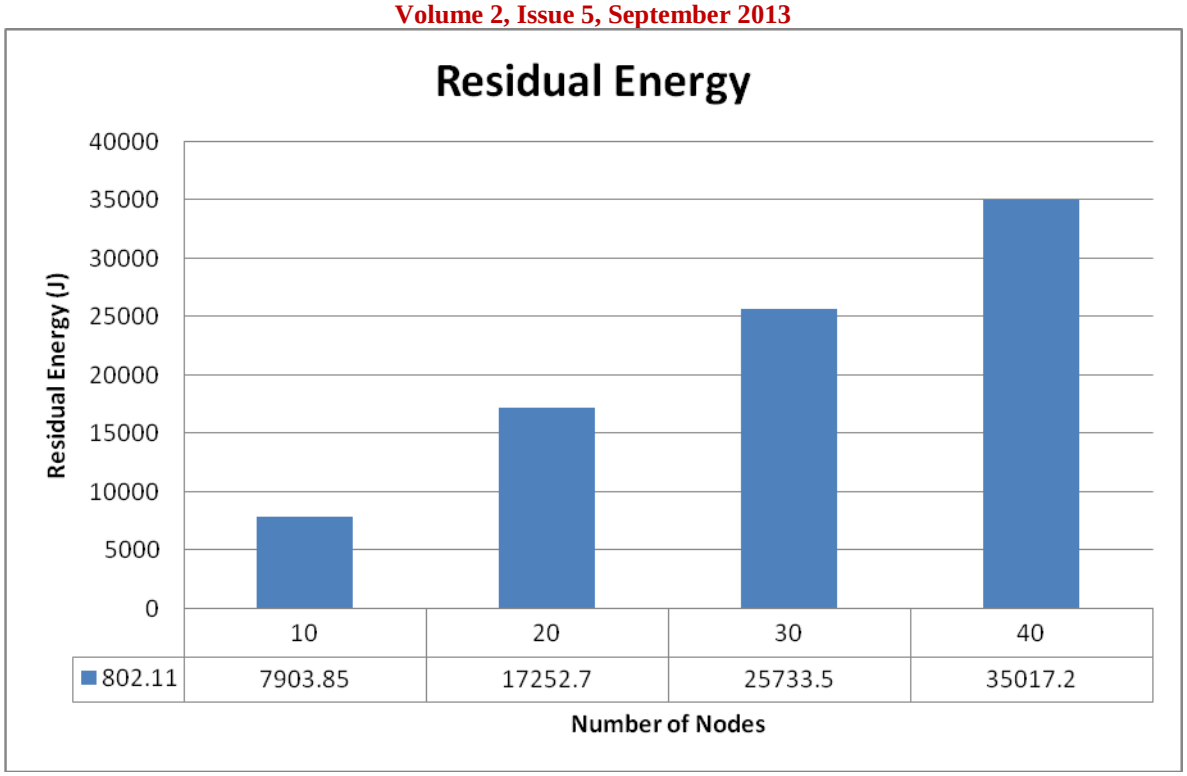

Fig 4: Residual Energy Performance Analysis

REFERENCES

[1] S. Wen-miao, L Yan-ming, and Z. Shu-e,"Research on SMAC protocol for WSN,"in Proc. IEEE 4th International conference on Wireless Communications, Networking and Mobile Computing WiCOM'08, Oct 2008,pp.1-4.

[2] J. F. Kurose, K. W. Ross, and Computer Networking: A Top-Down ApproachFeaturing the Internet, 3rd Edition, Addison Wesley, 2005.

[3] IEEE, IEEE Standard 802.11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications (1999).

[4] W. Ye, J. Heidemann, D. Estrin, Medium access control with coordinated adaptive sleeping for wireless sensor networks, IEEE/ACM Transactions onNetworking 12 (3) (2004) 493–506