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A NOVEL GAME THEORY SCHEME TO EGEST LARCENY IN COCKROACH TOPOLOGY WIRELESS SENSOR NETWORK

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ABSTRACT

Wireless Sensor Network (WSN) deploys for remote monitoring applications namely healthcare monitoring, finance and military. The nature of WSN in certain application makes it impossible to inspect and repair the nodes physically at certain times. In such cases, an unwanted user can associate to the node and retrieve crucial information. Moreover, conventional routing mechanism include Dynamic Source Routing (DSR) scheme to transmit data to destination. In DST routing scheme the whole data shift from one node to other node. The routing mechanism pose a disadvantage when network deal with confidential data. We propose, a Game theory routing scheme to forward data to destination with secrecy. The objective is to transmit data to destination under compromised node condition, without sacrificing network parameters namely throughput, network lifetime, end to end delay and packet delivery ratio. The proposed routing scheme is simulated and the same implement in hardware for comparative analysis and validation.

Keywords: wireless sensor networks, game theory, energy efficient, DSR.

1. INTRODUCTION

Wireless sensor network is more beneficial compared to wired networks in terms of coverage region, mobility and installation cost. Wireless sensor network can save cost up to 90% compared to wired networks. Recent trends in IOT (Internet of Things) show improved demand for wireless devices due to its mobility and ease of use. Wireless sensor network employ for applications such as remote health care monitoring, military and financial applications. In such applications, data security is crucial and all data's in transmission medium should be kept confidential. Researchers devise new routing scheme and cryptographic techniques to improve data secrecy in transmission medium. Often, the objective attain by sacrificing network parameters such as throughput, end-to-end delay and energy consumption. In particular, conventional routing scheme such as Dynamic Source Routing (DSR) routing scheme forwards whole data from one node to other node until the data reaches destination.

The DSR routing scheme increases data latency and decreases efficiency [1]. Furthermore, Collection Tree Protocol (CTP) gathers information from all the nodes in the network. The CTP algorithm has load-balancing problem due to selection of parent node with optimum link quality. The CTP algorithm raises delay in the network [2].

The Back Collection Protocol (BCP) creates more delay compared to CTP. In BCP protocol the data forward only after computation of link weightage. The weightage computation for each packet leads to more delay in network [3]. The delay incur due to computation, minimize with SPIN routing method. In SPIN method, node forwards data only to nodes interested in data. Moreover, the sender node sends ADV descriptor about the data to surrounding nodes. Receiver nodes on receiving the descriptor, request for the data from the sender node [4]. The process increases network traffic. Directed diffusion routing scheme reduces network traffic by collecting sensor data from nodes on demand. The sensor data comprises of attribute values. The sink node with the data pair, queries the sensor nodes. The sink node lifetime drain proportionally to number of sensor nodes [5]. However, clustering hierarchy with LEACH improves network lifetime of sink nodes. In LEACH the nodes in a cluster take turns as cluster head. The random rotation of node as cluster head improves energy balancing in network. The selection of cluster head decide by node at intervals without communication with other nodes to minimize overhead [6]. In addition, TEEN protocol (Threshold Sensitive Energy Efficient Sensor Network Protocol) built with hierarchical cluster architecture. In TEEN protocol, nodes closet to each other form clusters. The clusters form up to coverage region of base station. The cluster head has two threshold namely hard threshold and soft threshold for data transfer [7].

2. RELATED WORK

SDF (Semi-Directional Flooding) based AODV (Ad hoc On-Demand Distance Vector) routing algorithm reduce route overhead in network. The route overheads in network reduce by semi directional flooding. The flooding mechanism has no knowledge of location of nodes in network [8]. Oppcode use opportunistic flooding method. The flooding method involves nodes transmitting multiple data packets to other nodes instead of single packet. Moreover, the flooding concept improves transmission overhead and data reliability [9]. The coarse industrial environment affects reliable data communication in wireless sensor network. The reliable data communication establish with CDRRP (critical data reliable routing protocol). The protocol route data with respect to constraints namely deadline time and data type. Selection of appropriate relay node to transfer data depends on the parameters. Moreover, relay nodes fast forward critical data in network compared to normal data [10]. Dynamic Clustering approach improves energy efficiency in cluster

based wireless sensor network. In cluster based, network the nodes in the network take turns to become cluster head. The rotation of cluster head balances energy consumption of nodes in network. The combination of clustering and multi hop routing protocol forms JCR protocol. The JCR protocol enhances network lifetime by limiting hops in neighboring nodes [11]. Data from sensors employed in industries have time validity. The data from the sensors should reach control centre within a specified time interval. The data forwarded by node depends on deadline time and distance to the end node. Moreover the real time routing protocol improve packet reception before deadline [12]. Data transmission by scheduling process implement in wireless sensor network. The scheduling methods improve data reliability and delivering data before deadline [13]. A routing protocol based on two hop neighbor information delivers data to forwarding nodes in network. The approach improves end to end data reception while improving network lifetime [14]. The QOS routing protocol selects paths, which minimizes energy consumption. Moreover, genetic algorithm in combination with QOS routing determine appropriate path for data forwarding. The approach improves network life time over all nodes in network [15]. The above-described routing schemes rely on entire data packet transmission from one node to the adjacent node in routing path. The routing path use repeatedly till energy of all nodes utilize completely. Furthermore, in data critical applications such as banking and military if any one of the node in transmission medium is compromised then all data flowing in the routing path is at risk. Hence, a game theory routing scheme implement to improve data security and occurrence of first dead node in network. Furthermore, the routing scheme utilizes energy of all nodes in the network uniformly unlike conventional DSR routing protocol.

3. METHODOLOGY

The influence of wireless technologies is growing faster than ever before with improvements in fast processing controllers and improved coverage region of wireless modules amidst noise. The energy efficiency and data security play a vital role in wireless sensor network especially in applications such as health care and finance. We propose, a bio inspired cockroach topology and game theory routing scheme to secure data transmission and improve network lifetime. In conventional topologies the data's are transferred completely from source to destination through interconnected nodes. If a hacker gain access to one of interconnected nodes the entire data in network is compromised. In addition, the complete data transfer between nodes reduces battery of node considerably. The Proposed algorithm working explains with node scenario as in Figure-1. The network model considered node frame with parameters is tabulated in Table-1.

Table-1. Simulation parameter.

Parameter	Description
Wireless Channel Propagation	channel type
Propagation/Two Ray Ground Network Interface	radio-propagation model
Phy/Wireless Phy	network interface type
Mac/802_11	MAC type
Queue/DropTail / PriQueue	interface queue type
Queue length	500 bits
Number of Nodes	50
Link layer type	LL
Antenna model	Antenna / Omni Antenna
Max packet in if q	50
Number of mobile nodes	71
Routing protocol	DSR
X dimension of topography	1000
Y dimension of topography	1000
Time of simulation end	45.0s
initial energy	100J
packet size	100 bits

3.1 Algorithm

Step 1: Create source and destination nodes.
Step 2: Route data's between source and destination nodes by game theory.
Step 3: Main transmitter node (n0) transmits send signal to nodes closer (n2, n3) to it.
Step 4: Up on reception of acknowledgement signal from nodes n2, n3 main transmitter node splits entire data into to half.
Step 5: First half of data is sent to node n2. The second half of data sent to node n3.
Step 6: The nodesn2 and n3 looks for nodes closer to it to transfer data. The process repeats itself until the data reaches destination.
Step 7: The data accumulates at the destination node n9.
Step 8: The destination node combines all data to form original data.

3.2 Pseudo code

Transmitter side
a) Sender node scan for neighbor node.
b) If more than one neighbor node detect
Split data evenly based on number of node
Transfer data packets
c) else
send complete packet to neighbor node.

Receiver side

a) check destination ID of received packet
b) if destination id == node id
collect data packet and start process
c) else
merge all the received packet
d) if duplicate packet ==True
drop packet.

Route identification

a) Multipath DSR routing protocol is used
b) If more than one routing path is found
Apply game parameters
c) Else
Check for alternate path.

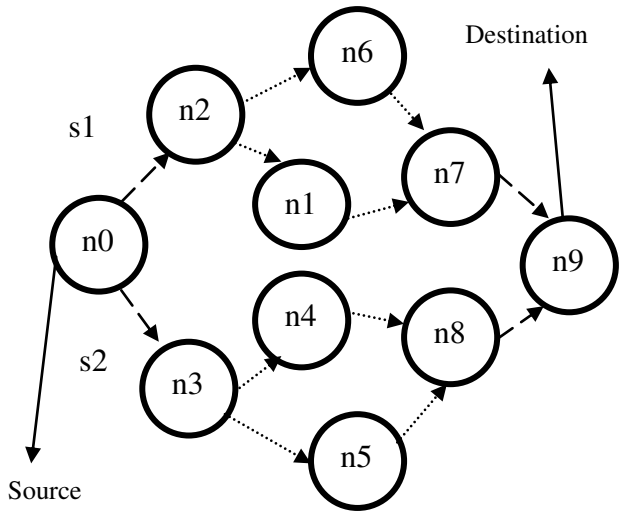

Figure-1. Cockroach Topology.

In Cockroach topology as in Figure-1 the entire data‘s’ are split in to fragments ‘s1’ and ‘s2’ by the source node. The source node then transmit receive request signal to nodes n2 and n3. If node n0 receives acknowledgement from n2 and n3 then the node n0 splits the data ‘s’ into ‘s1’,’s2’ and transfers data to nodes n2 and n3 (as in figure). The node n2 further splits the data and transfers data to nodes ‘n6’ and ‘n1’ as shown in figure. The process repeats itself till the nodes reach the destination node ‘n10’. In destination node the data fragments converge to form entire data. The routing mechanism maintains data security under compromised node scenario. The routing mechanism consumes entire network energy uniformly unlike conventional routing schemes. In conventional routing schemes the data path is fixed. The fixed data path energy drains quickly compared to other nodes in network.

3.3 Network simulation tool

Subsequent to the installation of NS2, it is used for evaluate and simulate work apart from other tools used. The Network Simulator is an Object Oriented Simulator, and it can be written in C++ language. The development of NS2 codes are done by using both OTcl (Object oriented extension of Tool Command Language) and C++. Trace Graph is an essential part for displaying a result, so we plot a graph to show a various result comparison with packets, throughput, delivery ratio, network delay and energy efficiency etc. The results are achieved by using Xgraph tool. The proposed and existing methods are compared through the graphs generated. The network is designed using a Network Simulator (ns2) and parameters like throughput, packet loss ratio, packet delivery ratio, an end to end delay are calculated.

The proposed routing scheme implement in NS-2 (Network Simulator) to evaluate game theory routing scheme effectiveness. The network performance evaluate in terms of network parameters namely, throughput, network life time, packet delivery ratio and end to end delay. The nodes in network simulate with DSR scheme and proposed Game theory routing scheme. Figure-2 shows the comparison of throughput for DSR and Game theory routing scheme. It is observed from graph, the through put of game theory linearly high compared to DSR algorithm. The packet delivery ratio express in terms of Kbps.

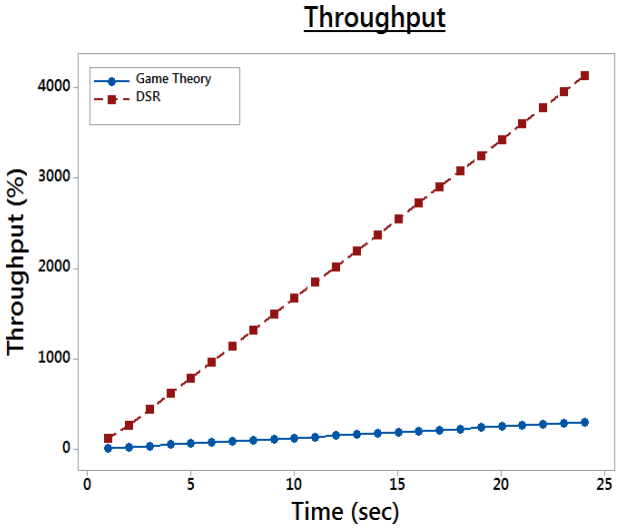

Figure-2. Throughput.

Packet delivery ratio defined as ratio of packets successfully delivered to destination with respect to number of data transmitted.

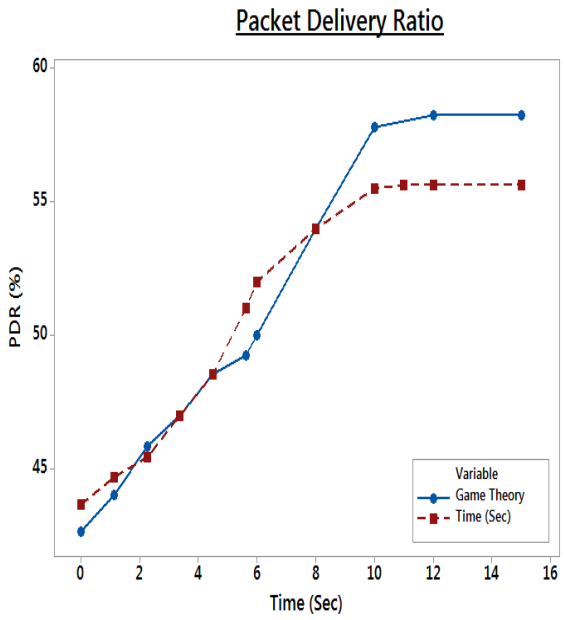

Figure-3. Packet delivery ratios.

Figure-3 shows the comparison of packet delivery ratio for Game theory routing and DSR routing. The graph plot with number of packets on y-axis and time on x-axis. The number of packets transmission starts from the origin. As the time increases the number of data transmitted also increases. The packet delivery ratio for Game theory routing scheme is comparatively high compared to DSR routing scheme.

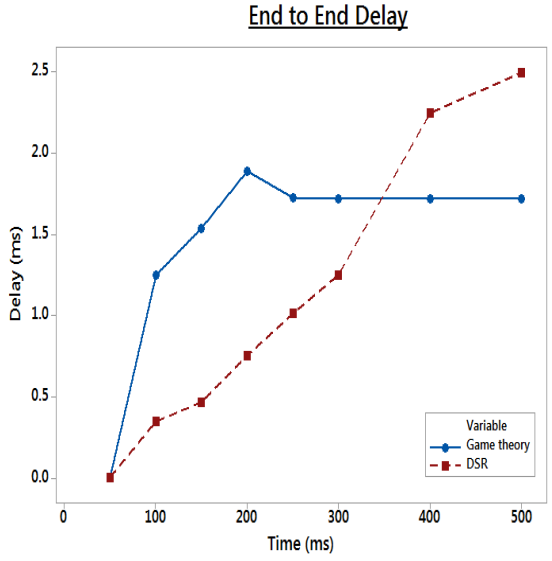

Figure-4. End to end delays.

The Figure-4 show end to end delay defines by time consumed for data to travel from source to destination. The figure show end to end delay for game theory and DSR routing scheme. The graph is conclusive evidence that end to end delay for Game theory routing scheme is low compared to DSR routing scheme.

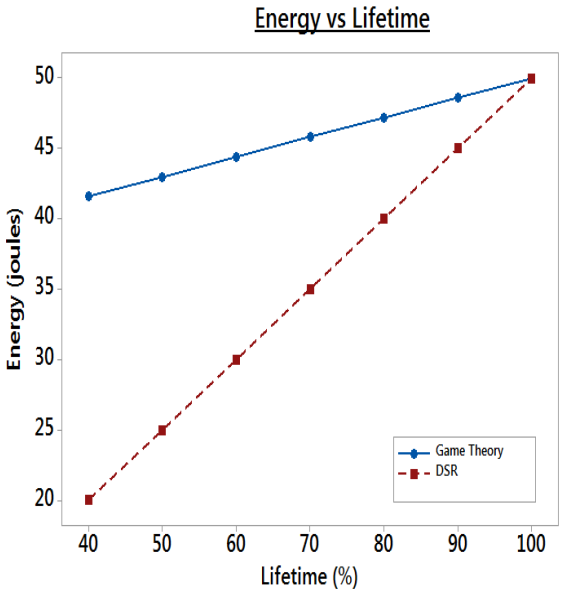

Figure-5. Life time of network.

The Figure-5 shows the lifetime of network and energy consumption. The graph plotted with available energy in node.

3.4 Hardware implementation

The Game theory routing scheme implement in hardware to validate proposed system effectiveness. The nodes in network include PIC microcontroller and tarang zigbee module. The nodes are powered by non-rechargeable battery. The microcontroller in each node performs routing mechanism. The tarang zigbee module transfers data from microcontroller in wireless medium. The data from PIC microcontroller sent to tarang zigbee module by serial interface. Figure-6 shows hardware description of a node.

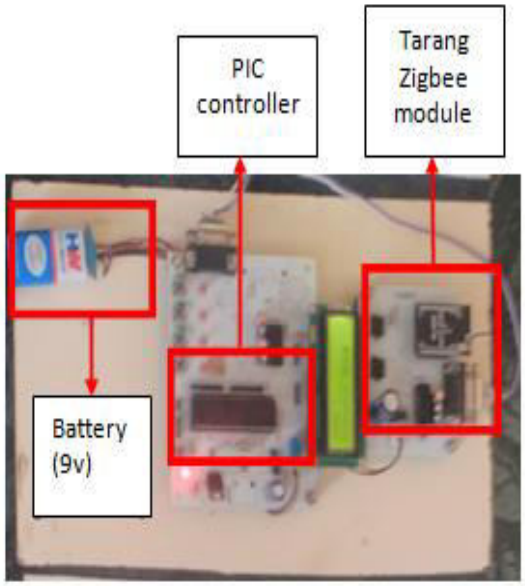

Figure-6. Hardware description of a node.

The game theory routing mechanism implement in hardware to validate proposed system effectiveness. The performance of game theory evaluate in terms of throughput, network life time, packet delivery ratio and end to end delay. The hardware results lag the simulation results by a slender margin. Figure-7 shows the implemented hardware.

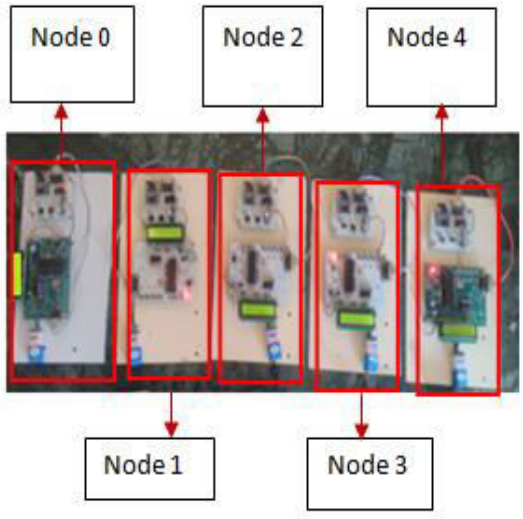

Figure-7. Hardware implementation.

Table-2. Power consumption and time.

Node	Battery level		Tx power consumed (mv)	Data reception time (ms)
	Before Tx (volt)	After Tx (volt)		
n0	9	8.31	0.699	-
n2	9	8.63	0.376	10
n3	9	8.66	0.348	9.76
n6	9	8.81	0.19	17.82
n1	9	8.759	0.241	17.51
n4	9	8.754	0.246	16.82
n5	9	8.782	0.218	16.54
n7	9	8.579	0.421	19.81
n8	9	8.614	0.386	19.24
n9	9	8.156	0.844	26

In Table-2 shows the power consumption and time at which the data is received by nodes. In the initial stage node, n0 consumes more power due to large data. The data transfers to node n2 and n3. The nodes process half the data compared to node n0. The nodes show similar power consumption with minimal variations. The data split further for nodes n6and n1. The analysis shows power consumption varies with respect to quantity of data being handled. To validate proposed system effectiveness under node compromised condition, one of nodes n5 was manually connected to an external controller to receive data. The data from node 5 varied each time a data frame received form node0. The data had variations without pattern at the compromised node. Moreover, the data routing and splitting vary dynamically with change in location of nodes.

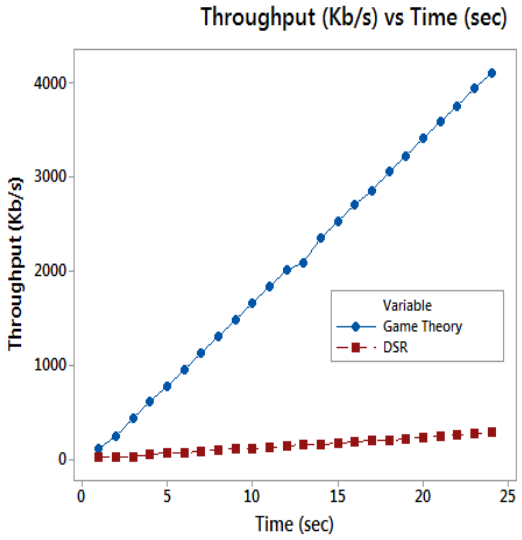

Figure-8. Throughput.

Figure-8 show throughput of network implemented on hardware. The comparative analysis of algorithm shows, increased throughput for game theory algorithm. The throughput increases linearly with slight deviations. The deviations occur due to data parsing by the nodes.

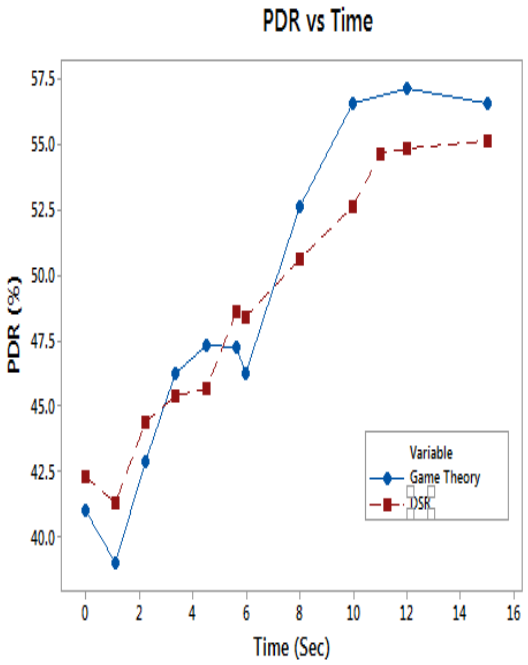

Figure-9. Packet delivery ratio.

The node data reception time vary with respect to routing scheme and surroungindg environment.

$$\lambda = P_{on}\lambda_j \quad (1)$$

λ denotes data reception rate. The arriaval of data is given by λ_j. The probabillity of data reception of node is given by P_{on}. The data reception rate for Game theory algorithm is given by eqvation.

$$C_{aj}^{r2} = c_{aj}^2 + k\lambda_j \quad (2)$$

$$P_{on} = \frac{\beta}{\alpha+\beta} \quad (3)$$

$$k = \frac{\alpha\left(\nu_{on}\alpha^2 + \nu_{off}\beta^2\right)}{(\alpha+\beta)^2} \quad (4)$$

Game theory has improved packet delivery ratio as shown in figure 9 with oodles variations. The packet delivery dips at one point since the node takes more time interval to dissever the data. The data then route through nodes to reach the destination.

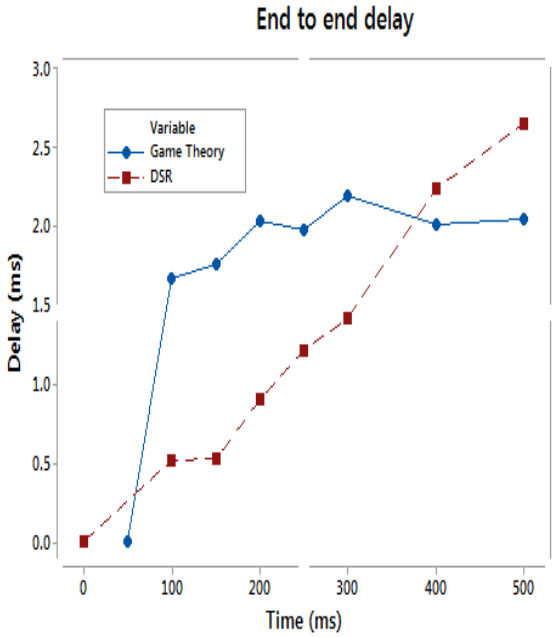

Figure-10. End to end delay.

$$\mathrm{Min}\sum_{i=1}^{n}\left\|\tilde{n}l - ni\right\| \quad (5)$$

Where n_i is position of nodes $\|\tilde{n}1 - ni\|$ represents distance between nodes. Compared to the simulation results in figure 10 and figure 11 the end-to-end delay is increased. The delay is increased due to increased controller execution time.

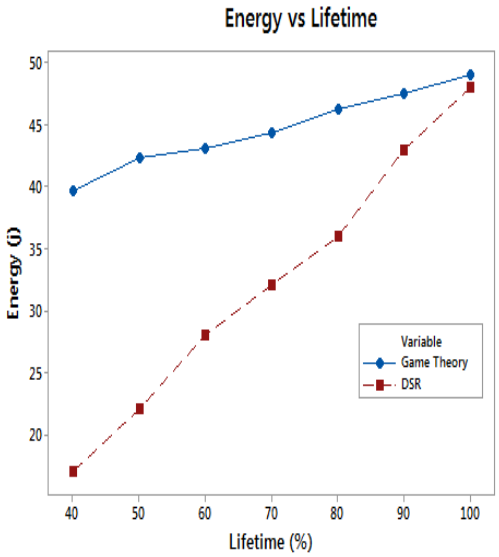

Figure-11. Network life time.

Let battery power of node represent by $P_i, i = 1....N$. Where,

i - Initial energy

D_{Rt} _ Data Routed by the nodes. The lifetime of the network determined by,

$$P_l = P_l - K\left\|\tilde{v}_1 - V_1\right\| D_{Rt}.D_{rec}\left\|\tilde{v}_2 - \tilde{V}_1\right\|^2 (1) \quad (6)$$

$$P_l = P_l - K\left\|\tilde{v}_i - V_i\right\| - D_{Rt}.D_r\left[\left\|\tilde{v}_{i+1} - \tilde{v}_i\right\|^2 + \left\|\tilde{v}_i - \tilde{v}_{i-1}\right\|^2\right] (2) \quad (7)$$

$$P_N = P_N - K\left\|\tilde{v}_N - V_N\right\| - D_{Rt}.D_r\left\|\tilde{v}_N - V_{N-1}\right\|^2 (3) \quad (8)$$

Energy consumption of node due to data transmission is given by

$$P_i \geq 0, i = 1.....N \quad (9)$$

The node placement for optimal data routing is used to improve the network lifetime. The $\mathrm{Max} = \sum_{i=1}^{n}\tilde{p}_t$ subject to constraints 1 to 4. Network lifetime improve with game theory routing as shown in figure 6.16. Relative analysis of lifetime for hardware and simulation shows minimal reduction in network lifetime when implement in hardware.

4. CONCLUSIONS

In this work, data security in wireless sensor network under compromised node condition with game theory routing scheme is addressed. In addition, a relative analysis of game theory routing mechanism and state of the art DSR routing mechanism simulate in NS-2

environment and the same implement in hardware to validate proposed routing scheme effectiveness. The relative analysis show game theory routing scheme is immune to data hacking under compromised node condition. The compromised node induces with an external node physically connected to a node in the network. The analysis show Game theory routing is immune to data theft and outperforms DSR routing in terms of throughput, packet delivery ratio, network lifetime and end to end delay.

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