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An approach to implement Energy Efficiency for MAC Protocol in WSN

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Abstract: ***In wireless sensor networks, energy efficiency is one of the most powerful factor. In wireless sensor networks, energy consumption can be occur in various forms and states like receiving, idle, transmitting and sleeping state energy consumptions. This is the reason, why implementation of energy efficiency model becomes important and energy model considered as a resource constraints.***

In this research, we implemented energy efficiency model for Sensor-MAC, which is a medium access control (MAC) layer protocol in wireless sensor network (WSN). We've traced energy consumption in four different states of network that includes sleep state, receive state, transmitting state and idle state. We further calculated average energy consumption for all states. We added energy breakdown in each state to support detailed energy analysis.

We calculated average energy consumption in all states by taking different number of nodes and making different numbers of connection between them in WSN and have a conclusion that when we increase number of connections in a WSN, for the SMAC protocol the energy consumption is also increases. We also noticed energy consumption in network when the network has no connection between nodes.

Keywords: Energy Model, MAC Protocols, S-MAC, Wireless Sensor Networks, Network Simulator2.29

Introduction

In the simulations of S-MAC and other energy –efficient protocols, for support it needs extended energy model in ns2. Previous model does not have sleep state, there is integrated additional sleep state and also added energy consumption while state transition from sleep state to active state [2]. There is also enhancement of energy traces on individual states through analysing energy consumption in different states, there are different states as sleep, idle, receive and transmit [4].

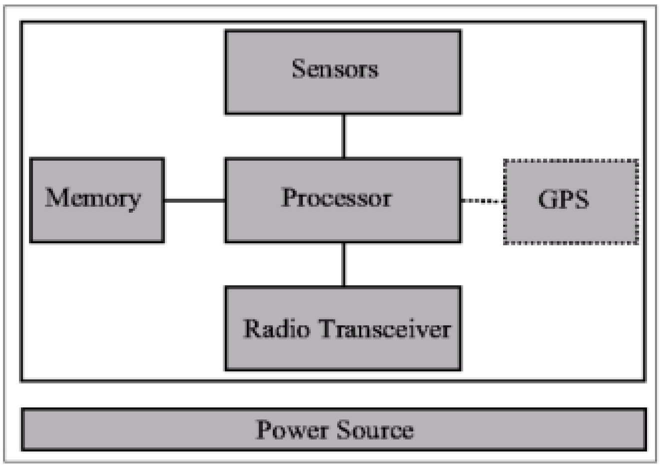

Figure 1. Basic WSN Components

1.1 Modification in NS2

Some modifications have been made in the physical layer and some changes have been made in energy model. By doing this the physical layer gets the full control over radio states and gives an interface to put radio into sleep state and wake it up. Radio energy consumption is tracked at all times through it. When the radio state goes into another state, it makes some changes to energy model to subtract some amount for the previous state. Modified physical layer provides accurate energy calculations even MAC is running on top of this [3].

Radio states are not maintained by energy model it only maintains the total energy. It is enough for consumption of the CPU power. It is to note that the energy model requires some radio states, and have procedures to amend them. Sometimes it may cause inconsistency.

1.2 Energy Model API

The energy model is used by node config through Energy Model API. An example is shown as follows

```
$ns_ node-config -adhocRouting DumbAgent \
-llType $opt(ll) \
```

```
-macType Mac/SMAC \
-ifqType $opt(ifq) \
-ifqLen $opt(ifqlen) \
-antType $opt(ant)
-propType $opt(prop) \
-phyType $opt(netif) \
-channelType $opt(chan) \
-topoInstance $topo_ \
-agentTrace ON \
-routerTrace ON \
-macTrace ON \
-energyModel $opt(energymodel) \
-idlePower 1.0 \
-rxPower 1.0 \
-txPower 2.0 \
-sleepPower 0.001 \
-transitionPower 0.2 \
-transitionTime 0.005 \
-initialEnergy $opt(initialenergy)
```

The following parameters are newly added: -sleepPower: power consumption (Watt) in sleep state -transitionPower: power consumption (Watt) in state transition from sleep to idle (active) -transitionTime: time (second) used in state transition from sleep to idle (active).

1.3 The Energy Analysis through Trace Files

We have added energy breakdown in each state in the traces to support detailed energy analysis. In addition to the total energy, now users will be able to see the energy consumption in different states at a given time. Following is an example from a trace file on energy.

[Energy 979.917000 ei 20.074 es 0.000 et 0.003 er 0.006]

The meaning of each item is as follows:

Energy: total remaining energy

ei: energy consumption in IDLE state

es: energy consumption in SLEEP state

et: energy consumed in transmitting packets

er: energy consumed in receiving packets.

I. SMAC

S-MAC is an energy-efficient MAC protocol designed for wireless sensor networks. The major design goals are energy efficiency, self-configuration and flexibility to node changes. S-MAC has four major components [4]. First, it enables low-duty-cycle operation of nodes in a multi-hop network. Nodes periodically listen and sleep, and form virtual clusters based on common sleep schedules. Second, S-MAC adopts similar contention schemes as the IEEE 802.11 ad hoc mode. Third, S-MAC avoids overhearing unnecessary traffic to further save energy. Finally, S-MAC supports efficient transmissions of long messages.

II. EXPERIMENTAL SETUP

We have made changes to network simulator 2.29 for Sensor-MAC simulation process. By default network simulator do not support the energy efficiency model so we did some modifications (explained under introduction section) in the simulator. Further we set different numbers of connections between the nodes to analyze the behavior of Sensor MAC protocol in more challenging scenario.

In this research, all the experiments are performed under following specifications:

1) **Host System**: Intel i5 processor with 6 GB RAM and 500 GB Hard disk.
2) **Operating Environment**: Ubuntu 14.04
3) **Network Simulator 2**: version 2.29 is used.
4) **Simulation Parameters**

In Table 1, various simulation parameters are given which has been used during the process of simulation.

Table 1. Simulation Parameters

Parameter	Value
Simulation time	150 seconds
Simulation area	1000 m x 1000 m
Maximum Packets	50
Node movement	Random waypoint
Connections	5,10,15,20,25
Network interface	Phy/WirelessPhy
MAC Type	Mac/802.11
Bandwidth	10 Mbps

III. RESULT & ANALYSIS

A. *Energy consumption in idle state:*

Table 2. Performance Table between Idle State Energy Consumption & Connections

No. Of Connections	Idle State Energy
5	11.2563
10	12.5574
15	12.6603
20	13.5586
25	15.3242

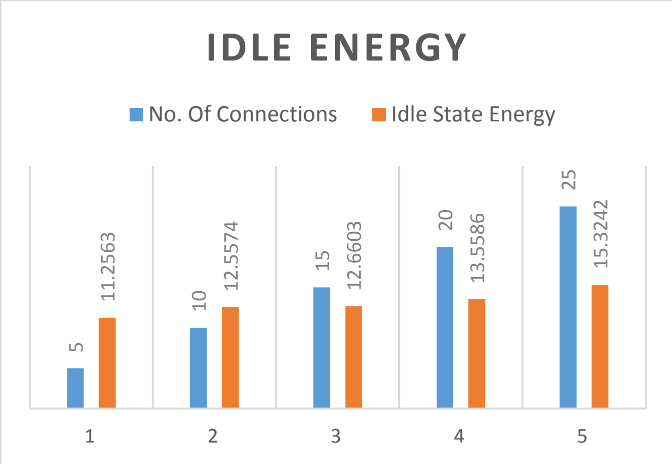

Figure 2. Energy model between idle state energy consumption & connections

From the figure 2 it is clear that as we increase the number of connections between nodes the idle state energy almost remains same, even after we increase the number of connections by 200% still the increment in idle state energy is about 10%.

B. *Energy consumption in transmit state:*

Table 3. Performance Table Between transmit State Energy Consumption & Connections

No. Of Connections	Transmit Energy
5	0.003655
10	2.76E-05
15	8.75E-07
20	0.010459
25	0.017186

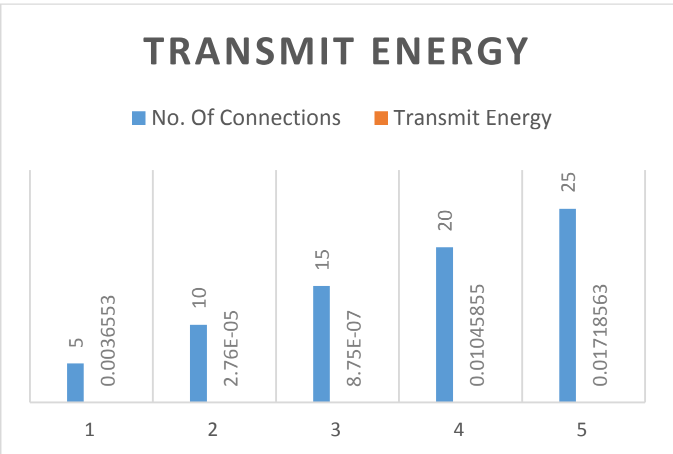

Figure 3. Graph between transmit State Energy Consumption & Connections

From the figure 3 it is clear that as we increase the number of connections between nodes the Transmit energy gets increased but the amount is almost negligible.

C. *Energy consumption in receiving state:*

Table 4. Performance Table between receive State Energy Consumption & Connections

No. Of Connections	Receive Energy
5	0.006357
10	0.008564
15	0.009856
20	0.031543
25	0.012534

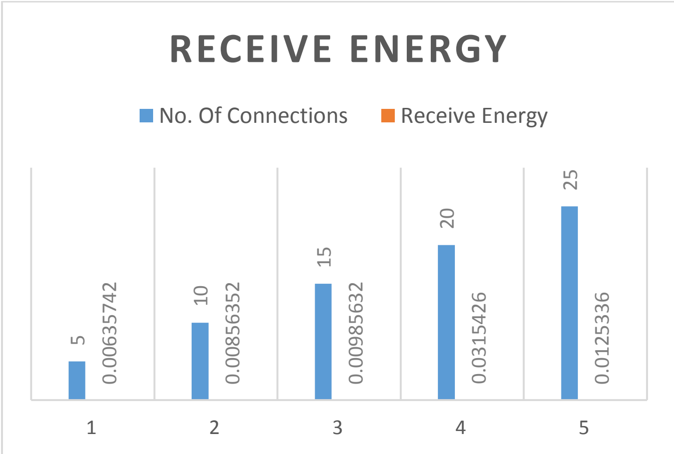

Figure 4. Graph between receive State Energy Consumption & Connections

From the figure 3 the analysis can be done that as we increase the number of connections between nodes the consumption of receive state energy increases significantly.

D. *Energy consumption in all states:*

Table 5. Performance Table between Overall Energy Consumption & Connections

No. Of Connections	Idle State Energy	Transmit Energy	Receive Energy
5	11.2563	0.003655	0.006357
10	12.5574	2.76E-05	0.008564
15	12.6603	8.75E-07	0.009856
20	13.5586	0.010459	0.031543
25	15.3242	0.017186	0.012534

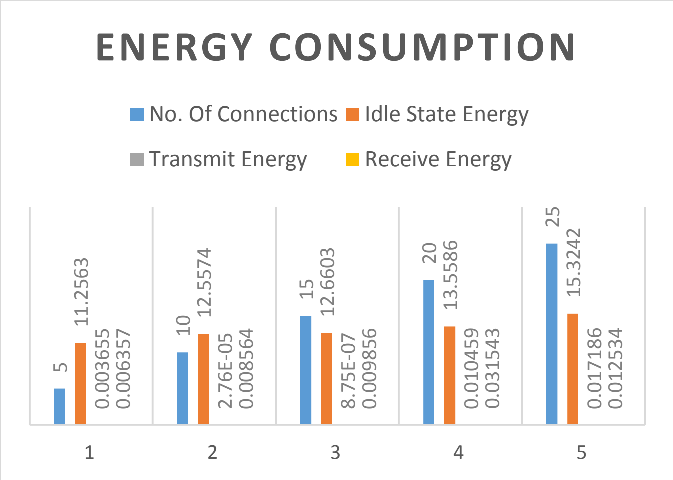

Figure 5. Graph between Overall Energy Consumption & Connections

Figure 5 consists the collective results of all energy states. It clears that as we increase the number of connections between nodes all the states of energies increases, except the receive energy.

IV. CONCLUSION

In this research, the analysis for the energy efficiency model for S-MAC protocol in wireless sensor networks (WSNs) is done. Our simulation process has been conducted in same scenario with different number of connections (i.e. 5, 10, 15, 20, 25), then we evaluated the variation in different states of energy for different number of connections.

The final simulation result clears that the variation of energy in S-MAC is that, as we increase the number of connections in our network then over all energy consumption of all states (idle, sleep, transmitting receiving) is also increases except the receive energy state. Till a certain level the receive energy increases as we increase the number of connection but after a certain number of connection it again starts decreasing as we can see in our experiment till 20 connections it is clearly increases but as number of connections are 25 the receiving energy also start decreasing.

We also noted that if a network do not have any connection between nodes then energy consumption is very high.

V. FUTURE SCOPE

For the purpose of future work we can consider a scenario that if in a network the number of nodes are very much greater than the number of existing connections, in this case many nodes will be in idle state only, it is just like there is no connection between nodes and energy consumption will be very high. More tests can be done on this model with different conditions.

We can also perform analysis for energy efficiency model for T-MAC, H-MAC, B-MAC and EE-MAC, the MAC-layer protocols. We can compare the energy variation and consumptions between these protocols and can achieve the results to prove which one is better.

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