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Static Sleep Scheduling Protocol for Forest Fire Detection System

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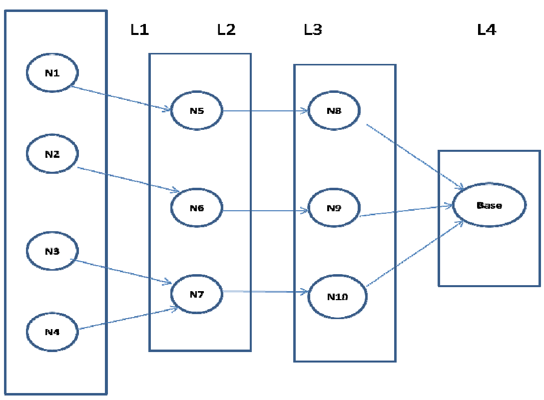
Abstract: In wireless sensor networks, sensor nodes generally switch between active and sleep modes in medium access control (MAC) layer to reduce energy consumption. In previous synchronization protocols, each node begins to synchronize the active/sleep schedule with other nodes at the network setup phase and maintains the synchronization even if it has no packet to send. Therefore, the control overhead and energy consumption during synchronization cannot be ignored under low traffic scenario like forest fire. In this paper, we propose a new Static Sleep Schedule Protocol (SSSP). In this proposed method, each node communicates with its neighbors periodically with a static time gap, hence the name is static scheduling. In addition, our protocol considers clock skew between nodes to maintain the synchronization for a longer period and reduce the number of control packet transmissions. We also study the advantages of our proposed method by introducing computer simulation results using ns2.

KEYWORDS: Forest Fire, Static Sleep Scheduling Protocol, SSSP, Sleep Schedule, Hoping Network

I. INTRODUCTION

Wireless Sensor Networks (WSN) is a collection of spatially deployed wireless sensors by which to monitor various changes of environmental conditions (e.g. forest fire, air pollutant concentration and object moving) in a collaborative manner without relying on any underlying infrastructure support. Recently, a number of research efforts have been made to develop sensor hardware and network architecture in order to effectively deploy WSNs for a variety of applications. Many network parameters such as sensing range, transmission range and node density have to be carefully considered at the network design stage, according to specific applications. To achieve this, it is critical to capture the impacts of network parameters on network performance with respect to application specifications. The main performance measures affected by the routing scheme are throughput (quality of service) and average packet delay (quantity of service).

II. METHODOLOGY



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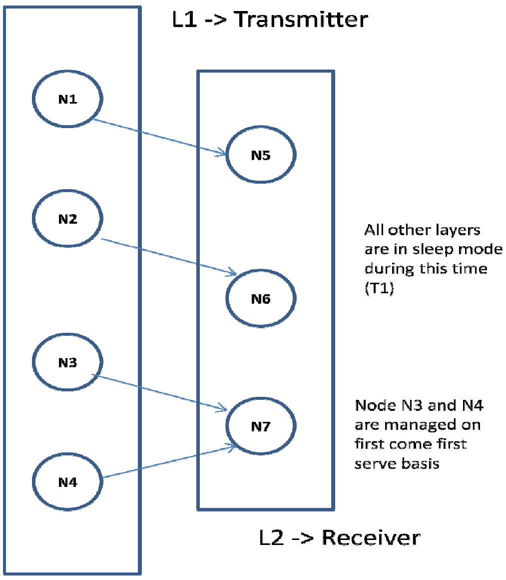
As far as forest network is concerned, the frequency of data transmission is very low, as the conditions never change dramatically. The data packet of 256 bytes can accommodate complete information of forest fire. Hence there is no need to keep pinging signal periodically. The proposed protocol is developed considering the above requirement of forest. The sleep scheduling and low, almost zero power consumption are the key issues in this work.

Logic for Static Sleep Scheduling Protocol using static single hop network
Consider above forest network. The network comprises of four layers. The time cycle is completed in n-1 steps where n is number of layers, here 3.
T1 – S1 cycle:
Layer 1 communicates with layer 2.
Layer 1 nodes act as transmitters and layer 2 nodes act as receivers. Here we are considering the worst case situation where all nodes need to send some critical data. The pairing is pre defined; hence N5 only listens to N1, and N6 to N2. But N7 need to read both N3 and N4. This conflicting situation is very easily managed by sending repeatedly the data from both nodes in random time interval. Just like LAN protocol. If N4 gates through first then N3 has to



wait till N4-N7 completes data transfer. Once the data is successfully transferred, N4 is disabled and now random sampling again starts for remaining input nodes. In above case only one node is remaining which is N3. This node is then detected by N7 and data transfer completes.

Now sleep cycle S1 begins:
Here all nodes of layer 2, that is N5,N6 and N7 compare their individual data with data of its predecessor for its criticalness. If own data is more critical than the data of predecessor, own data is assigned high priority, other wise predecessor is assigned high priority. The sleep time is used by all nodes of layer 2 for re-arranging data packets. These packets are then transmitted to layer 3 during T2 cycle of timing sequence.
T2 – S2 cycle:
Layer 2 communicates with layer 3.
Just as in T1 cycle, here layer 2 will communicate with layer 3 keeping remaining network in sleep mode. Now layer 2 acts as transmitter and layer 3 as receiver. If any node needs to read data from multiple transmitting nodes, the LAN protocol is used and all data is received on first come first serve basis.
The S2 sleep time is used by layer 3 to priorities the received data and prepares each node of layer 3 for T3 – S3 cycle.

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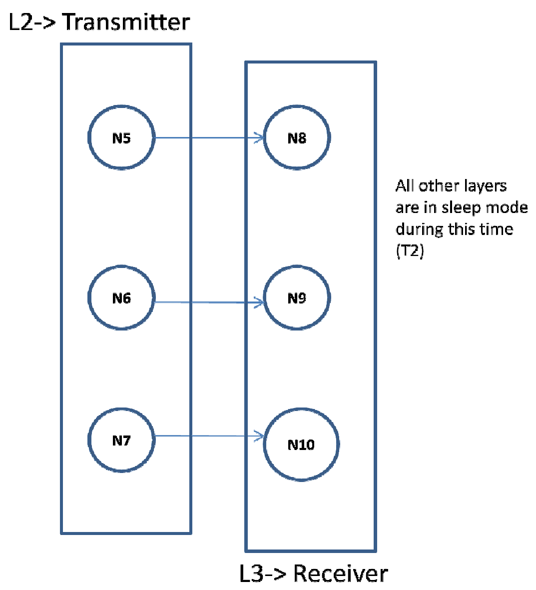
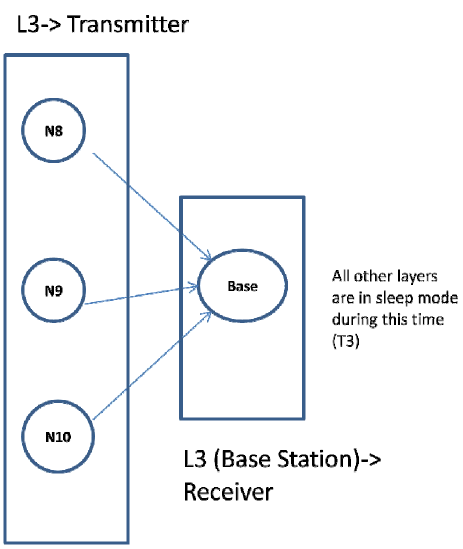


T3 – S3 cycle:
In above sample network this is the last cycle. In this cycle all nodes of layer 3 act as transmitter and base station acts as receiver. The base station gets highest



priority three massages in first come first serve basis. The decisions are taken by the base station and the entire network is thrown in deep sleep for long duration of approximate 10-15 minutes. After deep sleep the system restarts from T1-S1 cycle and repeats all steps in progression as explained earlier.
The time scheduling system is explained in following timing diagram.

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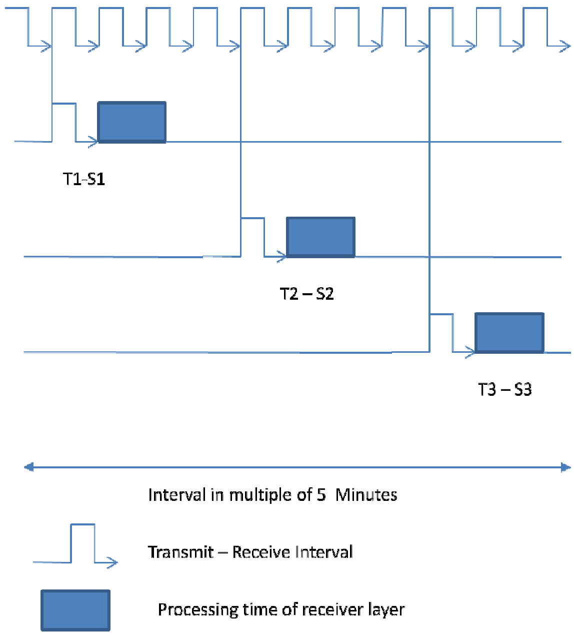

Relative comparison of SSSP protocol with 802.11 and Q-MAC

System Analysis
Latency Issue:
Let Hp be the hopping nodes end to end.
Let Td be the time required to transmit complete 256 byte of data packet.
In QMAC: L = (Hp * Td)
In 802.11 DCF: L= (Hp *T)
In SSSP: L = (Hp * Ts) + (Hp * Td)
Latency increases in SSSP due to its periodic sleep, as the data packets have to wait. Though Q-MAC has a large sleep time, the latency of Q-MAC is less than that of SSSP because the intermediate nodes are activated in advance during data packet transmission. So the latency of Q-MAC and 802.11 are same. Moreover, latency in Q-MAC is same whether the destination's location is known or not known.

Energy Consumption issue

III. SIMULATION PARAMETERS

Transmission Power	14 mw
Receiving Power	13 mw
Power consumption in idel mode	12 mw
Power consumption in sleep mode	0.016 mw
Data packet size	256 Bytes
Transmission range	100 Mtr

Let Energy consumed by Transceiver be Etr-avg
Let Energy consumption of Transceiver in sleep time be Etr-Slp
Let Data transfer rate be 256 bytes / sec.
Let there be 200 hop static network covering distance of 20 KM
The pessimistic time to reach data from node 1 to node 200 will be 200 sec=3.5 minutes
As every node operates for only 5 seconds in time interval of 200 seconds.
The total power consumption in single iteration of communication cycle (End to End Node)
in SSSP is [5 * (Etr-avg) + 195 * (Etr-slp)]/200
in any other active protocol is [200 * (Etr-avg)]/200 = Etr-avg

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where Etr-avg=[2*Erecv+1*Eproc+2*Etran+195*Eidel]/200
For example, if we consider the parameter list of a sensor as given below
Then the calculations show that power consumption in any other protocol is
Etr-avg=[2*13mw + 1 * 5 mw + 2*14 mw + 195 * 12 mw] / 200
Etr-avg=11.995mw
On the other hand power consumption in SSSP protocol will be
Etr-slp=[5 * (Etr-avg) + 195 * (Etr-slp)]/200
Etr-slp=[5*11.995mw + 195 * 0.016mw]/200
Etr-slp=0.3154 mw per iteration of communication cycle
The % energy saving is 11.995 mw-0.3154 mw / 0.3154 mw =1094 %
Even if we add the circuit warm up time of 5 seconds consuming active power of 12 mw the efficiency increases by factor more than 500 %.
This will certainly improve the battery life hence maintenance and other replacement issues are eliminated by great extent.

IV. CONCLUSION

The above timing diagram shows that the static sleep schedule protocol (SSSP) with single hop network has following important advantages. Every node is operating in simplex mode at any given point of time hence the system scores on issue of power consumption. As the system is always in simplex mode the chances of data collision are immediately eliminated. There are very low chances of adding noise to signals arising due to signal interference. Battery life of every sensor node increases to very large time interval. As every sensor is operating for few seconds after time interval in multiple of n minutes. (here we are considering n=5 minutes) As we are planning the SSSP protocol for applications like forest fire, where it hardly makes any difference, if information of forest fire is conveyed with a time gap of 3.5 minutes over a distance of 20 KM. The maintenance of instruments on all nodes and battery life are two critical issues while handling sensor network in remote areas like forests. Here more emphasis is on rigidity and longevity of system than speed. Hence the SSSP protocol offers advantage over any conventional systems like 802.11 or Q-MAC systems

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