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Energy Efficient and Delay Aware P-Mac Protocol for Wireless Sensor Network

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ABSTRACT: To increase the life of the sensor networks, each sensor node has to conserve energy. Due to the fact that each sensor node has one battery energy to remain alive for long times, energy management is a one of critical issues in wireless sensor networks. In this paper we discuss about Pattern MAC (P-MAC) for wireless sensor network. The proposed Pattern-MAC (PMAC) protocols, instead of having fixed sleep wakeups, the sleep-wake up schedules of the sensor nodes are adaptively determined. The schedules are decided based on a node's own traffic and that of its neighbours. We simulate the proposed protocol in NS2 and we compare the results of SMAC, in-terms of Packet delivery ratio, Energy Consumption, End to end delay and throughput. We analyze the results with SMAC, based on the simulation results the proposed protocol have less energy consumption compare to SMAC.

KEYWORDS: SMAC, PMAC, NS2,wireless sensor netwo*rk*

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I. INTRODUCTION

Communication in wireless sensor networks can, like most network communication, be divided into several layers. One of those is the Medium Access Control (MAC) layer. This layer is described by a MAC protocol, which tries to ensure that no two nodes are interfering with each other's transmissions, and deals with the situation when they do. Wireless

Sensor networks have an additional aspect: as sensor nodes are generally battery-operated, energy consumption is very important. The radio on a sensor node is

Usually the component that uses most energy. Not only transmitting costs energy; receiving, or merely scanning the ether for communication, can use up to half as much, depending on the type of radio [1]. While traditional MAC protocols are designed to maximize packet throughput, minimize latency and provide fairness, protocol design for wireless sensor networks focuses on minimizing energy consumption. The application determines the requirements for the (modest) minimum throughput and maximum latency. Fairness is usually not an issue, since the nodes in a wireless sensor network are typically part of a single application and work together for a common purpose.

The important design features for medium access control protocols in a WSN are: energy, latency, throughput, and fairness. Among these important requirements for MACs, energy efficiency is typically the primary goal in WSN. Previous works (in particular [2], [3], [4], [5], [6], [7]) have identified idle listening as a major source of energy wastage. As traffic load in many sensor network applications is very light most of the time, it is often desirable to turn off the radio when a node does not participate in any data delivery. The scheme proposed in [5] puts idle nodes in power saving mode and switches nodes to full active mode when a communication event happens. However, even when there is traffic, idle listening still may consume most of the energy. Consider a sensor node with 1 report per second at 100 bytes per packet — data transmission takes only 8ms for a 100Kbps radio, 992 ms are wasted in idle listening between reports.

S-MAC [2] provides a tunable periodic active/sleep cycle for sensor nodes. During sleep periods, nodes turn off radio to conserve energy. During active periods, nodes turn on radio to Tx/Rx messages. Although a low duty cycle MAC is energy efficient, it still has three shortcomings. First, it increases the packet delivery latency. An intermediate node may have to wait. Although a low duty cycle MAC is energy efficient, it still has three shortcomings. First, it increases the packet delivery latency. An intermediate node may have to wait until the receiver wakes up before it can forward a packet. This is called sleep latency in SMAC [2]. The sleep latency increases proportionally with respect to number of hops, with the constant of proportionality being the duration of a single cycle (active period plus sleep period). Secondly, a fixed duty cycle does not adapt to the traffic variation in sensor network. A fixed duty cycle for the highest traffic load results in significant energy wastage when traffic is low while a duty cycle for low traffic load results in low message delivery and long queuing delay. Thirdly, a fixed synchronous duty cycle may increase the possibility of collision. If neighboring nodes turn to active state at the same time, all may contend for the channel, making a collision very likely.

In this paper, we propose a new MAC protocol called Pattern-MAC (PMAC) for sensor networks that adaptively determines the sleep-wake up schedules for a node based on its own traffic, and the traffic patterns of its neighbors. We analytically and experimentally show that by doing so, our protocol is able to achieve a better throughput at high loads, and conserve more energy at light loads than SMAC.

II. RELATED WORK

In SMAC,. the sensor node are capable to communicate with additional nodes and send some control packets such as SYNC, RTS (Request to Send), CTS (Clear to Send) and ACK(Acknowledgement) are only for listen period. By a SYNC packet exchange all nearest nodes can synchronize collectively and using RTS/CTS switch over the two nodes can communicate with each other.

SMAC and TMAC reduce energy consumption by using Coordinated scheduling, but this requires periodic synchronization. CMAC supports low latency and avoids synchronization overhead [6]. CMAC allows operation at very low duty cycles by using unsynchronized sleep scheduling .TMAC uses adaptive duty cycle and has the advantage of dynamically ending active part [1].

Another contention based MAC protocol is Berkeley Media Access Control (B-MAC) which is widely used in WSNs [3]. B-MAC is like to Aloha with Preamble Sampling [4], BMAC duty cycles the radio transceiver i.e. the Sensor node turns ON/OFF again and again without missing the data packets. The preamble length is provided as a parameter to the upper layer, which provides optimal trade-off between energy savings and latency or throughput [2]. BMAC is also similar to CSMA protocol with having a feature of Low Power Consumption [3].

Timeout- MAC (T-MAC) [4] is proposed to enhance the poor results of S-MAC protocol under variable traffic load. In T-MAC, when no activation event has occurred listen period ends for a time threshold TA. Along with some solutions the decision for TA is presented to the early sleeping problem defined in [4]. Dynamic Sensor-MAC (DSMAC) [5] it sum the dynamic duty cycle feature to S-MAC. The aim is to Decrease the latency for delay sensitive applications. Within the SYNC period, all nodes share their one-hop latency values (time between the reception of a packetinto the queue and transmission). All nodes start with the same duty cycle

WiseMAC [6] when the sender starts the preamble before the receiver is expected to wake up rather than selecting a random time. For alerting the receiving node the

preamble precedes each data packet. The nodes which are presents in the network sample is having the medium with a common period, but their relative schedule offsets are independent. If a node finds the medium busy after it wakes up and samples the medium, it regularly listen till it receives a data packet or the medium comes to the idle state.

TRAMA [7] is algorithm based on a TDMA it proposed to increase the utilization of classical TDMA in an energy efficient manner. It is like Node Activation Multiple Access(NAMA) [8], where a distributed election algorithm is used to select one transmitter within two-hop neighborhood for each time slot.

The another schedule based MAC protocol is Data–Gathering Medium Access Control (DMAC) [9]. Which has been planned and optimized for tree based data gathering in wireless sensor network. The low latency and still maintaining the energy efficiency is the main aim of this MAC protocol. In this the time is divided in small slots and runs carrier sensing multiple access (CSMA) with acknowledgement within each slot to transmit/receive one packet. The sensor node sometimes executes the basic sequence of ‘1’ transmit, ‘1’ receive and ‘n’ sleep slots. In this approach a single packet from a source node at depth ‘k’ in the tree reaches the sink node with a delay of just ‘k’ time slots

Name of protocol	Scheme used	Energy Saving	Advantages	Disadvantages
SMAC	Fixed duty cycle, virtual cluster, CSMA	Power savings over standard CSMA/CAMAC	Low energy consumption when traffic is low	Sleep latency, problem with Broadcast
BMAC	LPL, channel assessment software interface	Better power savings, latency, and throughput than S-MAC	Low overhead when network is idle, imple to implement Consumes less power	Overhearing, bad performance at heavy traffic. Long transmission latency
TMAC	Adaptive duty cycle, overhearing, FRTS	Uses 20% of energy used in S-MAC.	Adaptive active time	Early sleeping problem
WISE MAC	Minimized preamble sampling, schedule	Better than SMAC and Low Power Listening	Energy Consumption both at sender And receiver, and at non target receiver, increase latency at each hop.	Low power for low traffic, Do not incur overhead due to synchronization.
TRAMA	TDMA	Utilization of classical TDMA	Higher energy efficiency & throughput	time is divided into random access period
DMAC	Converge cast communication	Low latency	Energy saving and low letency	Aggregate rate is larger

III. PERFORMANCE EVALUATION

We implemented our prototype in the ns-2 network simulator. For comparison, we also implement a simple version of SMAC with adaptive listening, but without its synchronization and message passing scheme. This will serve as the baseline of latency, energy, and throughput performance. We choose three metrics to evaluate the performance of PMAC: energy cost is the total energy cost to deliver a certain number of packets from sources to sink. This metric shows the energy efficiency of the MAC protocols. Latency is the end to end delay of a packet. Throughput or Delivery ratio is the ratio of the number of packets arrived at the sink to the number of packet sent by sources.

We use Network Simulator Version-2 (NS2) to simulate our proposed algorithm. In our simulation, the channel capacity of mobile hosts is set to the same value: 2 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the PMAC layer protocol. It has the functionality to notify the network layer about link breakage. In our simulation, mobile nodes move in a 1200 meter x 1200 meter region for 25 seconds simulation time. All nodes have the same transmission range of 250 meters. The simulated traffic is Constant Bit Rate (CBR). Our simulation settings and parameters are summarized in table 1

TABLE 1: SIMULATION PARAMETERS

No. of Nodes	25,50,75,100
Area Size	1200 X 1200
Mac	PMAC/SMAC
Routing protocol	AODV
Simulation Time	10 sec
Traffic Source	CBR
Packet Size	512 bytes
Antenna	OmniAntenna
Initial Energy	10J
Channel	Wireless physical
Transmission Rate	10,20,30,40 Kbps
Receiving Power	0.395
Sending power	0.660
Idle Power	0.035

IV. RESULTS

If the number of nodes are increasing the energy consumption level vary in both cases due to the more number of nodes contribution rate with respect of comparison rates the PMAC energy consumption rate 22% less than SMAC

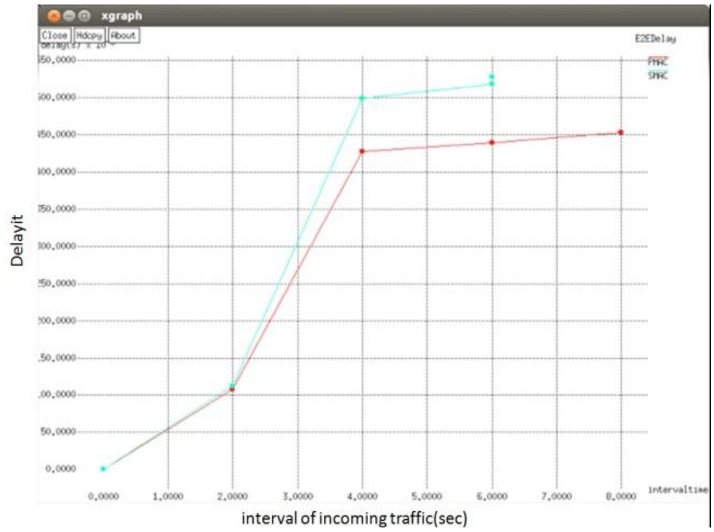

Fig1 avg end to end delay vs interval time

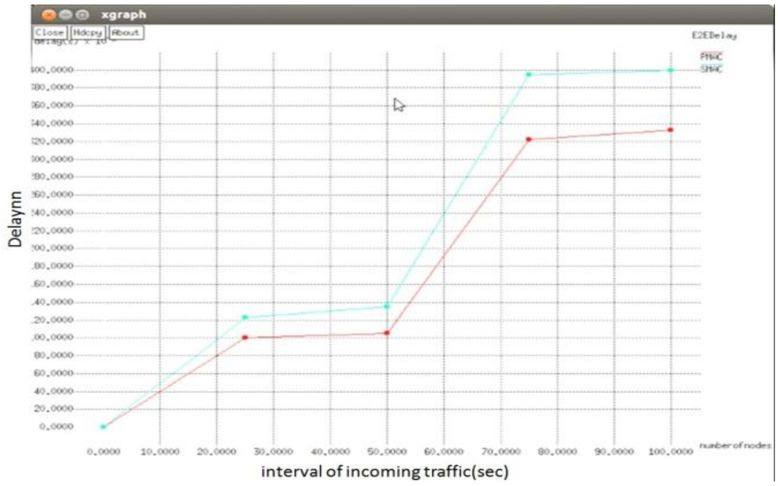

Fig2 average end to end delay vs no of nodes

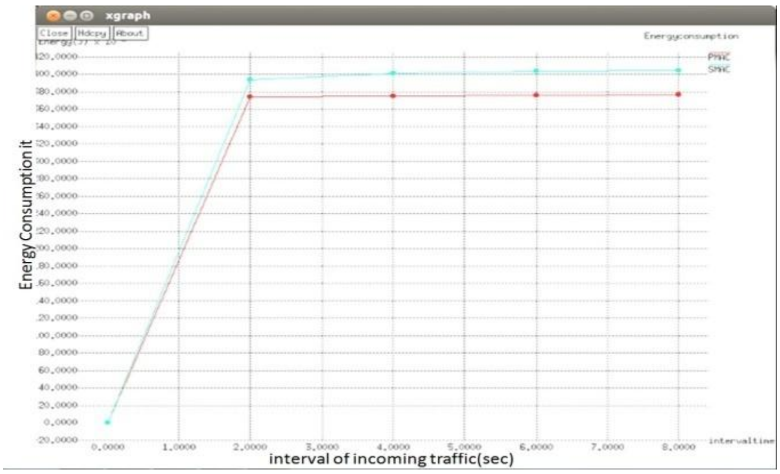

Fig3 avg energy consumption vs interval time

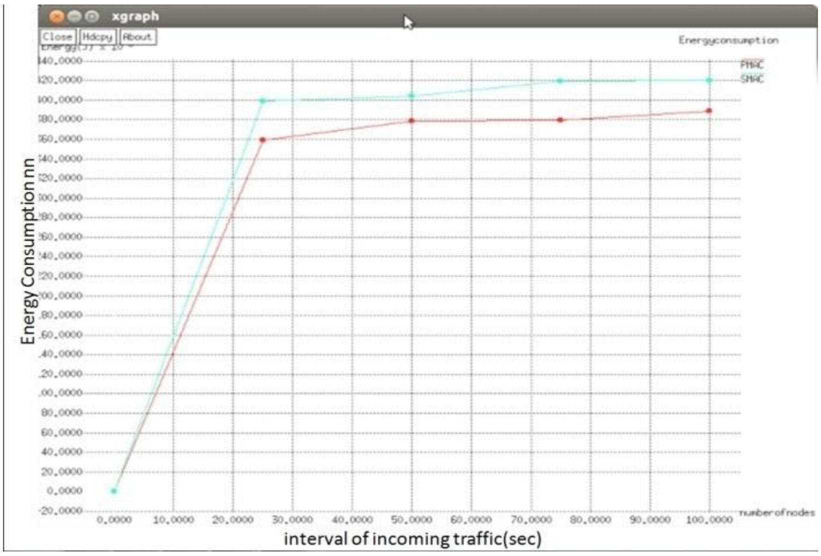

Fig4 average energy consumption vs no of nodes.

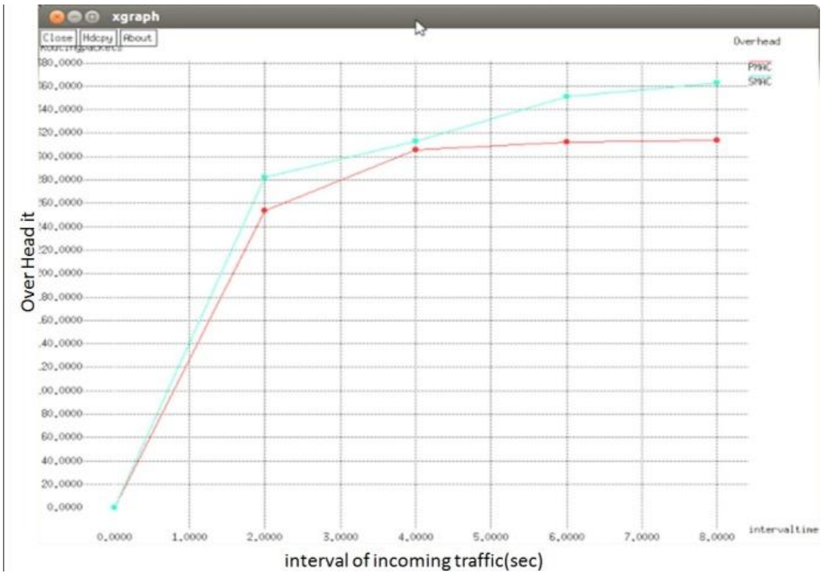

Fig5 overhead vs interval time

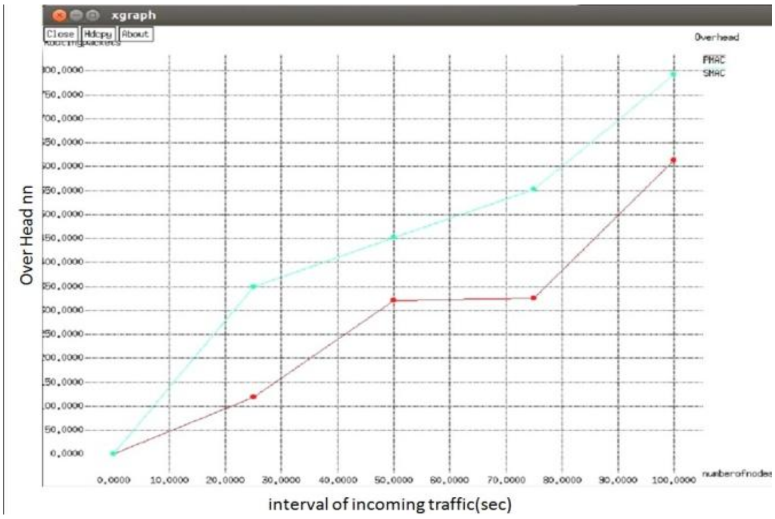

Fig6 overhead vs no of nodes.

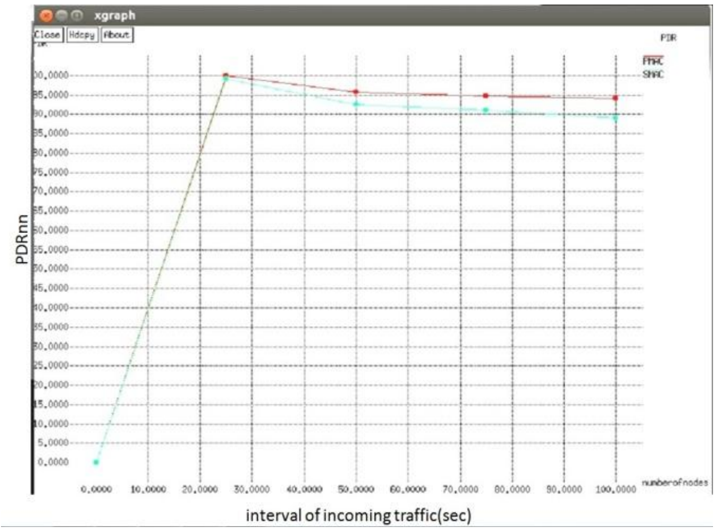

Fig7 packet delivery ratio vs no of nodes

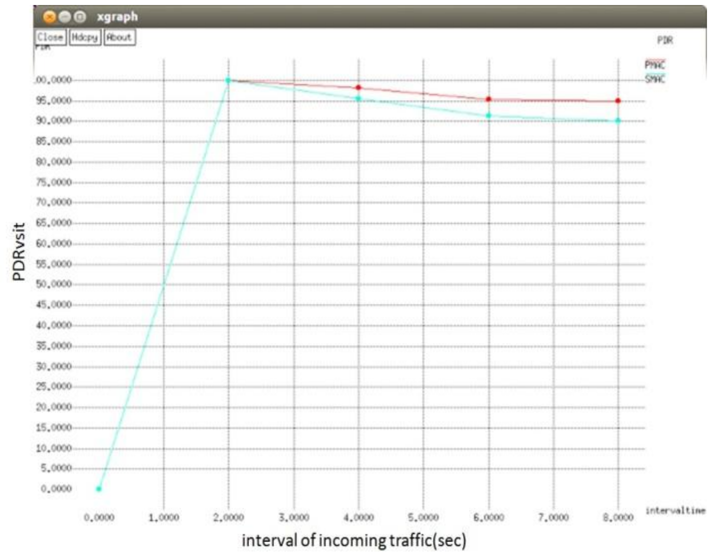

Fig8 packet delivery vs interval time

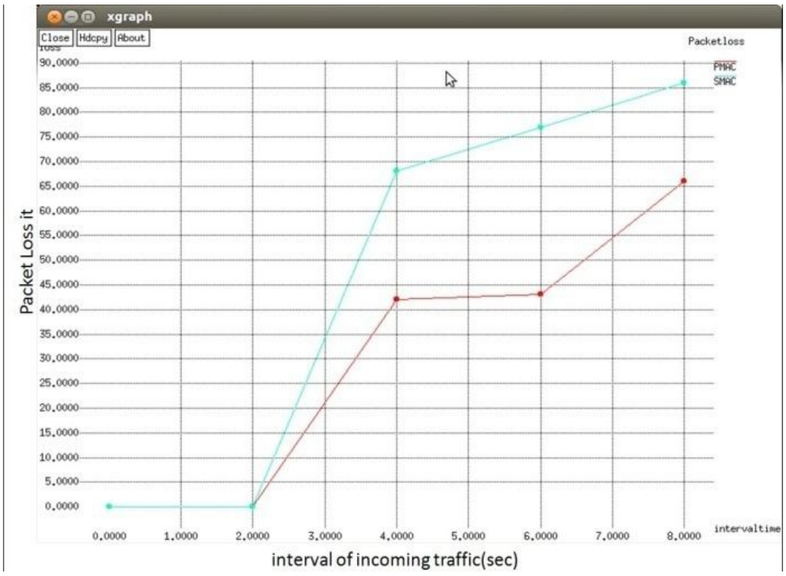

Fig9 packet loss vs interval time

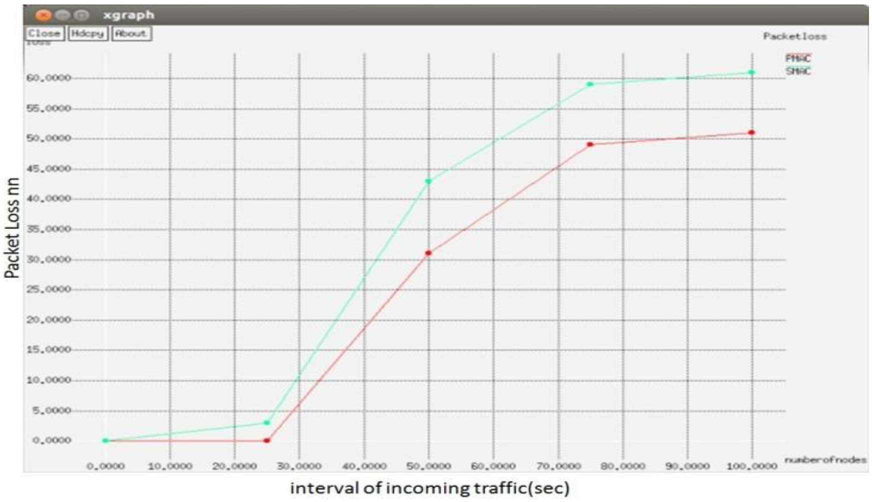

Fig10 packet loss vs no of nodes.

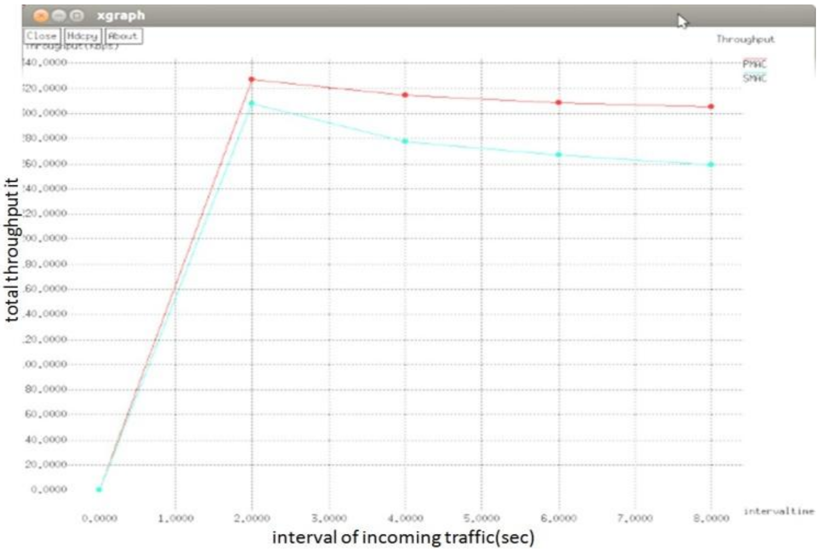

Fig11. avg throughput vs interval time

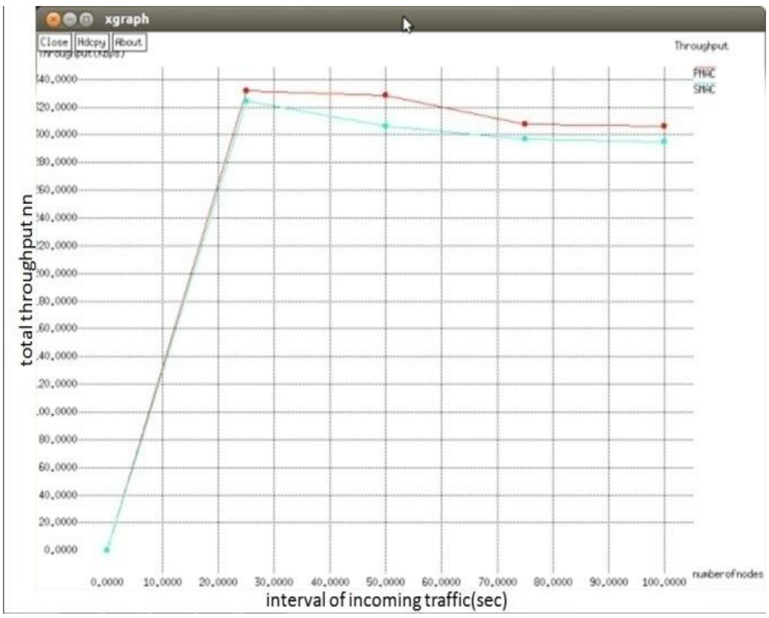

Fig12 average throughput vs no of nodes

if the no of nodes are increasing the energy consumption level vary in both cases due to the more no of nodes contribution rate with respect of compartion rates the pmac energy consumption rate 22% less than smac.

V. CONCLUSION

This paper has proposed PMAC, energy efficient and low latency MAC protocol for tree-based data gathering in wireless sensor networks. The major traffic in wireless sensor networks are from sensor nodes to a sink which construct a data gathering tree. PMAC utilizes this data gathering tree structure specific to sensor network applications to achieve both energy efficiency and low packet delivery latency. Where the sleep-wakeup times of the sensor nodes are adaptively determined. The schedules are decided based on a node's

own traffic and that of its neighbors. PMAC staggers the active/sleep schedule of the nodes in the data gathering tree according to its depth in the tree to allow continuous packet forwarding flow in which all nodes on the multihop path can be notified of the data delivery in progress and duty cycle adjustment command. Data prediction is employed to solve the problem when each single source has low traffic rate but the aggregated rate at an intermediate node is larger than the basic duty cycle can handle. The interference between nodes with different parents could cause one traffic flow be interrupted because the nodes on the multihop path is not notified of the data transmission requirement. Our experimental results show that in comparison to SMAC, PMAC achieves more power savings under light loads, and higher throughput under heavier traffic loads.. In our future work, we aim to implement this MAC on a Mote-based sensor network platform and evaluate its performance through real experiments.

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