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Effects of Drift in Time Synchronization in Nodes on Performance of WSN

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Abstract

The duty-cycle based MAC protocols in wireless sensor networks (WSNs) periodically repeats sleep and wake period. Duty cycling is a common mechanism for achieving energy efficiency in wireless sensor networks (WSNs) [1]. Data communication is not possible in the sleep period. Although energy is consumed in both the sleep and the wake periods of a sensor node, only the minimum energy required for activation is required during the sleep period, while full energy is required for communication during idle listening of wake period [2]. However, for data consistency and coordination, accurate time synchronization is required between the nodes as well as PAN coordinator(s) of WSN field. This paper analyzes the effect of drift in time synchronization of PAN coordinator with respect of nodes in the network on parameters like network lifetime, throughput, packets dropped, delay and jitter. A WSN network comprising of 500 nodes with PAN coordinator in 100 x 100 square meters terrain size has been implemented in QualNet 6.1 simulator. The results indicate significant packets dropped in case of time synchronization failure between nodes and PAN Coordinator.

Keywords: Clock drift, MAC, Duty Cycle, WSNs.

1. Introduction

A wireless sensor network consists of sensor nodes deployed over a large geographical area for monitoring physical phenomena like temperature, humidity, pressure, wind etc. Typical application areas of WSN include Disaster relief operation, Acoustic detection, Bio-Diversity mapping, Intelligent building and bridges, Precision agriculture, Medicine and health care and Military surveillance. Recent advances in miniaturization and low-cost, low-power design have led to active research in large-scale networks of small, wireless, low-power sensors and actuators. Time synchronization is a critical piece of infrastructure in any distributed system, but wireless sensor networks make particularly extensive use of synchronized time. Almost any form of sensor data fusion or coordinated actuation requires synchronized physical time for reasoning about events in the physical world. However, while the clock accuracy and precision requirements are often stricter in sensor networks than in traditional distributed systems, energy and channel constraints limit the resources available to meet these goals. The nodes operating in WSN works independently and their clocks may or may not be synchronized with one another. Such situation can cause difficulty while interpreting the information sensed at nodes. Hence time synchronization is important for Routing, Power conservation, Lifetime, Scheduling.

One of the main design goals of WSNs is to carry out data communication while trying to prolong the lifetime of the network and prevent connectivity degradation by employing Time synchronization technique.

2. Literaure Survey

Traditionally, time synchronization is maintained by pre synchronizing the clocks. Then nodes clock are time stamped. For low energy radio operation of TDMA scheduling is done. A technique used to conserve energy is to turn off the radio periodically and wake up to exchange messages, then go back to sleep again [1][2].Various TDMA schemes proposed for ad hoc networks consider clock synchronization [4]. A costly technique in this field is Global positioning system to synchronize nodes.

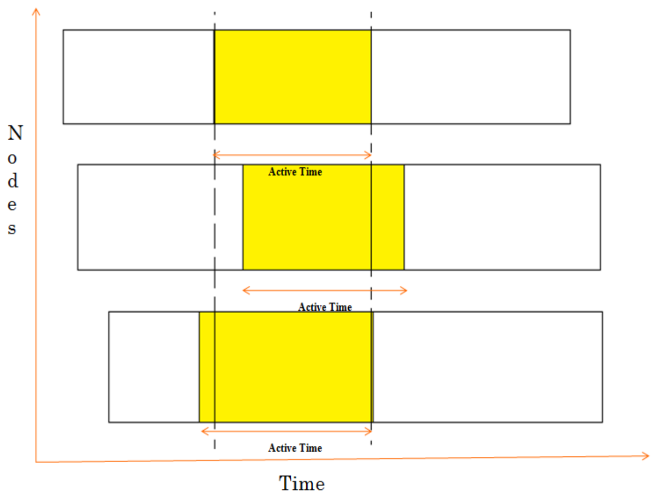

Fig 1: Time Asynchronization.

The technique known as Post facto synchronization proposed by Elson and Estrin [3] is based on synchronized local clocks but transmit range is limited to mobile computing nodes. It lacks a deterministic bound on the clock drift but the precision achieved by them is very good.

3. Network Simulation

This section describes simulation scenario and various simulation parameters considered for performance analysis.

3.1 Simulation Scenario

To analyze the time synchronization between nodes we have simulated a WSN comprising of 500 nodes in terrain size of 100mX100m on Qualnet 6.1 software.

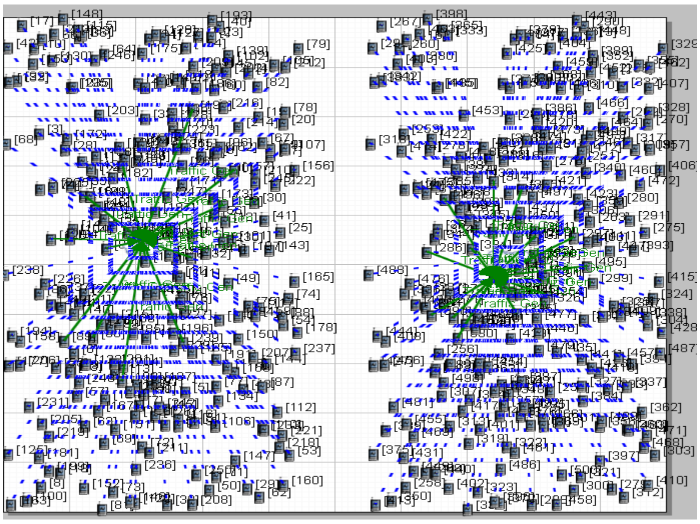

Fig. 2: Simulation scenario.

3.2 Simulation parameters

Table 1: Gives the simulation parameters

S. No.	Parameters	Values
1	Simulator	Qualnet 6.1
2	No. of nodes	500
3	No of PAN coordinator	2
4	Traffic Type	Traffic Gen
5	Terrain Area	100 m X 100 m
6	MAC Type	IEEE 802.15.4
7	Protocol	AODV

8	Battery Model	Linear
9	Energy Model	Generic
10	Sleep circuitry power consumption time	0.2mW
11	Simulation Time	1000sec
12	Packet Size	38
13	Radio type	802.15.4Radio
14	Channel type	Wireless channel

Table 1 Shows the Simulation Parameters Values

A WSN where the time schedule of nodes drift approximately by 2% with respect to PAN coordinator has been simulated. The same network with no time drift has also been simulated to compare the results.

4. Result

With the use of QualNet 6.1 we have studied different parameters for two cases.

Table 2: Shows the comparison of various parameters

Parameters	Time synchronized	2%Skewed Timing
Network lifetime(Days)	32.39617673	23.97446815
Unicast Received Throughput (bits/second)	1461.139	1200.035
Number Of Data Packets Dropped Due To Channel Access Failure	24113	52603
Average Unicast End-to-End Delay (seconds)	0.395066	0.966059
Average Unicast Jitter(seconds)	0.540841	1.288535

Network life time is defined in terms number of surviving nodes after a particular interval of time. This may be calculated with the help of Residual battery capacity. Fig 3 shows the Network Lifetime. Throughput is one of the dimensional parameters of the network which gives the fraction of the channel capacity used for useful transmission when network selects a destination at the beginning of the simulation i.e. information whether or not data packets were correctly delivered to the destinations. Fig 4 shows Unicast received Throughput.

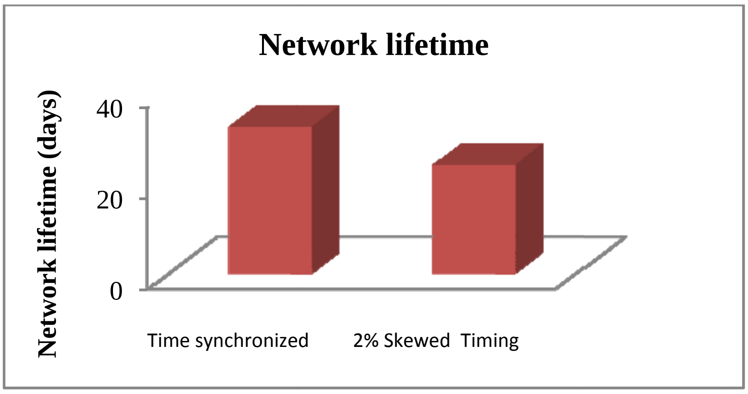

Fig. 3: Network lifetime.

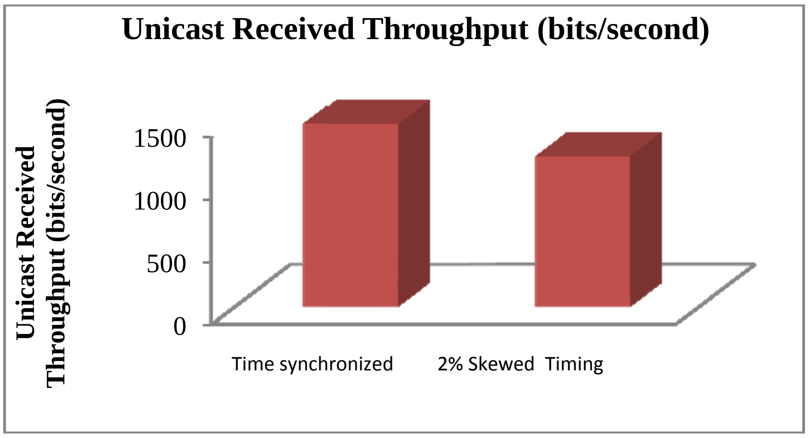

Fig. 4: Unicast Received Throughput.

The Average End-to-End Delay of data packets is the interval between the data packets generation time and time when the last bit arrives at the destination. Fig 5 shows Average End to End delay. Average Jitter is the variation of the packet-arrival times between the two successive packets received. Fig 6 shows Average Unicast Jitter.

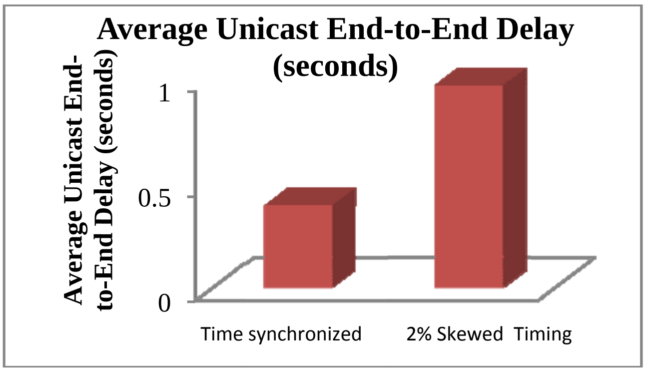

Fig 5: Average Unicast End to End delay

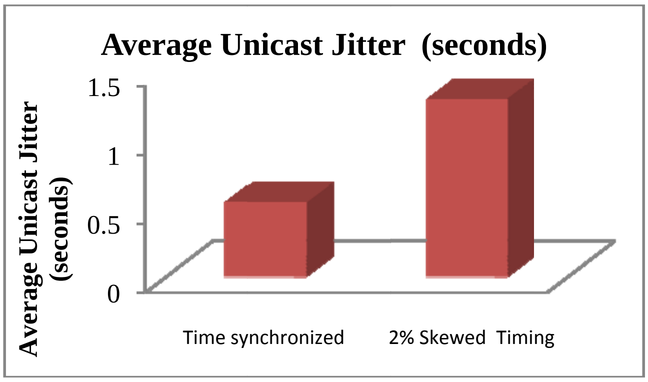

Fig. 6: Average Unicast Jitter.

Number of data Packets dropped due to channel access failure:-It tells the number of packets dropped when the channel is proceeding to failure point. Fig 7 shows Number Of Data Packets Dropped Due To Channel Access Failure.

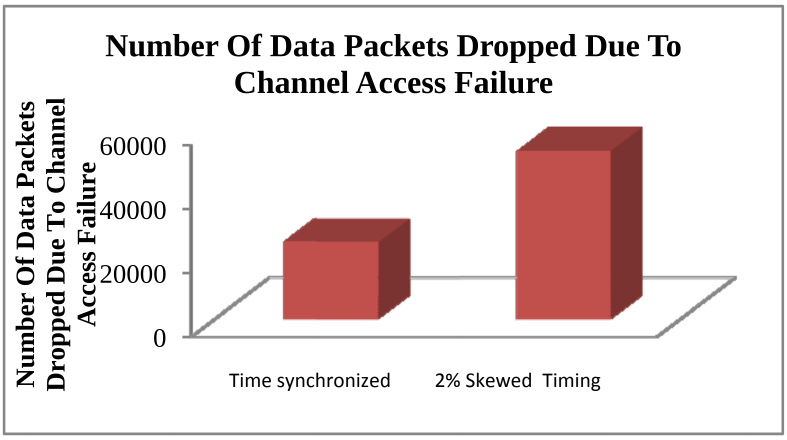

Fig. 7: Number Of Data Packets Dropped Due To Channel Access Failure.

5. Conclusion

The results indicates that with only 2% drift in time synchronization network lifetime is decreases from 32 approximately days to 23 approximately days. Similarly other parameters like packet dropped, average jitter, average end to end delay and throughput detracts.

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