Noise Factor Improved Temperature Compensated Time Synchronization in Wireless Sensor Network

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***Abstract*: Time Synchronization in wireless sensor networks is an indispensable service of wireless sensor networks. While there are many approaches made towards synchronization, the effect of noise factor on temperature change which leads to frequency changes of the sensor nodes is ruled out. This in turn decreases the beacon interval. The paper presents a noise factor improved temperature compensated time synchronization (NFTC TS) which uses a temperature sensor to remove the effects of environmental temperature keeping in accordance with the noise factor. As the noise factor increases the performance of the system deteriorates. By careful simulations, improvement in noise factor incorporated with the temperature changes which leads to the frequency changes is studied. The simulation results prove that a noise factor improve ment in TC TS increases the beacon interval, without losing synchronization accuracy**.

Keywords- Sensor Networks ,synchronization, Noise Factor

I. INTRODUCTION

Time Synchronization has been an emerging area of research for over a decade. Several synchronization protocols have been implemented to achieve the synchronization. There are several sources of error that creep in , including time stamping of occurrence of an event, changes in frequency of clock due to changes in temperature. The most crucial challenge encountered is energy efficiency.

Noise present in the environment is affected by temperature changes. The temperature effect on the clock frequency is often considered neglected and assumed not to effect the changes in frequency [1]. This in turn assumes constant frequency errors. Due to this reason, clocks need to resynchronize quite often. This implies that beacon interval gets reduced which in turn decreases the throughput and energy of the nodes soon get depleted. Noise present in the atmosphere also leads to changes in temperature. One way to avoid the problem is to deploy some nodes within the sensor network that respond effectively to the temperature changes due to atmospheric noise and estimate corresponding frequency errors so that beacon resynchronization intervals are reduced. This is referred to as noise factor improved temperature compensation (NFTCTS).

We have validated our results taking into consideration three aspects: increasing throughput, minimizing energy consumption, minimizing delay. Simulations on QualNet version 6.1 software clearly validate that our proposed protocol outperforms TCTS which does not consider effect of noise power on temperature [1]. Noise power plays an indispensable role in the environment. The variations in temperature bring about changes in noise power as well .These further produces variations in the frequency adjustments of clock which in general cases is neglected. Because of assumption of constant frequency errors resynchronization period increases. We have made an attempt to adjust the noise factor to an optimized vale so as to compensate for the frequency errors and a corresponding increase in resynchronization interval.

II. RELATED WORK

Elson *et al.* [2] proposed reference broadcast synchronization, which is a receiver-receiver protocol whereby a sender sends a beacon to all the nodes within its area. The receiver nodes then synchronise with one another by the relative drift between its local clock and every other clock in the network. A large number of broadcast messages are sent and a comparative study between the time stamps of the periodic broadcast message is noted. The nodes in this way calculate clock offsets .Here, the send time delay and propagation delays are eliminated. But it involves a huge amount of energy expenditure because periodic broadcasts of the messages are done by the sender.

Ganeriwal *et.al* [3] proposed a more refined protocol timing-sync protocol for sensor networks (TPSN,). In TPSN, a synchronization tree is set up whereby every node attempts to synchronize to the reference node. A handshake mechanism is used here that eliminates receive, transmit, and propagation delays. But this lost its feasibility as the size of network increased because now the error could propagate to larger levels in the branches of the tree. Hence it is not scalable.

Maroti *et.al* [4] proposed a new protocol flooding time synchronization protocol (FTSP) improves upon TPSN by providing an elaborative and accurate method of time stamping messages. In addition, in FTSP a reference node is elected and implicitly establishes a synchronization tree. Synchronization algorithm is extremely simplified and used extensively to compensate for the clock drifts. The problem associated with FTSP, relying on a synchronization tree, is that two nodes which are in different synchronization branches can still be radio neighbours.

A solution to this problem is provided by the gradient time synchronization protocol (GTSP, [7]). Here the nodes update their local time based on the beacon messages of all the neighbouring nodes. Thus there is neither any reference node nor any synchronisation. None is these protocol addresses the frequency errors.

Ganeriwal *et al.* [8] Estimating clock uncertainty for efficient duty- rate adaptive time synchronization protocol (RATS). which uses a model of long term clock drift in order to predict the synchronization interval. But, it does not address temperature measurements directly. It is a well-known fact that the quartz crystal’s resonant frequency changes with change in temperature.

Thomas *et al.* [1] proposed a temperature compensated time synchronization involving calibration and compensation that account for the frequency errors and reduces the resynchronization intervals. But none of the synchronization protocol has ever studied the effect of noise power that causes changes in temperature.

We have made an attempt to account for the changes in temperature caused by the noise power. Noise factor tells the extent to which the system is affected by variations in environment. When it increases, it in turn increases the noise power which in turn deteriorates the performance of the system. It further impacts the temperature of local crystal oscillators embedded in the sensors. Results prove that our proposed protocol is an edge towards the existing time compensation techniques.

IV. PROPOSED MODEL

In the proposed scheme we have taken different temperature readings at different time. NFTCTS is applied to four nodes. We have selected different wake up times for these nodes [9]. The readings for different beacon intervals were taken. We consider the effect of system noise on temperature by taking readings at different noise factors. The system noise is shown by Eq. 1:

$$P = KTBF \quad (1)$$

Where,

P =Noise Power
K =Boltzmann constant
B =System Bandwidth
T =Temperature
F =Noise Factor

$$\delta_E(T) = \frac{1}{f_0 . T} \quad (2)$$

Where

$\delta_E(T)$ = error in frequency error estimation
f_0 = nominal frequency of time
T= Resynchronization time between time stamp beacons

Frequency error is shown by Eq. 2. We analyzed the variations in the system performance in terms of throughput, delay and energy efficiency.

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V. SIMULATION ANALYSIS

The main objective of the simulation here is -

i. To increase beacon interval so as to increase network lifetime.

ii. Different time settings for different temperature.

iii. Effect on Noise power on the temperature that gives different frequency error estimates.

Table I enlists the simulation parameters . We have considered two values for noise factor and its effect on noise power. Different readings at different values of temperature are taken.

Figure 1 shows the network in an area of 50*50m² where we have deployed 20 nodes in a dynamic fashion.

Table I Simulation Parameters

Parameter	Value	Parameter	Value
Terrain	50*50 m²	Energy model	Generic
Nodes	20	Transmit Circuitry	24.75 mW
Application Type	Traffic Gen	Receive Circuitry Power Consumption	13.5mW
Data Rate	1packet per sec	Idle Circuitry Power Consumption	13.5mW
Message Size	38 bytes	Sleep Circuitry Power Consumption	0.02mW
Simulation time	51 sec	Routing Protocol	AODV
Noise Factor (F)	0,10	Temperature	0,290,350 400 (K)

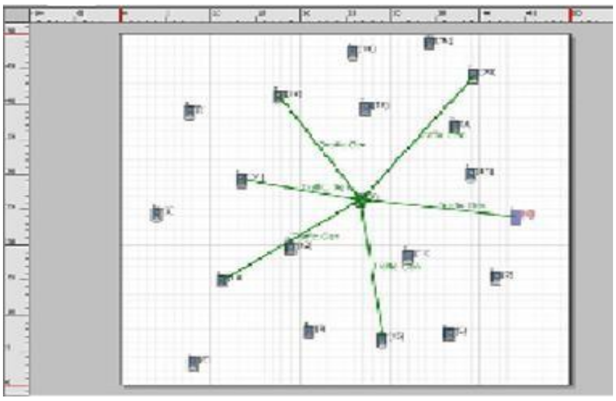

Figure 1 Network Scenario

Throughput defines the efficiency with which packets are delivered to the destination. We observe that when the noise factor is less throughput of the network is high. Figure 2 shows the variations in throughput of the network. When noise power is less throughput is high. As we increase the noise power throughput falls down.

Network Lifetime demonstrates the extent of existence of a node's battery capacity. In order to increase the capacity network lifetime has to be increased. It is observed from figure 3 that the lifetime of the network increases when noise factor is decreased.

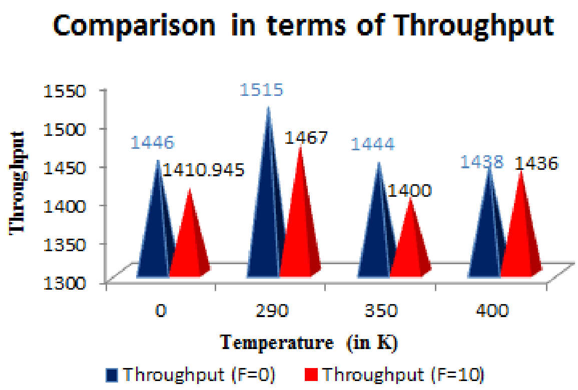

Figure 2 Throughput

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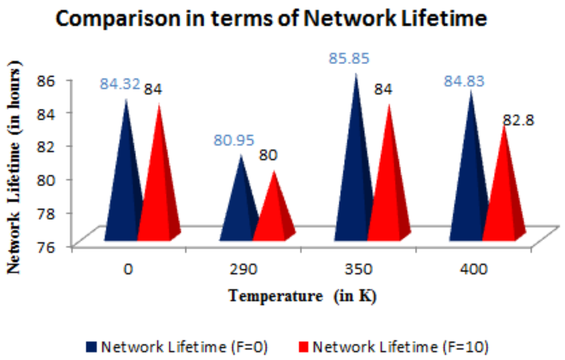

Figure 3 Network Lifetime

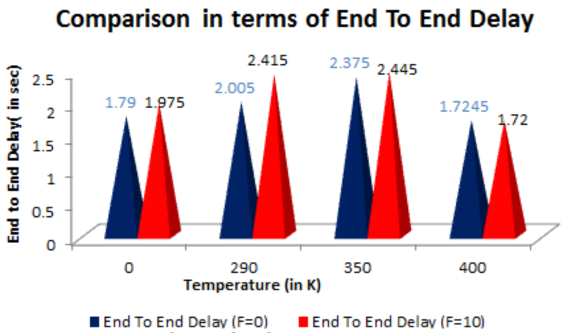

Figure 4 End to End Delay

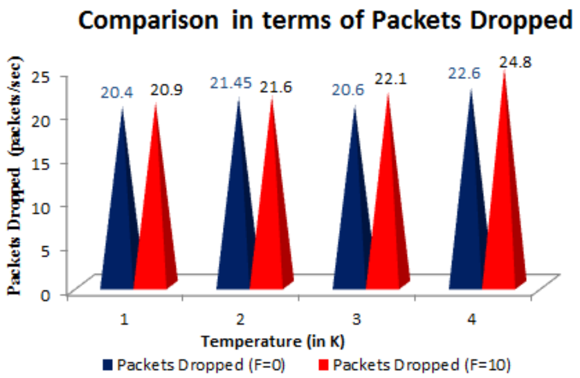

Figure 4 Packets Dropped

End to End delay is defined as the delay encountered in reception of packet by the receiver nodes. Figure 4 shows that end to end delay decreases as noise factor thereby the noise power decreases.

Figure 4 illustrates the numbers of packets dropped as we increase the noise factor. Number of packets dropped increase with the increase in noise power.

VI. CONCLUSIONS

Noise factor improved Temperature Compensated Time Synchronization (NFTCTS) is the first step towards consideration of Noise Power towards an automatic temperature calibration of a local clock. It uses improvements in temperature information according to the noise present in atmosphere to increase the beacon interval. There is an increase in power savings as now only a few messages have to be transmitted. To implement Noise Factor improved Temperature Compensated Time Synchronization (NFTCTS) Temperature Compensated Time Synchronization protocol (TCTS) is used as the host protocol. It is observed that as the noise power increases with the temperature and noise factor increases, the performance of the system deteriorates.

VII. FUTURE SCOPE

The results are simulated using only a small number of nodes. In future the scenario may be subjected to testing by increasing the node density.

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