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LEVEL-CLUSTERED TIME SYNCHRONIZATION PROTOCOL (LCTPSN) FOR WIRELESS SENSOR NETWORKS

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ABSTRACT

Wireless Sensor Networks (WSNs) have emerged as an important research area in recent years. WSN have wide variety of promising potential applications, such as monitoring of health & wellbeing of humans, keeping a close eye on our environment, measurement and control of industrial machines and also home appliances. In most of these applications, efficiency and reliable working is desired. Nodes in the WSNs have limited energy source, Low bandwidth of communication and low storage for real, time applications. These constraints necessitate the need of mechanism for increase in energy efficiency. It may consider a synchronization scheme which is very much important for improving the performance of WSN Network.

In this paper we propose an efficient protocol for Time synchronization in Wireless Sensor Network which addresses the critical parameters, like energy consumption, jitter, and dropping ratio. An attempt has been made to propose an energy efficient time synchronization protocol for wireless sensor networks.

KEYWORDS: Time Synchronization, Wireless Sensor Networks, Level Clustering

INTRODUCTION

In recent years, the use of Wireless Sensor Network (WSN) has been increased tremendously. Some of the application areas of WSN are

- Military
  - Battlefield surveillance, target detection, biological & nuclear attack detection
- Environmental,
  - Air pollution monitoring, greenhouse monitoring, landslide monitoring
- Medical,
  - Patient Monitoring System, drug administration, monitor human physiological data
- Disaster management such as
  - Tsunami alarming, forest fire detection, flood detection

- Home monitoring etc.

Wireless Sensor Networks have some basic requirements like they should work with minimum energy consumption, should require no or very minor infrastructure overhead, they should work in harsh environmental conditions, they should work on data fusion or aggregation property. Generally WSN implement large number of nodes and they work independently & often remain unattended.

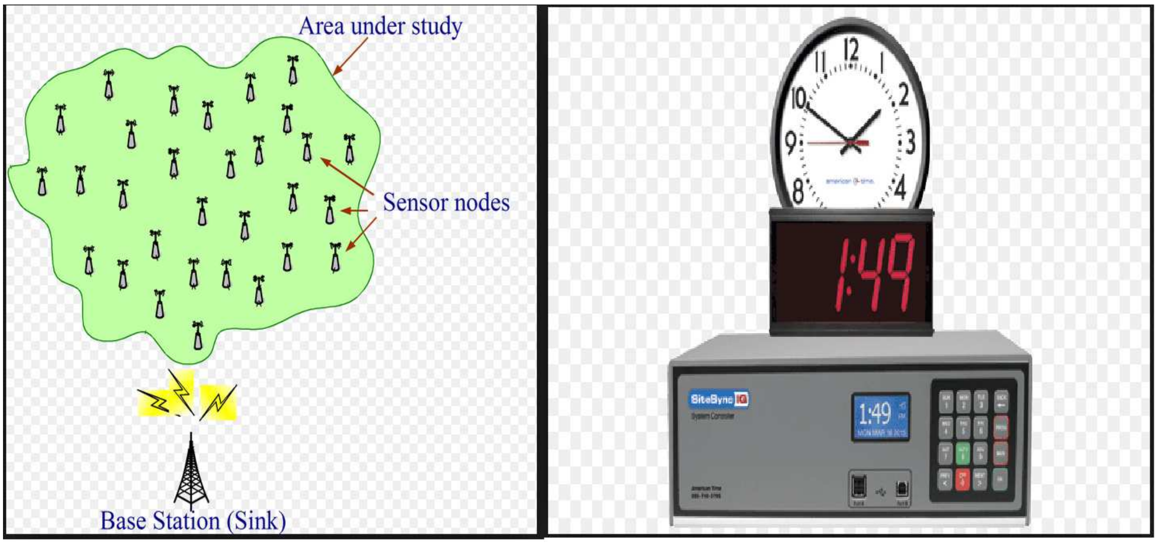


Figure 1: WSN Associated with Global Clock

To identify the correct event time, these nodes need to be synchronized with global clock. Hence time synchronization is a significant feature in WSNs. Key parameters being better synchronization accuracy and low power consumption. A network is formed by hundred to thousand of sensor nodes. Sensor nodes are responsible for collecting environmental information and sending it towards a sink node, which receives the information gathered by the network and delivers it to the end-user.

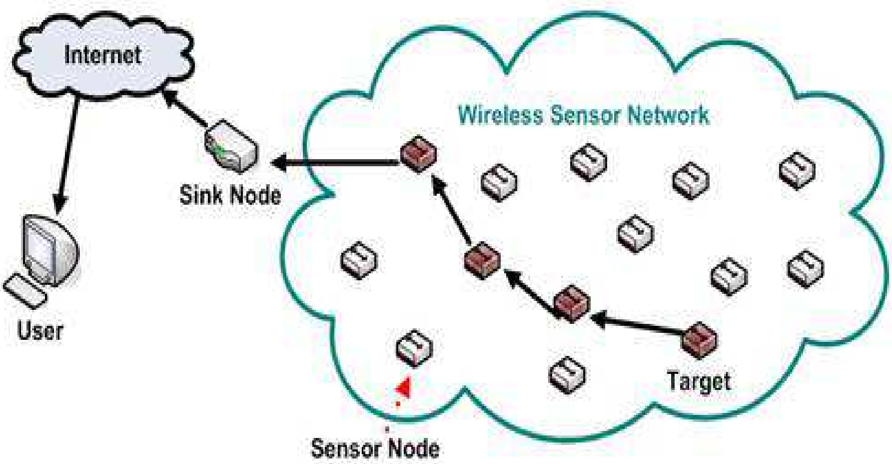


Figure 2: WSN Architecture

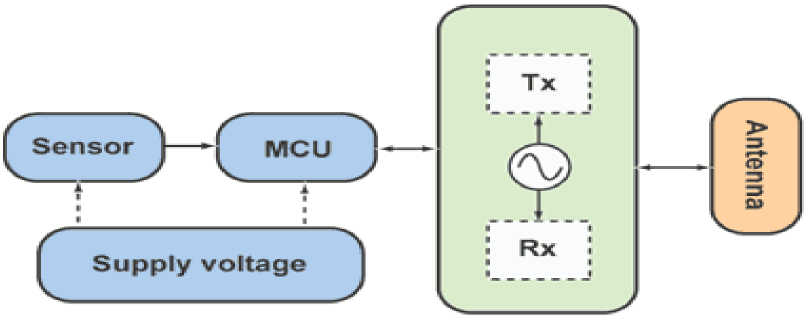


Figure 3: WSN Node

The wireless technology has been attracting the industrial field equally. It has also made it wire free providing time of the industrial engineers to concentrate on the actual wireless system processes than on wiring.

SYSTEM MODEL

There are several reasons for addressing the synchronization problem in sensor networks. First, sensor nodes need to coordinate their operations and collaborate to achieve a complex sensing task. Data fusion is an example of such coordination in which data collected at various nodes are aggregated into a meaningful result. For example, in a vehicle tracking application, sensor nodes report the location and time that they sense the vehicle to a sink node which in turn combines this information to estimate the location and velocity of the vehicle. Clearly, if the sensor nodes lack a common timescale (i.e., they are not synchronized) the estimate will be inaccurate.

Secondly, synchronization can be used by power saving schemes to increase network lifetime. For example, sensors may sleep (go into power-saving mode by turning off their sensors and/or transceivers) at appropriate times, and wake up when necessary. When using power-saving modes, the nodes should sleep and wake-up at coordinated times, such that the radio receiver of a node is not turned off when there is some data directed to it. This requires a precise timing between sensor nodes.

Scheduling algorithms such as TDMA can be used to share the transmission medium in the time domain to eliminate transmission collisions and conserve energy. Thus, synchronization is an essential part of transmission scheduling.

Traditional synchronization schemes such as Network Time Protocol (NTP) or Global Positioning system (GPS) are not suitable for use in sensor networks because of complexity and energy issues, cost and size factors. NTP works well synchronizing the computers on the Internet, but is not designed with the energy and computation limitations of sensor nodes in mind. A GPS device may be too expensive to attach on cheap sensor devices, and GPS service may not be available everywhere, such as inside the buildings or under the water. Furthermore in adversarial environments, the GPS signals may not be trusted.

Time synchronization involves a way for providing a common reference of time across a distributed system. It is crucial for WSNs when performing a number of fundamental operations, such as:

- **Data fusion:** Data merging is a major operation in all distributed networks for processing and integrating the collected data in a meaningful way, and it requires some or all nodes in the network to share a common timescale.

- **Power management:** Energy efficiency is a key factor when designing WSNs since sensors are usually left unattended without maintenance and battery replacement for their lifetimes after deployment. Most energy-saving operations strongly depend on time synchronization. For instance, duty cycling (sleep and wake-up modes control) helps the nodes to save huge energy resources by spending minimal power during the sleep mode. Thus, network wide synchronization is essential for efficient duty cycling and its performance is proportional to the synchronization accuracy.
- **Transmission scheduling:** Many scheduling protocols require time synchronization. For example, the time division multiple access (TDMA) scheme, one of the most popular communications schemes for distributed networks, is only applicable to a synchronized network.
- **Miscellaneous:** any localization, security, and tracking protocols also demand the nodes to timestamp their messages and sensing events. Therefore, time synchronization is one of the most important research challenges in the design of energy-efficient WSNs.

PROPOSED SCHEME

Level Discovery Phase

Root node is assigned a level 0 and it initiates by broadcasting a level discovery packet which contains level and ID. Neighbors of the root node receive this packet and increment level themselves based on previous level. This process is continued and eventually every node in the network is assigned a level

Synchronization Phase

Two-way message exchange between a pair of nodes can synchronize them

Node A' synchronization pulse packet at T1 with its level Node B receives this packet at T_2

$T2 = T1 + \Delta + d$

Δ - > the clock drift between the two nodes

d -> propagation delay

At time T3, 'B' sends back an acknowledgement packet to 'A'.

At time T4 'A' receives an acknowledgement packet from 'B'

Node A' then calculates the clock drift and propagation delay with level and T1, T2, T3, T4 as:

$\Delta = (T\,2 - T\,1) - (T\,4 - T\,3)$

$d = (T\,2 - T\,1) + (T\,4 - T\,3)$

Knowing the drift, node A can correct its clock accordingly, so that it synchronizes to node B. Where the sender synchronizes its clock to that of the receiver. Root initiate time sync packet and Rx node wait for random time to avoid contention before Two-way message exchange between a pair of nodes. If node not assign with level it sends level request message and its close neighbor reply with its level to update called local discovery. If acknowledgement to sender synchronization pulse not received then retransmit synchronization pulse packet. Even after 3 retransmission if acknowledgement is not received then send level request message.

PERFORMANCE EVALUATION

This test completely removes source error at synchronization. Clustering is used for scalability; routing and optimizing energy consumption .Network contain Cluster Head CH used to collect data from sensors

This improves network life time and battery life. Clustering runs with Neighbor discovery, cluster-head selection, cluster-head member admittance, and transmission processes. Using hello message discover neighbor at the Level-0, the sink picks I number of nodes from its neighbor table as the next level cluster-heads depends on the distance and transmission power level estimates of selected nodes choose CH with high power in each level.

Once the cluster-head selection completed, each selected cluster-head broadcasts at its peak power to all its neighbors. Receiving node then replies with a JOIN message to the cluster-head that it has received with the strongest signal strength. In a transmission, each member node transmits its sensed data to its cluster-head in its allocated TDMA slot. Slot time is the time allocated to a member node by its cluster-head as per member count

Total number of nodes = N Total Number of cluster heads = k

Number of CHs at Level-1 = k1 Number of sensor nodes = N–k

Compute Transmitter Power and compute total energy consumed at each level

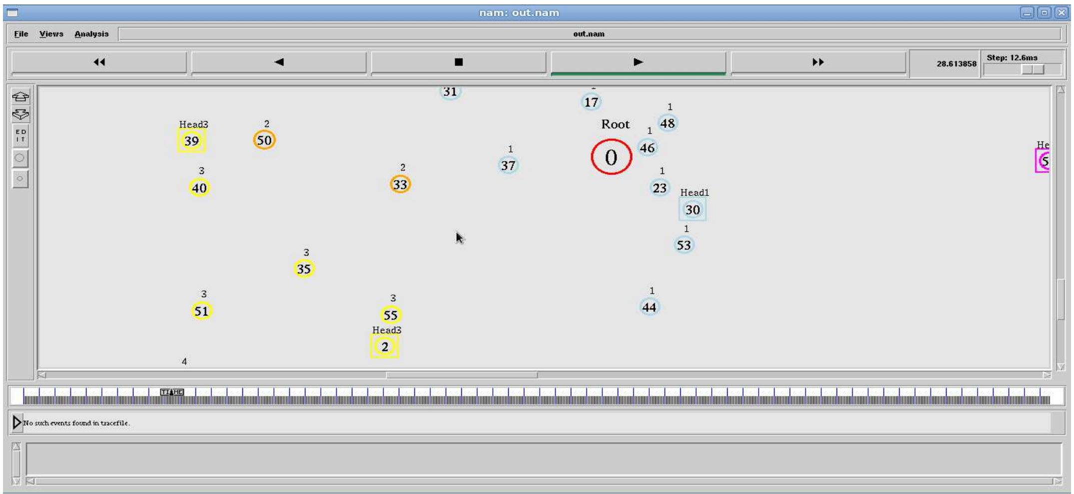


Figure 4: LCTPSN Simulation for 60 Numbers of Nodes

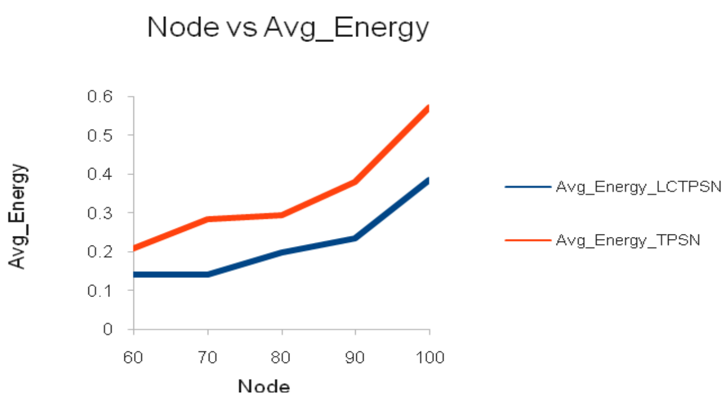
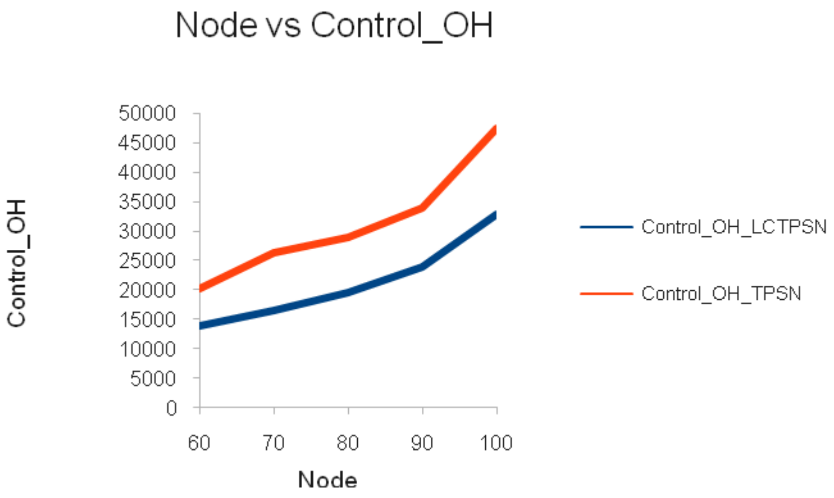


Figure 5



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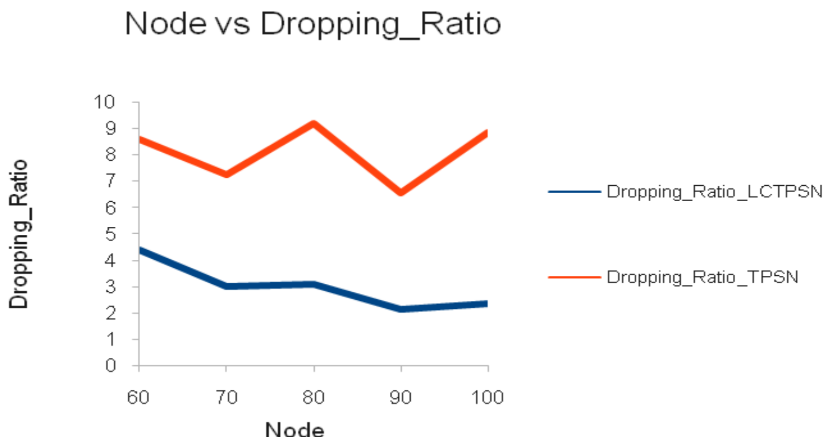

Figure 7

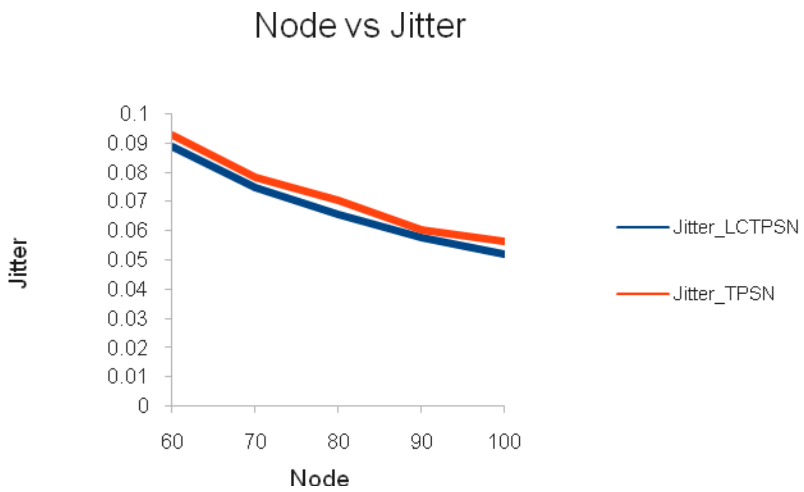

Figure 8

CONCLUSIONS

The time synchronization scheme proposed in this paper is novel and simple. Through creating Level clustering, all the nodes are connected with one another. The concept of cluster-head makes the whole synchronization process be divided into multiple clusters, called Level-clustered time synchronization (LCTPSN). Performance analysis and simulations show that our proposed scheme has much less synchronization overhead, dropping ratio & jitter than TPSN

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