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A Review on the Wireless Sensor Network Time Synchronization Solution Strategies Related Issues and Challenges

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***Abstract*--Sensor network conventions have a one of a kind self-sorting out capacity with interesting component of WSNs of the sensor nodes collaboration with each other. Sensor hubs have an in-assembled processor, utilizing which raw data are handled before transmission. These components encourage extensive variety of uses of WSNs extending from biomedical, natural, military, occasion recognition and vehicular telematics. These days, modern applications are based on conveyed structures and they are required to be economical, adaptable and tried and true. The framework's execution can be enhanced by interfacing sensors and actuators straightforwardly to the mechanical correspondence system, as information and diagnostics can be made available to numerous frameworks furthermore shared on the web. This paper introduces a survey of the examination issues in the uses of Wireless Sensor Networks.**

Keywords: Data Synchronization, Cross Power Spectral Density, FFT, and WSN.

1. Introduction:

A Wireless Sensor Network (WSN) is a group of hundreds or thousands of sensor nodes that have capabilities of sensing the environment and communicate the information in wireless medium [1].Wireless sensor network is the collection of sensor nodes with limited resources that collaborates in order to achieve a common goal. Sensor nodes are not only used for military applications, they have also used in geographical monitoring, environmental monitoring and control, pollution monitoring, health and medical, target tracking , navigation, transport, emotion based computing and so on.

The limited energy resource is the drawback of the wireless sensor networks, therefore to save the energy, the nodes power consumption must be reduced, to reduce the consumption the nodes must turn their transceiver on and off at appropriate time, an accurate timing is required between the nodes. Sensor nodes are very tiny instruments and running with a limited energy, so it is not easy to synchronize nodes effectively because an energy consumption

There are many reasons to showing the synchronization problems in sensor networks. Some reasons are as following:

1. Sensor nodes are necessary required to co-ordinate their operations to perform a special task, e.g. Data fusion. In which data is collected at different nodes are combined into a meaningful result.

2. Life time of network is totally dependent on the power. So to increase the life of network, we need to used power saving methods. For example when using power-saving modes, the nodes should sleep and wake up at coordinated times.

Time synchronization is important for a sensor network. Time synchronization in a network is for providing a common time for nodes in the network. To identify the correct event time, sensor nodes must be synchronized among themselves with universal time i.e. global time. Therefore, time synchronization is significant aspects in Wireless sensor networks. Local clock make time synchronization an important part of WSN.

Four basic components of time synchronization which provide communication delay [5]:

- Send Time
- Access Time
- Propagation Time
- Receive Time

Send Time: Send time which is the total time of building the message and transfer it to the network interface to be sent. This time highly depends on the operating systems in use.

Access Time: Access time which is the time needed to access the channel. Every network employs a medium access control scheme.

Propagation Time: Propagation time which is the time required to propagate the message through the air from network interface of the sender to the network interface of the receiver.

Receive Time: Receive time which is the time spent in receiving the message by network interface and transferring it to the application layer of the host.

The performance of time synchronization is influenced by various factors such as Precision, Network size, Complexity, Convergence time and Energy consumption.

2. Related Work:

If partners derive utility from joint leisure time, it is expected that they will coordinate their work schedules in order to increase the amount of joint leisure. In order to control for differences in constraints and selection effects, this work uses a new matching procedure, providing answers to the following questions: (1) Do partners coordinate their work schedules and does this result in work time synchronization?; (2) which partners synchronize more work hours?; and (3) is there a preference for togetherness? **Chris van Klaveren, and Henriette Maassen van den Brink, (2007) [1],** found that coordination results in more synchronized work hours. The presence of children in the household is the main cause why some partners synchronize their work times less than other partners. Finally, partners coordinate their work schedules in order to have more joint leisure time, which is evidence for togetherness preferences.

In [2] recent years there has been a growing interest in Wireless Sensor Networks (WSN). Recent advancements in the field of sensing, computing and communications have attracted research efforts and huge investments from various quarters in the field of WSN. Also sensing networks will reveal previously unobserved phenomena. The various areas where major research activities going on in the field of WSN are deployment, localization, synchronization, data aggregation, dissemination, database querying, architecture, middleware, security, designing less power consuming devices, abstractions and higher level

algorithms for sensor specific issues. This work provides an overview of ongoing research activities, various design issues involved and possible solutions incorporating these issues. This work provided a cursory look at each and every topic in WSN and our main aim is to introduce a newbie to the field of WSN and make him understand the various topics of interest available for research.

Wireless Sensor Networks have created wide range of challenges that still needs to be addressed. In this work **Gowrishankar. S, T. G. Basavaraju, Manjaiah D. H, and Subir Kumar Sarkar, (2008),** [2], have identified a comprehensive list of issues associated with Wireless Sensor Networks. They have also discussed some popular protocols implementing these issues in part or as a whole. The impact of wireless sensor networks on our day to day life can be preferably compared to what Internet has done to us. This field is surely going to give us tremendous opportunity to change the way we perceive the world today.

Frequency domain decomposition (FDD) has been widely used for output-only system identification due to ambient excitations in the frequency domain [3]. FDD, however, usually requires a prior knowledge on natural frequencies, and also has troublesome in modal damping ratio identification as well as its strict hypothesis on uncorrelated white noise excitation and lightly-damped structures. Recently, wavelet transform (WT) has been developed most recently for the output-only system identifications in the time-frequency plane, especially its unique advantages on dealing with non-stationary, transient and non-linear inputs and outputs as well as dynamic system information in both time and frequency domains. This work aimed to present FDD and WT used for the output-only system identification of the ambient vibration structures. Modal parameters will be estimated from full-scale ambient vibration measurements of 5-storey steel structure.

Modal parameters identification with emphasis on the natural frequencies and mode shapes of the 5-storey steel structure based on both FDD and WT has been presented in comparisons between them as well as with FE model results by **Thai-Hoa Le and Yukio Tamura, (2008)** [3]. Identified natural frequencies and mode shapes from FDD and WT are quite good agreement with the FE results. It seems that FDD expresses better than WT in the natural frequencies extraction not the low-order modes but also high-order ones. FDD can extract natural frequencies at arbitrary frequency resolution, where WT is favorable for actually dominant frequencies. WT also requires more localized high-resolution analysis for extracting natural frequencies of high-order and non dominant mode shapes.

The effect of non-synchronous sensing when using wireless sensors on structural modal identification is addressed and a methodology for correcting such errors proposed by **Z.Q. Feng, and L.S. Katafygiotis (2011)** [4],. Their work first discussed the potential sources causing non-synchronous sensing and estimates the extent of non-synchronous sensing based on data collected from Imote2 sensors, and then investigated the impact of synchronization errors in the measured output response on modal identification using numerical simulations. The simulation results show that even small synchronization errors in the output response can distort the identified mode shapes. A new methodology is proposed herein for eliminating such errors. This methodology estimates the power spectral densities (PSDs) of output responses using non-synchronous samples directly based on a modified FFT. As long as the corrected PSDs are obtained, the correlation functions can also be easily obtained by IFFT. Then these corrected PSDs or correlation functions can be fed into various output only modal identification algorithms. The proposed methodology is validated using numerical simulations. It is found that the simulation results closely match the identified parameters based on synchronous data.

The purpose of this work is to address the problem of non-synchronous sensing on modal identification when using wireless sensor networks. The potential sources causing non-synchronous sensing are first discussed and their extents are estimated based on data collection from Imote2 sensors. Among these error sources the dominant ones are non-simultaneity in sensing start-up and differences in sampling frequency among sensor nodes. According to numerical simulations, these errors can distort the identified results of the mode shapes. A new methodology is proposed for eliminating such errors. This methodology estimates the power spectral density (PSD) of output responses using non-synchronous samples based on a modified FFT. As long as we get the corrected spectral density, the correlation functions can also be easily obtained by IFFT. Then, these corrected PSDs or correlation functions can be fed into various output-only modal identification algorithms. Comparing with other existing methods of raw synchronous time history reconstruction, this methodology is simple and computationally efficient. The proposed methodology is validated using numerical simulations. The simulation results closely match the identified parameters based on synchronous data.

Considering its central importance to sensor networks, time synchronization has received extensive attention by the research community. Nevertheless, **Yin Cheny Qiang, Wangz, Marcus Changy and Andreas Terzis, (2011)** [5], argue in this work that existing approaches introduce undesirable trade-offs. For example, while GPS offers excellent accuracy for outdoor deployments, the high cost and power consumption of GPS receivers make them prohibitive to many applications. Message-passing protocols, such as FTSP, introduce different sets of compromises and constraints. In this work, we present an inexpensive and ultra-low power (< 100 μA) mote peripheral, we term the Universal Time Signal Receiver, that leverages the availability of time signals transmitted by dedicated radio stations around the globe to provide access to UTC time with millisecond-level accuracy. We present experimental results measuring signal availability, quality of synchronization across motes, and power consumption. We show that the proposed universal time signal receiver achieves global time synchronization and for applications where millisecond-level precision is sufficient, it consumes up to 1,000 times less energy than GPS or FTSP.
Yin Cheny Qiang, Wangz, Marcus Changy and Andreas Terzis, (2011) [5], presented a mote peripheral that leverages the availability of time signals transmitted by radio stations around the globe to provide access to UTC time with millisecond-level accuracy and < 100 μA current draw. While not as accurate as GPS or message passing protocols such as FTSP, the energy consumption of this peripheral is several orders of magnitude lower than these alternatives, providing sensor network applications an attractive trade-off between accuracy and energy efficiency. We show that this Universal Time Signal Receiver can be used in both indoor and outdoor deployments and outline how sensor networks can leverage universal availability to global time that is practically free to further improve their energy efficiency. With both the WWVB and DCF77 being driven by highly accurate atomic clocks and signals transmitted with microsecond precision, it is disappointing that the accuracy of the CME6005 receiver is only at the millisecond level. Radio chips of similar size, cost, and power consumption, such as the MAS-OY MAS9180 and HKW UE6015, all report similar accuracy. Nevertheless, radios, such as the Meinberg PZF511, that use a different receiver technology are capable of achieving microsecond precision but at a much higher price and power consumption. We intend to investigate the trade-offs between using a more expensive receiver and the increased accuracy that it can achieve. More information on the prototype universal.

Time synchronization in wireless sensor node networks is a hot topic. Many works present various software algorithms and hardware solutions to keep accurate time information on mobile nodes. In terms of real life applications wireless sensor nodes are preferred in many domains, starting with simple room monitoring and finishing with pipeline surveillance projects. Positioning applications are far more restrictive on timekeeping accuracy, as for the velocity of nodes calculations precise time or time difference values are needed. The accuracy of time information on nodes has to be always correlated with the application requirements. In this work, **Eugen COCA, and Valentin POPA, (2012)** [6], presented some considerations regarding time synchronization linked with specific needs for individual practical applications. A practical low energy method of time keeping at node level is proposed and tested. The performances of the proposed solution in terms of short and long term stability and energy requirements are analyzed and compared with existing solutions. Simulation and experimental results, some advantages and disadvantages of the method are presented at the end of the work.
They proposed a simple method of keeping the time accurate on a wireless sensor node network, by adding a low-cost and low-power circuit to every node. The time is kept locally, without the need to permanently synchronize the time on the node before every data transmission. This software eases the design of nodes, adding more flexibility to the application designer. The saved energy on the node is available for the main task, instead of consuming it on bulky timekeeping algorithms. The precision of the time stamp on every event depend only on the accuracy of the local lock circuit, essentially on the quality of the crystal oscillator. This solution has to be seriously considered for real applications due to it's' effectiveness and low lost.

Wireless Sensor Networks (WSN) are used in variety of fields which includes military, healthcare, environmental, biological, home and other commercial applications. With the huge advancement in the field of embedded computer and sensor technology, Wireless Sensor Networks (WSN), which is composed of several thousands of sensor nodes which are capable of sensing, actuating, and relaying the collected information, have made remarkable impact everywhere. **Edwin Prem Kumar Gilbert, Baskaran Kaliaperumal, and Elijah Blessing Rajsingh (2012)** [7], presented an overview of the various research issues in WSN based applications.
An overview of the broad spectrum of applications of WSN has been given in this work. The application of WSN in the areas of biomedical, intelligent parking, healthcare applications, environmental, industrial, and military applications have been briefed. These interesting applications are possible due to the flexibility, fault tolerance, low cost and rapid deployment characteristics of sensor networks. Though wireless sensor networks are constrained by scalability, cost, topology change and power consumption, new technologies are being devised to overcome these and to make sensor networks an integral part of our lives. A review on the various research issues involved in the WSN applications has been outlined. Research on these issues will lead to promising results, making WSN based applications very popular. The application of WSNs is not limited to the areas mentioned in this work. The future prospects of WSN applications are highly promising to revolutionize our everyday lives.

Sensor network consists of tiny sensors with general purpose computing elements to cooperatively monitor physical or environmental conditions, such as temperature, pressure, etc. They have a great potential for long term applications and also have the ability to transform human lives in various aspects. However, there have been resources constraints problems such as memory, power consumption of nodes in WSNs. Depending on the resources limitations and used applications of WSNs , security is very important and big challenge in WSNs. In this work **Himani Chawla (2014)** investigated issues and challenges associated with development of wireless sensor networks.

In this work, various applications of WSN along with the knowledge of security issues & attacks of WSN are discussed. This work can be helpful for research scholars who are working in this field. Security is an important requirement and complicates enough to set up in different domains of WSN. Adding security in a resource constrained wireless sensor network with minimum overhead provides significant challenges, and is an ongoing area of research. There is currently enormous research potential in the field of WSN.

The emergence of wireless sensor networks (WSN) as one of the dominant technology trends in the coming decades has posed numerous unique challenges to researchers. The sensing technology combined with processing power and wireless communication makes it lucrative for being exploited in abundance in future. The inclusion of wireless communication technology also incurs various types of security threats. The intent of this work is to investigate the security related issues, the challenges and to propose some solutions to secure the WSN against these security threats. While the set of challenges in sensor networks are diverse, this work focus only on the challenges related to the security of Wireless Sensor Network. This work begins by introducing the concept of Wireless Sensor Network (WSN). The introductory section gives brief information on the WSN components and its architecture. Then it deals with some of the major security issues over wireless sensor networks (WSNs). **Vikash Kumar, Anshu Jain and P N Barwal, (2014)** [9], also proposed some of the security goal for Wireless Sensor Network. Further, as security being vital to the acceptance and use of sensor networks for many applications; I have made an in depth threat analysis of Wireless Sensor Network. Lastly it proposes some security mechanisms against these threats in Wireless Sensor Network.

Security in Wireless Sensor Network is vital to the acceptance and use of sensor networks. In particular, Wireless Sensor Network product in industry will not get acceptance unless there is a full proof security to the network. **Vikash Kumar, Anshu Jain and P N Barwal, (2014)** [9], summarized the attacks and their classifications in wireless sensor networks and also an attempt has been made to explore the security mechanism widely used to handle those attacks. The challenges of Wireless Sensor Networks are also briefly discussed.

Global synchronization is important for many sensor network applications that require precise mapping of collected sensor data with the time of the events, for example, in tracking and surveillance. It also plays an important role in energy conservation in MAC layer protocols. **Qun Li, and Daniela Rus, (2006)** [10] described four methods to achieve global synchronization in a sensor network: a node-based approach, a hierarchical cluster-based method, a diffusion-based method, and a fault-tolerant diffusion-based method. The diffusion-based protocol is fully localized. They presented two implementations of the diffusion-based protocol for synchronous and asynchronous systems and prove its convergence. Finally, they showed that, by imposing some constraints on the sensor network, global clock synchronization can be achieved in the presence of malicious nodes that exhibit Byzantine failures.

Qun Li, and Daniela Rus, (2006) [10] considered the global synchronization problem in sensor networks. They proposed several methods: the all-node-based method, the cluster-based method, the diffusion-based methods, and the fault-tolerant diffusion-based method to solve the problem. The first two methods require a node to initiate the global synchronization, which is neither faulttolerant nor localized. In the diffusion-based method, each node can perform its operation locally, but still achieve the global clock value over the whole network. They present two implementations of the clock diffusion: synchronous and asynchronous. The synchronous method assumes all the nodes perform their local operations in a set order, while the asynchronous method relaxes the constraint by allowing each node to perform its operation at random. They present the theoretical analysis of these methods and show simulation results for the asynchronous averaging synchronization method. Moreover, they show how to design synchronization protocol in the presence of Byzantine fault. Our proposed algorithms can be extended to other sensor network applications, such as data aggregation. They are currently examining how the methods presented here fit to more general applications. Our future work also includes implementing the algorithms in a real sensor network using our Mica Mote sensor network platform.

Time Synchronization is one of the most important support Technology in WSN, plays an irreplaceable role in the development of WSN. For this reason, an improved algorithm based on the RBS algorithm is proposed by **Lin Zhou, Jialun Li, and Longpin Yang, (2015)** [11], combination of some classic time synchronization algorithm. Referring to the idea of cluster-based, the introduction of Synchronization mechanism for both cluster-head and cluster-within, ensure the synchronous accuracy and save the energy consumption. By comparing the experiment results, the improved mechanism reduce communication overhead.

For the time synchronization in wireless sensor network, this work presents an improved algorithm based on the RBS algorithm, introducing clustering mechanism. Considering the cost of energy and exchange capacity, by comparison the improved algorithm can improve the energy consumption and the exchange capacity.

Wireless sensor networks have emerged as an important and wide research area in the recent years. Time synchronization is important factor for many sensor network applications that require very accurate mapping of gathered sensor data with the time of the events, as it provides a common time to different nodes. Several real time applications depend on network nodes having a synchronized time. In wireless sensor networks giving a common notion of time is one of the most basic services because of energy efficiency. **Ms. Suvarna T. Sonone, and Ms. A. P. Sakhare, (2015)** [12], provided different existing methods, protocols, significant time parameters (derivative of derivative of clock speed, clock speed, synchronization errors, and topologies) to achieve precise synchronization in a sensor network & examine the time synchronization problem and the need for synchronization in sensor networks. Then presented various most common previous time synchronization approaches and shows the need of a new class of secure-time synchronization protocol which is scalable, topology independent, high speed direction, energy efficient, less hidden and few application existing methods, protocols, significant time parameters (derivative of clock speed, clock speed, synchronization errors, an topologies) to achieve precise synchronization in a sensor network. This work provides a very useful framework by which methods designers can compare new and existing synchronization methods. So, I am hopeful that this work will give a complete full-stop investigation to study the characteristics of existing time synchronization protocols and its implementation mechanism in a Sensor network environment.

A family of previous time synchronization algorithms, protocols is studied and a comparative history has been giving in this work. As growing demand and for successful real time application of sensor network , the need of exact secure clock measurement approach which are vital for error free from clock time measurements whether it is loosely or tightly packed or any other topological structure. The authors strongly considered that using this comparative history work, it will make future researchers to expand previous time synchronization methods, approaches, algorithms in easier way and will give them a choice to enhance their application based on our study on different time sync protocols. Sensor network applications can advantage greatly from synchronized clocks to perform data joining or energy efficient communication. An accurate clock synchronization algorithm, protocols should fill different properties at the same time: exact global and local time synchronization, fast convergence, fault-tolerance, and energy-efficient.

3. Conclusion:

WSNs are extremely productive in supporting different everyday applications. WSN based advances have upset home and elderly medicinal services applications. Physiological parameters of patients can be observed remotely by doctors and overseers without influencing the patients' exercises. This has brought about decrease of costs, change of supplies and better administration of patients profiting. These advances have altogether minimized human blunders, permitted better comprehension into starting point of infections and has helped in formulating techniques for restoration, recuperation and the effects of medication treatment. The use of WSN in the regions of biomedical, keen stopping, social insurance applications, environmental, industrial, and military applications have been informed. These fascinating applications are conceivable because of the adaptability, adaptation to internal failure, minimal effort and fast arrangement qualities of sensor systems. Despite the fact that remote sensor systems are obliged by versatility, cost, topology change and power utilization, new innovations are being formulated to conquer these and to make sensor organizes a fundamental piece of our lives. An audit on the different examination issues included in the WSN applications has been laid out. Research on these issues will prompt promising results, making WSN based applications exceptionally prevalent.

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