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Various Time Synchronization Methods in MANET: A Review

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Abstract- **With the development of computer technology and widespread use rapidly, computer goes deeply into every areas of life and plays a very important role. AD HOC network technologies and standards, such as IEEE 802.11's ad hoc mode, allow the quick setup of a wireless network among a group of mobile stations, where the stations communicate with each other either directly or indirectly through multiple hops, without the aid of an infrastructure (e.g., cables, access points or base stations). Since mobile stations are typically powered by batteries, the success of MANETs strongly relies on energy efficient communications. The radio of a mobile station can be in one of three awake states, namely, transmitting, receiving, and idle listening, or in the doze state. To achieve this, at the same time, high precision time synchronization among computers appears more important than before. Especially in measurement, communication, finance, electric, transportation, military affairs and other major areas, the precision of time synchronization have great effect on every system's safe directly.**

Keywords- **Time Synchronization, MANET, Energy efficient, Power management**.

I. INTRODUCTION

With the development of computer technology and widespread use rapidly, computer goes deeply into every areas of life and plays a very important role. At the same time, high precision time synchronization among computers appears more important than before. Especially in measurement, communication, finance, electric, transportation, military affairs and other major areas, the precision of time synchronization have great effect on every system's safe directly. However the time synchronization of these areas traditionally make use of the hardware method, and have to receive the absolute clock signal from outside, such as GPS and Compass signal, to come true the clock synchronization. By means of this way, it can attain totally precision clock synchronization, but it will be high cost and inconvenient in practice as well. While the software method means that it takes the advantage of clock-synchronization algorithm to realize every node computer of the distributed network clock synchronization without using the outside signal. And this is perfectly appropriate for the miniature distributed network whose time synchronization precision acquired is 10^{-6} to 10^{-3} second and absolute time is not necessary. Moreover it has the advantages of low cost and flexibility. In order to realize time synchronization through software method, this method is studied in this paper, and the time synchronization precision is analyzed as well.

There are several possible strategies for network time synchronization [1]. One option is to have full autonomy, where the clocks function independently without affecting to each other. This option requires frequent calibrations since clocks tend to drift from each other. Precise clocks that provide autonomy for a period [2] or external precise time source such as global satellite navigation system (GNSS) are also possibilities herein. A second option is the (centralized) master-slave structure. This is a hierarchical system where the lower level nodes synchronize with the higher level nodes but not vice versa. A drawback of this method is that a fault in a master (or sub master) node affects the whole (rest of the) network. This makes the network vulnerable. The advantages of this method are its simplicity and hat clock quality requirements are reduced to the higher hierarchy levels, which lowers the costs. The third alternative is the mutual (distributed, decentralized) synchronization in which the nodes synchronize themselves based on mutual cooperation without a master. Naturally, there are also hybrid strategies where a master (or a group of masters) leads the game but the rest of the nodes cooperate in a mutual fashion. Possibly, there is a hierarchical structure and cooperation exists within a hierarchy level. Furthermore, the master could be one that is not permanent but it can be replaced by another node in the case of failure or if it is not available for some other reason.

Inside the strategies are protocols, which describe how timing messages are distributed in a network and what and how many messages are needed. Several protocols have been proposed for network time synchronization (NTS) of wireless sensor and ad-hoc networks. References [3],[4],[5],[6],[7], [8] provide a good snapshot of these protocols. They follow the above mentioned general strategies in a way or another.

In recent years, averaging-based algorithms for fully distributed global clock synchronization have been studied [10], [11], [12], [13], [14], 15], [16]. Those averaging-based algorithms estimate the averages of clock rates and/or offsets, and they can essentially be connected to the discrete-time agreement/linear-consensus algorithms [18, Chap. 7], [19] that enable a large number of distributed nodes to reach agreement on a common value, e.g., the global average among their local values, in an iterative and fully distributed manner.

II. LITERATURE REVIEW

A. *Simple Averaging Scheme for Global Clock Synchronization*

Simple averaging scheme for global clock synchronization in sparsely populated MANETs. We discussed the fundamental characteristics of the scheme through the analysis and simulation results. Recall that the performance was evaluated in terms of two metrics: The speed of convergence to the steady state and the variation of relative time differences in steady state. Roughly speaking, the former is determined by the meeting frequency, independent of relative clock skews. On the other hand, the variation of relative time differences in steady state is influenced directly by relative clock skews. Even though those features were derived under the assumption of Poisson meetings, we demonstrated their applicability to real situations by showing the simulation result with real trace data [32].

B. *CQPM*

Tsenget al.[21] proposed the first asynchronous power mananagement protocols that can correctly operate in an 802.11-based MANET without need for synchronization. Then, Jianget al.in [18], Zhenget al.in [19], and Chouet al.in [22] concurrently and independently proposed similar cyclic quorum-based power management (CQPM) protocols to improve the performances in [21]. In these CQPM protocols [19], [22], [18], [19], there are two types of BIs, namely, fully awake BI (FBI) and normal BI(NBI). In Fig. 1(a), the FBI starts with the beacon window followed by the data window.

Every station shall broadcast its beacons only in its beacon windows. After the close of the beacon window, a PS station needs to remain awake during the entire data window. The design purpose of the FBI [17] is to impose a PS station to stay awake sufficiently long so as to ensure that neighboring stations have chance to receive each other's beacons (and thus discover each other) even if their clocks are different. On the other hand, the NBI[1] starts with an ATIM window.

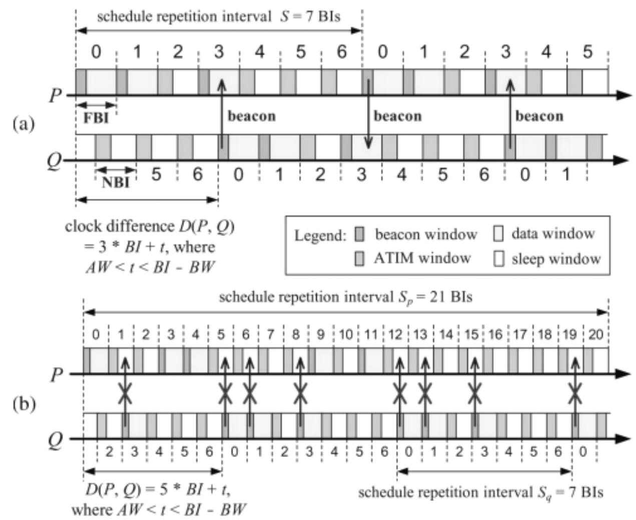

Fig. 1 (a) Example of the neighbor maintenance in CQPM. (b) P forever loses Q's beacons when P's clock leads Q's clock by 5×BI+t, where AW<t<BI−BW. Note that some arrows representing the beacon frames are ignored for clarity.

After the ATIM window ends, a PS station may doze off during the sleep window. Let the lengths of the beacon window, the ATIM window, and the BI be denoted by BW, AW, and BI, respectively. CQPM protocols require that AW ⩾ BW. Importantly, in CQPM, when a station switches to the PS mode, it selects a quorum qi ⊆{0,1,...,S−1}from the cyclic

quorum system Q={qi}0⩽i⩽S−1 as its FBIs in a schedule repetition interval(SRI), whereas the residual BIs are NBIs, where SRI=S means that these S consecutive BIs that constitute the specific awake/sleep schedule regularly repeat. In Fig. 2(a) for example, S=7 and Q={q0={0,1,3},q1={1,2,4},q2={2,3,5},q3={3,4,6},q4={4,5,0},q5={5,6,1},q6={6, 0,2}}, both PS stations P and Q select the q0={0,1,3}th BIs as their FBIs in every consecutive seven BIs. To keep the analysis and presentation simple, we assume that no collisions occur in beacon broadcast throughout this paper except for simulations. Under this assumption, [18], [22], and [19] have proven that two PS neighbors, i.e.,P and Q, are able to discover each other in finite time, regardless of their clock difference D(P,Q).

C. *IEEE 802.11 TSF*

In 802.11 TSF, clock synchronization is achieved by periodical timing information exchange through beacon frames, which contain timestamps. In the IEEE 802.11 standards [20], an ad-hoc network is called an Independent Basic Service Set

(IBSS), in which all of the stations are within each other's transmission range.

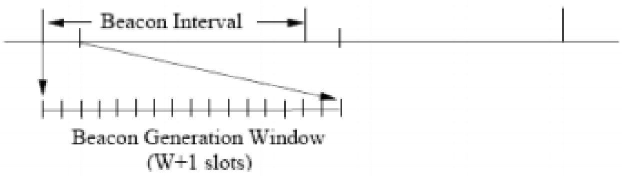

Fig. 2 Beacon generation window [2]

According to the IEEE 802.11 specifications [20], each station maintains a TSF timer (clock) of the order of microseconds. Clock or timing synchronization is achieved by nodes periodically exchanging timing information through beacon frames. Each node in an IBSS shall adopt the timing received from any beacon that has a TSF time value (the timestamp) later than its own TSF timer. All nodes in the IBSS adopt a common value, aBeaconPeriod, which defines the length of beacon intervals or periods. This value, established by the node that initiates the IBSS, defines a series of Target Beacon Transmission Times (TBTTs) exactly aBeaconPeriod time units apart. Time zero is defined to be a TBTT. Beacon generation in an IBSS is distributed; all nodes in the IBSS participate in the process as follows.

1) Beacon Generation and Clock Synchronization

1. At each TBTT each node calculates a random delay uniformly distributed in the range between zero and 2.aCWmin.aSlotTime.

2. The node waits for the period of the random delay.

3. If a beacon arrives before the random delay timer has expired, the node cancels the pending beacon transmission and the remaining random delay.

4. When the random delay timer expires, the node transmits a beacon with a timestamp equal to the value of the node's TSF timer1.

5. Upon receiving a beacon, a station sets its TSF timer to the timestamp of the beacon if the value of the timestamp is later than the station's TSF timer2.

Thus, as illustrated in Fig 2, at the beginning of each beacon interval, there is a beacon generation window consisting of W+1 slots each of length aSlotTime, where W = 2.aCWmin. Each node is scheduled to transmit a beacon at the beginning of one of the slots.

D. ATSP

ATSP was proposed in [21] to solve the scalability problem. Here in ATSP the fastest station competes for beacon transmission every beacon period and other stations compete occasionally. In ATSP each node is assigned an integer I(i) that determines how often each node shall participate in beacon contention. Each node contends for beacon transmission once every I(i) beacon periods. Therefore smaller the value of I, higher the node chances of beacon transmission. The only problem arises with ATSP when the fastest node leaves the IBSS. Then the network takes more time to synchronize.

E. *TATSP*

TATSP is proposed in [22]. TATSP dynamically classifies the stations into three tiers according to the clock speed. The stations in tier 1 compete for beacon transmission in every beacon period and the stations in tier 2 will compete once in a while and the stations in tier 3 rarely compete. TATSF is compatible with 802.11 TSF.

F. *ABTSF*

ABTSF protocol is proposed in [23]. ABTSF allows clock to move in positive direction as well as negative direction. In other words we can say that it allows clock to move in both directions. It is not compatible with 802.11 TSF. It selects a token holder who is responsible for the beacon transmission. Each station resets its clock after receiving from the beacon holder. The token holder rotated periodically. The accuracy in maximum clock drift is improved.

G. *TSPTA*

TSPTA stands for Time Synchronization Procedure Toward Average (TSPTA). It does not give priority to a particular node. In TSPTA, each node gathers time information through the received beacon signal, and using this calculated information for self correcting. One of the majos advantages of this method is achieved through the decentralized processing, we obtain short convergence time and high accuracy [24].

H. *Some other Global Clock Synchronization*

There are extensive studies on global clock synchronization in multi-hop wireless networks and the surveys are given in [26], [27]. If the network is composed of static nodes and/or low-mobility nodes, the simplest way is to form a hierarchical topology rooted by a special node, i.e., root node, and to broadcast the clock time of the root node to all other nodes along with the topology. This category of global time synchronization schemes includes Network Time Protocol (NTP) [28] and its extension [29], tree-based approach [30], [31], and cluster-based approach [32]. These approaches, however, will not work well in challenged networks due to the following reasons: i) Making and maintaining the hierarchical topology are difficult due to sparse node density, node mobility, and node failures, and ii) estimation errors increase with the number of hops from the root node.

III. CONCLUSIONS

From the research and analysis, we can get the conclusion for the time synchronization. In a MANET environment, it is often essential to maintain network time synchronization Power Conservation is essential for battery life in portable devices. There is various efficient energy power saving methods. Some of those are for single-hop and some of others are for multi-hop MANET. We have studies some of those methods for the same in this paper, which motivates to work for time synchronization in MANET environment to increase the life time of the network.

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