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A Study of Time Synchronization Methods for IoT Network Nodes

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Abstract

Many devices are connected on the internet to give functionalities for interconnected services. In 2020', The number of devices connected to the internet will be reached 5.8 billion. Moreover, many connected service provider such as Google and Amazon, suggests edge computing and mesh networks to cope with this situation which the many devices completely connected on their networks. This paper introduces the current state of the introduction of the wireless mesh network and edge cloud in order to efficiently manage a large number of nodes in the exploding Internet of Things (IoT) network and introduces the existing Network Time Protocol (NTP). On the basis of this, we propose a relatively accurate time synchronization method, especially in heterogeneous mesh networks. Using this NTP, multiple time coordinators can be placed in a mesh network to find the delay error using the average delay time and the delay time of the time coordinator. Therefore, accurate time can be synchronized when implementing IoT, remote metering, and real-time media streaming using IoT mesh network.

Keywords: *Internet of Things, Mesh Network, Time Synchronization, Edge Computing, Network Time Protocol*

1. Introduction

The explosive development of the Internet of Things and cloud computing technology is driving a hyper-connected society, where many devices are interconnected. Gartner announces 'Scenarios for the IoT Marketplace, 2019' to estimate the growth of IoT. The report predicts that by 2020, the enterprise and automotive IoT markets will grow to 5.8 billion endpoints, up 21% compared to 2019. By the end of 2019, 4.8 billion endpoints are expected to be used, up 21.5% from 2018 [1].

In addition, according to S.S. Shin et al., IoT endpoints will explode in the future, resulting in explosive device-server communication, increased latency in cloud computing, and technical limitations such as temporary network outages [2]. When these technologies are combined, real-time services, immersive services, and self-contained services through IoT networks will be possible [2].

Moreover, wireless mesh networks have been introduced to efficiently connect a large number of devices

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concentrated in one area [3][4][5]. In order to implement services through data collected by various types of sensors, various IoT devices It is very important that the device nodes synchronize their time.
However, the NTP network-based time protocols can only achieve relatively accurate time synchronization in a centralized and hierarchical network structure. Therefore, this paper proposes a relatively accurate time synchronization method based on the existing NTP, especially in heterogeneous mesh networks.

2. Related Studies

Figure 1 shows the structural difference between the existing network and the mesh network. Unlike existing networks, mesh networks have an auto-configuration feature that uses adjacent nodes to maximize network packet forwarding.

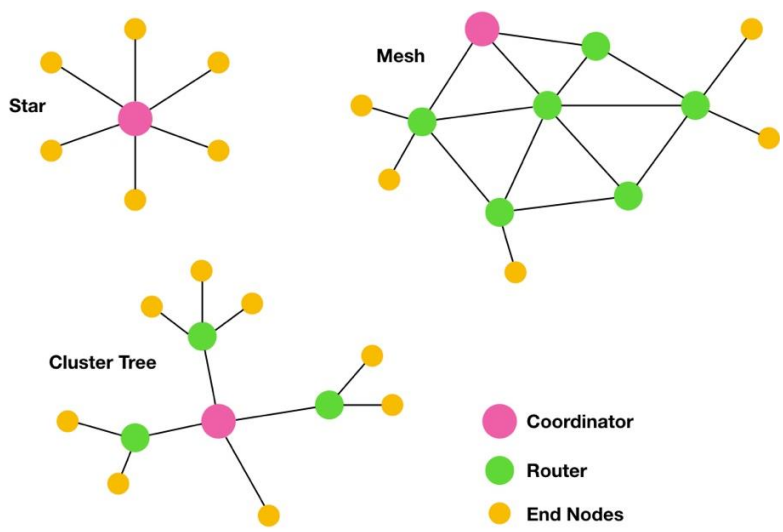

Figure 1. A structural difference between traditional network and mesh network.

Therefore, compared to the existing network, the number of hops that need to deliver a packet is deep and changes frequently. Existing NTP calculates propagation delay in a network where a network structure is defined, so that time synchronization is relatively accurate (within 1 ms). However, in an environment such as a heterogeneous mesh network, time synchronization must be frequently performed because the propagation delay characteristics also change whenever the network configuration changes. Therefore, the low power device has the disadvantage of increasing power consumption. Therefore, as a conventional time synchronization method, Korean Patent No. 10-0726476 (announced June 12, 2007) discloses a time synchronization method for minimizing power consumption of heterogeneous sensor nodes and a network using the same [6]. Kim, Yong-Gil, and Kyung-Il Moon were suggested an adaptive time delay compensation process in networked control system [7]. However, those methods of time synchronization are not suitable for the mesh network but for traditional tree network structure. In addition, Ji, S., Kim, S., Yun, E., and Seo, D. Y have suggested time synchronization between IoT devices in a private network using Block-Chain, but it is also not considered massive nodes on mesh network [8]. Next, Korean Patent Publication No. 10-2006-0109687 (published on October 23, 2006) described the asynchronous method. A method and system for synchronizing time based mobile communication terminal based on the present invention are disclosed [9]. However, this time synchronization method has a problem that heterogeneous time synchronization is not considered. Lastly, Kim, Min-young, and Jong-Wook Jang have proposed the design of a multi-hop network

protocol based on LoRaWAN gateway, it much more similar to our situation, but the design does not focus on time synchronization issues[10]. In order to solve this problem, a method has been proposed in which a real-time clock (RTC) is internally maintained in the device to maintain time by using internal time after time synchronization is performed. There is also a disadvantage that this is necessary.

3. Proposed system

Therefore, to solve this problem, two or more coordinators are set in the network as shown in Figure 2. Every network node can act as a time coordinator. If there are 2 time-coordinators, set one to be the closest to the external network and one to the farthest from the external network.

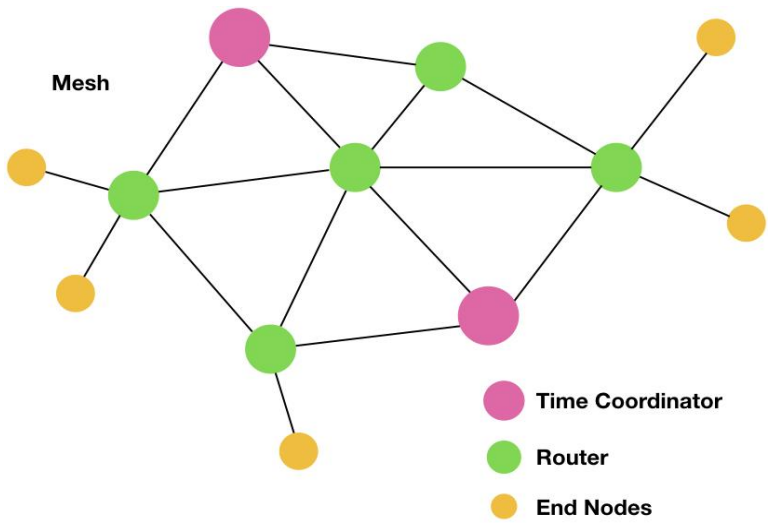

Figure 2. A proposed time synchronization method for mesh network nodes

Network nodes can broadcast the heart-beat signal periodically to calculate the distance to the external network. If there are two or more, set one to be far from the outside and one to be near, and use the same method as K-means to distribute the remaining time coordinators evenly. time-coordinator plays a simple role. It uses NTP to synchronize its own time through the external network, and when the neighboring nodes request it, it uses NTP to perform time synchronization. It also advertises its function to the surrounding nodes. Once the time-coordinator performs time synchronization with an external NTP server, all network nodes can connect to at least 2 time-coordinators to perform time synchronization. If a network node requests time to 2 time-coordinators at the same time, a delay occurs while the request is transmitted to the network, and the time received from the 2 time-coordinators is different. If the 2 time-coordinators have the longest network distance, the average latency of this mesh network can be obtained by dividing the difference between the two delay times by the number of hops of the two time-coordinators in the network. The more time-coordinators, the more accurate the average latency of the network. Therefore, the network node can find the delay error using the average delay time and the delay time of the time-coordinator and can compensate for this to accurately calculate the time. The system will be adopted many IoT network applications such as remote metering or real-time media streaming using a mesh network.

4. Conclusion

In this paper, we introduce the current state of the introduction of the wireless mesh network and edge cloud

in order to efficiently manage a large number of nodes in the exploding Internet of Things (IoT) network and introduces the existing Network Time Protocol (NTP). Considering the characteristics of a mesh network with a large number of hops in the network, we reviewed many network time synchronization methods for IoT mesh network. Finally, we propose a relatively accurate time synchronization method, especially in heterogeneous mesh networks. We proposed a method to correct the error by calculating the time error between nodes with two or more time-coordinators. At present, the technology has been applied for a Korean patent (application number: 10-2019-0107037) and registration is in progress. In the future, this technology can be applied to all industries that apply it because the accurate time can be synchronized when implementing remote metering or real-time media streaming using a mesh network. Also, we considered our technology as an accurate time synchronization method on network nodes the Low Power Wide Area (LPWA) such as Sigfox, Zigbee, LoRaWAN consist of wireless mesh networks.

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References

[1] Gartner, “Scenarios for the IoT Marketplace,” 2019.
https://www.gartner.com/en/documents/3955769/scenarios-for-the-iot-marketplace-2019

[2] ETRI, "Edge Computing Market Trends and Application Scenarios," Electronics and Telecommunications Trends, 2019.

[3] Xudong Wang and Azman O. Lim, “IEEE 802.11s wireless mesh networks: Framework and challenges,” Ad Hoc Networks, pp. 970-984, August 2008.
DOI: *https://doi.org/10.1016/j.adhoc.2007.09.003*

[4] Lee, Ae-Young, and II-Soon Roh, "An Optimal Path Routing in Wireless Mesh Network," The Journal of The Institute of Internet, Broadcasting and Communication (JIIBC), Vol. 9, No. 2, pp. 43-48, 2009.
UCI: *G704-001948.2009.9.6.015*

[5] Lim, Chan-Sook, and Hong-Young Ahn, "Effects of Forwarders on TCP Performance in Network Coding for Wireless Mesh Networks." The Journal of The Institute of Internet, Broadcasting and Communication (JIIBC), Vol.10, No.6, pp. 39-45, 2010
UCI: *G704-001948.2010.10.6.024*

[6] Myong-Jin, Lee., Time synchronization method for minimizing power consumption of hetero-species sensor nodes and network adopting same. KR Patent 10-2006-0136842, 2006

[7] Kim, Yong-Gil, and Kyung-Il Moon, "Adaptive Time Delay Compensation Process in Networked Control System," International journal of advanced smart convergence (IJASC), Vol. 5, No. 1, pp. 34-46, 2016.
DOI : *https://doi.org/10.7236/IJASC2016.5.1.34*

[8] Ji, S., Kim, S., Yun, E., and Seo, D. Y. "Time Synchronization between IoT Devices in a Private Network using Block-Chain," The Journal of The Institute of Internet, Broadcasting and Communication (JIIBC), Vol. 18, No.5, pp. 161-169, 2018.
DOI : *https://doi.org/10.7236/JIIBC.2018.18.5.161*

[9] Young-Jae, Lee., METHOD SYNCHRONIZING TIME OF MOBILE TERMINAL BASED ONASYNCHRONOUS MODE AND THE SYSTEM THEREFOR. KR Patent 10-2005-0031942, 2005

[10] Kim, Min-young, and Jong-wook Jang. "A Design of Multi-hop Network Protocol based on LoRaWAN Gateway," International journal of advanced smart convergence (IJAS C), Vol. 8, No. 2, pp. 109-115, 2019.
DOI : *https://doi.org/10.7236/IJASC.2019.8.2.109*