Journal of information and
communication convergence engineering
http://jicce.org

J. Inf. Commun. Converg. Eng. 18(3): 183-187, Sep. 2020

Regular paper

# A Study on Intelligent Edge Computing Network Technology for Road Danger Context Aware and Notification

**Am-Suk Oh*** , ***Member*, *KIICE***

Department of Digital Media Engineering, Tongmyong University, Busan 48520, Korea

## Abstract

The general Wi-Fi network connection structure is that a number of IoT (Internet of Things) sensor nodes are directly connected to one AP (Access Point) node. In this structure, the range of the network that can be established within the specified specifications such as the range of signal strength (RSSI) to which the AP node can connect and the maximum connection capacity is limited. To overcome these limitations, multiple middleware bridge technologies for dynamic scalability and load balancing were studied. However, these network expansion technologies have difficulties in terms of the rules and conditions of AP nodes installed during the initial network deployment phase In this paper, an intelligent edge computing IoT device is developed for constructing an intelligent autonomous cluster edge computing network and applying it to real-time road danger context aware and notification system through an intelligent risk situation recognition algorithm.

**Index Terms**: Access Point Node, Autonomous cluster, Intelligent Edge Computing, IoT Device, Switching technique

## I. INTRODUCTION

The problem of the existing cloud-centric network is that as the data throughput increases, the data transmission speed becomes slower as the load increases as shown in Fig. 1, and the entire system is paralyzed when a failure situation occurs in the cloud server or gateway. In this paper, through intelligent edge computing network technology as shown in Fig. 2, we aim to improve existing dependent network structure and provide an environment where automatic recovery of various situations such as the establishment of the early network, device breakage, addition, network failure, etc. is possible [1, 2].

The IoT device, which is the core of this study, is a node at the edge of the network with intelligent computing functions, and it even acts as an AP as the device detects the network state by itself and the AP/STA mode is flexibly changed. As a result, the network is autonomously configured and is not affected by the failure situation of the higher-level elements constituting the network [3, 4]. In addition, edge computing technology in this study is a technology that analyzes and utilizes data in real time in the local area and can be linked to existing cloud computing technologies. Edge computing technology enables efficient and intelligent situation analysis through organic connection between devices, and refined data are transmitted back to the cloud to process information through deep learning-based machine learning algorithms, and various information-linked services can be provided through connection with external systems [5, 6].

The representative area where intelligent edge computing network technology can be applied is C-ITS (Cooperative Intelligent Transport Systems), and C-ITS requires intelligent situational detection and real-time response technology. C-ITS is a transportation system that can improve the convenience and safety of traffic use by collecting, managing and providing traffic information between components of traffic

**Received** 15 September 2020, **Revised** 27 September 2020, **Accepted** 27 September 2020
***Corresponding Author** Am-Suk Oh (E-mail: asoh@tu.ac.kr, Tel: +82-51-629-1211)
Department of Digital Media Engineering, Tongmyong University, Busan 48520, Korea.

Open Access **https://doi.org/10.6109/jicce.2020.18.3.183** print ISSN: 2234-8255 online ISSN: 2234-8883

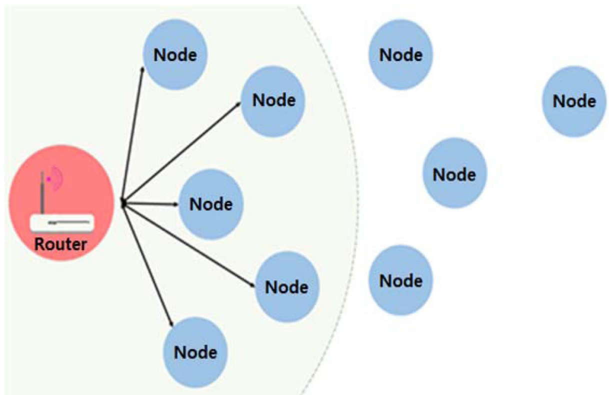



**Fig. 1.** Existing Wi-Fi network architecture.

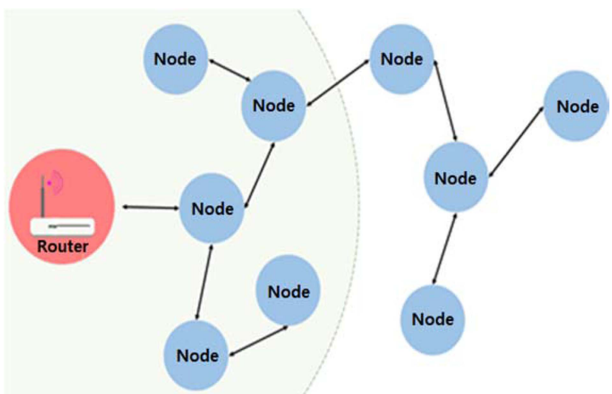



**Fig. 2.** Intelligent edge computing network architecture.

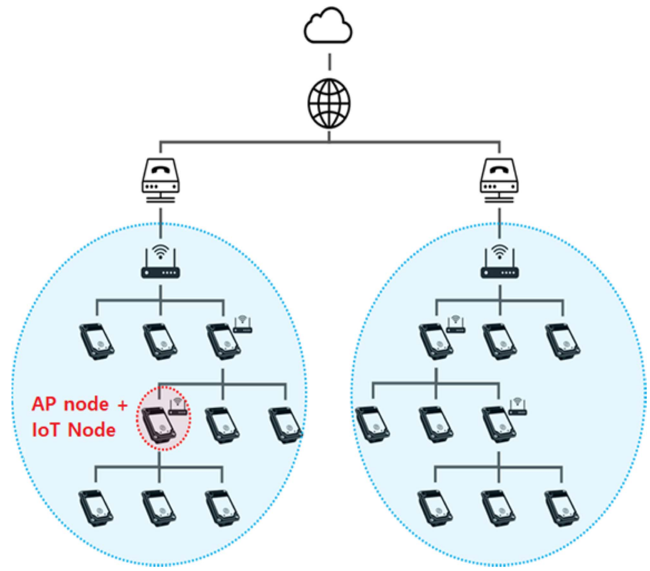



**Fig. 3.** Intelligent autonomous cluster network structure.

(automobile, road infrastructure, driver, pedestrian, etc.) through V2X (Vehicle to Everything) communication technology. In order to realize C-ITS, advanced road infrastructure for collecting road information along with communication technology between traffic elements is essential, and solutions that can provide accident prevention and prompt response using advanced road infrastructure are needed. Therefore, in this paper, we intend to develop a real-time road hazard situation recognition and notification system for the application of C-ITS based on an intelligent edge computing network [7, 8].

In this paper, we study intelligent edge computing network technology that autonomously builds a network using intelligent IoT devices in a network edge environment, and a real-time road hazard recognition and notification system applying intelligent IoT device technology [9, 10].

## II. DESIGN OF INTELLIGENT EDGE COMPUTING NETWORK

In a general Wi-Fi network connection structure, multiple IoT (Internet of Things) sensor nodes are directly connected to one AP (Access Point) node, and the AP node is connected to the network through various types of Internet modems. In this structure, the range of the network that can be established within the specified specifications such as the range of signal strength (RSSI) to which the AP node can connect and the maximum connection capacity is limited. To overcome these limitations, multiple middleware bridge technologies for dynamic scalability and load balancing were studied. However, these network expansion technologies have difficulties in terms of the roles and conditions of AP nodes installed during the initial network deployment phase, and network construction and maintenance that must be fixed, set up, and setting all the connection structures between IoT nodes [11, 12].

In this paper, we study the network structure in which intelligent IoT devices configured at the network edge as shown in Fig. 3 are autonomously clustered based on Wi-Fi to overcome the limitations of such existing network construction. This structure is very easy in terms of network automatic construction, expansion and maintenance, and response to failure situations. As shown in Fig. 4, intelligent IoT devices distinguish between stable and unstable areas in transmitting and receiving data according to the signal strength of adjacent intelligent IoT devices (AP mode). Intelligent IoT devices that belong to stable areas are set to STA(STAtion) mode and connected to adjacent APs, while IoT devices that belong to unstable areas are set to AP mode, forming clusters and expanding networks.

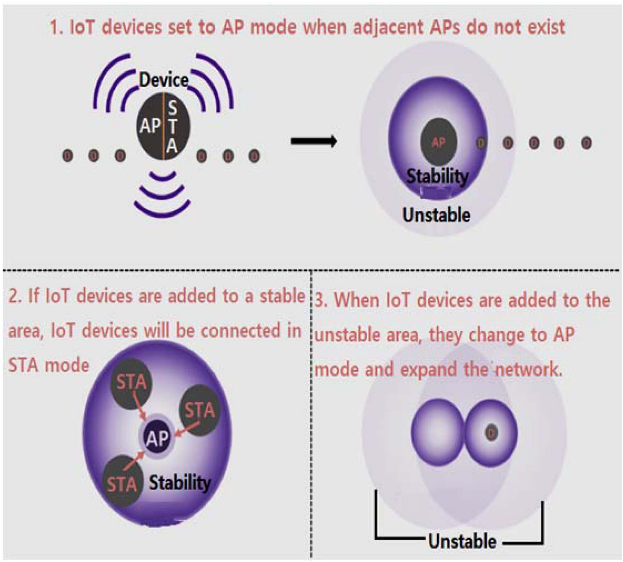



**Fig. 4.** Area classification according to signal century.

## III. AP/STA MODE SWITCHINGTECHNIQUE OF INTELLIGENT EDGE COMPUTING

In this paper, we divide into AP Area/ STA Area as shown in Fig. 5 on the basis of signal strength of the AP, and study AP/STA mode switching techniques that support flexible connections between devices by switching into the appropriate mode when new devices enter each area. STA Area is an area where STA can be stably connected when a new IoT device is added, and AP Area refers to an area outside the AP's STA Area where signal strength is weakened and network scope expansion is needed. When dividing the area, the link margin shall be derived by taking into account the maximum output, reception sensitivity, antenna gain and path loss as shown in Fig. 6. In this study, the value is derived through the Friis power transmission equation for transmission and reception in the link design of the radio communication system. Link Budget is the performance required (gain, loss, BER, etc.) by a given link and calculates the expected link margin. In Fig. 6, $P_r$ and $P_t$ refer to the Transceiver radiation electric power, $G_t$ and $G_r$ refer to the transmit/receive antenna gain, $\lambda$ refers to the wavelength of the used frequency, and $d$ refers to the distance between the receiving antenna and the transmitting antenna. In addition, by using the Friis power transmission equation, the sum of the loss, attenuation and gain at each step on the path between both ends of the transmission and reception does not exceed the link budget.

In this paper, the method of securing time series data on traffic conditions is studied through connection of IoT devices based on intelligent edge computing. We study ways to stably secure traffic situation time series data (distance measurement,

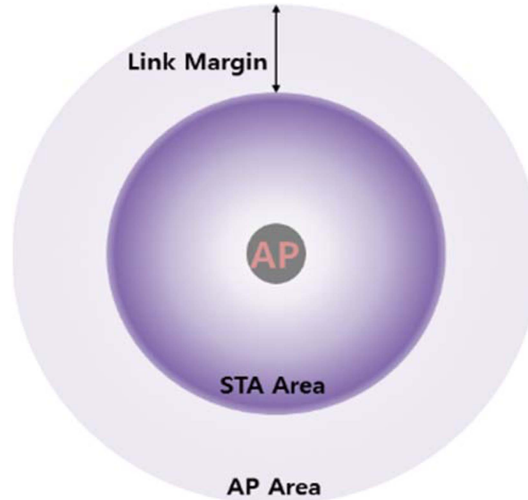
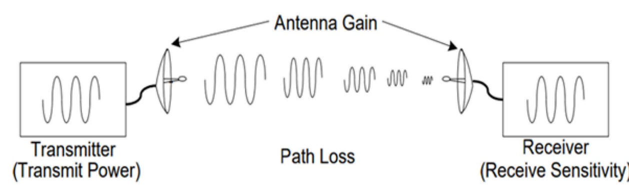



**Fig. 5.** AP Area/STA Area.




$$\frac{P_r}{P_t} = G_t G_r \left(\frac{\lambda}{4\pi d}\right)^2$$

**Fig. 6.** Friis equation for deriving Link Budget [13].

shock detection, GPS) of IoT devices transmitted by configuring adjacent IoT devices as a network. Based on the secured traffic situation information, we develop an algorithm that can intelligently recognize the traffic flow and accident situation through an intelligent traffic situation recognition algorithm. Research is conducted on how to utilize RNN (Recurrent Neural Network), which has excellent performance in processing time series data with algorithm that is intended to be applied. In particular, the algorithms intended to be applied to this study are intended to study the utilization of LSTM(long short-term memory), one of the recursive neural networks.

In this detailed study, we study an algorithm that self-recovers faults when a fault condition occurs during operation of the IoT devices that make up the network. Network failures Situation is classified into cases in which empty space is created in the network due to the sudden stop of AP mode Fig. 7 and cases in which IoT devices are added outside the effective range of other APs Fig. 8.

When the IoT device (AP mode) constituting the network is stopped, the adjacent IoT device (STA mode) periodically recognizes a bad connection to the AP through the context information of the adjacent node and re-sets the IoT device to establish the network Recover. When attempting to gradually expand the network by adding IoT devices, if it is out of

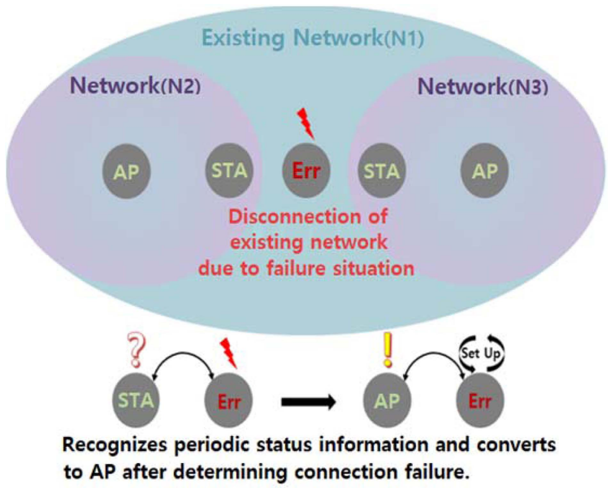



**Fig. 7.** Existing network disconnection due to failure.

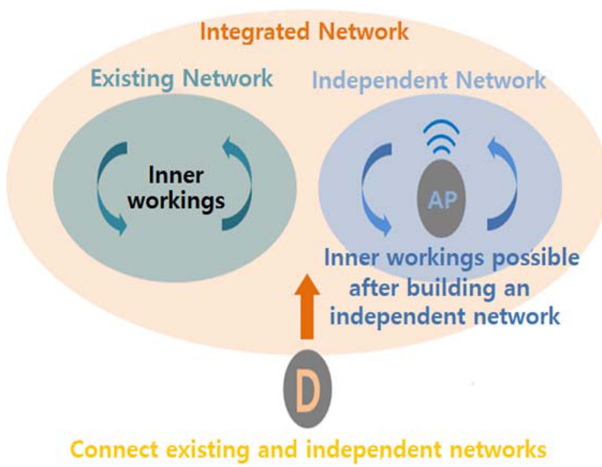



**Fig. 8.** When added outside the effective range of the AP.

the effective range of the AP, a network independent from the existing network is built autonomously and internal operation is possible. In addition, IoT devices are integrated into one network when they are added between two independently established networks.

## IV. INTELLIGENT ALGORITHMS OF EDGE COMPUTING IoT DEVICES

In this paper, an intelligent edge computing IoT device is developed for constructing an intelligent autonomous cluster edge computing network and applying it to real-time road hazard recognition and notification system through an intelligent risk situation recognition algorithm. Fig. 9 shows the connectivity composition of these edge computing IoT devices.

The learning algorithm of the LSTM recursive neural network used in this study is developed using the BPTT (Back

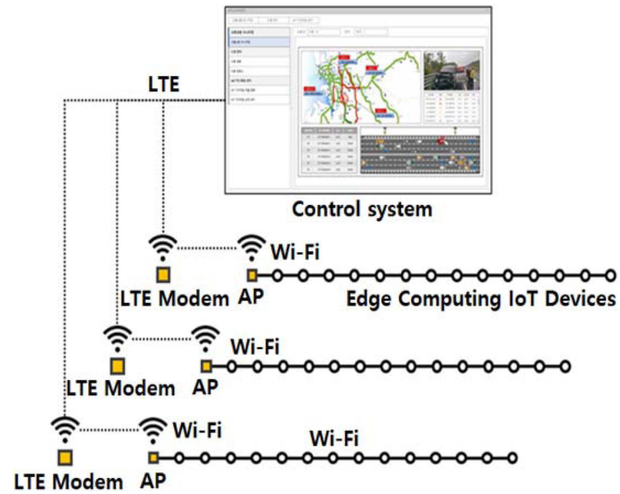



**Fig. 9.** Intelligent edge computing IoT device connection diagram.

Propagation Through Time) algorithm. The gradient of the error function $E$ for the gate and state storage is learned by calculating the error function $E$ and the partial derivative of the Kth element of each gate and internal state using the following equation to obtain the error gradient. Based on this learning base, we develop an algorithm that can recognize the traffic situation by analyzing the input data coming into time-series data.

$$\frac{\partial E}{\partial c_t^k} = \frac{\partial E}{\partial h_t^k}\frac{\partial h_t^k}{\partial c_t^k} = \frac{\partial E}{\partial h_t^k} o_t^k(1-\tanh^2(c_t^k)), \tag{1}$$

$$\frac{\partial E}{\partial i_t^k} = \frac{\partial E}{\partial c_t^k}\frac{\partial c_t^k}{\partial i_t^k} = \frac{\partial E}{\partial c_t^k} a_t^k, \tag{2}$$

$$\frac{\partial E}{\partial f_t^k} = \frac{\partial E}{\partial c_t^k}\frac{\partial c_t^k}{\partial f_t^k} = \frac{\partial E}{\partial c_t^k} c_{t-1}^k, \tag{3}$$

$$\frac{\partial E}{\partial a_t^k} = \frac{\partial E}{\partial c_t^k}\frac{\partial c_t^k}{\partial a_t^k} = \frac{\partial E}{\partial c_t^k} i_t^k, \tag{4}$$

$$\frac{\partial E}{\partial o_t^k} = \frac{\partial E}{\partial h_t^k}\frac{\partial h_t^k}{\partial o_t^k} = \frac{\partial E}{\partial h_t^k} \tanh(c_t^k). \tag{5}$$

$$\frac{\partial E}{\partial c_{t-1}^k} = \frac{\partial E}{\partial c_t^k}\frac{\partial c_t^k}{\partial c_{t-1}^k} = \frac{\partial E}{\partial c_t^k}\frac{\partial(i_t^k a_t^k + f_t^k c_{t-1}^k)}{\partial c_{t-1}^k} = \frac{\partial E}{\partial c_t^k} f_t^k. \tag{6}$$

$$\frac{\partial E}{\partial c_{t-p}^k} = \frac{\partial E}{\partial c_t^k} \prod_{n=t-p}^{t} f_n^k. \tag{7}$$

The (1-5) is a gradient calculation process, and $\partial E/\partial c_{t-1}^k$ is induced like (6) when the (1-5) is $t$-1. In addition, the gradient $\partial E/\partial c_{t-p}^k$, which is passed to the $p$-stage historical point, develops algorithms that can be learned by multiplying the value of the oblivion gate by $p$ times, as shown in (7).

## V. CONCLUSIONS

In this paper, we researched the network technology of the intelligent edge that autonomously builds a network using intelligent IoT devices in the network edge environment and the development of a real-time road hazard recognition and notification system using intelligent IoT device technology. As a result of this paper, intelligent edge computing network technology is highly important in that it will ultimately contribute greatly to improving national competitiveness through the development effect of related academic fields, securing social safety nets, and economic ripple effects.

The proposed technology is very efficient in terms of network deployment convenience, functionality, and data processing time compared to the existing network environment and is easy to apply to related industries that require real-time responses such as autonomous vehicles, Internet of Things services, and smart factory. In particular, the C-ITS sector is an area where future technological growth can be achieved rapidly, and in the case of data-based road safety service technology, it has sufficient competitiveness and potential to prevent traffic disasters. In the case of intelligent information service, it is expected that it will bring positive technical and economic ripple effects through the activation of technology development of autonomous vehicles.

The future use plan is to support the establishment of a monitoring system that can proactively respond to traffic accidents in accordance with the quantitative reduction of traffic accidents occurring on highways (car-only roads).

Through the establishment of an intelligent IoT network, it detects and recognizes various risk factors that can occur on highways (car-only roads) and provides road information in real-time to support the early introduction of advanced countries' smart transportation disaster safety systems.

## ACKNOWLEDGEMENTS

This Research was supported by the Tongmyong University Research Grants 2019 (2019A016) and this work was supported by the BB21+ Project in 2020.

## REFERENCES

[ 1 ] P. Jianli and J. McElhannon, “Future edge cloud and edge computing for internet of things applications,” *IEEE Internet of Things Journal*, vol. 5, no. 1, pp. 439-449, 2017. DOI: 10.1109/JIOT.2017.2767608.

[ 2 ] J. M. Castillo-Secilla, P. C. Aranda, F. J. B. Outeiriño and J. Olivares, “Experimental procedure for the characterization and optimization of the power consumption and reliability in ZigBee mesh networks,” *IEEE 2010 Third International Conference on Advances in Mesh Network*, pp. 13-16, 2010. DOI: 10.1109/MESH.2010.16

[ 3 ] K. Mase, H. Okada, and Y. Nakano, “RSSI-based cross layer link quality management for layer 3 wireless mesh networks,” in *SoftCOM 2009-17th International Conference on Software, Telecommunications & Computer Networks*, pp. 101-105, 2009.

[ 4 ] N. Tatebe, K. Hattori, T. Kagawa, Y. Owada, and K. Hamaguchi, “Energy-efficient construction algorithm for mobile mesh networks,” in *The 20th IEEE Asia-Pacific Conference on Communication (APCC2014)*, pp. 73-77, 2014. DOI: 10.1109/APCC.2014.7091608

[ 5 ] N. Mohan and J. Kangasharju, “Edge-Fog cloud: A distributed cloud for Internet of Things computations,” In *2016 Cloudification of the Internet of Things (CIoT)*, pp. 1-6, 2016. DOI: 10.1109/CIOT.2016.7872914

[ 6 ] H. M. Park and T. H. Hwang, “Changes and Trends in Edge Computing Technology,” *Journal of The Korean Institute of Communication Sciences*, vol. 36, no. 2, pp. 41-47, 2019.

[ 7 ] J. S. Song, B. J. Lee, K. T. Kim, and H. Y. Youn, “Expert system-based context awareness for edge computing in IoT environment,” *Journal of Internet Computing and Services*, vol. 18, no. 2, pp. 21-30, 2017.

[ 8 ] F. Bonomi, R. Milito, J. Zhu, and S. Addepalli, “Fog computing and its role in the internet of things,” in *Proceeding of the first edition of the MCC workshop on Mobile cloud computing*, pp. 13-16, 2012.

[ 9 ] Y. Xu and A. Helal, “Scalable cloud-sensor architecture for the internet of things,” *IEEE Internet of Things Journal*, vol. 3, no. 3, pp. 285-298, 2016.

[10] C. Perera, A. Zaslavsky, P. Christen, and D.Georgakopoulos, “Context aware computing for the internet of things: A survey,” *IEEE Communications Surveys & Tutorials*, vol. 16, no.1, pp. 414-454, 2014.

[11] J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, “Internet of Things (IoT): A vision, architectural elements, and future directions,” *Future Generation Computer Systems*, vol. 29, no. 7, pp. 1645-1660, 2013.

[12] H. H. Yang, “Lode location management using RSSI regression analysis in wireless sensor network,” *Journal of the Korea Institute of Information and Communication Engineering*, vol. 13, no. 4, pp. 1935-1940, 2009.

[13] Chipsen. 2.4Ghz wireless communication (reach) distance estimation [Internet]. Available: https://help.chipsen.com/support/solutions/articles/22000209779-2-4ghz/.

**Am-Suk Oh**
received the B.S. and M.S. degrees in computer science from Busan National University and Chungang University, respectively. He received Ph.D. degree at the computer engineering of Busan National University. He is currently with the Department of Digital Media Engineering, Tongmyong University as Professor. His research interests are Database, Healthcare System, Big Data and IoT.