



Design of Independent Information Transmission System in WSN Using Community Co-ordination

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Abstract—Wireless Sensor Network (WSN) is widely used in Emergency However, when multiple emergencies happen, the real-time property will decrease for the transmission collision between communities.

Therefore, this paper proposes Autonomous Emergency Information Transmission Technology in which the communities autonomously coordinate with each other to avoid the transmission collision between the main routes. The simulation results show the improvement of proposed technology. **Keywords**— *Wireless Sensor Network, Autonomous Community, Emergency information transmission, real-time*

I. INTRODUCTION

In recent years attention has been focused on the development of large-scale, ad-hoc systems of interconnected sensors for a wide range of purposes.[1] Dubbed Sensor Networks, these systems in many ways form a natural progression from previous work done in the fields of ubiquitous computing and mobile ad-hoc networks. Like ubiquitous computing, they involve collections of many possibly heterogeneous devices and sensors communicating to obtain some kind of emergence. And like mobile ad-hoc networks, connections between nodes are created dynamically, routing problems

introduced by mobility must be tackled, and resources such as battery power are constrained. Such Sensor Networks are envisaged for a wide range of applications, from military ends such as target tracking and surveillance [2], [3] and emergency disaster countermeasure [4], to commercial systems such as end-to-end monitoring of a supply chain and cold-chain management [5] and monitoring of native environment [6]. Unlike most of research focusing on out-door deployment, this paper addresses an environmental monitoring system in the nuclear plant as a practical application of the sensor network. The system requires efficient surveillance of environment. In order to satisfy these application needs, real-time property is needed for monitoring system to become adaptive in dynamically changing topology, as a lot of cheap sensors can be installed easily, and they can be flexibly added, removed and relocated in wireless environments. In addition, wireless environment dynamically and drastically changes due to interference caused by environmental factors and varying application requirements.

In order to adapt the dynamically changing situations without failure, Autonomous decentralized System (ADS) [7] was proposed. Each subsystem of ADS gathers information, autonomously judges

and autonomously processes. Therefore, ADS could achieve on-line property which consisted of on-line expansion, on-line maintenance and fault-tolerance. Based on ADS concept, community [8] was proposed. Community is defined as a group that all members cooperate and coordinate with each other autonomously for the same objective. In this paper, to achieve real-timely transmitting emergency information in rapid changing environment, Autonomous Emergency Information Transmission Technology is proposed. The paper is organized as follows. In the next section, the application are described. Community concept and system architecture are presented in Sect. 3. Autonomous Community Construction is described in Sect. 4. Autonomous Emergency Information Transmission Technology is described in Sect. 5. Sect.6 shows the effectiveness of proposed technology by evaluation. We conclude the paper in Sect. 7.

II. APPLICATION

A. System Requirement

Fig.1 shows the outline of the application. The target application involves that of the Environmental Monitoring System (EMS) in the nuclear power plant. The purpose of application is to tell the manager emergency in the plants immediately. To achieve that, the sensor should regularly perceive the oscillation data, humidity, and the thermal data. And, when emergencies happen, it should be transmitted to the manager promptly.

B. Advantage of Wireless

Compared to wired sensor, Wireless Sensor Network is suitable because wired sensor is difficult to change and expand the system. The nuclear plants are necessity to update the equipment and expand the scale as time goes by. But the building of nuclear power plant is much with 550mph speed. Thus it is difficult to more solid than normal building, the wall even can endure the impact of an airplane do something on the building like digging

whole on the wall for setting wire. Or, it will cost much more than digging at normal building. Thus, wired sensor is not appropriate for EMS at nuclear power plant.

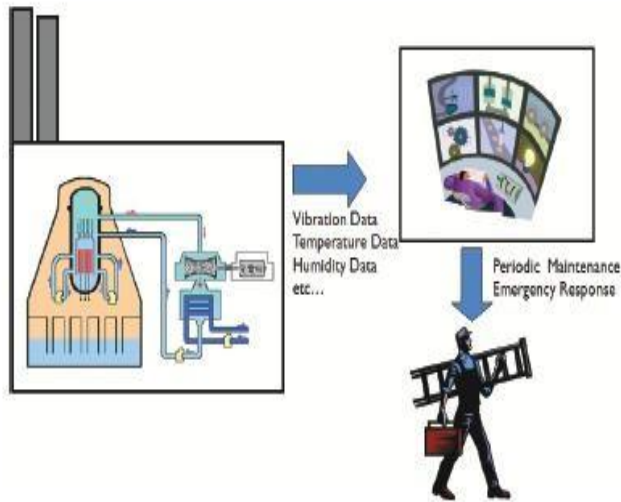


Fig. 1: Environmental Monitoring System in the Nuclear Plant

C. Problem of Centralized System

The wireless sensor network is required to adaptive in presence of varying environmental situations, which dynamically and drastically changes due to interference caused by environmental factors and varying application requirements. Currently most of systems have central management of network in which all directives are sent periodically from sink node [1]. However, it is difficult to manage a large and dynamic network with the conventional centralized management systems in the following points.

- Because it is central control, a complicated topology change procedure is needed in situation like node addition or the relocation.
- Because the environment changes dynamically, it is necessary to exchange control information for maintenance of the routing frequently, to central sink node.
- The excessive control information sent to sink node contributes towards high probability of collisions at routers nearby

sink node. All these are caused by structure of the system not being flexible. Superficial “functional approach” cannot resolve the problems. Architectural approach that revolutionizes structure is necessary.

III. AUTONOMOUS DECENTRALIZED COMMUNITY WIRELESS SENSOR NETWORK SYSTEM

A. Community Concept

Autonomous Decentralized Community System (ADCS)[8], [9] is the system that community is defined as a group whose members cooperate and coordinate with each other for the same objective. Each member acts as subsystem, autonomously process based on gathered information. In this paper, Autonomous Decentralized Community Wireless Sensor Network System (ADCWSNS) is defined as a group composed of multiple wireless routers, include main route and barrier. When emergency happens, community is autonomously constructed. Main route is only for transmitting emergency information. Barrier will protect the emergency information’s transmission from influence of normal sensing information’s transmission.

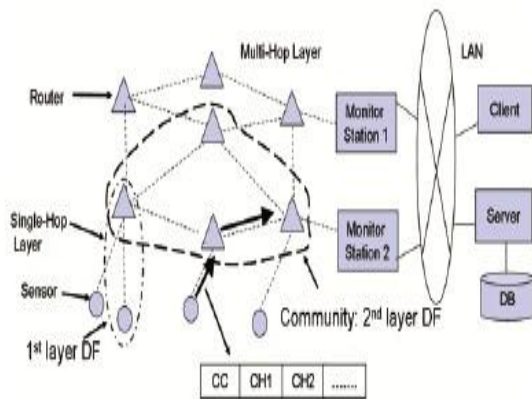


Fig. 2: System Architecture

B. System Architecture

Fig. 2 shows the ADCWSNS’s architecture, routers[13] and multiple monitor stations. Monitor station connects with each other by wired communication.

Connections between router and monitor station, router and router, router and sensor are wireless. Mesh network model is utilized. Each sensor will connect one router and send sensing information to router. Each router, connects with sensors and other routers, receives information from sensors and other routers, autonomously processes and forwards information via own judgment. In this architecture, sensors only sense and submit the sensing information to routers. Routers which have more battery and stronger transmission ability act as transmitters. Lifetime of ADCWSNS is longer than conventional WSN which is only consisted of sensors. No centralized management exist at this architecture. Thus, even one monitor station is down, sensing information could reach another monitor station through cooperation and coordination between routers and monitor stations. Loss of emergency information could be avoided. Two layers Data Field(DF)[7] architecture is introduced. First layer DF is constructed via one sensor and its connected router. Normally, this DF is permanent except system updating. Second layer DF is constructed by community members which are routers. Unlike conventional DF which is permanent, this DF is temporary. It is generated by community when emergency happens and removed when emergency disappears. In this system, messages are uniquely defined by Content Code(CC)[7].

IV. AUTONOMOUS COMMUNITY CONSTRUCTION

The manager of the nuclear plant should judge the situation promptly and adequately when emergency happens. Therefore, the sensor that detects emergency should shorten the period of the emergency information, and transmit information accurately. However, it is not possible to transmit information due to collision of information. Autonomous community construction is used to transmit emergency information promptly by the router transmitting data with the highest

importance by cooperating surrounding nodes.

A. Message Definition

We define three kinds of message according to the importance of data which is emergency information message, emergency detection message and normal message. The normal message is a message including the sensing data within the normal range, and the emergency information message is a message including the sensing data within the emergency range. The purpose of the emergency detection packet is to tell emergency to differ from other two a little, not to have the data part, and to have occurred promptly to the sink node.

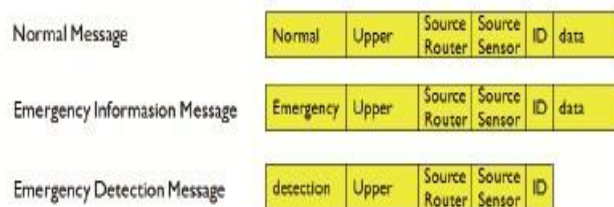


Fig. 3: Definition Of Message

B. State Definition

Each router at this network should belong to only one of these following states.

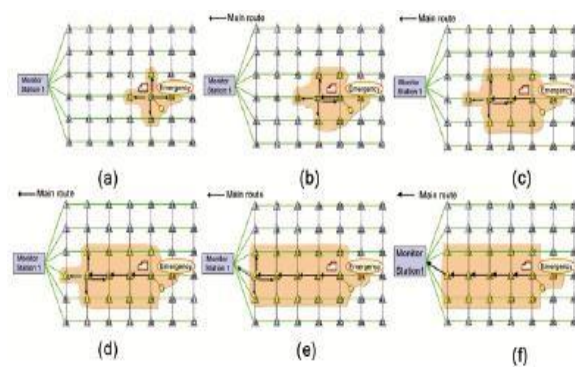
- Normal: The router forwards information received from connected sensor and message received from lower router.
- Detection: The router forwards received "emergency information
- Suppressed: The router suppresses normal message and received message.

Fig. 4: Sequences of Autonomous

C. Community Construction

We introduce the sequence of community construction. When emergency happens, the sensor senses emergency and makes emergency detection message whose CC is "Detection" and send to connected router. After that, the sensor makes emergency information message whose CC is

"Emergency" and send to connected router. Each router autonomously judges the situation by received message, acts as follows. When the router state of which is "Normal" receives emergency detection message, firstly compare own id with "Upper" field. If the field is own id, the router changes state to "Detection" and rewrite the emergency detection message. "Upper" field is changed to this router's upper router's id and "Sender" field is changes to own router's id. Then this router broadcast information. This router become the member of main route. If the fields is not own id, the router changes state to "Suppressed". This router becomes barrier of main route. That is reason why the router acts like this is that the router judges emergency information on other routers is more important than its own normal information. By coordinating among many routers, one emergency information message is transmitted to the monitor station. And the group of the router to cooperate is called an emergency detection state community.



Community Construction

Fig 4 shows the example of Autonomous Community Construction. Firstly, the router detects emergency from the sensor. Then, the router changes state from "Normal" to "Detection", and makes "emergency detection message" whose "Upper" field is its own upper router's id, and broadcasts the message to its neighbor routers. The router which receives the

message changes state. If "Upper" field of the message is its own router's id, the router changes state from "Normal" to "Detection", if not, changes state from "Normal" to "Suppressed". As the result, the community is constructed such as (a) of Fig 4. The routers change state and broadcast the message until the message arrives the monitor station. The figure of the completed community is (f). After community is constructed, the router could transmit the "emergency information message" safely, because the routers surrounding the main route become barriers of main route. And the router in community knows which router received the emergency information from sensor sensing the emergency.

D. problem

There is one problem above approach. Multiple emergencies may bring collision among communities. The messages are sent to all routers in the range of the communication to transmit information, so when the main routes come in succession or are adjacent, some router may receive multiple messages at the same time. When collision is happened, the router must retransmits information and it causes delay or it may stop the message. Fig. 5 show the example of overlap between communities. In this case, two main routes are adjacent, so the possibility of collision is more higher than the case only one community exists.

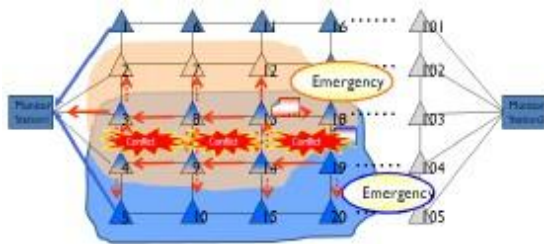


Fig. 5: Overlap between Communities

V. AUTONOMOUS EMERGENCY INFORMATION TRANSMISSION TECHNOLOGY

We propose Autonomous Emergency Information Transmission Technology to solve this problem. This

technology protects the main routes from interference from other kind of information by coordinating among multiple communities. The router doesn't transmit the message statically but dynamically by judging the state of the adjacent router.

A. Autonomous Coordination between communities

In this chapter, we discuss about the case where two main routes are adjacent. The router which belongs to multiple communities acts following. X defines router's suppressing time

- When the router state of which is Suppressed receives other community's emergency information message or emergency detection message whose Upper field is own id, the router changes state to Detection.
- When the router state of which is Detection receives other community's emergency information message or emergency detection message whose Upper field is not own id, the router set the timer for X (ms). The router changes state to Suppressed".
- When timer changes from X to 0 (ms), the router state of which is Suppressed change state to Detection". Then the router comes to be able to transmit emergency information message.
- When the router state of which is Detection succeeds in transmitting the emergency information message, it changes state to Suppressed".

Fig 6 shows the sequence of Autonomous Emergency Information Transmission Technology. This is a situation that the X is 2T, and emergency happens adjacent to the router receiving emergency in the community already existing. T is the time from the router sending the message to its upper router sending the message.

(a) Firstly, when the emergency newly happens, the router 17 would make the

emergency detection message, and broadcast the message to its neighbor routers. The router 26 28 33 becomes the barrier of the new main route. And, the router 28 sets the timer because it belongs to multiple communities. By setting timer, the router suppress own message in 2T.

(b) The router 21 that receives the message from the router 27 broadcasts it to its neighbor routers. Then, the router 22 that receives the message from the router 21 sets the timer.

(c) The router 27 confirms that the router

21 receive the emergency information message by receiving the message from the router 21, and it changes state from "Detection" to "Suppressed", becomes the barrier of the orange community. The router 27 suppress own message until he router 28 transmits the message. The router 28 change the state from "Suppressed" to "Detection" because the timer becomes 0 (ms). The router 14 that receives the message from the router 21 broadcasts it to neighbor routers. The router 15 that receives the message from the router 14 sets the timer.

(d) The router 21 confirms that the router

14 receive the emergency information message by receiving the message from the router 14, and it changes state from "Detection" to "Suppressed". The router 9 that receives the message from the router 14 broadcasts it to its neighbor routers. The router 10 that receives the message from the router 9 sets the timer. The router 28 broadcasts the emergency information message to its neighbor routers. The router 27 that receives the message from the router 28 set the timer. The router 22 changes the state from "Suppressed" to "Detection" because the timer becomes 0 (ms).

(e) The router 14 confirms that the router 9 receive the emergency information message by receiving the message from the router 9, and it changes state from "Detection" to "Suppressed". The router 3 that receives the message from the router 9 broadcasts it to its neighbor routers. The

router 4 that receives the message from the router 3 sets the timer. The router 22 that receives the message from the router 28 broadcasts it to its neighbor routers. The router 21 that receives the message from the router 22 sets the timer. The router 15 changes the state from "Suppressed" to "Detection" because the timer becomes 0 (ms). (f) The router The router 27 and 10 changes the state from "Suppressed" to "Detection" because the timer becomes (ms). The router 27 newly make the emergency information message and broadcasts it to neighbor routers. The router 28 that receives the message from the router 27 sets the timer. The router 15 that receives the message from the router 22 broadcasts it to neighbor routers. The router 14 that receives the message from the router 15 sets the timer. In this way, the router that belongs to multiple communities transmits the emergency information message of own community, after the neighbor router transmits the emergency information message of other community. By this technology the routers could transmits the message without the collisions.

B. Autonomous Timer Modification

There is difficult problem how much time to set the timer because the best time is different according to the topology of the network. For example, in Fig 7, the two messages is transmitted alternately without collision. In such a situation there is no problem. However for example, in the situation that the topology of the network is such as Fig 7, a collision will occur. The router 14 receive both message from the router 21 and from the router 10. If you want to prevent the collision, suppressing time should be longer. The shorter suppressing time is, the shorter the period of message is. And the shorter the period of the message is, the more real-timely the router can transmit the message. However, the shorter the period of message, the higher the possibility that collisions of the

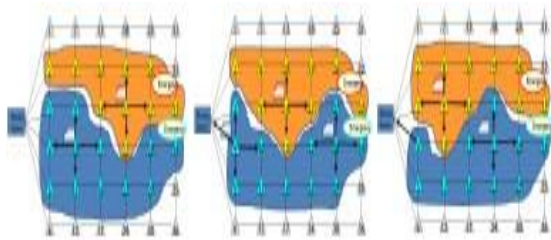


Fig. 6: No collision

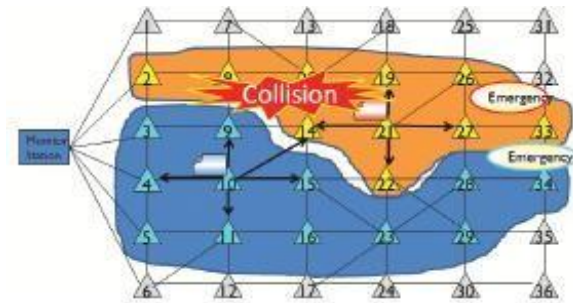


Fig. 7: Collision of message between routers

message happens is. We want to know the shortest time of the timer which enables to prevent the collisions of the message. But, it is impossible because it is different depend on the topology of the network. The topology is dynamically changed. So, the timer should change dynamically according to the dynamical situation. The approach to this problem is that when collision happens and the router retransmits the emergency information message, the router autonomously changes the timer longer. To implement this approach, we add "timer" field to the packet and the table which the router has.

C. Community Removal

If emergency is disappeared, the community should be disappeared too. We will introduce the method of remove one community in several communities. When emergency in the plant disappeared, the message which the router received is changed from emergency information to normal information. The normal

information message is the trigger for community removal. When the router that belongs to multiple communities receives the normal information message, the router autonomously changes the state as follows. If the router belongs to only one community, it changes state to "Normal". If it belongs to other communities, the router judges whether it is a main route or not in other communities. If true, it changes state to "Detection", otherwise, it changes to "Suppressed". Fig .9 shows a sequence of the community removal.

(a) The two communities still have existed.

(b) The emergency that the router 18 receiving disappears. Then, the router 18 receives the normal message and broadcasts it to its neighbor routers and changes state "Suppressed" because it belongs to other community and is not a main route. The router 29 and 34 that receive the normal message from the router 18 change their states from "Suppressed" to "Normal" because the routers belong only one community. The router 27 keeps the state "Detection", because it belongs to other community and is a main route.

(c) The router 22 that receives the normal message from 28 broadcasts it to its neighbor routers and changes the state "Suppressed". The router 21 keeps the state "Detection". The router 23 changes the state to "Normal".

(d) The router 15 that receives the normal message from 27 broadcasts it to its neighbor routers and changes the state "Suppressed". The router 21 keeps the state "Detection". The router 23 changes the state to "Normal".

(e) After the normal message is transmitted to the monitor station, the blue community is removed. In this way, the blue community is being gradually removed from (b) to (e) by the transmission of normal information message and each router's judgment by the approach in this subsection.

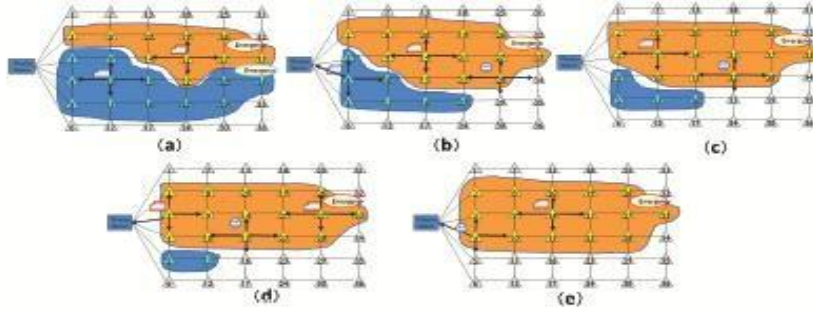


Fig. 10: Sequence of Community Removal

VI. VALUATION

The object of evaluation is to prove the effectiveness of Autonomous Emergency Information Transmission Technology by judging the improvement of real-time property of transmitting emergency information. The simulator Omnet[17] is used for the simulation. The network topology used in the simulation is a 4D mesh network. In this network, each router only connects with one sensor. Table.1 shows the main parameters used in the simulation. By evaluating the arrival rate of emergency information message in

requested time, how real-time performance of emergency information is improved can be seen. n is the number of emergency information messages that monitor station received. In this evaluation, requested time defines 500 (ms). Arrival rate of emergency information in 500 (ms) is represented by the rate between number of emergency information messages which could be transmitted from sender router to monitor station in 500 (ms) and total number of emergency information packets generated by each router. m is the number of routers.

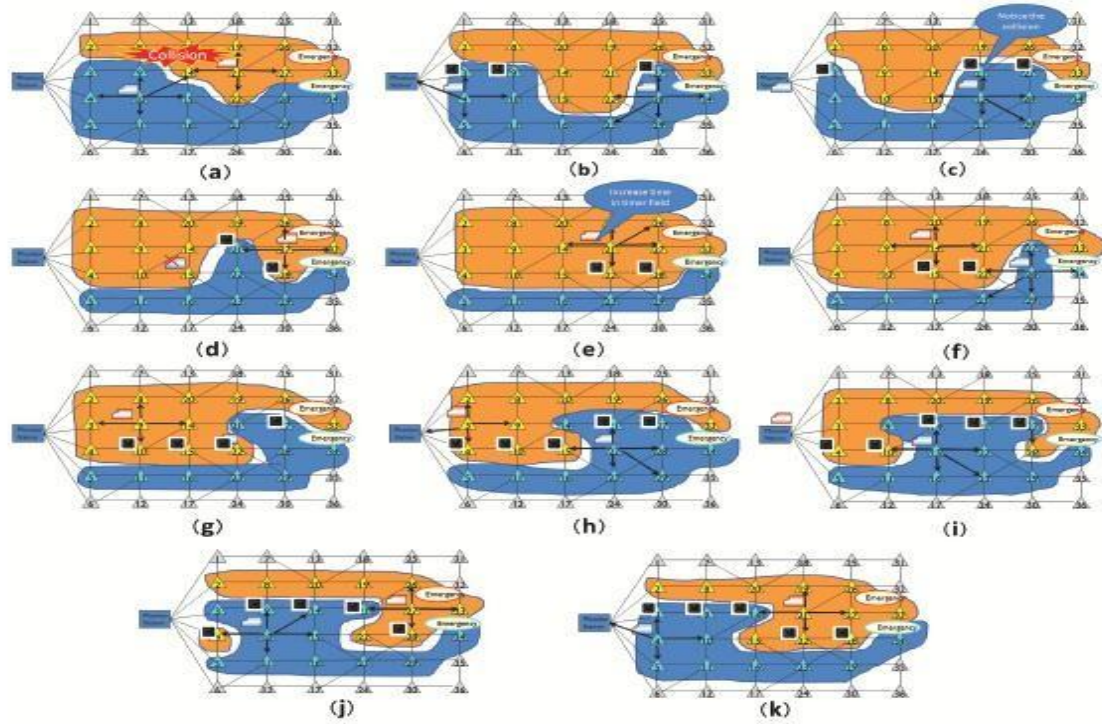


Fig. 9: Sequence of Autonomous Timer Modification

TABLE I: Simulation Parameter

Parameter	Description	Value
<i>SimTime</i>	Total Simulation Time	500[s]
<i>NetworkRange</i>	Network Range	300m × 300m
<i>RouterNum</i>	Number of Routers	100
<i>ServerNum</i>	Number of Servers	1
<i>ProcessTime</i>	Processing Time of one Message	32 [ms]
<i>Trans_Time</i>	Transmitting Message Time in one hop	16 [ms]
<i>N_Period</i>	Period of Normal Sensing Information Message	5 [s]
<i>E_Size</i>	Emergency Information Message Size	8196 [byte]
<i>E_Period</i>	Period of Emergency Information Message	128 [ms]

achieves higher real-time performance than conventional approach.

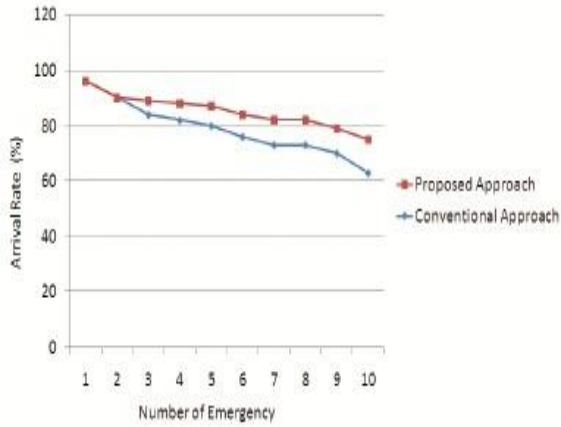


Fig. 11: Average Arrival Rate of emergency information In 500 (ms)

For evaluating this technology, we compared it with conventional approach. In Fig. 11, horizontal axis is number of emergency, and vertical axis is average arrival rate of emergency information message in 500 (ms). In this simulation, we randomly select the position of emergency and the result is the average of 50 times, This figure shows that Autonomous Emergency Information Transmission Technology improves real time property. That is because routers in the community coordinate the router in the neighboring community to transmit both emergency information. Collision among multiple communities is decreased as possible as it could. Therefore, when multiple emergencies happen, this technology

VII. NCLUSION

Concept and architecture of Autonomous Decentralized Community Wireless Sensor Network System (ADCWSNS) has been introduced to assure the flexibility of EMS. Via this architecture, EMS could be easily updated and expanded. However, timely transmitting emergency information has to be assured. Therefore, Autonomous Decentralized Community has been proposed. By this approach, when emergency happens, community which is composed of main route and barrier is autonomously constructed. Routers of barrier protect the transmission of emergency information from influence of normal sensing information's transmission. But, this approach can not satisfy real-time property hen multiple emergency happen, because collision between main routes happens. To solve this problem, we propose Autonomous Emergency Information Transmission technology through community coordination. By each community autonomously coordinating, the router transmit the message without collision between communities. The efficiency of this technology has been confirmed by the results of simulation.

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REFERENCES

- [1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci, "Wireless sensor networks: a survey," *Computer Networks* 38, pp. 393-422 , 2002.
- [2] The 29 Palms Experiment: Tracking Vehicles with a UAV-Delivered Sensor Network. www.eecs.berkeley.edu/~pister/29PalmsOI03
- [3] 1. M. Kahn, R. H. katz, and K. S. 1. Pister, "Mobile Networking for 'Smart Dust'," *Proc. 5th IEEE/ACM MOBICOM*, pp. 271-78, August 1999.
- [4] D. Malan et al. "CodeBlue: An Ad Hoc Sensor Network Infrastructure for Emergency Medical Care," In *Int'l. Workshop on Wearable and Implantable Body Sensor Networks*, April 2004.
- [5] R.Riem-Vis, "Cold Chain Management using an Ultra Low Power Wireless Sensor Network," In *WAMES 2004*, Boston, USA, June 2004.
- [6] Tanenbaum A. S., Gamage C., Crispo B., "Taking Sensor Networks from the Lab to the Jungle," *Computer*, 2006, v. 39, n. 8, p. 98-100, August 2006
- [7] K. Mori, Autonomous decentralized systems: concept, data field architecture and future trends, In *Proceedings of the International Symposium on Autonomous Decentralized Systems (ISADS '93)*, pp. 28-34, 1993.
- [8] K. Mahmood, X. Lu, Y. Horikoshi, K. Mori, Autonomous Pull-Push Community Construction Technology for High Assurance, *IEICE TRANS. INF. & SYST.*, Vol. E92-D. No.10 pp.1836-1846, October 2009.
- [9] S. Niki, S. Murakami, K. Mahmood, X. Lu and K. Mori, Autonomous Decentralized Community Wireless Sensor Network Architecture to Achieve High- Speed Connectivity under Dynamical Situation, In *Proceedings of 9th IEEE International Symposium on Autonomous Decentralized Systems (ISADS '09)*, pp. 297-304, 2009.

- [10] K. Lorincz, D.J. Malan, T.R.F. Fulford-Jones, A. Nawoj, A. Clavel, V. Shnayder, G. Mainland, M. Welsh and S. Moulton, Sensor networks for emergency response: challenges and opportunities, IEEE Pervasive Computing, Vol. 3, Issue 4, pp. 16 - 23, 2004.
- [11] Hsu-Jung Liu, Mei-Wen Huang, Wen-Shyong Hsieh and Jan C.J, Priority Based Hybrid Protocol in Wireless Sensor Networks, In Proceedings of 11th IEEE International Conference on High Performance Computing and Communications (HPCC '09), pp. 214 - 221, 2009.
- [12] A. Boukerche, R.B. Araujo and L Villas, A Wireless Actor and Sensor Networks QoS-Aware Routing Protocol for the Emergency Preparedness Class of Applications, In Proceedings of 31st IEEE Conference on Local Computer Networks, pp. 832 - 839, 2006.
- [13] C. Intanagonwiwat, R. Govindan, J. Heidemann, F. Silva, D. Estrin, Directed diffusion for wireless sensor networking, IEEE/ACM Transactions on Networking, Vol. 11, Issue 1, Feb. 2003, pp. 2-16 [14]
- M. Ahlberg, V. Vlassov and T.Yasui, Router Placement in Wireless Sensor Networks, In Proceedings of IEEE International Conference on Mobile Adhoc and Sensor Systems (MASS '06), pp. 538 - 541, 2006.
- [15] S. Vakil and B.Liang, Balancing Cooperation and Interference in Wireless Sensor Networks, In Proceedings of 3rd Annual IEEE Communications Society on Sensor and Ad Hoc Communications and Networks (SECON '06), Vol. 1 pp. 198-206, 2006.