Content Oriented Communications for emergencies in wireless environments

Kazuya SAKAI, Hiroki NAKANO, Akiko NAKANIWA,
Hiroyuki EBARA, Hiromi OKADA
Information Network Laboratory, Department of Electronics Engineering
Kansai University, 3-3-35 Yamate-cho, Suita, Osaka, 564-8680 Japan
E-Mail {sakai, nakano, akiko, ebara, okada}@jnet.densi.kansai-u.ac.jp

Abstract

In the conventional WWW search or P2P file sharing systems, users search for some information by using the Explicit Information such as keywords, addresses or content names. However, it is very difficult to obtain real-time information immediately just after serious accident (i.e. Fires, Earthquake, Explosion by terrorism, Traffic accidents and so on) happens suddenly. The conventional information systems, whether it is centralized nor distributed, cannot support user accesses, since they cannot provide any contents with the Explicit Information, in such short time.

In this paper, we propose a new communication scheme named COC – Content Oriented Communications. In COC, distributed information systems don't observe the Explicit Information (keywords, addresses, content names, etc.) but the Implicit Information (locations, time, speed, etc.). This is why we call our system Content Oriented. In this paper, we introduce COC, which enables us to decrease the personal damage of a disaster in a local area where the disaster occurs by searching and getting some information for the evacuation.

Keywords
Contents Oriented Communications (COC), Peer-to-Peer (P2P), Multi-agent Systems, Distributed Systems, wireless environments, real-time information

1. Introduction

The WWW is a killer application representing the Internet. The essence of the WWW is in the WWW Search which uses the client-server model. When users search for some contents with a search engine such as Google etc., they type keywords and click a search button. Then users can obtain some Web pages which match to their keywords. Namely, in a search engine, a user searches for the Web page containing the keywords from the indexes, which is generated by the search engine beforehand. Contents are searched using keywords specified by users, and the keywords or URL are in the indexes. Thus, a keyword is indispensable in order to search for any contents in the WWW.

In recent years, P2P Systems which don't use any servers appeared. P2P is a network architecture in which all of nodes in the network have the same responsibility and the same authority. P2P technology has caused the paradigm of serverless communications. The P2P file sharing systems attract attentions as the application using P2P technology. There is Gnutella [1] as an example of a P2P file sharing system. In Gnutella, a user can search for contents by the method named Query Flooding without servers. Thus, in the P2P file sharing systems, the name of contents is also indispensable in order to search for any contents.

As having described, in the WWW search and the P2P file sharing systems, keywords or content names is essential for searching specific contents. In these systems, contents which don't have any keywords nor content names cannot be accessed. For example, imagine that you are walking in a shopping area and then an explosion accident suddenly occurs. Probably you will wonder what happens?. But the information of this explosion accident doesn't have any keywords and content names. So with the conventional methods, you cannot search any information about this explosion accident which happened just several seconds ago.

In this paper, we propose COC which enables us to search contents immediately even in such emergency situations. In COC, we don't observe the Explicit Information such as keywords, URL, content names, and so on. Instead, COC use the Implicit Information such as locations, time, speed, and so on. COC for emergencies is a technology that makes it possible to decrease the personal damage of a disaster by searching and getting some information for the evacuation in a local area where the disaster occur. This paper introduces COC, describe the structure and algorithm of COC, and show its validity by computer simulations.

In what follows, we describe our basic concept for Contents Oriented Communications in Section 2. We describe and evaluate the real-time data processing to realize this system in Section 3, and discuss our simulation and results in Section 4. We provide conclusions in Section 5.

2. Content Oriented Communications

In COC, we pay attention to the Implicit Information such as locations, time, speed and so on. COC enables the distribution of any contents in the following situation.

1) You don't know any keywords.
2) You don't know content names.
3) You don't know where content is.
4) You don't know what kind of contents you want.
5) You want to get interesting contents in real time.

In this paper, we propose COC for smart evacuation in case of emergencies such as Fire, Earthquake, Explosion accident by terrorism and Traffic accident. We discuss what contents is exchanged and how contents is circulated in such a situation. That is, the essence of COC is in the search method of contents. We believe that our system brings about new paradigm which we call Content Oriented Communications.

2.1. COC Example

Before we describe COC in case of emergency in detail, we will show an example of a communication system with COC.

We assume an Explosion accident in a shopping area. Those people who close to the place of the Explosion accident recognize what happened and that they should escape from there. But other people just heard the big explosion noise but don't know any information about that.

Usually, many people take action as shown in Fig. 1 in shopping area. They walk in shopping area arbitrarily, and enjoy their shopping. When an accident happened, many people take extraordinary action and run toward some exits to escape from the accident spot as shown in Fig. 2.

With GPS information or sensors, people's action can be obtained. When people take action as the above, the information such as locations, speed, direction, and so on is changed. If these data are observed, we know something wrong happens when many people take extraordinary action.

When a Explosion accident happens and the information propagation is delayed, there are many people those who are failed to escape. With COC, users can detect an accident earlier and can escape more effectively.

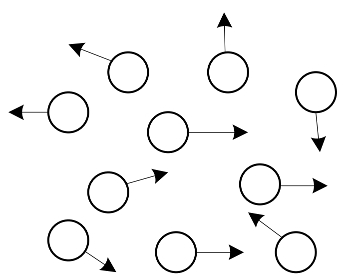

Fig. 1. ordinary action in shopping area

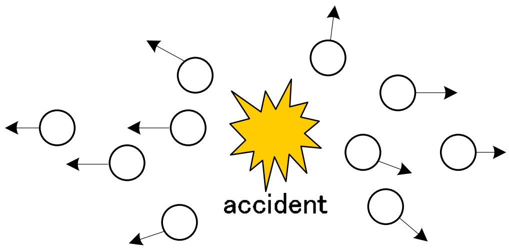

Fig. 2. extraordinary action at an accident

2.2. Run time of COC in emergencies

It is possible to implement COC in both a wired environment and a wireless environment. We consider that COC should be implemented in mobile equipment such as a cellular phone, a PDA, and so on. We call an equipment which implements the COC system as a COC terminal. COC terminals receive GPS information from a satellite or sensors and exchange the location information with each other. We describe about the exchanging of information in section 2.3.

2.3. Exchanging information

We define two types of information exchanged in a situation of emergencies.

1) Low-level information

This type of information is continuously exchanged per 1 second. This information includes locations, time, speed, direction and state. The field of time represents the time of getting GPS information from satellites or sensors. The field of state represents this terminal action is ordinary or not. Low-level information isn't forwarded, which means this type of information is alive only in one hop.

2) High-level information

This type of information is used in emergencies. This information includes content ID, time, priority, type of disaster, level of danger, evacuation information, locations of the disaster. The field of time represents the time when this content was generated. The field of evacuation information includes the direction where to escape. This information is generated from the data processing of Low-Level Information or given by other users. This type of information is forwarded by multi hop.

In addition to the above two, we define Authorized Information. This type of information is generated by some authority system. Authority system collects emergencies information and broadcasts this information to COC terminals. The information broadcasted is reliable. But, it takes much the time for authority system to collect and broadcasts emergencies information. In this paper, we don't consider this type of information.

Each COC terminal receives GPS information from a satellite or sensors every one second. A COC terminal broadcast its Low-level information to the neighbor terminals per one second. Simultaneously, the Low-level information of the neighbor terminals is transmitted and received. This is shown in Fig. 3. A user carries out the data processing from the received Low-level information. We describe about the data processing is in section 3.

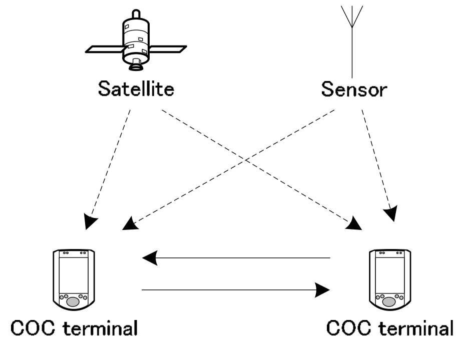

Fig. 3. Exchanging Low-Level information

If a COC terminal detects extraordinary situation, it generates and circulates the content, as shown in Fig. 4. For example, in Fig. 4, we assume that the terminals 1 and 2 detected some emergency. Then they generated contents to notify that something wrong happens. Users will know what to do, where to escape, and so on, by this information. Terminal 3 receives High-level information from the terminals 1 and 2. The terminal 3 should forward this information to the terminal 4. But it is wasteful of the network resource to forward all the received High-level information. If the information received from the terminals 1 and 2 is similar, the terminal 3 aggregate or delete this information and send it to the terminal 4. If the received High-level information isn't necessary, this information must not be forwarded. Each terminal has to do contents filtering and aggregation to reduce High-level information traffic. We will describe the strategy of contents filtering and aggregation in section 3.2.

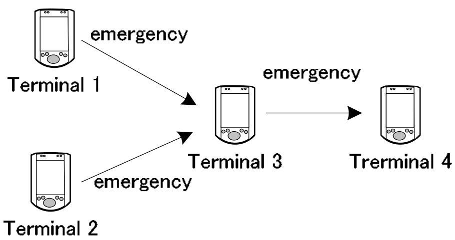

Fig. 4. Exchanging High-Level information

3. Real-Time Data Processing

In this section, we describe data processing in real-time. Each terminal carries out the data processing – the detection of the emergencies, the distribution of contents, and so on. The detection of emergencies is described in section 3.1 and the distribution of contents is described in section 3.2.

3.1. Detection of emergencies

This system detects emergency situations from Low-level information. Generally, many people run to escape from a disaster. That is, the speed of many people is changed. Thus we pay attention to the change of speed. This system catches extraordinary action of other terminals from the change of speeds. The extraordinary action is defined as follow.

$$S_0 > \overline{S} + \alpha \cdot \sigma(S)$$

S_0 is the current speed change of a terminal. $\overline{S}$ is an average speed change of the past n seconds. $\sigma(S)$ is a standard deviation of the speed change of the past n seconds. α is the coefficient of the sensitivity to detect emergencies. The smaller this value is, the more sensitively the system reacts.

If the above function is satisfied on a terminal, this terminal is considered as extraordinary status. When many terminals is considered as extraordinary status, we can judge something wrong happens. If a terminal catches extraordinary phenomenon like this, this terminal will generate and send High-level information to the neighbor terminals.

3.2. Distribution of contents

If a COC terminal detects any emergencies, this terminal generates and distributes High-level information. When this terminal has similar information in the generated High-level information, it doesn't distribute this information because it is wasteful of bandwidths. In this system, we should distribute only necessary information. It is necessary to filter unnecessary information. A terminal forwards High-level information satisfying with the following requirements.

1) This terminal doesn't have a content holding the same content ID. The content ID is a unique identifier. It is given in generating content.

2) Elapsed time from which this content is generated is less than T. T is the parameter of time for the content filtering.

3) The distance between the generating place and receiving place of this content is less than L. L is the parameter of distance for the contents filtering.

4) Dissimilarity between this content and all the contents this terminal has is more than K. K is the parameter of dissimilarity for the contents filtering.

If a terminal receives similar contents from multiple terminals, we select if we delete or aggregate these contents. However in this paper, we don't consider about dissimilarity yet and we are to delete these contents. We will discuss the dissimilarity of contents as a future work. In the case we consider the aggregation, the parameter K can be considered as the parameter for the content filter and aggregation.

4. Evaluation of COC System

We apply the multi-agent approach as a simulation method. In a multi-agent system, a lot of programs called agents act autonomously and achieve their purpose. We use a simulator tool named MAS, which is a multi-agent simulator developed by KOUZOU KEIKAKU ENGINEERING Inc [4].

We evaluate COC by a simulation experiment in which people evacuate from a Fire accident in an underground shopping area – HANKYU 3rd Avenue, Osaka, JAPAN. We show that the COC system makes it possible for pedestrians to evacuate more efficiently in some disaster than the case without the COC system.

4.1. Simulation model

Fig. 5 is the map of HANKYU 3rd Avenue for a simulation experiment. We assume a Fire accident happened in the middle of this map (100m x 80m) and people run away to exits. An algorithm of people's activity and the simulation methodology are in [3].

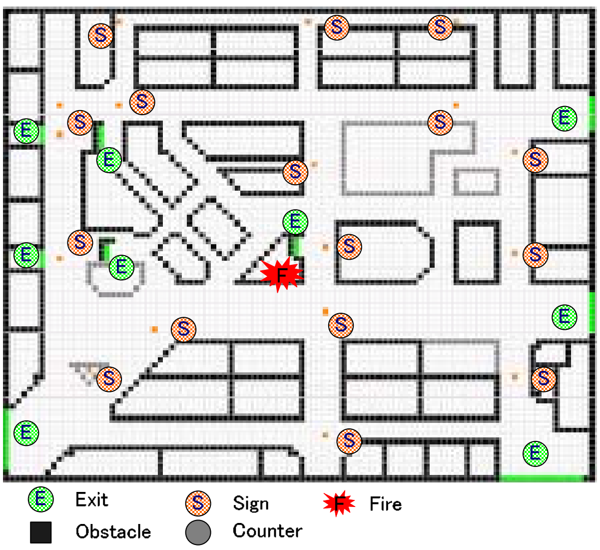

Fig. 5. HANKYU 3rd Avenue

For computer simulations, we classify pedestrians into three classed, COC-ped, NCOC-ped, and NHCOC-ped. We describe the model of three classes of pedestrians as follows.

1) COC-ped

We call pedestrians with COC terminals as COC-peds. We assume that a COC terminal knows the route to the proper exit and tells this information to the COC-ped. For the computer simulations, we settle the parameters of COC-ped as follows.

- Average walking speed : 1.0m/s
- Average run speed : 1.4m/s
- View area : 50m
- Method of the detection of emergencies : detecting by the COC system or finding an accident in their view.

2) NCOC-ped

We call pedestrians without any COC terminals as NCOC-peds. NCOC-peds take two kinds of actions when they evacuate. One is to run away according to own decision autonomously. The other is to follow COC-peds who have useful information. In this simulation, a half of NCOC-peds are the former and the rest of them are the latter. Their parameters are as follow.

- Average walking speed : 1.0m/s
- Average run speed : 1.4m/s
- View area : 50m
- Method of the detection of emergencies : finding an accident in their view.
- An NCOC-ped follows COC-ped when the distance between two is less than 10m.

3) NHCOC-ped

In order to deal with more realistic simulation in the computer simulations, we introduce pedestrians with handicap who don't have any COC terminals. We call them as NHCOC-ped. These are old senior person. Their action speed is slower and their view is narrower than NCOC-peds. Their parameters are as follow.

- Average walking speed : 0.6m/s
- Average run speed : 0.8m/s

- View area : 20m
- Method of the detection of emergencies : finding an accident in their view.
- An NHCOC-ped follows COC-ped when the distance between two is less than 5m.

Generally, the walking speed changes depending on the density of the crowd d. The higher the density of the crowd is, the slower the walking speed is. The speed change depending on the density of the crowd is defined as follows. This equation is referred from [3].

$$\text{Modified speed} = \text{speed} - 0.389 * d$$

Walking speed and Run speed is corresponding to the modified speed in this equation. These parameters are given based on the triangle distribution which is similar to the normal distribution. Here, the number of additions in the triangle distribution is 10.

The sensitivity that COC system detects emergencies depends on α and β. Here, α is the sensitivity coefficient described in 3.1, and β is defined as follows.

$$\beta = \frac{N_e}{N_t}$$

N_e is the number of COC-ped with extraordinary action in neighbor. And N_e is the total number of COC-ped in neighbor. If more than β of neighbor terminals take extraordinary action, this system detects emergencies. Here, α is set as 10 and β is set as 30%.

The total number of pedestrians is 100. And the total number of trials is 100.

4.2. Results

(A) Detection Rate of Emergencies

We made a simulation experiment on following three scenarios in Table 1. For example, in Scenario 1-1 the number of COC-peds, NCOC-peds

Table 1. Scenarios for the simulation

	COC	NCOC	NHCOC
Scenario 1-1	0	80	20
Scenario 2	40	40	20
Scenario 3	80	0	20

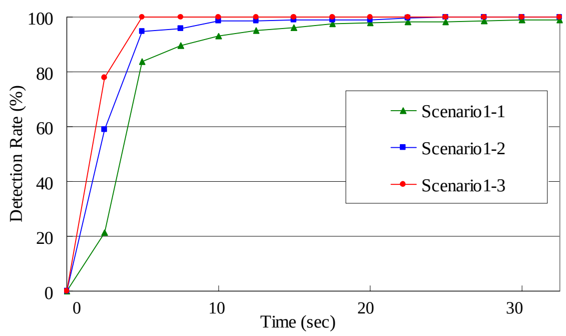

Fig. 6. Detection Rate of emergencies

and NHCOC-peds are 0, 80 and 20, respectively.

Fig. 6 shows detection rate of the Fire. Hear, the horizontal axis is the elapsed time from the occurrence of the Fire accident, and the vertical axis is the detection rate of the Fire.

NCOC-peds and NHCOC-peds can detect the Fire by finding an accident in their view. Otherwise, those people may know the Fire by the action of COC-peds. COC-peds can detect the Fire by the COC system.

(B) Detection Time of Emergencies

We made a simulation experiment to obtain the time for all people to detect emergencies. In this simulation experiment, we observe the time that all people detects the Fire.

In Fig. 7, the horizontal axis is the rate of COC-peds and the vertical axis is the time to detect the Fire. This time means the average time for all people to detect the Fire from the occurrence of the Fire. As shown in Fig. 7, with the COC system, people catch the Fire earlier than without one the

COC system.

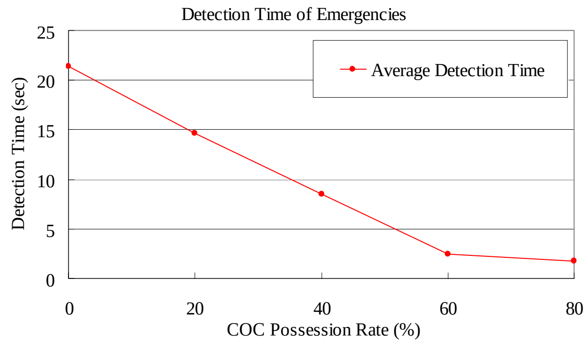

Fig. 7. Detection of Emergencies

(C) Characteristic of the Type of People

We made a simulation experiment to obtain the characteristic of evacuation at the Fire for three classes of pedestrians. In this simulation experiment, we have three scenarios as follow.

Table 2. Scenarios for the simulation

	COC	NCOC	NHCOC
Scenario 2-1	100	0	0
Scenario 2-2	0	100	0
Scenario 2-3	0	0	100

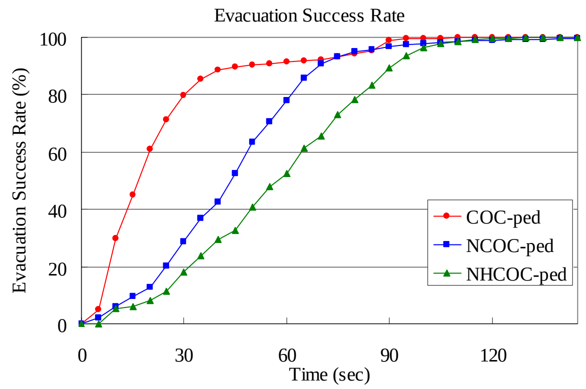

Fig. 8. Characteristic of the Type of People

In Fig. 8, the horizontal axis is the elapsed time from the occurrence of the Fire accident, and the vertical axis is the rate of people who are able to evacuate. Naturally, Senario1 shows the best performance because COC-peds can catch emergencies earlier than the others type of people. Since this scenario isn't reality, we made a simulation experiment in more realistic scenario in next section 4.2 (D).

(D) Evacuation Success Rate

We made a simulation experiment on the following four scenarios. In Table 3, each value shows the number of people. Note that all of NHCOC-peds have COC terminals in Scenario 3-4.

Table 3. Scenario for the simulation

	COC	NCOC	NHCOC
Scenario 3-1	0	80	20
Scenario 3-2	50	30	20
Scenario 3-3	80	0	20
Scenario 3-4	80	0	20 (COC)

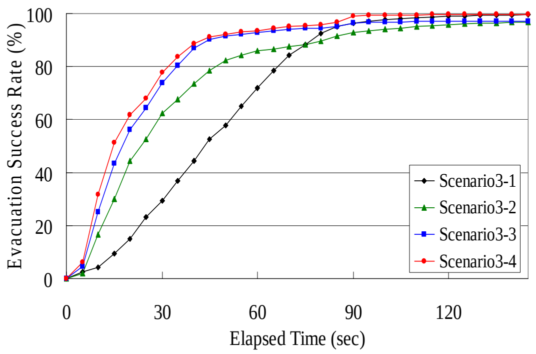

Fig. 9. Evacuation Success Rate

If NCOC-peds and NHCOC-peds don't find the Fire accident in their view area, they cannot understand what happened. So they will delay to evacuate from the Fire accident. On the other hand, COC-peds can catch the emergency by their COC terminals even if they cannot watch the Fire in their view. COC-peds, who know the routes to the exits, can lead NCOC-peds and NHCOC-peds. In Fig. 9, the horizontal axis is the elapsed time from the occurrence of the Fire accident, and the vertical axis is the rate of people who are able to evacuate. As you can see from Fig. 9, we obtain the result that the more the number of COC terminals increases, the more efficiently people can evacuate.

(E) Evacuation Time

We also made another simulation experiment. In these scenarios, the total number of people is 100. We observe the time to take for people to evacuate.

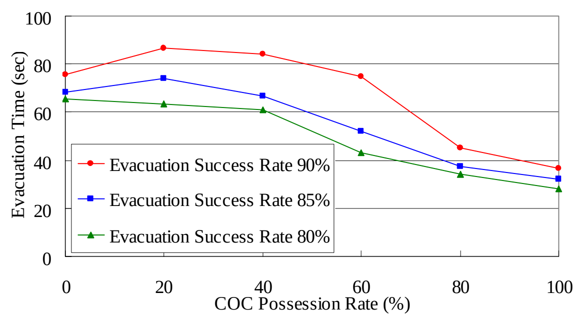

Fig. 10. Evacuation Time

In Fig. 10, the horizontal axis is the rate of COC-peds to the total number of pedestrians. The vertical axis is the time to evacuate. As shown in this Fig., the more the number of COC-peds are, the less the time to evacuate is. This result also indicates that the COC system enables people to evacuate efficiently.

5. Conclusions

In this paper, we have presented COC system for smart evacuation in case of emergencies. COC is totally a new communication system which searches and distributes some contents with the Implicit Information. We have discussed about a method of searching and distributing contents to which anybody cannot access with the conventional method. We have evaluated the COC system in a more realistic situation by using a multi-agent approach in simulation experiments of the evacuation in a Fire accident. We have shown that COC enables people to evacuate efficiently in emergencies. Consequently, we can conclude that the COC system presented in this paper is useful to evacuate in emergencies such as a Fire accident.

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