Demand of Trips and Telecommunication Informing Personal Safety -- Rough Estimation Using Person Trip Survey --

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Abstract: In the Kobe Earthquake on January 17, 1995, telephone facilities and communication cables were not so seriously damaged. But the bursting demand of telephone calls seriously decreased the performance of the telephone system. In order to make cities safer, we must prepare enough capacity of communication system for everyone to check their family members' safety in a severe disaster. For more quantitative discussion, this paper proposes a rough estimation of trips and telecommunication informing personal safety. This paper uses Person Trip Survey data in Keihanshin (Greater Osaka) Metropolis and discusses the several interesting features of the trip/telephone demands in Kobe city.

Keywords: telecommunication, emergent contact, person trip, safety

1. Introduction

The Hanshin Earthquake attacked at 5:46AM on January 17, 1995. Telephone facilities and communication cables were destroyed and lost their functions. Owing to the previous earthquake experiences, telephone network system had been reinforced or made redundant before the earthquake. Hardware damages were not so serious as other lifelines, e.g. water supply, or power supply systems, while soft congestion by the bursting demand of telephone calls absolutely decreased the performance of the telephone system.

The earthquake attacked early in the morning before people would leave home, it minimized the need of telephone calls between family members. If such an earthquake attacks in daytime, people may try to contact with other family members via telephone, because now in metropolitan areas home is too far from workplace to return on foot. The ability to check and inform family members' safety is a basic condition for safer city. National and local governments as well as telecommunication companies should prepare enough capacity of telephone system to secure the ability.

This paper aims to propose a rough estimation method of telephone call demand to inform personal safety in a disaster such as the Hanshin earthquake. We make use of a rich database of personal activities, Person Trip Survey and build a procedure to estimate timing of telephone calls as well as the volume of them. The reminder of the paper is organized as follows; section 2 reviews the damages and performance of the telephone network in Kobe on the date of the Hanshin earthquake, section 3 discusses the idea of telephone demand estimation, section 4 investigates the result of the estimation on Kobe city, and section 5 concludes the study.

2. Damages in telephone system and their effects

(1) Damages in telephone system

Telephone system basically consists of three parts; access networks between each station to switching machine, switching machines in building and trunk network between switching machines. Due to the Hanshin Earthquake, physical damages were seen in 0.19 million access lines out of 1.44 million lines. Half of them were caused by crush or burn of buildings. Besides them, eleven switching machines in 7 buildings stopped due to power service shutdown or discharge of the batteries. It affected 0.28 million stations, but they are no more than one fifth of the stations in Kobe area [1]. We can summarize above in that physical damages were not so serious.

Much more serious issue reduced the performance of telephone system was the congestion by the bursting demand of telephone calls. Numerous people called up stations in Kobe, but in many case calls were rejected by the over-occupied switching machines with the message of "Telephone line is crowded now. Try later." They never recognized the real situation in Kobe and tried again just after hearing the message. In that way, telephone calls to Kobe on January 17 were bursted twenty times as many as an ordinal weekday. The telephone company had to set the calling limitation for six days, under which four fifth of calls to Kobe were rejected at the switching machines near sending stations. Similar demand bursting was also reported in the cellular phone system.

(2) Performance of the telephone system

Now in Japan, we could not get any internal records of the telephone companies to grasp communication origins and destinations in each hour of the day. Instead, we gathered four published books compiling personal reports and extracted descriptions about telephone use on the day [2]. Based on the 200 descriptions contained absolute objective, time, sending and receiving places, we can evaluate the performance of telephone system on the day as follows: 1) Because public telephones on streets were more successful than ordinal stations in houses, they were very crowded just after the earthquake. Sooner, telephone machines became dead by coin full. 2) Cellular phone system became unreachable soon. 3) Longer distance calls were more reachable than shorter ones e.g. between Osaka and Kobe. 4) Exclusive lines were almost alive. 5) Success rates of calling varied on time: calls after 6:00 were more successful than just after the earthquake, but after 7:00, success rate went down and at 8:00, they thought almost unaccessible.

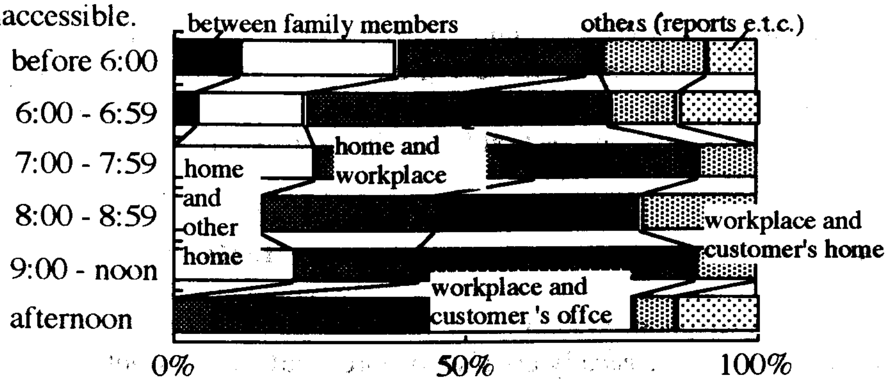

figure-1. Telephone Calls in Different Hours

From those reports, we suppose that telephone demand had at least two peaks; first lower peak just after the earthquake and second large peak after 7:00 AM. Fig.1 classifies telephone calls on the day based on the types of stations according the personal reports. Two things can be read from it: 1) Because the earthquake occurred early in the morning before commuting hours, many people still stayed at home, therefore, communications between family members were small in number and almost accomplished before 7:00. 2) Ordinai companies began to investigate employments' safety and call them up after 7:00, while newspaper and broadcasting companies did it just after 5:47. Communications between firms and customers increased after 8:00 AM.

(3) Effects of the poor telephone service

It is not easy to grasp succeeding effects of the poor telephone service on the people's behavior in the disaster, but we get some hints from an interview about sources of several kinds of information for disaster area inhabitants [3)]. Telephone was mainly used to get news of family members, relatives and acquaintances. Here we focus on the information about personal safety just after the disaster, that cannot be easily conveyed through mass media or other communications. According to Tomita et al (1996), to investigate personal safety was main purpose of trips on the earthquake day, followed by evacuation. One third of the people who had made such kind of trip answered that they would have used telephone instead of trip if telephone service had not been so poor[4)]. From emergent transportation planning point of view, less traffic is desirable, then a robust telephone system is welcome.

In Kobe, most of family members stayed in home and soon notified other family members' safety without telephone nor trips. People had to make contact with staffs of their workplace several hours later the earthquake, because there were no staffs in workplaces in such early hours. Business communications occurred much later. In that way, several types of communication happened with different peaks on time. But we must consider what would happen if a disaster hits at different time in a day. We can easily expect that telephone calls would burst much faster if it comes in daytime. In the following section, we propose an estimating method which enable to test the above expectation more quantitative.

3. Estimation Method

(1) People's location

Needlessly, telephone demand is very much sensitive to when a disaster occurs. At each point on time, different number of people stay at home, in workplace, in school, and travelling. These situations may dramatically alter the basement of demand forecasting. It is critical to get human behavior data on time axis for telephone demand estimation as discussed in Nakabayashi(1992), which first tried to evaluate number of obstructed homeward commuters based on population census data and questionnaire about departure time from workplaces to home [5].

This study uses person trip survey data, which is collected via household questionnaire in the U.S., Japan and several other countries. Recently, there are plans to collect such data also in Chinese metropolises. That database includes sampled persons' home address, workplace address, origin and destination, departure and arrival time of each trips as well as sampling rate.

If we trace a trip chain of a sample, we can easily know, at a certain point on time, whether he (she) is travelling or staying, and the location of stay, as explained in Nakano et al.(1995)[6]. When he (she) is travelling, we calculate relative travel duration in the trip, for example, if he departs at 7:30, arrives at 9:00. At 8:00 AM, his relative duration is derived as (9:00-7:30)/(8:00-7:30)=30/90=1/3. We prepare networks and calculate relative distance of zones on route for each OD pairs. Then we select the zone that has the nearest relative distance as his relative duration. In that way, at a certain point on time, we locate the travelling person, and the distance from his home as well. At last, using the inverse of the sampling rate, real number of people are considered in each zone.

We apply this procedure on 1990 Keihanshin (Greater Osaka) Metropolis Person Trip Database to get the number of people staying in eleven zones in Kobe city. Figs.2 and 3 show the results in two typical zones. CBD area gathers many people in daytime (see Chuo Ward: fig.2), while newly developed housing area shows concave shape because of outward commuters (see Suma Ward: fig.3). Old downtown where indigenous industrial activities has developed as well as residential buildings (e.g. Nagata Ward) possesses a characteristics in between the above two extreme cases; constant number of people are locating there, regardless to timing.

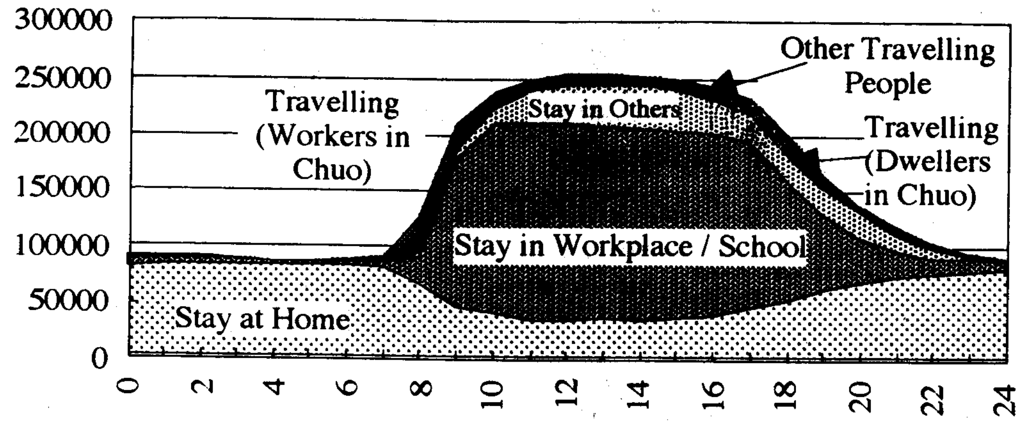

figure-2. Number of People in Chuo Ward (CBD area)

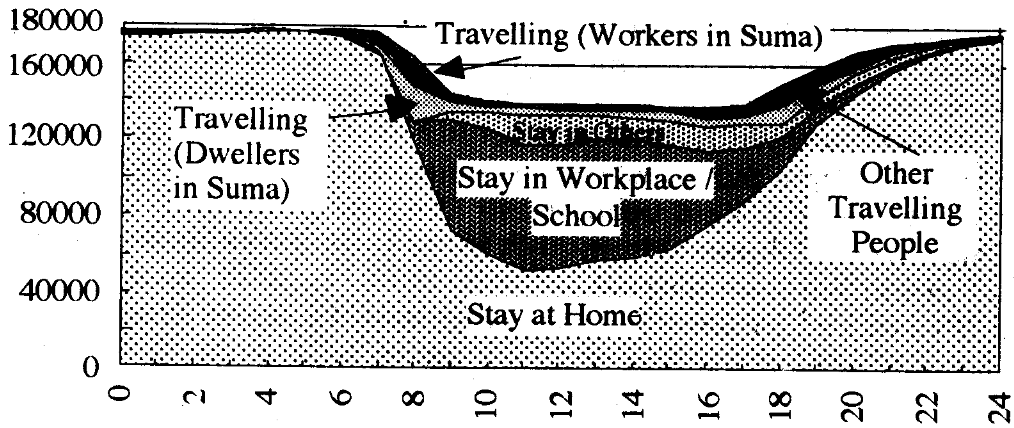

figure-3. Number of People in Suma Ward (new residential area)

(2) Demand estimation of telephone calls

When earthquake occurs, people outside home may immediately try to inform his news to home or to investigate other family members' safety. If he (she) is staying in the walking distance from home, that person can return on foot, while person in further distance inevitably relies on telephone call. If the location is in home zone, consider a travel on foot. Tomita et al.(1996) reports that almost of such trips are under 2 km or inside zone[4)], then we set 5 km for inter-zonal cases as a threshold to distinguish telephone call from trip.

Second type of telephone call is one for workplace or school, when a disaster happens while they are not staying there. We set the following assumptions about telephone timing: 1) If it is before his working hours, he calls up at his planned arrival time. In reality, he may call as early as some staff arrives at workplace, but we cannot get such information from person trip data. 2) If it is in working hours, he calls immediately from staying place or at his planned arrival time if he is travelling. 3) If it is after working hours, he makes a contact on the following day.

Third type of call implies cancellation. We assume that if a disaster happens before one's visiting somewhere, he informs cancellation of his planned visit. Timing is assumed as the planned arrival time.

As explained above, if we assume a timing of a disaster, we estimate the volume and timing of walking homeward trips and three types of telephone calls in the following hours. Timings of disaster and calls are considered on every one hour.

4. Estimation Result

At first, we reproduces the situation of the Hanshin earthquake, stated in section 2. Fig.4 shows the expected number of homeward trips and three types of telephone calls sent to Kobe city in every hour on the assumption that the disaster hits at 6:00 AM. Three demand peaks are expected: 1) The first one at 6:00 AM is small one consisting of homeward calls by a few early bird workers. It may include the shorter distance communications shown under the horizontal axis in fig.4. 2) The highest peak beginning at 7:00 reaches on its summit at 8:00, and it well explains the decrease of success rate after 7:00 in Kobe. 3) Small peak due to cancellation calls is expected in the afternoon, however in reality, some of these cancellation were done earlier and some else were not realized because the planning visit was not so important. We can understand that the demand of calls to workplace or school are horribly large and harmful to the telephone system.

Demand volume varies very much according to disaster timing. Fig.5 shows the total demand of homeward trips and telephone calls in the reminder of the day in Kobe under different timing of a disaster. It teaches that the later a disaster hits, the smaller telephone demand is expected, with a significant exception on the morning peak hours. It is because the reminder of the day become shorter and more communication will be postponed to the following day. We should remind that this result is based on the assumption that short distance communications are negligible; in reality, people near to home may also use telephone, in that case, the demand has the third peak in daytime.

If a disaster comes in daytime, people may try to contact with other family members, while many agencies may call up their business partners and customers just after the disaster. Demand is supposed to sharply concentrate just after the disaster. Fig.6, showing the relationship between disaster timing and call timing supports this expectation. If earthquake hits before commuting hours, the demand has three peaks, while we expect a single peak for afternoon disaster. As popularly discussed, a disaster in morning peak hours generates very large amount of telephone calls concentrated on time axis. We must investigate the capacity of the system based on that most severe setting.

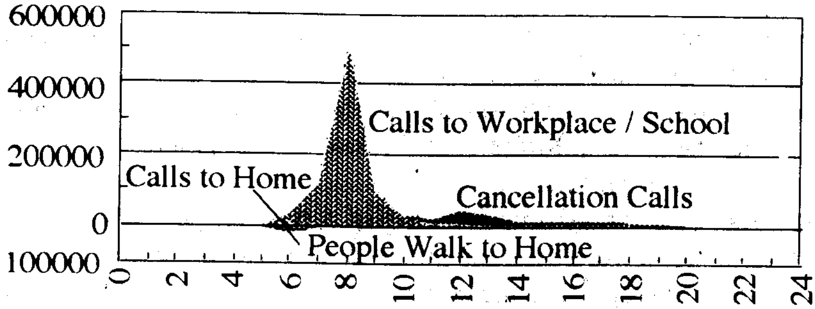

figure-4. Timing of Expected Calls after 6:00AM Disaster

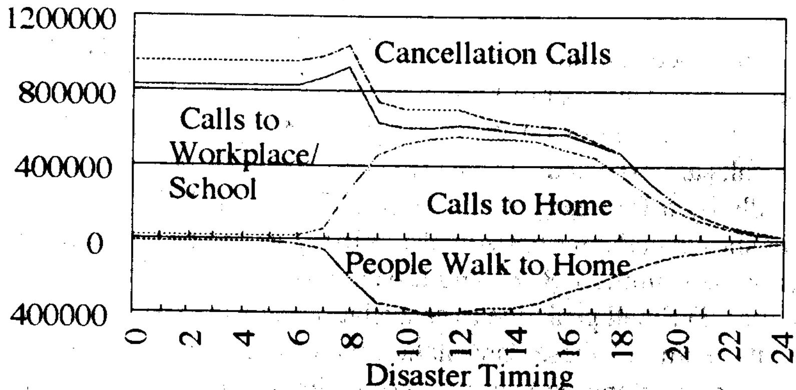

figure-5. Expected Telephone Calls (Kobe City)

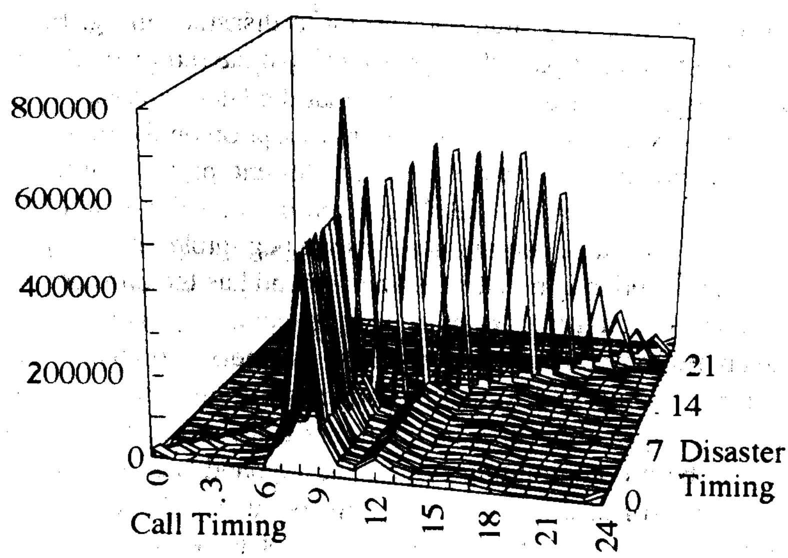

figure-6. Disaster Timing and Expected Call Timing

5. Conclusion

Although personal safety information is very essential for our safety, telephone system now does not cover the expected demand of calls. This paper suggests a stepping stone to analyze this issue quantitatively and makes a rough sketch of what was happen in Kobe. The idea of the estimation is general and extendable; it can be disaggregated based on purpose of analyses. Now in China, person trip surveys have begun in several cities. It is our great pleasure if people understand a new useful application of the person trip data and surveys will be expanded.

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