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Developed and Evaluation Satellite/Terrestrial Integrated Coordinate Control Simulator

[#]Kunio Endoh, Hiroyuki Tsuji, Amane Miura, Yoshiyuki Fujino,
National Institute of Information and Communications Technology
4-2-1 Nukui-kita, Koganei, Tokyo, Japan, Email: k-endoh @nict.go.jp

1. Introduction

Importance of social role using mobile communication services has increased consecutively. Correspondence of mission- critical cases especially disaster prevention, disaster mitigation and safety measure are especially important. We have a goal to make a social contribution by mobile communication infrastructure using a new satellite system named STICS (Satellite/Terrestrial Integrated mobile Communication System). STICS is a system which realizes seamless disaster-resistant mobile communication infrastructure by integrating both terrestrial communication system and satellite communication system controls, and requires some technologies to control extremely various functions in a coordinated manner. Therefore we developed a satellite/terrestrial integrated coordinate control simulator which has three functions: simulation of mobile communication environment, coordination control of communication system and evaluation of the calculated results of system analysis. The simulator can simulate the whole systems including terrestrial system, satellite system, and the coordination control between satellite and terrestrial systems. The simulator can also simulate the resource coordinate control (handover control) between satellite and terrestrial systems depending on the real-time traffic condition where the speed of mobile terminals can be set flexibly.

As a result, the simulator enables us to evaluate the effective allocations of the frequency and satellite power resources given by STICS under the condition of arbitrary communication traffic conditions in whole of Japan and in the sea of Japan. And it also enables a creation of a flexible system which simulates actual disaster traffic conditions.

We evaluated the effectiveness of STICS including the coordinate control function by simulating the traffic change when the Great East Japan Earthquake occurred, which is said to be increased 60 times as much as normal . As a result, we confirmed that the operation by STICS reduced the lost-call by 63% under the condition that the terrestrial calls in disaster area are transferred to a satellite link while the satellite resources are focused on the disaster area and the dynamic control of the occupied satellite line rate was applied by monitoring the satellite use rate and traffic changing rate.

2. Simulator Function

We propose Satellite/Terrestrial Integrated mobile Communication System which is applied frequency shared technology (coordinate control technology) both terrestrial mobile communication and satellite mobile communication. This validation is enabled by the simulator that implemented the dynamic control technology. In order to verify the system at the situations which are more similar to the actual use, it is necessary to consider the case using the communication service that a large number of terminals actually are on the move. Assuming a disaster, etc. in fact, the incidence of extreme intensive traffic is expected, the system will be in a situation that cannot handle all call processing in a usual manner. In order to optimize the communication resource, the selected control technology that takes into account the priority of the call can be considered as one of the prerequisite technology. Based on these discussions, the STICS simulator is equipped with the ability to simulate the three controlling functions; random walk traffic generating control function, which is responsible for movement control of the user terminals, the dynamic control function responsible for traffic generation and the priority terminal control function responsible for the priority call arrangement.

First, random walk traffic generating control function provides a simulation capability to generate traffic while the terminal moves according to the random walk mobility model using the communication service. Random walk is a fundamental model, that can be , for example, the model of physical phenomena such as Brownian motion, the model in the area of mathematical finance, such as stock price and also the model of mobile communication users. Therefore, in the STICS simulator, we adopt this model and generate traffic simulating the mobile movement.

Then, the dynamic control function is to provide simulation capabilities which makes it possible to simulate the frequency sharing between terrestrial and satellite communication systems using resource allocation control performed dynamically for changes in traffic patterns in the above random walk traffic generation control function.

At the end, priority terminal control function is to provide simulation capabilities which can be processed in accordance with the specific policy of the call processing terminal, such as high-priority emergency call. In general, commercial service of the mobile phone system, in accordance with standard specifications of international standards organizations, such as 3GPP (3rd Generation Partnership Project), has been deployed in worldwide. See an overview of treatment of priority calls in 3GPP or standardization of the outgoing call restriction. Previously, priority calls such as emergency calls outside the scope of regulation has become basically be divided into three categories for all regulatory regulations call. Restrictions are divided into roughly three categories; all restrictions, international call restrictions and restrictions of the call other than the home network. Regulatory services are vendor-dependent (3GPP TS23.088). In this simulator, we define a priority control policy which is considered reasonable, and conduct a priority control of the call.

3. Simulation and Analysis Result

Summary of results in the satellite/terrestrial integrated coordinate control simulator are shown the case was conducted based on published traffic data when the Great East Japan Earthquake.

3.1 Model of Simulation

About the surge of traffic in the event of a disaster, there was no concrete data available so far, however a graph was distributed at the Committee showing the changes of traffic after the Great East Japan Earthquake[1]. In the simulation, a surge of traffic was described as the model based on this graph as shown in Fig. 1. In this model, the traffic has increased immediately after the earthquake, the call request has occurred 60 times more than usual.

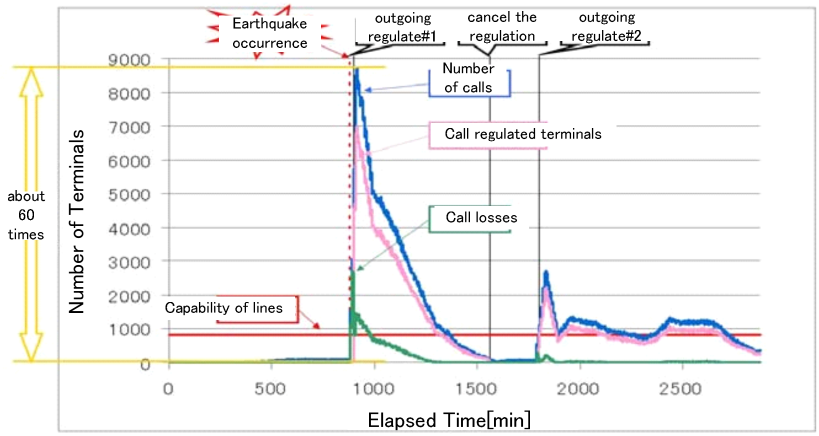

Figure 1: Traffic Model of the Disaster for Simulation

The targeted area is the city which was measured at the time of maximum intensity at the earthquake for traffic calculations and set the 8km square in the center of the city. Number of terminals was calculated from the ratio of the target area and population as the applicable city. Accommodate the number of lines at the ground base stations and number of ground base stations were assumed average number which calculated from east Japan traffic changes data of the earthquake.

3.2 Result of Simulation

Fig. 2 shows the number of lines connected to the satellite communication system, depending on the traffic connection request at the satellite beam area where applied disaster occurred. Number of lines is able to increase using satellite resource rearrangement algorithm in STICS system. Therefore, STICS system can accommodate the traffic change. Traffic connection request immediately after the disaster has so exceeded the number of lines can be connected that the upper limit of the satellite communication system resources are diverted to the disaster area satellite beam. Then the number of connection lines of a satellite communication system has been changing according to the connection request, simulation that recombination of satellite resources has been shown as expected.

STICS system is assumed to service utilizing the advantage of wide coverage communication area that satellite beams are deployed to cover the entire Japan and coastal waters. When disaster occurred, STICS system is assumed to operate utilizing advantage of a disaster-tolerant, such as a complement to stop working ground base stations, is concentrated satellite resources to the disaster area.

The simulation result shows satellite resource rearrangement algorithm is working properly and STICS system is valid to ease for immediate traffic change. STICS system has the feasibility for measures to ensure communication path at the disaster.

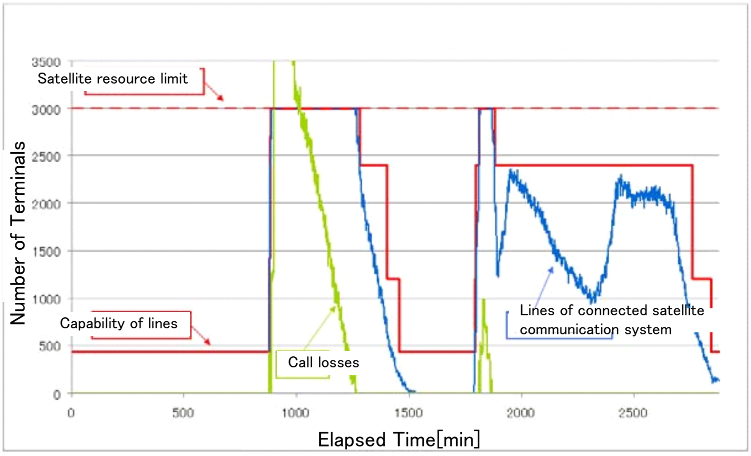

Figure 2: The number of lines connected to the satellite communication system

The simulation calculated the number of call loss for traffic changes in the Great East Japan Earthquake under following three conditions; without satellite communication system, satellite communication system is available but satellite resource control is not available and both satellite communication system and satellite resource control are available.

Fig. 3 shows the results were compared for the call loss whether satellite resource controled or not.

The simulation results of the conditions that both satellite communication system and satellite resource control are available show the effect of the decrease in the total of call loss of 63% compared to the conditions of leave without satellite.

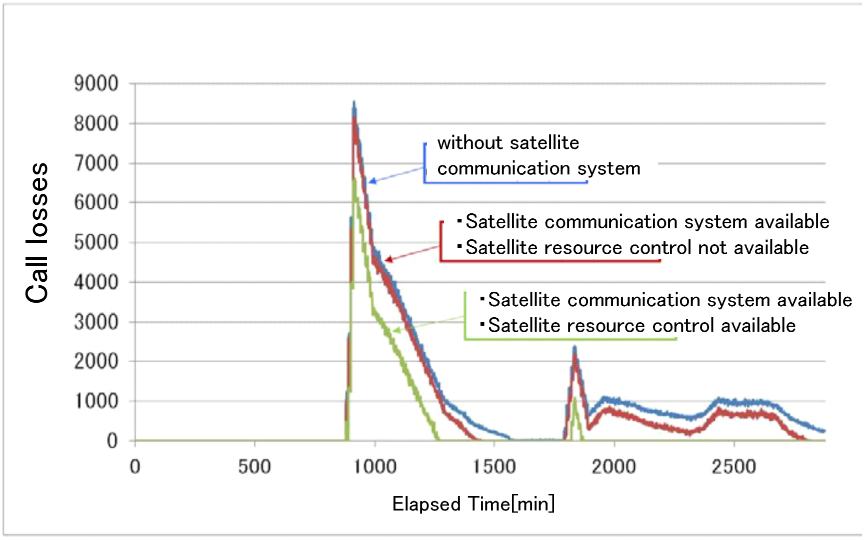

Figure 3: Difference of Call Loss

4. Conclusions

We developed a satellite/terrestrial integrated system simulator which provides the comprehensive simulation environment s not only for satellite/terrestrial system simulation but evaluation of the coordination between two systems depending on real-time traffic condition. The simulator can set mobile terminal position and moving speed flexibly and also realizes to calculate and analyse the effectiveness of STICS resource (frequency, satellite power) sharing at whole of Japan and its surrounding seas under arbitrary communications traffic conditions. Also it realizes to architect a system flexibly using actual disaster traffic conditions.

We evaluated the effectiveness of STICS including the coordinate control function by simulating the traffic change when the Great East Japan Earthquake occurred, which is said to be increased 60 times as much as normal . As a result, we confirmed that the operation by STICS reduced the lost-call by 63% under the condition that the terrestrial calls in disaster area are transferred to a satellite link while the satellite resources are focused on the disaster area and the dynamic control of the occupied satellite line rate was applied by monitoring the satellite use rate and traffic changing rate.

In the simulations, we assumed that the satellite resources were diverted to the disaster area maximally considering the situation of a place where the maximum intensity was registered at the Great East Japan Earthquake.

However there is a possibility of increasing the call requests from non-disaster areas to disaster areas and between non-disaster areas at the time of disaster. It will be necessary that traffic coordinate control should be considered all over Japan about above mentioned calls. We also consider how to treat the occupied lines when the satellite resources are reallocated in the aftermath of the disaster.

Acknowledgments

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References

[1] Irie(NTT docomo) “Network infrastructure working group” 2nd meeting handout
Committee on ways of securing communication in emergency situations as large-scale disasters Ministry of Internal Affairs and Communications