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Critical Communication Simulation in Natural Disaster Situations

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Abstract*— After natural disasters such as earthquake, flood, hurricane; because of damage to telephone and internet networks and instantaneous traffic density created by subscribers, voice and data networks lose their functions to a large extent. Service providers make many practices to prevent service interruptions in communication networks and not to disrupt the operation of the protocols used during and after a natural disaster. Since natural disasters are non-repeatable and unpredictable, these measures cannot be carried out with comprehensive assessments. In this context, simulation software is the best approach for testing communication networks in case of natural disasters. In this study, the issue of analyzing the outages that may occur in the infrastructure of Telecom service providers after natural disasters with network simulations is mentioned.

***Index Terms*— Telecommunication systems, communication in natural disasters, network modelling under congestion**

I. INTRODUCTION

After natural disasters, the first urgent need in all disaster management task areas is to collect post-disaster data and to provide a communication network for reliable real-time information exchange between the teams that will respond. In disaster situations, communication losses occur due to overloading of the transmission network and damage to the network infrastructure due to the disaster.

Mobile and fixed telephone networks are designed considering the average subscriber density and traffic and provide voice and data services when there is no natural disaster or traffic density.

Considering the unpredictability of natural disasters and the chaotic post-disaster situation, the measures taken by the service and the network are lacking. Communication after natural disasters is of vital importance and should be provided with minimum loss.

Simulators can play an important role in evaluating system performance and service continuity based on the mobility of users and nodes on the network. Simulators can analyze possible scenarios of service providers and prepare their infrastructures for possible disaster situations. In this way, communication continuity can be ensured by preventing losses.

There are many studies in the literature to increase the application areas and effectiveness in situations such as natural disasters. Ray & Turuk proposed a system for post-disaster communication in their work. The proposed structure is aimed at maximizing network throughput, minimizing average end-to-end latency, and improving network lifetime [1]. In their study, Saha et al. proposed a four-stage planned hybrid architecture that would adapt to nearly 100% information packet delivery, minimum delay for information exchange and resource constraints of a post-disaster communication network. They modeled the case scenarios with the ONE simulator [2]. George et al. proposed a combination of wireless ad hoc and sensor network architecture that supports end-to-end paths in a multi-channel radio environment. They used both on-demand and delay-tolerant routing to address connected and disconnected networks, respectively [3]. Fujiwara & Watanabe focused on special network scheme and routing protocol for communication in emergency situations. They describe a hybrid wireless network that combines ad hoc and cellular networks to maintain connectivity between the base station (BS) and nodes in the event of a disaster [4].

II. NETWORK MODELING UNDER NORMAL CONDITIONS AND DISASTER SITUATIONS

The simulation software will reflect all the general characteristics of different types of communication. Among the common simulation software in practice, simulators used in disaster scenarios literature NS-2, NS-3, OPNET, OMNet++, JiST, NetSim, QualNet are general simulation software. Judging by the comparisons in the Weingärtner et al study, the NS-3 is the fastest simulator among the mentioned simulators in terms of computation time [5]. NS-3 was used in the modeling of the telecommunication network based on reasons such as being an open-source software, frequently used in academic studies, supporting many protocols, being designed to be closer to real computers, and being flexible and scalable. The simulation environment was built on the Ubuntu 20.04 LTS operating system and scenarios were run.

III. APPLICATION OF THE MODEL

A. Normal Operation Scenario of Fixed Telephone Network

While designing carrier networks in voice communication, calculations are made based on the sum of the bandwidths to be provided to the end devices, to meet the traffic in the busiest time interval.

A scenario in which the fixed voice network operates normally is modeled with the parameters in Table 1. The algorithm we created for the scenario animates the randomly started and terminated voice traffic.

Table 1 –Simulation parameters

Parameters	Value
End point count	100
Home Gateway count	10
Channel Type	CSMA/CD, P2P
Duration	100 s
Packet Size	Signaling 160,1024 byte
Protocols	UDP

In scenarios where the packet size is 160, 1024 bytes for the voice network, the end-to-end delay time is 20 ms on average and the packet delivery rate is 99.98%.

B. Congested Operation Scenario of Fixed Telephone Network

Physical losses on the lines in natural disasters and the panic demand of subscribers will reduce the package delivery rate to zero due to queue delay and lack of resources.

A scenario in which the fixed voice network operates under congestion is modeled with the parameters in Table 2. The algorithm we created for the scenario animates the fully operated voice network traffic.

Table 2 –Simulation parameters

Parameters	Value
End point count	100
Home Gateway count	10
Channel Type	CSMA/CD, P2P
Duration	100 s
Packet Size	Signaling 160,1024 byte
Protocols	UDP

The congestion scenario is based on the average access speed (50 Mbps) across Turkey. In the scenario where the traffic demand in the busiest hour increased 10 times, there was no difference in the transmission of voice packets, while the rate of establishing new calls decreased by 40%. Delay increased from 20 ms to 189 ms.

In the other scenario, where the traffic demand increased by 50 times, losses of up to 35% and delays of 250 ms were seen in voice packets. Up to 75.86% unsuccessful attempts and 400 ms delays occur in newly established calls. In the data network, these rates decrease to 85% depending on the size of the downloaded data.

C. Analysis of Results

In the simulations of the scenarios, the packet size is given as input, and the Throughput delay and packet delivery rate are calculated as output.

Throughput is the number of bits transferred to the other party on the network at a given time. Delay Specifies the time in the end-to-end Transfer of the Packet. Packet Delivery Rate is a parameter we use during the experiments and is the ratio of received packets to send packets. Assuming that there will be physical losses in the devices in the network and in the transmission environment in disaster scenarios, it is aimed to measure what proportion of packets are transmitted and how much is lost in transmission.

While running the tests in the simulation environment, Multiple Tests were performed. The results of the outputs of these tests were averaged. In order to give realistic results, calls made by each end device in the model were started and ended randomly. Therefore, although the throughput values differ, the fact that the packet delivery rates are close to each other shows that the network is working properly. Latency is one of the important variables affecting service performance in a voice network. In disaster situations, the call establishment time takes quite a long time. The increase in delay times in case of congestion is another indication that the model is working properly.

IV. CONCLUSION

In the scenarios in our studies, we have shown that the outputs produced by the simulation environment are close to reality and that it can be tested with different scenarios to ensure the continuity of communication.

It has been shown that telecommunication systems and campus networks can make their own risk analysis by modeling their existing infrastructures as we mentioned in the study. With modeling in the simulation environment, Service providers can both achieve Testing for Unpredictable Situations and save time, cost and effort.

In addition, by diversifying the parameters in our study, the results of the outputs for different scenarios can be seen.

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