Resource Allocation in Post Disaster Situation using Delay Tolerant Network

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ABSTRACT

Disaster response and recovery are very necessary in disaster management. Decision-support systems used in disaster management must have to deal with the complexity and uncertainty related in these kinds of situations. Operational conditions, precedence conditions, resource availability make the resource allocation more difficult and harder. Failure to assign proper humans and proper strategies may harm the reputation of the organization. Therefore, this paper proposes a resource allocation system for such post disaster situations.
Keywords - Disaster Response, Message Prioritization, Modular Fashion, Synthetic Movement Models, Point Radio Communication.

I. Introduction

In post disaster situations, the availability of the Internet is not naturally possible; mobile phones are also seen not working properly. The only way to communicate is satellite phones or specialized point-to-point radio communication systems. As communication systems become crippled, so do the management of the relief operations. One of the common problems during disasters is that the rescue and relief operations are not well-coordinated. For this reason, there is a need for a system that will help in the efficient distribution of rescue and relief to disaster-affected areas. The objective of this paper is to propose proper resource allocation and distribution system for post disaster scenario. The response of governmental agencies and relief agencies in these situations are crucial as they are the only hope. The failure to allocate needed resources in a timely manner is not uncommon and may exacerbate the disaster situation for inter-organizational communication and collaboration problems in disaster situations often heighten stress levels for the response team managers. By using proper Resource Allocation System, resources can be actually allocated to those who are in need.

2. Related Work

A considerable amount of investigation has been carried out for efficient distribution of rescue and relief todisaster-affected areas by the method of message prioritization and forwarding prioritized messages over DTN. However, it has been noticed that the message content has been not taken into consideration. Few works have been discussed below:

A dynamic virtual star topology was developed by SagarBose, Debanjan Das Deb,SomprakashBandyopadhyay with static central control station as root node and static shelter points as end nodes. [1]

Erik Rolland. Raymond A. Patterson,Keith Ward. BajisDodin introduced decision support for disaster management which focusses on labor requirements, precedence constraints, resource availability.[2]

The connectivity between root node and each of the end nodes is achieved using mobile volunteers opportunistically as message ferry. Chandra Shekhar S. Pawer and Rajnikant B Wagh introduced a priority based dynamic resource allocation in cloud computing in disaster time. They proposed an algorithm which considered preamble task execution and multiple SLA parameters such as memory, network bandwidth and required CPU time. [3]

MohammaedMuaafa, Ana Lisbeth Concho and Jose Emmanuel Ramirez-Marquer developed an evolutionary approach regarding emergency resource allocation for disaster response. This resources mainly reduces the casualties and economic losses by efficiently allocating emergency resources to process emerging incidents. [4]

Cameron A.Mackenzie, HibaBaroud, KashBarkar introduced an application to the deep-water horizon oil spill that is “Static and Dynamic Resource Allocation Models for Recovery of Interdependent Systems”. Two decisions models, one static and one dynamic are proposed to minimize the production losses due to disruption by determining the optimal resource allocation to facilitate the recovery of impacted industries after damage. [5]

A process of determining the priority of patients’ treatments based on severity of their conditions named TRIAGE was proposed by Luqman is a framework for message prioritization based on message content and user content. TRIAGE examines the content of the message, the role of the sender and then determines the message priority and it is also used for patients arriving at the emergency department, or telephoning medical advices among others. However, it fails to specify whether the message is structured or unstructured and the mechanism to critically extract the information from the message content.

Spray and Wait routing protocol was modified by Joe which is a prioritized message routing protocol by DTN deployed in disaster areas. It was designed to work where path may be unknown and frequently. This protocol depends on the time of the last encounter, the distance between the nodes which carry the message from a destination, the speed of the nodes and based on that it determines the priority of the message.

Therefore, it has been seen from the above researches that the message content is hardly taken into consideration in the process of message prioritization and forwarding which lead us to propose decision-support system for disaster response and recovery that will help in the efficient distribution of rescue and relief to disaster-affected areas and distribution system for post disaster scenario.

3. System Model

The major focus of this study is to come up with a framework for post-disaster resource requirement analysis, resource allocation & distribution, which involves on-going determination of what resources are needed, what resources are present, what resources need to be acquired and how long will it take for them to arrive, also implementation of recover environment on restoring, individual facility-level restoring operations.

Through this project we intend to solve one of the major problems, resource allocation in post disaster situation, through a proposed approach by providing volunteers associated in different fields after a large-scale disaster for the help of the victims residing in the safe areas nearby in temporary tents and other risk-free areas. The volunteers will carry out different relief operations by providing medical aid, relief materials and other needs from the command and control station which is established away from to the disaster affected areas for the victims.

We assumed the number of control station be (l) where high end desktops and proper internet connection is available which will provide the resource and receive the message from different sources. These stations provide the resources as per the requirements, type of the resources, quantity and the priority of the products.

The number of shelters(N), each containing a communication device that sends and receives the situational related messages from the volunteers. The requirements of resources are requested to the volunteers who then inform it to the control station by the use of any communication devices or by informing to the teammate and the overall situational information.

Each team has a number of volunteers(O) which are sent to collect resource type priority in camps and to inform the control stations about the resources and also sends different situational messages. They also circulate conversations and sentiment related messages to other camps on a daily basis. The volunteer enrollment is carried out by following the Volunteer Enrollment algorithm discussed below. Volunteers communication involves interaction with the different camps for the resource request and situational messages to the control stations, resource allocation messages from control stations to the camps and other teams' volunteers and the conversational and sentimental messages from one volunteer to the other. It is assumed that the areas where connectivity is unavailable, the volunteers transmit data in DTN mode.

The messages are assumed to be sent using DTN for the disconnected patches and through a partially available cellular network. The messages which are transmitted by the volunteers are seen to be of different categories after analysis based on the its content like Resource requirements and allocation, situational messages, conversational and sentimental. Based on these categories it is assumed that the resource requirement message holds the highest priority as there is a lack of resources after any post disaster situation. Following this, the next priorities are given to the situational messages as the resources are sent examining the situation and condition of the disaster affected areas. Resource allocation is done by the Resource Allocation algorithm discussed below. Conversational and Sentimental messages hold the least priority.

Algorithm for priority wise resource allocation on a daily basis:

1. Take input No Of Shelters (N) , No Of Volunteers Per Team(O)
2. Set No Of Control Centre = 1
3. Set No Of Volunteers (U) = No Of Shelters (N) * No Of Volunteers Per Team(O)

Control Centre :

4. Take input each Type of Resources
5. For each Resource Type,
   Take input of quantity in R[Resource Type]

Shelter:

6. For each Shelter,
   Volunteers are sent to collect Resource Type Priority in P[Shelter Number][Resource Type]

Resource Allocation:

7. For k^{th} Shelter i^{th} Resource Type, Required Allocation:

$$A_{k,i} = \frac{R_i/2 \times P_{k,i}}{\sum_{j=1}^{N} P_{j,i}}$$

Volunteer Enrolment:

8. For k^{th} Shelter j^{th} Volunteer, Required Carrying Quantity:

$$V_{k,j} = \sum_{i=1}^{M} \frac{A_{k,i}}{U}$$

9. Repeat steps 6 to 8 for 2 cycles
10. Repeat steps 4 to 8 on a daily basis
11. End

3.1 One Simulator

In this project ONE simulatorversion 1.4.1 is used for the simulation because ONE simulator has been specifically designed for evaluating DTN routing and application protocols. It allows users to create simulations based upon different synthetic movement models and real-world traces and offers a framework for implementing routing and application protocols. Interactive visualizing methods and post-processing tools support evaluating experiments and an emulation mode allows the ONE simulator to become part of a real – world DTN test bed. The One Simulator offers an extensible framework itself supporting mobility and event generation, message exchange, DTN routing and application protocols. It has an extensive set of ready-to-use modules which includes synthetic mobility models that can be parameterized and combined to approximate real-world mobility scenarios. The ONE simulator is designed in a modular way, allowing extensions of virtually all functions to be implemented using well defined interfaces.

4. Simulation

The result from the proposed technique is much better than the previous result which was obtained earlier, as we see analyzing other papers. Simulation of the algorithm proposed in this paper is left for future work. Then only we can justify a quantifiable answer to support the statement I made in the beginning of this section. Through the above algorithm we can easily find out the exact requirement in proper situation that helps to reduce the sufferings of the victims after post disaster situation.

After using this configuration, the network has been started practically ONE.

Table 1.General Parameters For Simulation

Parameters	Settings
Simulation Time	43200 sec (12 Hours)
Number of nodes	124
Generation rate of messages	One new message per node every 1800 - 2100 sec
Size of messages	0.5 – 1 MB
Buffer size	5MB
Message TTL	100 minutes
Routing Protocols	MaxProp Spray and Wait Epidemic PRoPHET Pen-PRoPHET

Let us assume a scenario where a flood affected area of the likes of Kerala has the typical requirements of 3 types of common resources namely Resource 1, Resource 2 & Resource 3. Each of these resources are stock piled at 1 unit at the control centre and are distributed in accordance with the priority ratios of the shelters. Now we assume 3 shelters namely Shelter 1, Shelter 2 & Shelter 3. The resource distribution is to be done in 2 turns or cycles every day & on the next day, the stocks are updates. So we represent here the simulations from a single day, keeping stocks constant, but varying priority & hence distribution with every cycle. The concept of 2 or in other cases more cycles enhances the disaster management technique as priorities change continuously in the field. The data used is in accordance with unofficial post disaster results from the floods of Kerala in 2018. The simulation environment is considered to be 3 sq. km area consisting of 3 villages.

All the relevant graphs & charts are representations of results obtained from simulations of the dummy data provided to the simulation environment through one simulator.

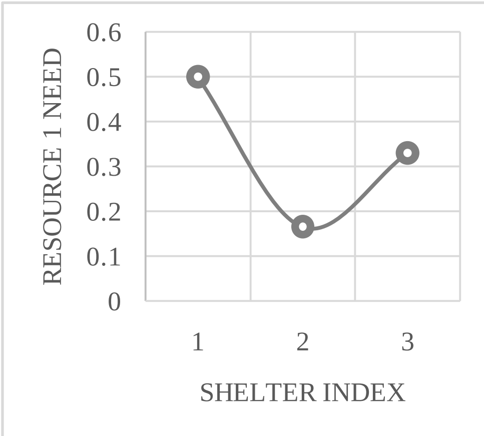


Fig.1 Resource 1 Cycle 1

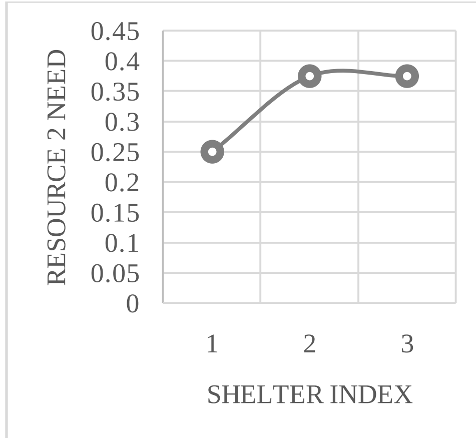


Fig.2 Resource 2 Cycle 1

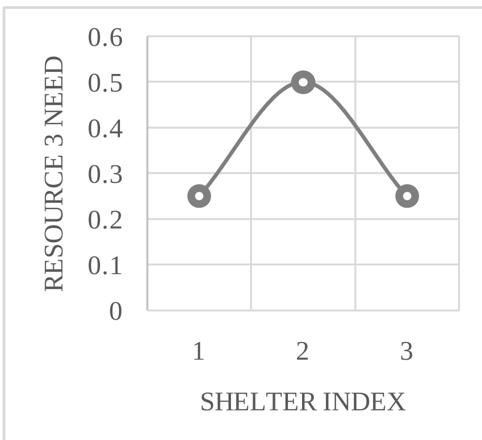
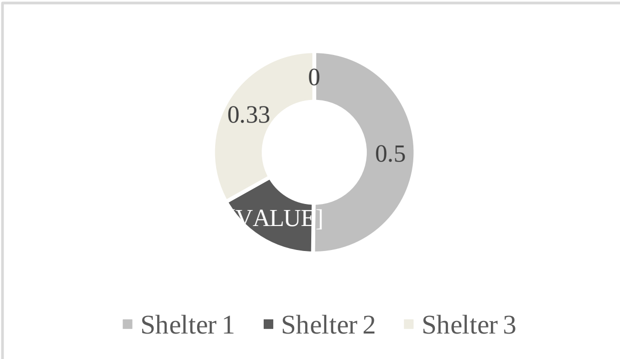


Fig.3 Resource 3 Cycle 1

In Fig.1, 2 & 3 the varying requirements of each shelter is simulated with respect to Resource 1, 2 & 3 respectively. This scenario is a representation of cycle 1 whose data was separately collected by the volunteers at the very beginning if this is the first day or at the end of last cycle of the previous day.



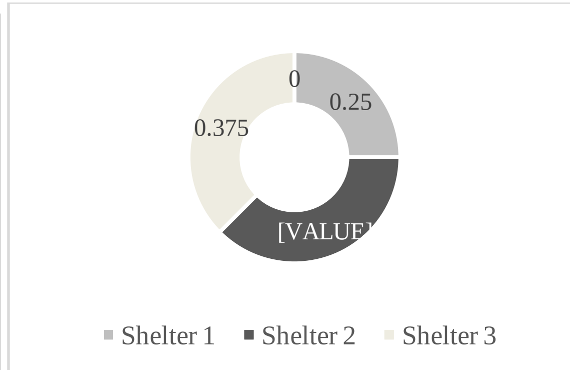


Fig.4 Resource 1 Cycle 1

Fig.5 Resource 2 Cycle 1

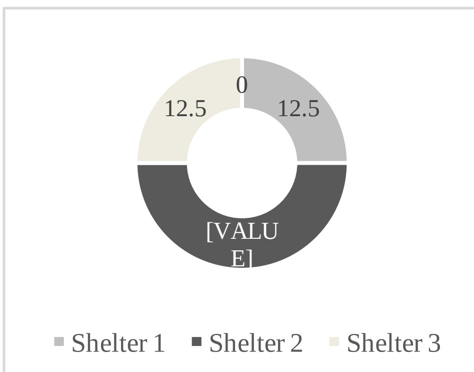


Fig.6 Resource 3 Cycle 1

In Fig.4,5& 6 the usage & distribution of each resource can be properly understood. The shelters having more priority of a particular resource receive more quantity of that resource. This repeated for each of the other resources & represented as pies of the simulation here. In Fig.7 the overall resource allocation for each type of resource & for each shelter is shown in case of cycle 1. Hence this wraps up the 1st half of the day. The priority data for the next cycle is collected by the volunteers.

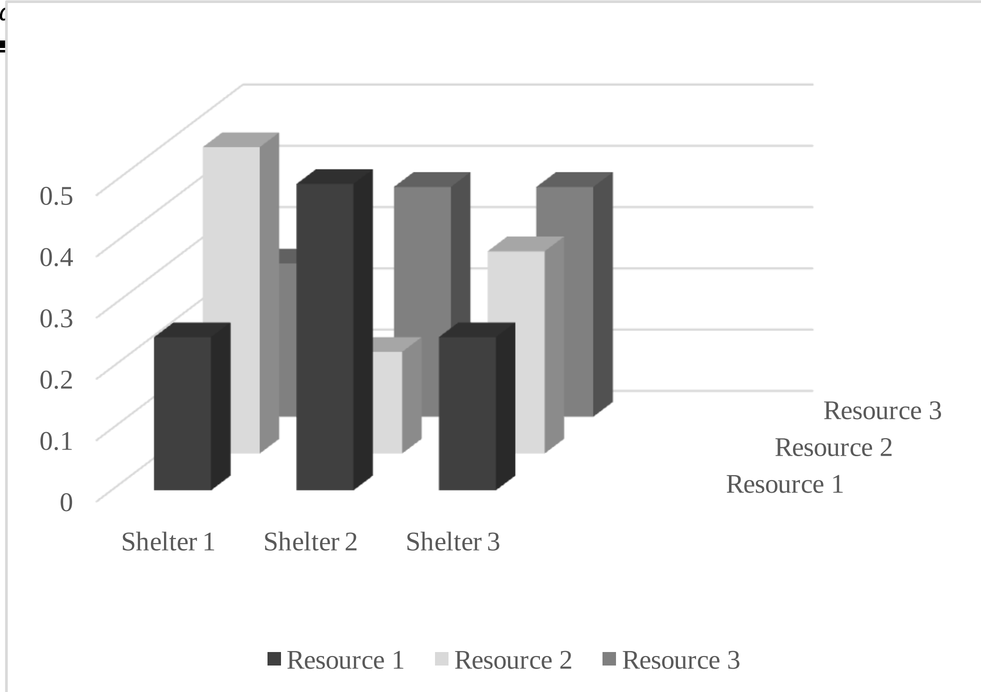
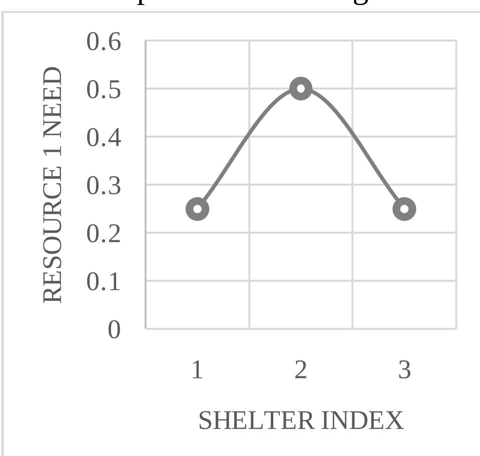


Fig.7 Overall Cycle 1

Now the second half of the day or the next cycle commences. The priorities have already been updated in accordance with the data collected by the volunteers. The distribution is calculated & executed upon the remaining half of the stocks released.



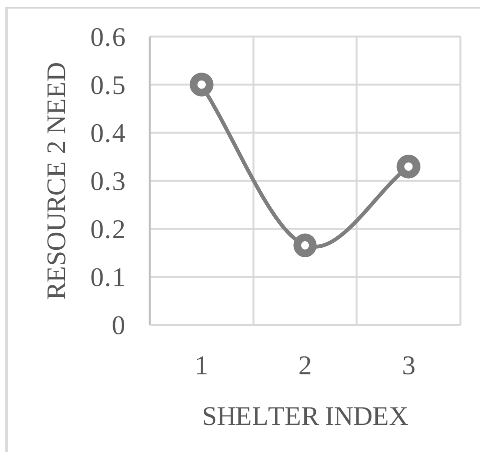


Fig.8 Resource 1 Cycle 2

Fig.9 Resource 2 Cycle 2

Fig.10 Resource 3 Cycle 2

In Fig.8, 9 & 10 the varying requirements of each shelter is simulated with respect to Resource 1, 2 & 3 respectively. This scenario is a representation of cycle 2 whose data was separately collected by the volunteers at the end of first cycle of this day.

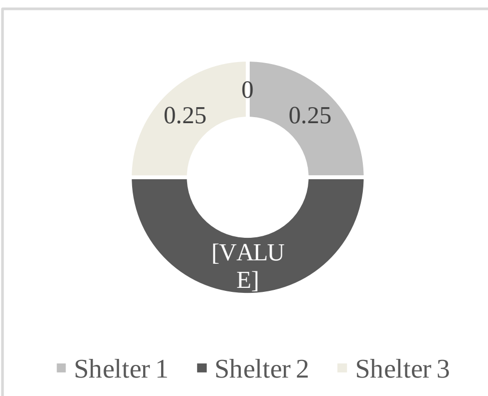


Fig.11 Resource 1 Cycle 2

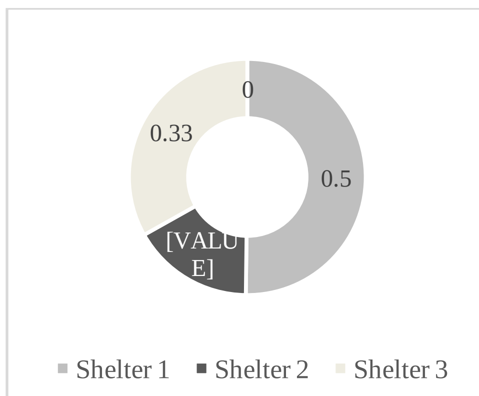


Fig.12 Resource 2 Cycle 2

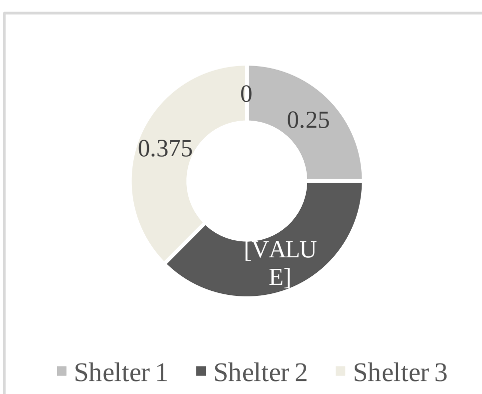


Fig.13 Resource 3 Cycle 2

In Fig. 11, 12 & 13 the usage & distribution of each resource can be properly understood. The shelters having more priority of a particular resource receive more quantity of that resource. This repeated for each of the other resources & represented as pies of the simulation here. In Fig.14 the overall resource allocation for each type of resource & for each shelter is shown in case of cycle 2. Hence this wraps up the 2nd half of the day. The priority data for the next cycle is collected by the volunteers.

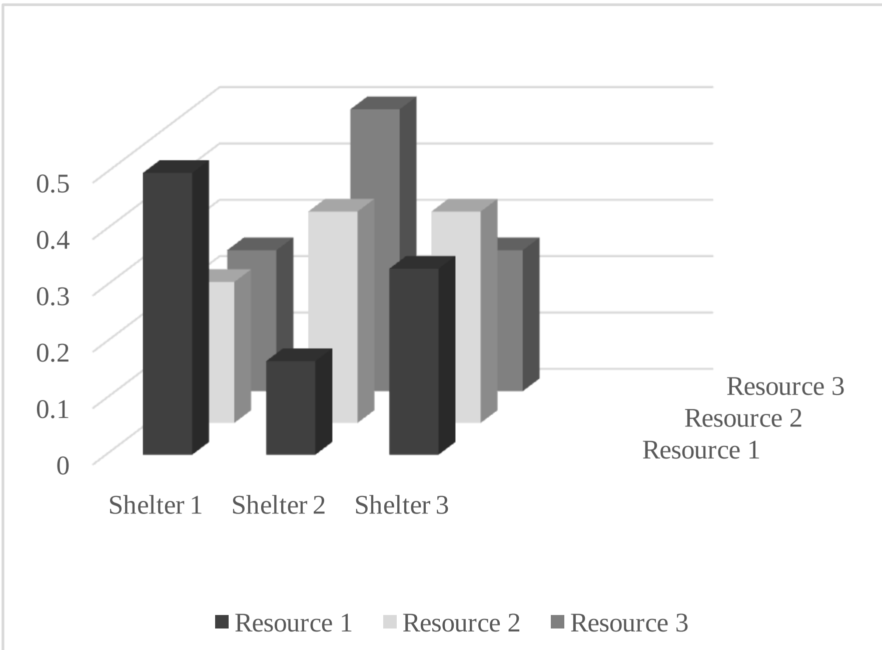


Fig.14 Overall Cycle 2

5. Results & Discussion

In this section we have analyzed the different sections of the simulation results obtained from different simulation scenarios. In Fig.1, 2 & 3 graphs are plotted which demonstrates the varying requirements of each shelter with respect to Resource 1, 2 & 3 respectively.

Fig.4,5& 6 is represented as pie charts which demonstrates the usage & distribution of each resource. The resources having the highest priority are supplied more than that having lesser priority at a particular shelter. In Fig.7 the overall resource allocation of the 1sthalf of the day for each shelter is shown.

In Fig.8, 9 & 10 graphs are plotted for the second half of the day which demonstrates the varying requirements of each shelter with respect to Resource 1, 2 & 3 respectively.

Fig.11, 12 & 13 is represented as pie charts which shows the usage & distribution of each resource. Similar to the first half, the resources having the highest priority are supplied more than that having lesser priority at a particular shelter.In Fig: 14 the overall resource allocation of the 2ndhalf of the day for each shelter is shown.

In Fig.15, 16 & 17 the varying priority cycles with respect to time of the day or respective cycle is represented. The efficiency of the structure & the simulation is improved by the introduction of time constraint over the allocation as per priority.

6.Conclusion & Future Work

In this work we proposed a Resource Allocation system for disaster response and message prioritization scheme which consists of two (2) loops to allocate the resources on a daily basis and to repeat the necessary steps two times on a single day. With a per day resource allotment to Control Centre, here volunteers are sent to each and every shelter to collect the requirements and the resources are shared on the basis of priority of the resources in a two time process.

In a nut shell we can say that this proposed technique is quite a good effective as we have taken care of usage of memory space and priority checker will also check the emergency requirements of Resource Allocation in Post Disaster Situation.

In future, we wish to utilize these dynamically assessed needs to propose an emergency resourceallocation model with the dual objectives of maximizing resource utility and minimizing resource deployment time.

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