A Disaster Management Platform Based on Social Network System Oriented to the Communities Self-relief

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***Abstract*—For the development of computer systems or platforms that can be helpful in case of disasters, it is important to take in consideration some important factors. first one rely in the importance of having all the information about the disaster contained in one repository or database. Then, the distribution of the information, and the constant communication between the principal actors before, during and after a disaster. For this research we created an algorithm that can generate aid links between the people inside a social network system. These links based on each user abilities and disabilities intends to improve the fast response and resolution of the majority of the problems that emerge from a disaster.**

***Index Terms*—Social network service system, Disaster mitigation, Disaster management, Self-relief community, Assistance system.**

I. Introduction

A. Communities in Disaster and the Social Network System Possibilities

IT is common to observe that with every disaster the communities learn, so in most of the cases when a disaster occurs the next step is the learning phase. This is essential for the mitigation and preparation in case of a new disaster. It is also important to add that when a disaster occurs, the communities act in a specific process described by Takazawa A. and Williams K. [1] . Basically this process starts when the communities respond to disasters in stages without relying in the stronghold of the disaster. Then, the people in the affected community start to help to each other, facing the dilemma of helping at first instance, their own family and close friends or start helping anyone who need it. The community starts its own relief in which the main base of human force relies on the community for a better efficiency in emergency response. Then at the end of all the stages the rescue and relief includes the participation of the groups that are coming from outside the community, the public agencies and the newly created groups from the community itself. This statement is important for the development of our system. We are considering not only the utilization of the abilities and disabilities of the people from the community. We want to joint in one platform all the previous mentioned groups. In that case they will be able to share important information that can be used for the relief efforts.

Another important matter to consider in this kind of platforms is the well established models for disaster management like those mentioned by Patterson Olivia et al. [2]. The importance of these models resides on the reliance on its good organization in which the participation of community residents have more value due to specific skills. The analysis of vulnerable conditions, the discovery of problems, development of solutions and the establishment of organizations for the disaster management tasks between all the groups is also considered. In the specific case of our research we found the model called *Integrated Community-Based Disaster Management* (ICBDM) [3], this model relies on the cooperative work of all groups, in which the community, government and other groups are included. Into the division of the responsibilities we can find, disaster prevention and response groups sponsored by fire fighting agencies, disaster response and recovery actions actively undertaken by communities, and community-based disaster management programs.

On recent years with the use of the social networks the interactions between the people are experiencing a change. Social Network Systems (SNS), gather the information from the users, in which their social contacts and attributes are included. This information can be shared with all or just some restricted members within the network. After getting all the information. This services constructs an interconnected social network [4]. If we take a look to these connections inside the social network it is possible to have a virtual model of the relations that people have outside it. We consider that for the development of this platform these SNS structure can be useful to obtain each user's characteristics and connections. And make them useful as part of the management and preparations for any case of disaster. Added to this, we also have seen different ways in which the SNS have been used for the relief and communication efforts in the disaster management [5]. But in most of the cases these systems or services are not specifically designed for this task. However, this is an important proof of the way SNS are helping. That is why for this research our goal is to construct SNS for self-relief community in disasters with a big dependency on the string between the community people, and the other groups like the public agencies.

B. Our proposal

For this study we propose a platform for disaster management based on a Social Network System (SNS) structure.

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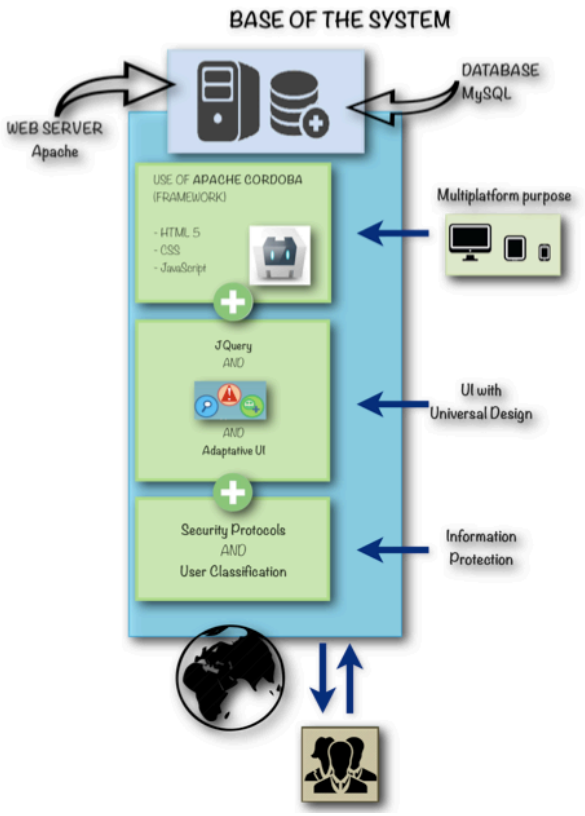

Fig. 1. Systems general diagram

Using this structure the system main algorithm will create aid links between the users, the government and other groups inside the SNS based on a helped-helper relation. In addition the system will learn from past experiences. So when the community faces another problem, the people will have their links and the support between them can be faster. empowering the communities to have a fast response in the relief efforts.

In the next section, we made the description of the system, followed by section 3 with the characteristics of the platform. In section 4 we present the discussion. and in section 5 the conclusion of this paper.

II. System's Outline

A. Structure of the system

In figure 1, we can see the general structure of the platform. This system is implemented having as the core of the system a web Server and its Database. One of the main characteristics of this system is that it is developed under the universal design statements.

This kind of platforms are open to be used by any user. Because they can be accessed via internet. That is why, it is important to establish a security control, due to the importance of the information that is exchanged in a system like this. So as part of the system design we considered Security protocols and the user classification to determine each kind of users can access to which kind of information. Due to the importance of information we are gathering inside the system's database.

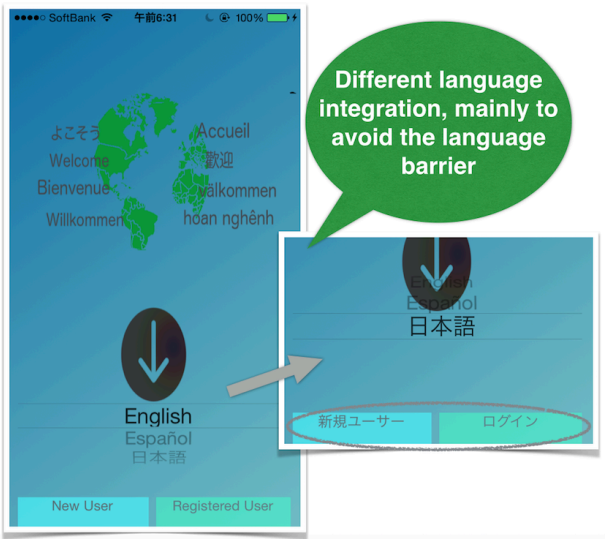

Fig. 2. Application: Support for different languages

B. User-end application

A Human Interface is important when the user needs to perform one task using a tool providing an understandable way for this interaction allowing the empowering of the users abilities to perform certain task [6]. It is necessary to find a way to create an Interface that can be used by a wide range of people. So for this system we are using an interface that can provide to the user an easy and fast utilization.

If we take a look to the definition of Universal design concept which is: The design of products and environments to be usable by all the people, to the greatest extent possible, without the need for adapt or specialized design [7]. We can see that universal design improve the accessibility and usability of any product or service that will be used by a user. At the beginning we can think as accessibility something to include certain type of user with some kind of physical disability or elder users. But the best way to get a better universal design is to consider a complete spectrum of users [8]. According to Steinfield E. and Smith R. s research about Universal Design, we can forget the old schema when we used to divide the users in two main groups: those with specific disabilities and the general consumer, based on the idea that all users deal with some kind of disability in their life [9]. Having a Universal Design not only will eliminate this division, it also will rest importance to other factors such as cultural, or even the language differentiation. It is a reality that the people who is weaker in case of disaster are those considered in the CWAP (C: Children, W: Women, A: Aged People, P: Patients) group, also we can include to these specific group disable people, babies, and foreigners or visitors in the middle of a trip [9]. So that is why in our research we consider all this groups making a system interface that can be easily used, and understandable. Also we are considering the extension of this platform to a wider variety of devices.

One way we are improving the usability of the user-end application is adding different languages to the main platform as we can see on figure 2. We added this characteristics as an effective way to eliminate the language barrier that can be an obstacle for the user. At the same time, the application tries

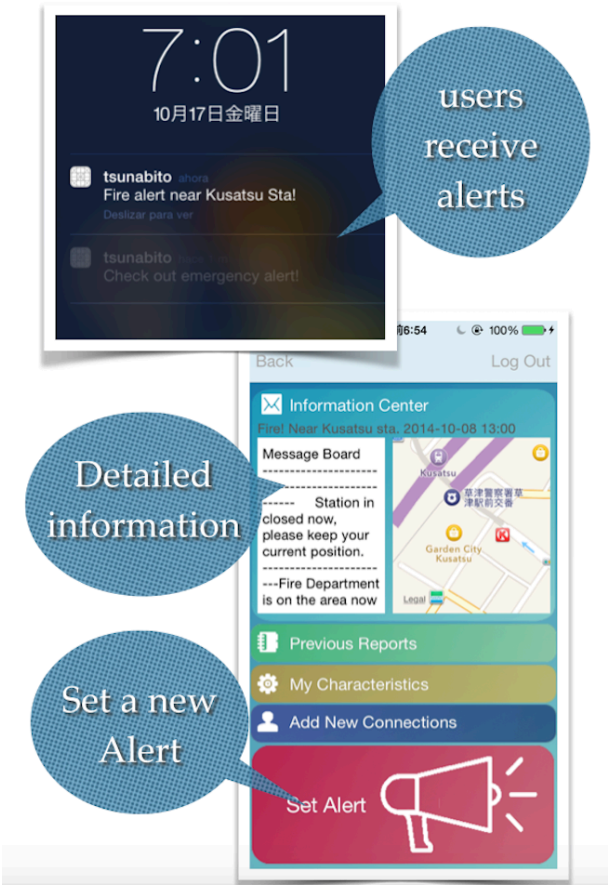

Fig. 3. Application: Alerts and main screen

Fig. 4. Application: Assistance required

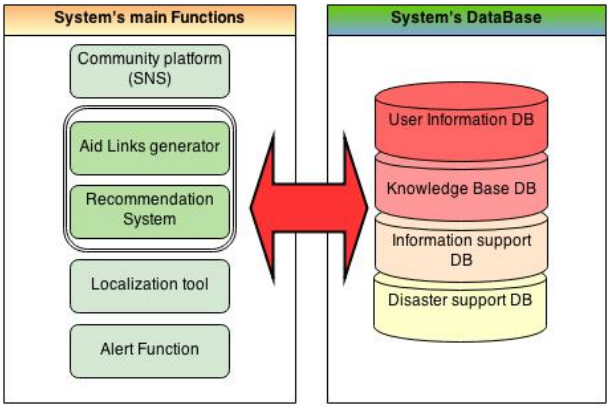

Fig. 5. Characteristics of the platform

to show all the information in a simple way. For example in the main screen shown on figure 3, the options are presented directly to the user, eliminating the need to go through different screens to take the action the user wants to perform. Mainly in the case of the Alert submission button is presented directly. This will give the user the opportunity to establish an alert quickly.

Another aspect is that the information is also presented directly to the user. Empowering the user to do the required actions as fast as possible. In case of the requirement of a skill from the user, the system will send a notification (Figure 4). Then the user will receive all the information and he will be able to do an action based on this skill.

III. Characteristics of the Platform

It is very important to note that into the main functions of this platform we can find five main units integrated. These units will be working together with the system's database, as we can see on figure 5.

A. Community platform

The first unit is the community platform. Basically this unit's structure is based on a social network system . Inside this SNS, the users establish their relations based on their own trust circle that mainly includes their familiar and close friends. Also, the users will input their characteristics. The main process inside the community platform starts with the users registration.

1) User Registration and circle establishment:: This process is represented on the figure 6. Principally in this part, we are obtaining the users information and storing it into the systems database.

Part of the information required by the system are name, address, age, sex, country, profession, which are considered distinctive properties of each user. Then, the establishment of each user's abilities (in which the skills are included) and disabilities (where for example we can find illness, serious medical conditions, disabilities, and others). These will be used to determine and make the indexation of each user during the creation of aid links function that will be detailed later. After that, the system ask the user to establish the trust circle and helped-helper level 1 circle. Mainly, these two circles let the user start making connections with the rest of the users inside our SNS. Each definition and characteristics of these is detailed on the table I.

2) User type distribution:: In addition to the division of the users based on their trust strings and personal relations.

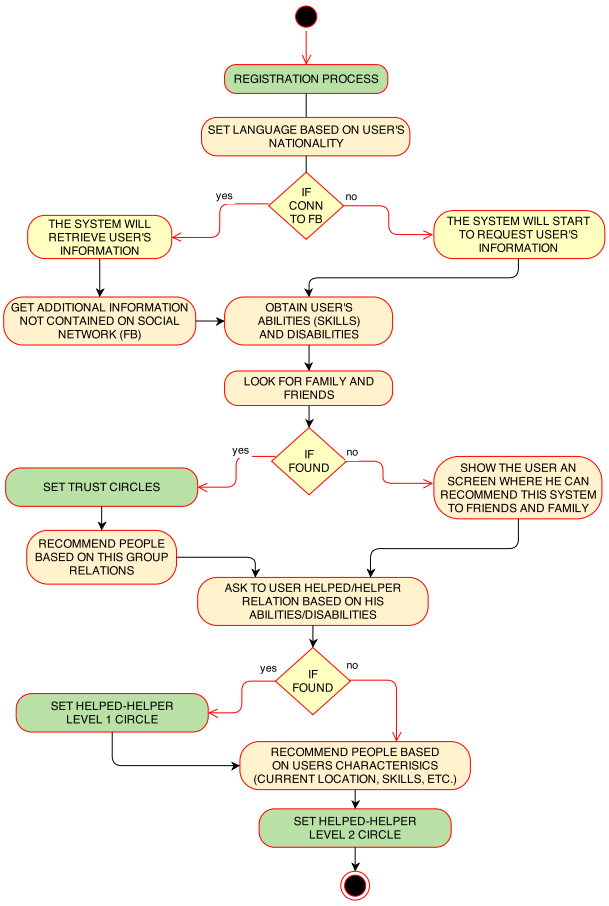

Fig. 6. User registration diagram

TABLE I
SYSTEM'S CIRCLES DEFINITION

Circle	Description
Trust circle	Inside this circle it is possible to find all those previously registered users that have a direct relation to a user, such as familiar and friendship relations that can be found outside the social network system. The system will send a message to this group of people to make them known the user current situation in disasters. The importance of this circle lies in the need to start having the first connections. Avoiding a cold start, which can be generated due to the inability of having any connection.
Helper-helped level 1 circle	Inside this circle we will find those between a user with disability (e.g. Illness, serious medical condition, etc.) and another user with an ability corresponding to the disability. The most common case can be the doctor-patient relationship. This will allow the immediate attention of these problems by a helper. The system will create these links as part of the preventive action. And will use this information in case a complication presented during and after a disaster, related to this relation.
Helper-helped level 2 circle	This circle includes all the links based on each user's abilities and disabilities. Mainly this circle is generated by the system, so there is not any personal relation between the users. However, the system considers this link useful for a specific problem or emergency. Most of the time these circles are established in real-time based on the user's current status. This kind of circles are variable depending on each case and type of emergency. the creation of this circle will be detailed on later on the aid link generation function.

Their abilities should be divided as well. With this we will be able to attend needs with the abilities or skills that can be useful from another user. For our system, a good way to make a division is based on the ICBDM model for disaster management [3]. Originally, in this model 5 groups were determined as medical, search and rescue, treatment, evacuation, communication. For our system we decided to make a minor modification to this model, joining the medical and treatment tasks. Resulting in four groups as: Medical and treatment, rescue, evacuation and communication. We did this joint because both of them are related to the medical area, so they can be resolved by the same group of people who have this type of skills.

This division intends to cover each user needs in case of disaster. To have a better comprehension of these tasks. We will make a brief description next.

a. Medical: As helper we can consider those users with medical skill, for example doctor, medical specialist, nurse, or any other user with first aid skill, emergency specialist or users with a special training related to disabilities (sign language). These abilities can be used to perform a task in order to assist the helped users. In some case the helped will require attention related to a medical condition previously registered by the user or as a consequence of a disaster.

b. Search and rescue: As helper we can consider for this group all those people who belong officially to a search and rescue agency, volunteer people with special training or with a skill that can be useful to perform the rescue of someone else. Mainly the helped user is able to ask for help or advice in a particular problem, get localizations of the helper users. The helper user is able to assist people directly if helper is near helped localization, or even inform about rescue advances in a specific area.

c. Communication: This group is very important for all the people in the community. In this group we can consider as helper those people who are witnesses of an event in place and can communicate about the event with users in the system. That is, the helper user should have an important skill, including a foreign language or with the proper media to get important information that can be useful. On the other side helped is the rest of the people, which is benefited by the information obtained and shared. For example, foreign people who can't understand language, or even people who for any situation did not get the alert emitted by a public agency or other.

d. Evacuation: We must not forget the importance of the government agencies which are main actors in the disaster management. These agencies like fire fighters, public health agencies, public utilities, and others, already have done preventive efforts. For example, the design and establishment of emergency routes and procedures that should be conducted in case of disaster. Using the system's Report generation obtained from all the community feedback, public agencies can perform their task based on these reports.

Having all the actions and abilities divided and already registered into these main four tasks. Each ability accomplishes and solve a problem derived from a disaster. However, there is also the possibility to face a problem or ability not registered previously. For these cases, the system permits the addition of new ones following a validation process. Making them available for future use by other users. For

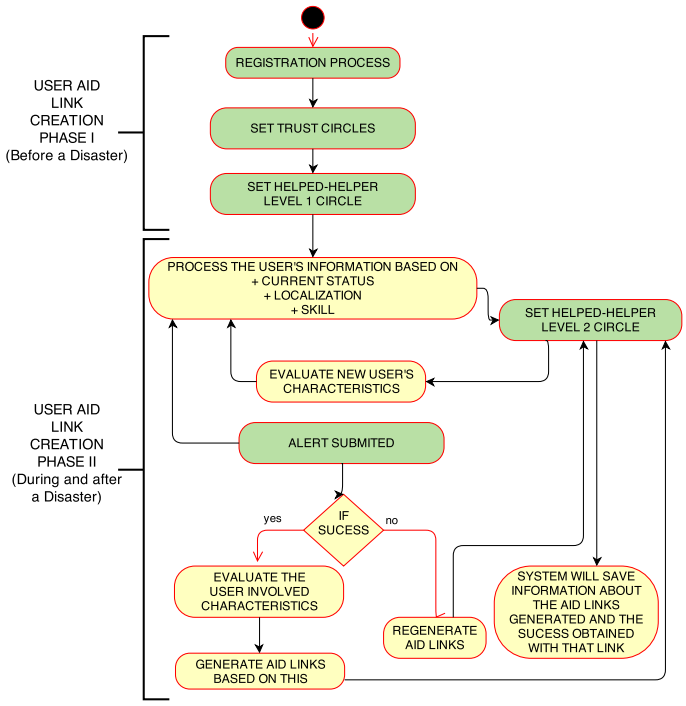

Fig. 7. User aid link workflow diagram

this validation process the users will be required to make a relation or establishment of the new ability or disability with an existing one, this is just to make sure that there is not duplicity. The constant increase and validation of each user's personal information is a key part to make the system able to manage the disasters.

B. Aid links generator function

The second unit is the aid links generator function. We consider this part, our main proposal and core function in the disaster management system that we are describing. Based on each abilities and disabilities for each user, our system is able to establish the aid links for the people. At the same time the recommendation system will allow our users to set their trust circles and helped-helper circles. Each link will be weighted based on the strength of the relation between Helped and Helper. We need to take all the abilities and disabilities of each user. Based on this, the system will match which abilities of one user can be used to fulfill the disabilities of other user.

Based on the relation of ability and disability for the four groups, we define the strength of the helped-helper relation between two users. Concretely, the strength of the helped-helper relation is defined as the total number of matched relations as helped-helper in every group. Based on this, the system proposes priority of users as aid links.

The establishment of the aid links is divided into two main phases as we can see in figure 7. The first one is performed before the emergency on a preventive basis. And the second phase is performed during and after a disaster occurs. The second phase is related to the capacity of the system to create the aid links.

- First phase (before emergency): We need to remember that when the user is on the registration process, the user will input his characteristics related to abilities (skills) and disabilities (illness, serious medical condition, etc.). Then the system will ask and set the trust circle, which is the first step for the creation of the first links. Next the user will set the helped-helper level 1 circle, which is useful for helping the user in case of disaster. It is expected that the users can have the helped-helper circle based on their abilities (resp. disabilities) because most of them have relation between others with the corresponding disability (resp. ability) in the real world. The next step is the verification of the coverage of the just registered new user. This means that the system will make sure that the user disabilities are covered in a satisfactory level. Additionally to this the system will post via message board information about the new situations that should be prepared as a preventive mechanism. If there is a user that can fit or has an ability that can cover this new problem, the user will be able to set him as a helper in that kind of situation.
- Second phase (during and after an emergency): In second phase, We need to define the helped-helper level 2 circle, which is generated by the system. This type of circle is used by the system as a base to establish the aid links. The aid links in this circle are created in most of the occasions in real time. There is a big dependency on three factors from the user and three factors or characteristics of the disaster to take in consideration:
  - Current user's status: This is related to the status which represents that the user is not damaged and can be a helper in a disaster. That is, the status is well or bad. When the user sets his current status to "well", this mean that the user is not having any problem. So this user can be considered as a potential helper.
  - User's localization: The localization of each user is very important to determine whether the user is in the possibility to help other users. Depending on the type of disasters, there may be cases that the help should be performed on site and those done in a remote way.
  - User's weight parameters: The weight parameters depends on the type, status, and location of disaster. For each disaster D, these parameters indicates which characteristics has good impact for D. That is, the parameters should be determined by the success rate.
  - Disaster's type: This factor is related to the differentiation of a disaster and the category or intensity reported for this disaster.
  - Disaster's status: This factor is based on the degree of recovery of a disaster. There is a direct relation between the time and the current situation that the community is facing related each new problem as a consequence of the disaster.
  - Disaster's geographical position: We need to know the geographical position of the disaster to be able to set the possible group of users that are susceptible.

1) Rules for Aid Link System's Function: Our system uses a series of rules to perform the aid link selection process. In those cases when we are requiring a skilled user during

a disaster, the system will make the evaluation based on the previous mentioned characteristics of the users and the disaster. As a final stage of this process, we require to compute the priority of helped-helper relation for each case. Our system proposes the users in the order of highest priority. This process can be defined in the next function.

Let T be the set of the types of disaster, S be the statuses of disaster, and P the geographical position of the disaster. Each disaster d in D is represented by (t, s, p) where t in T, s in S and p in P. Let U is the set of users. A user u in U is represented by $(a, d, s(t), p(t))$, where a is the user's ability, d is the user's disability, $s(t)$ is the user's status at time t, and $p(t)$ is the user's position at time t. For a user u in U, the priority of user u' is defined by:

$$f(d, u, u') = g_1(u')(g_2(u, u') \cdot w_2(d) + g_3(p(t), p'(t)) \cdot w_3(d))$$

The first function g_1 returns the evaluation results of the status of the user u. If this user's status is set as bad the system will not consider that user a possible helper,getting from $g_1(u')$ a return value of 0. Otherwise $g_1(u')$ returns 1. Then the system will continue performing function g_2 and g_3. Function $g_2(u, u')$ returns the strength of helped-helper relation between the users, and g_3 returns the evaluation results about the distance between the users. As mentioned above, there are cases that the helper should help remotely. In this case, the parameter $w_3(d)$ returns a positive value, that is, the remote user has higher priority. In the other case, in which the helper should help on site, $w_3(d)$ returns a negative value.The $w_2(d)$, and $w_3(d)$ is the weight of each evaluation value. These values are determined by the disaster.

C. Knowledge base establishment

The third unit is the knowledge base establishment on the system database. The aid links are generated based on the current state and abilities/disabilities of each user. For the type and the location of a disaster, the impacts of these elements for self relief may be changed. So, the weight parameters depend on disaster should be set to the elements. In our system, the parameters are set automatically by the analysis of success. Our system will start to record all the information related to the solution and the aid links between the people who are considered as effective. This function allows our system to learn about problems and find the best way to solve them.

D. Localization tool & Disaster Status analyzer

On the fourth unit we have the localization tool. This unit uses the Global Positioning System (GPS) to allow the georeferenced information in case for example of injured people or massive problems about communication for awareness(e.g. Fire, Collapsed Building, etc.). This geographically referenced information stored in the system will be able to determine where and who is facing a problem. So it is also possible to measure the impact of the disaster, and the relief level at the same time.

On figure 8 we can see another important part of this system algorithm. This part is related to the disaster status analyze. The main task is to detect any alert caused by a disaster or any alert created by a user inside the SNS. If

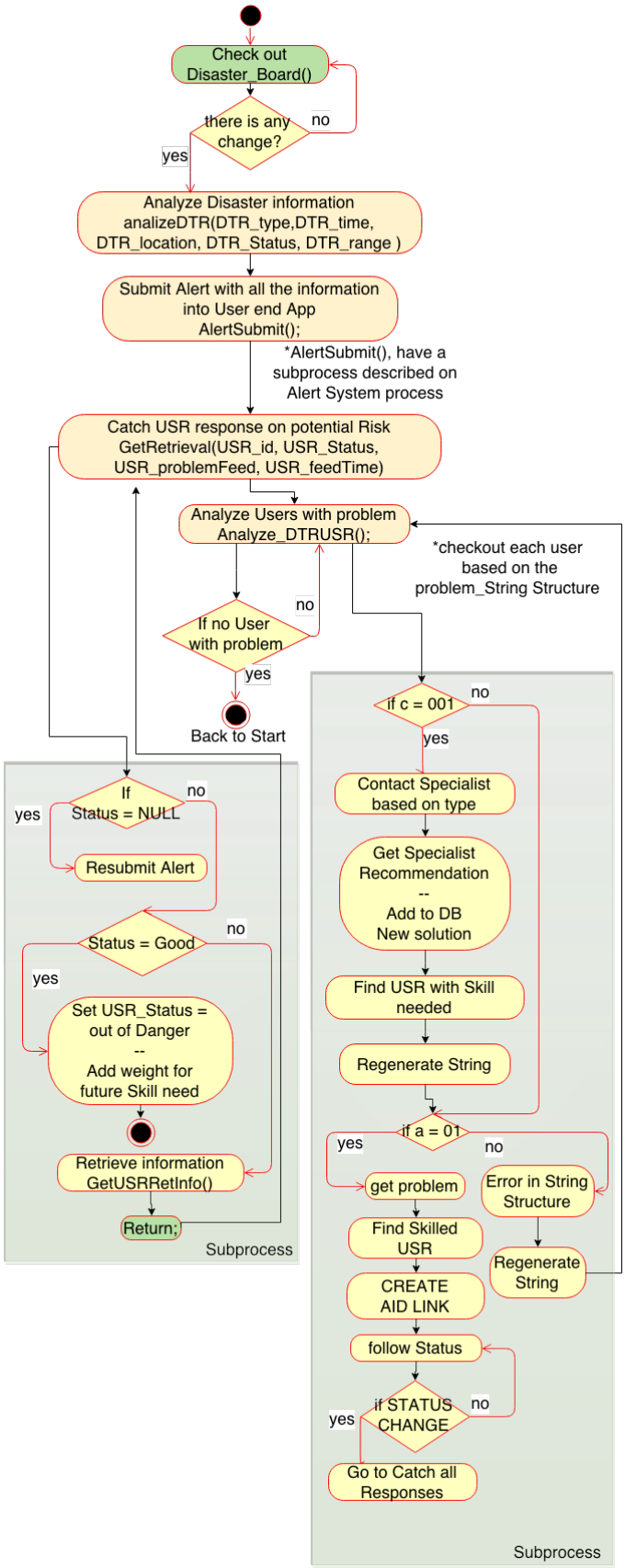

Fig. 8. Disaster analyzer diagram

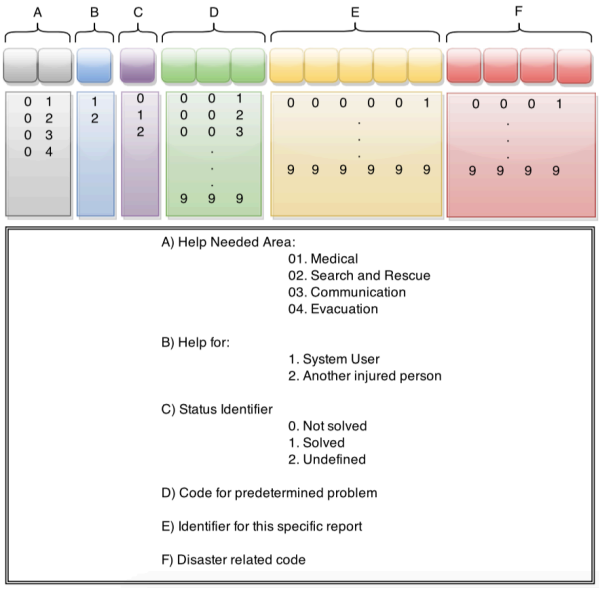

Fig. 9. User problem Feed String Structure

there is any change in the status of a disaster the system will start the analysis of the circumstances, weighting the possible impact of the disaster. After doing this, the system starts getting the feedback from any other user or public agency inside the system. The system uses the initial information and the just generated information to broadcast a warning alert to other users inside the SNS. At the same time the system starts the analysis of users problems. Based on the information submitted by the users the system will calculate the best way to solve those problems, and will generate the aid links previously mentioned.

The way this system manage the information obtained from the users is using a string created to fit the information in just one package. This small package is created to eliminate the over weighted messages, and to allow the fast retrieval of information. On the figure 9 we can see the main structure of this package called Problem feedback String. The header refers to the Area in which the user identified his problem, based on the four main areas (Medical, Search and Rescue, Communication, Evacuation). After that, we have an identifier for the type of help is required: For the application user, or another injured person. The next digit is used to identify the status of the problem referenced. the next three digits are used to identify the problem, we already have inside the knowledge base of this system some predefined problems, with their solutions and their best way to solve them. Each of this solutions are identified with this number. The next part of this string is the identifier for this specific report, each report has its own number. And as the footer we have the identifier that makes the relation of this problem to a specific disaster. This identifier and the Status one, are used to calculate the percentage of resolution of a disaster.

E. Alert function

Finally on the fifth unit we have the alert function, Which is important in first instance to aware the people in our platform. And also it will be used to set the first actions to be performed and start the relief efforts. After the alert was in the system's server, the system will distribute the

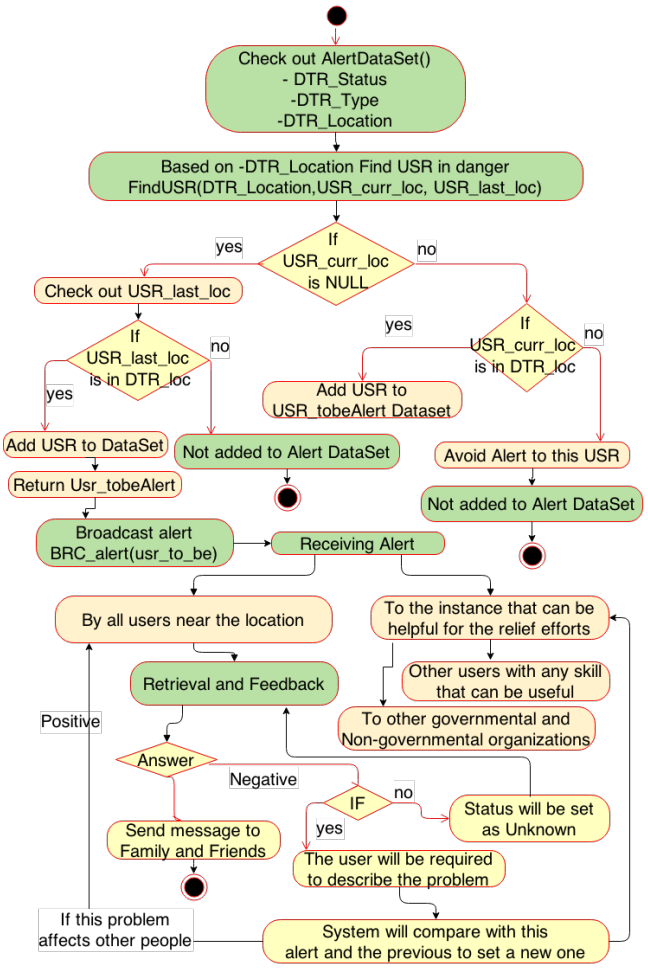

Fig. 10. Alert System Diagram

information among the users of the social network service. We can find this process on figure 10.

The process starts with the distribution of the information on the alert to those people who is near the localization of the problem. The system will compare the current location of the disaster with the users current location. If the system can't retrieve any location from the user, it will check out the location related to the user's last position registered. For those users that are inside the range of the disaster, the system will broadcast the alert. The public agencies and people in the community can be helpful for the relief efforts. So when the users received the information related to a disaster or any other important event, the system requires them to retrieve information about their status, or also about any problems in which they are eyewitnesses. The system will try to reach the user and get as much information that can be gotten, so at the end each user will be helped based on each particular problem, but also the system can manage the priority of these problems.

F. Relation Between people and disaster

We already defined the groups of user specialization (Medical and treatment, Search and Rescue, Communication, Evacuation) in which this system is based, Now it is important to define in which cases the alerts will be set up per group. This is, the relation or connection between disaster and people. For this purpose, firstly the system gets

the essential information of the occurring disaster or problem based on the Five-Dimensional disaster typology proposed by Berren et al. [10]. This topology is based on the relation of a disaster and their psychological impact in communities. Allowing the identification of the disaster elements which subsequently can be used for the assistance of communities in the planning process. Five factors included in this topology are: 1. Type of disaster, 2. Duration of Disaster, 3. Degree of personal impact, 4. Potential of occurrence and 5. Control of the Future impact.

The way this system receive this information is explained next:

1) Type of disaster: As we mentioned at the beginning of this document, a disaster can occur at any moment and in any place, having this characteristic the communities had experienced lots of different disasters, making the human being able to distinguish them and give them a name, scale and a complete description for future references. According to the Fire and Disaster Management Agency in Japan [11], There are four principal Types of disasters:
   a) Large-scale natural disasters: Earthquake, Storms and floods, Volcanic eruptions.
   b) Fire, Airplane accidents, Traffic Accidents, Dangerous material- Induced accidents, maritime accidents, nuclear-related accidents, railroad accidents.
   c) Serious incidents: Hijackings, Mass-murdering type terrorist attacs, Terrorist attack on vital facilities.
   d) Armed Attacks

   Initially the system have as information the Japan Federal Disaster Management Agency (FDMA) disaster classification, so at lease all the disasters that are well defined will be covered by the system, however, this system have the characteristic to obtain as a new knowledge base, its own logs about events or disasters that may not be covered by the FDMA classification .
2) Duration of Disaster and intensity: Taking in consideration the amount of time and the intensity of a disaster is also essential to understand the impact of a disaster. In most of the cases the natural disasters use well defined scales where the given values have a significant meaning for the people who maybe don't experienced the disaster but when they get these values they can understand and imagine the possible impact, at the same time these values can be used by expert to determine how to deal with them in the future. These values also will be based on those well established scales that are used to measure each kind of disaster.
3) Degree of personal impact: Even if the Human has created different scales that are used to measure the disasters, we need to take in consideration the degree of personal impact, which is related directly to the people inside the community that experienced a disaster. For example if we compared two earthquakes with the same values of magnitude and intensity and we compare the level of destruction, death people, or even material lost we can see that they were considerably different, so the personal impact should be different. The alert system as being part of the main characteristics of this system, also have a log that can be explored to get the values needed to determinate the degree of personal impact.
4) Potential for Occurrence: If we take as a reference the existing amount of records and information that have been collected in every disaster that had occurred. It is possible to understand that there are some places where the occurrence of a specific kind of disasters happens. This information is obtained from the historical background of each community as well this can be obtained several months or years after this system starts to get the information from people.
5) Control of future impact: This factor have a big relation with the fourth factor; in all the communities there should be a future plan taking in consideration the history and the occurrence of disasters, the people inside a community can be more aware and prepared; this factor had been used to have strong structures in buildings, better measure equipment or even better disaster management. Always there should be some preparedness, that in most of the cases is managed by the governmental instances, however, this system can be also considered as a preparedness tool.

IV. Discussion

The creation of a platform for disaster management is a complete challenge. Considering that the basis are at the end the ability to help as much people as we can and the complexity of having a robust system that can be helpful in all circumstances. That is why we based this system considering these two points. During the design phase in the development of this platform we concluded that this system should be used in almost all the circumstances and covering as much disasters types as we can. Of course there is a big dependency in the information that we already have from the yet detected disasters. Lately, in most of the countries there is a knowledge base of disasters, and some plans to solve the problems derived from a disaster. We have the statistics, and the probabilities to know which kind of disaster is the most probable to occur. However, there is no way to avoid the disasters. We can prevent, and we can make use of the technology to provide the tools that will help the people to counteract the high effects of the disasters.

We have as well those research we covered on the introduction that encourage us to believe that if we are looking to help the people. We need to stop leaving everything only in the hand of the government. This means that the people inside the community and the government should start to work together and prepare for the disaster. Based on this, the use of a SNS, will allow us to have all these groups together, letting us to share information. We mention this point because, this platform intend to be a platform that can be used by the government and the common people from the community. Having these two groups together on the same platform will allow not only the cooperation but also the improvement in the relief efforts. Having a direct impact on the speed of the response.

The correct organization of all the activities related to the disaster management is a key point. For the creation of the aid links that uses the people's abilities, we also rely on

the same distribution of main tasks to be performed during the recovery efforts. Having this well established groups of activities. After a disaster we will be able to know exactly the parts that need more attention and prioritize them.

There is an important point to consider. The significance of having an effective evaluation. For evaluation a huge amount of data is required. We have a knowledge base that needs to be filled with all the information needed. In first instance with all that information we already know from the disasters and the ways to solve the problems that come with them. On the other hand we need to have an active and healthy SNS with all the information we require to establish the aid links between the people. Fulfilling these two elements we will be able to avoid a cold start. Which means that point in which the platforms are not ready to start correctly. Furthermore, these evaluations should be done following specific cases. Following these evaluations results, the algorithm can be improved and the cases and solutions can be studied correctly. Definitely to be able to continue with this study, as a future work, we think on doing several evaluations of this platform.

V. Conclusion

In this paper, we present a platform that is designed to be used as a platform that can be used for the disaster management. In this case we are proposing five elements that are very important and that allows this system to perform its task properly. Into the core of this system we have the addition of the community people into the disaster relief efforts, and effective detection of the impact of the disaster including the correct sharing of information and feedback to find a fast solution.

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