STSM Report

COST STSM CA15127 - 38853

STSM title

Redaction of Chapter 2.3: Post-disaster recovery and emergency networks

STSM Applicant

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Period

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Working group

WG1

Purpose of the STSM

In the STSM COST-STSM-CA15127-37058 «Modeling floating content in a disaster scenario », we started analising the feasibility of the Floating Content paradigm feasibility in the aftermath of a disaster, as a communication service in support of applications for rescue coordination and situational awareness. The outcome of that work has been the publication: Rizzo, Gianluca, and Helmut Neukirchen. "Geo-Based Content Sharing for Disaster Relief Applications." International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing. Springer, 2017.
The proposed STSM, whose topic is “Redaction of Chapter 2.3: Post-disaster recovery and emergency networks” is within the context of the activities of WG1, and the proposed work has been designated as one of the preferred subjects for this call.

Description of the work carried out during the STSM

In this STSM, we have focused on a specific scenario of reference for our investigation. We have chosen to focus on disaster scenarios with the following characteristics:

- They involve a “sufficiently high” amount of people in a given area, for delay tolerant ad-hoc communications to give satisfactory performance in the store-carry-and forward mode.
- They involve a population consisting by people residing in the location (or passing by) at the moment of the disastrous event, by organized rescue teams, and by volunteers.
- They happen where either no cellular/ fixed communications are available, or where they have been disrupted by the disaster itself and its consequences (e.g. fiber cuts, destruction of antenna masts, power black-outs).

Making the case for ad-hoc communications in the immediate aftermath

As infrastructure support to communications can often be restored or supplied (typically, by truck mounted base stations) in the disaster site after some time (on the order of a few days, usually), we focused on mobility and FC performance in the immediate aftermath (6-12 hours after, up to 2-3 days after the event) of the disastrous event.

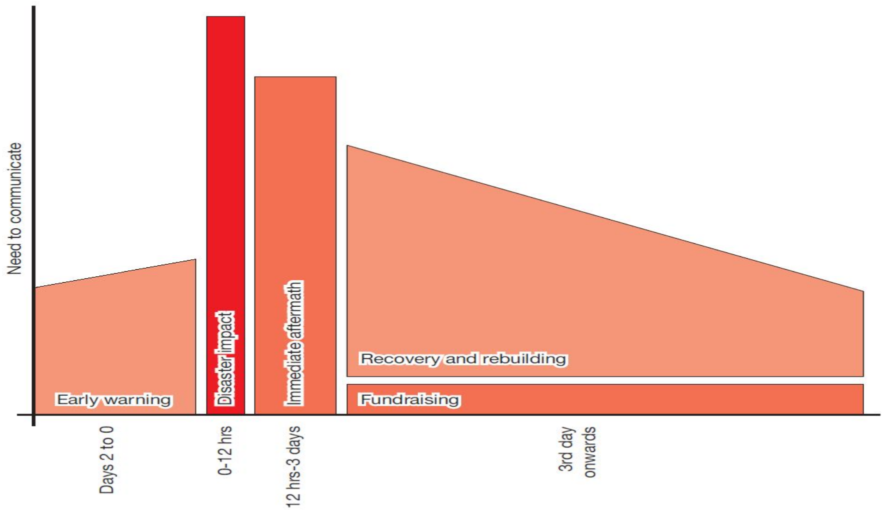

Fig 1. Demand for communication services before and after a disastrous event [1]

N. days after earthquake	# of people extracted	% of people extracted alive
0	379	87.9
1	57	35.3
2 - 3	35	8.5
> 4	77	0.0

Table 1. Data about percentage of people extracted alive in the Irpinia earthquake, Italy. Source: WHO [1]

Indeed, the immediate aftermath of such event is the one in which the most could be done to save lives. For the case of earthquakes, Tab 1 shows that after three days from an earthquake, the chances of extracting people alive are practically zero. In the 2003 earthquake which struck the city of Bam, in Iran, organized, professional rescue teams could start operating only after 3 days. In that earthquake, 43.000 people have died, and only 30 have been extracted alive [1]. This shows the importance of optimizing resources in such a short time, and a way to implement this is through the use of information, by engaging all on-site actors, and by empowering them with the information they need to take correct decisions and assume correct behaviors. Even in cases in which only specialized and organized rescue can actually intervene, the phase of initial study, in which information about the environment, the emergency, the needs, and the constraints need to be acquired before action can be planned and priority established, takes time. And this time could be drastically slashed by facilitating local information collection and diffusion.

As we have commented, the critical time interval of 3 days is one in which information exchange between all actors on site is very precious to organize rescue and mobilize resources for a first response, as well as to mitigate the human cost of such events. Unfortunately, such time interval is also the one during which the communication infrastructure is least available. Fig 2 and 3 show respectively, the amount of call attempts failed, and the amount of operational cell sites during the 2005 Katrina hurricane, in USA. It should be noted that this data is relative to a developed country, for a type of event which takes place quite regularly every few years, and which had been largely forecasted. This data shows too that after a few days the infrastructure manage to adjust to the new conditions, and revert almost completely to operational state.

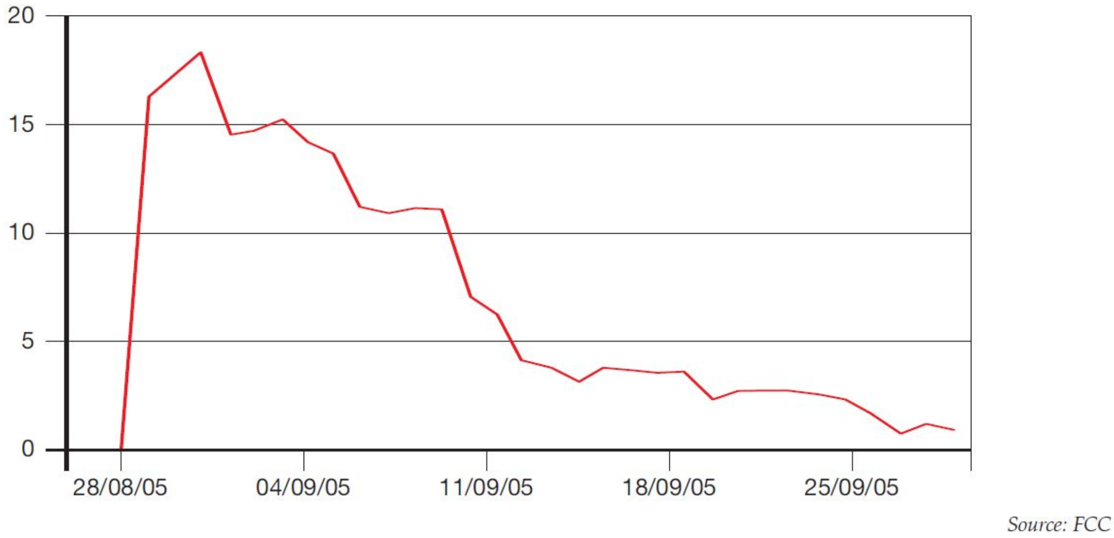

Fig 2. Daily failed calls in the wake of Hurricane Katrina, in millions [1].

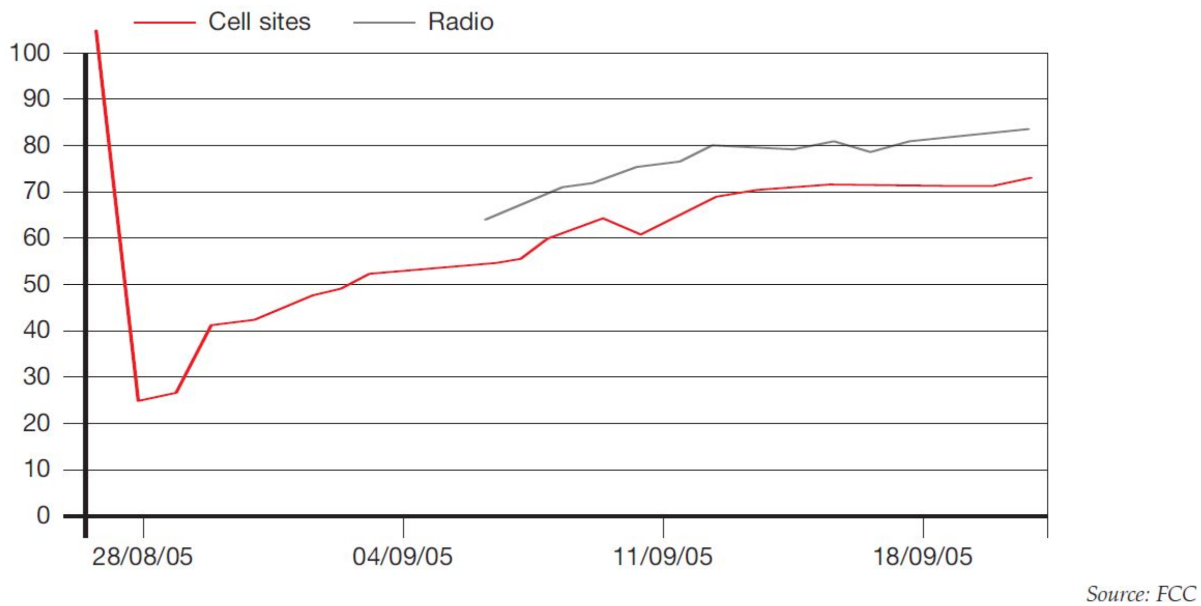

Fig 3. Percentage of cell sites and radio stations operational, in the wake of Hurricane Katrina [1]

Feasibility of a situational awareness service based on FC

A second step of our work has been to address two fundamental issues.

- What services could be implemented in such scenarios, which could be supported by the FC paradigm?

- In which conditions, in such scenarios, would FC be feasible, and what would be its performance? How to exploit the characteristics of mobility in such scenarios in order to engineer a FC application for a given target performance?

For the first issue, we chose to focus on the situational awareness application described in [3].
For the second issue, we have identified as a key issue the characterization of mobility patterns in emergency scenarios, in the immediate aftermath time period.

State of the art on immediate aftermath mobility patterns in emergency scenarios

The investigation over the state of the art has revealed that existing works on mobility patterns characterization are few, and spread over several domains (social sciences, civil engineering, medicine, epidemiologic studies, land planning and management).
A few case studies exist, from which little qualitative common traits can be inferred.
Unsurprisingly, all case studies show an increase in people mobility wrt pre-disaster state, in the first days following the disaster.
Overall temporal patterns in the first 3 days. Call records from mobile operators show that in the first 5-6 hours there is a spike in call attempts, which slowly declines during the first days. This suggests that after the critical time interval critical information has spread, so that people either know what they need to know, or they cannot get more info using the available channels.

Moreover, from the literature it emerges that, in the immediate aftermath time period, three kind of populations, and hence three different mobility patterns, can be identified:

- People who move away from the site of the disaster, possibly staying around the location of the event (to remain close to home) but at a safe distance, far enough not to be in danger, and close enough to resources (power supply, food, lodging, communications).
- People who move towards the location of the disaster. Organized rescue teams, and spontaneous, volunteers, and families of involved people;
- People whose mobility has been affected by the disaster, who got isolated and stuck by the disaster, and who need some form of help.

However, we have found very few studies which focuses on the features of such mobility patterns with the level of details required to perform our evaluations of FC feasibility and performance. Moreover, the collection of detailed data on people mobility during such events is something which has almost never been performed. Studies which focus on such mobility with a level of detail acceptable for our evaluations belong to the architectural domain. However, they have been performed with the aim of designing optimal evacuation plans in building and public places. Hence, they focus on relatively small areas and scenarios.

Given the difficulty of obtaining mobility traces, our goal has been to elaborate a mobility model which captures some of the main features of mobility which are typical of the scenarios of interest, and which affect FC performance.

In order to elaborate such model, we have focused on obtaining information which allows building realistic synthetic traces of people mobility in such scenarios.
We have laid down a strategy for obtaining this information, by contacting a set of actors in the domain of rescue and disaster response. Our hope is to exploit their feedback and their experience to reach a qualitative description of the main mobility patterns during the first three days following a disastrous event. We think that some of such mobility patterns are induced by protocols and best practices which such rescue and disaster response institutions adopt in those cases. Hence we aim at investigating such protocols in order to extract useful information for elaborating a synthetic mobility model in a disaster scenario.

The planned investigation, will form part of the contribution of the STSM applicant, as well as of the host (prof. Neukirchen, prof Hyytia) to the book chapter “2.3: Post-disaster recovery and emergency networks”. To this end, during this STSM the host and the applicant have tried to advance the design of the chapter, by defining more in detail its main focus, and by stimulating the discussion among all the other potential contributors.

Bibliography

[1] Coyle, Diane, and M. B. Childs. "The role of mobiles in disasters and emergencies." *London, GSM Association,* 2005.
[2] Masetti, Paolo. “La pianificazione in protezione civile.” (in Italian). URL: http://slideplayer.it/slide/927994/
[3] Rizzo, Gianluca, and Helmut Neukirchen. "Geo-Based Content Sharing for Disaster Relief Applications." International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing. Springer, 2017.