STSM Report

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STSM title

Modeling floating content in a disaster scenario

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Purpose of the STSM

Floating Content (FC) is in infrastructure-less communication paradigm based on opportunistic replication of a piece of content in a geographically constrained location and for a limited amount of time. The fact that it does not rely on any infrastructure makes it appealing for all those settings where infrastructure is not available or malfunctioning, for instance as a consequence of a disaster.
In this STSM we intend to analyze its feasibility in the aftermath of a disaster, as a communication service in support of applications for rescue coordination and situational awareness.

Description of the work carried out during the STSM

In the STSM, we have started by analyzing the possible scenarios of disaster, with a special focus to the local context (Iceland). We have analyzed a subset of disasters which are of economic and social interests, focusing on a well precise set of disaster scenarios of reference. We have characterized the communication network available in the island, its structure, and we have individuated some criticalities which could play a key role in case of disaster.
Next, we have considered how to make the case for the use of an ad hoc communication paradigm as Floating Content. We have considered that the lack of wireless connectivity (cellular network coverage) in case of a disaster, due either to lack of infrastructure in the interested areas, or to unavailability of infrastructure due to disaster itself, as a major obstacle to the provision of search and rescue services in the areas affected, and to the spreading of warning and information about hazards and disasters, which is key to preventing further damages and accidents following a disaster.

In order to make the analysis more concrete, we have chosen to focus on two specific scenarios, corresponding to two well defined needs which arise on the onset of a disaster. A first one is the implementation of some form of situation awareness without the support of infrastructure. A second, on the exchange of information between vehicles in the vicinity of a region interested by a disaster, in order to mitigate the effects of disasters and hazardous conditions on vehicle traffic. In both cases, we have described the services, and a possible implementation using Floating Content (FC).
Finally, for these scenarios, we have individuated some research issues which stand in the way of a realistic, practical implementation of such services based on FC. We have described and characterized these issues, and outlined some possible approaches.

Description of the main results obtained

Diffusion of information in the aftermath of a disaster

Coverage holes make any measure to mitigate consequences of a disaster hard to apply.
Disasters might exacerbate the coverage issue, further reducing availability of communication infrastructure. Indeed, at the occurrence of a disaster, various kinds of infrastructure might be not available (or only partially available), namely:

- Roads;
- Power supply (power grid);
- Cellular access network, internet, phone network.

For instance, in the reference scenario, the water flow might have erased the power lines and/or the cellular base stations, making it even harder for people in the region to be aware of the incoming hazard and of its features.
In what follows, we focus on specific issues which are relevant in case of the aforementioned disasters, and which arise from lack of communication infrastructure.

1. **Situation awareness, for search and rescue coordination in the aftermath of a disaster**.
   In such a context, one of the main aspects affecting the effectiveness of rescue operations is availability of information on the status of the affected region, on the status of operations, on the local conditions in which the rescue teams have to operate, and so on. Indeed, the lack of infrastructure following a disaster makes it hard to collect data about the pre-disaster status of the affected area, and to implement a common, shared vision of the status of the affected area, and of the ongoing search and rescue actions (situation awareness).
   Coordination of rescue and search is a key problem. Diversity of rescue teams, presence of random, untrained rescuers make coordination very challenging with delays in interventions and waste of resources.
   For instance, in the reference scenario, people already invested by the water flow typically have precious information for the rescuers (e.g number of people affected, their medical condition, strength of the water flow in their proximity, etc) but they cannot make it available because of lack of communication and because of physical isolation from rescuers.
   Coordination of action indeed can only be achieved by sharing a common information base, and achieving this without infrastructure and without prior coordination between all actors is particularly challenging. Sharing effectively info may speed up intervention, optimize it and build correct priorities for actions.
   In search and rescue operations, coordination may be facilitated if everyone shares same platform, or in any case a common vision of the current status of damages, of people to be rescued, of people who could be under rubble, and of availability of rescuers, of their skills, etc.

2. **Mitigation of effects of hazardous conditions on vehicle traffic.** In non-urban settings, under adverse and rapidly changing weather conditions, or following natural disasters affecting viability

(e.g. floods wiping off roads, earthquakes destroying bridges), road conditions are affected in a way which is hard to predict. Travelling in the areas affected by such conditions might be unsafe, given the difficulty of rescue operations in those contexts.
As an example, several unbridged rivers in the Icelandic highlands are regularly crossed by tourists in off-road cars. It depends on current and past weather conditions and type of off-road car whether they can be crossed. (Same applies for mountain hiking routes.) Errors of evaluation here are frequent, and they are at the origin of several accidents, which take place in hostile regions, often with no cellular coverage. Indeed, communications availability could enable road users to take timely and informed decisions, and to ask for help. In the reference scenario, warning vehicles of the dangers related to travelling along routes which are going to be (or are already) affected by the flow might save lives. In those cases, often some vehicles (e.g. those getting out of the zone interested by the danger) posses informations on the hazard, which could be valuable for other vehicles and people in the region.

Service Implementation through Floating Content

Being a communication paradigm which does not require (but can benefit from) support from infrastructure, FC is a good candidate for data sharing in the two scenarios depicted in the previous section.
In the **situation awareness** scenario, we assume that the mobile phones of all the people on site (and hence of both the people affected and of the rescuers) run an application which implements FC.
One possible implementation of the situation awareness service via FC, could be as follows. The app starts with fluctuating in the region affected a map of the region itself. Each participant then enriches the map with geographically contextualized information, and float the resulting, enriched map. Whenever a user receives different versions of the same enriched map (with different tags and information), he consolidates the information, possibly eliminating duplicated data and outdated information. For instance, during a floor, the first rescuers (or the people getting isolated by the flood itself, in a car or on a hill) could start floating the info on who needs help, and where it is located. But as rescue operations progress, those info are updated by other rescuers, and the enriched map is updated before being replicated. This helps creating a shared vision of the disaster area and of the status of rescue operations, without necessarily having a pre-established coordination between the different rescue teams. If the density of the users fluctuating the information is not sufficient, battery powered motes running the FC application could also be employed. They could be disseminated in the area in a random fashion, with the only constraint of keeping a minimum density of devices.
Such enriched map should allow to be updated in near-real time, and it could be used to “mark” space in the form of digital graffiti, in a context where there are no more walls for physical graffiti. Augmented reality apps could be a good way to use the info spread through the platform.

In the **vehicular scenario**, the FC application could reside on the phones of the vehicle passengers, or be integrated in the vehicle itself. In this case, the seeder could be any vehicle which detects a hazardous event (flood, etc) or an issue on the road, which the lack of communication infrastructure makes it difficult to announce in the region interested by the hazard. In this case the information would be replicated by vehicles flowing in both directions on the road. The extension of the floating region would depend on both the area interested by the hazard, and the area within which the road users should be aware of the issue.

Some research issues

To make the implementation of the services described above feasible, several research issues need to be addressed. Among these, are:

1. **FC Implementation over WIFI Direct**

In all the scenarios described, a large transmission range would be essential for FC performance. Hence, implementing FC over Wi-Fi (possibly, on Wi-Fi Direct) is an option to be explored. Existing results for ad hoc networking over Wi-Fi Direct are based on building a complex network architecture, [1] based on playing with double role of nodes (AP, and WIFI direct peer).
The main research challenge here is how to create such network structure in an automatic, unsupervised fashion, without a central coordination function, and how to maintain it in case of churn.

2. **Fast, efficient dissemination of FC App**
   The main weakness of the FC approach is its relying on the availability of an application residing on each device, for enabling content to be replicated. Of all the mobile devices present on a disaster scenario, only those endowed with such an application can take part in the exchange of floating information. As we have stated, coordination is one of the main challenges in the immediate post-disaster. Hence, managing to increase the adoption of FC application using other channels than communication itself might prove ineffective and too slow with respect to the reaction times required by the emergency.
   We propose to tackle this issue by devising an approach to effectively spread and inject the application to the largest possible amount of devices within a region. We envision that an architecture which combines Floating Content and captive portal techniques [10] could be a viable option.
3. **Modeling and evaluation of Offline Waze over vehicular FC out of urban centers**. One of the main engineering issues in FC is determining the size and shape of the region within which replication should take place. Limiting geographically the content replication is essential in order to maximize the efficiency with which bandwidth is used by FC. Existing results [9 and references therein] do not apply on a linear geometry, such as that of a highway or country road.

Future collaboration with Host institution

In order to tackle some of the aforementioned issues, we plan of looking for partnership with local institutions, associations and operators, both in Switzerland and in Iceland, which deal with rescue operations in case of hazards.
The goal is, on one side, of revising the service requirements we have characterized, checking all the possible operational constraints (e.g. battery lifetime, size of the area where information should be available). On the other side, we aim at a characterizing people and vehicle mobility patterns in the time immediately after a hazard, by collecting data about past hazards.
We plan of creating partnership with such institutions, with the aim of either getting funding for tacking issues 1 and 2, and of jointly applying for EU funding, when a suitable call will be available. As the three research issues mentioned require at least 12 MM to be tackled, our goal is to prepare the ground for these works, by collecting data, by better characterizing the issues, and by looking for collaborations with local institutions to maximize the impact of the planned research.

References:

[1] Wifi direct and AP mode:

[2] Collective response of human populations to large-scale emergencies
Quantifying Human Mobility Perturbation and Resilience in Hurricane Sandy

[3] TETRA coverage Iceland (computed models which are far too optimistic): http://112.is/utbreidsla

[4] Mobile telephone network coverage(computed models which are far too optimistic, 3G[L] refers to some long-range variant) : https://www.siminn.is/english/support/coverage/ (That page contains also a link to a PDF)

[5] 112 safetravel.is app http://safetravel.is/112-iceland-app/

[6] ICE-SAR http://www.icesar.com/

[7] Icelandic Civil Protection http://www.almannavarnir.is/english/

[8] Icelandic Road Administration http://www.road.is/

[9] Ali, S., Rizzo, G., Mancuso, V., & Marsan, M. A. (2015, April). Persistence and availability of floating content in a campus environment. In Computer Communications (INFOCOM), 2015 IEEE Conference on (pp. 2326-2334). IEEE.
[10] https://null-byte.wonderhowto.com/how-to/fake-captive-portal-with-android-phone-0167030/