Adaptive Process Coordination through Mobile File Sharing: A crisis management case study analysis

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ABSTRACT

This paper describes an ongoing project that exploits the capability of mobile sharing systems for ad-hoc wireless networks (MANET) operating in a post-emergency scenario. The aim is to support an existing adaptive process management in which users handle multimedia files (e.g. disaster photos) in a nomadic way by exploiting the capability offered by mobile file sharing middleware to reduce the connection time for each nomadic operator performing emergency workflow. The paper compares user activities with and without file sharing capability in order to show the efficiency gain that could be obtained. A preliminary discussion with example of activity diagrams evidences the benefits in terms of workflow efficiency and gives the opportunity in the software project development phase to obtain a more scalable and efficiently performing mobile adaptive process management for crisis scenarios.

Keywords

mobile file sharing, post emergency scenarios.

INTRODUCTION

Adaptive Process Management Systems (aPMS) are a powerful technology that has been recently used in emergency scenarios where operators must changes their workflow in a dynamic way. This happens especially in the case of MANET systems in which users communicating through a wireless ad-hoc network, are subject to disconnections from other nodes. A solution to this problem is to consider aPMS in which dynamically neighboring nodes change their process task by inserting proximity task (bridge) in order to maintain connectivity ([2]). We explore the case of combining aPMS with Mobile File Sharing in order to achieve in some way a disconnection-independent adaptation. In this paper we study the case of an adaptive workflow tailored for users moving in a crisis scenario with the task of capturing photos and sending them to a team coordinator. The emergency goal is to furnish a set of photos useful to understand the main reasons of the disaster. We define a case study and process schema in absence of a mobile shared file system and study the challenge provided by the use of a mobile file sharing system that allows to send photo in a distributed way with sharing capabilities (advertisements). A comparison analysis is carried out showing that emergency knowledge could benefit from aPMS combined with mobile file sharing in the sense that users are not more constrained to follow other users to maintain the connections required by the MANET. An applicative example for a case of railway disaster in which operators are faced to a real emergency happened in Italy is shown. The paper is organized in the following way. Mobile Workflows and nomadic emergency scenarios are described in Section 2 with an example of a real scenario taken from a railway emergency in Italy motivating the need to introduce file sharing to support photo exchange. Our solution with the use of MobiSHARE application designed on the top of each mobile PDA is described in section 3 and the benefit that could be obtained in terms of workflow efficiency is outlined in section 4 by comparing the two sequence diagrams (with and without MobiSHARE).

NOMADIC EMERGENCY WORKFLOW AND FILE SHARING

In emergency scenarios information sharing is a crucial task, in fact the mitigation of a crisis situation is for a large part determined by the information that is promptly available.

Many studies on crisis response and management situations evidence one of the main problems with regard to information is the incompleteness, partial availability and slow accessibility of correct and full information for an effective execution of tasks and decision-making ([5,6]). Moreover there are several examples where errors in the distribution of information between emergency response actors caused further damages. For example, in the Mont Blanc vehicle tunnel disaster on the Italy-France border, there was a scarcity of up-to-date information which played a large role in finding a prompt solution to the disaster situation (……*Communication between both sides is very limited, no coordinated efforts were made* [4]). Additionally in emergency situation, new information is continuously created, therefore a standard query-return model of information retrieval will not suffice: team members cannot continuously query a database for information they need, especially if they do not know that the information exists. Also, systems that filter and distribute information based on user-supplied (static) profiles or long-standing queries are also inadequate.

In this framework, is possible identify roles and actors and associate tasks to each role, restructuring and combining different workflows and creating on the fly new flexible workflow. Flexible (i.e. adaptive) workflow would be able to execute the new task that needs to be executed for a specific situation. Therefore, in such a system acquisition and distribution of information must be based on this adaptive model.

To deal with these issues, we propose to support such dynamic emergency management workflows by means of a software system based on file sharing through mobile users (MobiSHARE). In this way mobile operators could take advantage from the use of a shared folder with captured photos that allows a more efficient workflow execution.

We make use of the following example of Post Emergency Scenario in which rescue team operators are moving around a crisis area.

Nomadic Emergency Scenarios (NES)

Let consider nomadic emergency scenario (NES) as a post emergency scenario in which mobile team emergency operators (T1, T2,…) are coordinated by a team leader (TL) communicating through a MANET network.

Mobile nodes performs tasks following a typical Emergency Workflow in which each operator performs different tasks such as:

- Moving towards a given destination,
- Capturing photo
- Sending corresponding file to TL trough MANET communication system.

For simplicity we restrict to NES with only three operators, the coordinator team leader (TL) and two emergency operators, team member T1 and team member T2: although this is quite a strong and not real assumption, all the conclusions and result obtained in this scenario turn out still valid for groups with more than three rescuers, indeed then we will show like in these cases the results will be still more favorable because of scalability of MobiSHARE.

Another fundamental assumption is the following one: *only the team leader can assign task and take decisions;*

all the operators have the same equipment, that is equipped of a mobile device in communication with other operators with a MANET controlled by aPMS, therefore they are in a position to carrying out the same operations: to communicate with the others, to take photo, to send photos/data but they cannot take decisions autonomously. Only TL can take decisions about the next actions. We will see that adding file sharing capabilities could help much in reducing the communication overhead due to this centralized decision flow assumption.

As example of NES, we have used a real scenario coming from train disaster (derailment) occurred in Southern Italy last year.

Figure 1 shows, in simplified way, the railway disaster and the arrival of emergency team described above.

Our aim is to show how the use of MobiSHARE integrated into adaptive process management systems (aPMS) provides advantages with the respect to the use of aPMS without MobiSHARE in the sense of making collaborative response work much more effective.

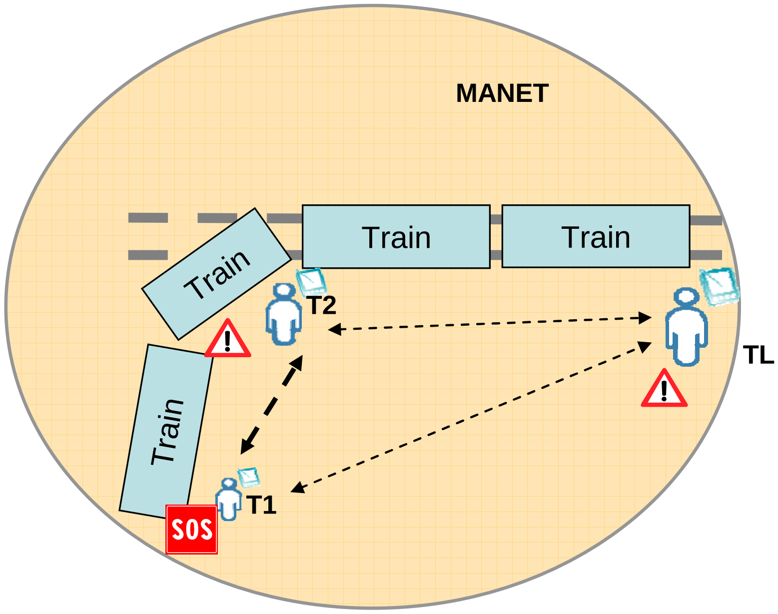

Figure 1. Railway Emergency Scenario

Photo Exchange based WORKFLOW

To describe the impact of MobiSHARE in the workflow executed on a NES we give a comparative description for an example of Workflow executed in the NES shown in Figure 1. We assume the following activities while executing the workflow.

1. T1 and T2 discovered a critical situation independently and each one of them coordinates with TL (by capturing and sending a photo)
2. After receiving T1 and T2 photos TL decides to give priority to one of the two operators (T1 in this case) by notifying to the other one (T2) and sending to him the missing photo (T1 photo) and eventually suggesting him to move close to the other (i.e. moviong towards T1).

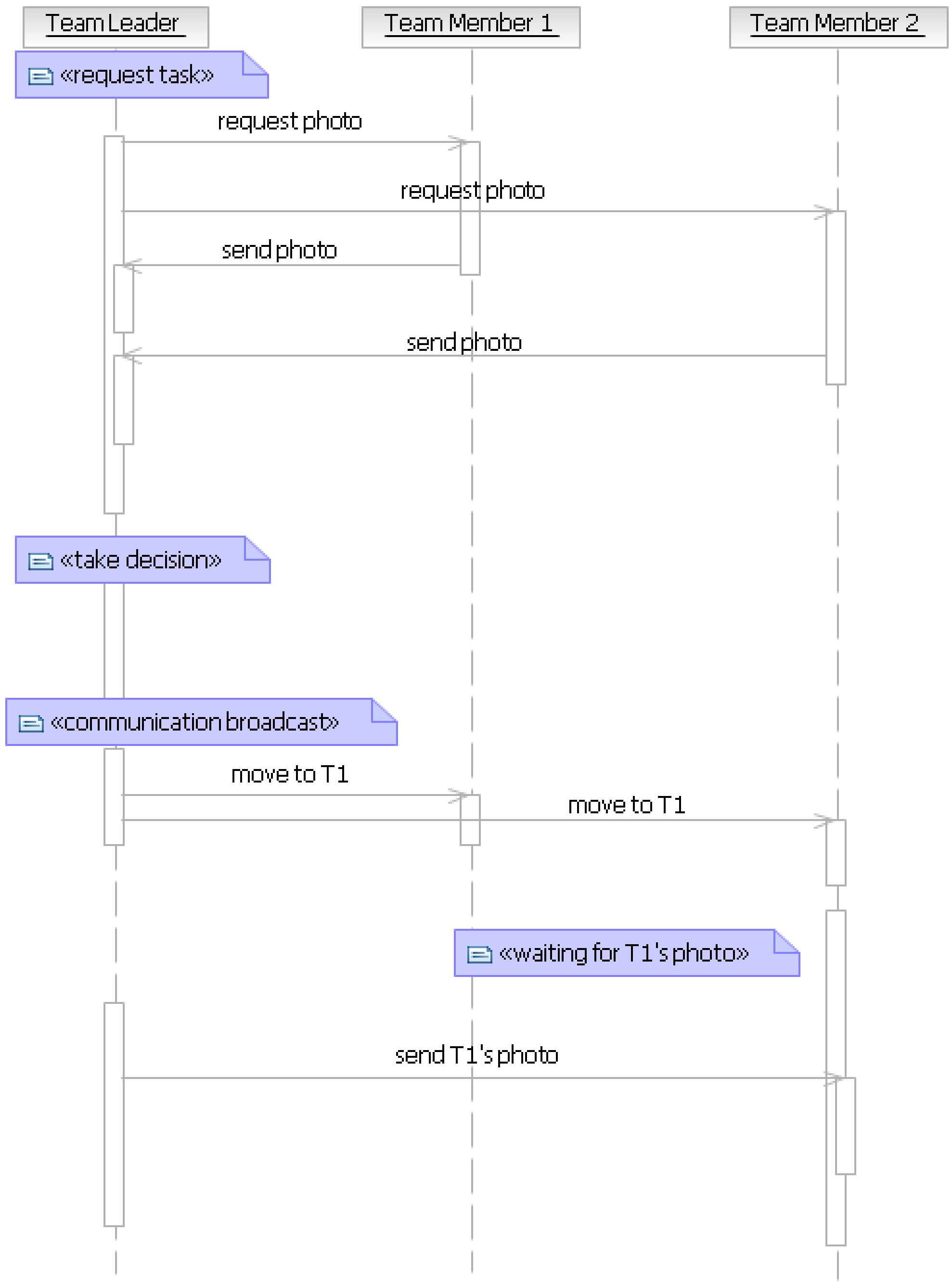

Figure 2. Emergency Nomadic Workflow Example with Photo Exchanging and Moving tasks

Figure 2 shows an example of Sequence Diagram that describes this two-steps workflow by evidencing the file exchange among T1, T2 and TL. Note that due to workflow assumptions the short-range communication link between T1 and T2 cannot be used thus avoiding the chance to improve file exchanging efficiency (T2 must wait for TL instead). On the other side, the file sharing introduction is shown in Figure 3 in which MobiSHARE provides a shared folder that allows the synchronization and the sharing of photo/data. From the communication point of view, this has the following is important because with MobiSHARE, instead, TL could limit himself to the notify/assignment task without additional photo sending and consequently T2 can download in independent way T1 photo hence gaining in efficiency and speed of execution.

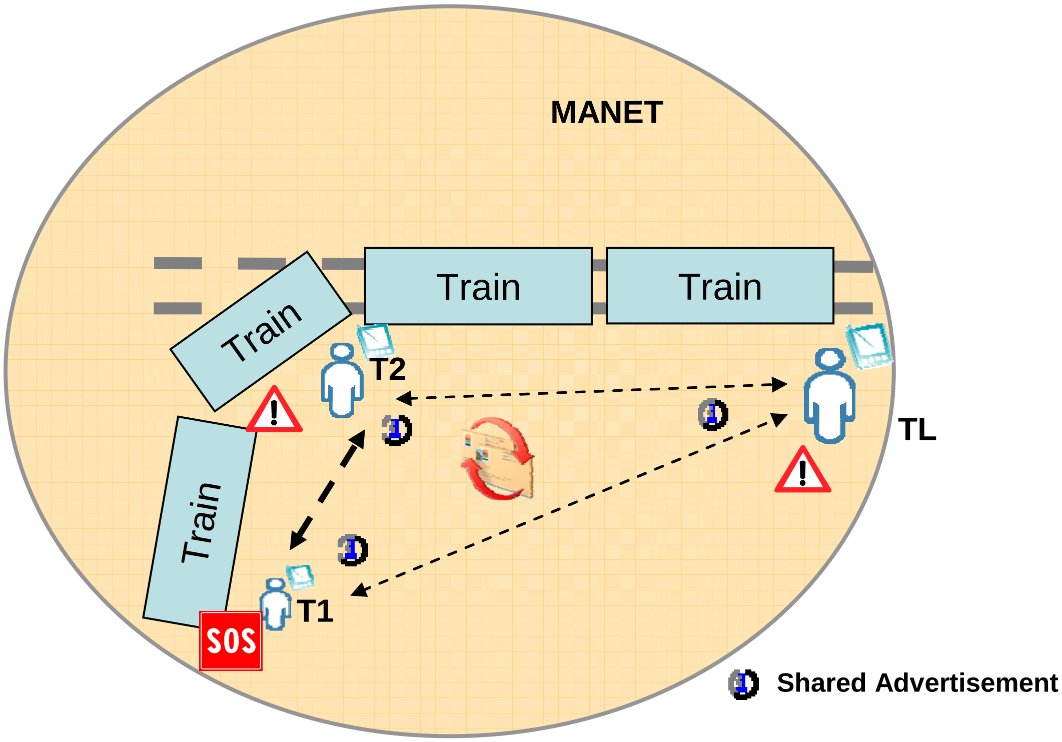

Figure 3. Emergency Scenario Workflow with MobiSHARE

In the next section we give an architectural description of MobiSHARE system with the shared advertisement behavior sketched in Fig 3. In this way a more analytical study based on a comparison between corresponding sequence diagrams could be obtained as shown in the subsequent section.

MOBISHARE OVERVIEW

MobiSHARE aim is to provide a file sharing application interface for peers nodes communicating through a MANET and using as protocol the mobile version of JXTA framework JXME (see for a description of MobiSHARE and a review on mobile file sharing systems and java platforms). Project JXTA is a open source project that defines a set of open, generalized, P2P protocols, defined as XML messages, which allow any connected device on the network – from mobile phones and wireless PDAs, to Clients and servers – to communicate and collaborate in a P2P manner. Our solution is to provide a file sharing application with the following issues:

- A low level file communication implemented by socket communication without relying on JXME pipes
- A new *shared folder advertising system* (*SFAS*) based on a cyclic advertising discovery and updated at each file communication among peers. This is alternative to share files through pipe advertising of JXME

The diagram in Figure 3 shows the overall high-level architecture of MobiSHARE. The base level is the *Messenger*, which is the core of the architecture together with the *Peer, PeerGroup, Advertisement (Peer and Share), ID Management*. Services built on top of the core platform implement functionality that may be required by a variety of P2P applications. The application layer relies on the capabilities of the Services layer to provide common P2P applications, such as *Broadcast Messaging, File Sharing*, etc.

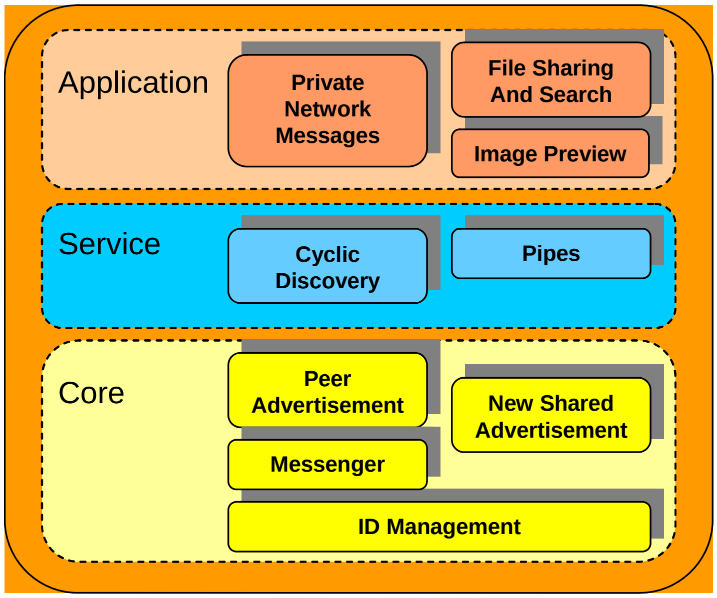

Figure 4. MobiSHARE Software Architecture

In the next section we show how the shared folder advertising is applied to a NES like the one described in the previous section.

ADAPTIVE WORKFLOW ANALYSIS

The role of advertisement based file sharing is particularly useful to improve communication efficiency in the case of workflow running in a NES like the one described above. In fact communication links like T1-T2 that could be used are discovered in the MobiSHARE discovering phase as new shared advertising. In this way, MobiSHARE takes advantage of the potentialities of a MANET in the sense that it is not more necessary to establish only point-to-point communications activated by *send operation*, but new sharing functions could be activated: for example, once executed the *capture photo operation*, the new **save&share** operation implies that it is activated automatically the ***share operation*** that allows for synchronization among the emergency operators with a shared folder in the MANET. In such way operators are not forced to receive photos/data only by TL but they could be *proactive*, as soon as shared folder could be syncronized via advertisemnt system and after that TL has assigned a precise task. From the communication point of view, the main difference is the use of a ***download operation*** instead of a send-receive communication. This has the following advantages:

- The user (or even automatically the system) could select the closest member from which to receive a detail photo/data thanks to information based on the proximity parameters.
- From theoretical/technical point of view the *send operation* is less efficient than the *download operation* because send operation requires a fixed (and synchronized) point-to-point communication; the *download operation* instead implies that there is only one active operator (that is the operator who wants to receive a detail photo/data) that can select the operator from which to take the demanded resource based on information coming from the MANET.

The figure 4 shows a comparison between the to sequence diagrams (without and with MobiSHARE) evidencing the described advantages.

With scalability of MobiSHARE, the effective gain grows to increasing of the number of the rescuers. As with MobiSHARE the workload of the TL diminishes because once identified the critical point and envoy the notification to all the operators TL does not have more the task to send the photo identified critical to every operators and therefore to establish a point-to-point communication for time. All this involves a remarkable delay in the performance of the task "*move towards T1*", as all the other operators are waiting for T1's photo from TL.

With MobiSHARE, instead, once notified the task "*move towards T1*", the TL is free to execute *send operation* for every operators involved in the task, and *T1 photo download* could be implicited executed by each other operator.

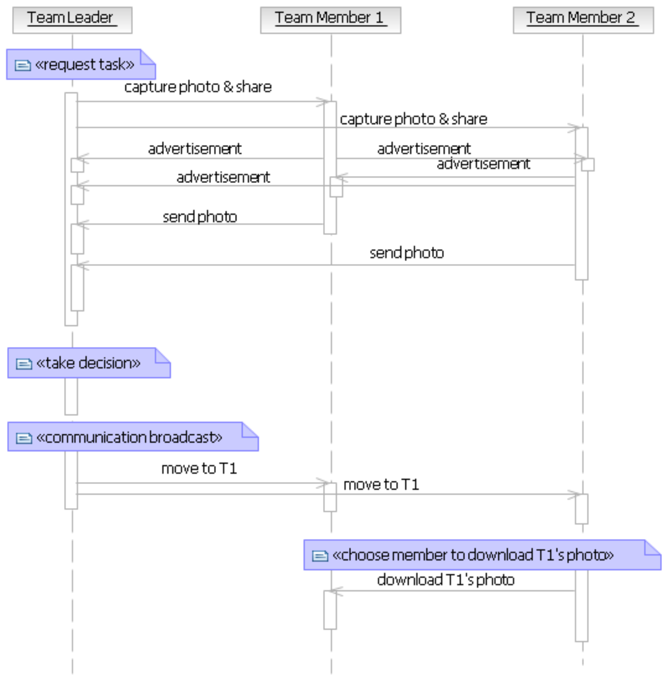

Figure 5. Emergency Nomadic Workflow Example refined with the use of Mobile File Sharing

CONCLUSION

Nomadic Emergency scenarios could take advantage from the potential communication offered by MANET systems. In this paper we exploit the idea to support process coordination among team operators moving and communicating tasks /files among them by means of a file sharing system that introduces a virtual shared folder synchronized as soon as photos are captured and saved. We have outlined a description of advantages and sketched a brief analysis of the performance gain by an analytical activity comparison based on sequence diagrams.

The conclusion is that there are sufficient reasons to motivate the introduction of a mobile file sharing system on the top of a MANET system both from a process optimization view and from a performance point of view. In a subsequent work we exploit more results by the detailed implementation and use of MobiSHARE in other projects like the one describe in [1].

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