WORKPAD: an Adaptive Peer-to-Peer Software Infrastructure for Supporting Collaborative Work of Human Operators in Emergency/Disaster Scenarios

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ABSTRACT

The system presented in the paper is the main result of an on-going European research project WORKPAD (IST-2005-5-034749) that aims at building and developing an innovative software infrastructure (software,models, services, etc.) for supporting collaborative work of human operators in emergency/disaster scenarios. In such scenarios, different teams, belonging to different organizations, need to collaborate each other to reach a common goal; each team member is equipped with handheld devices (PDAs) and communication technologies, and should carry on specific tasks. In such a way we can consider the whole team as carrying on a process (macro-process), and the different teams (of the different organizations) collaborate through the interleaving of all the different processes. The idea is to investigate a 2-level framework for such scenarios: a back-end peer-to-peer community, providing advanced services requiring high computational power, data-knowledge-content integration, and a set of front-end peer-to-peer communities, that provide services to human workers, mainly by adaptively enacting processes on mobile ad-hoc networks.

Keywords

WfMS, Adaptivity, CSCW, P2P systems, emergency/disaster

1. INTRODUCTION

The widespread availability of network-enabled hand-held devices (e.g., PDAs with WiFi - the 802.11x-based standard - capabilities) has made the development of pervasive computing environments an emerging reality.

Disaster is a broad term which can include rapid-onset natural and man-made hazards containing avalanches and railway accidents, slower creeping crisis such as drought, famine or disease and disaster events that have a different time lapse like floodings or hazardous incidents in nuclear power plants [8]. It is difficult to define a disaster because it has varying magnitudes, temporal and spatial dimensions and varying social and economic consequences. The impacts of disasters change the socio-economic environments of our life locally, in many cases regionally. For the purpose of this project, disasters can be defined as a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. The total systematic coordination activities for the prevention and respectively the coverage of natural and man-made disasters are termed as disaster management activities. These activities can be grouped into five phases. They are structured by time and function for all types of disasters. These phases are related to each other and they involve different types of skills. The preventive measures are divided into planning, mitigation and preparation activities. During the planning phase it is necessary to analyze and document the possibility of an emergency event or a disaster and the potential consequences or impacts on life, property and environment. The results of this phase are essential for the next preventive phases. Mitigation activities eliminate or reduce the probability of a disaster. It includes long-term activities designed to reduce the effects of unavoidable disasters. In the preparedness phase governments, organizations and individuals, develop plans to save lives and minimize disaster damage. Preparation measures seek to enhance disaster re-

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sponse operations. When a disaster or emergency happens, the response activities are designed to provide emergency assistance for victims. They also aim to stabilize the situation and reduce the probability of secondary damage and speed recovery actions. The recovery activities aim to return the living conditions to normal or better and they usually include two sets of activities. Short-term recovery activities return vital life-support systems to a minimum operating standard. Long-term recovery activities may continue for a number of years after a disaster. This phase represents also the first step to a new planning phase, because this is the point when the analysis of the cause of the disaster or emergency takes place. WORKPAD will focus on **response** and **short-term** recovery phases, by providing an IT software and communication infrastructure supporting operators. Nevertheless the results achieved in terms of novel data and content integration techniques for the back-end can be also exploited in the other phases; of course the response and short-term recovery phases are the more demanding ones (i.e., real-time support should be provided, reliability, security, etc.) and therefore it should be feasible to apply the achieved results also in the other phases, that present less demanding needs. Public Safety Systems (PSS), typically arranged in specialized organizational centres, are used in three phases within the disaster management. During the preparedness phase governments and organizations provide personal training in how to use the PSS. The main application of these systems is in the response phase, where computer programs give instructions to the rescue teams. In the case of the emergency situation, the emergency call will be accepted and the rescue teams alarmed and controlled. In the recovery phase PSS produce reports, maps, information showing the extent of the damage caused by the disaster. An analysis of the typical architectures of PSSs can be found in [1], in which it is also discussed how current systems are mainly centralized. The comparison shows that they can be used for emergency cases e.g., traffic accidents or small fires, where the emergency teams need GIS functions to query addresses, to find the way and to map the emergency location. The disadvantage of the compared PSS systems is that they do not use real-time traffic data such as information about the current traffic flow and traffic jams for the network analysis. They are also only partially usable for large emergencies or disasters because the covering activities of these unusual events need systems which can be used directly at the emergency locations. For these requirements it is necessary to develop mobile applications. The objective of the WORKPAD project is to investigate how to create communities of PSSs, and how to enable mobile teams to exploits such back-end PSSs through the interplay of MANET technologies, workflow management and geocollaboration.

In such scenarios, different teams, belonging to different organizations, need to collaborate. Each team member is equipped with hand-held devices (PDAs) and communication technologies, and should carry on specific tasks. In such a way we can see the whole team as carrying on a process, and the different teams (of the different organizations) collaborate through the "interleaving" of all the different processes. In turn each team is supported by some back-end center, and, in order to coordinate between teams, the different centers need to cooperate at an inter-organizational level. In the context of a recent project, a framework is proposed in Figure 1 for addressing such issues.

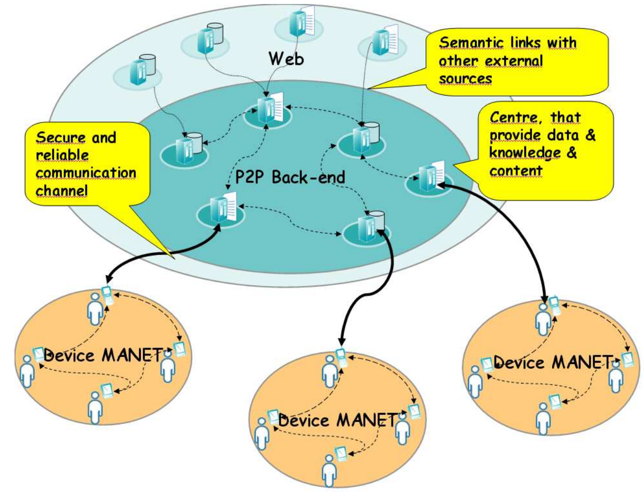


Figure 1. A 2-layer P2P Reference Framework for Emergency/Disaster Scenarios

We can distinguish between a *back-end peer-to-peer community*, providing advanced services requiring high computational power, and a set of *front-end peer-to-peer communities*, that provide services to human workers:

- The back-end community is constituted mainly by static traditional computers running in a static way, possibly arranged in a Grid, that interact in a P2P fashion. Such services, coarse-grained, require integration of data, knowledge and content. The interesting aspect is that the community is inter-organizational (each peer belongs to a certain organization) and each system is enabled to act as service provider, requestor, or integrator. In particular, the integration should be dynamic, flexible, and non-intrusive.
- A single front-end community is constituted by the operators of a team, equipped with mobile devices, connected in an ad hoc and peer-to-peer fashion, that carry on a process, in which the adaptiveness to connection/task anomalies is fundamental.

1.1 Rational and scenario

Let's consider a scenario of disaster recovery. After an earthquake (or a hurricane), a team (e.g., belonging to the Homeland Security Department) equipped with mobile devices (laptops and PDAs) is sent to the disaster area to evaluate the state of specific sites. Their goal is to document the damage directly on a situation map, and to schedule following activities (e.g., reconstruction jobs).

In literature [7] [8], disaster management activities can be grouped into five phases. These phases are related each to other and they involve different types of skills. Our scenario can be collocated on response and short-term recovery phase whose purpose is to return vital life-support systems in a minimum operating standard. This phase is anticipated by the one immediately after a disaster or emergency happens where precedence is given to emergency assistance for victims. They also aim to stabilize the situation and reduce the probability of secondary damage and speed recovery actions. Typically, short-term recovery phase is followed by long-term recovery activities that may continue for a number of years after a disaster.

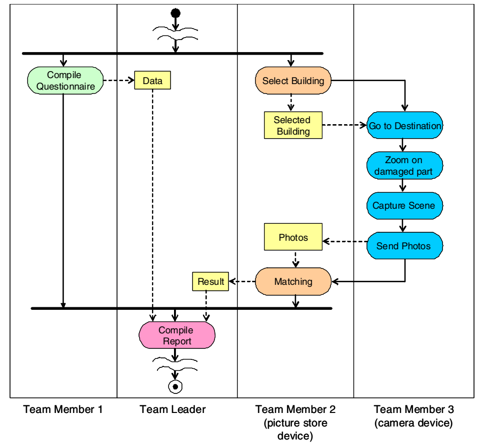
Before this typical cooperative process for short-term recovery phases starts, the team leader has stored all area details, including a site map, a list of the most important objects at the site, and some previous reports and materials. All such details have been provided by the back-end center of the Homeland Security Department, which has constructed them by integrating information, knowledge and content stored by many other peer organizations (e.g., the Ministry of Internal Affairs, some basic spatial data provided by different public and private organizations, etc.). [1]

On the front-end, the team constitutes a MANET (mobile ad hoc network) in which the team leader's device coordinates the other team members devices[2] by providing appropriate information (for example, maps, important objects, and so on) and assigning activities. Mobile (or Multi-hop) Ad hoc NETworks (MANETs, [6]) are networks of mobile devices that communicate with one another via wireless links without relying on an underlying infrastructure. This distinguishes them from other types of wireless networks: for instance, cell networks or infrastructure-based wireless networks. To achieve communication in a MANET, each device acts as an endpoint and as a router forwarding messages to devices within radio range. MANETs are a sound alternative to infrastructure-based networks whenever an infrastructure is no longer available, or can't be used, as in emergency scenarios [11]. As an example, consider what happened recently during the Katrina's emergency in New Orleans, USA: among the different communication infrastructures, only the satellite-based one survived, but it was not possible to use it for all communications of the teams working in the area, with the known dramatic consequences. Conversely, forces equipped with PDAs forming a MANET would be able to communicate each other, and exploit a possible satellite channel available to one of them (e.g., the team leader) for possible coordination with other teams. The team members' devices let them execute some operations. Such operations, possibly supported by particular hardware (for example, digital cameras, satellite-based connections, computational power for image processing, main storage, etc.), are offered as software services to be coordinated. Such a coordination is carried out by a specific coordination layer hosted by the team leader device.

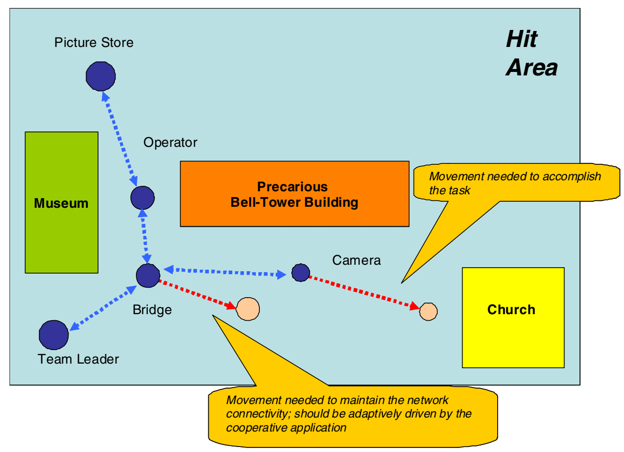
As an example of a possible process, after visual analysis of a building, supported by some map-based application, team member 1 (using his or her device, i.e. a PDA) fills out a report and enter attributes and graphic data related to the damage. The team leader will analyze these reports and spatial data, with the help of specific software, to schedule the next activities. Team member 3 takes pictures of the precarious buildings, whereas the team member 2 is in charge of the image processing of older and recent photos of the site (for example, to initially identify architectural anomalies). The outlined process is shown in figure 2(a).

[1]Please observe that the integration and involvement of a particular peer has been dynamically and adaptively decided on the basis of the specific process, which in turn depends on the given emergency situation. Therefore no pre-existing, defined integration infrastructure exists among the back-end peers, but it is rather dynamically built on-demand.

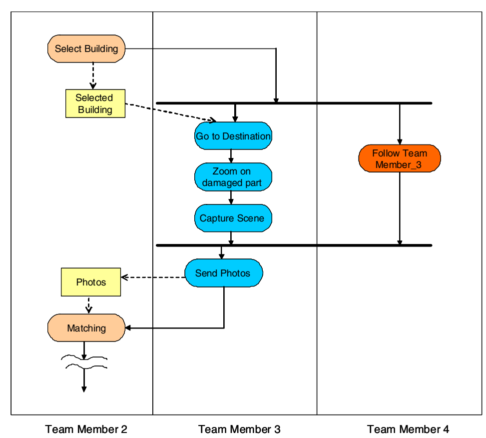
[2]Devices can be laptops (for specific requirements) or mostly PDAs



(a) Cooperative Work to be Enacted in MANET Environment



(b) Cooperative Process Modified (detail) by Adding Supporting Activities



(c) Critical Situation and Adaptive Management

Figure 2. Disaster/Recovery Scenario

In this situation, matching new pictures with previous ones might be useful. So, the device/PDA with the high-resolution camera and the device/PDA with the older stored pictures must be connected. But in a scenario such as the one in figure 2(b), the camera-equipped device/PDA's movement might result in its disconnection from the other devices.

A pervasive architecture should be able to predict such situations in order to alert the coordination layer. The coordination layer, in turn, would direct a "bridge" device (team member 4's PDA) to follow the device/PDA that's going out of range, maintaining the connection and ensuring a path between the devices (see figure 2(c)). In this way, the coordination layer, on the basis of the disconnection prediction, schedules the execution of new, unforeseen activities (note the new activity for team member 4). Such an adaptive change of the process is centrally managed by the coordination layer, which has global knowledge about the status of all the devices and takes into account idle devices, operations that can be safely delayed, and so on.

In order to support such a complex scenario, from the provision of information & content to front-end teams to their process executions, different research problems should be addressed:

- Devising a 2-layer peer-to-peer architecture, including both the back-end peers and the front-end teams.

- Investigating novel basic techniques for P2P data knowledge content integration, to be exploited on the back-end.

- Investigating novel adaptive techniques for cooperative work and workflow management among mobile devices on the front-end, with attention also to usability issues.

- Investigating how to exploit and leverage geo-referenced information, that plays an important role both (i) in the dynamic building of the back-end integration system and (ii) in the adaptive process management on the front-end teams.

- Devising safety and security solutions around emergency communications, threat detection and management, wireless communication and robust back-end networks (e.g., satellite-based), as they are key elements in helping emergency services respond in extreme situations.

The purpose of this paper is to describe how WORKPAD project aims to solve these goals by the 2-layered P2P architecture outlined in Figure 1.

The paper is organized in the following way. Section 2 introduces WORKPAD organization. Section 2.1 and Section 2.2 describe more deeply basic layers used by cooperative architecture at the level of Back-end. The other two sections : 2.3, 2.4 show the issues that have been exploited at Front-end level.

2. WORKPAD ORGANIZATION

The overall WORKPAD approach can be summarized as shown in Figure 3. Agencies/Organizations Emergency Networks (in the back-end) and Collaborative Nomadic Teams

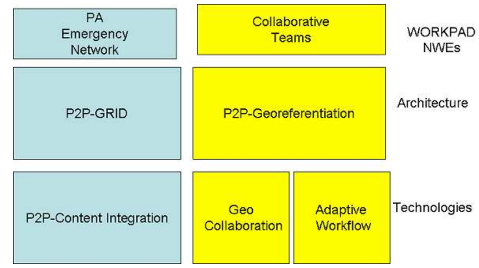


Figure 3. WORKPAD Organization

(in the front-end) are considered as the basic New Working Environments (NWEs) that will be deployed upon innovative architectural and technological results. The Peer-to-Peer (P2P) paradigm plays an important and disruptive role in the overall WORPAD organization. P2P Systems are popular because of the many benefits that they offer: adaptation, self-organization, fault tolerance and massively distribution and replication of large amount of resources. Moreover such benefits are particularly important for Collaborative Information Systems that have indeed dynamicity and fault-tolerance requirements. In recent years the two field of P2P systems and Collaborative Information systems have started to exploit the emerging idea of Collaborative P2P Information System (COPS). This direction is now being investigated by re-visiting many concepts from database systems and theory, distributed systems and communication models, with the ultimate goal of defining new COPSs tailored for different applications. In this sense, WORKPAD is an example of COPS for adaptive workflows in emergency scenarios, organized in a 2-level framework. The main issues to address are:

- at the Application/Technology level:
  - P2P Data -Content Integration: P2P information integration systems that do not rely on a single global view (ontology), but use mappings, dynamically established between peers, to collect and merge data from the various sources when answering user queries. Exchange and management of information is supported by a minimal suitable infrastructure adopted by the various peers in the system.
  - Geocollaboration in COPS: a disruptive idea that enhances WORKPAD front-end user collaboration by innovative methods for working with geospatial data.
  - Adaptive workflow management on MANETs: our approach combines local connection management among devices with global management of both network topology and task assignment.
- at the Architectural level:
  - P2P on GRIDs: Grids are emerging as a possible architecture realizing the P2P paradigm, which aim at providing a suitable infrastructure for Internet working communities, based on standardized services that implement well-established and largely supported patterns, which hides the complexity of heterogeneous data sources and handles the dynamics of the networking environment.

– P2P MANETs: devices of a team can communicate without relying on any infrastructure (which in general is not available after disasters), and sharing reliable communication channels in order to coordinate different teams.

In the following we give more details about each WORKPAD component.

2.1 P2P Data Integration

In order to integrate different PSSs/centers, WORKPAD will exploit some preliminary results achieved in the context of the Hyper framework ([2]). The WORKPAD backend framework will be based on the distinction of kinds of nodes: datapeers and hyperpeers. Each datapeer is a system that exports its data in terms of an exported schema. Hyperpeers instead do not have access to local data but are interconnected with both hyperpeers and datapeers from which they extract data. Interconnections are formally captured by mapping assertions between peers. More precisely, each hyperpeer P maintains mapping assertions in which a query q over the schema of another peer P is put in correspondence with a query q over its own schema. Informally, such a mapping assertion expresses the fact that P can use data retrieved by q from P, and that such data are mapped to the schema of P according to what is specified by the query q. Whereas datapeers are interpreted in terms of classical database instances in the First Order Logic (FOL) sense, the semantics of hyperpeers is given in terms of epistemic logic. In a nutshell the formalization based on epistemic logic reflects the idea that each peer in the system is an agent with its own knowledge of the world, and that only what is known by a peer is transferred to another peer via the mapping assertions. Given a query to a peer, query answering in the WORKPAD framework is realized by recursively visiting the peers that are accessible and generating a query plan for querying the data at the various peers and suitably compose such data to obtain the answer to the original query. Such an algorithm is sound and complete and optimal wrt data complexity since it requires time that is polynomial in size of data stored in the peers. Notably, the technique can be applied every time peers are able to do query answering based on reformulation; this ability is at the base of several recent results on data integration. The WORKPAD framework will be deployed as an OGSA-compliant Data Access and Integration Service (DAIS), where OGSA is the IBM Open Grid Services Architecture. By implementing this standard, the framework will exploit available, well supported and understood infrastructures, which allow nodes discovering, binding, and exchanging data the one another in their environment, without hierarchical constraints. Based on OGSA, the Data Access and Integration (OGSA-DAI) specification details a service oriented treatment of heterogeneous data sources/PSSs, by modeling them as Grid services. In the current proposal, based on the specific application scenario, the main improvement to the Hyper framework would consist in making a P2P data integration system able to repair inconsistent data coming from different peers. In fact, due to the rapid deployment of integrated infrastructure in an emergency situation, the quality of data and data source cannot be completely ensured in advance. Obviously, in doing this, we want to preserve the modularity of P2P systems. In order to formalize such systems we can again adopt an epistemic logic, however this time we may need to resort to forms of nonmonotonicity. In this setting we aim at devising new sound and complete distributed query answering algorithms which allow for obtaining informative answers also in the presence of inconsistency, and at characterizing their computational properties. In P2P data integration systems, each peer may want to specify information on how it trusts and/or understands peers, with respect to certain kind of data, to which it is connected, e.g., by assigning different quality values (e.g., reliability, availability, etc.) to data coming from different peers. Obviously, the best data should be preferred to the others. We aim at equipping the WORKPAD with new mechanisms enabling the specification of preference/trust/understanding assertions on data coming from different peers. By means of such assertions, a peer will be able to specify its preference for all data coming from one peer with respect data coming from another peer, but will also be able to limit such preference only to specific portions of data, e.g., data satisfying views specified on the peers schema. Preference/trust/understanding specifications will be used to solve data inconsistencies, and to rank data belonging to query answers. Indeed, when dealing with mutually inconsistent data coming from different peers, a peer may choose to trust only those data coming from the preferred peer (e.g., the most reliable one). Furthermore, in the cases in which answers to queries are constituted by a big amount of data, a peer may choose to select which data have to be first returned in the answer to the query, on the basis of preference/trust assertions.Finally, when establishing mappings with external data sources, a peer can declare the degree of understanding of the other peers schemas, i.e.the confidence that the ontological commitment conveyed through their exported relational symbols is correctly intended. Observe that preference specifications can also be used during the query answering process to avoid or delay access to peers that have a low preference degree. Once again, we stress that the possibility of setting such specifi- cations is a crucial factor when deploying and maintaining an integration infrastructure under emergency, with a limited possibility of selecting information sources accurately and in advance. A different approach in P2P data integration looks at peer data management under the perspective of exchanging data between peers. Peers are again interconnected by means of mappings, but in this case, the focus is on materializing the data flowing from one peer to another. Traditional Data Exchange is the problem of taking data structured under a source schema and creating an instance of a target schema that reflects the source data as accurately as possible. Since there may be many solutions to the data exchange problem for a given source instance, identifying universal solutions which are homomorphic to every possible solution is a crucial issue in Data Exchange. Furthermore, in order to materialize databases which are as small as possible, smallest universal solutions need to be identified.Whereas traditional Data Exchange has been the subject of several recent investigations, P2P Data Exchange has so far received little attention. However, Data Exchange in a full-fledged P2P setting remains still unexplored. We aim at facing this problem and provide results for materializing solutions which can be exploited for sound and complete query answering. We point out that materialized data can be profitably used in P2P data management in several ways, e.g., can be exploited to reduce the number of accesses to remote peers during query processing.

2.2 P2P Content Integration and Front-end/Back-end communication

One of the main framework enabling collaborative work on Internet are Content Management Systems (CMS). Most of these systems are based on a centralized architecture where most of the tasks are performed on a server accessed by many clients. In future scenarios, there will be the need to explore *global* distributed CMS alternatives. In particular in WORKPAD we have outlined the following issues:

- (Distributed CMS middleware)Some first attempts of CMS middleware are defined on top of structured P2P networks (e.g., DHT model) and they provide only a part of the CMS functions (access control and accounting). WORKPAD back-end peers requires the capability to performs tasks for which traditional CMS must be extended in a more general way. To this purpose a cooperative searching could be encapsulated in a traditional CMS and that could be used on a distributed platform to integrate web searching with P2P searching following a general search process ([3]).

- (UML extension for *Adaptive* Web Applications) Moreover the lack of design methodologies makes difficult to use P2P-based CMS for cooperative workflows. Modelling Adaptive Peer-to-Peer Software Infrastructure for Supporting Collaborative Work of Human Operators in Emergency Disaster Scenarios is much difficult due to the communication between P2P architecture and Front-end/Back-end System Interface. In order to make the developing of such project more easy, maintainable and more extensible we have introduced a paradigm design based on software components action-based. By following this paradigm we consider a Web Application as a set of small, atomic tasks, that we call actions (an action example can be for example, a Web page to perform a login operation) and which operates together. To facilitate the use of such components action-based paradigm, it has been developed (at the DIST of University of Rome Tor Vergata) a very powerful UML profile that allows, already in modelling phase, the design for an entire application according to the paradigm MVC (Model-View-Controller). Thanks this graphical interface the designer can separates an application's data model, user interface, and control logic into three distinct components so that modifications to one component can be made with minimal impact to the others.

2.3 GeoCollaboration

Current research and future trends in geospatial application development include collaborative methods for working with geospatial data. For example, in emergency management situations such as fire in the city, or a bomb attack at a special event, teams of specialists from multiple, disparate organizations often need to share (geo)information, maps, GPS locations, and other related data. They also have a need to cooperate in making decisions based on the analysis and visualization of geospatial data. A new term some researchers use to describe this approach is geocollaboration([4]and [5]). Collaboration is viewed as a committed effort on the part of two or more people to devise a new understanding or solution for a geographical decision task. Collaboration can be differentiated from cooperative or coordinated efforts in that in cooperative efforts, participants agree to work on different tasks and share results, and in coordinated efforts, participants agree to sequence the results of their cooperative effort. Geocollaboration can be then seen as a group working together to solve geographic problems facilitated by geospatial information technologies. One level of collaboration in a geospatial context involves sharing of data and/or applications by and among various individuals or organizations. It comes in a form of Internet geoinformation portals. This level of geocollaboration is at the less interactive, open community end of the spectrum and illustrates the trend toward increased awareness of the need for better geocollaboration capabilities. Tools that support geocollaboration can be useful in enabling an effective, collaborative geospatial decisionmaking process in crisis situations. Most geospatial technology has been developed to support a single user at a time. More research is needed to support group decision-making processes based on geospatial data visualization, especially in a synchronous, real-time communication mode. There has been little progress made in the realm of commercial software to provide collaborative tools that are integrated with geospatial analysis activities.

2.4 Adaptive WfMS Architecture for MANET

In this section we report our approach to the workflow management system on MANETs. It is based on the following specific assumptions:

- each device includes hardware that lets it know its communication distance from the surrounding devices that are within radio range. This isn't a very strong assumption, because specific techniques and methods are easily available, i.e., TDOA (time difference of arrival), SNR (signal-to-noise ratio), and the Cricket compass [12];

- no device in the MANET is equipped with GPS hardware, as we are interested in MANETs of low-profile devices, in which the GPS-availability (that is the availability of landmarks) is not mandatory.

- at start-up, all devices are connected (that is, each device has a path, possibly multihop, to any other device). Each device doesn't have to be within range of any other device; that is, it is not require a tight (one-hop) connection. It require only a loose connection, guaranteed by appropriate routing protocols;

- a specific device in the MANET, called the coordinator, centrally predicts disconnections and manages them by rewriting the workflow schema and (if it is required) by a reassignment of the process tasks among the participants.

The proposed approach combines local connection management among devices with global management of both network topology and task assignment. Local connection management consists of monitoring and checking one-hop communications between a device and its neighbours. It's realized as special services running on hand-held devices that implement techniques for estimating and calculating distances and relative positions (angle and direction of arrival) between a specific device and its direct neighbours.

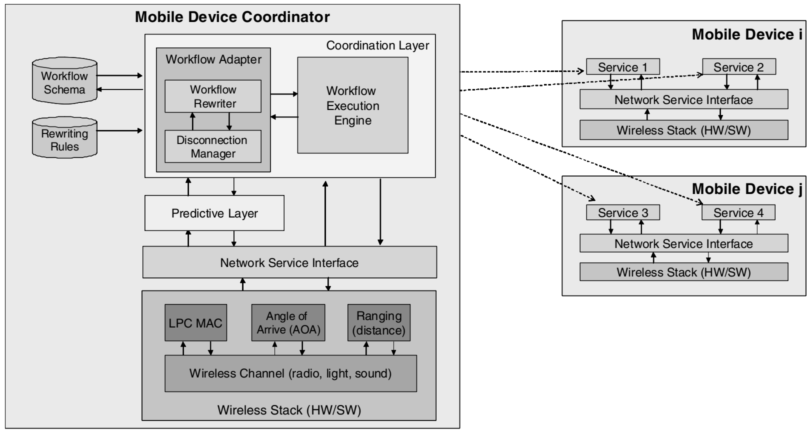


Figure 4. The Proposed Architecture for Supporting Cooperative Work on MANETs

Global management maintains a consistent state of the network and of each peer in the network. It manages the network topology (and its predicted next states) and the tasks each peer is in charge of, as well as services that peers offer (that is, it provides a service registry). On the basis of that information, the coordinator applies algorithms for choosing a bridge and/or executes workflow task reassignment when needed.

Figure 4 shows the proposed architecture: each device has a *wireless stack* consisting of a wireless network interface (the *wireless channel* and *LPC MAC* modules) and the hardware for calculating distances from neighbours (*angle of arrive* and *ranging* modules). On top, a *network service interface* [9, 10] offers to upper layers the basic services for sending and receiving messages (through multihop paths) to and from other devices, by abstracting over the specific routing protocols. Offered services (i.e., specific applications supporting tasks of the devices' human users) are accessible to other devices and can be coordinated and composed cooperatively. Some of these services are applications that don't require human intervention (for example, an image-processing utility). Others act as proxies for humans (for example, the service for instructing human users to follow a peer is a simple GUI that alerts the user by displaying a pop-up window on his or her device and emitting a signal).

In contrast, the coordinator device presents the *predictive layer* on top of the network service interface, signalling any probable disconnection to the upper *coordination layer*.

The coordination layer manages situations when a peer is going to disconnect, by applying algorithms for choosing a bridge, and by executing workflow schema restructuring and workflow task reassignment when needed (e.g., it assigns the activity "follow peer X" to the selected bridge). At the Front-end Level, in order to define processes to be adaptively enacted, the key idea is to develop and perform interaction mining in current human-to-human collaborations, human-to- service collaborations and service-to-service collaborations, to collect log data. Based on this log data, by applying process/interaction mining algorithms, we can detect and derive new collaboration patterns among humans and software applications. This newly found patterns (Adaptive collaboration patterns in Front-End Activity) could then be used to pro-actively aggregate new software services/organizations that can be valuable and reusable for further collaborative tasks. In such a way, the contribution of the project will be not only at the software infrastructure level, but also innovative ways of collaborating in emergency situations will be devised.

3. CONCLUSIONS AND FUTURE WORK

This paper has presented, WORKPAD, a system to provide a 2-layered workspace suitable in emergency scenarios for workflow management on ad-hoc networks that through

- a basic predictive layer for disconnection anomalies and
- an adaptive coordination layer is able to change the process schema when disconnection anomalies are raised.

The WORKPAD approach to New Working Environments (NWEs) is based on the interplay between emergency networks and collaborative nomadic teams on one side and geo/work-data and content integration on the other side.

The most innovative aspects of the WORKPAD system are: P2P data and content integration, Adaptive workflow management services and Geo-collaboration. The WORKPAD project will produce middleware and software components to improve the development of specific emergency IT infrastructures. At the same time, new paradigms of peer-to-peer (P2P) communication and information integration will be developed and refined in a relevant and challenging applicative scenario. Hence, the strategic impact of this project is twofold: on one hand, the application of new technologies will help addressing the new and increasing threats to public security; on the other hand, the development of an innovative solution for emergency operations will improve the state of the art in several IT emerging disciplines enabling the interoperability among different teams belonging to different organisations (fire brigades, national security, national guard, civil protection units, etc.). For that reason, the benefit we expect from this project consists in both the improvement of Homeland Security capabilities and the progress of European IT industry. The availability of a specific IT and data infrastructure for emergencies can significantly improve the quality of the intervention of first-responders. Moreover, it can effectively assist in coordinating rescue teams and operations in the first crucial days after the emergency/disaster event. Finally, it can help planning and performing recovery activities in later emergency/disaster management phases. In particular, thanks to its innovative P2P architecture, the WORKPAD framework will give the ability of integrating a mobile wireless network to a rich back-end information network in a flexible, cost-effective, reliable, and powerful manner.

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