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Universal, mobile-centric and opportunistic communications architecture

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List of Definitions

Term	Meaning
DTN	Delay Tolerant Networking (DTN) supports interoperability of other networks by accommodating long disruptions and delays between and within those networks. DTN operates in a store-and-forward fashion where intermediate node can temporarily keep the messages and opportunistically forward them to the next hop. This inherently deals with temporary disruptions and allows connecting nodes that would otherwise be disconnected in space at any point in time by exploiting time-space paths.
ICN	Information-Centric Networking (ICN) supports efficient delivery of both content and services by identifying information by name rather than the actual location. This decoupling of the information from its actual location breaks the need for end to end connectivity thus enabling much wider flexibility for efficient content and service retrieval. ICN also inherently supports caching thus enabling much better localised communications.
Content	Content refers to a piece of digital information that is disseminated and consumed by the end user equipment.
User	An entity (individual or collective) that is both a consumer and a relay of user services.
User Service	Context-aware services are considered as a set of mechanisms that assist incorporating information about the current surrounding of mobile users in order to provide more relevant of services.
User Interest	A parameter capable of providing a measure (cost) of the “attention” of a user towards a specific (piece of) information in a specific time instant. Particularly, users can cooperate and share their personal and individual interests that enable the social interactions and data sharing across multiple users.
User Requirement	User requirement corresponds to the specifications that users expect from the application, device or network.
Upstream	Upstream traffic refers to traffic sent from the user equipment to the network.
Downstream	Downstream traffic refers to traffic sent from the network to the user equipment.
Gateway	Gateway typically means an equipment installed at the edge of a network. It connects the local network to larger network or Internet. In addition, gateway also has the capability to store services and contents in its cache to subsequently provide localized access.
Customer Premises	Customer Premises relate to residential households and enterprise market and are, as of today, controlled by the end user.

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Term	Meaning
User-centric	User-centric refers to a new paradigm leveraging user information at large to deliver novel content or services by users towards other users.
UMOBILE System	UMOBILE System refers to an open system that provides communication access to users through wired or wireless connectivity. This system exploits the benefit of local communication to minimize upstream and downstream traffic. The service or content can be exchanged and stored in several devices such as gateways; user equipment; customer premises equipment such as Wi-Fi Access Points in order to efficiently deliver the desired contents or services to end users.
UMOBILE Architecture	A mobile-centric service-oriented architecture that efficiently delivers content and services to the end users. The UMOBILE architecture integrates the principles of both DTN and ICN to enable reliable delivery of both content and services to the end users.
User-equipment	User-equipment (UE) corresponds to a generic user terminal (for example a smart phone or notebook). In terms of UE and for operating systems we consider mainly smartphones equipped with Android; notebooks with UNIX, Windows, Mac OS.
Social Trust	Trust which builds upon associations of nodes is based on the notion of shared interests; individual or collective expression of interests; affinities between end users.
Application	Computer software design to perform a single or several specific tasks, e.g. a calendar and map services. In UMOBILE, context-aware applications are considered.
Incentive	A factor (e.g., economic or sociological) that motivates a particular action or a preference for a specific choice.
Service	Service refers to a computational operation or application running on the network which can fulfill an end user's request. The services can be hosted and computed in some specific nodes such as servers or gateways. Specifically, services are normally provided for remuneration, at a distance, by electronic means and at the individual request of a recipient of services. For the purposes of this definition; *"at a distance"* means that the service is provided without the parties being simultaneously present; *"by electronic means"* means that the service is sent initially and received at its destination by means of electronic equipment for the processing (including digital compression) and storage of data, and entirely transmitted, conveyed and received by wire, by radio, by optical means or by other electromagnetic means; *"at the individual request of a recipient of services"* means that the service is provided through the transmission of data on individual request. Refer to D2.2 for further details.

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Term	Meaning
Trust Association	An unidirectional social trust association between two different nodes.
UMOBILE gateway	Role (software functionality) which reflects an operational behavior making a UMOBILE device capable of acting as a mediator between UMOBILE network(s) and non-UMOBILE network(s).
UAV	Unmanned Aerial Vehicle, which is an aircraft with no pilot on board.

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Executive Summary

This document covers user requirements for the UMOBILE architecture, from the perspective of the end users. The goal is to ensure that there is an alignment on DTN as well as ICN requirements for end users, in order to support information or data-centricity.

The mentioned requirements shall be integrated in the protocol stack located in end user devices and eventually, customer premises equipment.

As the first step and in the context of task 2.1, the UMOBILE consortium has been discussing typical accessibility scenarios and requirements in different environments, namely, urban, remote and disaster areas. The project has analysed assumptions and requirements, as well as related literature, and technology. A key focus relates to the applicability of social interaction, derived from contacts between citizens not necessarily acquainted, and how different applications and services will see and perceive different user requirements.

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Section 1-Introduction

The main objective of UMOBILE is to develop a mobile-centric service oriented architecture that efficiently delivers content/service to the end users. The UMOBILE decouples services from their origin locations, shifting the host-centric paradigm to a new paradigm - one that incorporates aspects from both information-centric and delay tolerant/opportunistic networking with the ultimate purpose of delivering an architecture focused on:

1. improving aspects of the existing infrastructure (e.g., keeping traffic local to lower OPEX);
2. improving the social routine of Internet users via technology-mediated approaches.

UMOBILE aims to push network services (e.g., mobility management, intermittent connectivity support) and user services (e.g., pervasive content management) as close as possible to the end users. By pushing such services as close to the users as possible, we can optimize aspects such as bandwidth utilization and resource management. We can also improve the service availability in challenged network environments. For example, users in some areas may suffer from intermittent and unstable Internet connectivity when they are trying to access the services.

The present document describes user requirements for UMOBILE architecture by taking into account the perspective of the end users. Its main goal is to guarantee the alignment on DTN [1] and ICN [2] requirements for end users in order to support information-centricity and data-centricity.

The document is organized as follows: Section 2 covers the applicability areas of UMOBILE providing requirements that assist in defining the main challenges in the different areas. Section 3 provides examples of applicability cases detailing for each, the main actors, type of equipment involved, assumption and requirements. Section 4 summarizes the assumptions and requirements from the perspective of an UMOBILE end user.

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Section 2-UMOBILE Areas of Action

UMOBILE focuses on three specific types of areas, namely: urban, remote, and disaster areas.

An **urban area** typically refers to an area wherein the network infrastructure is well connected. Users can directly connect to various networks such as cellular networks, Wi-Fi hotspots in the town and fiber/cable Internet at home. In such urban scenarios, UMOBILE considers the following assumptions:

- The network topology tends to be dense, as a lot of users carry wireless enabled devices.
- There may be clusters of devices with strong interference.
- Environments are user-centric [3][4], i.e., nodes correspond in their majority to end user devices carried by humans and therefore, exhibit roaming movement patterns that share features of human mobility.
- Some user services may be stored closer to/in end user devices (e.g., content).
- User behaviour is very dynamic (i.e. users move and interact according to social ties [5], interests [6]) imposing increased challenges (lack of end-to-end paths) to content/service exchange [7][8].

A **remote area** typically refers to a vast geographical area having only intermittent network connectivity (e.g., a national forest, an isolated island, a rural village). In remote areas, UMOBILE assumes that the Internet access conditions are limited, e.g., limited bandwidth of upstream and downstream. It is also assumed that a gateway at the remote area can request the services/contents and cache them whenever network connectivity is available. As a result, users can continue using the services during the periods of offline connectivity, since the services are locally cached and available [9]. Furthermore, the UMOBILE system aims to utilize the potential of opportunistic and delay tolerant networking allowing service requests and responses to be passed through the intermediate nodes (serving as the data mules) until reaching the hosted service nodes and end users. The intermediate node can be a device carried by a user in a car between e.g. a remote area and an urban area; UAVs flying around these areas; a car itself. Hence, in the context of user requirements, underlying assumptions in this scenario are:

- The network topology tends to be sparse.
- The network exhibits partitions (in time and space).
- Environments are user-centric.
- Some user services can be stored in gateway nodes.
- Gateway can be considered as a mobile gateway moving across different locations.

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- Only few end user devices will be part of the network and hold networking services.
- Content/service may be exchanged based on users social engagement and interests to improve the utilisation of scarce resources.

In a **disaster area**, the actual network infrastructure is partially or fully disrupted. The UMOBILE takes advantage of all available Internet access technologies, e.g., 3G/4G, ad-hoc wireless deployment, satellite and UAV links. Furthermore, rescue operation teams can install the ad-hoc UMOBILE hotspots across the disaster area and also use the UAVs equipped with Wi-Fi to create a local network infrastructure. As a consequence, the UMOBILE users will be able to retrieve emergency services and communicate to other users. Assumptions in this scenario are:

- Network is self-organizing.
- Network is divided to partitions and each partition may have intermittent connectivity.
- There are both fixed and mobile gateways.
- Some end user devices will be part of the network and hold networking services, e.g., shared Internet access.
- Different social groups (e.g., doctor, police, emergency teams, civilians) and interest on disaster-relief content can help mitigating the effects of lack on readily available infrastructure. Users have a humanitarian behaviour.

Considering that UMOBILE integrates delay tolerant networking/opportunistic networking as an inherent feature, it is mandatory to support reliable and efficient transmission of information.

Section 3-Applicability Scenarios

The diversity of possible services in UMOBILE is illustrated in this section via four main applicability scenarios: *micro-blogging, emergency situation, civil protection* and *social routine improvement*. These applicability scenarios are mapped to the requirement of the three main areas described in Section 2.

3.1 Micro-blogging Function Scenario

The micro-blogging UMOBILE use-case allows users to generate and to share expressions of interest in the form of tagged information (time-space tag correlated with data timely and, in some cases, geographic meaningfulness) to the UMOBILE system where all UMOBILE users can benefit from the local information such as an interesting event, recommended place and social interaction activities. The sharing policy of such

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information is based on the dynamic computation of social trust circles [10] and event subscriptions defined by users and/or recommended by the system. Particularly, the UMOBILE users will be able to exchange and share information, e.g., photos, videos, social text comments among the contacts in their trust circles. Users' devices do not have to be always connected to the Internet. Data is exchanged among people passing by based on the social interaction approaches. Local hotspots may store data based on its local context. Such data may be further disseminated among other peering hotspots in the city.

The UMOBILE system will keep track of the local event and update useful information to the subscribed users. This information can be referred to the availability of some form of service, as well as to user experience and user perception shared among users.

Therefore, a micro-blogging service will exploit the potential context-aware computing to provide useful information to the user at the right time. For instance, a user that has posted interest in an art exhibition at a local gallery will automatically receive some useful information such as available car parking places, number of available tickets and users' comments about this exhibition when he/she moves close to the place.

Moreover, in crowded events, such as a music festival, the UMOBILE system can monitor the activity of the assistants in the different areas where the event is taking place. The management can use this information, for example, to control the staff's positions in different areas.

In addition, the UMOBILE is an open system and compatible with other social applications. In case the requested service is not available in the domain, the UMOBILE system can automatically retrieve the service instance and instantiate within the domain to achieve local communication. Regarding retrieving and disseminating information, the UMOBILE system will take advantage of all available connectivity (e.g., wired or wireless) and intelligently choose the most suitable transmission protocol depending on the network environment.

3.1.1 Description

It is Saturday morning and Bob decides to go out for shopping: In the afternoon Bob will drive to Glastonbury with his friends to attend the music festival. Since Bob does not want to spend too much time shopping, he uses the UMOBILE micro-blogging functionality in his Android smartphone, while entering Oxford street, to get information from other people about nearby sales (Figure 1). While strolling between some shops, he registers micro events that take place (e.g., interesting articles, street events).

In the afternoon Bob picks up his friends to go to Glastonbury. When Bob moves close to the Tate Gallery (three blocks away), his UMOBILE application gets a notification about the availability of tickets for an exhibition from Salvador Dali that he had posted interest 2

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days before. Since the waiting time in the ticket office is lower than 20 minutes, he and his friends decide to make a stop over to visit the exhibition at Tate Gallery. Since parking is very difficult around the Tate Gallery, Bob uses the UMOBILE application to get acquainted with the best streets to park, based on the experience of other people in his trust circles. On the way to Glastonbury, Bob drives by an accident on M3: he posts the event on the UMOBILE application. Due to the local importance of his post, data is collected by a nearby hotspot. The hotspot disseminates collected data to other hotspots that subscribed traffic-jam events on the UMOBILE application: this allows other Micro-blogging users to avoid M3 on that area (Figure 2).

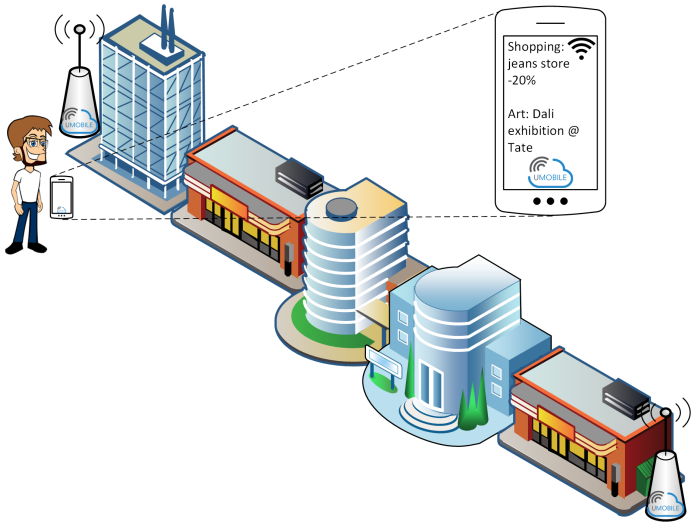

Figure 1. Micro-blogging scenario: Context-aware information retrieval

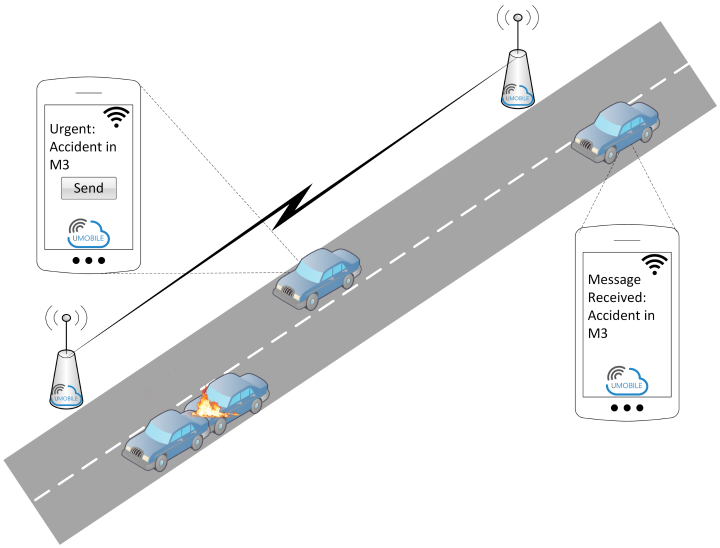

Figure 2. Micro-blogging scenario: Accident warning

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In the festival area, the UMOBILE system has been deployed in order to provide free Wi-Fi local communications to music fans. The UMOBILE UAVs circulate between the different activity areas to record images about the festival. After enjoying the Radiohead concert in the festival main stage, Bob does not find the next artist interesting. In the meantime, his friend, Alice, is in a secondary stage where a not well-known group has the audience really motivated. Alice posts a message of the status and a picture through UMOBILE. The notification is made available for the rest of the people in the festival area, both through hotspots and through UAVs. Since Bob had subscribed high interest about Alice's posts (they have similar music tastes) he can see through the notifications which area is most interesting for him at this given time and does not have to walk to a new area to find something he dislikes. In the meantime the management of the festival can monitor the activity in each of the areas in real time, or whether participants are unhappy based on the images provided by the UMOBILE UAVs: the management team uses such information to control the positions of staffs in the surrounding area. This local event communication scenario is illustrated in Figure 3.

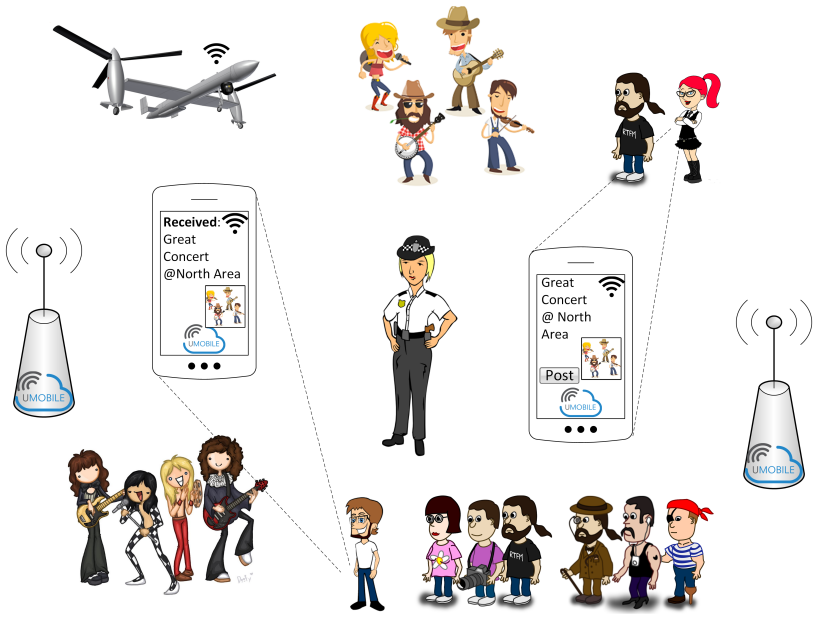

Figure 3. Micro-blogging scenario: Local event communication

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3.1.2 Characteristics and Actors of the Application Scenario

- Communication takes place between devices which belong to the same or different trust circle.
- Data is exchanged based on the expression of users' interests.
- Data is exchanged based on how socially well connected an intermediate node is to others interested in such data.
- Users carry UMOBILE-enabled devices holding the UMOBILE application.
- The UMOBILE hotspots collect relevant information (e.g., road accident, local events).

3.1.3 Assumptions

- Social trust computation is performed dynamically.
- There are cooperation mechanisms that allow nodes to exchange information with unknown nodes (i.e., newly encountered with whom no trust association is yet available).
- Users are given incentives to cooperate.

3.1.4 Requirements

- Users shall have access to the services through wired/wireless connectivity.
- Users must be able to exchange data using any form of Internet access, and even when not connected to the Internet.
- Users shall provide only information (e.g., photo, concert info) that they are interested in and willing to share.
- Users shall receive only information (e.g., photo, concert info) that they are registered and interested in.
- Users shall add initial preference based on their interests (e.g., local event music, shopping, food, art).
- Users interests shall be learned as they use UMOBILE services.
- Users' privacy must be ensured.

3.2 Emergency Situation Scenario

In emergency situations, traditional communication services such as fixed or mobile network and local Internet access are completely/partially inoperable. Furthermore, circumstances of this particular situation imply that the people involved may experience additional difficulties in receiving and dealing with emergency information, which may prove to be critical.

Therefore, the design of the UMOBILE system aims to support these particular aspects, expecting to assist users in disseminating emergency information directly via end user

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devices as well as via the UMOBILE hotspots and UAVs. Such emergency information can be shared among UMOBILE users and also forwarded to the local authorities (e.g., fireman, rescue teams).

In such cases, information shall comprise expression of interests in the form of photos, voice or written messages. It is also expected to comprise alert messages concerning public safety. However, regarding the limited bandwidth connectivity, emergency services will have higher priority over other services [11].

Hence, the UMOBILE application shall have an emergency functionality that allows the user to take photos and describe events with a short voice or short written message, and whenever feasible, integrate geo-location as well as social contacts (e.g., to assist in looking for other persons). The data is expected to be passed directly via any means of connectivity: short-range, between end user devices; long-range, via the available types of Internet access.

3.2.1 Description

It is Monday morning and Bob goes for mountain climbing, as usual. While trying the usual path, Bob starts to see some smoke in the vicinity of the path. He uses the emergency functionality of his UMOBILE application to take some photos, and describes the event with a short voice or written message. Geo-location is automatically added. As illustrated in Figure 4, Bob tags that info as “urgent” and makes it available to be shared globally, as he has no cellular coverage.

Figure 4. Emergency scenario: Emergency message tagging

After that, Bob decides to continue his trekking exercise in an alternative path close to main roads, where he passes by several cars. Drivers, including Henry, are UMOBILE users, whose app collects any emergency info by default, after checking its authenticity

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(Figure 5). Henry drives towards home. As soon as Henry enters the city limits he is notified by his smartphone that he gained some points within the UMOBILE community since he just participated in an emergency situation: his smartphone passed the message towards an authorized emergency entity via UMOBILE system using all potential access technologies, e.g., whenever 3G was present. Upon reception of such message, a team of firefighter is sent to the location. They use UAVs equipped with Wi-Fi to create a local communication infrastructure: the UAVs are instructed to keep a formation able to cover the complete area affected by the fire. The video cameras on the UAV are used to provide the several control units in the field with real-time images of the ground.

In the meantime, Henry continues his trip to take his children to school before going to work. While at work, Henry and his wife Alice, who work in the other side of town, start getting notified by their UMOBILE application that an earthquake is happening: they use the UMOBILE application to subscribe to the emergency alerts from the local authorities. They try to call each other, but the cellular communications are not working. Hence, they use the UMOBILE system to disseminate these small messages among the UMOBILE users. They also collect information from the authorized authority about the safe places to go. They agree to go to the same safety location. After the earthquake is over, since communications are still off, they use the UMOBILE application to listen to the notifications sent by their children school. They realized that their son Karl is missing. They immediately send a search request with the description of their son. UMOBILE users in the city start getting the request, since all UMOBILE users subscribe by default the emergency service. One citizen located their son, takes a photo, adds a voice message from Karl and tags the message with the geo-location. That information is received by Karl's parents and by the authority responsible by the rescue operation. Instructions are given to bring Karl to the safety location where his parents are.

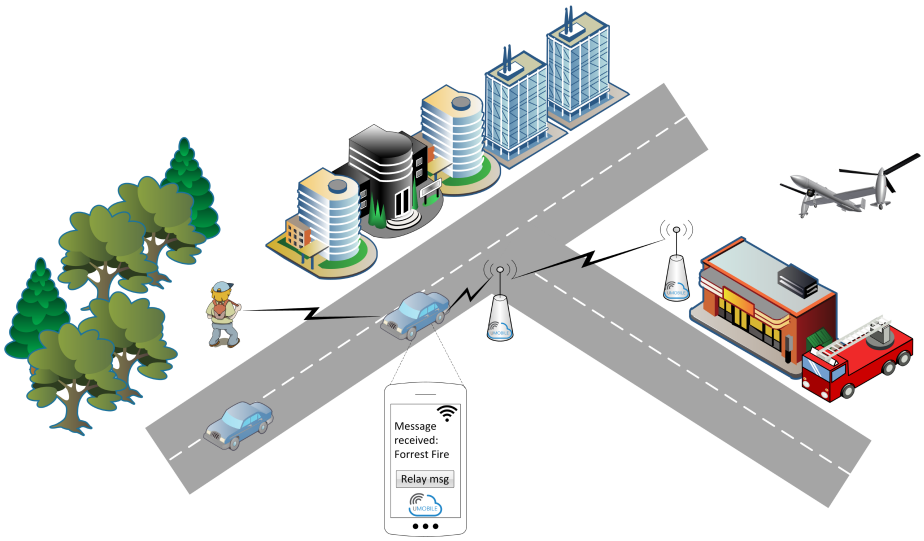

Figure 5. Emergency scenario: Emergency message dissemination

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In the meantime, the rescue authority starts detecting a high communication delay in the message sent by people in the north neighbor of the city. A fleet of UAV is sent with the mission to create a spontaneous communication infrastructure in the area.

3.2.2 Characteristics and Actors of the Application Scenario

- Communication takes place between devices which which belong to the same or different trust circle.
- Any contact opportunity is exploited.
- Data is exchanged based on the expression of users' interests.
- Communication experiences strong partitions (intermittent connectivity with potentially long delays).
- Users carry UMOBILE-enabled devices holding the UMOBILE application.
- The UMOBILE hotspots collect and emit relevant information (e.g., alert message).

3.2.3 Assumptions

- The network is self-organized.
- Users have a cooperative behaviour.
- The UMOBILE hotspots assist in disseminating information (thus reducing partitions).
- The mobile gateways (UAVs) assist in providing connectivity as well as disseminating information.

3.2.4 Requirements

- Users must be able to exchange data using any form of Internet access, and even when not connected to the Internet.
- Users shall receive emergency information (emergency event is registered by default).
- Users must be able to issue an emergency request/post, i.e., tagged as "urgent".
- Users should not receive outdated emergency messages.
- Users shall receive only emergency information relevant in that area [12].

3.3 Civil Protection Scenario

UMOBILE provides mechanisms that may assist responsible authorities in the case of challenged events. For instance, in the case of an earthquake, authorities in the affected areas can exploit data from different sources (satellite imagery, sensor-based, UAVs) to efficiently organize their efforts. While satellite images are used to analyze the state of the affected areas, UAVs are used to set up communications in areas where networks were damaged. Such communication infrastructure is used to exchange sensing data collected by mobile devices/objects such as smartphones, wearable devices, sensor-equipped

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vehicles. Such sensing data can be related to the environmental conditions (e.g., atmospheric pressure, temperature, noise) as well as to the human conditions (e.g., detection of people subjected to high anxiety levels). Local authorities rely on urban dynamics and social event monitoring to provide data for decision-making. Situational information as well as decisions taken are available in real-time to all neighbor cities and to all drivers that may be present in areas that may be affected (data dissemination is configured based on the geographic spreading of the flood).

However in the remote and disaster areas where Internet connection is intermittent, it may not be feasible to collect and deliver the sensing data to the local authorities, which are located faraway. In this situation, the UMOBILE can migrate services from the authorities to be stored at the gateway of the target areas (the computation and data collection can be controlled at the edge). Consequently, the processed data and sensing data will be synchronized with the local authorities whenever the connection is available (e.g., connecting through UAVs).

3.3.1 Description

Bob and Alice like to stroll nearby their home, which is near a nice river. However, on this particular Saturday, the place is crowded with people that are participating in a local fair. While Bob and Alice are trying to keep their regular path near the river, Bob gets a notification on his UMOBILE application that it will be difficult to continue in that path in 100 meters. Bob and Alice decide to circumvent that area via the street recommended by the UMOBILE application. UMOBILE system handles the service retrieval and delivery in case the requested service is not in the domain (e.g., the map service in our case).

In the meantime their friend, Peter, who also likes to stroll near the river, was caught in the crowd. Peter is alerted by his UMOBILE application about the easiest way to get out of there. Peter tries to call home, but the cellular network was not available due to the overload of calls: Peter decides to use the UMOBILE application to chat home (via the opportunistic network built up by UMOBILE personal devices): in the meantime Peter is notified by the UMOBILE application that he may use Skype to call home (via a set of instantaneous access points deployed by the Police via drones that were flying over the area). During the skype call, Peter's wife, Jenny tells him that the river passing by her brother's town, 100 Km north, is flooding the area.

Peter gets anxious about the flooding getting to their city. In the meantime authorities in the affected town are exploiting data from different sources (satellite imagery, sensor-based, UAVs) to efficiently organize their efforts. While satellite images are used to analyze the extension of the flooded area, UAVs are used to set up communications in areas where networks were damaged. Such communication infrastructure is used to exchange sensing data collected by mobile devices/objects such as smartphones, wearable devices, sensor-equipped vehicles. Such sensing data can be related to the environmental conditions (e.g.,

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atmospheric pressure, temperature, noise) as well as to the human conditions (e.g., detection of people subjected to high anxiety levels). Local authorities rely on urban dynamics and social event monitoring to provide data for decision-making. Situational information as well as decision taken are available in real-time to all neighbor cities, and to all drivers that may be present in areas that may be affected by flooding (data dissemination is configured based on the geographic spreading of the flood). The usability of UMOBILE in flooding situation is illustrated in Figure 6.

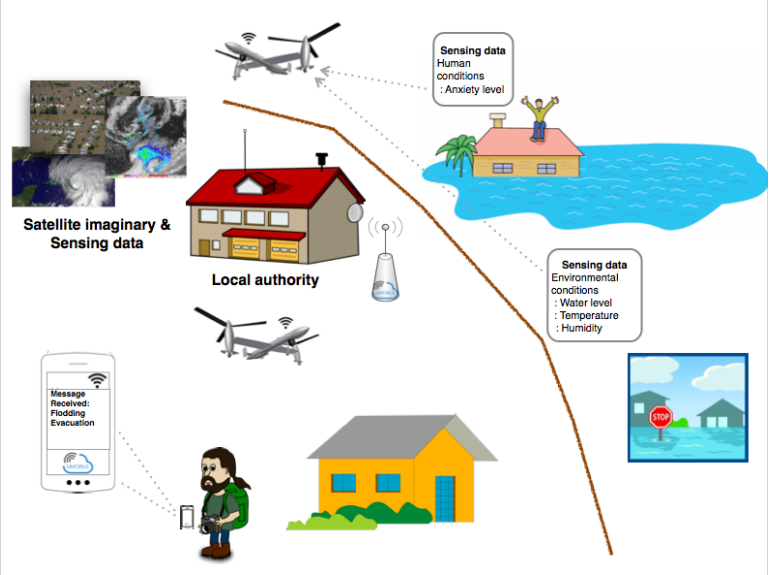

Figure 6. Civil protection scenario: Data dissemination in a disaster situation

3.3.2 Characteristics and Actors of the Application Scenario

- Communication takes place mostly between the UMOBILE hotspots and user devices.
- Any contact opportunity is exploited.
- Data can be controlled by local authorities and gateway at the edge.
- Users carry the UMOBILE-enabled devices holding the UMOBILE application.
- The UMOBILE hotspots collect and emit relevant information.

3.3.3 Assumptions

- Social trust computation is performed dynamically.
- There are cooperation mechanisms that allow nodes to exchange information with unknown nodes (i.e., newly encountered with whom no trust association is yet available).
- Users are given incentives to cooperate.

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3.3.4 Requirements

- Users shall access to the services through wired/wireless connectivity.
- Users must be able to exchange data using any form of Internet access and even when not connected to the Internet.
- Users shall provide only information (e.g., photo, concert info) that they are interested in and willing to share.
- Users shall receive only information (e.g., photo, concert info) that they are interested in and registered.
- Users shall add initial preference based on their interests (e.g., local event music, shopping, food, art)
- Users must take part in the dissemination of civil protection content.
- Users' privacy must be ensured.

3.4 Social Routine Improvement Scenario

A fourth aspect supported by UMOBILE is the capability to capture personal data based on the social routine of UMOBILE users, keeping it local, and with the sole purpose of improving the user's routine. The system shall perform simple and complex activity recognition, and learn with the users' habits to improve and prevent aspects such as social isolation, which is an increasing problem e.g., in urban areas. This aspect of UMOBILE can also be relevant to improve the development of social cohesion in remote areas giving rise to new forms of collective expression (e.g., groups of interest) as well as of collective services (e.g., organic farming in a rural village).

To address such aspects, we are considering non-intrusive capture of data. For instance, understanding the affinity network of a user; his preferred visited locations over time and space. Such data may be shared in specific trust circles (e.g., family) with prior user authorization. The data shall be kept local on the end user devices and customer premises authorized devices. If it turns out interesting, the functionality may be integrated also in scenarios involving local authorities.

3.4.1 Description

Bob is a user visiting London and carrying an Android device with the UMOBILE application around. Bob has expressed interest in local coffee shops, restaurants, as well as highlights of the local social life. Using UMOBILE, he is also allowed to express opinions about the places along his way as well as social interaction with other people.

Bob arranged a meeting with his old friend Mary, and using instant message she suggested trying a restaurant in the vicinity. Both Bob and Mary get UMOBILE information about the restaurant's movement and realize that the best time to eat is before noon, as afterwards the restaurant seems to be packed and the service quality decreases. The

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UMOBILE app provides Bob with additional information concerning that restaurant, and potential interesting locations that are similar in nature, not only in terms of commercial offer, as well as in terms of affluence (e.g., volume of users sitting at that moment; probability of finding a seated place). The UMOBILE app provides an estimate of the time that both Bob and Mary will take to reach the restaurant and both of them realize that in order to best suit their busy agendas on that day, they should meet instead at 11.45.

Bob can also suit better his own interests by using the UMOBILE app. For instance, Bob has an apartment to be rented announced in several places, such as AirBnB. While strolling, the UMOBILE app sends information (e.g., sunny apartment to rent in Algarve, Portugal, rental price) to other users that carry the UMOBILE app too. Joan is one of such users and is interested in getting such an apartment for 1 week during the summer. Her UMOBILE app has that interest registered e.g. due to searches that Joan has done before via Google. Realizing that there is a common interest, the UMOBILE app finds, via GPS, a suitable location for both to meet during that day, and asks both of them if there is interest in doing so. This scenario is illustrated in Figure 7.

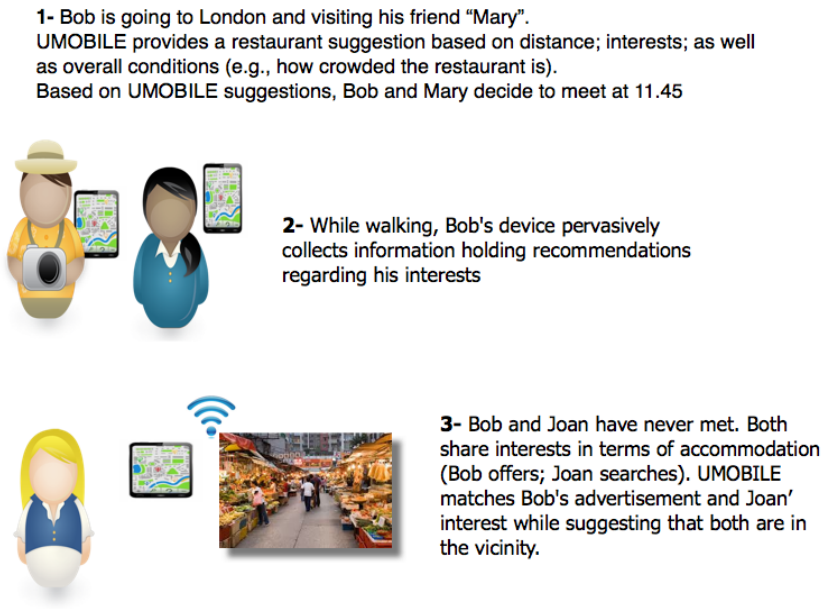

Figure 7. Social routine improvement due to interest expressions and match.

Bob and his wife Mary have a 10-year old son, called Jon who goes to public school every day. Jon carries the UMOBILE app on a smartphone and while on the move as well as while waiting for the bus, Jon's UMOBILE app gathers information concerning his physical surroundings and social context (e.g., affinity networks) and classifies that context in association to other profiles detected. For instance, the UMOBILE app infers whether or

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not Jon is alone or in a place with a lot of social affinity; type of movement; time spent in different places; potential new location; potential new affinity network. When Jon reaches school its UMOBILE detects the context as known. The UMOBILE app follows missions requested by Bob and Mary e.g. “monitor affinity network”; “track anxiety level”. The data collected by UMOBILE is periodically transmitted via the school platform enabled access points to a personal platform at home. Jon’s parents can therefore visualize Bob’s data and context in close to the real-time. They can then better address Jon, without becoming intrusive, and assist Bob in gaining better control over his life. The data collected over UMOBILE is transmitted opportunistically to the platform at home, which is only accessible by Bob and Mary. At night Mary realizes that Jon visited a new location and talked with 3 different persons. Based on the timestamp that Jon took walking from the coffee shop home, Jon’s patterns identified the shop and updated Jon’s profile. Next Saturday Jon’s parents go to the near coffee shop to assess the environment. The scenario is illustrated in Figure 8.

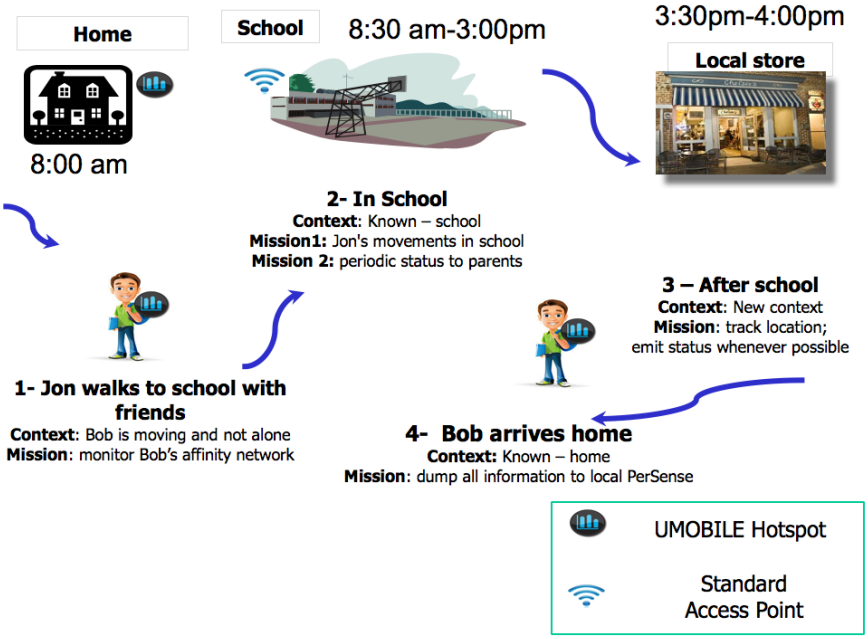

Figure 8. Social routine improvement scenario: Missions provided by Bob and Mary concerning their son Jon's affinity network and context

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3.4.2 Characteristics and Actors of the Application Scenario

- Communication takes place between authorized (belonging to specific trust circles) UMOBILE devices and hotspots.
- The user privacy is kept intact.
- Users carry the UMOBILE-enabled devices holding the UMOBILE application.
- The UMOBILE hotspots collect and emit relevant information.

3.4.3 Assumptions

- Social trust computation is performed dynamically to assist trust circles to change in time and space.
- Users have previously authorized trust circles.
- There are cooperation mechanisms that allow nodes to exchange information with unknown nodes (i.e., newly encountered with whom no trust association is yet available).
- Users are given incentives to cooperate.

3.4.4 Requirements

- Users shall access to the services through any form of Internet access.
- Users must be able to exchange data using any form of Internet access,and even when not connected to the Internet.
- Users shall provide only information (e.g., photo, concert info) that they are interested in and willing to share.
- Users shall receive only information (e.g., photo, concert info) that they are interested in and registered.
- Users shall add initial preference based on their interests (e.g., local event music, shopping, food, art)
- Users' privacy must be ensured.

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Section 4-Assumptions and Requirements

Out of the mentioned descriptions, UMOBILE has compiled an initial set of assumptions and requirements, from the perspective of the Internet/UMOBILE end user.

4.1 Assumptions

Number	Description
A-1	Users have installed the UMOBILE application.
A-2	Users provide an initial list of interests.
A-3	Users provide prior authorization to disseminate a basic set of information.
A-4	UAVs are equipped with Wi-Fi.
A-5	UMOBILE hotspots are available to provide Wi-Fi connectivity.
A-6	Intermittent connectivity may be experienced by users.
A-7	Users exchanging data have some form (dynamic) of trust association established, or a set of static agreements on how to exchange data has previously been agreed.
A-8	The UMOBILE application shall perform service discovery for the UMOBILE service directly between devices or via available Internet access.

Table 1. List of Assumptions

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4.2 Requirements

Number	Description
R-1	Users SHOULD be able to access the UMOBILE services though wired/ wireless connectivity.
R-2	Users SHOULD provide an initial local list of interests.
R-3	Users MAY provide prior authorization to disseminate a basic set of information to specific trust circles.
R-4	Users sharing resources SHOULD state amount of resources to be shared, example: time, bandwidth, energy level of its device.
R-5	User MAY state the amount of cooperation incentives which he/she considers reasonable to be part of UMOBILE.
R-6	Users involved in the collaborative behavior SHOULD be informed of the legal/regional requirements in place, as well as of where the information shall be kept (just local; authorities, etc).
R-7	Collaborative data gathering SHOULD prevent data duplication.
R-8	Users SHOULD be graded with a reputation level (integrity and relevancy of the data disseminated).
R-9	Trust management MUST ensure that trust associations can be built on-the-fly.
R-10	The user MUST be able to exchange data while on the move.
R-11	The UE's SHOULD be capable of resource sharing (e.g., take into consideration energy consumption).
R-12	The involved devices MUST be able to create trustful data exchange.
R-13	Users' data privacy MUST be ensured, based on their predefined set of values.
R-14	The UMOBILE system MAY require registration.
R-15	Users SHOULD receive recommendations for new contacts, groups and other social connections regarding their behaviours, activities or common interests, reputation of contacts, etc.
R-16	Users MAY tag information with different scopes (e.g., family, affiliation) and different levels of relevancy (e.g. URGENT).
R-17	Users MAY receive recommendations based on inference of matches (expressions and publishing of interests) and/or based on activity recognition over time.
R-18	The user SHOULD be able to back up his/her data whenever feasible.
R-19	The user SHOULD get free wireless over UMOBILE hotspots.

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Number	Description
R-20	Users MUST be able to have access to services even if the requested services are not in the domain (e.g., map services).
R-21	The UMOBILE system SHOULD be able to deliver data to users while on the move.
R-22	Users MUST be able to exchange data using any form of Internet access, and even when not connected to the Internet.
R-23	Users SHALL provide only information that they are interested in and willing to share.
R-24	Users SHALL receive only information that they are interested in and registered (emergency information is registered by default).
R-25	Users MUST be able to issue an emergency request/post, i.e., tagged as "urgent".
R-26	Users MUST be able to communicate with other UMOBILE users in a way that ensures privacy, in both Internet and opportunistic modes of operation.

Table 2. List of Requirements

Section 5-Conclusion

In this document, we defined the four typical user scenarios in the UMOBILE project. The four scenarios cover two important aspects of people's life: daily social routines and emergency situations. In both aspects, the UMOBILE aims to provide a consistent and robust communication infrastructure to enable various user applications to provide information-centric and delay-tolerant Internet services. Based on the aforementioned user scenarios, we generalised their commonalities and further derived the user requirements. This document will guide us in designing the system requirements in the next step of the UMOBILE project.

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