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Universal, mobile-centric and opportunistic communications architecture

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UMOBILE

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Version 0.2	27/04/2016	Second draft created based on D3.3 and the outcome of the consortium meeting held in Xanthi in April 2016.
Version 0.2	07/10/2016	Revised for the first project review.
Version 0.3	28/02/2017	Third draft based on comments provided in the Lisbon plenary meeting and comments from partners
Version 0.4	31/03/2017	Fourth draft based on comments provided in the Brussels interim meeting and comments from partners
Version 1.0	31/05/2017	Final version
Version 2.0	17/07/2018	Revised final version based on comments received from the Project Officer.

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List of Definitions

Term	Meaning
DTN	Delay Tolerant Network (DTN) is an emerging technology that 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 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.
Data	Data is raw. Data is numbers that have no interpretation. In UMOBILE, Data is a specific type of packet that carries named content as a response to an Interest packet.
Content	Content is digestible forms of information. In UMOBILE, content refers to a piece of digital information that is disseminated and consumed by end-users.
User	An entity (individual or collective) that can be a consumer, a producer or a relay of content.
Service	A set of mechanisms that assists in incorporating information about mobile users in order to optimize the overall system. A service refers to a computational operation running on the network. Services can be hosted and computed in some specific nodes such as surrogates or gateways.
Interest	A parameter capable of providing a measure (cost) of the “attention” of a user towards a specific content in a specific time instant. Users can cooperate and share their interests. In what concerns communication systems, Interest packets carry requests for specific pieces of data. In UMOBILE, Interests can also carry short pieces of information, as part of a push-service.
Upstream	Upstream traffic refers to data that the user equipment sends to the network.
Downstream	Downstream traffic refers to data that the user equipment gets from network.
Gateway	Equipment installed at the edge of a network. It is a software functionality, which reflects an operational behaviour making a UMOBILE device capable of acting as a mediator between UMOBILE systems and non-UMOBILE systems.
Surrogate	Device with large storage and computational capability, able to store services and contents to subsequently provide local access communication.

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Term	Meaning
Customer Premises	Customer Premises relate to residential households and enterprise market and are, as of today, controlled by the end-user.
User-centric	User-centric refers to a new paradigm that leverages 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 services or content can be exchanged and stored in several devices such as surrogates; user equipment; customer premises equipment such as Wi-Fi Access Points in order to efficiently delivery the desired contents or services to end-users.
UMOBILE Architecture	A mobile-centric opportunistic architecture that efficiently delivers content to the end-users. The UMOBILE architecture integrates the principles of Delay Tolerant Networks (DTN) and Information-Centric Networks (ICN).
User-equipment	Generic user terminal. In terms of operating systems we consider mainly smartphones equipped with Android; notebooks with UNIX, Windows, Mac OS.
Application	Computer software designed to perform a single or several specific tasks, e.g. a calendar and map services. In UMOBILE, context-aware applications are considered.
User Requirement	User requirement corresponds to the specifications that users expect from the application, device or network.
UAV	Unmanned Aerial Vehicle, which is an aircraft with no pilot on board.

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List of Acronyms

Term	Meaning
AP	Access Point
CM	Contextual Manager
DABBER	Data reAchaBility BasEd Routing
DTN	Delay Tolerant Network
EUS	End-User Service
FIB	Forwarding Information Base
ICN	Information-Centric Networking
INRPP	In-Network Resource Pooling Principle
ISP	Internet Service Provider
KEBAPP	Application-centric naming framework
NDN	Named-Data Networking
NDN-OPP	Named-Data Networking for Opportunistic Wireless Networks.
Now@	Data Exchange application for NDN over wireless networks
NREP	Name-based Replication Priorities Protocol
Oi!	Instant message application for NDN
OOCD	Opportunistic Off-path Content Discovery
ONE	Opportunistic Network Environment simulator
OPEX	Operating expenses
OS	Operating System
RFC	Request For Comments
UAV	Unmanned aerial vehicle
UMOBILE	Universal, Mobile-centric and Opportunistic Communications architecture.

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Executive Summary

This document covers system and network requirements (described based on RFC2119 notation), as well as assumptions, for the high-level design of the UMOBILE architecture. A first version is provided on M18, as deliverable D2.2, while a refined description of system requirements, assumptions will be provided on M28 (initially planned for M30), as deliverable D2.3.

The goal of the current deliverable, D2.3, is to describe the final set of requirements and assumptions of the UMOBILE framework, which is being developed based on the analysis of the four applicability pictures described in D2.1 [1], and the initial set of requirements and assumptions set in D2.2 [2].

Special attention is given to the needed alignment with the *Delay-Tolerant Networking* (DTN) architecture [3], and the most relevant proposal for an *Information-Centric Networking* architecture (ICN) [4] that fits the identified *Universal, Mobile-centric and Opportunistic Communications* architecture (UMOBILE) and the network requirements.

The starting point for this report is deliverable D2.2, which describes the initial set of requirements and assumptions for the project. Deliverable D2.3 aims to revise that initial set of requirements and assumptions, to reflect the strategic and development decisions that were taken during the project.

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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 opportunistic networking with the ultimate purpose of delivering an architecture focused on: i) improving aspects of the existing infrastructure, e.g., keeping traffic local to lower operating expenses (OPEX); ii) 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 closer to the users, we can optimize, in a scalable way, 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 document is organized as follows:

- **Section 2** reviews, briefly, the applicability scenarios of UMOBILE, described in D2.1.
- **Section 3** provides a description of the actors identified in the UMOBIILE scenarios.
- **Section 4** summarizes the overall system and network assumptions of the UMOBILE architecture.
- **Section 5** describes the overall system and network requirements of the UMOBILE architecture, divided into three types (Mandatory, Recommended, and Optional).

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2 Applicability Scenarios

As initially described in deliverable D2.1, the diversity of services in UMOBILE is ensured for four different applicability scenarios: *micro-blogging, emergency situation, civil protection* and *social routine improvement*.

In a **micro-blogging scenario**, UMOBILE users are allowed to generate and share expressions of interest in the form of tagged information (time-space tag), benefiting from local information such as interesting events, recommended places and social interaction activities. User devices do not have to be always connected to the Internet. Data is exchanged among people passing by, based on social interaction approaches. Local hotspots may store data based on its local meaningfulness. Such data may be further disseminated among other peering hotspots in the city.

In an **emergency situation scenario**, traditional communication services such as fixed or mobile networks and local Internet access are completely/partially inoperable. Therefore, the design of the UMOBILE system is expected to assist users in disseminating emergency information directly via end-user devices as well as via the UMOBILE hotspots and *Unmanned Aerial Vehicle* (UAV). Such information can be shared among users and also forwarded to the local authorities.

In a **civil protection scenario**, UMOBILE provides mechanisms that may assist authorities in the case of challenged events. For instance, in the case of a flood, authorities in the affected areas can exploit data from different sources (e.g. satellite imagery, sensor-based, UAVs) to efficiently organize their efforts. While satellite images can be used to analyse 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.

In a **social routine improvement scenario**, an UMOBILE system should be capable of capturing personal data about users (e.g. visited networks, affinity network) with the ultimate goal to improve the user's routine. The system shall perform simple and complex activity recognition, and learn with the user 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, as well as collective services.

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3 Actors in UMOBILE Scenarios

This section provides a presentation of all actors identified in the four UMOBILE applicability scenarios (c.f. Table 1, and Table 2). The study of the interaction between the identified actors drove the revision of the system assumptions and requirements.

			UMOBILE Scenarios			
Device	**Function**	**UMOBILE Open Source Software**	**Micro-Blogging**	**Social Routine Improvement**	**Emergency**	**Civil Protection**
Mobile Devices	Provide communication over opportunistic wireless networks	NDN-OPP; DABBER; Now@; Oi!; Contextual Manager; End-User Service; DTN Face; RouteFinder; KEBAPP Emergency service;	⊕	⊕	⊕	⊕
UAV		DTN Face	⊕		⊕	⊕
Hotspot	Provide local wireless connectivity.	Raspberry Hotspot; DTN Face; Service Migration;	⊕	⊕	⊕	⊕
Gateway/ Surrogate	Store data; Perform computational functions; Provide Internet access	DTN Face; Service Migration;			⊕	⊕
Service Manager	Coordinate service migration to hotspots and end-use devices	Service Migration;			⊕	⊕

Table 1: UMOBILE Actors, available as open-source software, per defined scenarios

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			UMOBILE Scenarios			
Device	**Function**	**UMOBILE Software for Simulators**	**Micro-Blogging**	**Social Routine Improvement**	**Emergency**	**Civil Protection**
Router[1]	Provide QoS in UMOBILE networks and improve data transport efficiency	INRPP; OOCD; DTN Face	⊕	⊕	⊕	⊕

Table 2: UMOBILE Actors, available as simulator software, per defined scenarios

Table 1 provides a list of open-source software developed within the UMOBILE project in order to support a set of scenarios related with micro-blogging, social-routine improvement, emergency and civil protection. The listed open-source software, described in the following set of bullets, was developed for different network entities, such as mobile devices (which also act as routers), hotspots, gateways, service managers and routers. Table 2 provides a list of the software that was developed for simulators, namely the ndnSIM simulator. This software, also listed below, was developed to provide QoS in UMOBILE networks and improve data transport efficiency.

- **Provide communication over opportunistic wireless networks**:
  - NDN-OPP (NDN branch for peer-to-peer communications between wireless devices):
    - Github: https://github.com/COPELABS-SITI/ndn-opp
    - Google Play: https://play.google.com/store/apps/details?id=pt.ulusofona.copelabs.ndn
  - DABBER (Information-centric Routing for Opportunistic Wireless Networks):
    - Github: https://github.com/COPELABS-SITI/ndn-opp/tree/dabber
    - Google Play: https://play.google.com/store/apps/details?id=pt.ulusofona.copelabs.ndn
  - Contextual Manager (Manager to collect meta data about the behaviour of mobile devices):
    - Github: https://github.com/Senception/ContextualManager
    - Google Play: https://play.google.com/store/apps/details?id=com.senception.contextualmanager

[1] This functionality was developed for router to be used in wired networks. The project developed a new routing protocol for mobile devices, Dabber, which is a functionality installed in mobile devices.

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- Now@ (Application to collect and share information among UMOBILE users over NDN):
  - Github: https://github.com/COPELABS-SITI/NowAt
  - Google Play: https://play.google.com/store/apps/details?id=pt.ulusofona.copelabs.now
- Oi! (Application to allow UMOBILE users to send instant messages over NDN):
  - Github: https://github.com/COPELABS-SITI/NowAt
  - Google Play: https://play.google.com/store/apps/details?id=pt.ulusofona.copelabs.now
- DTN Face:
  - Github: (Android) https://github.com/umobileproject/ndn-dtn-neighbour-routes; (Linux) https://github.com/umobileproject/ndndtn-cxx; (Linux) https://github.com/umobileproject/ndn-dtn-code
- RouteFinder:
  - Github: https://github.com/umobileproject/KEBAPP_routefinder
- End-User Service (UMOBILE End-User Service application):
  - Github: https://github.com/Senception/UMOBILE_UES
  - Google Play: https://play.google.com/store/apps/details?id=com.senception.umobile_ues
- KEBAPP Emergency service app:
  - Github: https://github.com/umobileproject/KEBAPP_emergency_video

- **Provide local wireless connectivity**:
  - Raspberry Hotspot**:**
    - Github: https://github.com/umobileproject/raspi-image
  - DTN Face: See above.
  - Service Migration:
    - Github: https://github.com/umobileproject/PiCasso

- **Store data; Perform computational functions; Provide Internet access**:
  - DTN Face: See above.
  - Service Migration: See above.

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- **Coordinate service migration to hotspots and end-use devices**:
  - Service Migration: See above.

- **Provide QoS in UMOBILE networks and improve data transport efficiency**:
  - OOCD (Off-path Opportunistic Content Discovery): *Code for ndnSIM simulator*
    - Github: https://github.com/umobileproject/OOCD
  - INRPP (In-network Resource Pooling Protocol): *Code for ndnSIM simulator*
    - Github: https://github.com/umobileproject/ndnSIM-inrpp
  - DTN Face: See above.

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4 UMOBILE Assumptions

This section provides an overall perspective of the systems and network assumptions of the UMOBILE architecture.

Table 3 provides a list of the overall assumptions, derived from the analysis of the four applicability scenarios.

Number	Description
A-1	UMOBILE is to be implemented in a set of networked devices: mobile personal devices, hotspots, UAVs, which have limited local storage capabilities. Tentatively also in wearable/embedded devices
A-2	UMOBILE is to be implemented in surrogates, which have significant computational and storage capabilities.
A-3	UMOBILE surrogates can be collocated with any UMOBILE-enabled device.
A-4	UMOBILE is to be implemented in gateways, which can be collocated with hotspots or embedded in hotspots, and may have a satellite interface.
A-5	UMOBILE systems are able to communicate via wireless (Wi-Fi access networks; Wi-Fi direct; Bluetooth) and/or cellular communications.
A-6	UMOBILE systems may be equipped with sensing capabilities (e.g. accelerometer, microphone, wireless interface, Bluetooth interface, temperature, barometer).
A-7	Internet connectivity may be intermittent.
A-8	The Content/Service provider delegates to the ISP provider the responsibility of deploying services within its infrastructure (for example on UMOBILE Hotspots) for the benefit of the end-users.
A-9	Services need to be delivered with different QoS requirements as agreed upon between the *Content/Service provider* and the *ISP provider*. Therefore, it is the duty of the *ISP provider* to instrument its infrastructure with QoS mechanisms that are capable of satisfying the system requirements listed below.

Table 3: List of overall UMOBILE systems and network assumptions

The remaining of this section provides a detailed description of the assumptions derived from each applicability scenarios. The assumptions derived from each scenario were then analysed in order to identify the overall assumptions of an UMOBILE system (c.f. Table 3).

Assumptions in the **micro-blogging scenario**:

- UMOBILE is to be implemented in mobile devices (e.g. smartphones), hotspots, and UAVs, which have limited local storage capabilities.
- UMOBILE is to be implemented in surrogates with significant computational, storage and power capabilities.
- UMOBILE surrogates can be collocated with hotspots or embedded in hotspots.
- UMOBILE systems are able to communicate via wireless (Wi-Fi access networks; Wi-Fi direct; Bluetooth).

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- UMOBILE systems may be equipped with sensing capabilities (e.g. accelerometer, microphone, wireless interface, Bluetooth interface, temperature, barometer)
- Internet connectivity may be intermittent.

Assumptions in the **emergency situation scenario:**

- UMOBILE is to be implemented in mobile devices (e.g. smartphones), hotspots, UAVs, and wearable/embedded devices (e.g. Raspberry Pi).
- UMOBILE systems are able to communicate via wireless (Wi-Fi access networks; Wi-Fi direct; Bluetooth) and cellular communications.
- UMOBILE systems may be equipped with sensing capabilities (e.g. accelerometer, microphone, wireless interface, Bluetooth interface, temperature, barometer).
- Internet connectivity may be intermittent.

Assumptions in the **civil protection scenario:**

- UMOBILE is to be implemented in mobile devices (e.g. smartphones, smartwatches), hotspots, UAVs, and wearable/embedded devices (e.g. Raspberry Pi), which have limited local storage capabilities.
- UMOBILE gateways may have a satellite interface.
- UMOBILE systems are able to communicate via wireless (Wi-Fi access networks; Wi-Fi direct; Bluetooth).
- UMOBILE systems may be equipped with sensing capabilities (e.g. accelerometer, microphone, wireless interface, Bluetooth interface, temperature, barometer).
- Internet connectivity may be intermittent.

Assumptions in the **social routine improvement scenario**:

- UMOBILE is to be implemented in mobile devices (e.g. smartphones, smartwatches), and hotspots, which have limited local storage capabilities.
- UMOBILE is to be implemented in surrogates with significant computational and storage capabilities.
- UMOBILE surrogates can be collocated with hotspots or embedded in hotspots.
- UMOBILE systems are able to communicate via wireless (Wi-Fi access networks; Wi-Fi direct; Bluetooth).
- UMOBILE systems may be equipped with sensing capabilities (e.g. accelerometer, microphone, wireless interface, Bluetooth interface, temperature, barometer).
- Internet connectivity may be intermittent.

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5 UMOBILE Requirements

This section provides an overall perspective of the systems and network requirements of the UMOBILE architecture, divided into three types:

- MUST (Table 4), which are an absolute requirement of the UMOBILE specification, and so are required in any implementation.
- SHOULD (Table 5), which are recommended features, meaning that there may exist valid reasons in particular circumstances to ignore such features, but the full implications must be understood and carefully weighed before choosing a different course.
- MAY (Table 6), which are optional features.

Table 4, Table 5, and Table 6 include a column indicating the project tasks that will investigate the required solutions and a column that enumerates the functionality developed to fulfil the mentioned requirements.

Nº	Description	Task	Functionality
R-1	UMOBILE systems MUST be able to exchange data also based on users' interaction in the system, ensuring user privacy in dynamic networking scenarios.	T3.3	NDN-OPP
R-2	UMOBILE systems MUST be able to exchange data and exploit all major communication opportunities through Wi-Fi (structured, direct), 3G/4G, and Bluetooth, among UMOBILE systems, operating even in situations with intermittent Internet connectivity.	T3.3	NDN-OPP
R-3	UMOBILE systems MUST be able to exchange data taking into account user interests and context.	T3.3	NDN-OPP, Oi!, Now@
R-4	UMOBILE systems MUST support the following services: data dissemination, data synchronisation, and data filtering.	T3.3	NDN-OPP Oi!, Now@
R-5	UMOBILE systems MUST provide alternative options for enhanced availability and reliability of data.	T3.2 T3.3 T4.1	KEBAPP NDN-OPP Service Migration
R-6	UMOBILE systems MUST be able to make messages available to different receivers simultaneously.	T3.3	NDN-OPP

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Nº	Description	Task	Functionality
R-7	UMOBILE systems MUST deliver emergency data with higher priority and probability of delivery.	T3.1 T4.1 T4.3	DTN Face Service Migration NREP
R-8	UMOBILE systems MUST be able to deliver information within geographic regions and time frames that are relevant to different types of data.	T3.2 T3.3 T4.3	KEBAPP NDN-OPP NREP
R-9	UMOBILE systems MUST be able to provide users with relevant information, i.e., matching user interests.	T3.3	NDN-OPP Oi!, Now@
R-10	UMOBILE gateways MUST be able to interconnect UMOBILE with an IP network.	T3.2	UMOBILE Gateway
R-11	UMOBILE systems MUST be able to provide services with alternative connectivity options when there is no Internet connectivity.	T3.1 T3.2	DTN Face KEBAPP

Table 4: **Overall mandatory requirements**

Nº	Description	Task	Functionality
R-12	UMOBILE system SHOULD be able to deliver data based on user interests (e.g., parking places near recommended art gallery) and behaviour (e.g. mobility patterns), in order to reduce delays in data delivery	T3.3	NDN-OPP
R-13	UMOBILE systems SHOULD be able to sense user context (geo-location, relative location, proximity, social interaction, activity/movement, roaming, talking) in a non-intrusive manner.	T4.2	Contextual Manager
R-14	UMOBILE systems SHOULD provide information about the network status (e.g. network diameter, average path length, link bandwidth, network delay) is order to allow authorities to take corrective measures (e.g. deploy UAV infrastructure).	T4.2	Contextual Manager
R-15	UMOBILE systems SHOULD be able to provide local services when the system cannot connect to the Internet.	T3.1 T3.2	DTN Face KEBAPP

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Nº	Description	Task	Functionality
R-16	UMOBILE systems SHOULD have a functionality that allows authorized people (e.g. parents) to track the routine of particular devices (e.g. son's/daughter's device).	T4.2	Contextual Manager
R-17	UMOBILE systems SHOULD be able to exchange data by exploiting every communication opportunity between UMOBILE systems and non-UMOBILE systems.	T3.1	NDN-OPP
R-18	UMOBILE system SHOULD be provided with QoS mechanisms to be deployed at its discretion to accomplish its duty and at different levels of its software stack ranging from the application to the network.	T3.1 T4.1	DTN Face Service Migration
R-19	UMOBILE system SHOULD provide transparent QoS mechanisms. For instance, the operation of Service Migration should be transparent to the end-user.	T4.1	Service Migration
R-20	UMOBILE system SHOULD explore all possible network paths and use caches as temporary custodians to deal with congestion when pushing services to the hotspots.	T4.1	INRPP
R-21	UMOBILE system SHOULD opportunistically exploit content cached by off-path nodes without requiring any explicit signaling or update protocol in the wired network.	T3.2	OOCD

Table 5: Overall recommended requirements

Nº	Description	Task	Functionality
R-22	UMOBILE systems MAY be able to sense user surroundings (crowds, environmental, noise level).	T4.2	Contextual Manager

Table 6: Overall optional requirements

The remaining of this section provides a description of the requirements derived from each applicability scenario. Such requirements were analysed in order to identify the overall requirements of an UMOBILE system (c.f. Table 4, Table 5, and Table 6).

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Requirements in the **micro-blogging scenario**:

- UMOBILE gateways MUST be able to interconnect UMOBILE with an IP network.
- UMOBILE systems MUST be able to exchange data also based on users' interaction in the system, ensuring user privacy in dynamic networking scenarios.
- UMOBILE systems MUST be able to exchange data by exploiting all major communication opportunities (in this case by Wi-Fi – structured or Wi-Fi direct), among UMOBILE systems (mobile devices, access points and UAVs).
- UMOBILE systems MUST exchange data considering users' interests and context.
- UMOBILE systems MUST support the following services: data dissemination, data synchronisation, and data filtering.
- UMOBILE systems MUST provide alternative options for enhanced availability and reliability of data.
- UMOBILE systems MUST be able to provide services with alternative connectivity options when there is no Internet connectivity.
- UMOBILE systems SHOULD be able to exchange data by exploiting every communication opportunity between UMOBILE systems and non-UMOBILE systems.
- UMOBILE systems SHOULD be able to deliver data based on user interests (e.g., parking places near recommended art gallery) and behaviour (e.g. mobility patterns), in order to reduce delays in data delivery.
- UMOBILE mobile systems SHOULD be able to sense user context (geo-location, relative location, proximity, social interaction).
- UMOBILE system SHOULD be able to provide users only with information that match their interests (e.g. art exhibitions).
- UMOBILE system SHOULD explore all possible network paths and use caches as temporary custodians to deal with congestion when pushing services to the hotspots.
- UMOBILE system SHOULD opportunistically exploit content cached by off-path nodes without requiring any explicit signaling or update protocol in the wired network.
- UMOBILE systems MAY be compatible with existing applications.
- UMOBILE systems MAY be able to sense user surroundings (crowds, environmental, noise level).

Requirements in the **emergency situation scenario**:

- UMOBILE gateways MUST be able to interconnect UMOBILE with an IP network.
- UMOBILE systems MUST deliver emergency data with higher priority and probability of delivery.
- UMOBILE systems MUST exchange data while ensuring that emergency data is not changed by malicious entities.
- UMOBILE systems MUST be able to exchange data by exploiting all major communication opportunities (Wi-Fi – structured; Wi-Fi direct; 3G), among UMOBILE systems (mobile devices, access points and UAVs), operating even in situations of intermittent Internet connectivity.
- UMOBILE systems MUST support the following services: data dissemination, data synchronisation, and data filtering.

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- UMOBILE systems MUST be able to make messages available to different receivers simultaneously.
- UMOBILE systems SHOULD be able to exchange data by exploiting every communication opportunity between UMOBILE systems and non-UMOBILE systems.
- UMOBILE systems SHOULD be able to infer user context (geo-location, social interactions, activity tracking) to complement emergency description.
- UMOBILE systems SHOULD be able provide local services when the system cannot connect to the Internet.
- UMOBILE systems SHOULD provide information about the network status (e.g. network diameter, average path length/delay) in order to allow authorities to take corrective measurements (e.g. deploy UAV infrastructure).
- UMOBILE systems SHOULD reward for the cooperative behaviour of users (e.g., point-gaining system).
- UMOBILE system SHOULD be able to deploy different mechanisms at different levels of its software stack to accomplish its duty, for example: at application level, it should be able to deploy Service Migration to reduce latency; at network level, it should be able to deploy traffic engineering mechanisms to satisfy throughput or to deploy DTN tunnelling to provide availability.
- UMOBILE systems MAY be able to dynamically coordinate distributed surrogates to ensure data resilience and availability.

Requirements in the **civil protection scenario:**

- UMOBILE systems MUST deliver emergency data with higher priority and probability of delivery.
- UMOBILE systems MUST be able to exchange data by exploiting all major communication opportunities (Wi-Fi – structured; Wi-Fi direct; 3G), among UMOBILE systems (mobile devices, access points and UAVs), operating even in situation of intermittent Internet connectivity.
- UMOBILE systems MUST be able to deliver information within regions that are relevant to the detected incident (e.g., flooding of town by its nearby river).
- UMOBILE systems MUST have an interface allowing users to publish new emergency data and subscribe/register their interests.
- UMOBILE systems SHOULD be able to exchange data by exploiting every communication opportunity between UMOBILE systems and non-UMOBILE systems.
- UMOBILE mobile systems SHOULD be able to sense users' context (e.g. roaming patterns).
- UMOBILE systems SHOULD be able provide local services when the system cannot connect to the Internet.
- UMOBILE systems SHOULD provide information about the network status (e.g. network diameter, average path length/delay) in order to allow authorities to take corrective measures (e.g. deploy UAV infrastructure).
- UMOBILE system SHOULD be able to deploy different mechanisms at different levels of its software stack to accomplish its duty, for example: at application level, it should be able to deploy Service Migration to reduce latency; at network level, it should be able to deploy traffic engineering mechanisms to satisfy throughput or to deploy DTN tunnelling to provide availability.

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- UMOBILE system SHOULD explore all possible network paths and use caches as temporary custodians to deal with congestion when pushing services to the hotspots.
- UMOBILE system SHOULD opportunistically exploit content cached by off-path nodes without requiring any explicit signaling or update protocol in the wired network.
- UMOBILE systems MAY be able to infer individual and crowd movement, in order to identify data exchange patterns.
- UMOBILE systems MAY be able to dynamically coordinate distributed surrogates to ensure data resilience and availability.

Requirements in the **social routine improvement scenario**:

- UMOBILE systems MUST be able to exchange data by exploiting all major communication opportunities (Wi-Fi – structured; Wi-Fi direct; 3G), among UMOBILE systems (mobile devices, and access points), operating even in situations of intermittent Internet connectivity.
- UMOBILE systems MUST take into account the user interests and social interactions to aid forwarding decisions.
- UMOBILE systems MUST support the following services: data dissemination, data synchronisation, and data filtering.
- UMOBILE system MUST provide users only with relevant information, i.e., user interest.
- UMOBILE systems SHOULD be able to exchange data by exploiting every communication opportunity between UMOBILE systems and non-UMOBILE systems.
- UMOBILE systems SHOULD be able to sense user context (social interaction, movement, relative location, roaming) in a non-intrusive manner.
- UMOBILE systems SHOULD have a functionality that allows authorized people (e.g. parents) to track the routine of particular devices (e.g. son's/daughter's device).
- UMOBILE mobile systems MAY be able to sense user surroundings (noise levels, talking) in a non-intrusive manner.

6 Conclusion

This document covers system and network requirements, as well as assumptions, for the high-level design of the UMOBILE architecture. The goal is to identify the final set of requirements and assumption of the UMOBILE framework.

This is the final version of the system and network requirements specification: an initial version was provided by D2.2 on M14.

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