Ref. Ares(2017)29863 - 04/01/2017

PART B

UMOBILE

Universal, mobile-centric and opportunisticcommunications architecture

History of changes

V1

- GOWEX Wireless S.L. (GOWEX) has been replaced by FON Technology S.L (FON Technology) and the relevant sections of the Grant Agreement have been updated.
- The List of Deliverables has been corrected to match the number of deliverables.
- Task 2.1 is now lead by UCAM instead of GOWEX.
- FON Technology participates in Task 2.2.
- All partners participate in Task 5.3, now lead by AFA.
- Two bullets of Task 6.1 have been merged into one.
- A deliverable on Data Management Plan (D6.10) has been added, since UMOBILE will participate in the "Pilot on Open Research in HORIZON 2020".
- FON Technology has moved 2PMs from WP5 to WP2. Therefore, the total PMs of WP2 has been increased from 47 to 49, while the total PMs of WP5 have been reduced from 129 to 127.
- Figure 5 has been updated.
- FON Labs S.L. (FON Labs) has been added as a third party linked to FON Technology.
- The total cost of the project has been slightly increased. EU requested distribution remains the same.
- Travel description has been updated.
- Other costs section has been updated.
- Subcontracting section has been updated.
- DUTH CVs have been updated.
- Ethics section has been updated, based on the ethics screening report.

V2

- Ga
  ntt chart has been updated.

V3

- The
  need for submission of a certificate of financial statements from DUTH has been removed.

V4

- Part
  icipation of DUTH in the project has been terminated.
- AT
  HENA Research and Innovation Center is replacing DUTH in remaining tasks in all WPs.
- CO
  PELABS-COFAC added their third party, COFAC
- GA
  NTT chart updated
- 2.3.
  5 Planned use of Resources is updated accordingly due to Athena addition and changes proposed to the periodic report

Table of Contents

2.1. Excellence 4
2.1.1. Objectives 4
2.1.2. Concept and Approach 6
2.1.3. Ambition 12
2.2. Impact 17
2.2.1. Expected Impact 17
2.2.2. Measures to maximise impact 21
2.3. Implementation 27
2.3.1. Work Plan 27
2.3.2. Management structures and procedures 31
2.3.2.1. Consortium management 31
2.3.2.2. Management processes 32
2.3.3. Consortium as a whole 35
2.3.4. Capacity of participants and links to third parties 38
2.3.5. Planned use of resources 58
2.3.6. Ethics and security 61

2.1. Excellence

2.1.1. Objectives

The Internet has crossed new frontiers with access to it getting faster and cheaper. Considering the architectural foundations of today's Internet were laid more than three decades ago, the Internet has done remarkably well until today to cope with the growing demand. However, the Future Internet architecture is not only expected to support ever growing number of users and devices but also diverse set of new applications and services. At one extreme, the Future Internet is expected to transport applications such as tele-immersion and at the other extreme to connect vast numbers of tiny devices integrated into appliances, sensors, actuators, and a range of previously independent systems forming the notion of Internet of Things (IoT). The Future Internet is most importantly expected to support the ever-growing need of user mobility. Now here lies the main obstacle: it is impossible to have 100% universal coverage. Access problems often result from sparsely spread populations living in physically remote locations – it is simply not cost effective for Internet Service Providers (ISPs) to install the required infrastructure for broadband Internet access to these areas. Coupled with physical limitations of terrestrial infrastructures (mainly due to distance) to provide last mile access, remote communities also incur higher costs for connection between the exchange and backbone network when using wired technologies because the distances are larger. A large exchange may accommodate many users and allow for competition between service operators; in contrast, a rural/remote broadband often does not offer economies of scale, raising the costs per user. This problem is widely and publicly recognised, for example, in 2012, 9.1 million homes in Europe still do not have fixed broadband coverage, more than 90% of which are in rural areas. Achieving ubiquitous mobile broadband coverage is also currently seen as not feasible by major operators as direct investment in local infrastructure may be uneconomic. For example in the UK, 3G coverage is far more patchy ironically including major towns and cities.

One potential solution to this pertinent problem of improving pervasive access is to change how users communicate and access information, by moving from the traditional host-centric access paradigm (where access to a desired content is mapped to its location) to a content-centric model where access to a desired content is mapped to the content itself irrespective of the location where the content is held. Such a model when combined with the added benefits of delay tolerant networking can support inherently secure communication based on named-content objects. Such decoupling of the content from location removes the need of being to be able to connect to the Internet and it also supports natively content caching, either in the form of traditional caching, or in a more revolutionary diffusion-based form (*e.g.,store-carry-and-forward*). Our proposal exactly seeks to address this.

The proposed UMOBILE architecture combines two emerging architecture and connectivity approaches: *Information Centric Networking (ICN)* and *Delay Tolerant Networking (DTN)*. The aim is to build a novel architecture that defines a new service abstraction that brings together both information centric as well as delay tolerant networking principles into one single abstraction. We further integrate social trust computation and cooperative incentive modeling into the architecture that will enable prioritary dissemination of information based on the notion of smart trust circles in opportunistic communication environments. Such an abstraction would enable network services to pervasively operate in any networking environment, independently of the underlying communication technology. Such abstraction also allows innovative application and services development, providing access to data independently of the level of end-to-end connectivity availability.

In such vision, the UMOBILE project has the following objectives:

Objective 1: To develop a consolidated information centric and delay tolerant communication platform
In UMOBILE, we will support the delivery of information and services across both ICN-centric and DTN-centric, guaranteeing however, a smooth transition from the current Internet communication model to the ICN-DTN one and vice versa. For this, we need to avoid further architectural ossification of the current Internet through extending the current Internet architecture with a plethora of protocol choices. Instead, our *approach* develops an information-centric delay-tolerant communication platform based on a node architecture that unifies the various underlying protocol choices within a single architectural framework and at the same time supporting backward compatibility with IP. UMOBILE integrates both ICN and DTN into one single abstraction on top of IP enabling diversity in supported networks that range from all-optical high-speed networks, through backhaul links provided by UAVs or satellites, to localised deployments that include challenged mobile environments.

Objective 2: To extend the boundaries of Future Internet

The proposed architecture will provide Future Internet architectures with a three dimensional perspective. UMOBILE shall expand the reach of current infrastructures (capillarity) and in particular, allow connectivity to reach remote areas. UMOBILE is thought to allow a scalable growth, by contemplating design parameters to include devices many orders of magnitude higher than the current Internet. UMOBILE is expected also to change the functional nature of the Internet by providing novel services and applications, devised to consider intermittent connectivity. Moreover, UMOBILE shall introduce service abstraction to allow a wide diversity of mobile and embedded devices to be integrated, in particular in the verge of intermittent connectivity.

Objective 3: To enablea tighter integration of opportunistic communications within the Internet

The Future Internet is expected to connect a wide range of sensors forming the notion of Internet of Things (IoT). Such sensors may not need the always-on nature of the Internet. Moreover, it is mandatory that rural/ remote communities have the capability to support future IoT infrastructure. However, despite the expansion of the Internet so far, certain nodes are still remote, having no or only restricted access to the backbone Internet. In such a scenario, it is mandatory to utilise all available resources to provide a robust and scalable network infrastructure. UMOBILE proposes to create such an infrastructure to integrate diverse sensors by exploiting the operational capabilities of both ICN and DTN. Its storage feature and custody transfer allows for reliable and delay-tolerant services. UMOBILE architecture will give Future Internet a new perspective by extending it geographically (by exploiting opportunistic contacts and interconnecting remote areas), quantitatively (by including devices many orders of magnitude higher than the current Internet) and functionally (by providing novel services and applications). The scenarios to be exploited in UMOBILE project encompass a panoply of heterogeneous devices with their users sending and retrieving content while on-the-go.

Objective 4: To drive new application and services

The Internet has spurred a tremendous wave of innovation in services and applications, in particular due to the rise of software defined networking and open-source operating systems. The services and applications being devised suffer from the fact that they have as underlying assumption a well-connected nature of the current infrastructure while either inadequately dealing with challenged connectivity. In this project, we aim at developing a range of new application enablers that will serve as the basis for innovation across the range of connectivity options that are enabled by our platform. We will focus on the wider societal needs for digital inclusion with a strong focus on personal and community safety. This will address the technological disparity that weakens many of today's solutions. Our approach to support such new services is to extend our basic architecture with crucial network level services in order to enable various levels of QoS to support diverse set of services from low priority free Internet access using Less-than-best effort services to higher priority access for emergency services.

Objective 5: To drive the Internet towards a communication platform for universal coverage

Universal Internet Access is considered as one of the fundamental requirements in today's digital age as clean water, roads, schools etc. Enabling universal Internet access is one of the key issues that is being currently addressed at the European level via the Digital Agenda for Europe (DAE) as well as globally. UMOBILE project directly addresses the need for enabling Universal Internet access irrespective of geography, socio-economic and technological barriers, thus creating an enabler for connecting the people, content, clouds and things. Such an enabler can play a crucial role in safety and security in societies. For this, we will make use of advancements in the area of ICN and its inherent ability to push content to the edges. We will also consider advancements concerning social trust computation, as a way to automatically and seamlessly create trusted communication circles, increasing motivation for Internet stakeholders to engage in data dissemination activities and hence resulting in robust pervasiveness, even in remote areas. With this approach, we enable the utilisation of connected and disconnected modes of access under a single architectural abstraction.

Objective 6: To create an engagement platform that will bring together stakeholders with interests in universal coverage

UMOBILE platform aims to provide universal coverage through the engagement of all stakeholders involved. To achieve that, the right policies as well as economic and societal incentive models need to be developed. UMOBILE partners will carefully extend research with an active engagement with relevant (pre-) standardization bodies with the goal of influencing the way in which Future Internet technologies are designed, delivered and operated to support underserved communities. The IRTF Global Access to the Internet for All (GAIA) group, which is chaired by members of the consortium, will be the gateway to influencing standardisation efforts at the IETF that could potentially change the Internet landscape to be more inclusive.

2.1.2. Concept and Approach

2.1.2.1. Concept

In recent years, there has been a tremendous increase in the amount of devices, which are capable of communicating either within small networks, or the Internet. Smart devices, such as sensors, vehicles and mobile phones, have the potential to connect with each other or with base stations, forming large, heterogeneous internetworks. Typically, infrastructure-less ad hoc networks are attached to the Internet occasionally through architectural patches presenting isolated communication spots with limited capabilities. In most cases, applications for such internetworks depart from some form of specialized demand: protocols, services and applications are designed based on specific conditions of locality, user group commonalities, and societal requirements; and are adjusted from scratch based on the technical capacity of each network and networked device. This architecture lacks flexibility and expandability and cannot satisfy the demand for inter-device, internetwork communication of devices, sensors etc.

Future Internet lacks a service layer to support heterogeneity of device constraints, application requirements, user or group evolving properties, traffic priorities and restrictions, as well as behavioral patterns of groups and objects. Lacking a common service layer and the supportive communication architecture, all such isolated devices cannot really be exploited globally. The UMOBILE proposal aims to tackle this problem by proposing to architect the Future Internet to address three dimensions:

(i) *Geographicaldimension*: UMOBILE extends in a low-cost and self-organizing way the Internet capillarity, by providing reachability based on opportunistic transmission and allowing periodic or occasional communication of isolated regions including satellite and UAV-assisted communications. Such approaches have recently attracted the interest of communication giants, such as Google [LOON] and Facebook [INT13]

(ii) *Scalability dimension:* UMOBILEis thought and implemented in a way that intends to accommodate any type of moving object, via the applicability of abstraction techniques such as virtualization and

(iii) *Functional dimension:* UMOBILE exploits principles of social aspects such as social interaction; assisting users in getting access to the content they want as well as to content that may be of shared interest to their trust circles; balancing network traffic with observed similarities; scheduling on the basis of application requirements; prioritizing selected sensor data on the basis of application impact; and maximizing energy efficiency of energy-constrained devices with minimal cost on throughput as well as improving the overall network lifetime. This is combined with always-on authentication and name-based communications that will radically change information exchange, but will also improve the performance of the mobile network setup.

The technical core of UMOBILE revolves around three main aspects:

- **Information-centric Communication.** Communication is to be performed based on data interests expressed passively or actively by the user. What the applications above the UMOBILE abstraction layer shall see is an interface that allows them to access data (request, capture; make data available, disseminate data).We utilise advances in ICN to provide a uniform abstraction towards application - an abstraction driven by access to and provisioning of information. Through this abstraction, we accommodate today's web-based services while providing a path to future immersive and sensor-rich applications, such as those envisioned by the Internet of Things. The focus on information also enables inherent support for rich caching policies that ultimately increase the efficiency of the network across different technologies.
- **Intermittent connectivity support.** The UMOBILE data-centric approach will be complemented by the paradigm of DTN (which also includes opportunistic communications), which enables Internet operation in challenging infrastructural deployments. We then enhance our platform with a pragmatic integration of opportunistic access to other peers or backhaul links, to create a flexible and resilient hybrid network infrastructure that can work in both connected and disconnected environments. Across all connectivity options, a fine-grained Quality-of-Service (QoS) abstraction is enabled for all applications. Specific QoS specifications include the minimum required data rate, maximum allowed delay, desired throughput, jitter, packet dropping probability, bit error rate etc. In order to guarantee optimum resource utilization and satisfy specific service QoS requirements, the system must accomplish a dynamic resource allocation and call admission control policy that has to take into consideration the dynamic variations of the physical channel, standing as a major challenge for modern communication systems.

- **Trust-based networking.** To ensure adequate levels of motivation to engage in dissemination, our proposal considers social trust computation aspects as the scheme that allows robust pervasiveness to emerge based on both data-centric and DTN principles, as well as on the natural and human way of exchanging information in society. Trust is therefore seen as a potential Quality of Experience metric, an aspect that has been initially exploited during the FP7 ULOOP project.

Our proposal, UMOBILE, is a mobile-centric service-oriented architecture (Fig. 1), which integrates the core principles of ICN, DTN and IP together into one single architecture under a common service abstraction. The proposed architecture exploits two major properties that are common to both ICN and DTN: (a) *storage*, which allows for storing data for as long as necessary until a communication link is established and (b) *custody transfer*, which allows for intermediate nodes to act as relays that surpass the communication limitations imposed by the end-to-end architecture of the Internet: hence, communication is possible even when the initial end-to-end path no longer exists. Moreover, the inherent ability of ICN to push content to the edges provides more localized access to important content and enables a transmit-when-needed policy. The proposed architecture applies to a variety of devices, allowing a context-aware design of applications and communication flexibility. This architecture is designed in order to allow for inter-device communication, optimise system performance, and promote multi-device applications that cope with different challenging conditions. UMOBILE will efficiently exploit all possible communication opportunities, from fixed or mobile broadband networks to disruptive networks and satellite communications, while providing a unified abstraction to application developers for supporting current Internet-based services and enabling innovative future solutions.

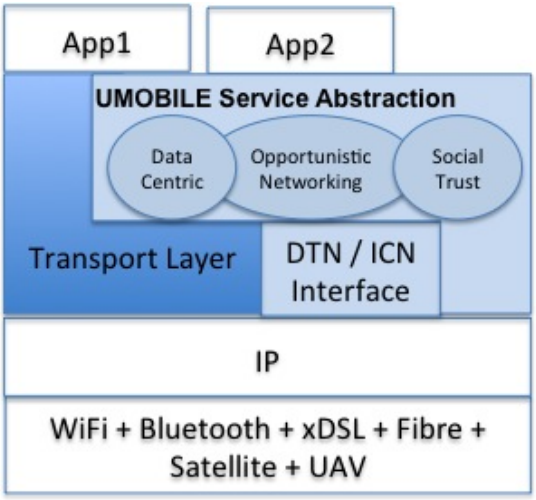


Fig. 1. UMOBILE architecture

Enabling ICN has a number of advantages. Efficient distribution of content to a large set of recipients can be implemented. Content caching is built into the architecture and is thus provided without resorting to either interception of requests or special configuration at the receiver. Load balancing is provided without depending on add-ons such as DNS round robin. Both reliability and performance are improved, since information can be retrieved from the closest available source. Performance and reliability can be enhanced by an information-centric paradigm in a heterogeneous wireless environment where there are disruptions in communication, transient access opportunities and multiple access choices. An information-centric communication abstraction gives more flexibility in the delivery of named data objects compared to using an end-to-end byte-stream, operating between location-based and location-restricted end-host (IP) addresses. The network has better knowledge of the intent of the applications and therefore has the possibility to treat the data more intelligently. The network can easily deliver the explicitly named data using multiple routes, redundancy over the available paths, and intermediate storage to overcome connectivity disruptions. These functions will be implanted in the sophisticated naming schemes designed through this project. The extreme is a scenario when an end-to-end path never exists. With an end-to-end reliable byte-stream, the network has to violate the assumptions of the abstraction, or the application must implement these functions itself, including application gateways at suitable network locations. The performance and reliability benefits from using storage also benefit non-dissemination applications, such as personal email. Another example is that direct delivery of email between two laptops with WiFi connectivity can be supported without involving infrastructure. The information-centric approach gives new possibilities to prevent denial-of-service (DoS) attacks. With an information-centric approach nobody can force network traffic towards some particular way without the consent or more precisely the interest of the participating users/devices. This is made

possible by moving control from the sender to the receiver. A sender can make information available, but for that information to be transferred, the receiver has to ask for it. Prevention of DoS attacks is a motivation to design ICN as a replacement to the current TCP/IP for end-to-end communication. The interaction patterns of emerging applications no longer involve simply exchanging data end-to-end. These new patterns are centred on pieces of information, being accessed in a variety of ways. Instead of accessing and manipulating information only via an indirection of servers hosting them, putting information objects themselves at the centre of networking is an enabler for radically new applications.

DTN creates a common overlay on top of existing protocols, able to communicate with diverse underlying technologies with the support of multiple convergence layer protocols. This overlay network is performed in DTN architecture by Bundle protocol, which can provide interoperability among different platforms even in disruptive environments. In particular, DTN could bind different internetworks and incorporate devices and applications with limited and/or local functionality, which require a form of internetworking capability in order to be globally use.

2.1.2.2. Approach

The Internet is currently operating as a massive network of pipes that passively push bits between end-host machines, be it servers, end-user fixed or mobile devices, or sensors. No one apart from the two communicating end-points "understands" what is being transferred, *i.e.*, ***the network is not content-aware***. This agnostic mode of operation affects several of the network's key functionalities, for example, efficient content distribution and content-aware traffic engineering, but also restricts the evolution of others, *e.g.*, mobility is not gracefully supported as attachment points change.

The Information-Centric Networking concept comprises important features that advance the way we do networking today. For instance, security is guaranteed by securing the content itself, rather than the end-hosts [JAC09], user (and content) mobility is inherently supported [NDN11], and content distribution and user quality of experience is enhanced due to in-network caching [PSA11]. However, transition from today's host-centric model to a content-centric one is still a crucial and not yet properly addressed problem. In this project, we propose a realistic approach towards a future ICN-based Internet, which, in contrast to efforts so far (*e.g.*, [JAC09], [FOT11], [SAI11]), guarantees non-disruptive and cost-efficient transition. This transition maintains key aspects behind the current Internet success, such as the addressing and routing framework, and introduces at the same time ICN-centric operation with the majority of the relevant benefits. We elaborate below on the key innovations of the project, which relate to the set objectives.

(a) Architectural Issues: Node Design and the UMOBILE Service Abstraction Layer

Here we provide an overview of the concepts introduced in this proposal, as well as the prerequisite requirements that need to be met.

(i) Naming Architecture: According to our approach, content providers generate a name for every content they create and intent to publish. Content files are split in *chunks*, according to universal rules similar to today's content delivery. The content name is bundled together with the actual content file and is put in the beginning of the first chunk of the content file. The exact sequence of events from *content publication* to *content delivery* is explained below. The structure of the name in our approach is not as important as in alternative proposals (e.g., [JAC09], [SAI11], [CAE06]), since content resolution and request routing in our case is not based solely on content names, but is rather based on hybrid operation through both IP addresses and content names. The key prerequisite in our case is *uniqueness* of the content name, which we intend to achieve through hash-based encoding.

(ii) UMOBILE Service Abstraction Layer: Adding extra functionality, or altering completely the operation of existing core network protocols cannot be done incrementally (*e.g.*, IPv6) and "flag-days" are not an option for incorporating new components. Therefore, in this project, we propose *addition* instead of *replacement* through an extra layer to the OSI protocol stack (see Fig. 1). We call this layer the *UMOBILE Service Abstraction Layer*. The *UMOBILE Service Abstraction Layer* sits on top of the network layer (IP layer) in order to guarantee fully backwards compatibility with legacy devices, but also smooth transition to the new networking paradigm. The *UMOBILE Service Abstraction Layer* incorporates functionalities from both the DTN world and of the ICN world. In other words, the benefits of the ICN and DTN networking model are incorporated into this extra layer instead of a disruptive totally new, clean slate and unrealistic architecture.

The *UMOBILE Service Abstraction Layer* will be able to operate based on content names and in-network caches, and adopts functionalities of both the transport and network layers, but incorporates them independently of the main content resolution operations in today's Internet.

(iii) UMOBILE Node Design: In a similar fashion to the interconnection between layer-2 switches and layer-3 IP routers, our scheme adds an extra layer, namely the *UMOBILE Service Abstraction Layer* and therefore, transforms *layer-3 IP routers* to *layer-3.5(UNodes).*

Our approach necessitates that at least edge-routers of a domain are upgraded to UMOBILE Nodes (UNodes). This is required in order for an ISP to control traffic rates within its own network.

UNodes deploy caches, which they exploit to store temporarily incoming data [PER11] [ARI10]. We have performed an initial investigation of cost- and performance-efficient cache sizing in [PSA12]. We have found that with today's technology, it is economically affordable to hold at least two seconds worth of traffic in DRAM chips, even when caches are deployed at the end of high-speed 40Gbps links.

UNodes maintain a routing table and the Forwarding Information Base at the IP layer (as is done today) and a Recently Served Name (RSN) table at the *UMOBILE Service Abstraction Layer*. The RSN table keeps track of the chunk *names* that this particular UMOBILE NODE served in the recent past. They also maintain a mapping between content names and the respective IP addresses of served requests. This is done in order for ICRs to be able to identify recently served requests for specific content names and redirect (if needed) the respective content requests. RSN table entries expire depending on the size of the respective caches; in [PSA12], we have defined the size of caches as *the amount of traffic a router or node can serve per unit time*.

(b) Lifetime of Content: Publication, Resolution, Caching and Delivery

We briefly describe the sequence of events from content publication to content consumption.

(i) Content Publication and Resolution:*The initial content resolution is location-dependent and is based on DNS resolvers and IP addresses*. Hence, the first part of the conversation remains unchanged, *i.e.*, the user is pointed to an IP address that hosts the content s/he is looking for. This guarantees resolution scalability, which has not yet been achieved in existing proposals and constitutes a major drawback of ICN in terms of deployability to date.

The very first frame of every content file contains the content's actual name and is provided by the content provider as noted before. The very first *flowlet* of each communication is therefore responsible for bringing back to the user the packet containing the content name (together with metadata, if necessary).

(ii) In-Network Caching Functionality and Content Delivery: At this point the user knows the IP address of the end host that stores the content, but it also knows its globally unique name. From that point on, the user requests subsequent parts of the file by assigning *the server's IP address at the IP layer and the content-chunk name at the UMOBILE Service Abstraction layer of the request packet.*

IP routers (and UMOBILE-incompatible domains) along the path process and forward requests based on the end-point's IP address. Instead, UNodes match the content name with their RSN table entries. If they have served requests for the same content recently and from a different IP address, then they have to choose whether to replace (spoof) the IP address originally attached to that request with the one they have (and therefore, create a new *flowlet*), or not. This decision is based on the distance to the destination copy (*e.g.*, using the hop-based distance metrics introduced in [PSA12]) and/or network condition or topology criteria [CHA12].

In case of multiple quasi-simultaneous requests for the same content at an ICR, the latter has two options: either forward all requests towards the destination (server) leaving the source (user) address intact, or replace the source IP address (or node ID) of the request with its own IP address and forward one request only. In the second case, the UMOBILE NODE creates (and is responsible thereafter for) new *flowlets* between itself, the content's location and the end-users. These design choices will be judged against their respective impact on the performance and density of the network, and will be based on issues of path asymmetry, redundant traffic elimination [ANA08] and modeling of in-network caching [PSA11].

The goal of UMOBILE will be achieved in *three stages*:

- At the **first stage**, emphasis will be given on the design and implementation of the architecture along

with the supportive service protocol stack and the supported services. At this stage, a set of protocols will be designed and deployed, allowing for the incorporation of devices of different types.

- At the **second stage**, the system will be evaluated in terms of extensibility, potential to accommodate user-centric and device-centric applications, as well as scalability. Fine-tuning of the system is crucial, in order to guarantee its wide development for a variety of communication conditions.

At the **third stage**, the developed architecture along with the deployed applications will be validated initially through simulations and emulations and, then, in field trials in the area of Lisbon. Given its expertise, FON Technology will build WiFi networks and opportunistic communications among devices will be exploited using UMOBILE platform. Moreover, TEKEVER will provide backhaul links over Unmanned Air Vehicles UAVs to disconnected devices. The usage of real components will highlight the applicability of the developed architecture in a variety of situations.

2.1.2.3. Applicability Scenarios

This section describes two different applicability scenarios that exploit UMOBILE architecture, starting with a brief description and providing both initial assumptions and requirements. The first scenario refers to an application that captures data based both on contacts and visits to networks, while the second scenario refers to a disaster prevention situation.

2.1.2.3.1. Applicability Scenario 1: Children Safety Prevention

This scenario focuses on a specific UMOBILE application that captures data based on contacts and visits to networks. The intention of such an application is to learn roaming habits as well as usual social context and to infer specific aspects of social interaction based on such learned information, e.g. relevancy of contacts, contact time and granularity; reputation of contacts; different trust circles. Real-time geographic positioning is a complementary solution for this application as intermittent connectivity is considered. What matters to the application is the definition, over time, of a regular social behaviour pattern to allow the identification of abnormal situations and, as a consequence, emit alerts within the context of specific trusted circles (e.g. family, school).

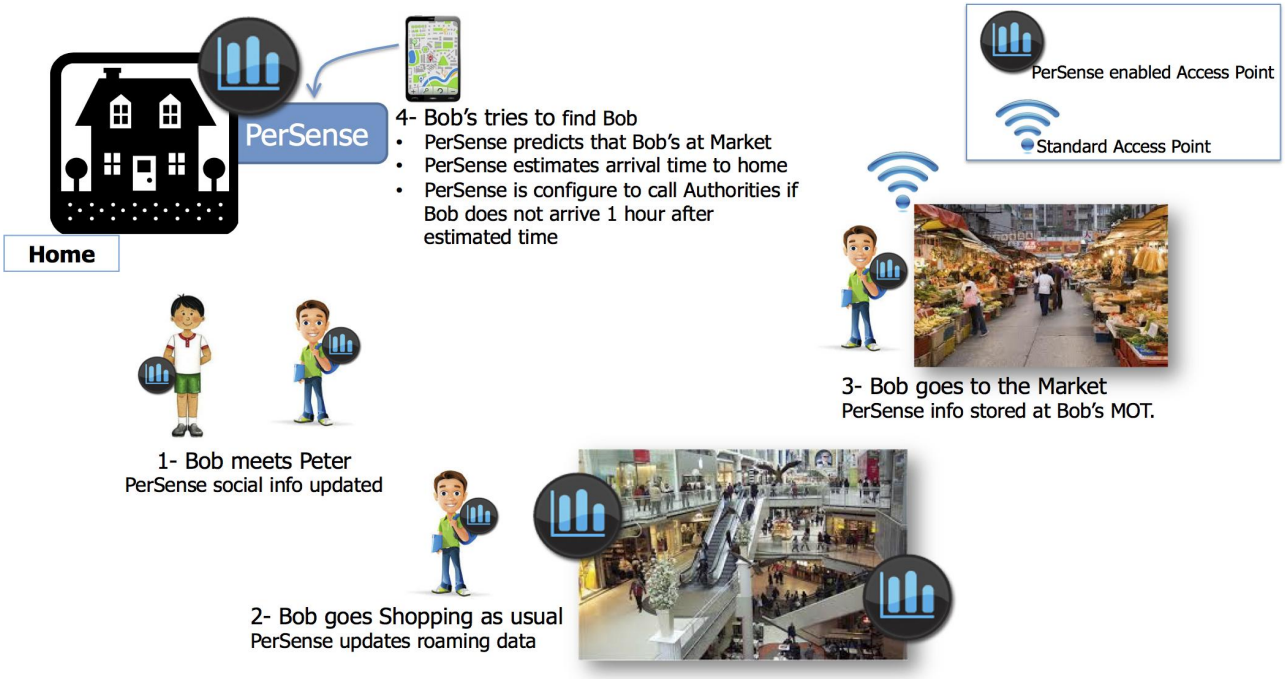


Fig. 2. Children safety prevention scenario

In the scenario illustrated in Fig. 2, Bob's parents have a private cloud system at home (e.g. a NAS box) with PerSense, an open-source Pervasive Sensing Framework currently being developed by SENCEPTION, which supports, among other aspects, data collection. Bob carries a smart application in his Android device. On the course of his daily routine, Bob meets Peter (1) and the devices exchange information concerning their casual encounter e.g. inter-contact time; social context; number of people that each of them met; their speed during the encounter; reputation level on that specific trust circle (family), which is also computed based on the social interaction between Bob and Peter, not only between each of them but also among thirds. Bob then continues

walking and goes to the shopping mall in the vicinity (2). When in range of a wireless access point, Bob's device tracks information concerning the different visits to the different networks. If a wireless access point is PerSense enabled, then the wireless access point makes information about Bob available to trusted circles, which includes the PerSense platform at Bob's parents. Inside the mall, Bob goes to the market (3), which is not covered by any low-cost infrastructure. Experiencing intermittent connectivity, Bob's device stores the collected information to be disseminated whenever feasible.

Periodically (4), the PerSense platform at Bob's parents updates Bob's location via inference, due to previously learned behaviour on Bob's routine. The PerSense platform predicts that Bob should be at the market as usual, and estimates also his return back home, providing regular alerts to the subscribed users. Such alerts are not based on geographical circles as current applications do; instead, they are based on abnormal behaviour pattern detection.

The following list of requirements is necessary to guarantee the operation over such use-case:

- <The architecture> MUST use any contact opportunity to disseminate data in trusted circles.
- <The architecture> MUST use any trusted communication means as to reduce delivery time of up-to-date data.
- <The architecture> SHOULD be able to identify and to prioritize contacts that the user meets.
- <The architecture> SHALL make use of any wireless technology available to allow the inexpensive exchange of information
- <The architecture> SHOULD be able to infer the different level of social relationships among users as a way to better provide contextual information.

Here's what exists in terms of functionalities to allow such operation, but yet are not integrated:

- The PerSense open-source platform, provided by Senception, can be considered a starting point to validate the application to be developed.
- The MTracker tool, developed by COPELABS in the context of the European project ULOOP, LGPLv3.0, and currently available in C#, is a first solution for collecting visited network parameters and to estimate a potential handover target. MTracker design is expected to be extended to collect more relevant data in the context of UMOBILE.
- MOT (Mobility Object Tracking), under development by Senception, is an Android plugin based on the open-source MTracker, which adds the potential for inference of human behavior and some aspects of social context, in conjunction with PerSense. In UMOBILE, Senception commits to provide an application that serves this specific use-case by ensuring support also in the context of intermittent connectivity.

Social- and Interest-based opportunistic routing, namely dLife [Moreira 2012] and SCORP [Moreira 2013], that infer user social interaction and drive information exchange through levels of social relationship and user interest.

2.1.2.3.2. Applicability Scenario 2: Prevention in Disaster/Emergency Situations

This use-case focuses on a disaster prevention situation and considers whichever contact opportunity devices may have as a way to exchange data. Information is exchanged in a seamless fashion and users/devices simply produce data at their will or as programmed to do it so. Fig. 3 shows a use case where a user is exploring the national park close to his hometown. Here, the user is photographing different moments of this countryside experience, which surely will later be shared with family and friends. Additionally, the national park is covered by an array of temperature sensors, which produce data for fire prevention. Thus, the use case comprises the exchange of personal and public utility data, with such data being processed, independently of its source, as to aid disaster prevention measures.

Fig. 3. Disaster prevention scenario

After a few hours of hiking, Charles reaches the highest grounds of the national park just before sunset. From such point, Charles is amazed with the view towards his hometown and surely wants to share such moment with people through his online social networking page. He takes a photo, which is publicly posted online through a car that passed by Charles (1) or through a UAV operating in the area (possibly acting as an additional sensor). At this same moment (2), sensors in the national park detect a sudden increase in the temperature, which triggers a fire hazard alarm at the local fire department and also broadcast public safety messages to passers-by. As the fire department is getting resources ready to check the fire alarm, a car, which drove by the area, delivers the public safety message confirming the alarm (3). At the same time, Dave spots smoke in Charles' photo, and also decides to notify the local fire dept. Fire-fighters are able to locate the place of interest and prevent a massive fire based on information coming from different sources (sensorial and user data). During this time, UAVs may be operating in the area complementing existing sensors and providing additional coverage and links to the "outside world" or serving as data mules until connected regions can be reached.

The following list of requirements is necessary to guarantee the operation over such use-case:

- <The architecture> MUST use any contact opportunity to disseminate public safety data.
- <The architecture> MUST use any communication means as to reduce delivery time of safety data.
- <The architecture> SHOULD be able to identify and prioritize safety information

Here's what exists in terms of functionalities to allow such operation, but are not integrated yet:

- Epidemic routing [VAH00] can be employed in the case of public safety data exchange given the high priority of such data. Regarding personal data the already mentioned Social- and Interest-based opportunistic routing, dLife [MOR12] and SCORP [MOR13], can be used to disseminate such content.

2.1.3. Ambition

Our proposal comprises of two primary goals: (1) to gracefully integrate the disruptive ICN and DTN technologies into the current IP-based Internet communication system, (ii) to integrate both ICN and DTN into one single architecture to develop a novel platform that will enable the Future Internet to be fully pervasive. To achieve this we build on the current advances of both ICN and DTN research, putting backward compatibility and smooth migration in the forefront of our design efforts. In more detail, our ambitions are discussed below.

Ambition 1: Develop a new ICN architecture that is backward compatible with IP

DONA [KOP07] was one of the first, clean-slate, ICN proposals. DONA uses flat, self-identifying and unique names for information objects and binds the act of resolving requests for information to locating and retrieving information.

The Content Centric Networking (CCN) [JAC09] project developed a new network layer based on an information centric approach. CCN has a hierarchical namespace for naming content. The namespace is used to route requests for content, called interest, toward the producer using longest prefix matching. Namespace prefixes are announced in the network in a similar fashion as IP prefixes are announced using BGP today. When an interest meets the corresponding data, either a cached copy found en-route to the producer, or ultimately at the producer, the content data is sent back the reverse path.

Although CCN has been mostly developed to retrieve content stored in the network, its use in case of real-time applications such as audio-conference has been also investigated in [ZHU11]. CCN is the basis of several relevant research projects. COPSS [CHE11] presents an extension to the basic CCN architecture by introducing a multicast-based pub/sub capability and extends the naming framework with the introduction of the concept of content descriptors to enable efficient large-scale information dissemination. CONIC [ZHU10] is a network architecture designed for efficient data dissemination using storage and bandwidth resources in end-systems (i.e., available storage located in end hosts is used for caching). A similar approach, where content is cached in routers is the Cache and Forward architecture [DON09]. MultiCache [KAT10] is an information-centric overlay network architecture aiming to improve network utilisation via resource sharing. In MultiCache, network operators deploy and control proxy overlay routers that enable the joint provision of multicast and caching, targeting both synchronous and asynchronous requests.

The 4WARD project developed the Networking of Information (NetInf) architecture [AHL08, OHL09]. The NetInf service can handle information at different abstraction levels, which makes it possible to refer to information independent of its encoding. The naming scheme provides both self-certification and name persistency. The NetInf service interface is inspired from publish/subscribe. Information is published, but subscribers ask for named content instead of receiving publication events.

PSIRP – Publish-Subscribe Internet Routing Paradigm [EST08, JOK09], set out to solve the main security and trust related problems with current networking technology; mainly stemming from that the sender is overly trusted, resulting in problems with spam and denial of service attacks. The approach in PSIRP was to design the future internet on a publish/subscribe paradigm, where senders publish information, and receivers explicitly ask for information by subscribing to it. The PSIRP project addressed same problem space as NetInf in 4WARD, but has different approach and focus on the basic mechanisms using publish-subscribe with a strong emphasis on redesigning the lower layers.

4WARD, CCN and PSIRP all largely take a clean slate approach to developing networking technology based on an information-centric paradigm. A clean slate approach is excellent for the initial concept development phase where new ideas and their potential are investigated without being restricted by current standards and practices. The goal is to overcome the limitations of the current synchronous host-to-host communication model. In an information centric approach, named content is the principal concept, and the network provides transmission, storage and mobility resources to make named content available to interested users.

One of the objectives of the FP7 SAIL project (http://www.sail-project.eu/) was to proof the large-scale, carrier-grade, practical feasibility of a Network of Information by developing a concrete set of mechanisms and protocols that realise the benefits of the information-centric approach. SAIL adapted the NetInf architecture to meet the deployment goals. NetInf could now possibly be used in multiple existing information-centric content delivery models, such as proprietary CDNs and P2P networks. In doing this, SAIL largely builds on the results from the 4WARD project (http://www.4ward-project.eu/), taking also results from CCN (http://www.parc.com/work/focus-area/networking/) and PSIRP (http://psirp.org/) into account, as well as influences from Delay Tolerant Networking.

The EU IST FP7 ULOOP - User-centric Wireless Local Loop - project (2010-2013) also focused on user-centric networking. The approach followed by ULOOP envisioned assisting the Internet end-user in gaining an active networking role via Internet access sharing, and Internet services sharing. For that purpose, ULOOP considered social trust computation as the tool that assisted a natural and viral growth of user-centric networks, complementary to access technologies. It then considered trust as a QoE metric to improve wireless resource management, including trust-based call admission control, and downstream multiuser transmission based on reputation of the users - the more a user shared, the higher the likelihood of having better services.

Instead of radical and risky approaches to ICN, which require redesign of the whole protocol stack [JAC09], application redesign and “flag-days” for switching to an ICN-based Internet [CAE06], here we propose a more realistic route to exploit the advantages of the Information-Centric Networking concept. In particular, according to our proposal, the first stage of communication between the user and the content source, *i.e.*, the content resolution stage, will follow the approach of the current Internet and will use search engines, with the URL containing the name of the primary content server. This approach is in contrast to location-independent content resolution approaches, whose scalability is questionable. Instead, UMOBILE will follow a smooth shift to an ICN

environment, where content names are communicated together with end-host identifiers and IP addresses. This will guarantee worst-case, best-effort service over IP, but will also take advantage of ICN benefits where the ICN technology is supported.

Ambition 2: Develop new name based forwarding and replication schemes for ICN

Names play a crucial role in ICN architecture as their design pervades all aspects of the system. For example, names may reflect a hierarchical structure or include embedded location information in order to assist routing. Typically in ICN, a receiver expresses its interest in some identified data that the network then returns when it becomes available, possibly taking advantage of multicast and caching. CCN uses an explicitly specified number of ordered components to hierarchically name content chunks [JAC09]. COPSS [CHE11] extends the CCN naming framework by introducing of the concept of content descriptors to enable efficient large-scale dissemination. PURSUIT/PSIRP uses flat names to identify both hierarchically nested scopes of information and information items themselves [RAJ10], [LAG10a], allowing names to be interpreted in different ways [VIS09]. DONA [KOP07] replaces the hierarchical DNS namespace with a cryptographic, self-certifying namespace where names consist of a provider handle and an information object label. NetInf/SAIL [DAN10] proposes a secure naming scheme composed of two main components: a naming scheme based on URIs and an information object structure holding information about a piece of content.

Current IP-based DTN networks focus on the destination of the content, i.e., where the content should go. This reduces the flexibility of the network to make content-centric decisions such as if the data is worth transferring/replicating in the network. ICN, with its focus on content-centricity-based forwarding allows for nodes (i.e., routers in case of the fixed Internet infrastructure) to make decisions based on the name of the content. Since nodes are aware of the content or message name, they can retrieve the data from their own cache or forward it towards one of the sources of the data. With a few exceptions ([WAN11], [WAN12], [TYS13]), most of the on-going research [KOP07], [CHE11] addresses non-DTN scenarios.

UMOBILE will leverage the benefits of ICN in case of infrastructure-less environments (e.g., the aftermaths of a disaster), where ad hoc DTN communication becomes essential in order to deal with fragmented networks and the increase in traffic demand. We argue for the need of a name-based forwarding/replication scheme, wherein intermediate nodes use a *Name* associated with each message to make decisions such as whether to replicate and if so, according to what priority, or otherwise, store (-and-carry) and for how long storage should be allocated.

Ambition 3: Develop an integrated ICN-DTN platform

Delay/Disruption Tolerant Networking (DTN) [CER07] is an emerging technology to support a new era in interoperable communications, either on Earth, or in Space. Like IP, DTN operates on top of existing link layer and network protocols and technologies, creating a DTN overlay. The key advantage over IP is that DTN allows interconnecting networks with very diverse characteristics. In particular, DTN extends internetworking in the time domain: rather than relying on an end-to-end path as IP networks do, DTN operates in a store-and- forward fashion: intermediate nodes assume temporary responsibility for messages and keep them until the next opportunity arises to forward them to the next hop. While stored, messages may even be physically carried with a node: *store-carry-forward* to reach the next hop. This inherently deals with temporary disconnections or disruptions and allows connecting nodes that would be *disconnected in space* at any point in time by exploiting *time-space paths*.

In essence, DTN technology enables seamless communication between diverse devices, by hiding the complexity, the diversity, and the potential discontinuity of the end-to-end heterogeneity from the communication service. This is accomplished by an inherently asynchronous interaction service offered to applications and by using numerous convergence layer protocols to map to link/network layers, which allows for a great variety of devices, ranging from common sensors and smart (mobile) devices to space located sensors to desktop PCs to embedded routers. DTN offers a communication framework independent of the type of device. Various options on convergence layers for different types of common transport and network protocols are already available in the existing DTN implementations, such as DTN2 [DTN2], IBR-DTN [IBR-DTN], and (for mobile embedded devices) the SCAMPI router implementation [KPO2012]. All implementations are based on the DTNRG Bundle Protocol (RFC 5050) [SCO07] and related convergence layer specifications.

DTN has already been tested in numerous stressed terrestrial environments, such as sensors in underwater

environments [MER11][BER2011] and remote villages that have no access to the backbone Internet infrastructure [JAI04][SNC02][N4C]. A number of Internet applications were adapted to run over DTNs [BAL07][PIT10][KPO13] and numerous new applications were designed leveraging the DTN paradigm at their core (e.g. [FLO11]). One of today's important challenged terrestrial environments with frequent and unpredictable connectivity opportunities and disruptions is *opportunistic networking* (also dubbed *pocket-switched networking*) between mobile devices (e.g., smart phones) of human users. As people move in their daily routines they encounter others and, upon such encounters, may exchange data between their devices, thus forming a network that follows repeated social interactions but also encompasses random encounters of strangers. Such a network may be exploited to share information and exchange messages even when there is no (wireless) network infrastructure available, but occasional infrastructure access (e.g., WLAN hot-spot) may complement connectivity and provide access to resources on the Internet. Projects such as Haggle and SCAMPI have explored ways to offer communication and computing services on top of mobile opportunistic networks. While Haggle diverges from the DTN stack structure but enables the automated propagation of information across concatenated time-disjoint communication links in ways that focus on specific application constraints, SCAMPI has chosen to retain the DTN bundle protocol but adds infrastructure that is particularly suitable for mobile opportunistic communications.

In UMOBILE, we will support the delivery of information and services across both IP-centric and novel DTN-centric environments. For this, we need to avoid further architectural ossification of the current Internet through extending the current Internet architecture with a plethora of protocol choices. Instead, it is our *approach* to develop an information-centric communication platform based on a node architecture that unifies the various underlying protocol choices within a single architectural framework, while enabling diversity in supported networks that range from all-optical high-speed networks, through wide-area coverage provided by satellites, to localised deployments that include challenged mobile environments.

Ambition 4: Enable social based DTN routing support

Given the capabilities of DTNs, especially for not relying on the existence of end-to-end paths to successfully deliver bundles, one can easily observe the potential of such networking paradigm when employed in scenarios where humans carry devices. People have a very dynamic behavior, which is reflected in their social interactions and interests. This gave rise to social-aware routing [MOR13] with proposals focusing on different social similarity metrics (common communities [HUI11], shared interests [MOR13], node popularity [MTI10], dynamic user behavior [MOR12]). This social-aware routing family has shown great potential when it comes to support the exchange of data between users: as only socially well-connected nodes are considered, forwarding takes place with low associated cost and delay, when compared to other families.

TECNALIA defined the HUman Routines optimize Routing (HURRy) protocol, which defines a probabilistic routing approach that infers and benefits from the social behaviour of nodes in disruptive networking environments [URT14]. This mechanism is intended for human carried devices (e.g. mobile phones interacting as DTN nodes), so that the dynamics and mobility of those DTN nodes can be translated into people's social behaviour that the routing protocol is able to use. HURRy is based on Probabilistic Routing Protocol based on Historical EncounTers (PRoPHET) [DAV12] but it incorporates the contact duration to the information retrieved from historical encounters among neighbors, so that smarter routing decisions can be made. A testbed was deployed so as to integrate this mechanism with the ICN-based implementation of Bundle Protocol Query (BPQ) [KUT12] in order to show the cooperation between previous knowledge of social encounters among nodes and the possibility of intermediate caching of the demanded content. This prototype was intended to show how several smart phones present in a large crowd scenario could act as integrated ICN-DTN nodes in such a way that whenever a user initiates a request (Query) for a multimedia content (i.e. photo or video file), the application interface sends an ICN request (GET req(content, location)), and the local Service Orchestration Process is able to select a combination of BPQ+HURRy as the best service solution to serve that request.

HURRywalla is the comprehensive implementation of the DTN service described, including HURRy routing and BPQ extension over Android. HURRywalla has been released as an open source project evolved from the existing Bytewalla3 [BYT10] and it is available from [TEC13]. The whole code release can perfectly be reused and/or extended for specific user applications or with other routing protocols, bundle extensions, etc. The project is implemented in such a way that some parts of the DTN suite can be reused as individual modules as well.

Collecting data about people interactions based on wireless technologies is a quite recent activity. Until recently its potential usage did not seem to transcend beyond the biological or sociological fields, but the irruption of new

concepts in telecommunication networks, which mobility plays a key role for, became a powerful tool in the study of human behaviour. Detecting one or several aspects related to human behaviour like people's social activity, the reason why people move to certain places, in which specific moments, or with who, together with human ability to associate, could be of a great value in order to optimize both network design [SCO06], [BAG11], as well as societal structures [KIT00], [BRO06]. That is a relevant linkage between the monitoring of social behaviour and wireless communication networks. Thanks to frequent changes in the activity and communication patterns of individuals, the associated social and communication network is subject to constant evolution [EBE02], [PAL07]. Our knowledge of the mechanisms governing the underlying community dynamics is limited, but is essential for a deeper understanding of the development and self-optimization of a network topology or deployment.

The use of mobile phone data as a proxy for social interaction has already proved successful in several recent investigations. [ONE07] has analyzed the structure of weighted call graphs arising from reciprocal calls that serve as signatures of work-, family-, leisure- or service-based relationships. [SZA06] has studied social network effects in the spread of innovations, products and new services. They investigated different mobile phone-based services and found the coexistence on the same social network of two distinct usage classes, with either very strong or very weak community-based segregation effects. [GON08], [SON10a] and [SON10b] continued working with special focus on human dynamics, the exploration of scaling properties and the limits of predictability in human mobility patterns.

Additionally to mobile phone networks, where the user terminal is mobile but the rest of the infrastructure is fixed, there are also other types of wireless networks where the concept of mobility becomes more complex, provided that any device in the network can be mobile. Some good examples are Mobile Ad-hoc NETworks (MANETs), sensor networks, or Delay Tolerant Networks (DTNs), which indeed represent suitable tools to monitor diverse aspects of human behaviour. [EAG06] and [EAG08] performed experiments regarding proximity interactions (based on short-ranged Bluetooth technology) using people's mobile phone as a contact sensor. They worked on the identification of communities and patterns of behaviour. [CAB08] specifically designed Bluetooth medallions intended for the monitoring of human MANETs.

As this project envisions the low-cost communication among users in urban setting as well as providing communication support in underserved/disaster-affected areas, social-based routing is a good option given its ability to provide wise use of node and network resources, and to allow for user to overcome either the lack of infrastructure or the existing, expensive available infrastructure. The idea is combining social-aware and interest-based routing solutions to allow the exchange of information only among those parties that are socially well connected and/or are interested in the content traversing the network.

Although valuable efforts have been conducted, there is still room for further improvements in the modeling and processing techniques, as well as the application of such inference of information. Likewise, it is expected that a wide variety of target fields can be influenced by (and benefited from) the highlights of social interaction analysis through all kinds of communication networks. UMOBILE will take advantage of the expertise of several partners in smart routing approaches on DTN deployments in order to combine context awareness with social behavior of people involved in the final services so as to optimise content retrieving and delivery.

Ambition 5: Enable content, host and user mobility

Approaches such as Mobile IP introduce various techniques for supporting mobile IP endpoints. However, these proposals have not flourished due to security, scalability and route optimization issues. Although many of these techniques may be applicable to ICN, there is a fundamental difference when looking at these approaches from an ICN angle. An information-centric approach is concerned with disseminating information to a possibly changing set of consumers, while the endpoint-centric approach of IP is concerned with establishing a communication channel between two dedicated endpoints.

The exchange of data between mobile endpoints, as well as between mobile endpoints and access points to the fixed Internet, under energy and storage-constrained challenged environments, has been studied in the context of DTN. JEDI was the first ICN-like, publish-subscribe overlay system that supports mobile clients [CUG01]. Huang et al. [HUA04] show how the anonymity, dynamism, asynchrony and multicast nature of publish-subscribe architectures make them ideal for mobile environments.

CCN supports mobility mainly through caching and the transmission of interest packets from multiple interfaces.

Moreover, it has introduced the Listen First Broadcast Later protocol (LFBL) [MEI10], which enables the requesting node to pick the preferred data source for receiving the desired content. The PSIRP/PURSUIT architecture regards mobility as a multi-dimensional problem and proposes various solutions for each dimension. For instance, methodologies to improve mobility support have been proposed, which exploit proactive caching strategies [VAS12].

A general solution to the mobility problem is missing from all proposed ICN architectures even if we admit that ICN supports mobility for selected scenarios. In particular, mobility of content receiver in ICN can in principle be based on multipathing Interest packets, which is a native feature in current ICN design. However, an open problem in ICN is how to handle the mobility of the source of Data packets. To see this notice that Interest packets always need to be directed towards the location of the content being it a cache or the origin server. Thus, updating the information related to the location of requested content is key in ICN. In UMOBILE, we will go beyond the state of the art to incorporate content-, server- and user-mobility by taking advantage of our novel naming schemes, but also of our architecture, which will incorporate ICN benefits on top of IP to foster smooth migration to the ICN ecosystem. Although IP has been shown to be inferior in mobile environments, it still guarantees scalability and location-reference (instead of location-dependence, as assumed in other approaches).

2.2. Impact

2.2.1. Expected Impact

The key expected impact of UMOBILE project can be summarized as follows:

To bring together existing technologies to architect a platform that targets the mobile part of the Internet and assists mobile users in getting access to the content they want as well as content that may be of shared interest to their trust circles.

UMOBILE touches on a number of areas directly, but, given the fundamental role that the Internet plays in modern societies and economies, its main benefits (i.e. enabling opportunistic Internet access) are likely to be society-wide. As a result, potential beneficiaries are numerous. These include: local and national government, the general public, industry, academia, and third sector. The value is **international** in scope, as it is desirable for allnations, developed and developing.

With the development of UMOBILE platform, our project intends to support interoperability among completely diverse devices and interconnection of different technologies providing major scientific contributions in the areas of opportunistic communications and context-aware applications to improve network performance. Business industries are often unaware of the possibility of interoperability among different providers and consumers with such applications. UMOBILE will also provide the framework for the response in emergency situations providing great benefits for the general public in terms of public alertness and public safety.

The impacts of UMOBILE project naturally fit in the expected impacts of the work program. Each partner has its own particular expertise area, and this expertise is not possible to be found from a single institute and following European approach is essential.

2.2.1.1. Scientific Impact

UMOBILE contributes to the development of a unified communication platform that exploits all communication opportunities and intelligently manages network capacity in order to create new access models
The current Internet architecture is progressively reaching a saturation point in meeting increasing user's expectations and behaviours as well as progressively showing an inability to efficiently respond to new technological challenges. This widening range of requirements imposed on the Internet architecture leads to a growing collection of solutions and hence the ossification of the Internet, which each in their own right address a set of requirements while furthering the fragmentation of solution. Future broadband networks (mobile, satellite, and other terrestrial) will only be sustainable by overcoming this trend of fragmentation in order to create the necessary reach and scale of future deployed infrastructures.

A major outcome of the UMOBILE project is to directly address the needs of users from all parts of the society, including the multitude of devices they use and heterogeneous networks they need to connect to. We achieve this by developing a communication platform that unifies the various underlying protocol choices within a single

architectural framework, enabling diversity in supported networks that reach from all-optical high-speed networks, satellites to localised deployments (including challenged environments). We not only **design** and **develop** such a platform, but also **demonstrate** its efficacy (and the benefits of the emerging technologies it utilises, such as ICN and DTN) by actual deployment in a trial setting. Showcasing a successful deployment combined with a strong and focused dissemination and exploitation plan will lay the foundations for influencing the way in which **high-speed broadband and mobile network infrastructures** are designed, delivered and operated. We complement this technological development through a engagement with major stakeholders via the IRTF GAIA allowing the evaluation of the platform's viability in the wider societal settings of its possible deployment and the formulation of an action plan that can ultimately lead to a societal success of UMOBILE.

UMOBILE provides an abstraction layer to allow applications to be truly pervasive and focused on information. UMOBILE supports the collection and processing of data among nodes, according to their context. This means that devices and nodes communicate with others in the network based on application and data context. This will be realised with cooperation and interoperability among diverse devices and nodes that handle data with the same context. In this way, the data circulated in the network will be used efficiently, thus increasing the performance of the network.

One of the most important advantages of UMOBILE project is its contribution in providing the required information collection and retrieval in emergency situations, as well as extending the Internet even in remote, restricted areas. In this critical case, UMOBILE permits the automated cooperation among a variety of involved parties in a crisis management, who will also be able to communicate and receive critical information from various and heterogeneous sources (temperature sensors, sensors from space etc.) in diverse environments (satellites, forests, cities etc.). In this way, efficient and reliable communication and coordination among rescue teams is achieved to guarantee effective protection of citizens and environment under crisis. Moreover, UMOBILE will give the potential to circulate the data to locations of high demand or interest, utilizing the inherent capabilities of ICN.

2.2.1.2. Socio-economic and Business Impact

The telecommunications market is currently undergoing a constant change in the way it is implemented. On one side, the emergence and proliferation of technologies such as WiFi, widely allowing users for freely connecting to the Internet, is challenging the traditional operators models. The new communication services exploitation approaches along with the well-known challenges being introduced in the telecommunications world such as expansion of use of mobile devices, the IoT, Smart Cities, etc., are fostering the emergence of convergent models, where operators of all kinds (3G/4G, WiFi, Satellite, land line…) build cooperative exploitation plans and business models. On the other side, the "always-on" paradigm demanded by users is also slightly changing the view, where now **users want to be always connected when needed, but only when needed**, reducing costs being a main objective in this vision. The final view, anyway, is to provide users with the information they claim for, at the moments they claim for it, with some services demanding to be immediate, but a large amount of them not presenting this characteristic.

Given this scenario, it becomes clear that UMOBILE will have a deep impact in the world of future communications. The opportunistic communication, low cost and information centric approach from the project will enable the creation of new business views both in the individual exploitation and in the collaboration among operators. There, the service definition can move its base from the provision of connectivity itself to an information-delivery base, where business models supported not by billing the users, but moving the monetizing of the network into application and service providers, open a blue-ocean market yet to be explored. Not ending here, legacy models will also be highly impacted, as the capacity of implicit, infrastructure-less network and information delivery extension brought by the project will allow all kind of operators to reduce both CAPEX and OPEX while maintaining and even increasing the general QoE offered to users.

Of course and as can be easily recognized, all the aforementioned has a direct impact in the society as a whole. Generally speaking, the extension of service provision and low-or-zero cost introduced for final users will help in the universalization of the use of ICT-based services and applications and, widely, to the evolution of the Information Society and the reduction of the technology breach. The Smart City concept and its emergence will play a vital role here, with UMOBILE results allowing its introduction and fostering widely acceptance of its related services into the society. Furthermore, the project approach will enable the extension of this concept into new ones such as Smart Regions, where the concept overpasses the boundaries of cities themselves and bring the provision of ICT-based services into outer scopes such as rural or isolated areas.

It must be finally noted that the results from UMOBILE in combination with other initiatives for which companies are beginning to define exploitation measures, such as the whole FI-PPP program by the European Commission and the resulting FI-WARE technology, will impact one each other for creating exponential innovation capabilities and related market and social improvement paths

Assist in the development of business opportunities/new business models

The project will enable new models for revenue creation allowing current business stakeholders to expand their revenues. By adopting an information-centric architecture, allowing more users to access the Internet enables more efficient caching at the edge nodes which in turn provides faster access to important content (performance incentive to the user) and also reduces the need for unnecessary transmission of data over the network (cost incentive for the operator). By providing tools to manage and deliver content from locations closer to the end-user, better service quality can be provided at lower costs, increasing the competitiveness of European operators. This increased content delivery efficiency is expected to result in significant energy savings for the network operator.

WISPS and SMEs may take advantage of the universal framework developed in UMOBILE, to generate truly data-centric applications and services. UMOBILE creates a driver for the uptake of smartphones by offering multiple connectivity options at no extra cost, while enabling additional benefits through the computational capabilities of modern smartphone platforms that can be exploited for, e.g., education, health as well as safety purposes. Additionally, there is the opportunity for businesses creating novel applications/services targeting opportunistic communications

Contribute to the definition of global standards, interoperability and European IPRs.
The project will contribute to the Internet Society (ISOC), both from the wider goal of enabling universal Internet access and specifically by ensuring the work is aligned to IETF priorities (the IETF is the primary standards group for Internet technologies). Several project partners are actively participating in various standardization bodies such as the IETF as well IRTF. Candidates for a focused contribution are current efforts in the IETF and IRTF to position DTN and ICN as an exploitable technology. UMOBILE will allow Europe to evolve and to dictate the pace in data-centric architectural evolution of the Internet, thus accelerating an uptake of the next generation of network and service infrastructures.

Strengthen European industry for closer integration of datacom and telecom.

Macro-trends are also showing that Internet is moving towards the next big evolutionary step, becoming the so-called things platform. By 2020 Cisco estimates that the number of connected objects will reach 50 billion (in 2008 it exceeded the world's population). IBM forecasts that soon there will be a trillion connected instruments. Our environment will be full of devices (sensors, actuators, cameras) that need an Internet connection, making the Internet of Things (IoT) a reality.As it always happened with any major Internet evolution, IoT will not delete the previous evolutionary steps: it will add a layer to the other features the Internet platform has always offered. T**he UMOBILE project is placed in the context of this evolutionary step: it will contribute to the emergence and adoption of innovative business models, concerning both the access network (how UMOBILE will operate in order to make money) and the applications that could arise from this new network-based scenario.** New access models will emerge, thanks to specific features enabled by the flexible architecture of UMOBILE. Furthermore, new spillover opportunities regarding the elaboration/aggregation of *big data* may emerge, albeit with a focus on localized communities, complementing the current big data trend in the well-connected Internet with *little data* opportunities of creating focused and localized opportunities of knowledge creation and exploitation. It places the end users in the center and under control of their data, while contributing to communal objectives and goals.

As of today, no products and networks combine both Information Centric Networking and Delay Tolerant Networking are available on the market. This provides the European companies participating in the UMOBILE project with the possibility of pioneering this important research area and be the first to the market ahead of other companies, thus bringing a competitive advantage to Europe. By basing this proposition on successful EU-funded efforts in both spaces of ICN and DTN, the consortium is well positioned to exploit the existing knowledge and enhance it asnecessary towards the objectives of the project.

We strongly believe that the goals of the UMOBILE project require a European approach since Europe has been in the forefront in pioneering research in Information Centric Networking and Delay Tolerant Networking. Several

projects have been funded in this space and all of the technology partners in the consortium have been involved in some of these projects. Hence, the need for European level collaboration on these research areas stems from the need to bring together a consortium with the necessary skills in the subject areas this proposal covers. Clearly, no single member country has the required expertise or the breadth of both academia and industry needed to make such an ambitious project realizable, let alone any single partner. We strongly believe that the European space is uniquely positioned to validate and realise our combined visions of experience, design and architecture. The open information exchange between the partners will naturally be extended towards third parties, thus benefiting both the project and its external partners.

2.2.1.3. Dissemination and Standardization Impact

Contributions to standards: IETF and IRTF.

The proposed UMOBILE framework may be used as a reference to allow for more sophisticated future designs and contribution to standards and will open a new perspective for the design of next generation unified networks that will make available a new range of services in everyday life. With regards to standardization of results, the project will adopt an indirect approach. We believe that direct submission of results to classical fora such as the W3C or IETF will not be fruitful due to the highly radical departure of the project from the current state of affairs. However, the relevant standardization organizations also maintain research branches, such as the Internet Research Task Force (IRTF) in the case of the IETF, that are much more open to innovations in communications architecture. The project is aiming to approach such groups and use them as a vehicle in order to eventually approach the more classical venues. Candidates for a focused contribution are current efforts in the IRTF to position DTN and ICN as an exploitable technology. Our work on enabling less-than-best effort services could influence IETF working groups such as the Active Queue Management and Packet Scheduling (AQM) WG.

UMOBILE's standardization and IPR strategies, together with the involvement of service providers and system integrators, ensures that project's research results will make their way into actual deployments.

Links with related International developments, e.g. with the US NSF Future Internet Architecture programme follow up and with similar programmes in Asia, notably Korea and Japan, supporting global views on open standards and interoperability.

We plan to build particularly strong links to other emerging EU projects in our domain and actively promote our technology to them, too. The existing strong links of the partner organizations towards national future Internet initiatives will be exploited, and also contacts by project participants to other key entities such as FIA, the Network of Excellence on Internet Science, GENI/FIND and IETF/IRTF will be used to enhance the dissemination of results. All such dissemination shall be carried out in accordance with the detailed procedures set out in the Consortium Agreement designed to provide a rapid system of dissemination whilst preserving the participants' confidential information and IPR.

The project will undertake a series of activities to maximise impact, targeting a wide range of stakeholders including policy makers, industry, the third sector, academia and the public. We will review impact performance at each project meeting to ensure we take full advantage of current and emerging impact opportunities.

The inclusion of focused SME partners in UMOBILE project provides access to the important solution development community, complemented by the technology developments in WP3 and WP4. The enhancement of existing solutions will provide the necessary backing required for showcases, trials and tradeshow events to engage with this community. The consortium further includes research institutions contributing to cutting edge research and assessments of different technological strategies to feed their knowledge back to industry. The partners from industry and academia bring complementary scientific andtechnological skills as well as different business perspectives for a successful outcome of the project.

Contribution towards at least one large-scale validation trial.

We not only **design** and **develop** UMOBILE platform, but also **demonstrate** its efficacy (and the benefits of the emerging technologies it utilises, such as ICN and DTN) by actual deployment over mobile networks in a trial setting composed of several technological demos. Showcasing a successful deployment combined with a strong and focused dissemination and exploitation plan will lay the foundations for influencing the way in which **network infrastructures** are designed, delivered and operated.

Peer-reviewed scientific publications, patents, new PhDs, and new open source software releases. Key scientific publications like ACM Sigcomm will be targeted.

The project will, of course, generate visibility for its work through all the usual academic and industrial dissemination channels. These include, for example, submission of scientific articles to key conferences and journals as well as submission of demonstration and tutorial proposals on the new technology in the main conferences in the field. The academic partners are targeting the highest levels of publication venues, including journals such as IEEE/ACM Transactions on Networking, Computer Networks, ACM Sigcomm, ACM MobiCom, ACM Sigmetrics, IEEE Infocom, ACM CoNext, ACM IMC, PAM, IEEE CCNC, etc. The university partners have a strong track record on publishing their research results in the venues of this level, and also on generating more visibility for their work through publications in magazine type publications such as Communications of the ACM, IEEE Communications Magazine and the ACM Computer Communications Review. The industrial partners of the project will also be heavily involved in dissemination activities right from the start. This includes co-authoring of scientific publications, but also participation and creation of visibility in trade shows, company internal reports and publications as well as other suitable events.

2.2.2. Measures to maximise impact

Dissemination will be a regular flow of information continuously throughout the project lifetime. The consortium as a whole will contribute to the dissemination and each partner will have concrete dissemination plan. Moreover, UMOBILE has a dedicated Work package for dissemination exploitation and standardisation activities (WP6), which will take care of planning beyond the end of the project. A dissemination strategy will be planned for the project lifetime. This plan will describe all dissemination activities of the project partners to generate synergies and to ensure an efficient dissemination on regional, national and international level. The participants of UMOBILE project have a concrete commitment towards dissemination and exploitation

The main long-term success criterion for UMOBILE is the widespread adoption of its information-centric architecture on the Internet. This goal requires careful orchestration of dissemination and exploitation activities covering all aspects of the project. Key enabler for the successful dissemination and exploitation of the project results is **openness**. All key documents will be made publicly available, and the partners are committed to open source releases of prototype code as detailed in WP4 and WP5. This open approach will not adversely affect the exploitation possibilities of the project partners themselves: as originators of the technology, they will have first-mover advantage in the initial adoption of the technology, also retaining the possibility of patenting the key results created by them in the project. Instead, we believe it will greatly enhance the efficiency of exploitation by enabling much more rapid adoption of UMOBILE technologies than what would be otherwise possible. The success of the project's architecture will in turn enable new experience offerings, new services, new operator concepts, and create a need for new software and hardware,thus creating new opportunities for the European telecom, computing, and service industries.

The project will, of course, generate visibility for its work through academic and industrialdissemination channels. These include, for example, submission of scientific articles to key conferences and journals as well as submission of demonstration and tutorial proposals on the new technology in the main conferences in the field. The industrial partners of the project will also be heavily involved in dissemination activities right from the start. This includes co-authoring of scientific publications, but also participation and creation of visibility in trade shows.

Our detailed plan for dissemination reflects our strong commitment to the clustering and concentration events of the European Union, since we see them not only as excellent dissemination and coordination opportunities, but also as useful avenues for getting our results accepted in the larger community. Overall the project sees dissemination as an integral part of exploitation, and especially academic partners arecommitted to also using their own resources in creating visibility to the project. Dissemination and exploitation activities will include:

- Setting up a project website with information on the project's consortium, scope, objectives, milestones and activities, and with easy access to public results. Where suitable, social media and video media will be used to maximise engagement. Website hits and similar analytics will be recorded as a measure of impact.

- Production and distribution of promotional material, such as white papers, flyers and posters that will be distributed to research centers and relevant academic institutions.

- Publication of results in top scientific event proceedings, journals and professional magazines, such as ACM SIGCOMM.

- Establishing relationships with research institutions working on related topics, and organising joint events

to achieve a mutual understanding of the solutions being developed and explore possibilities for coordinated development efforts.

- Establishing contact with potential users of the knowledge and solutions developed by the project, and organising events with these users to explore possibilities of knowledge transfer and valorization of solutions.

- Organisation of a workshop, which will promote and disseminate the actual results and technological impact of the project to all parties interested and involved, including industrial companies, research institutions, academic partners, regulatory and standardisation bodies and end users.

- Organisation of a summer school that focuses on specific aspects of UMOBILE platform. The summer school addresses both Ph.D. graduates and junior researchers. It will be open to researchers and external interested participants.

- Conference tutorials will also be exploited as additional means for dissemination.

We plan to build particularly strong links to other emerging EU projects in our domain and activelypromote our technology to them, too. In particular, members of the consortium will collaborate with following projects and will utilise the knowledge they obtained through their participation in these projects:

- EU FP7 / Japan NICT **GreenICN: Architecture and Application for Green Information-Centric Networking** (04/2013-04/2016) (http://www.greenicn.org)
  GreenICN will expose a functionality-rich API to spur the creation of new applications and services expected to drive EU and Japanese industry and consumers into ICN adoption.
- EU FP7 **COMET: Content Mediator Architecture for Content-Aware Networks** (01/2010- 01/2013) (http://www.cometproject.eu)
  COMET Project targeted the use of industrial robots for high-end machining for cost effective, flexible and reliable manufacturing solutions in the 'Factory of the Future'.
- EU FP7 **COSMOS** (part of EU FP7 **CONFINE**) (2014-2015) (http://www.cosmos-fp7.eu)
  The CONFINE project complements existing FIRE infrastructure by establishing a new facility built on the federation of existing community IP networks constituted by more than 20,000 nodes and 20,000 Km of links.
- EPSRC **Public Access WiFi Service (PAWS)** (2012-2014) (http://publicaccesswifi.org)
  PAWS (Public Access WiFi Service) is a RCUK funded project that seeks to develop technology that will enable free Internet connectivity to access essential services for all. This will provide greater opportunities of access, enabling digital inclusion and, in turn supporting the UK Government's 'digital by default' programme.
- FP7 **User Centric Networking** (2013-2015) (http://usercentricnetworking.eu)
  UCN challenge is how to re-center future connected media services on the user and develop improved *content recommendation* and *content delivery frameworks* by taking into account rich user context information.
- FP7 ULOOP: **User-provided Local Loop** (2010-2013) (http://uloop.eu)
  ULOOP brought in a fresh approach to user-centricity by exploring user-provided networking aspects in a way that expands the reach of a multi-access backbone.
- FP7 **4WARD –Architecture and design for the future Internet** (http://www.4ward-project.eu/)
  4WARD's goal is to make the development of networks and networked applications faster and easier, leading to both more advanced and more affordable communication services.
- FP7 **SAIL – Scalable and Adaptive Internet soLutions** (http://www.sail-project.eu/)
  SAIL projects aims at designing architectures for the Networks of the Future
- EPSRC EP/K019589/1 "**COMIT: Active Content Management at Internet Scale"** (01/2014-01/2017)
  (http://gtr.rcuk.ac.uk/project/E445E778-D286-4488-86DA-B2340FE51162)
  COMIT project focuses on active content management though information-centric networking.

Management of Open-source software and Statistics Handling

Most of the UMOBILE results are expected to be open-source. Hence a first step in the project will be an analysis of good practices for the production of open-source software. A second step will handle the basic definitions such

as: define which outcomes will be open-source; define licensing and transfer of copyright policies; define open-source or non open-source status of previous work. The third step is related to the development work, namely to decide on the use of forge, and how it will be used. In this step will also be analysed the potential contribution of expert open-source developers, to guide over the major issues around the development of open-source. During the development phase relationship with open-source communities will be maintained.

In what concerns the distribution of UMOBILE open-source results, the coordinator or a specific designated partner will store all the results on a specific server. While the project is on-going results will be limited by password authentication to the partners involved to avoid potential dissemination of results in a non pre-decided manner. Once results are made public, the server will have the results moved to a public directory where the results can be analysed as and when needed. Anonymous user data and records will be stored for statistical analysis. Anonymous user data and records will be stored for statistical analysis. Financial details and private data will not be stored on the server. A bi-monthly backup of the data to an external hard drive will help preserve the results as they are on-going and when more activity occurs it will be decided with the steering community how often updates should occur

Exploitation Strategy

UMOBILE addresses several aspects within its lifespan that will assist the exploitation of results during the project and also after its lifespan. Exploitation is performed in full alignment with the roadmaps of the involved industry partners, ensuring that the strategies proposed will result in reasonable benefits, within a reasonable timeframe.

The exploitation strategy is developed in parallel both by academic and by industry partners. While industry partners are expected to assist in the integration of the innovation and technology developed in UMOBILE, the academic partners shall make use of the results to assist in the development of new scientific aspects.

At the project level the strategy passes by exploiting the project results among group of partners. It is expected to identify during the third year of the project groups of partners aiming to jointly exploit the project results as joint ventures.

To provide detailed information about the impact that the consortium expects UMOBILE framework to have in the business of each partner (with emphasis on industrial partners), a summary of preliminary dissemination and exploitation plans of individual partners is provided in the Table below. Once the project starts, individual plans will be refined and harmonized for maximum impact.

Partner	Exploitation interests and plan
ATHENA	The group will exploit results by providing open source protocols and mechanisms for DTN and ICN. For ATHENA, the UMOBILE project will help maintain and increase its expertise on the areas of Delay Tolerant Networking, Information-Centric Networking, mobility, nomadicity, overlay services and Future Internet architectures and testbeds. The developed applications, services and protocols for the project purposes will be released to the research community as open source, further advancing the exploitation potential of the project outputs. Finally, collaboration with the consortium members with strong publication record will result in the joint publishing of various top quality conference and journal articles.
DUTH	Not applicable
UCL	At UCL, we plan to use architectures, algorithms, methodologies and other public results of the project for advanced, specialized courses given to graduate students and to industry (UCL has already successfully exploited the results of previous IST projects in a similar fashion). It is also expected that the simulation tools and the experimental platforms developed by the team at UCL through UMOBILE will be used to support teaching activities. UCL will take an active role in the dissemination of the results of UMOBILE. This will be through presenting the project achievements to the international community through presentations to conferences

	and workshops and through the publication of articles and scientific papers in magazines and journals. To further facilitate dissemination of project results and know-how, UCL and the rest of the universities intend to make software developed during UMOBILE publicly available as open-source code, subject to approval of the other partners and the IPR provisions in the consortium agreement and the contract with the Commission. Last but not least, UCL is actively involved in the ICNRG group of the IRTF, which constitutes the main standardisation body in the ICN community. We have already contributed to the first documents of the group and plan to continue with the findings of UMOBILE. In addition to the above exploitation plans, UCL intends to co-operate with UCL Business given its significant know-how in the content-centric area. UCL is physically placed in Bloomsbury, London, close to one the world's biggest Media hubs, and wants to exploit the relevant know-how and infrastructure from EU and industrial projects in this area and its links with media companies in the UK and overseas.
UCAM	**UCAM** will use the IRTF GAIA (Dr. Sathiaseelan is the Chair) as an engagement and dissemination vehicle, embedding UMOBILE into the wider community (that includes organisations like the Commonwealth Telecommunications Organisations, Alliance for Affordable Internet, Google.org, Microsoft etc.) of efforts to bring the Internet to those who cannot current afford it. This will allow for developing migration and deployment strategies that will go beyond our dedicated efforts within the deployment, ultimately providing the desired impact in terms of technology adoption that we set out to achieve with our vision. In addition, UCAM will make the results of this project visible to a wide audience by publications in leading peer-reviewed research conferences and journals, to generate awareness and induce constructive comments and feedback from the scientific and industrial-research community. UCAM will participate in program committees and editorial boards defining key areas of interest for the research community including organization of Magazines and Journal special issues. UCAM will also participate in high-visibility events concerning emerging paradigms (for example, ICN). These include academic and industry oriented events including national and international bodies. UCAM will participate in the Cambridge Science Festival, which is the largest free Science Festival in the UK (about 35.000 visitors), attracting a wide audience of all ages from the local area and beyond, including many international visitors. Recruited researchers from Cambridge will contribute to the program with shows, experiments and workshops.UCAM will also engage with policy makers through UCAM's Centre for Science and Policy, which embeds senior civil servants in the university as visiting fellows.
COPELABS	COPELABS is an R&D unit from University Lusofona with the vision to develop technology that is useful to the society. The unit exploits results achieved by establishing strategic partnerships with associated Schools of University Lusofona as well as with partner Universities to ULHT. The unit exploits also results by transferring technology to preferred industrial partners. COPELABS has been developing work in the context of data-centric and DTN approaches, among other paradigms of future Internet architectures, such as user-centric networking. Its current scientific interests relate with the interdisciplinary fields of Internet Science and Social Internet Design, as well as Cyberpsychology. In the context of UMOBILE, the initial exploitation plans are: ● To pursue the topics addressed with industrial partners and customers, by providing concrete advantages and realistic benefits focused on data-centric services. ● To support the creation of spin-offs, as a way to commercially exploit derived technology. ● To exploit knowledge and concepts developed in UMOBILE for teaching purposes. In particular, within the context of master degrees and the PhD programme on Informatics – New Media and Pervasive Systems. To develop and to maintain open-source data collections derived from the project.This activity will be done in collaboration with other partners and within the agreement on open source software licenses, if required.

TECNALIA	TECNALIA is the first leading private and independent research and technology organisation in Spain. Tecnalia, performs Technology transfer to companies either via public funded projects (e.g. more than 264 participated European projects) or via private contracts. Additionally, TECNALIA has an organisational structure called VENTURES, to support the creation of Start-ups, entrepreneurship, business angels' networks, etc., and an instrument called Inspiring Business Forum (IBF) with associated organisations to promote innovation.As a Research Institute Tecnalia's exploitation goals are different, yet complementary to those of industrial partners. Technical developments will be integrated quickly into its research agenda giving to Tecnalia a competitive edge compared to other research institutions. Specifically, Tecnalia will exploit the following results: ● Tecnalia will use the obtained know-how to go for real implementation of network coding techniques that improve current physical layer transmission techniques. On the other hand the development of self-management techniques in DTN networks will be incorporated to current and new personal communication devices for a more efficient routing and caching when the devices are mobile and highly constrained in terms of resources, such as memory, battery, or CPU.
TEKEVER	TEKEVER Autonomous Systems exploits the results of collaborative projects with the goal of improving existing or creating new product lines. These new products or system evolutions may then be incorporated in market segments where the company already acts or incepted in new business areas for novel applications. In the UMOBILE project, TEKEVER will improve an existing UAV product line and validate it for a new type of application. In short, the exploitation plan will base itself on three premises: • Incorporate new radio technology onboard the UAV platforms. • Study the potential of using UAVs to complement terrestrial networks. Pave the way to open a new business line with mobile operators.
SENCEPTION	SENCEPTION as a recent SME derived from work developed in academic research intends to explore new concepts and to produce technology that is useful to society, in particular, pervasive applications that can capture and infer interactions among people and their surroundings.SENCEPTION plans to integrate parts of its contribution in this project in its first set of products (PerSense and MOT) as well as to develop new products derived from the know-how exchanged in the context of UMOBILE. Part of the software developed by SENCEPTION is open-source, a strategic decision plan to increase user engagement and satisfaction. ● Exploit new business models by merging academic and industrial know-how. Expand its initial set of products with a data-centric innovative perspective, thus expanding its range in terms of pervasive access.
FON Technology	As an industrial partner and owner of the largest Wi-Fi network in the world, FON Technology will dedicate greateffort in the project results exploitation. UMOBILE will allow FONTechnologyto easily extend its service coverage among boundaries mainly thanks to the opportunistic communications architecture UMOBILE provides. Main beneficiaries will be the users of FON community WiFi, who will experience an improvement over the current service. Additionally, new services can be enabled, which exploit social interactions and media sharing across users having similar profiles. This type of services can also allow a better and more efficient use of FON Technology network resources. In addition to the FON community WiFi, FON Technology also offers a solution for small and medium retailers. This solution allows the customization of the WiFi experience (look & feel, social networks integration, etc.) and provides analytics for the owner to improve the

	knowledge about e.g. the shop performance. UMOBILE can extend current solution capabilities and exploit the eventual social interactions among customers UMOBILE enables e.g. by exchanging opportunistically useful information about the commerce such as personalised offers, opinions, comments, etc. Finally, UMOBILE may also make FON network better prepared to cope with M2M communications.
AFA	AFA Systems srl is a ICT company specialized in network solutions and advanced IP communications. Results from UMOBILE for exploitation purposes will be adopted in the AFA Systems business unit, which deals with design and building of large-scale wireless networks, telecommunication systems, smart video-surveillance systems for emergency scenarios. UMOBILE solutions will offer new experiences, new services, new operator concepts, and create a need for new software and hardware, thus creating new opportunities for the European telecommunication, computing, and service industries. AFA Systems will take advantage of the new technology by exploiting new business models and by expanding its set of products. The plethora of market-successful services and products that can be developed thanks to the UMOBILE technology spreads over several different applications scenarios; as a starting point, AFA systems will focus on customized solutions for Civil Protection Agencies (which are already in its portfolio). Digital divide rural areas will be a specific market field to effectively explore, since widely spread in Italy yet. AFA Systems will ensure wider exploitation of UMOBILE results through permanent demo showing the effectiveness of the UMOBILE architecture, held in collaboration of local government. Public, press and media will be invited to the demo. AFA System will take this opportunity to showcase the different applications/services developed during the UMOBILE project, while press and communication activities will foreground the message of 'everyone, everywhere' Internet access, which is a compelling vision that will attract considerable public interest. AFA will also participate in key tradeshows and related events, thus creating visibility and generating awareness of the UMOBILE solutions. Key enabler for the successful dissemination and exploitation of the project results is openness.All documents will be made publicly available, and AFA Systems, in collaboration with other partners, will be committed to open source releases of prototype code. The "open approach", which is already widely adopted by AFA Systems business strategy, will not affect the exploitation possibilities of the partners: as originators of the technology, all of them have first-mover advantage in the initial adoption of the technology, also retaining the possibility of patenting the key results of the project.

The existing strong links of the partner organizations towards national future Internet initiatives will be exploited, and also contacts by project participants to other key entities such as FIA, the Network of Excellence on Internet Science and IETF/IRTF will be used to enhance the dissemination of results. All dissemination shall be carried out in accordance with the detailed procedures set out in the Consortium Agreement designed to provide a rapid system of dissemination whilst preserving the participants'confidential information and IPR.

Press and communication activities will foreground the message of UMOBILE project. Press releases will be generated at major project milestones and disseminated through existing channels. On completion of work packages, stakeholder briefings will be generated, published on the project website, and distributed to stakeholders in industry (for example ISPs and technology designers). We willkeep record of all press coverage sought and received.A final report will be published detailing project aims and headline descriptive results, drawing together themain findings from different disciplinary perspectives, targeting industry, government and academia. The best practice toolkit will be published, targeting local government and third sector, including recommendations forengagement with the scheme, case studies of the impacts achieved, and demonstration of the technology.

Besides these activities coordinated by the project and targeted to external dissemination and exploitation, the project will also take care of effective internal dissemination of knowledge among the project partners. In addition,

each of the partners will use its own network to raise interest for the project's activities and results.

As far as exploitation activities are concerned, the involved partners will reinforce their knowledge and technical background from the results and the research executed within the project. Additionally, they will promote commercially the new technologies developed within the project by addressing the relevant business market. This can also be done by inviting relevant stakeholders to the organised workshop, in order to promote the novel business models derived from UMOBILE project to current and future market.

2.3. Implementation

2.3.1. Work Plan

UMOBILE project is planned to run over a three-year period. The overall project goal is to develop a universal mobile-centric and opportunistic communications architecture, which integrates the principles of Delay Tolerant Networking (DTN) and Information Centric Networking (ICN) in a common framework. UMOBILE focuses on assisting users in getting access to the content they want as well as content that may be of shared interest to their trust circles. For that, it includes new content and knowledge dissemination approaches, making it self-organized based on social interaction approaches. Through UMOBILE architecture, users are able to share information directly with other peers, without relying on infrastructure or expensive connectivity services. The information exchange is expected to take place seamlessly and according to how users interact with one another in different settings.

The project will be split in six individual work packages in order to be able to focus on selected work items but still ensure the system will be fully integrated and tested. Technologically-wise the work plan is parallelized. The first work package (WP1) includes the management activities of the project. During the definition phase, the end-user requirements, along with system and network requirements are sufficiently defined in work package (WP2) to start the basic development of the infrastructure and services. The core of the UMOBILE system will be developed and deployed in WP3. WP4 deals with the enablement of services using UMOBILE system. After a major part of the development is finished, WP5 starts to combine the different modules into one operational prototype. Two field trials of UMOBILE platform have also been planned within WP5. Dissemination and exploitation activities, such as participation in internal and external workshops and submission of papers to conferences and journals, will be done throughout the duration of the project as part of the WP6. WP6 also includes input to standardisation bodies.

It is noted that UMOBILE partners are all experts on their respective fields and there is already much existing work in each field. Thus, the approach followed in UMOBILE work plan is not a clean-slate approach. For example, UMOBILE partners already have long experience on both DTN and ICN technologies, so early trial experimentation and implementation will help design and define the requirements of UMOBILE platform.

We elaborate briefly the UMOBILE work packages below.

WP1 "Project Management"

The basic purpose of WP1 "Project Management" is to ensure the proper level of coordination and cooperation amongst the project consortium members. Additionally, WP1 includes the day-to-day management of the project, ensuring that contractual obligations are met, payments are made, cost statements are filled correctly, handling any contract amendments, liaising with the Commission, supporting the technical work packages by following and assessing the project's progress.

The outcome of WP1 is the timely handling and execution of all administrative activities of the project.

WP2 "System requirements"

The objective of WP2 is to define the requirements and the specifications of the overall platform in terms of user requirements, network and system design and deployability. In this WP, we will define the system requirements from the perspective of the network and the end-users, we will analyze the operational requirements and deployability aspects of UMOBILE platform and we will align application and protocol requirements with validation scenarios.

The outcomes of WP2 are the requirements and specifications of UMOBILE platform.

WP3 "System and node architecture development"

The core activity of WP3 is the design and implementation of UMOBILE platform. Departing from the existing properties of DTN and ICN, we will establish an architectural framework that extends connectivity options by being delay-tolerant and exposing a common information-centric abstraction to applications.

The outcome of WP3 is a prototype implementation of the platform.

WP4 "Services enablement"

The main objective of WP4 is to enhance UMOBILE architercture in terms of QoS and QoE and enable solutions that take advantage of the unique features of the developed architecture. This WP will use the architecture developed during WP3 to provide a set of services.

The outcome of WP4 is the enablement of services that support the key characteristics of the developed platform, such as the provision of multiple QoS levels and the collection, processing and dissemination of different types of data.

WP5 "Overall platform integration and validation"

WP5 aims at evaluating our platform through simulations, emulations and real field trials. This involves defining the validation setup and the roadmap for incremental validation. For the actual validation, WP5 will carry out the integration of the networking and application layer software from WP3 and WP4 on the selected hardware that will be used for the prototype. Field trials of UMOBILE platform will take place in the area of Lisbon were TEKEVER has flying permissions for UAVs. FON Technology will build a terrestrial network for experimentation purposes in this area.

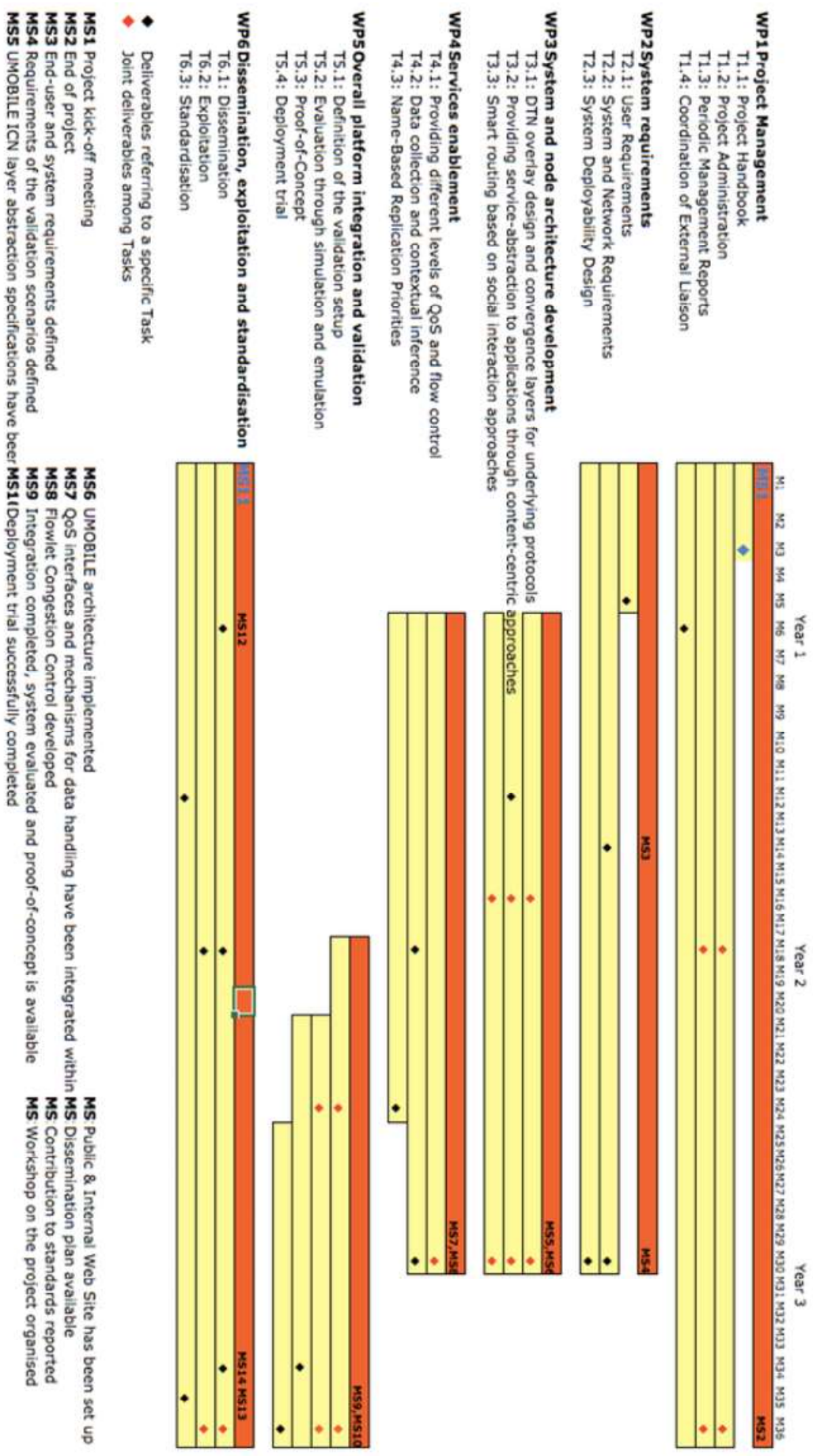
The outcome of WP5 is an overall technological validation of UMOBILE platform.

WP6 "Dissemination, exploitation and standardisation"

This work package will contribute to the dissemination and exploitation of the project deliverables covering both theoretical and practical results. Moreover, contributions to relevant standardisation processes are foreseen. The dissemination of theoretical results consists of contribution to conferences and journals as well as (pre-) standardisation forums. WP6 will help coordinating the creation and publication of scientific papers and standards documents. Practical results will be disseminated as (open source) code releases of UMOBILE system (network and applications). In the context of WP6, workshops will be held to increase the awareness of UMOBILE and to collect valuable feedback from external parties. WP6 will also assist partners in their exploitation plans.

The outcome of WP6 is a set of dissemination and standardisation activities that will take place throughout the duration of the project, as well as a clear exploitation plan for the developed platform after the end of the project.

2.3.1.1. The timing of the different WPs and their components



2.3.1.2. Graphical presentation of the components showing their interdependencies

Figure 4 shows a PERT type representation of the interactions between different Work Packages.

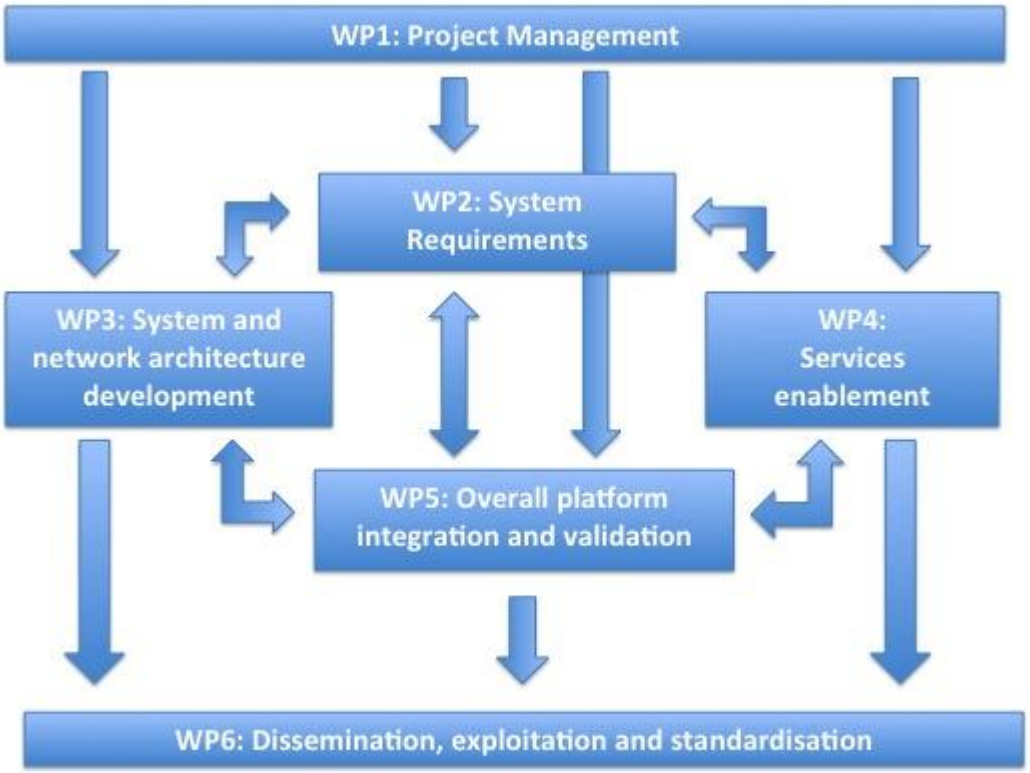


Fig. 4.UMOBILE PERT diagram

2.3.2. Management structures and procedures

The basic purpose of project management is to ensure the proper level of coordination and co-operation among project consortium members. Additionally, project management has the following responsibilities: project administration, project organisation, management of the technical progress of the project, coordination with other EU funded projects and other interested parties. All UMOBILE partners have previous experience of working in EU consortia or working in large, complex, international projects.

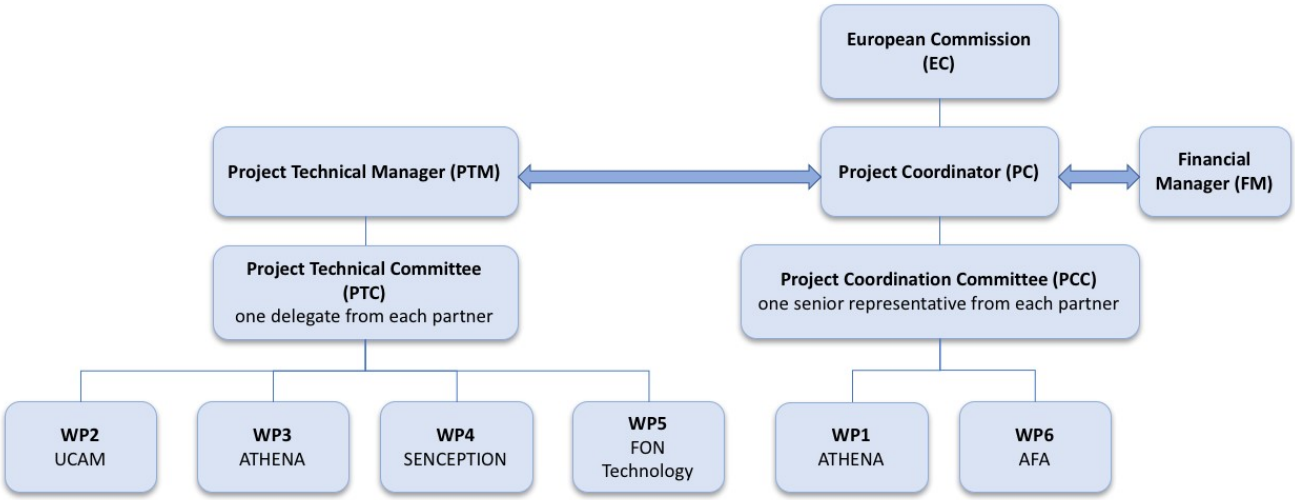


Fig. 5. Project Management Structure

An overview of the most important parts of the project management structure is illustrated in Fig. 5. The mandate and the constraints of the above roles or groups are described in the following sections.

2.3.2.1. Consortium management

The management of the consortium partners consists of the key mechanisms and people introduced in the subsequent sections.

Project Coordinator (PC)
The Project Coordinator is the Partner Representative of the Prime Contractor. The Project Coordinator will coordinate both technical and overall management activities. The mandate of the Coordinator is to:

- Represent the project in relations with the European Commission (EC),
- Report to the European Commission and monitor overall performance of the project,
- Promote project visibility and dissemination of project results in relevant international fora,
- Promote acceptance of project results among telecommunications stakeholders and
- Administer project resources and monitor project spending.

Specific tasks are:

- To convene and chair Project plenaries, Project coordination and technical meetings,
- To collect Quarterly Reports from Partners and forward an overall Annual Control Report and Periodic Progress Reports to the Project Officer,
- To communicate with Partner Representatives with the view of coordinating the exploitation of the Project's results,
- To enforce compliance to the project's internal communication and editorial conventions and to maintain a Project document library,
- To convene and participate in Project Review meetings, to ensure preparation of Technical Audit Documentation and to organise the team of delegates to the Technical Audit,
- To supervise the preparation of the Final Technical Deliverable,
- To supervise the preparation of at least one pamphlet to support high level dissemination of Project results, and to ensure representation of the project in external events, such as workshops on related topics,
- To co-ordinate technical activities of the project,

- To report to the Project Coordination Committee on the technical progress of the project and to co-ordinate the production of technical deliverables and
- To attend the Technical Audit.

Project coordination Committee (PCC)
The project is managed and administered at its topmost, non-technical level by the Project coordination Committee (PCC). The PCC is the formal decision-making body for the project. The PCC consists of one delegate (Partner Representative) from each organisation participating in the project. Normally, Project coordination Committee meetings will be called in association with Technical Meetings. Participation by full partners or their delegates is mandatory. The chairperson of the PCC is the Project Coordinator. The PCC shall meet as required (either physically or through teleconference), between two to six times per year. Prior to each PCC meeting, the Project coordination Committee will also receive feedback by the Project Technical Committee on the evolution of the project, in order to identify any problems that may have arisen.

Partner Representatives
Each Partner Representative will represent their organisation in the course of PCC activities. A requirement on each organisation is that their Partner Representative be authorised to make decisions on behalf of the organisation, following partner's organisation internal decision process, during the normal course of PCC business.

Project Technical Committee (PTC)
The Project Technical Committee is the body responsible for making and overseeing all technical decisions made within the project. It directly controls all WP Tasks, through the consensus of the partners. The PTC is responsible for putting into place mechanisms to be used by the WPs to ensure the quality of work, produced deliverables, and any technical papers produced at the WP level. The PTC consists of one delegate from each organisation participating in the project. The chairperson of the PTC is the Project Coordinator. WP Leaders are responsible for summarising the progress of WPs during PTC meetings. The PTC will meet (either physically or through teleconference) as required, between three to six times per year. Prior to each PTC meeting, the Project Technical Committee will also receive feedback by the Project coordination Committee on the evolution of the project, as far as management is concerned, in order to identify any problems that may have arisen and set barriers to the technical evolution of the project.

WP Leaders, WPs and Tasks Meetings
In order to promote cooperation and coordination between the on-going work of different Work Packages, periodic WP Leader meetings will take place. Additionally, WPs and Task meetings will take place appropriately. All partners are required to attend these meetings accordingly. The chairman for these meetings will be the respective Project Coordinator, Technical Manager, WP or Task Leader.

WP/Task Leaders
The WP/Task Leader is the representative of the partner responsible for the Work package or Task according to the Technical Annex. The project WPs/Tasks will each annually appoint WP/Task leaders to organise and chair WP/Task meetings, and to ensure the proper organisation and execution of WP/Task work. The WP/Task Leaders are responsible for the performance of the corresponding WPs/Tasks. WP/Task Leaders are required to attend WP/Task Leader meetings.
Specific tasks for Work Package Leaders are to ensure accomplishment of the technical objectives of the work package and to report to the Technical Manager, to participate in technical meetings, including meetings of the Project Technical Committee, to coordinate the production of WP/Task relevant part of the Deliverables and to co-ordinate the production of external papers in topics dealing with their activities. Under serious circumstances they will flag insufficient quality or unacceptable delays in the contribution of individual members. WP/ Task Leaders can be dismissed by the Project Coordinator in case of major deviations from the agreed plan of work, provided an alternative person is approved by a two-third majority of partners.

Liaison Delegates
Appropriate Liaison Delegates will be nominated within appropriate WPs for interaction and technical liaison with other EU funded projects. It is their role to resolve outstanding technical issues that may arise when dealing with other projects.

2.3.2.2. Management processes

Planning, Monitoring and Reporting

The Project Coordinator will use automated planning and reporting tools to collect information from Partner Representatives so that project information is always up to date and can be reported in a timely and consistent manner. The Project Coordinator is responsible for preparing all reports sent to the EC Officer (ECO). Quarterly Control Reports (QCRs) will be generated by each Partner Representative. The QCRs will contain the following types of information: statement of all expenses incurred by the partner in each WP during that period, equipment purchased, progress report on Partner's activities, etc. Every three months a Quarterly Management Report (QMR) will be compiled and submitted to the Commission by the Project Coordinator. The Prime Contractor is responsible for organising the preparation of the Periodic Progress Reports (PPRs), the Annual Review Reports and the Final Project Report. Partners are responsible for contributing to the completion of these reports. These reports will be submitted to the ECO for the purpose of reviewing and evaluating the progress of work in the project. The reports will include or reference all deliverables for the reporting period.

Review Procedure and Decision Process

Project Technical work is first reviewed within WP meetings. This can be further reviewed and refined at a technical level with WP Leader meetings. The final authority for reviewing the technical work of the project will be during the PTC meetings. Review of the quality of project results, deliverables, papers, and so on will take place at the WP level in processes to be decided by the PTC, and executed by the WPs. Non-technical review of the project will take place in WP1 and when necessary by the PCC. The PTC and PCC are responsible for putting into effect other types of review procedures as needed. Decisions within the project are generally made by common agreement of all the parties involved. Technical decisions which are not easily resolved within a WP by consensus, are then delegated to qualified technical experts for resolution within the WPs. Failing this, resolution is attempted during WP Leader meetings, or next by the PTC. If no resolution is still possible, the problem will be resolved by Partner Representatives in the PCC. Failing this, and if no other possibilities exist to resolve the problem, a Red Flag procedure can be used by the PCC to notify the ECO.

Deliverables Handling and Confidentiality

Public deliverables will be approved by the project technical and coordination committees before submission to the Commission. The editor of each deliverable is responsible for ensuring that the appropriate procedure is followed and the deliverable is submitted to the Commission and the project manager (for reference). All results of the project will be made available to the H2020 Programme, except where they utilise background information and where imminent commercial exploitation/patents are foreseen. For these cases, the confidentiality of the deliverable will be changed appropriately. To facilitate the handling of intellectual property rights and ensure that they are not abused, the consortium agreement will make provision for an exploitation plan to be signed in the middle of the project.

Management of Knowledge and Intellectual Property Rights

The consortium recognizes the key importance of properly managing Intellectual Property Rights (IPR) in the project. The rules for the confidentiality of information and the handling of IPRs are fixed in the Grant Agreement. The Grant Agreement will be considered in conjunction with the applicable legislation, in particular the "Rules for Participation". Any other legislation that applies will also be respected. Moreover, guidance given in the 2008 Commission Recommendation on managing intellectual property will also be taken into account. In the perspective of potential result exploitation, the project will define beforehand a coherent IPR framework through the development of the Consortium Agreement. During the project, IPR will be systematically identified, processed, and protected either by the owner itself or, when the owner is unwilling or unable to properly protect IPR by itself, by other members of the consortium. Our basic philosophy related to the IPR issues is the following: **Most general scientific results, most of the architecture, and, wherever possible, the source code of the reference implementation developed during the project will be made available to the public domain.** This open-source policy will help achieve widespread use of UMOBILE results and we will actively encourage other European projects, researchers and industry to leverage and exploit our results. We believe that opening most of the results to scientific scrutiny and providing them to other interested parties will increase the impact of the project and its eventual acceptance by the Internet community and industry. This is the only believable method to influence the future development of major changes in the networking technology in our domain. However, a few valuable pieces of IPR may arise in the project in specific areas, and it might not be desirable for the owner to provide them for free to everyone. In particular, we expect that there will be innovations related to implementation techniques, especially in the case of algorithms and protocols. These specific items of IPR will be owned by the party that created them. In view of the comparatively long time until some of them will be needed, all partners not owning a project result will automatically get a right to use it royalty free, as specified by the consortium

agreement.

The project has a dual approach to IPR: Although most of the generic results that are suitable for dissemination as part of standardization efforts will be open, we will aggressively and diligently protect valuable industrial innovations and IPR for exploitation. All such activities shall be governed in accordance with the rules and procedures on standardisation, IPRs and Access Rights set out in the Consortium Agreement, including the preservation of the individual participant's right to exploit its own IPRs and information as it wishes. IPR protection in the consortium is ensured by an IPR review process, which is performed biannually. Hence, there is a process inside the consortium for recognizing and systematically tracking IPR issues. During this review, we will identify possible IPR that the owner is incapable or unwilling to protect by itself, and notify the project management to take appropriate measures to protect such IPR. If there is a need for quick action on IPR protection, we will of course not wait for the biannual review. There shall be an easy procedure in the form of an IPR Announcement form, delivered to the PC, which will be used to inform consortium partners about possibly IPR findings. An IPR Management Committee, led by one of the industrial partners, will manage the IPR review. The purpose of the IPR Management Committee is to evaluate the merits of the findings, propose how to handle issues of ownership, and so on. The specific rules for the IPR management will be laid out in the Consortium Agreement.

The consortium has already discussed possible standardization paths, the required background information and the IPR policy in their preparatory meeting. There exists a good understanding and agreement on how to proceed, and IPR issues are not expected to present obstacles on reaching consortium agreement, if the proposal is accepted by the EU. This is in part guaranteed by our aim towards publicly available interface and standards development, combined with the protection of selected results, as well as by the non-owning partners' royalty-free right to use such protected results as specified in the consortium agreement. For handling patents, the consortium will also apply proven methods used in previous EU funded projects. The partners will inform the consortium of technologies, algorithms etc. that they offer for use without compensation in specific WPs that they have already patented, are in the process of patenting, or consider patenting in the future. Similarly, if patentable methods and techniques are generated within project activities, the partner generating and owning them will, if it so desires, undertake patenting activities. In case the owning partner is incapable or unwilling to protect its IPR, the project management may initiate patenting activities with the aim to protect the rights and interests of all participating partners. Lists of patents related to the project, whether adopted, applied or generated, will be kept and maintained for reference, and such information will be included in the management reports made to the Commission.

Information Flow, Consensus and Co-operation

The information flow of the project is illustrated by the project management structure shown in Fig. 5. The project will also put mechanisms in place to ensure that significant project results are presented in international conferences or publications. The project will participate through the Consensus mechanisms set up within H2020-ICT priority. As part of the dissemination process, a workshop will be organised during the final stage of UMOBILE project to promote the developed architecture, along with the specialized applications, to all interested parties.

Coordination with the Outside World

In general, the policy will be to exchange documentation with other projects on an open basis, as this gives the project an extra opportunity to acquire inputs regarding its results. The project is also open to communication and cooperation with other relevant projects or forums outside the scope of H2020, according to any restrictions that may be imposed by participation in H2020, or from project partners themselves. The project is open to negotiation with other R&D projects that wish to join or make use of the project's work while project work is on-going. The project could set up permanent sites for demonstrations of project results and evaluation by other R&D projects.

Conflict Resolution

The proposed procedure for conflict resolution is to have a project management meeting within 15 days of being requested in writing by any one partner and informing the ECO at this early stage, in order to be informed in case a conflict arises. If the conflict cannot be resolved by this method, then the ECO should be formally informed within 7 days by the Project Coordinator of an unresolved dispute within the Project, the ECO and the Project Coordinator must meet within 21 days and the project manager must then put a proposal in writing to the Project Management Board within 7 days. The Project Management board must meet within a further 14 days. If the conflict cannot be resolved, then the dispute shall be finally settled under the Rules of Conciliation and Arbitration of the International Chamber of Commerce by one or more arbitrators appointed in accordance with these rules. The language of the arbitration shall be English and the arbitration shall take place in Brussels, Belgium.

Policy on gender issues

Since UMOBILE project addresses research areas that are "gender-neutral", that is they are not addressing solely the needs of men or women, or the needs of both but in an unbalanced manner, no gender issues are identified. However, the consortium will ensure that gender issues, if arising will be properly and justly addressed and further ensure gender equality during the entire project lifecycle. Regarding employment policies of the partners, all partners are committed to ensure equal employment rights for female and male applicants for their normal operation including the management and implementation of UMOBILE project. All advertisements for new research posts will specify our commitment to equal opportunities, with applications from women and men equally welcome, and selection based on merit and the potential of individuals. All partners are committed to ensuring that the staff, who is recruited and trained, are treated solely on the basis of their relevant merits and abilities. When we have the ability to choose between otherwise equally able candidates, we will consider gender balance in our selection criteria.

The partners in this project will:

- Encourage women to apply for research positions,
- Ensure that equal opportunities will be promoted in recruitment at all levels,
- Enable women researchers to participate in all project activities,
- Encourage women to participate in the management and scientific committees and
- Ensure, as far as possible, that women will be equally represented on interview panels.

The attraction of female applicants will be ensured by extended dissemination of working positions to women scientist forums and organisations. Special attention will be paid to working conditions (flexibility) to enable women to participate in research.

2.3.3. Consortium as a whole

UMOBILE consortium has been thoroughly assembled in order to ensure a full coverage of all the competences required to achieve the goal of the project. To this end, different partners present strong individual skills to succeed in the development of the various technical challenges, yet at the same time all those skills combined together lead to a perfect match to complete the focused goal of the project. Therefore, the consortium presents a perfect balance between individual strong competences totally aligned with the project scope that allows each individual partner to work on critical topics for its institution or company, and at the same time the necessity that each partner has on the expertise from other members that leads to the completion of the project goals. Furthermore, the consortium has access to the resources required to successfully complete UMOBILE project.

With the requirements in mind, the spectrum of partners forming the UMOBILE consortium comprises *4 SMEs, 3 universities and 2 research institutes*(i.e. 56% academia and 44% industry).This composition provides considerable combined knowledge, as well as substantial industrial and academic influence, ensuring that the expected results will be applied for the benefits of the end-users and the competitiveness of the European industry. UMOBILE consortium has therefore 9 partners distributed across Europe as follows: 1 partner in Greece (coordinator); 3 partners in Portugal; 2 partners in Spain; 2 partners in the United Kingdom. Partners that reside on the same country provide an adequate balance between academia and industry thus providing the grounds for solid local experimentation.

The partners have been carefully selected for their specific expertise, the complementarity of their know-how and research activities, and their commitment to achieve the project objectives. The consortium consists of research institutions that present complementary skills (marked in bold below) required within the scope of the UMOBILE project. Below, we provide a "competency matrix" which indicates a healthy amount of overlapping competence between partners, and most importantly, that each partner provides a set of skills that together form a well-balanced team, i.e., the focus domains are clustered so that partnership is well justified.

The vendors and software houses in the consortium have a strong interest in developing the architectural intelligence to sustain application pervasiveness based on data-centric approaches.Operators have a strong interest in shaping future technology that allows them to optimize the investment in differentiated services that are appealing to the end-user; increase pervasiveness (and hence reach of the service); attain low CAPEX/OPEX. Early awareness of future developments will allow the effective introduction of new innovations into their business.Academic partners aim at expanding scientific borders and map the latest digital media technology advances onto the industry. The connection between academia and industry is guarantee by the nature and expertise of the Universities and R&D labs involved in the project. Vendors, operators and academia all benefit from the synergy that a common effort such as the one that UMOBILE provides. Academia brings the scientific skills needed and a view on the latest state of the art. Vendors and software houses bring a more practical view on

what is technically and commercially viable. Operators know what it takes to provide operational services within the context of mobile networks and can provide the business requirements. Jointly, the consortium can ensure that the concept and research results will both advance the state of the art and be commercially viable.End-users will also be key beneficiaries of the technology that UMOBILE will provide. The consortium includes a set of demonstrations and whenever feasible, statistics will be collected, based on hundreds of users in a later phase of technology demonstration and concept validation.As active members of the European research community, many of the academic partners also have experience in the peer review, proposal selection, and self-management processes of national and international research programmes. Similarly, industrial partners have experience in running their own research activities. This experience will enable them all to function successfully within the research environment of an Integrated Project, guiding the programme through its phases while flexibly reacting to changing priorities.

	DTN	**INFORMATION-CENTRIC APPROACHES**	**NETWORK MANAGEMENT**	**PERVASIVE SENSING**	**QoS**	**SOCIAL TRUST COMPUTATION**	**DEPLOYMENT TRIALS**	**STANDARDIZATION**
ATHENA	X	X			X		X	X
DUTH	X				X		X	X
UCL		X	X		X		X	X
UCAM		X	X		X		X	X
COPELABS	X					X	X	
TECNALIA	X	X					X	
TEKEVER			X				X	
SENCEPTION				X			X	
FON Technology			X				X	
AFA			X				X	

Covering 5 EU countries, the 10 consortium partners are shown altogether in the table below, highlighting their different expertise and complementary competences.

		Organisation Type	**Role in project**
1	**ATHENA**	Research Institute	• Project coordinator (leader of WP1) • Contribute to the definition of system and network requirements from the perspective of delay-tolerant networking • Lead WP3 and define the architectural framework of Bundle Protocol (BP) within UMOBILE platform by building the required convergence layers • Contribute to the dissemination of local knowledge and the provisioning of multiple levels of QoS • Perform simulations, emulations and participate in the field trials of UMOBILE platform • Contribute to scientific exploitation and incorporation into education • Participate in (pre-)standardisation committees such as CCSDS.
2	**DUTH**	Higher, secondary education establishment	• Contribute to the definition of system and network requirements from the perspective of delay-tolerant networking • Contribute to the dissemination of local knowledge and the provisioning of multiple levels of QoS • Perform simulations, emulations and participate in the field trials of UMOBILE platform • Contribute to scientific exploitation and incorporation into education • Participate in (pre-)standardisation committees such as CCSDS.

3	**UCL**	Higher, secondary education establishment	• Expertise in content resolution and delivery in ICN environments, naming systems and architectures and optimal server placement for content distribution to remote regions • Study issues of energy efficiency and security will be taken into account from the onset • Participate in the design of energy efficient algorithms for disaster-tolerant scenarios, where battery- limited mobile devices are the main carrier of content
4	**UCAM**	Higher, secondary education establishment	• Work on the integration of UMOBILE architecture with UAVs • QoS provisioning, multipath transport, caching and time-shifting of content performance analysis • Simulations using ns-2 and emulations using NS-3 • Dissemination activities in particular at the IETF and IRTF GAIA. • Lead WP2 requirements definition.
5	**COPELABS**	Research Institute	• Knowledge on the social trust computation obtained from the European project ULOOP • Develop social- and interest-based communication approaches based on dLife and SCORP, some of which are currently in a standardization track at IRTF DTNRG.
6	**TECNALIA**	Research Institute	• Extensive use of Telecom Unit's expertise in the field of opportunistic networking and the implementation and deployment of DTN based topologies • Networking requirements specification within the envisaged and the system deploy ability • Participate in the design of the DTN overlay and ICN layers • Lead of smart routing approaches based on social interactions (task 3.3) • Participate in deploying test scenarios
7	**TEKEVER**	SME	• Main involvement will be in the validation and testing of UMOBILE prototypes • Integration of UMOBILE enabled radios on unmanned aerial platforms • Operation and deployment ofUMOBILE platform in validation exercises as backhaul add-ons and data mules • Contribute to the definition of deployability requirements for UMOBILE system (technical, regulatory and operational) • Participate in the development of convergence layers with applicability in aerial platforms among others in WP3
8	**SENCEPTION**	SME	• Contribute with its know-how in pervasive sensing, both conceptually and as developers/integrators • Provide its core pervasive middleware platform, to assist in developing contextual inference that is required in UMOBILE • Lead WP4 that focuses on the enablement of services and applications
9	**FON Technology**	SME	• Provide expertise as WiFi network operator. • Collaborate in several WPs of UMOBILE project, being its mayor contributions allocated for WP2 and WP5. • Participate in the definition of user requirements, system and network requirements and system deployability design in order to ensure an appropriate integration of the UMOBILE platform into FON Wi-Fi network. • Lead the work package WP5 and, in particular, the definition of the validation setup and deployment trial activities. • Contribute in the preparation of the proof of concept that will be used during the validation tasks. • Lead with the exploitation task, as a representative of the industrial partners.
10	**AFA**	SME	• Provide the framework for collecting and distributing data, and for processing them by understanding their context

			• Set up and deploy the trials and lead the proof-of-concept Work Package • Disseminate the results of the project to interested parties, included governments and local organisations and other potential stakeholders. • Lead the dissemination, exploitation and standardisation strategy of UMOBILE project (WP6)

2.3.4. Capacity of participants and links to third parties

2.3.4.1. Participants

2.3.4.1.1. Athena Research and Innovation Center

Athena Research and Innovation Center

Partner CV & Role in UMOBILE project

The **Athena** Research and Innovation Center in Information, Communication and Knowledge Technologies was founded in 2003 comprising of three previously existing and two new institutes. It operates under the auspices of the Ministry of Education and Religious Affairs (General Secretariat for Research and Technology). It is based in Athens, with its Institutes located in Athens, Patra and Xanthi. It promotes innovative information, communication, environmental and knowledge technologies in the all scientific and engineering sectors. To this end, it promotes scientific and technological research in the above-mentioned sectors. The Unit of Environmental and Networking Technologies and Applications (ENTA), at ATHENA-RIC in Xanthi is dedicated to promoting fundamental and applied research in all aspects of the contemporary environmental and networking problems, such as climate change and space networking.

Role in UMOBILE project

In WP2, ATHENA will contribute to the definition of system and network requirements from the perspective of delay-tolerant networking and utilize its experience in providing less-than-best-effort to users for the definition of user requirements. ATHENAwill be leading WP3, working on the definition of the architectural framework of Bundle Protocol (BP) within UMOBILE platform by building the required convergence layers for underlying protocols and contributing to the development of the smart routing mechanism. In WP4, ATHENA will also use their experience on data dissemination over DTN towards achieving the dissemination of local knowledge and the provisioning of multiple levels of QoS. As part of UMOBILE evaluation in WP5, ATHENA will perform simulations (using Opportunistic Network Environment simulator and NS-2 DTN agent), emulations and will participate in the field trials of UMOBILE platform. Finally, ATHENA will contribute to scientific exploitation and incorporation into education by undertake the responsibility to participate in conference keynotes and related panels, adopt UMOBILE results in academic courses and participate in (pre-)standardisation committees such as CCSDS and GAIA.

Persons

Prof. Vassilis Tsaoussidis (M) holds a B.Sc. (honors) in Applied Mathematics from Aristotle University, Greece; a Diploma in Statistics and Computer Science from the Hellenic Institute of Statistics; and a Ph.D. in Computer Networks from Humboldt University, Berlin, Germany (1995). He held a postdoctoral appointment at the Department of Computer Science, Rutgers University, New Brunswick, and faculty appointments at the Computer Science Department of SUNY Stony Brook, and at the college of Computer Science of Northeastern University, Boston. He is now full Professor at the Faculty of the Department of Electrical and Computer Engineering of Democritus University of Thrace and the Director of the Internetworked Systems Laboratory. Vassilis holds a visiting Professorship at the Department of Aeronautics and Astronautics of Massachusetts Institute of Technology (MIT), and positions as ESA delegate for the DTN CCSDS and as member of the National Strategic Reference Framework. Vassilis was/is editor for major networking journals and is editor in chief for the Journal of Internet Engineering; he edited several special issues on related topics and chaired various networking conferences. Vassilis received the honorable mention award from IEEE ISCC 2002 and the

Research Award from the World Academy of Sciences.

Sotirios Diamantopoulos (M) graduated from the Democritus University of Thrace (DUTH) with a Diploma in ECE and he received an MSc in Computer Networks from the same university. He has been actively involved in several ESA and FP7 projects. Currently a PhD candidate under the guidance of Prof. V. Tsaoussidis, Sotiriosworks as a research engineer in Space Internetworking Center, with a significant involvement as a technical co-director in the "Space-Data Routers For Exploiting Space Data" project, funded by the European Commission. His research interests lie mainly in the areas of space communications and delay-tolerant networking and, in particular, in routing and transport algorithms and in the architectural design of space-internetworking protocols.

Christos-Alexandros Sarros (M) received his diploma in Electrical and Computer Engineering from Democritus University of Thrace in 2016. He is currently a PhD student under the advisory of Professor Vassilis Tsaoussidis and a research engineer in Athena Research Center. His research interests include Information-Centric Networks, Delay-Tolerant networks, energy efficient communications, as well as traffic shaping and control.

Christina Malliou (F), received a Diploma in Electrical and Computer Engineering from the Democritus University of Thrace (DUTH) in 2014. Currently, she is a Master's student at DUTH under Prof. V. Tsaoussidis supervision and she works as a research engineer at Space Internetworking Center. Her research interests lie in the areas of internetworking in delay/disruptive tolerant environments and wireless sensor networks.

Sotirios-AngelosLenas(M) holds a Diploma in Electrical and Computer Engineering (2009), an M.Sc in Computer Networks and Security (2011) and a PhD in Computer Networks (2015); all from Democritus University of Thrace, Xanthi, Greece. Over the past seven years, Sotiris has participated in eight multi-partner R&D projects, funded by the European Commission, the European Space Agency and the Greek government, having been frequently assigned the role of Task and Technical Leader. During the summer of 2011, he also served as a visiting researcher at Caltech/Jet Propulsion Laboratory, investigating issues related to DTN. Currently, he is a member of InterSys Lab and holds a postdoc research fellow position at Space Internetworking Center (SPICE). His expertise lies mainly in the areas of wireless sensor and delay-/disruption-tolerant networking. Apart from his contributions in those areas, Sotiris has also published a substantial amount of work in the areas of network queue management and network applications. His research interests also include social networking, network management, future Internet technologies and network security.

Dimitris Vardalis(M) received his B.S. degree in computer science from the Aristotle University of Thessaloniki. He holds an M.Sc. degree in computer science from the State University of New York at Stony Brook, an M.B.A. degree from the University of Macedonia in Thessaloniki and a Ph.D. degree at the Electrical and Computer Engineering Department of Democritus University of Thrace. Dimitris' main occupation is with IntelligenInc, where he heads the development of production-tracking enterprise software. His academic work focuses on networking and, more specifically, delay-tolerant networking and energy-efficiency of wireless networking devices.

AgapiPapakonstantinou(F) received her degree in Accounting and Finance from University of Macedonia, Thessaloniki, Greece, in 2005 and then in 2008 she received her MSc in Systems Engineering and Management from Democritus University of Thrace. Her expertise lies in managing FP7, ESA and national research projects.

Publications

1. S.-A. Lenas and V. Tsaoussidis, "Enabling free internet access at the edges of broadband connections: a hybrid packet scheduling approach", **SIGMOBILE Mobile Computing and Communications Review (MC2R)**, Vol. 18, Issue 1, pp.55-63, Feb. 2014. doi:10.1145/2581555.2581564
2. I. Komnios and V. Tsaoussidis, "CARPOOL: Extending Free Internet Access over DTN in Urban Environments", in **ACM MobiCom Workshop on Lowest Cost Denominator Networking for Universal Access, LCDNet '13**, Miami, Florida, USA, September 30, 2013.
3. S.-A. Lenas, and V. Tsaoussidis, "Traffic Shaping for Enabling Less-than-Best Effort Services at the Edges of Broadband Connections", in **ACM MobiCom Workshop on Lowest Cost Denominator**

Networking for Universal Access (ACM LCDNet '13), Miami, Florida, USA, September 30, 2013
4. L. Mamatas, A. Papadopoulou and V. Tsaoussidis, "Semi Markov modeling for User Mobility in Urban Areas", **2nd Stochastic Modeling Techniques and Data Analysis International Conference (SMTDA 2012)**, Chania, Greece, June 5-8, 2012.

Previous relevant projects

1. Space-Data Routers For Exploiting Space DATA, funded by EC FP7 Grant. 263330. This project provided a secure DTN overlay infrastructure to disseminate vast amounts of space data among space agencies, academic institutes and research centers (as members of DUTH)
2. Extending Internet into Space - Phases 1-3: ESA/ESOC DTN/IP Testbed Deployment and Optimization. This project was funded by the European Space Agency to build a DTN testbed, and, among others, evaluate the interoperability of Space DTN protocols with terrestrial Internet protocols (as members of DUTH)
3. Space Internetworking Center – SPICE, EC FP7 Grant. 264226. This project was funded by the FP7 Capacities "Research Potential" program to upgrade the DUTH DTN testbed, and enhance its functionality by obtaining new specialized equipment, such as sensors. (as members of DUTH)

Other

Infrastructure/Facilities details: (Software & Hardware)

1. ATHENAfacilities: multiple workstations and servers

Open source solutions

1.ATHENA is actively involved in the open source community mainly for DTN-related software. In particular, it has contributed to the Interplanetary Overlay Network (http://sourceforge.net/projects/ion-dtn/) DTN software with services and protocols, such as Bundle Streaming Service, for streaming audio, video, and telemetry over DTN, and Delay-Tolerant Payload Conditioning, for "transport"-like functionality over BP, plus application data aggregation and elision.
2. DTN Agent for NS-2 (http://www.spice-center.org/dtn-agent/): The DTN model is implemented as a set of classes in the ns-2 simulator. The model was developed in order to study the deployment of DTN on top of traditional, Internet-based networks.

2.3.4.1.2. Democritus University of Thrace (DUTH)

Democritus University of Thrace

Partner CV & Role in UMOBILE project

Democritus University of Thrace (DUTH) was established in July 1973. The Department of Electrical and Computer Engineering of DUTH was founded in 1975, in Xanthi, Greece. The Department is one of the leading European Departments in Space Technology and Internetworking and has significant expertise in various Computer Science fields such as Algorithms, Information Retrieval and Security.

The Internetworked Systems Lab (InterSys –www.intersys-lab.org) is the sole laboratory of the Software Division of the Department. It is directed by Prof. V. Tsaoussidis and consists of 7 faculty members, 2 technicians, 3 administrative assistants, 3 senior engineers and 17 engineers. The expertise of InterSys lies in Delay-tolerant Networking (DTN), design and evaluation of protocols for challenging environments, such as near and deep-space, or opportunistic terrestrial networks. InterSys research team also works on E2E protocols, security, load-balancing and energy-saving protocols. InterSys Lab established the first European “Space Internetworking Center - SPICE” (www.spice-center.org) in September 2010. The center includes a unique testbed for Europe, appropriate for evaluating Space and Internetworking protocols in challenging environments and includes satellite links, ground station hardware devices, protocols for delay-tolerant networks as well as for telemetry/telecommand. The testbed has also direct access to Hellas Sat. Intersys Lab has received funding from ESA and FP7 and coordinates large projects (some of which were ranked first in their respective category), such as ESA’s "Extending Internet into Space" and FP7 SPACE "Space-Data Routers" with a total budget over 5M

Euros.

Role in UMOBILE project

In WP2, DUTH will contribute to the definition of system and network requirements from the perspective of delay-tolerant networking and utilize its experience in providing less-than-best-effort to users for the definition of user requirements. In WP3 DUTH will work on the definition of the architectural framework of Bundle Protocol (BP) within UMOBILE platform by building the required convergence layers for underlying protocols and contributing to the development of the smart routing mechanism. In WP4, DUTH will also use their experience on data dissemination over DTN towards achieving the dissemination of local knowledge and the provisioning of multiple levels of QoS. Finally, DUTH will contribute to scientific exploitation and incorporation into education by undertake the responsibility to participate in conference keynotes and related panels, adopt UMOBILE results in academic courses and participate in (pre-)standardisation committees such as CCSDS and GAIA.

Persons

Prof. Vassilis Tsaoussidis (M) holds a B.Sc. (honors) in Applied Mathematics from Aristotle University, Greece; a Diploma in Statistics and Computer Science from the Hellenic Institute of Statistics; and a Ph.D. in Computer Networks from Humboldt University, Berlin, Germany (1995). He held a postdoctoral appointment at the Department of Computer Science, Rutgers University, New Brunswick, and faculty appointments at the Computer Science Department of SUNY Stony Brook, and at the college of Computer Science of Northeastern University, Boston. He is now full Professor at the Faculty of the Department of Electrical and Computer Engineering of Democritus University of Thrace and the Director of the Internetworked Systems Laboratory. Vassilis holds a visiting Professorship at the Department of Aeronautics and Astronautics of Massachusetts Institute of Technology (MIT), and positions as ESA delegate for the DTN CCSDS and as member of the National Strategic Reference Framework. Vassilis was/is editor for major networking journals and is editor in chief for the Journal of Internet Engineering; he edited several special issues on related topics and chaired various networking conferences. Vassilis received the honorable mention award from IEEE ISCC 2002 and the Research Award from the World Academy of Sciences.

Ioannis Komnios (M) received his Diploma in Electrical and Computer Engineering from Democritus University of Thrace, Xanthi, Greece, in 2007, and two years later, in 2009, he received his MSc in Computer Networks from the same department. Currently he is a Ph.D. candidate under the guidance of Prof. Vassilis Tsaoussidis and a researcher at the Space Internetworking Center. His research interests include Delay Tolerant Networking (DTN), the development of routing protocols for disruptive networks, frameworks for cellular data offloading as well as providing global internet access through less-than-best-effort services. Ioannis is involved as a technical co-director in the "Space Internetworking Center" project, funded by the European Commission.

Sotirios Diamantopoulos (M) graduated from the Democritus University of Thrace (DUTH) with a Diploma in ECE and he received an MSc in Computer Networks from the same university. He has been actively involved in several ESA and FP7 projects. Currently a PhD candidate under the guidance of Prof. V. Tsaoussidis, Sotirios works as a research engineer in Space Internetworking Center, with a significant involvement as a technical co-director in the "Space-Data Routers For Exploiting Space Data" project, funded by the European Commission. His research interests lie mainly in the areas of space communications and delay-tolerant networking and, in particular, in routing and transport algorithms and in the architectural design of space-internetworking protocols.

Nikolaos Bezirgiannidis (M) received a diploma in ECE from Aristotle University of Thessaloniki, Greece and a master's degree in ECE in the scientific area of Computer Networks from Democritus University of Thrace, Greece. Currently he works as a research engineer at Space Internetworking Center, DUTH, with active participation in several FP7 and ESA projects. He is also in his final year of his PhD under the guidance of Prof. V. Tsaoussidis. His expertise lies mainly in internetworking in challenged and delay/disruptive tolerant environments, with experience in the design and implementation of routing and transport protocols.

Sotirios-AngelosLenas(M) received his ECE diploma in 2009 and an M.Sc in Computer Networks and Security in 2011. His expertise lies mainly in the areas of internetworking in delay/disruptive tolerant environments,

network applications and network queue management. Over the past three years, Sotiris has been involved in several research projects, funded both by ESA and the EU, under the FP7 SPACE and REGPOT schemes.

LefterisMamatas (M) is a lecturer at the department of Applied Informatics, University of Macedonia and associate researcher at the Space Internetworking Center, Democritus University of Thrace. His research interests lie in the areas of network management, delay-tolerant networks and energy efficient communication. He published more than 30 papers in international journals and conferences.

AgapiPapakonstantinou(F) received her degree in Accounting and Finance from University of Macedonia, Thessaloniki, Greece, in 2005 and then in 2008 she received her MSc in Systems Engineering and Management from Democritus University of Thrace. Her expertise lies in managing FP7, ESA and national research projects.

Publications

1. S.-A. Lenas and V. Tsaoussidis, "Enabling free internet access at the edges of broadband connections: a hybrid packet scheduling approach", **SIGMOBILE Mobile Computing and Communications Review (MC2R)**, Vol. 18, Issue 1, pp.55-63, Feb. 2014. doi:10.1145/2581555.2581564
2. I. Komnios and V. Tsaoussidis, "CARPOOL: Extending Free Internet Access over DTN in Urban Environments", in **ACM MobiCom Workshop on Lowest Cost Denominator Networking for Universal Access, LCDNet '13**, Miami, Florida, USA, September 30, 2013.
3. S.-A. Lenas, and V. Tsaoussidis, "Traffic Shaping for Enabling Less-than-Best Effort Services at the Edges of Broadband Connections", in **ACM MobiCom Workshop on Lowest Cost Denominator Networking for Universal Access (ACM LCDNet '13),** Miami, Florida, USA, September 30, 2013
4. A. Sathiaseelan, D. Trossen, I. Komnios, J. Ott and J. Crowcroft, "Information centric delay tolerant networking: An Internet Architecture for the challenged", **Technical Report: UCAM-CL-TR-841**, ISSN 1476-2986
5. L. Mamatas, A. Papadopoulou and V. Tsaoussidis, "Semi Markov modeling for User Mobility in Urban Areas", **2nd Stochastic Modeling Techniques and Data Analysis International Conference (SMTDA 2012)**, Chania, Greece, June 5-8, 2012.

Previous relevant projects

1. Space-Data Routers For Exploiting Space DATA, funded by EC FP7 Grant. 263330. This project provided a secure DTN overlay infrastructure to disseminate vast amounts of space data among space agencies, academic institutes and research centers.
2. Extending Internet into Space - Phases 1-3: ESA/ESOC DTN/IP Testbed Deployment and Optimization. This project was funded by the European Space Agency to build a DTN testbed, and, among others, evaluate the interoperability of Space DTN protocols with terrestrial Internet protocols
3. Space Internetworking Center – SPICE, EC FP7 Grant. 264226. This project was funded by the FP7 Capacities "Research Potential" program to upgrade the DUTH DTN testbed, and enhance its functionality by obtaining new specialized equipment, such as sensors.

Other

Infrastructure/Facilities details: (Software & Hardware)

1. Internetworked Systems Laboratory, including: 18 workstations, 4 servers, 1 high-performance computer, networking equipment (switches, firewall, routers), traffic analyzer and components, Satellite Communication equipment, ESA Portable Satellite Simulator and CORTEX CRT System, and Satellite Tool Kit (STK) Software.
2. DTN Testbed, including: a rack with 15 emulation nodes, 18 mobile DTN nodes (notebooks and smartphones), networking equipment, and sensors. DTN Testbed is expandable with virtual machines on the 4 servers and the high-performance computer.

Open source solutions

1. DUTH is actively involved in the open source community mainly for DTN-related software. In particular, it has contributed to the Interplanetary Overlay Network (http://sourceforge.net/projects/ion-dtn/)

DTN software with services and protocols, such as Bundle Streaming Service, for streaming audio, video, and telemetry over DTN, and Delay-Tolerant Payload Conditioning, for "transport"-like functionality over BP, plus application data aggregation and elision.
2. DTN Agent for NS-2 (http://www.spice-center.org/dtn-agent/): The DTN model is implemented as a set of classes in the ns-2 simulator. The model was developed in order to study the deployment of DTN on top of traditional, Internet-based networks.

2.3.4.1.3. University College London (UCL)

University College London (UCL)

Partner CV & Role in UMOBILE project

University College London (UCL) is one of the premier universities in the UK and has been consistently ranked in the top 20 universities in the world. In the area of communications research, the department's activities span areas across all the layers of the communication protocol stack, ranging from radio, optical coding and transmission through routing, resource control and traffic engineering up to content-centric and peer-to-peer networking, multimedia applications and network/service management.

UCL's relevant expertise has been obtained through its participation in a number of research projects in the areas of QoS, network/service management, content-centric networking content distribution, virtualization and future Internet, in which it has had a leading role. UCL's relevance expertise is also testified through numerous prestigious publications and the high standing in the networking research community of the relevant academics who will be involved in the project. Examples of recent related projects are TEQUILA, MESCAL, CONTEXT, AMBIENT, MCDN, AGAVE, EMANICS, AUTOI, ENVISION and COMET. COMET has been one of the most successful projects in the area of content-networking and ICN. Currently, UCL is participating in the EU FP7/NICT GreenICN project, which focuses on ICN solutions to disaster management. Furthermore, UCL is running a UK-funded EPSRC project on "Active Content Management at Internet Scale" (COMIT), which focuses on a smooth migration path towards the shift to Information-Centric Networking. The team at UCL has been actively involved in the ICN-related IRTF group, called ICNRG, where members of the group contributed to the initial outputs of the group (see ICNRG ICN Research Challenges document).

Role in UMOBILE project

UCL will bring into the project its expertise in content resolution and delivery in ICN environments, naming systems and architectures and optimal server placement for content distribution to remote regions. More in particular, UCL will work on naming, content resolution and replication/caching of content close to the users in an environment, where direct access to the origin server is not possible. This will be achieved through smart content naming that allows for sophisticated and efficient replication based on content names. Issues of energy efficiency and security will be taken into account from the onset, in contrast to past approaches that consider these issues as an aftermath. UCL will also participate in the design of energy efficient algorithms for disaster-tolerant scenarios, where battery- limited mobile devices are the main carrier of content.

Persons

Prof. George Pavlou (M)holds the Chair of Communication Networks at the Dept. of Electronic & Electrical Engineering, UCL. Before re-joining University College London in the beginning of 2008, he was Professor at Surrey leading research activities in networking and network/service management. His research interests focus on networking and network & service management and have included aspects such as traffic engineering, quality of service management, policy-based systems, autonomic networking and information-centric networking. He has been instrumental in a number of key European and UK projects that produced significant results.

Dr. Ioannis Psaras (M)is a Senior Researcher in the Dept. of Electronic & Electrical Engineering, UCL. He has participated in several EU projects, such as Ambient Networks, 4WARD and EU FP7 COMET, where he acted as a member of the technical leading team. He is currently leading the efforts in the EU FP7/NICT GreenICN and EPSRC COMIT projects. His research interests include congestion control, information-centric networks and user-provided networks; he specializes in network-layer techniques to improve overall network performance

and energy efficiency.

Publications

1. Ioannis Psaras, Richard G. Clegg, Raul Landa, Wei Koong Chai, George Pavlou, *"Modeling and Evaluation of CCN-caching Trees"*, **IFIP NETWORKING 2011**, Valencia, Spain, May 2011
2. W. K. Chai, et al., *"CURLING: Content-Ubiquitous Resolution and Delivery Infrastructure for Next Generation Services"*, **IEEE Communications Magazine**, Special Issue on Future Media Internet, pp. 112-120, March 2011.
3. Wei Koong Chai, Ioannis Psaras and George Pavlou, *"Cache Less for More In Information-Centric Networks"*, **IFIP NETWORKING 2012**, Prague, Czech Republic, May 2012 **(Best paper award!)**
4. Ioannis Psaras, Wei Koong Chai and George Pavlou, *"Probabilistic In-Network Caching for Information-Centric Networks"*, **ACM SIGCOMM Workshop on Information-Centric Networks**, Helsinki, Finland, August 2012
5. Ioannis Psaras, Wei Koong Chai, George Pavlou, "In-Network Cache-Management and Resource Allocation for Information-Centric Networks", IEEE Transactions on Parallel and Distributed Systems (**IEEE TPDS**), in press, Article DOI: 10.1109/TPDS.2013.304

Previous relevant projects

1. EPSRC EP/K019589/1 "COMIT: Active Content Management at Internet Scale" (01/2014-01/2017)
2. EU FP7 / Japan NICT GreenICN: Architecture and Application for Green Information-Centric Networking (04/2013-04/2016)
3. EU FP7 COMET: Content Mediator Architecture for Content-Aware Networks (01/2010-01/2013)

Other

Infrastructure/Facilities details: (Software & Hardware)

At UCL, we already have a testbed that consists of 12 powerful workstations (projected to have become 16 by the time this project commences) that can be connected in arbitrary topologies. Each physical machine can host hundreds of virtual nodes. The intention is to build the UMOBILE Service Abstraction in either kernel- or user-space, based on the MiniNet platform, for instance, and deploy them in virtual machines. These virtual machines will in turn be connected in topologies of up to 1000 nodes in order to experiment with realistic Internet conditions. The testbed has been built up with resources from previous grants and will be kindly offered for the purposes to this project from EEE Dept. of UCL. The testbed will be used for software development and for experiments in order to obtain realistic results, in addition to those we intend to obtain through simulations.
The testbed consists of 12 machines in total. In particular, we have:
- two SUN servers with 4 CPU cores (2.5 GHz each) (Intel(R) Core(TM) 2 Quad CPU Q9300) and 8GB of memory,
- four machines with 8 CPU cores (1.9 GHz each) (2 X Quad-Core AMD Opteron(tm) Processor 2347 HE) and 32GB of memory, and
- six servers of 16 core (4 X quad core) - Intel(R) Xeon(R) CPU E5520 @ 1.6GHz each with 32GB of memory.

Open source solutions

1. Icarus Simulator: http://icarus-sim.github.io/
2. L. Saino, I. Psaras and G. Pavlou, Icarus: a Caching Simulator for Information Centric Networking (ICN), in Proc. of the 7th International ICST Conference on Simulation Tools and Techniques (SIMUTOOLS'14), Lisbon, Portugal, March 2014

2.3.4.1.4. The Chancellor, Masters and Scholars of the University of Cambridge (UCAM)

University of Cambridge (UCAM)

Partner CV & Role in UMOBILE project

University of Cambridge Computer Laboratory, Systems Research Group has some 40 members and is divided into a number of subgroups. Networks and Operating Systems group (NetOS), which is involved in this proposal, undertakes teaching and research into topics including computer architecture, operating systems design, network monitoring and protocol design, practical distributed systems and mobile communications. The group works closely with other groups in the Computer Laboratory and University, as well as industrial partners such as Microsoft Research. The University of Cambridge has an outstanding track record for start-ups and spinouts, as well as having attracted many large companies (example Microsoft, ARM, Intel, Nokia, Broadcom) to base some of their main laboratories and actual design teams in the area. The group has developed recently a strong expertise in the area of Information Centric Networking, Mobile Opportunistic Networking and Satellite Networking.
http://www.cl.cam.ac.uk/research/srg/netos
http://www.cl.cam.ac.uk/research/srg/netos

Role in UMOBILE project

UCAM will play a major technical role by working on the UMOBILE architecture integration with UAVs and wireless, QoS provisioning, multipath transport, caching and time-shifting of content performance analysis, Simulations using ns-2 and emulations using NS-3 blackadder. UCAM will also be involved in dissemination activities in particular at the IETF and IRTF GAIA.

Persons

Professor Jon Crowcroft (M) is the Marconi Professor of Communications Systems in the Computer Lab, at the University of Cambridge. He is a Fellow of the ACM, of the British Computer Society, of the IEE and the Royal Academy of Engineering and a Fellow of IEEE. He runs the Communications Innovations Institute, UCL and the Oxford Internet Institute economists, engineers, lawyers, social and computer scientists, which seeks to see how the impact of disruptive technologies can be factored into the communications and computing business arena, and comprehended by regulators and other government agencies. Currently Prof. Crowcroft holds several grants from the EU FP7 User Centric Networking, EPSRC; Horizon: Digital Economy Hub and INTERNET: Intelligent Energy aware Networks. http://www.cl.cam.ac.uk/~jac22/.

Dr. ArjunaSathiaseelan(M) is a Senior Research Associate at the Computer Laboratory, University of Cambridge. He leads work on LCD-Net: Lowest Cost Denominator Networking, new Internet paradigm that architects multi-layer resource pooling Internet technologies to support new low-cost access methods that would enable free Internet connectivity to enable social inclusion. He is currently the coordinator and PI of the EU COSMOS project which is part of the EU FP7 CONFINE as well as coordinating the EPSRC funded "PAWS: Public Access WiFi Service" project which he initiated. The project aims to utilise the unused capacity at home broadband networks to provide free Internet access to all to access essential services. He is the Chair of the Internet Research Task Force (IRTF) Global Access to the Internet for All (GAIA) initiative. His research also spans architecting the Future Internet and enabling quad-play (voice, video, data, mobility) convergence over next generation satellite networks. He has also co-authored and contributed to several Internet standards and drafts (IETF) and contributed to the DVB-RCS2 standardization at the ETSI TM-RCS. He was also an Associate and Convener for ICT4D group at the Center for Sustainable International Development (CSID) at Aberdeen, where he conducted cross-disciplinary research to look at ICT solutions for International Development. http://www.cl.cam.ac.uk/~as2330/.

Publications

1. LCD-Net: Lowest Cost Denominator Networking,
   A. Sathiaseelan, J. Crowcroft, **ACM SIGCOMM Computer Communication Review,** April 2013.

2. Internet on the Move: Challenges and Solutions
   A. Sathiaseelan, J. Crowcroft, **ACM SIGCOMM Computer Communication Review**, January 2013.

3. An Internet Architecture for the Challenged
   A. Sathiaseelan, D. Trossen, I. Komnios, J. Ott, J. Crowcroft, **IAB Internet Technology Adoption and Transition (ITAT) Workshop,** Cambridge, December 2013.

4. Public Access WiFi Service (PAWS)

A. Sathiaseelan, J. Crowcroft, M. Goulden, C. Greiffenhagen, R. Mortier, G. Fairhurst, D. McAuley, **Digital Economy All Hands Meeting**, Aberdeen, October 2012.

5. Universal Service Provisioning using Next Generation Access Technologies
A. Sathiaseelan and G. Fairhurst, **Digital Futures**, Nottingham, October 2010.

Previous relevant projects

1. EU FP7 COSMOS (part of EU FP7 CONFINE) (2014-2015)
2. EPSRC Public Access WiFi Service (PAWS) (2012-2014)
3. EPSRC Rural Public Access WiFi Service (2012-2014)
4. RCUK Horizon Digital Economy Hub (2010-2012)
5. FP7 User Centric Networking (2013-2015)

2.3.4.1.5. COPELABS—COFAC (COPELABS)

COPELABS – Association for the Research and Development in Cognition and People-centric Computing

Partner CV & Role in UMOBILE project

COPELABS is a research unit of University Lusófona, Lisboa, Portugal, focused on the interdisciplinary study of cognitive functioning, social interaction and behaviour inference, to assist the study of networking and information science technology, as well as to support a better use of technology towards society. The ultimate goal of this dual approach is to promote societal well-being.

Our mission is to design, to develop, and to validate pervasive, low-cost, and user-friendly technological solutions that are both useful in the context of psychological and cognitive intervention as well as capable of placing the citizen in the heart of the social structure that today encompasses the Internet. Overall, COPELABS comprises 27 researchers, 16 of each hold a PhD and have wide experience on project management and European initiatives. COPELABS integrates UMobile with the SITI group that is dedicated to informatics systems and technology, focus on pervasive wireless systems and social Internet design.

As research unit, COPELABS has a vast experience both in project development as well as in European project coordination, having been the most recently example of a coordinated project the FP7 IST ULOOP (gr 75148. Projects where COPELABS have previously been involved are: WiNeMo Cost; FP6 Ambient Networks; FP6 NOBEL II; FP6 6NET. COPELABS is an affiliate of the network of excellence on Internet Science, and actively engages in several technological platforms, such as the Future Internet Assembly, Net!Works.
Our list of results is openly available at http://copelabs.ulusofona.pt/scicommons/.A list of publications is available here: http://copelabs.ulusofona.pt/scicommons/index.php/topics.

Role in UMOBILE project

In UMOBILE, brings knowledge on the social trust computation obtained from the European project ULOOP and social- and interest-based communication approaches dLife and SCORP, some of which are currently in a standardization track at IRTF DTNRG.

Persons

Dr. Paulo Mendes (M) is a vice-Director (2014) of COPELABS, the SITI coordinator, and an Associate Professor of University Lusófona, where he heads the PhD programme in Informatics, NEMPS. Paulo is also a co-founder of SENCEPTION Lda, a spin-off of COPELABS. He has a BEng in Informatics Engineering by Univ. Coimbra (93); MSc in Computers and Electrotecnical Engineering (1998) by IST, UTL, Lisboa, and a PhD in Informatics Engineering by Univ. Coimbra (2004). He was the Telematics Director of Fernave, S.A.

(1994-1998); Invited Researcher (00-03) at Columbia University, NY, EUA; researcher at CISUC, Universidade de Coimbra (1996-2002). He was also a Senior Researcher (2003-2007) at NTT DoCoMo Euro-Labs, Munich, Germany, and the co-coordinator of the "Internet Architectures and Networking" area of UTM, INESC Porto (2007-2010). His research interests relate to cooperative wireless systems, self-organizing networks, and complex networks. His track-record includes over 50 scientific peer-reviewed papers. Paulo is also author in 13 international patents.

Mr.Waldir Moreira (M)is a Researcher in COPELABS, R&D group SITI. He was (2010-2013) a Researcher in SITILABS. Waldir got his degree on Computer Science at the University of Lehbridge in Canada (2001) and got another degree In Computer Sciences at Amazônia University in Brazil (2005). He is doing his PhD at Aveiro University - MAP Doctoral Programme in Telecommunications (MAP-TELE). He is working as a researcher at COPELABS. His research interests relate with opportunistic routing and Internet design.

Publications

1. Waldir MoreiraandPauloMendes,Routing in Opportunistic Networks, chapter Social-aware Opportunistic Routing: The New Trend, **Springer Verlag**, 2013
2.Ronedo Ferreira,WaldirMoreira,PauloMendes,MarioGerlaandEduardoCerqueira,Improving the Delivery Rate of Digital Inclusion Applications for Amazon Riverside Communities by Using an Integrated Bluetooth DTN Architecture (2014), in: **International Journal of Computer Science and Network Security,** Vol.14:No. 1
3.Rute C. Sofia,PauloMendes,José Manuel Damásio,SaraHenriques,FabioGiglietto,EricaGiambittoandAlessadroBogliolo,Moving Towards a Socially-Driven Internet Architectural Design (2012), in: **ACM SIGCOMM CCR** Newsletter, 42:3
4.Waldir Moreira,Paulo MendesandSusanaSargento,Opportunistic Routing Based on Daily Routines, in: Proceedings of the **6th IEEE WoWMoM Workshop on Autonomic and Opportunistic Communications (AOC 2012),** San Francisco, USA, 2012
5.Waldir Moreira,Paulo Mendes andSusana Sargento,Social-aware Opportunistic Routing Protocol based on User's Interactions and Interests, in: in Proc. **Adhocnets 2013**, Barcelona, Spain, 2013

Previous relevant projects

1. 2010-2013 *ULOOP: User-provided Local Loop*. EU IST FP7 call5, objective 1.1, funded by the European Commission, Framework Programme 7, grant number 75418. http://uloop.eu
2.2009-2013 *User-centric Routing*, Ph.D. grant reference number BD SFRH/BD/44005/2008, by Fundação para a Ciência e Tecnologia. 2009-2013. http://copelabs.ulusofona.pt/index.php/research/projects/past-projects/151-ucr
3. DTN-Amazon, Delay-Tolerant Networks for the Amazonia Region (2011-2013). http://copelabs.ulusofona.pt/index.php/research/projects/past-projects/195-dtn-amazon
4.CitySense I, Large Scale Opportunistic Sensing in Urban Scenarios. 2011-2013, http://copelabs.ulusofona.pt/index.php/research/projects/past-projects/156-citysense

Other

Infrastructure/Facilities details: (Software & Hardware)

1. Wireless Lab including: 4 wireless access points; 5 Android smartphones; 2 Windows smartphones;; 1 dedicated server; networking support (switches, router); VoIP devices.

Open source solutions

1. Ricardo BarbosaandPauloMendes,Maestroo - an Immersive Sensing Tool, SITI-SW-12-05, 2012
2. ICON - Information and Context Oriented Networking, http://copelabs.ulusofona.pt/index.php/technology/software/182-icon-dtn-amazon-project
3. WaldirMoreira,Social-aware Content-based Opportunistic Routing Protocol (SCORP), SITI-SW-13-01, 2013
4. WaldirMoreira,dLife v1.0: Opportunistic Routing based on Social Daily Routines, SITI-SW-12-02, 2012

Other supporting documents /references/infrastructures specified in the work programme for this call

1.Waldir Moreira,PauloMendes,Ronedo FerreiraandEduardoCerqueira,Opportunistic Routing based on Users

Daily Life Routine, IETF draft draft-moreira-dlife-01, 2012

2.3.4.1.6. Fundacion TECNALIA Research & Innovation (TECNALIA)

FUNDACIÓN TECNALIA RESEARCH AND INNOVATION (TECNALIA)

Partner CV & Role in UMOBILE project

TECNALIA is the first leading private and independent research and technology organisation in Spain and the 5th largest in Europe, employing 1445 expert and international people (164 PhDs) and income of 118M€ and over 4.000 clients. TECNALIA operates in the following market sectors: Industry and Transport, ICT, Sustainable Construction, Energy and Environment, Innovation Systems, and Health and Quality of Life, and it is very active in FP7, participating up to June-2012 in 264 projects and coordinating 64 of them. We are also participating within the launching of the main KIC's of the EIT, the KETs, the FET Flagships initiatives, towards the Horizon 2020 Programme, where TECNALIA is actively involved, as well as in the definition of other EU Work Programmes, through CDTI, EC, etc. TECNALIA has also key alliances with the main EU research centers through the EUROTECH, EARTO, JIIP, and ERANET AERTO.

TECNALIA has a good background in participating in EU funded project since FP6 programme. TECNALIA has been very active in FP7, participating in 264 projects and coordinating 64 of them. Besides, TECNALIA has a deep knowledge of FI-PPP (such as FI-WARE projects and related enablers to be used) and has also been involved in SAFECITY project (FI-PPP Phase 1) related to Smart City domain.

TECNALIA has also an organisational structure called VENTURES, to support the creation of Start-ups, entrepreneurship, business angels' networks, etc., and an instrument called Inspiring Business Forum (IBF) with associated organisations to promote innovation.

TECNALIA has a Division in charge of providing internal support for I+D+iProgrammes and managing the Innovation and research Unit of Prometeo technological platform, supported by CDTI.

TECNALIA has several collaboration alliances with the most important European industrial clusters such as Clusters: GAIA, AMETIC, DSP Valley, BICC-NET, CCAN, RedCI – Red CiudadesInteligentes, among others. And with the most important European Research Centers as VTT, CEA, SINTEF, TNO, Fraunhofer, Joanneum Research under the alliance of JIIP, and the alliance of EUROTECH-EARTO.

Among the Business Units in which the research activity of TECNALIA is divided, Telecom and Electronics emphasizes on the specific R&D needs of fields related to digital HW design and component integration, and wireless network deployments. With the aim of transferring value to the society through innovation and technology, Telecom and Electronics shows a high degree of specialization and focus on: ad-hoc embedded hardware design and prototyping, multicore computing, advanced FPGA-based design, indoor location solutions based on hybrid wireless technologies, sensor and actuator networks, Radio Frequency (RF) design, GNSS RF-Frontends, among others. The Telecom and Electronics Business Unit provides a response to market and research demands in terms of capacity and velocity, competence, critical mass, qualified professionals, equipment and anticipation to technological changes.

Within the TELECOM Business Unit we have been working in ad-hoc and opportunistic networks for several years now, mainly involved in EU projects: 4WARD (ended in 2011) and SAIL (ended in 2013). Tecnalia's expertise has been mainly focused on communications protocols and adaptations of these so as to follow specific design criteria. We worked with simulation environments for AODV (Ad-hoc On-demand Distance Vector Routing) and OLSR (Optimised Link-State Routing), and also developed our own modifications of the protocols for their NS2 implementations. Tecnalia has developed a system to allocate virtual resources over mobile opportunistic physical topologies, which derived in a European PCT. More recently, the Telecom Unit evolved its approach towards Delay Tolerant Networks (DTNs), especially those based on human-carried devices. We designed and developed a modification to the so-called PRoPHET routing protocol, incorporating the metric of "contact-duration" to the route selection. Apart from this specific work, we also have experience working with 802.15.4 sensor-actuator nodes for a variety of applications.

Role in UMOBILE project

In this project Tecnalia plans to make extensive use of Telecom Unit's expertise in the field of opportunistic networking and the implementation and deployment of DTN based topologies. The main contribution from Tecnalia will be based on the networking requirements specification within the envisaged scenarios (task T2.2) and the system deploy ability (task 2.3), the design of the DTN overlay in order to include the convergence and ICN layers demanded by the specific services (task 3.1) and the lead of smart routing approaches based on social interactions (task 3.3). During the platform integration and validation phase, Tecnalia will also participate in deploying test scenarios where main developments from WP3 can be validated as proof-of-concept (T5.3) so as to cover all demanded aspects from the use cases perspective.

Persons

José Mª Cabero (M)
(MSc): M.S. In Telecommunications Engineering, University of the Basque Country (1999). From 1999 to 2001 working in the Test Department of Ericsson Bilbao Technology Centre. From 1999 to 2005 he was working in the Telecom Unit of ROBOTIKER-TECNALIA as a researcher and Project leader participating in European Projects such as MOBILISING THE INTERNET, PULSERS and ROBOSEM. From 2005 to 2007 Visiting Scholar at Carnegie Mellon University, Robotics department, Human Sensing LAB, working on characterisation of human activities using wireless communication devices. From 2007 on he came back to the Telecom Unit with his main activity devoted to Future Internet research lines in FP7 Projects such as 4WARD, SAIL and the European Platform eMobility. His main research activities are focused on disruption tolerant networking, analysis of patterns of human behaviour with especial emphasis on mobility, design and implementation of wireless communication sensors and cloud networking.

Susana Pérez Sánchez (F)
M.Sc in Telecommunications Engineering by the University of Deusto (Bilbao, 2002), she also finished a Master Course in Computational Sciences in 2005 by University of Deusto. She has been a Project Manager in the Telecom and Electronics Business Unit of Fundación TECNALIA Research and Innovation since 2011. After a 6 month period in Madrid working for Telefónica I+D in 2003, she returned to Bilbao and worked as Researcher and Associate Professor in the University of Deusto until 2008. She joined Fundación ROBOTIKER then to participate in the technical developments of several European Projects such as 4WARD and SAIL. Being ROBOTIKER a part of TECNALIA already (2011), Susana had gained experience in Traffic Engineering and Architectures and Protocols for heterogeneous networks in the Future Internet. She is the author of various scientific articles, as well as of a PCT ("Method and System of Association of Virtual Networks on a Substrate formed by Mobile Nodes"). More recently, her research activity has been focused on opportunistic and mesh networks, especially the so-called DTNs (Delay Tolerant Networks), based on human-carried devices with scarce computational resources. Nowadays, she combines her technical activity with the management side of the project coordination within the Telecom Business Unit.

IñigoSedano Pérez (M)
Telecommunications Engineer by the University of Deusto (Bilbao, 2005) and Master in Information Technologies and Communications in Mobile Networks by the University of the Basque Country (Bilbao, 2007). In the years 2005-2006 he worked for DeustoTech (Deusto Institute of Technology) at the University of Deusto in the field of ambient intelligence and telematic solutions. Since October 2006 he works for the Division ICT-European Software Institute of Tecnalia and has participated in European research projects related to broadband networks (PlaNetS, Banits2, TRAMMS). Between November 2009 and November 2011 he completed a research fellowship at Acreo Research Institute, Sweden about methods to evaluate the video quality. From November 2011 he participates in various Spanish research projects in the area of scalable video coding at Tecnalia Research & Innovation (SILO, IGNIS Spanish national projects). He has also participated in a project related to tv contents generated by users, funded by the Basque government (TVSocial). He has also experience in the development of location systems based on embedded Linux and Bluetooth, which detection is based on proximity. Iñigo is involved in the preparation of proposals for national and European public funding programmes.

Publications

1. S. Pérez-Sánchez, R. Bless, Chapter 4: Network Design of the book Architecture and Design for the Future Internet: **4WARD EU Project. Ed. Springer**. ISBN: 9789048193455, 59-87 (2011)

2. G. Hernando, S. Perez, JM Cabero et al., Method and System of Association of Virtual Networks on a Substrate formed by Mobile Nodes. **PCT/ES2010/070305. Patent pending** (2010)
3. Hernando, G.; Pérez, S.; Cabero, J.M. Mobility-Aware Distributed Embedding (MADE) of virtual networks. **Future Network and Mobile Summit**. Print ISBN: 978-1-905824-16-8, 1-8. Florence, Italy. (2010)
4. G. Hernando, S. Pérez-Sánchez, J. M. Cabero. Adaptive Weighted Round Robin (AWRR) Scheduling for Optimization of the Wireless Medium Virtualisation. **2nd International Conference on Mobile Lightweight Wireless Systems (MOBILIGHT)** Lecture Notes of the Institute for Computer Sciences Social Informatics and Telecommunications Engineering, (Springer) ISBN 978-3-642-16643-3, 673-684. Barcelona, Spain (2010)
5. G.Hernando, S.Perez, J.M.Cabero. Analysis of Path Splitting and Migration in the Virtualisation of Mobile Substrates. **Proceedings of ICT-MobileSummit**. ISBN: 978-1-905824-12-0. Santander, Spain (2009)

Previous relevant projects

Within the TELECOM Business Unit we have been working in ad-hoc and opportunistic networks for several years now, mainly involved in EU projects: 4WARD (ended in 2011) and SAIL (ended in 2013). Tecnalia's expertise has been mainly focused on communications protocols and adaptations of these so as to follow specific design criteria. We worked with simulation environments for AODV (Ad-hoc On-demand Distance Vector Routing) and OLSR (Optimised Link-State Routing), and also developed our own modifications of the protocols for their NS2 implementations. Tecnalia has developed a system to allocate virtual resources over mobile opportunistic physical topologies, which derived in a European PCT. More recently, the Telecom Unit evolved its approach towards Delay Tolerant Networks (DTNs), especially those based on human-carried devices. We designed and developed a modification to the so-called PRoPHET routing protocol, incorporating the metric of "contact-duration" to the route selection. Apart from this specific work, we also have experience working with 802.15.4 sensor-actuator nodes for a variety of applications.

1. Title of the project: MUGITU – Integral Ticketing System for interoperable services of ticketing and payment in the Basque Public Transport
   Funded by: Basque Government
   Duration: from 10/12 to 06/14
   Main researcher: Susana Pérez

2. Title of the project: SILO – Geo-localized and contextualized Information System for Public Transportation
   Funded by: Spanish Government
   Duration: from 10/2011 to 04/2014
   Main researcher: IñigoSedano Pérez

3. Title of the project: SAIL – Scalable and Adaptive Internet soLutions (http://www.sail-project.eu/)
   Funded by: European Commission (FP7)
   Duration: from 02/2010 to 02/2013
   Main researcher: Susana Pérez Sánchez

4. Title of the project: 4WARD – Architecture and design for the future Internet (http://www.4ward-project.eu/)
   Funded by: European Commission (FP7)
   Duration: from 01/2008 to 06/2010
   Main researcher: Jose MaríaCabero

2.3.4.1.7. TEKEVER Autonomous Systems (TEKEVER)

TEKEVER Autonomous Systems

Partner CV & Role in UMOBILE project

The TEKEVER Autonomous System (TAS) an OEM UxV Platforms manufacturer and UAV and UGV system providers. With experience for the security, aerospace, civilian and commercial market. TAS was found in 2007 as a spin-off of the TEKEVER Group activities in the robotic market and, as part of TEKEVER Group, TAS jointly explore and benefits from the group implementation worldwide, Europe (PT and UK), SW Asia, the United States and Brazil. TAS activity is product-driven and significant investment is dedicated to research activities leading to innovative technologies, in different fields, from flight control, automatic planning to image processing, analysis and image features tracking, including robots move by camera. TAS targets its market in close collaboration with our customers and establishing important partnerships to bring our technology to a mature operating level and technological readiness driven by the market needs.

TEKEVER AS inhered significant experience our group from past collaborative research projects in (FP7, ESA, EDA). Moreover, since its spin-off TAS has participated in some TEKEVER group project, including numerous European projects involving rich consortia. Relevant project with TAS participation is the projects "AUTOLAND" (UAV Automatic Landing System on moving platform), or project "REMAR", where UAV's are used to provide ad-hoc network connectivity to ground systems in unprepared environment. TAS has also been developing field expertise with our customers and with other companies within the chain-value of the market to exploit of UxV's in performing operations in real context environment supporting our R&D activities. Moreover, TAS personnel are involved in several PT civil organization networks addressing the problematic of UAV's integration in the market, contributing to the development of standards, like EUROCAE. TAS is also a member and leading company of the R&D work group of the Portuguese FEEM organization a hipercluster organization for the Economical Sustainable Sea Exploitation that aggregates industry, Research centers, universities and governmental institutions acting in different sectors, from fishing to production, security, energy, biology and naval.

Role in UMOBILE project

TEKEVER AS main involvement will be in WP5, in the validation and testing of UMOBILE prototypes. In addition to defining the validation exercises and associated KPI to be measured, integrating UMOBILE enabled radios on unmanned aerial platforms, providing, operating and deploying these platforms in validation exercises as backhaul add-ons and data mules, TEKEVER AS will also contribute to the definition of deployability requirements for UMOBILE system (technical, regulatory and operational) and will participate in the development of convergence layers with applicability in aerial platforms among others in WP3.

Persons

Mr. Pedro Petiz(M) has a degree in Aerospace engineering by Instituto Superior Técnico a post degree on information systems management by Instituto Superior de Economia e Gestão and a training course in information and competitive intelligence. Mr. Petiz has a more than 10 years background and experience in software development and management of critical embedded systems. He has been involved in several research projects in UxS systems and participated in several studies to NATO (SG-157 interoperability ofrUxS) to EDA (UGV's). He was also the program manager responsible for the development of a validation and testing infrastructure for real-time embedded system to the aeronautical sector and he's the responsible for the R&D brach of the Portuguese Sea Economic Industrial association (FEEM).

Mr. Tiago Marques (M) has a degree in Aerospace engineering by Instituto Superior Técnico (in Lisbon), and is currently working on its Phd on advanced UAV's control systems at IST, Lisbon. With 7 years experience in the development of real-time control system for the aeronautic sector, Mr. Tiago Marques is the responsible for the development of TEKEVER UAV's control system.

Ms. Sofia Fernandes (F) Aerospace Engineer specialized in avionics and control systems, with two years of experience in a large-scale FP7 project as project manager and computational fluid dynamics engineer. Further work includes one year of research in thermal solar systems, one year of research in UAV control systems and active participation in the directory board of an international student association focused in satellite construction and deployment.

Products

TEKEVER's main products in the UAV domain include different platforms targeting different segments and

applications:

- AR-4 Light Ray is a small tactical, hand-launched UAV for ISR (Intelligence, Surveillance, and Reconnaissance) targeting the defense market. With an endurance of 2 hours and a range of 20Km it is designed essentially for over-the-hill operations. The AR-4 has a civilian counterpart, called AR-1 Blue Ray, which fulfills the surveillance needs of public safety users.
- AR-3 Net Ray is a higher endurance and longer range platform (4 hours, 80Km) that can be applied to other applications beyond ISR due to its higher payload capacity. These include maritime and coastal surveillance missions, working as an operational extender for vessels as well as serving as communications relay to other vehicles and communications range extender.
- AR-5 Life Ray is a MALE (medium altitude and long endurance) family of platforms designed to perform long missions such as maritime patrol, border surveillance and SAR (Search and Rescue). With an increased payload capacity, the AR-5 can carry a vast array of sensors including micro radars, AIS receivers, cameras and ADS-B transponders. The AR-5 also supports BRLOS (beyond radio line of sight) operations through the use of satellite communication systems.

Previous relevant projects

1. MACAU was a national project led by the TEKEVER group dedicated to the creation of networks of UAVs to support telecommunications in areas with low or no coverage, or to face demand peaks. TEK-AS staff was also involved in the adaptation of UAV platforms for the integration with developed communications systems (HW and SW).
2. IMPERIO is a Portuguese industry-wide offset programme for the development of civilian UAVs. TEK-AS staff is participating with other TEKEVER group companies in the provision of communications packages and on-board mission planning capabilities for the IMPERIO UAV.
3. REMAR is a national project led by TEK-AS and involving the Portuguese Navy where UAVs are used to provide ad-hoc network connectivity to ground systems in unprepared environments. TEK-AS is providing the technical solutions to both UAVs and communication systems.
4. MIDNET is an EDA project on Disruption Tolerant Networking. In the scope of the group's participation, TEK-AS is providing support in the assessment of installing, deploying and using DTN solutions aboard small UAVs.

2.3.4.1.8. SenceptionLda (SENCEPTION)

SenceptionLda

Partner CV & Role in UMOBILE project

SENCEPTIONis a recent SME focused on cooperative sensing and a spin-off of the Portuguese research unit COPELABS, University Lusofona. We cherish the vision of improving the daily routine of citizens via the development of user-friendly technology. We build such vision via the mission of designing and producing pervasive technology that assists the capture and the inference of interactions among people, and their surroundings.

We are currently developing an open software platform (PerSense), to be released as basic and premium version in 2014. Its value-add is inference of future roaming behavior based on data collected by multiple software add-ons, from multiple devices. The second part is one of such add-ons, MOT (Moving Object Tracker). MOT is focused on wireless location tracking and future behavior estimation and is based on a patent pending mechanism.

The PerSense platform can reside anywhere in the network. It can be an embedded system or a fully centralized system, and a specific module shall be provided to the global community, to be used in devices such as wireless access points (e.g. based on OpenWRT). MOT is a solution that resides on an embedded device.

Role in UMOBILE project

In UMOBILE, SENCEPTION is willing to contribute with its know-how in pervasive sensing, both conceptually and as developers/integrators. SENCEPTION shall provide its core pervasive middleware platform, to assist in developing contextual inference that is required in UMOBILE.

Persons

Dr. Rute Sofia (F) is a founder and co-Director of SENCEPTION. She is also a Director (2014) of COPELABS, where she is the Senior Researcher responsible for the thematic line of Internet Science, and an Associate Professor of ULHT. Rute holds a BEng in Informatics Engineering by Universidade de Coimbra (95); M.Sc.(99) and Ph.D. (04) in Informatics by Universidade de Lisboa. Since 1995 she has been developing research in the industrial context (Grupo Forum, Lisboa, 95-98; SIEMENS AG, Munich, Germany, 04-07; Nokia-Siemens Networks GmbH & KO, Munich as Senior Researcher 07) as well as in the academic context (Universidade de Lisboa, 95; FCCN, 98-03; Pennsilvania University, PA, USA as Invited Researcher 00-03; ICAIR, Evanston, IL, USA, 00; BundeswehrUniversitaet Munich, as Senior Researcher, 04; INESCTEC, as co-coordinator of the Internet Architectures and Networking area, UTM, 07-10; SITI, ULHT, 10-13). Her current research interests are: social Internet design; pervasive sensing; mobility modeling and management. Rute holds 8 patents and over 40 peer-reviewed publications in her fields of expertise. She was (2010-2013) the Scientific coordinator of the EU FP7 project ULOOP and has vast experience in project management worldwide.

Publications

1. P. Mendes, R. Sofia, PerSense, a Pervasive Sensing Framework. **Technical Report**, SENCEPTION /COPELABS. 2014

Previous relevant projects

1. CitySense Phase II, pervasive Sensing Framework. SENCEPTION and COPELABS, 2014-2016. http://copelabs.ulusofona.pt/index.php/research/projects/active-projects/228-citysense-2

2.3.4.1.9.FON Technology S.L. (FON Technology)

FON Technology S.L.

Partner CV & Role in UMOBILE project

FON Technology is a company founded in 2006 by CEO, entrepreneur and Internet pioneer Martin Varsavsky with the goal of blanketing the world Wi-Fi that is free for everyone. Even though it is an SME, it has more than 13 million hotspots in more than 170 countries across the globe and partnerships with world's leading Telcos. This makes FON Technology the world's largest Wi-Fi network. In addition to operate its WiFi network, FON Technology develops its own technology (access points and service platform).

FON Technology's network usage has evolved from laptops to mobile devices (including game consoles) in the last few years. FON Technology has had to integrate its network with heterogeneous networks and operators (both fixed and mobile), acquiring a very valuable expertise and building effective, low cost and seamless networks. This knowledge has allowed FON Technology to develop and implement mechanisms, which ensure best user experience, into its technology.

Role in UMOBILE project

FON Technology role in UMOBILE project lies on providing expertise as WiFi network operator. FON Technology will collaborate in several WPs of UMOBILE project, being its mayor contributions allocated for WP2 and WP5. In WP2, FON Technology will participate in the definition of user requirements, system and network requirements and system deployability design in order to ensure an appropriate integration of the

UMOBILE platform into FON Technology Wi-Fi network. Regarding WP5, FON Technology will lead the work package and, in particular, the definition of the validation setup and deployment trial activities. FON Technology will also contribute in the preparation of the proof of concept that will be used during the validation tasks. Finally, in WP6, FON Technology will also lead with the exploitation task, as a representative of the industrial partners.

Persons

David Valerdi (M).He is responsible for FON Technology R&D Unit general management. This unit is an active contributor to FON technology roadmap by providing experimental product development, acting as a research centre of latest technology trends, participating in industry forums and R&D consortium projects, etc. He has an extensive international experience in telecom sector. He was previously technical product manager in Vodafone Group PLC and also worked for companies like Motorola and Telefonica R&D, covering different technical positions. He also holds several patents and academic publications. David gained telecoms engineering qualifications, at University of Cantabria (Spain) and became MBA, graduated with honors, at Instituto de Empresa, in 2009.

Iker Pérez de Albeniz (M). He works as R&D engineer at FON Technology. He holds a Telecommunications Engineering master's degree from the Deusto University and a Master in ICT and Mobile Networks from the Technical University of Bilbao. Iker has more than 8 years of experience in different companies and research centres like Sarenet, Panda Security, InnovaliaorUPV. He has intensive technical knowledge and experience in national and international R&D projects.

Luis Simón Gómez (M). He is Project Manager at FON Technology. He manages some of the company's new product development and R&D projects. Luis is fluent in three languages and has a huge experience managing granted R&D and ICT projects. He is PMP certified who gained his master's degree in Telecommunications Engineering from the Technical University of Madrid and holds an Executive Program in Project Management.

Publications

FON owns different products since it can work as device vendor and operator:

- Foneras: These are the FON TechnologyWi-FI routers. There are different models available with different authentication methods available: Web, Facebook login or EAP methods and features.
- FON platform: Also known as FON Appliance. This is a product that acts as the "Wi-FI core" platform. It is modular and can be built upon deployment needs and provides management functionalities for each of the FON networks (authentication, device configuration, user management, etc).
- FON networks: FON Technology operates a number of Wi-Fi created with Foneras by end users. All networks are connected through a Roaming Platform creating a bigger network. Partners can choose to have Foneras or to integrate the FON service in their residential gateways. A connection manager (user space application level) is available for mobile devices to manage authentication seamlessly for the user.

Previous relevant projects

FON Technology principal asset related to the subject and objectives of this project is its experience as service provider and owner of the biggest Wi-Fi network in the world. In addition, FON Technology participates in the following European FP7 projects:

- MOTO: Mobile OpportunisTic Traffic Offloading.
- COMBO: COnvergence of fixed and Mobile BrOadband access/aggregation networks.

And has been a partner of the completed FP7 project ULOOP: User centric wireless local LOOP.

Infrastructure/Facilities details: (Software & Hardware)

FON Technology owns and manages the biggest Wi-Fi network in the world. This network is composed by over

13 million hotspots, what is the main asset of the company. The Wi-Fi newtork is formed by FON routers (foneras) and its partners' CPEs, which are connected through a roaming platform in order to create a whole entity.

FON Technologyalso holds well-equipped labs premises where proof of concepts, pilots and small trials can be developed.

2.3.4.1.10. AFA Systems srl (AFA)

AFA SYSTEMS srl

Partner CV & Role in UMOBILE project

AFA Systems srl is a successful ICT company specialized in network solutions and advanced IP communications. AFA Systems was founded in 1991 and it is headquartered in Termoli (IT), with offices and active projects throughout Italy. AFA Systems operates in two business units, coordinated and complementary:

- AFA Engineering (networking projects and systems integration);
- AFA Industrial (production of MajorNet®, an integrated IP platform, for IP security, IP messaging, VoIP, etc).

AFA Engineering business unit deals with design and building of large-scale wireless networks, telecommunication systems, video-surveillance systems, network solutions and advanced IP communications. In the AFA Engineering b.u. the company software group operates. In Italy, AFA Systems was a pioneer delivering innovative ICT infrastructure solutions for SMBs and government institutions and providing solutions, services and technologies for mission and business critical processes. Its success lies in bringing quality and innovation to the customers' IT assets in a timely and cost effective manner.

At the end of the 90s, from its production of special computers for machinery automation, **AFA Industrial** business unit started the production of the MajorNet® platform, a solution for Unified Communications that provides all the voice and data communication services required by business users, SMBs, administrations, schools, etc. The MajorNet® aims to capture the massive SMB market opportunity created by low cost broadband internet access and migration to VoIP that generates demand for sophisticated, reliable, integrated and easy-to use communication services. MajorNet® is sold through a network of channel partners; there are currently thousands of MajorNet® users, mainly in Italy, growing rapidly.

AFA Systems has a significant background and expertise, suitable for the project. In terms of telecommunications infrastructure, the company designs and installs large-scale heterogeneous networks, using routing protocols over both (wired) Telcos' IP networks and its own wireless networks (Hiperlan, Wi-Fi, SDH), with MPLS techniques. The company currently operates many Wide Area Networks (mainly radio), from its NOCs.

In terms of systems, the company manufactures an integrated IP platform (called MajorNet®), with functions of smart gateway with different interfaces: embedded interfaces, as ADSL2+, 3G, Frame Relay (V.35); Ethernet interfaces to: Hiperlan, Wi-Fi, SDH, Satellite. The platform can manage multiple IP links, also of different nature (delay, packet loss, etc.), in bonding aggregation and redundancy. The platform provides mechanisms of QoS (L3 and L4 (ToS) queuing). The platform is used in Internet access architectures and in end-to-end inter-networking architectures (L2 or L3); it supports optimizations (Van Jacobson, RoHC, etc.) based on the under-laying network's performances.

The integrated company's IP platform delivers "rich communication" solutions for standard applications (control of access to the Internet, Wi-Fi hotspot management, SIP PBX, video streaming).

Role in UMOBILE project

AFA Systems will provide the framework for collecting and distributing data, and for processing them by understanding their context; the company will care of the set up and the deployment of the trials.

AFA will be involved in disseminating the results of the project to interested parties, included governments and local organisations and other potential stakeholders.

Persons

Francesco Amorosa(M)
Since 1984 he has been involved in software R&D projects, firstly at the Department of Electronics, University of Bologna, then in several industrial companies. In 1995 he founded AFA Systems.
Until 1993 he collaborated with University of Bologna, as lecturer in the "Post-graduated Course in Management". He has been peer-reviewer of "'IEEE Guide to the Software Engineering Body of Knowledge". He has published articles in various journals.
With AFA Systems has designed and led many complex projects on infrastructure and applications both for public administrations and private companies. He gained professional experiences in Project Management including: research project for development and testing of network protocols for acceleration, control, management and the traffic balance on satellite links (Eutelsat Paris AFA Systems); highly fault tolerant networks for railways, design and deployment of large-scale IP networks (some aimed at security and environmental monitoring).

Angela D'Angelo (F)
She is a PhD in Information Engineering, graduated at University of Siena (Italy), where she has been Research Assistant for 5 years.
She has been reviewer for "IEEE Transaction in Image Processing" and she has published papers on many scientific journals and conferences, mainly on "Digital Image and Video Processing" and "Biometrics for Video Surveillance applications". Other specific research interests include: multimedia security, distributed source coding, video processing and compression.
She was Visiting Researcher at University College of London (UCL), University of Salzburg, Technical University of Denmark (Copenhagen). She was Research Engineer for two years at Eurecom (Sophia Antipolis, France). She has been involved in several EU projects.
She currently holds the position of Multimedia IP Platform Senior Engineer at AFA Systems, in Research and Development department. She is Project Leader in projects of advanced IP communications.

Publications

1. D'Angelo, Angela, and Jean-Luc Dugelay. "A statistical approach to culture colors distribution in video sensors." **Proceedings of VPQM (2010).**
2. D'Angelo, Angela, and Jean-Luc Dugelay. "People re-identification in camera networks based on probabilistic color histograms." **IS&T/SPIE Electronic Imaging**. International Society for Optics and Photonics, 2011.
3. Dantcheva, Antitza, D'Angelo, Angela "Bag of soft biometrics for person identification."**Multimedia Tools and Applications** 51.2 (2011): 739-777.

Previous relevant projects

1. **Smart Node** – AFA Systems is currently completing the "Smart Node" project, funded by a national research program. The project has two main goals: (i) To find out routing techniques based on dynamic measurements of the quality parameters of a network, choosing the best paths (respect to a service) among nodes. (ii) To deliver rich multimedia and interactive communication through the WebRTC protocol. The final result is to offer a unique and effective support to large deployments of networks and systems (aimed at communication and education, spreading vertical information for specific area of interest – e.g. agriculture, collecting data from peripheral nodes and, allowing interactive audio-video communication) also over low quality transmission infrastructures.
2. **Transportable Civil Protection Operating Centre** – The project was funded by a regional Civil Protection and was aimed at providing some vehicles with satellite communication capabilities fully integrated with the Regional Operation Centre: Internet access, VoIP telephony, fax, videoconferencing and access to the regional geographic information system (GIS). (The vehicles were widely used after the L'Aquila Earthquake (Italy) in 2009, remaining in operation continuously for 18 months, at the

refugee camps.)
3. **Regional environment monitoring network** – The project has covered a wide area (in a reach of about a hundred Km) with several nodes, providing intelligent environmental video-surveillance, with automatic recognition of patterns such as fire as well as solutions to collect data from monitoring systems (weather stations, seismic sensors, etc.).

2.3.4.2. Third parties involved

2.3.4.2.1. Athena Research and Innovation Center (Athena RIC)

Third parties involved:

Third parties involved:
Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted) Y
If yes, please describe and justify the tasks to be subcontracted

Athena will subcontract 1000 euro for the video production (relevant task 6.1).

Does the participant envisage that part of its work is performed by linked third parties N
If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party

Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement) N
If yes, please describe the third party and their contributions

2.3.4.2.2. Democritus University of Thrace (DUTH)

No third parties involved.

2.3.4.2.3. University College London (UCL)

No third parties involved.

2.3.4.2.4. The Chancellor, Masters and Scholars of the University of Cambridge (UCAM)

No third parties involved.

2.3.4.2.5. COPELABS—COFAC (COPELABS)

Third parties involved:

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted) N
If yes, please describe and justify the tasks to be subcontracted

Does the participant envisage that part of its work is performed by linked third parties N
If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party

Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement) Y
If yes, please describe the third party and their contributions

The COPELABS research center is a non-profit private association funded by 5 members, 3 of which represent COFAC, the management entity of University Lusofona, where COPELABS is associated. Since the creation of the research lab the personnel from COFAC are seconded to COPELABS. COFAC hires all of the staff and then seconds/temporarily places it in COPELABS, under a certain project. The agreement signed by the COPELABS researchers stipulates COFAC as the employer, being the researcher associated to a specific project, such as UMOBILE.

The protocol between COFAC and COPELABS covers a period until 2020 (as COPELABS has been established as a unit until 2020). All the seconded personnel work in COPELABS premises (a building outside the university main campus). Based on this agreement, COPELABS have to pay COFAC for the time that the personnel dedicate to COPELABS. For this COPELABS performs monthly payments to COFAC referent to the researchers associated to running projects, such as UMOBILE.

Personnel costs (196.000€, 49 personmonths) are paid by COFAC. Other direct costs and indirect costs are paid by COPELABS.

This is considered as an in kind contribution against payment.

2.3.4.2.6. Fundacion TECNALIA Research & Innovation (TECNALIA)

No third parties involved.

2.3.4.2.7. TEKEVER Autonomous Systems (TEKEVER)

No third parties involved.

2.3.4.2.8. SenceptionLda (SENCEPTION)

No third parties involved.

2.3.4.2.9.FON Technology S.L. (FON Technology)

Third parties involved:
Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted) N
If yes, please describe and justify the tasks to be subcontracted

Does the participant envisage that part of its work is performed by linked third parties Y
If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party

Fon Labs SL (PIC: 952920338) is an affiliated company to Fon Technology SL. according to the definition see Article 2.1(2) Rules for Participation. Both companies are under the same direct control of Fon Wireless Ltd. Fon Labs SL will be mainly providing support to Fon Technology S.L. at those activities primarily technical. Those mainly include tasks on WP2 and WP5 at a lesser extend.

Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement) N
If yes, please describe the third party and their contributions

2.3.4.2.10. AFA Systems srl (AFA)

No third parties involved.

2.3.5. Planned use of resources

The total cost for UMOBILE project will be **3.013.043,75€** and the EU requested contribution is **3.010.742€.**

UMOBILE plans a total of **465 person months for 3 years,** which is equivalent of approximately 12 engineers and scientists working full time for the project. The consortium provides well over 20 trained and experienced professionals directly working on the project and is a mix of academia (UCAM, DUTH, UCL), SMEs (TEKEVER, SENCEPTION, FON Technology, AFA) and research institutes (ATHENA, COPELABS, TECNALIA).

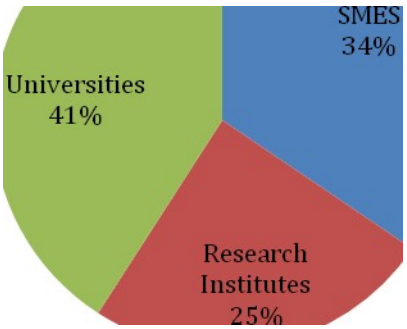


Fig. 6. Distribution of budget per organisation type

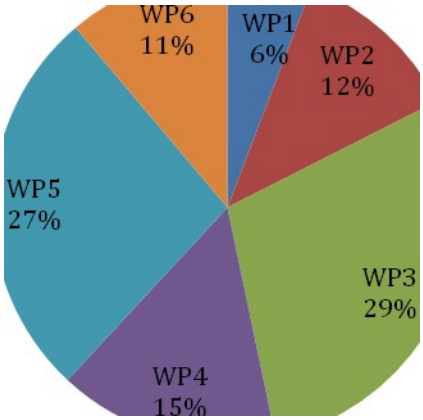


Fig. 7. Distribution of effort per WP

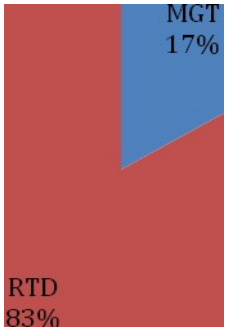


Fig. 8. Management Personnel effort VS RTD Personnel effort

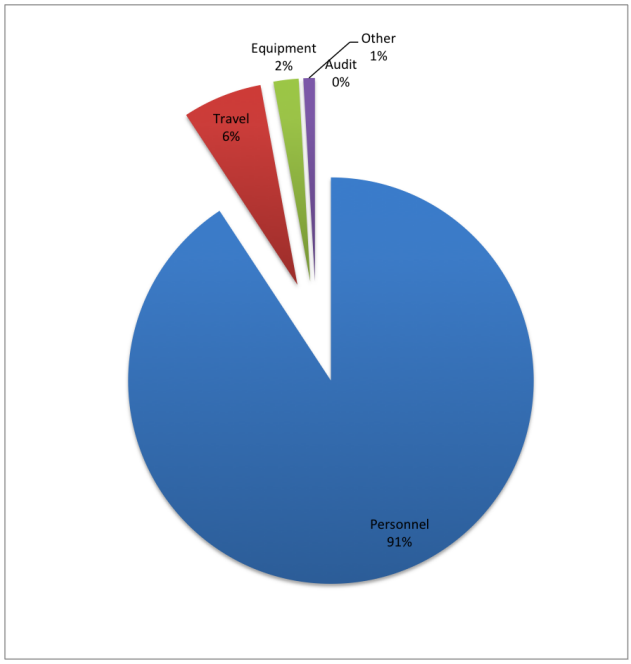


Fig. 9. Categories of costs in UMOBILE

Regarding **personnel costs**, a total of 465person months through the whole duration of the project is estimated to be adequate for the implementation of the project. The staff effort of the consortium is distributed in all Work Packages, ensuring that the workload is appropriately divided based on the objectives that are needed to realize the overall goal of the project. RTD activities cover the 83% of the total person months whereas management and dissemination activities (WP1 and WP6) cover the 17% of total person months.
The RTD other direct costs are described below:

TRAVEL
A substantial share of communication during the project will be done with the help of different communication channels (e.g., Skype, WebEx) and monthly teleconference meetings will be organised. At least five formal project meetings will also be held and participation in review meetings has also been foreseen. All partners have been assigned a travel budget sufficient to attend these project meetings (approximately 1500€/meeting/partner). Travel costs for the presentation of scientific and technical results in conferences and workshops, including the corresponding fees, and the participation in the deployment trials have also been foreseen.

EQUIPMENT

	Cost (€)	**Equipment Details**
ATHENA	2000	DTN nodes (Smartphones, Access Points, Mobile devices)
DUTH	1848	DTN nodes

COPELABS	2000	Mobile devices for experiments
TECNALIA	2000	Networking equipment
SENCEPTION	2000	Mobile devices for experiments
TEKEVER	5000	UAVs
FON Technology	2661	Networking and platform equipment
AFA	30000	Cameras, base stations, nodes controller, hand held devices

OTHER: The cost of the project website has been included in the budget of AFA. Up to 9.000€ have been allocated to ATHENA in order to organise the final workshop (including the travel cost of 1-2 invited speakers, room and equipment renting, publication costs, leaflets etc.). Budget has been assigned to UCAM and UCL for the submission of a certificate of financial statements.

Other direct costs for partner AFA are almost 15% of their total budget. This is justified by the fact that AFA has allocated 30.000€ for equipment, as explained in the Table above, and 15.000€ for travel costs in order to attend project meetings, review meetings and conferences.

SUBCONTRACTING: 1.000€ have been allocated to ATHENA for the production of the *project scenario video* described under task 6.1.

The allocation of these resources to tasks is performed in a manner that is appropriate for the required effort to achieve the milestones.

2.3.6. Ethics and security

2.3.6.1. Ethics

The gathering of user data in Task 2.1, as well as the participation of humans in Task 5.4, raise some issues regarding participant consent, personal data collection and processing or tracking or observation of participants.
In most experiments, participants will be asked to carry out an experimental task while being observed, or while their responses are being measured. It is of paramount importance that participants are treated with dignity and respect. Consortium partners will inform themselves about participants' rights and then disclose these rights to the participants. Among those rights:

- The right to stop participating in the experiment, possibly without giving a reason.
- The right to obtain further information about the purpose and the outcomes of the experiment.
- The right to have their data anonymised.

This list is not exhaustive.

The details on the procedures and the criteria that will be used to identify and recruit research participants will be identified during WP2 and prior to the start of the relevant experiments. No children, adults that are unable to give informed consent or vulnerable individuals/groups will be involved in the project.

It is often the case that people being asked to use new technologies while under observation find the experience stressful. We will reassure participants that our objective is to identify possible faults in the technology, and not to test the participants' own ability or intelligence. If they have trouble completing an experimental task, we will reassure them further, emphasising that they have had this experience because the technology is inadequate, and that it is not a reflection on their own ability. Experimenters will never offer any comment with regard to participants' intelligence, aptitude, or other factors that might give people the impression that a scientific judgment of their ability has been performed.

It is very important for participants to understand that their participation in the experiment is completely voluntary. In order to ensure that they understand this, consortium partners will prepare a 'consent form', stating the nature of the experiment and the rights of the participant. Before the start of the experiment, participants should be asked to read this form, and sign it to indicate that they have read and understood their rights.

We will assure participants that no personal data is collected, or if it is collected, that it will not be published, and will be destroyed. Tracking of persons is not envisaged. These things can be mentioned in a consent form.

If a participant appears to be experiencing any stress (for example due to task difficulty, or perhaps through factors unrelated to the experiment), partners will remind them that they are free to withdraw at any time.

If a participant is experiencing physical pain (e.g. because of extensive use of the mouse for the task) then we will abort the experiment immediately and consult a senior colleague for advice on whether to proceed with the experimental procedure.

For the purposes of experimental control, every participant should be given the same instructions before they commence the experimental task. Briefing instructions are normally written out in full, in order to ensure that this is done. The instructions can either be read from a script by the experimenter, or given to the participant to read, after which they are asked if they have understood everything, and are ready to start. If an experimenter script is used, it is a good idea for this to include all instructions and actions that the experimenter must carry out throughout the experimental session. This script should be tested during the experimental pilot, and helps gain maximum value from the pilot as a 'debugging' session for the main experimental procedure.

At the end of an experimental session, participants will be debriefed. Debriefing involves a short interview, often semi-structured, with some prepared questions that you ask every participant, and follow-up questions in the event that interesting points are raised. This provides a valuable data collection opportunity, especially as participants' subjective experience of the experiment could be of value in interpreting either their individual performance, or behaviour observed more broadly across the sample group. We will also discuss our experimental hypothesis with participants, because they might well be able to warn us of potential problems with task validity, from their perception of the task. Debriefing also provides an opportunity for the participant to reflect on the experience they have had. We aim to complete the debriefing interview by asking whether there is anything else the participant would like to tell us.

We plan to compensate participants for their time, although compensation need not be financial. People may be very willing to participate in experiments from which they gain interesting feedback, or experiments that are intrinsically enjoyable (for example games). If the participant has incurred direct costs such as travel these will be reimbursed.

If a participant chooses to withdraw, or not to complete the experiment, they will still be compensated. Experiments in which incentive payments are varied according to task performance are considered to be unethical. All data on human behaviour will be kept secure, and will be distributed only to known individuals as consistent with the terms on which the data was obtained (i.e., data like this should never be placed on websites, or distributed to mailing lists). Personal data will be kept secure. Data that would allow a participant to be identified should be kept in a separate place throughout the research project, with an anonymised code used during analysis work and at publication time. It is good practice to destroy any personal data after a stated period of time. In most cases, experimental data is used only by the person conducting the experiment.

All procedures regarding data collection, storage, protection, retention and destruction and confirmation will comply with national and EU legislation.

Data that is not anonymised, or could be used to identify specific classes of people, requires special precautions. We will consult system administrators to ensure that storage locations on machines and servers are appropriately secure against access by anyone other than the researcher needing to use this data. Data that is not anonymised should not be stored outside the partner premises, on personal laptops, or carried on removable media, without encryption. (There are several options by which data files can be securely encrypted before copying to such devices). Remember that many applications may create working files or other disk traces from which data could be recovered. In the case of very sensitive information, physical destruction of disk drives and other media at the end of the project may be appropriate.

If at all possible, we will arrange that data is provided to us in an anonymised format. Anonymised data should not include names, addresses, email addresses, or date of birth. It should not be possible to combine anonymised data with other data in a way that would make the subjects identifiable, for example by combining office numbers with a university directory, or student registration codes with exam entries. There are sophisticated statistical inference attack techniques that can be used to 'de-anonymise' data.

A designated individual or management body for ethical issues does not exist in the management structure of the co-ordinator. However, project partners, such as the University of Cambridge, can provide such feedback. If an individual or management body with sufficient relevant expertise does not exist in the management structure of a member of the consortium that can undertake this task, an external advisor will be employed. The periodic reports will include a section on ethical issues.

Finally, as far as the exploitation of SPICE DTN testbed is concerned, SPICE DTN testbed belongs to the participating research group from the Democritus University of Thrace and the project co-ordinator is also the director of Space Internetworking Center and, in essence, SPICE DTN testbed. Access to SPICE DTN testbed will be provided and all existing data are publicly available.

All participants in the UMOBILE project will conform to the legislation and regulations in force in the countries where the research will be carried out as well the EC Ethical Legislation, where the most relevant rules to the project are:
● The Charter of Fundamental Rights of the EU.
● Council Directive 83/570/EEC of 26 October 1983 amending Directives 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to processing of personal data and on the free movement of such data.

Moreover, UMOBILE partners are firmly committed to adopt the appropriate levels of ethical sensitivity, will consider issues of insurance, incidental findings and are ready to leave the study if they arise. UMOBILE partners will avoid the unnecessary collection and use of personal data and consider issues of informed consent for data falling in that category.

Since UMOBILE project addresses research areas that are “gender-neutral”, that is they are not addressing solely the needs of men or women, or the needs of both but in an unbalanced manner, no gender issues are identified. However, the consortium will ensure that gender issues, if arising, will be properly and justly addressed and further ensure gender equality during the entire project lifecycle. Similarly, the consortium is committed to ensure that no discrimination takes place during UMOBILE project, in terms of race or sexual orientation.
Regarding employment policies of the partners, all partners are committed to ensure equal employment rights for female and male applicants for the normal operation of the UMOBILE project. All advertisements for new research posts will specify our commitment to equal opportunities, with applications from women and men equally welcome, and selection based on merit and the potential of individuals. All partners are committed to ensuring that the staff that is recruited and trained is treated solely on the basis of their relevant merits and abilities. When we have the ability to choose between otherwise equally able candidates, we will consider gender balance in our selection criteria.

The partners in this project will:
- Encourage women to apply for research positions,
- Ensure that equal opportunities will be promoted in recruitment at all levels,
- Enable women researchers to participate in all project activities,
- Encourage women to participate in the management and scientific committees and
- Ensure, as far as possible, that women will be equally represented on interview panels.

The attraction of female applicants will be ensured by extended dissemination of working positions to women scientist forums and organisations. Special attention will be paid to working conditions (flexibility) to enable women to participate in research.

2.3.6.2. Security

Please indicate if your project will involve:

- Activities or results raising security issues: NO
- 'EU-classified information' as background or results: NO

References

[AHL08] B. Ahlgren, M. D'Ambrosio, C. Dannewitz, M. Marchisio, I. Marsh, B. Ohlman, K. Pentikousis, R. Rembarz, O. Strandberg, V. Vercellone. Design Considerations for a Network of Information. In ReArch'08: Re-Architecting the Internet, Madrid, Spain, Dec. 9, 2008.
[ANA08] A. Anand and et al. Packet caches on routers: the implications of universal redundant traffic elimination. In ACM SIGCOMM, pages 219–230, 2008.
[ARI10] S. Arianfar, P. Nikander, and J. Ott. On content-centric router design and implications. In ReArch Workshop, volume 9, page 5. ACM, 2010.
[BAG11]Bagrow, J. P., Wang, D., Barabási, A.-L. Collective Response of Human Populations to Large-Scale Emergencies. PLoS One 6:3, 1-8 (2011).
[BAL07] ArunaBalasubramanian, Yun Zhou, W. Bruce Croft, Brian Neil Levine, ArunaVenkataramani: Web Search from a Bus. ACM CHANTS workshop, 2007.
[BER11] Berni, A.; Merani, D.; Potter, J.; Been, R.;, "Heterogeneous System Framework For Underwater Networking", IEEE Military Communications Conference 2011, pp. 2050-2056, 8-11 Nov. 2011.
[BRO06]Brockmann, D., Hufnagel, L. and Geisel, T. The scaling laws of human travel. Nature 439, 462–465 (2006).
[BYT10]http://sourceforge.net/projects/bytewalla3/ Communication System Design. Android application version 3 of the project bytewalla, 2010.
[CAB08]Cabero J.M., Unibaso G., Sanchez A., Arizaga I. The Bluetooth Medallion: a wearable device for human MANETs. 3rd International Symposium on Wireless Pervasive Computing. ISBN: 9781424416523, 776-780. (2008).
[CAE06] M. Caesar, T. Condie, J. Kannan, K. Lakshminarayanan, and I. Stoica. 2006. ROFL: routing on flat labels. In *Proceedings of* SIGCOMM '06
[CER07]V. Cerf, S. Burleigh, A. Hooke, L. Torgerson, R. Durst, K. Scott, K. Fall, and H. Weiss, "Delay- tolerant networking architecture", IETF, RFC 4838, Apr. 2007, Available: http://www.ietf.org/rfc/rfc4838.txt.
[CHA11] W. K. Chai, N. Wang, I. Psaras, G. Pavlou and et al. Curling: Content-ubiquitous resolution and delivery infrastructure for next-generation services. IEEE Communications Magazine, 49(3):112–120, 2011.
[CHA12] W. K. Chai, D. He, I. Psaras, and G. Pavlou. Cache 'Less for More' in Information-centric Networks. In Proc. of IFIP Networking, 2012.
[CHE11] J. Chen, M. Arumaithurai, L. Jiao, X. Fu, K. K. Ramakrishnan, COPSS: An Efficient Content Oriented Publish/Subscribe System, ACM/IEEE Symposium on Architectures for Networking and Communications Systems (ANCS 2011), Brooklyn, NY, USA, Oct. 2011.
[CUG01] G. Cugola, E. Di Nitto, and A. Fuggetta, "The JEDI event-based infrastructure and its application to the development of the OPSS WFMS," in IEEE Trans. On Software Engineering, vol. 27, pp. 827-850, Sept. 2001.
[DAN10] C. Dannewitz, J. Golic, B. Ohlman, and B. Ahlgren, "Secure Naming for a Network of Information," IEEE Conference on Computer Communications (INFOCOM) Workshops, 2010.
[DAV12] E. Davies A. Lindgren, A. Doria and S. Grasic. Probabilistic routing protocol for intermittently connected networks. Active Internet-Draft, May 2012.
[DON09] L. Dong, H. Liu, Y. Zhang, S. Paul, and D. Raychaudhuri, "On the Cache-and-Forward Network Architecture," IEEE International Conference on Communications, ICC '09, June 2009.
[DTN2]DTN2, Delay Tolerant Networking Reference Implementation, available at: http://sourceforge.net/project/showfiles.php?group_id=101657.
[EAG06] Eagle, N. and Pentland, A. Reality mining: sensing complex social systems. Personal and Ubiquitous Computing 10: 255–268 (2006).
[EAG09] Eagle, N. and Pentland, A. Eigenbehaviours: identifying structure in routine. Behavioral Ecology and Sociobiology, 63:1057–1066 (2009).
[EBE02]Ebel, H., Davidsen, J. &Bornholdt, S. Dynamics of social networks. Complexity 8, 24–27 (2002).
[EST08] C. Esteve, F. Verdi, and M. Magalhaes, Towards a new generation of informationoriented Internetworking architectures. In ReArch'08: Re-Architecting the Internet, Madrid, Spain, Dec. 9, 2008.
[FLO11] JörgOtt, EsaHyytiä, PasiLassila, JussiKangasharju, SougataSantra: Floating Content for Probabilistic Information Sharing. Elsevier Personal Wireless Communications (PMC), Volume 7, Issue 6, Pages 671-689, December 2011.
[FOT11] N. Fotiou, D. Trossen, and G.C. Polyzos, "Illustrating a publish-subscribe Internet architecture", Springer Telecommunication Systems, Feb 2011.
[GHO11a] A. Ghodsi*et al.* Naming in content-oriented architectures. In ACM SIGCOMM'11 ICN Workshop, p. 1–6.
[GHO11b] A. Ghodsi*et al.* Information-centric networking: seeing the forest for the trees. HotNets-X, 2011.
[GON08] González, M. C., Hidalgo, C. A., Barabási, A.-L. Understanding individual human mobility patterns. Nature 453, 779-782 (2008).

[HUA04] Y. Huang and H. Garcia-Molina, "Publish/subscribe in a mobile environment", in Wireless Networks 10, pp. 643-652, 2004.
[HUI11] P. Hui, J. Crowcroft, E. Yoneki, "Bubble Rap: Social-Based Forwarding in Delay-Tolerant Networks", IEEE Transactions on Mobile Computing, vol. 10, no. 11, pp. 1576-1589, IEEE Educational Activities Department, November, 2011
[IBR-DTN]http://www.ibr.cs.tu-bs.de/projects/ibr-dtn/.
[INT13] Internet.org: Connecting the world from the sky, https://fbcdn-dragon-a.akamaihd.net/hphotos-ak-ash3/t39.2365-6/851574_611544752265540_1262758947_n.pdf
[JAC09] V. Jacobson, D. Smetters, J. Thornton, M. Plass, N. Briggs, R. Braynard. Networking Named Content. In ACM CoNEXT 2009, Rome, Italy, Dec. 2-4, 2009.
[JAI04] Sushant Jain, Kevin Fall and Rabin Patra, ―Routing in a Delay Tolerant Network‖, SIGCOMM'04, Aug. 30–Sept. 3, 2004, Portland, Oregon, USA.
[JOK09] P. Jokela, A. Zahemszky, C. Esteve, S. Arianfar, and P. Nikander, LIPSIN: Line Speed Publish/Subscribe Inter-Networking. In ACM SIGCOMM'09, Barcelona, Spain, Aug. 17-21, 2009.
[KAT10] K. Katsaros, G. Xylomenos, and G. C. Polyzos: "MultiCache: An overlay architecture for information-centric networking", Computer Networks, Elsevier, Volume 55, Issue 4, Pages 936-947, March 2011.
[KIT00] Kitamura, R., Chen, C., Pendyala, R. M. and Narayaran, R. Micro-simulation of daily activity-travel patterns for travel demand forecasting. Transportation 27, 25–51 (2000).
[KOP07] T. Koponen, M. Chawla, B.G. Chun, A. Ermolinskiy, Kye Hyun Kim, S. Shenker, I. Stoica: "A data-oriented (and beyond) network architecture", Proc. of ACM SIGCOMM 2007, August 27-31, Kyoto, Japan
[KPO13] TeemuKärkkäinen, JörgOtt, MikkoPitkänen: Applications in Delay-Tolerant and Opportunistic Networks. Book chapter in Stefano Basagni, Marco Conti, Silvia Giordano, Ivan Stojmenovic (eds): Mobile Ad Hoc Networking: The Cutting Edge Directions. John Wiley & Sons, Inc., ISBN 978-1-118-08278-2, 2013.
[KPO2012] TeemuKärkkäinen, MikkoPitkänen, JörgOtt: SCAMPI Application Platform. Demo paper. ACM MobiCom workshop on Challenged Networks (CHANTS), August 2012.
[KUT12] D. Kutcher S. Farrell, A. Lynch and A. Lindgren. Bundle protocol query extension block. Active Internet-Draft, May 2012.
[LAG10a] D. Lagutin, K. Visala, and S. Tarkoma, "Valencia FIA book 2010 Publish/Subscribe for Internet: PSIRP Perspective", IOS Press, 2010.
[LOON] Project LOON, http://www.google.com/loon/
[MEI10] M. Meisel, V. Pappas, L. Zhang, Ad Hoc Networking via Named Data, MobiArch 2010.
[MER11] Merani, D.; Berni, A.; Potter, J.; Martins, R.; , "An Underwater Convergence Layer for Disruption Tolerant Networking," , IEEE Baltic Congress on Future Internet Communications (BCFIC Riga), pp.103-108, 16-18 Feb. 2011.
[MOR12] Moreira, W., Mendes, P., and Sargento, S. "Opportunistic Routing Based on Daily Routines". In: Proceedings of IEEE WoWMoM AOC, San Francisco, USA, June, 2012.
[MOR13] Moreira, W., Mendes, P., and Sargento, S.. "Social-aware Opportunistic Routing Protocol based on User's Interactions and Interests". In: Proceedings of AdHocNets, Barcelona, Spain, October, 2013
[MTI10] A. Mtibaa, M. May, C. Diot, M. Ammar, "Peoplerank: Social Opportunistic Forwarding", in: Proceedings of IEEE INFOCOM, San Diego, USA, March, 2010
[N4C] Networking for Communications Challenged Communities: Architecture, Test Beds and Innovative Alliances, http://www.n4c.eu.
[NDN11] L. Zhang and et al, "Named data networking (ndn) project," Technical report NDN-0001, Xerox Palo Alto Research Center-PARC, 2010.
[OHL09] B. Ohlman (ed.). First NetInf architecture description. 4WARD project deliverable D-6.1. FP7-ICT-2007-1-216041-4WARD / D-6.1. 2009.
[ONE07]Onnela, J-P, Saramäki, J., Hyvönen, J., Szabó, G., de Menezes, M. A., Kaski, K., Barabási, A-L and Kertész, J. Analysis of a large-scale weighted network of one-to-one human communication. New Journal of Physics, volume 9 (2007).
[PAL07]Palla, G., Barabási, A.-L., Vicsek, T. Quantifying social group evolution. Nature 446:7136, 664-667 (2007).
[PER11] D. Perino and M. Varvello. A reality check for content centric networking. In ACM SIGCOMM ICN Workshop, pages 44–49, 2011.
[PIT10] MikkoPitkänen, TeemuKärkkäinen, and JörgOtt: Opportunistic Web Access via WLAN Hotspots. 8th Annual IEEE International Conference on Pervasive Computing and Communications (PerCom), Mannheim, Germany, March 2010
[PSA11] I. Psaras, R. G. Clegg, R. Landa, W. K. Chai, and G. Pavlou. Modelling and Evaluation of CCN-Caching Trees. In Proc. of IFIP NETWORKING, 2011.

[PSA12] I. Psaras, W. K. Chai, and G. Pavlou. Probabilistic In-Network Caching for Information-Centric Networks. In Proc. of ACM SIGCOMM ICN Workshop 2012.
[PSA14] I. Psaras, L. Saino, M. Arumaithurai, K.K. Ramakrishnan and G. Pavlou, "Name-Based Replication Priorities in Disaster Cases", IEEE INFOCOM NOM Workshop, May 2014
[RAJ10] J. Rajahalme, M. Särelä, K. Visala, and J. Riihijärvi, "On name-based inter-domain routing", Computer Networks Journal: Special Issue on Architectures and Protocols for the Future Internet, 2010.
[SAI11] SAIL Project: Web site, 2011. Available at: http://www.sail-project.eu/
[SAI14] L. Saino, I. Psaras and G. Pavlou, Icarus: a Caching Simulator for Information Centric Networking (ICN), in Proc. of the 7th International ICST Conference on Simulation Tools and Techniques (SIMUTOOLS'14), Lisbon, Portugal, March 2014
[SCO06] Scott, J., Crowcroft, J., Hui, P., Diot, C. *Haggle: a Networking Architecture Designed Around Mobile Users*. Proceedings of Third Annual Conference on Wireless On-demand Network Systems and Services (WONS). France (2006).
[SCO07]K. Scott, S. Burleigh, "Bundle Protocol Specification", IETF RFC 5050, experimental, November 2007, http://www.ietf.org/rfc/rfc5050.txt.
[SIN04] Shan Sinha, Srikanth Kandula, Dina Katabi, Harnessing TCP's Burstiness with Flowlet Switching, In HotNets-III, 2004.
[SNC02] AvriDoria, Maria Uden, Durga Prasad Pandey: Providing connectivity to the Saami nomadic community. Development by Design (dyd), 2002.
[SON10a] Song, C., Koren, T., Wang, P., Barabási, A-L. Modelling the scaling properties of human mobility. Nature Physics (Advanced Online Publications) 7, 713- (2010)
[SON10b] Song, C., Qu, Z., Blumm, N., Barabási, A.-L. Limits of Predictability in Human Mobility. Science 327, 1018-1021 (2010).
[SZA06]Szabó, G. and Barabási, A-L. Network effects in service usage. Physics, subject: Physics and Society (2006).
[TYS13] G. Tyson, N. Sastry, R. Cuevas, and et al, "A survey of mobility in information-centric networks," Commun. ACM 2013, pp. 90–98.
[URT14] I. Urteaga F. Liberal J. M. Cabero, V. Molina and J. L. Martin. Acquisition of human traces with bluetooth technology: Challenges and proposals. Ad Hoc Networks, January 2014.
[VAH00]Vahdat, A. and Becker, D. "Epidemic routing for partially connected ad hoc networks". Tech. Rep. CS-200006, Duke University, 2000.
[VAS12] X. Vasilakos, V. A. Siris, G. C. Polyzos, and M. Pomonis. Proactive Selective Neighbor Caching for Enhancing Mobility Support in Information-Centric Networks. In Proc. of ACM SIGCOMM ICN. Helsinki, Finland. August 2012.
[VIS09] K. Visala, D. Lagutin, and S. Tarkoma, "LANES: An Inter-Domain Data-Oriented Routing Architecture", ReArch'09, ACM, pp. 55-60. 2009.
[WAN11] L. Wang and et al, "Rapid traffic information dissemination using named data," in Proceedings of NOM '12, pp. 7–12.
[WAN12] J. Wang, R. Wakikawa, and L. Zhang, "Dmnd: Collecting data from mobiles using named data," in IEEE VNC 2010, 2010, pp. 49–56.
[ZHU10] Y. Zhu, M. Chen, and A. Nakao, "CONIC: Content-Oriented Network with Indexed Caching," INFOCOM IEEE Conference on Computer Communications Workshops , 2010, vol., no., pp.1-6, 15-19 Mar. 2010.
[ZHU11] Z. Zhu, S. Wang, X. Yang, V. Jacobson, and L. Zhang. ACT: Audio Conference Tool Over Named Data Networks. In Proc. of ACM SIGCOMM ICN. Toronto (Canada). August 2011