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Abbreviations and Acronyms

CCSDS	Consultative Committee for Space Data Systems
DTN	Delay Tolerant Networking
FP7	7th Framework Programme
ICN	Information-Centric Networking
IRTF	Internet Research Task Force
NetInf	Network of Information

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Executive Summary

Background: This Report is written in the framework of Task 1.4 "Coordination of External Liaison" of UMOBILE project and contains UMOBILE relations with relevant EU funded and national projects, organizations and standardization bodies. It explains how UMOBILE will use other projects results and establish synergies.

Objectives: The ultimate objective of UMOBILE is to advance networking technologies and architectures towards the conception and realization of Future Internet. In particular, UMOBILE extends Internet (i) functionally – by combining ICN and DTN technologies within a new architecture -, (ii) geographically – by allowing for internetworking on demand over remote and isolated areas – and (iii) socially – by allowing low-cost access to users but also free user-to-user networking. Along these lines, the goal of the present report is to provide a collaborative context for UMOBILE. In particular, we exploit the research and application context of relevant projects, aiming at a twofold target: to clarify the distinct objectives of UMOBILE and couple its ideas with complementary ideas of other projects. Hence, we seek to strengthen our results by widening the applicability and synergistic activities. We discuss the complementarity of context-aware networking projects and information-centric networking and highlight the relevance of architectural and application-oriented approaches that have already been funded or are currently underway. Within the UMOBILE project, we will contact the majority of the discussed projects and, whenever possible, we will get feedback on the research and deployment aspects of the UMOBILE project, as well as exploit the project outcome.

Results and implications: Liaison planning and maximization of liaison impact to the project.

It must also be noticed that this report expresses only the authors' views - the European Commission is not liable for any use that may be made of the information contained therein.

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1 Introduction

This report is divided into seven sections: Section 1 describes UMOBILE Project and liaison targets with other projects and bodies. Section 2 presents related projects funded by FP7 and Horizon 2020, whereas Section 3 presents related national and other projects. Relevant organization and standardization bodies to UMOBILE can be found in Section 4. Liaison planning with local authorities is analysed in Section 5.

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2 UMOBILE Project

Project Description: Cars, sensors, home appliances, every device in the daily life of citizens is becoming a constituent in Future Internet, adding to the need to reconsider requirements and assumptions in terms of network availability and affordability to support the ever increasing traffic demand. Still, the current Internet can only evolve adequately, if its infrastructure can be devised to accommodate the emerging services. The increased cost of adding new infrastructure and capacity has a drastic effect on rural and remote communities as well as nomadic users as they become marginalized by not gaining access to crucial Internet services. UMOBILE goal is to make the Future Internet universally pervasive supporting a diverse set of services.

To achieve this, UMOBILE consortium will develop a universal mobile-centric and opportunistic communications architecture (UMOBILE), which integrates the principles of Delay Tolerant Networking (DTN) and Information Centric Networking (ICN) in a common framework.

UMOBILE team will utilize the benefits of both ICN and DTN to enable resource exploitation at minimal bandwidth, opportunistic access to information and more localized access to information through novel caching strategies.

UMOBILE project focuses on assisting users in getting access to the content they want or content that may be of shared interest to their trust circles. By relying on an instance of the UMOBILE architecture, users are able to share information directly with other peers without relying on infrastructure or expensive connectivity services. The proposed architecture targets the mobile part of the networks, extends Internet connectivity to regions that are not typically covered enhancing network resilience and is fully backward compatible with the current Internet architecture. UMOBILE consortium will validate the architecture in a real world trial as well as participate strategically in carefully planned dissemination, standardization and exploitation activities to ensure that our architecture transcends from the lab to real world deployments.

Liaison Targets: Many worldwide organizations and projects, as well as various activities and standardisation groups propose and advance networking technologies and architectures towards the conception and realization of Future Internet. Along these lines, the goal of UMOBILE project is to contribute to the advancement of Future Internet in a collaborative way.

UMOBILE will build on the results from past projects and cooperate with relevant current projects. Liaisons will not be limited to European projects, but also international companies and projects, as well as various national initiatives that complement the scope of UMOBILE in the various Member States.

Liaison methods: To this end, UMOBILE partners will contact the involved parties of every relevant group and collaborate towards the maximization of effort gain and exploitation of results, within the Future Internet context. They will contact colleagues from the relative projects and/or authorities within different venues and meetings, or communicate via email to ask for specific feedback or discuss relative aspects of the projects.

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3 Related projects funded by the European Union

3.1 Projects funded by the 7th Framework programme

3.1.1 GreenICN: Architecture and Application for Green Information-Centric Networking

Project description: "*Information Centric Networking (ICN) is a new paradigm where the network provides users with named content, instead of communication channels between hosts. Research on ICN is at an early stage, with many key issues still open, including naming, routing, resource control, security, privacy and a migration path from the current Internet. Also missing for efficient information dissemination is seamless support of content-based publish/subscribe. Further, and importantly, current proposals do not sufficiently address energy efficiency. GreenICN* [1] *aims to bridge this gap, addressing how the ICN network and devices can operate in a highly scalable and energy-efficient way.*
The project exploited the designed infrastructure to support two exemplary application scenarios:
1) The aftermath of a disaster e.g., hurricane or tsunami, when energy and communication resources are at a premium and it is critical to efficiently distribute disaster notification and critical rescue information. Key to this is the ability to exploit fragmented networks with only intermittent connectivity;
2) Scalable, efficient pub/sub video delivery, a key requirement in both normal and disaster situations.
GreenICN also exposed 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. GreenICN team, comprising researchers with diverse expertise, system and network equipment manufacturers, device vendors, a startup, and mobile telecommunications operators, is very well positioned to design, prototype and deploy GreenICN technology, and validate usability and performance of real-world GreenICN applications, contributing to create a new, low-energy, Information-Centric Internet."

How it fits with UMOBILE: The ICN architecture that will be exploited and enhanced in UMOBILE, is partly based on the work performed in the GreenICN project. Furthermore, both projects operate in the presence of intermittence, and study scenarios that have a common context, the disaster management situation.

Differences: The main focus of GreenICN is energy efficiency in the Future Internet. The project looks to establish an energy-focused architecture, based on Information-Centric Networking principles. This is in contrast to the focus of UMOBILE, where although energy-efficiency is a main target, given the mobility aspects we will be investigating, our main focus in UMOBILE is the integration of ICN and DTN principles in a universal architecture. Furthermore, GreenICN uses CCN/NDN as the baseline architecture, something that is also in contrast to the focus of UMOBILE.

Possible liaison activities: We will get feedback from GreenICN partners in the technical and architectural details of the ICN architecture establishment, as well as the methods used

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to tackle intermittence. We will also collaborate on the emergency scenario, attempting to provide an enhanced solution that covers a larger perspective of disaster situations.

The common partner between UMOBILE and GreenICN is UCL.

GreenICN: Architecture and Application for Green Information-Centric Networking	
Project website:	http://www.greenicn.org
Funded by:	EU-JAPAN initiative by the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement №608518 and NICT under Contract No 167, April 2013 – March 2016
Contact Point:	Ioannis Psaras (UCL)

3.1.2 COMET: Content Mediator Architecture for Content-Aware Networks

Project description: *"In recent years there has been a growing proliferation of user-generated Internet content. This increasing trend has led to an abundance of intermediaries (e.g. YouTube, Flickr, BitTorrent, etc.) which is expected to grow in the future with massive live content generation (e.g. TV channels, SopCast, etc.) The problem is that, currently users need to know the content location a priori and content has to be typically searched through the relevant intermediary. As a result, a lot of content tends to be accessible only by particular user communities.*

The COntent Mediator architecture for content-aware nETworks (COMET) [2] *will take a unified approach to content location, access and distribution, irrespectively of the intermediary used. COMET will introduce a global naming scheme and will optimise both content source selection and distribution, by mapping the content to the appropriate network resources based on transmission requirements, user preferences, and network state. Content and network-aware mapping will consider current, evolutionary and revolutionary network approaches. The architecture will address two key aspects:*

a) Global content naming and addressing, with supporting infrastructure for search and content name resolution to the relevant identifiers required for access, and
b) Unified access and user-, content- and network-aware distribution by mapping the content onto the appropriate network resources through supporting infrastructure, providing content- and network-aware access to every type of content through all possible types of distribution.

The COMET content plane aims at becoming a global QoS-aware unified content access mechanism, essentially a content-wrapper around the Internet that shields the user from access details. The COMET project will identify relevant requirements, draw a complete architecture, research and specify required mechanisms, build prototypes, conduct validating experiments, and demonstrate the COMET content plane operation."

How it fits with UMOBILE: UMOBILE architecture may leverage the content naming and addressing proposed in COMET, and also include the caching strategies introduced there, in the framework of UMOBILE architecture.

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Differences: The COMET project designed an evolutionary architecture towards an Information-Centric Networking architecture. The evolutionary aspects integrated in the COMET architecture have been integrated mainly at the control plane. This is in contrast to the focus of the UMOBILE architecture, where we will be looking to integrate ICN and DTN principles at the forwarding plane of the architecture. Throughout the duration of the project, we will be looking to conceptually compare the benefits and drawbacks of the two approaches, that is, integrating ICN principles in the control plane, as opposed to the forwarding/data plane.

Possible liaison activities: UMOBILE will get feedback on the content strategies and exploit the will exploit the work done in COMET, in the context of, as well as caching strategies, for the deployed architecture deployment.

The common partner between UMOBILE and COMET is UCL.

COMET: Content Mediator Architecture for Content-Aware Networks	
Project website:	http://www.comet-project.org
Funded by:	the Seventh Framework Programme Theme (ICT-2009.1.5)
Contact Point:	Ioannis Psaras (UCL)

3.1.3 COSMOS (part of EU FP7 CONFINE)

Project description: "*The CONFINE project* [3] *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.*

Universal access to Internet is crucial. There have been several initiatives to enable wider access to the Internet. The Public Access WiFi Service (PAWS) is one such initiative that enables free Internet access to all and is based on Lowest Cost Denominator Networking (LCDNet) – a set of network techniques that enable users to share their home broadband network with the public. LCDNet makes use of a portion of the available unused capacity in home broadband networks and allows Less-than-Best Effort (LBE) access to these resources. The PAWS testbed is currently under deployment in a deprived community in Nottingham with a further planned deployment in rural Scotland.

However, PAWS has faced ongoing deployment challenges such as limited coverage and most importantly due to home user sharing patterns. The underlying problem with PAWS or any crowdshared network (such as FON) is that they serve as single point of access to users within the coverage of the wireless router and hence have no provision to extend the coverage or to provide any redundancy during unavailability of the routers. A potential solution to these problems would be to extend the PAWS network as a crowdshared mesh network where home broadband users share part of their own broadband connection to the public for free while such home routers are also connected to each other as a wireless mesh providing extended coverage as well as offering redundant paths to the Internet backhaul.

Extending PAWS to a crowd-shared mesh network departs from the norm: multiple users from different network operators/ISPs form part of the mesh network to provide free Internet

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connectivity while most wireless community mesh networks today are run by a single provider (either a network operator or an organization). This raises important questions: Who would be responsible for setting up, managing, resolving serious issues/tussles in such networks? What are the benefits or incentives for the various network operators to be involved as part of a community crowd-shared mesh network?

With the advent of Software Defined Networking (SDN), there are more opportunities for network operators to deploy and manage in large scale such open public wireless networks and to resolve the above mentioned tussles. The COSMOS project aims to investigate experimentally the feasibility and any potential benefits of work techniques that enable users to share their home broadband network with the public. LCDNet makes use of a portion of the available unused capacity in home broadband networks and allows Less-than-Best Effort (LBE) access to these resources."

How it fits with UMOBILE: The socio-economic aspect is common in both UMOBILE and COSMOS where users have incentive to share the WiFi connectivity through the community wireless mesh network. This aspect will also support the localised communication in order to minimise the bandwidth utilisation at the backhaul as well as to serve local services when connectivity is disrupted.

Differences: The COSMOS project aims to develop the feasible solution that enable users to share the Internet access within the community. However, the UMOBILE project also introduces the service migration technology where the service can be migrated and cached locally when Internet connectivity is available.

Possible liaison activities: UMOBILE will exploit the feasibility study of COSMOS on the potential benefit of resource sharing, and will accordingly enhance its social inclusion.

COSMOS (part of EU FP7 CONFINE)	
Project website:	http://wiki.confine-project.eu/experiments:opencall2
Funded by:	Seventh Framework Programme
Contact Point:	Arjuna Sathiaseelan (UCAM)

3.1.4 User Centric Networking

Project description: *"This project introduces the concept of User Centric Networking (UCN)* [4]*, which is a new paradigm leveraging user information at large to deliver novel content recommendation systems and content delivery frameworks. UCN recommendation and content delivery systems will leverage in-depth knowledge about users to help them find relevant content, identify nearby network resources and plan how to deliver the actual content to the appropriate device at the desired time. These systems will additionally account for influences from users' social networks on their content consumption. The goal of this project is to design a UCN system architecture for user-centric connected media services."*

How it fits with UMOBILE: UMOBILE and UCN aim to leverage user information to design recommendation and content delivery systems basis on user context. This includes better

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knowledge about user's interests and social interaction. The concept of Personal Information Hub (PIH) proposed by UCN introduces a logical repository for data collection. These common aspects would serve as valuable effort for the UMOBILE, project especially the developed services in mico-blogging and social routine improvement use case scenarios.

Differences: UCN project considers particularly to personal data that contains very sensitive information about individual user. For this reason, the most challenge constraint of the UCN is privacy issue. In contrast, UMOBILE aims to exploit the benefit of sharing and exchanging data in terms of social interaction to enhance the routine activities of users

Possible liaison activities: UMOBILE will exploit some core ideas about social aspect introduced in the UCN project for the development of UMOBILE services. UMOBILE partners will receive feedback for connected and social media use cases evaluated in UCN.

User Centric Networking	
Project website:	http://usercentricnetworking.eu
Funded by:	Seventh Framework Programme, grant agreement number 611001
Contact Point:	Jon Crowcroft (UCAM)

3.1.5 4WARD – Architecture and design for the future Internet

Project description: "*4WARD* [5] *aimed to increase the competitiveness of the European networking industry and to improve the quality of life for European citizens by creating a family of dependable and interoperable networks providing direct and ubiquitous access to information. These future wireless and wireline networks will be designed to be readily adaptable to current and future needs, at acceptable cost. 4WARD's goal was to make the development of networks and networked applications faster and easier, leading to both more advanced and more affordable communication services."*

How it fits with UMOBILE: Both 4WARD and UMOBILE projects work on innovative architectures with complementary elements towards a more direct access to information. 4WARD introduced the NetInf (Network of Information) approach for ICN, which shares the essential concepts with the ICN approach to be used in UMOBILE. Also the Node architecture design from 4WARD would serve for a valuable inspiration in the definition of UMOBILE node and system specification.

Differences: 4WARD aimed at the design of a family of architectures that enabled heterogeneous networks to emerge and coexist with previous deployments, so as to serve with quality current and future needs of demanding new services over the Internet. The scope of 4WARD was vast and less concrete than UMOBILE. UMOBILE highlights the mobility aspect of accessing a network in a seamless way, and aims at defining a UMOBILE architecture that primarily comprises the DTN and ICN paradigms within.

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Possible liaison activities: UMOBILE will exploit some core ideas introduced in the 4WARD project, in particular for the design of the node and ICN architectures and the interoperability of different networking strategies.

4WARD – Architecture and design for the future Internet	
Project website:	http://www.4ward-project.eu/
Funded by:	Seventh Framework Programme, grant agreement number 216041
Contact Point:	Henrik Abramowicz, henrik.abramowicz@ericsson.com

3.1.6 SAIL – Scalable and Adaptive Internet soLutions

Project description: "*Leading telecommunication operators, vendors, and research institutions collaborated in a strong, industry-led consortium to develop the Networks of the Future. A consortium of 25 operators, vendors and research institutions started on August 1st, 2010, the large EU-funded research project SAIL (Scalable & Adaptive Internet soLutions)* [6] *aiming at designing architectures for the Networks of the Future, as part of the European Commission's 7th Framework Program. Today's Internet rests on a foundation of technology, needs and visions that emerged 40 years ago. Since then, the purpose of Internet has changed profoundly. SAIL proposed to evolve the current network to better fit tomorrow's needs. The general perspective taken in the project concerning the end-user was that applications and content that he/she is using from the network should follow him/her when moving, ensuring that will always be responsive no matter how far he/she is from home or the office.*

SAIL both designed technologies for the Networks of the Future and developed techniques to transition from today's networks to such future concepts. SAIL leveraged state-of-the-art architectures and technologies, extended them as needed, and integrated them. SAIL used experimentally-driven research, building prototypes that proofed the advantages in concrete use cases. The project aimed at designing technology that takes advantage of the fact that information and applications are mobile, and can be found in many places in the network."

How it fits with UMOBILE: SAIL project includes in its core a specific Work package for the NetInf ICN approach, and is influenced also from DTN; these two networking elements comprise the core UMOBILE architecture.

Differences: SAIL looked at Networks of the Future through three main pillars: cloud networking, network of information and open connectivity services. Unlike SAIL, UMOBILE intends to derive a universal architecture, based on: mobility, opportunistic networking and information centric networking. The inspiration on how to derive network integration and ICN basis is clear, but also the dissimilar approaches will make more value of the outcome.

Possible liaison activities: UMOBILE partners will get feedback from SAIL partners on the integration of the different networking concepts into a single architecture and collaborate with them in standardization discussions for ICN.

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SAIL – Scalable and Adaptive Internet soLutions	
Project website:	http://www.sail-project.eu/
Funded by:	Seventh Framework Programme
Contact Point:	Thomas Edwall, Ericsson

3.1.7 PURSUIT Project

Project description: *"Imagine a system that is designed around the ability to adapt its appearance under the changing social needs and concerns of its actors! In other words, imagine a system that is designed to work in ways similar to how societies themselves work.*

Within PURSUIT [7]*, we contribute to this larger vision by focussing on changing the routing and forwarding fabric of the global internetwork so as to operate entirely based on the notion of information (associated with a notion of labels to operate the fabric on) and its surrounding concerns, explicitly defining the scope of the information. While we do not embed the higher level semantics of information into the network, we intend to devise means that will enable the higher levels to embed concerns and social structures surrounding this information deeply within the architecture. This will be reflected by selected work items in our project such as forwarding and rendezvous."*

The common partner between UMOBILE and PURSUIT is UCAM.

How it fits with UMOBILE: PURSUIT and UMOBILE focus on the ICN paradigm for shaping the Future Internet architecture. UMOBILE will inherit some principles of PURSUIT such as name-based routing/resolution schemes that allow clients to discover (cached) copies of content, thereby returning the object in the efficient manner. The initial efforts from PURSUIT would be very valuable inspiration for the design of Service Centric Networking architecture, namely SCANDEX [8].

Differences: UMOBILE also targets to the challenged network environment where connectivity is intermittent or disrupted (e.g., rural and emergency areas). With that unstable condition, a request to the services hosted in a location where no end-to-end path exists would simply fail. Therefore, the UMOBILE highlights this constrain and applies the principle of DTN to support disruption and discontinuity in end-to-end paths. However, PURSUIT is still underlined with the well-established connection between end-to-end path.

Possible liaison activities: UMOBILE partners may exploit the outcome of PURSUIT to design the ICN elements of the UMOBILE architecture in a more efficient way.

The performance of UMOBILE can be evaluated and compared.

PURSUIT Project	
Project website:	http://www.fp7-pursuit.eu/
Funded by:	Seventh Framework Programme
Contact Point:	Dirk Trossen, Interdigital

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3.1.8 ULOOP User-provided Local Loop

Project Description: "*The flexibility inherent to wireless technologies is giving rise to new types of access networks and allowing the Internet to expand in a user-centric way. This is particularly relevant if one considers that wireless technologies such as Wireless Fidelity (Wi-Fi) currently complement Internet access broadband technologies, forming the last hop to the end-user. This fact becomes even more significant due to the dense deployment of Wi-Fi Access Points that is nowadays common in urban environments. Due to such density, a relevant aspect that can be worked upon is leveraging such "wireless local-loop" by developing networking mechanisms that allow adequate resource management and a future Internet architecture to scale in an autonomic way. Such wireless local-loop could then reach rates closer to the ones provided by current broadband access technologies. This is the underlying idea of ULOOP* [9], *which shall provide software functionality to sustain a user-centric robust, secure, and autonomic network growth. ULOOP objectives are two-fold. Firstly, to develop and to validate identified core mechanisms that aid in the development of user-centric robust, trustworthy, low-cost, and indirectly energy-efficient wireless local-loops. Secondly, to bring awareness to the topic of user-centric networking from a standardisation and legislation perspective."*

How it fits with UMOBILE: ULOOP focused on developing software-defined approaches to optimize the design of the MAC and IP Layers of the OSI stack in a way that would allow wireless hotspots and wireless communities to form autonomously in a user-centric way. Aspects worked concerned an optimized software approach to the MAC layer to improve resource management (interference mitigation; fairness in shared Internet access); integrating trust management aspects that would allow to tackle aspects such as non-repudiation or social trust computation, to lower the need for strong security; relying on network coordination of mobility anchor points, together with prediction of movement in mobile devices to improve the mobility management, reducing CAPEX

Differences: ULOOP has been focused on making the network layers more user-centric thus being focused on taking advantage of opportunistic communication, while UMOBILE is focused on the smooth design of an architecture that integrates principles of ICN and opportunistic networking.

Possible liaison activities: The computational aspects of social trust computation developed and validated as well as implemented in ULOOP are expected to be a starting point for the development of opportunistic communication based on social trust circles, in UMOBILE.

ULOOP User-provided Local Loop	
Project website:	http://www.uloop.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 645124

Funded by:	FP7
Contact Point:	Rute Sofia (Scientific coordinator) (rute.sofia@ulusofona.pt)

3.2 Projects funded by the Horizon 2020 programme

3.2.1 POINT: iP Over IcN– the betTer IP

Project Description: "*The goal of POINT (iP Over IcN– the betTer IP)* [10] *is to develop technology, innovations, and business value chains for commercially viable IP-over-ICN deployment, based on the hypothesis that many current IP-based applications can run 'better' on an ICN-based network than on current IP networks. To achieve this, POINT consortium will first define a set of Key Performance Indicators (KPIs) to specify what exactly 'better' means. Then, will specify a communication platform based on the ICN prototype developed in FP7 PURSUIT and develop a set of abstractions to enable current IP, TCP, HTTP and CoAP based applications to run on our platform, complemented by new resource coordination mechanisms to improve the performance of the network.*

Point project will implement the platform as an operational prototype and validate it against the KPIs in a testbed as well as run a real world field trial in an operator's production network with real customers. Will openly publish its design and all relevant data needed to deploy and improve our prototype, which in turn will be released as open source code. Point team will also undertake a wide range of dissemination activities to establish POINT as a key driver in the ICN community.

The POINT platform will provide new business opportunities for systems vendors, operators and service providers, including SMEs and we will evaluate the commercial viability of their solution and develop migration scenarios for operators wishing to deploy ICN in production networks."

How it fits with UMOBILE: POINT and UMOBILE share a set of similar technologies for evolving the future Internet, with ICN being at the core of both projects.

Differences: POINT targets the infrastructure networks whereas UMOBILE additionally focuses on local, infrastructure-less future communications, such as micro-blogging and disaster scenarios. Thus, UMOBILE attempts to cover possible situations with communication disruptions and infrastructure failure.

Possible liaison activities: The two projects will discuss in future EC H2020 meetings and exchange views and directions of the related research, within the H2020 research goals. Furthermore, the ICN partners of the two projects will collaborate in ICNRG meetings, and coordinate their efforts for future deployments of ICN architectures.

POINT: iP Over IcN– the betTer IP	
Project website:	https://www.point-h2020.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 645124

Funded by:	European Union's Horizon 2020 research and innovation programme
Contact Point:	Dirk Trossen, Interdigital

3.2.2 RIFE

Project Description: "*RIFE* [11] *addresses the major societal challenge of providing affordable Internet access to those who cannot afford it by solving the technological challenge to increase the efficiency of the underlying transport networks and the involved architectures and protocols. The RIFE solution will harness unused transmission capacity, combined with placing content caches and service functionality closer to the user and will use heterogeneous transmission opportunities that range from localized mesh and home networks over well-connected ISP backhauls to scarce satellite resources. RIFE will build upon recent advances on information-centric and delay-tolerant networking by developing optimized dissemination strategies for the involved transport networks, unified within a novel communication architecture that will provide clear abstractions to application developers. RIFE team will develop, deploy and showcase our solution in a real-life setting within a large-scale community network in Spain, demonstrating the technology and economic opportunities that the RIFE platform provides. Will complement their real-life testbeds with emulation scenarios to enable the evaluation of our novel resource management schemes at scale, while integrating with our prototype platform. On the economic side, RIFE consortium will develop business opportunities for local authorities as well as backhaul network providers to create a sustainable value chain by introducing virtual network operators that utilize the under-used capacity in a new business relationship with local customers, enabling novel and often socially-driven business models. The involvement of a technology, equipment, as well as satellite and community network provider will allow for maximizing the commercial exploitation of RIFE within real deployments and towards standard communities within the IETF/IRTF and beyond, placing RIFE in the centre of a growing community of practitioners that all share the same goal: making the Internet affordable to everybody!*"

How it fits with UMOBILE: From the architecture point of view, both UMOBILE and RIFE aim to develop the platform that integrate the ICN and DTN together. These two platforms enable resource exploitation at minimal bandwidth and provide opportunistic access to localised information. Another line of commonality of RIFE and UMOBILE is related to the caching algorithm, both projects are targeting to push the localised content at the edge where the desired content will be available, even the connectivity is intermittent. The objective of this caching algorithm is to capture information contexts, such as kind of content, transaction or query, location of users, and leverage them for context-aware prediction and improved prefetching effectiveness in the storage cache at the gateway or wireless router.

Differences: RIFE is more focused on the content which is referred to the piece of information such as video files, photos, audio files and web pages. On the other hand, UMOBILE focused more on the services which combine both piece of information and computation. Underlining with the visualized technologies like container and unikernel, UMOBILE aims to develop the service migration where the service instances are entirely

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mobile and cacheable. This will enable the local services providing at the network edge without the need of well established connection.

Possible liaison activities: UMOBILE partner (UCAM) will work closely with the RIFE project in terms of research and development. Many cooperations will be envisaged, these will include the technical discussions as well as joint publications between two projects. In addition, UCAM also exploits the log data from Guifi network, a large-scale community network in Spain to study the user behaviour and design the contextual caching algorithm.

RIFE	
Project website:	http://rife-project.eu/
Funded by:	European Union's Horizon 2020 research and innovation programme
Contact Point:	Arjuna Sathiaseelan (UCAM)

3.2.3 From Bilbao to Oslo, intermodal mobility solutions and interfaces for people and goods, supported by an innovative communication network- BONVOYAGE

Project Description: *"BONVOYAGE* [12] *will design, develop and test a platform optimizing multimodal door-to-door transport of passengers and goods. The platform integrates travel information, planning and ticketing services, by automatically analysing non-real-time data from heterogeneous databases (on road, railway and urban transport systems); real-time measured data (traffic, weather forecasts); user profiles; user feedback.*

The platform is supported by an innovative information-centric communication network that collects and distributes all the data required. The highly heterogeneous, distributed and mobile nature of data, coming from data-centers, sensors, vehicles, goods and people on the move, calls for an innovative networking paradigm. Current networks (e.g. Internet) limit themselves to "just" providing communication channels between hosts. Our paradigm, called Internames, allows communications among entities identified by names, without the constraint of a static binding to a particular location.

The request of a "user" (be it a person or a parcel) to travel from source to destination is managed by the platform with several tools: Metadata Handler collects and elaborates data related to the request and generates a corresponding Context; User Profiler creates a personalized profile, conveying requirements including Quality of Experience parameters and special needs; Multi-Objective Optimizer develops personalized travel instructions, optimal for the Context and User Profile. The user may give feedback, before accepting the travel itinerary. If a trip is not available at request time, the user is notified if it becomes available later on. An Actuator triggers the necessary services. A Tariff Scheme Designer exploits platform data to define multi-part tariff schemes.
BONVOYAGE will trial and demonstrate the platform and communication network in integrated, large-scale, real life application scenarios, incorporated into the normal business operations of our transport operator partners."

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How it fits with UMOBILE: BONVOYAGE shares the UMOBILE concept of moving away from a host-centric Internet architecture, to an information or context-centric paradigm, with ICN supporting the architecture of both projects.

Differences: BONVOYAGE focuses on a single service for the user, i.e. the door-to-door transport of people and goods, whereas UMOBILE can extend to various services, from maps and microblogging to emergency and civil protection services.

Possible liaison activities: We will study the use cases of BONVOYAGE and search for common context, to identify any possible collaboration aspects.

BONVOYAGE	
Project website:	-
Funded by:	Horizon 2020
Contact Point:	Nicola Blefari Melazzi of Uni Roma Tor Vergata

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 645124

4 Related national & other projects

4.1 Public Access WiFi Service (PAWS)

Project description: *PAWS (Public Access WiFi Service)* [13] *is the UK national project funded by the EPSRC. The project aims to utilise unused capacity at home broadband networks and provide 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. The project extended the stakeholder value chain for incentivising Internet access deployment by including more than the two traditional parties (consumer and Internet service provider), for example, adding local government, who have a vested interest in decreasing the cost of human-centered service, and replacing these costly interactions with online services, which already prove popular with existing Internet users.*

How it fits with UMOBILE: PAWS and UMOBILE aim to tackle a crucial problem faced by inhabitants who cannot afford for the Internet access. The incentive solution where users can share the Internet access would provide a basis for the UMOBILE to develop the ICN - DTN platform aiming at optimising the capacity utilization with the lower cost solution.

Differences: The PAWS project targets to the areas where they already have the Internet access. However, the UMOBILE focused more on the challenged areas such as rural and disaster areas where there is no Internet connectivity at all or the network environment is highly unstable.

Possible liaison activities: UMOBILE partners may exploit the outcome of PAWS to design the ICN elements of the UMOBILE architecture in a more efficient way. Particularly, the access point developed by PAWS is able to form the wireless mesh network and provide the Internet sharing inside the rural community. This would be beneficial for prototyping a service execution gateway in SCANDEX architecture [8].

Public Access WiFi Service (PAWS)	
Project website:	http://publicaccesswifi.org
Funded by:	EPSRC and the Horizon Digital Economy Research Institute
Contact Point:	Prof. Jon Crowcroft (UCAM), paws@horizon.ac.uk

4.2 CitySense

Project description: "*Pervasive computing has been mostly used to build systems encompassing a small number of devices that interact with single users or small groups. As*

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technology becomes truly pervasive, low-cost sensing systems may be built and easily deployed based on diverse sensing devices, such as mobile phones, which are carried by a large number of people, as well as embedded systems that can be integrated into self-propelled sensing devices.

Recent research efforts aim to make large-scale sensing a reality by leveraging the increasing sensing capabilities found in personal devices such as cell phones. Architectural challenges include methods for opportunistic sensing, non-intrusive context extraction, inference and sharing data, as well as protecting the privacy of involved people.

Current approaches to opportunistic sensing focus on the usage of personal sensing devices, such as smart phones, to infer about individual activities. However, the major impact of large-scale sensing systems is expected to be in the inference about group, communities or swarm behaviour. For instance, the automatic recognition of the density of human gathering and the direction of movement of is relevant for many applications.

The CitySense project [14] *aims to develop a pervasive sensing system able to infer about individual behaviour (e.g. avoid social isolation, children protection), as well as collective behaviour (e.g. crowd control, detection of human swarms, urban sensing).*

CitySense is a COPELABS funded project developed by the SITI R&D group, which partners with Senception, a spin-off of COPELABS, responsible for the applicability of a set of services that can be improved to assist daily routines in the context of small, controlled trust spheres.

During CitySense's first phase (2012-2013) the project has explored the capability of smartphones to gather raw data as well as to exchange data following the most recent paradigms of data-centric networking.

On its current phase (2013-2015) the project is developing new firmware focused on non-intrusive large-scale *activity recognition, to improve specific scenarios integrating the well-being of citizens."*

How it fits with UMOBILE: CitySense aim to develop accurate systems for the inference of complex personal and group activities over a diverse set of contexts such as the ones provided by the emergency scenario and the social improvement routine scenario studied in UMOBILE. CitySense makes use of a pervasive data sharing approach that should be agnostic about the location of sensing devices and should operate even in the presence of intermittent Internet connectivity. Such pervasive data sharing approach follows a similar concept as the one UMOBILE architecture.

Differences: CitySense focuses on collecting sensorial data and inferring complex activity patterns in different contexts. For a large-scale operation Citysense relies on a pervasive data sharing system. UMOBILE on the other hand will attempt to provide a data-centric unified networking framework able to operate even in challenging scenarios data can be used for the exchange of contextual and sensorial data.

Possible liaison activities: The unified networking framework to be developed in the UMOBILE project will exploit the experience obtained by the validation of the pervasive data sharing system used in the CitySense project in similar scenarios. Moreover, the

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sensorial framework developed in the CitySense project may be exploit in the UMOBILE project in order to implement use-case that require exchange of data required to inferred individual or group activities..

The common partners between UMOBILE and CitySense are: Copelabs and Senception.

CitySense: Pervasive Sensing in Urban Scenarios	
Project website:	http://copelabs.ulusofona.pt/~citysense
Funded by:	COPELABS
Contact Point:	Paulo Mendes (Paulo.mendes@ulusofona.pt) (COPELABS)

4.3 COMIT: Content Management at Internet Scale

Project description: *"The Internet is currently passively pushing bits between end-host machines, be it servers, fixed or mobile user devices, or sensors. The network does not "understand" what is being transferred, i.e., it is not content-aware. This agnostic mode of operation affects several of its key functionalities, for example, efficient content distribution and content-aware traffic engineering. As a result, the network is not able to cope well with the exponentially increasing amounts of multimedia content access, which constitute the major mode of use in recent years. There is an urgent need to rethink traffic management under the umbrella of active content management, rather than passive content transfer, allowing ISPs to control traffic better and achieve a sustainable model for the long-term evolution of their networks.*
Recent research in the general area of Information-Centric Networks (ICN) has revealed the benefits brought by a content-focused mode of operation. Little attention, however, has been payed on the deployment incentives and the migration path from today's IP-dominated Internet architecture.
The COMIT project [15] *takes a closer look at the deployment challenges of Information-Centric Networks, focusing primarily on preserving the current Internet infrastructure, but at the same time taking advantage of the benefits of information-centricity and location-independence.*
The primary objectives of COMIT are:
Support the incremental and smooth deployment of ICN but at the same time benefit directly from all the important features of content-aware or Information-Centric Networking.
Allow ISPs to migrate to this "hybrid" ICN operation but at the same time maintain full backwards compatibility with ISPs that do not migrate and operate those ICN features."

How it fits with UMOBILE: The COMIT project looks at an evolutionary way of deploying ICN functionality in existing networks. In other words, it does not fall in the category of "clean-slate" projects. In this sense, it is very much aligned with the objectives of UMOBILE, where a similar architecture will be designed, albeit for the mobile part of the network.

Differences: The main difference of the COMIT project to UMOBILE is the focus area. That is, COMIT focuses mainly on the fixed part of the network, while UMOBILE focuses more on the mobile part of the network, including also opportunistic networks, DTN-functionality

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etc. Although this is a major difference in terms of design, there are also opportunities for cross-fertilisation of ideas in the more general area of content-oriented networking, or Information-Centric Networking.

Possible liaison activities: At the technical level, as discussed above, the architectural aspects of the two projects can be complementary to each other. At UCL, the COMIT team is composed of 3 researchers and 2 PhD students, which will be also following the developments of the UMOBILE project. We also plan to have a common plenary meeting, where the teams of the two groups can discuss on-going work and related research efforts.

The common partner(s) between UMOBILE and COMIT is UCL.

COMIT: Content Management at Internet Scale	
Project website:	
Funded by:	EPSRC
Contact Point:	Ioannis Psaras (UCL)

4.4 Project Loon of Google

Project description: *"Many of us think of the Internet as a global community. But two-thirds of the world's population does not yet have Internet access. Project Loon* [16] *is a network of balloons traveling on the edge of space, designed to connect people in rural and remote areas, help fill coverage gaps, and bring people back online after disasters.*

Project Loon balloons float in the stratosphere, twice as high as airplanes and the weather. In the stratosphere, there are many layers of wind, and each layer of wind varies in direction and speed. Loon balloons go where they're needed by rising or descending into a layer of wind blowing in the desired direction of travel. By partnering with Telecommunications companies to share cellular spectrum we've enabled people to connect to the balloon network directly from their phones and other LTE-enabled devices. The signal is then passed across the balloon network and back down to the global Internet on Earth."

How it fits with UMOBILE: Both projects study the extension of the Future Internet in disconnected environments, with little or no infrastructure at all. To this end, both projects exploit airborne communications; the use of balloons in Loon and the use of UAVs in UMOBILE provide an intermediate networking element to provide connectivity to remote, disconnected, or disaster areas.

Differences: The UMOBILE project uses UAV communications to extend connectivity geographically, with possible provision of a variety of services, while Loon project is designed to provide Internet connection to remote or disaster areas.

Possible liaison activities: As a liaison activity, we can present the outcome of the project to the Google Loon team, in the context of the service provisioning to remote and disaster areas.

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Project website:	https://www.google.com/loon/
Funded by:	Google
Contact Point:	

4.5 Project Internet.org of Facebook

Project description: "*Internet.org [17] is a partnership between social networking services company Facebook and six mobile phone companies(Samsung, Ericsson, MediaTek, Opera Software, Nokia, and Qualcomm) that plans to bring affordable access to selected Internet services to less developed countries by increasing efficiency, and facilitating the development of new business models around the provision of Internet access.*"

How it fits with UMOBILE: Both projects share the connectivity extensibility concept.

Differences: The Internet.org project attempts to interconnect less developed countries in certain geographical areas (e.g. in Africa), while UMOBILE targets also disconnected areas and people in rural and urban areas of developed countries.

Possible liaison activities: We will present at the Internet.org people the outcome of the project and receive their feedback, as well as discuss future collaborations.

Internet.org of Facebook	
Project website:	http://en.wikipedia.org/wiki/Internet.org
Funded by:	Facebook
Contact Point:	

4.6 Content Centric Networking (CCNx) Project

Project description: "*The vision of Project CCNx®* [18] *is to develop, promote, and evaluate a new approach to communication architecture we call content-centric networking. We seek to carry out this mission by creating and publishing open protocol specifications and a software reference implementation of those protocols. We provide support for a community of people interested in experimentation, research, and commercialization of this technology.*"

How does it fit with UMOBILE: UMOBILE has at its core a content-centric networking approach that is closely connected to the CCNx Project's concept. Therefore, UMOBILE can build on the CCNx architecture, further enhancing its functionality with elements that will be designed during the UMOBILE project.

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Differences: UMOBILE communication architecture aims to forward the CCNx approach with a delay-tolerant perspective, providing also a social networking aspect into the network architecture.

Possible liaison activities: Architectural discussions, exchange of expertise, and feedback on the CCNx architecture details will be made at different venues such as IETF ICNRG meetings, ICN-related conferences, etc.

CCNx Project	
Project website:	https://www.ccnx.org
Funded by:	*the Palo Alto Research Center (PARC)*
Contact Point:	Nacho Solis (nacho.solis@parc.com)

4.7 CAMION: Caching Based Mobile Social Network

Project description: "*CAMION* [19] *aims at offering cost-efficient, QoE-optimized content delivery, allowing for faster content access, as well as "offline" operation, while improving wireless network capacity and coverage.*

CAMION's approach is to design advanced content prefetching and caching techniques, exploiting social and user context information for informed content delivery decisions, while combining the capabilities of the Magic-Box technology provided by JCP with the FON wireless router platform and community network. One basic premise is that the exploitation of user and social context (based on algorithmic prediction of user behaviour and social links) will lead to optimized content delivery. CAMION will focus on studying and specifying, from a functional and architectural viewpoint, a wireless ad hoc network of Magic-Boxes, which further involves improving the interaction between the Magic-Boxes and FON entities through developing software embedded into the boxes.

The CAMION technical approach is to build on the following recent advances:
- *Improved storage capacity and communication capabilities of portable devices*
- *Information Centric Networking (ICN) architectures*
- *Community-based wireless access*
- *Availability of user and social context information*"

How it fits with UMOBILE: UMOBILE and CAMION projects have several similarities. Both projects use caching in order to predict and deliver services/contents. Moreover, they are based on ICN and provide users the possibility of continue using the services during periods of offline connectivity, since the services are locally cached and available.

Differences: The main difference is the focus area. UMOBILE is more focused on the mobile network part while CAMION objective is to offer new service to the users by developing new router-server solutions.

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Possible liaison activities: Some synergies can be delivered from cooperation in the caching of the access points (or an additional server located near to them) and the prediction of preferences of the users based on their previous information consummation.

CAMION: Caching Based Mobile Social Network	
Project website:	https://sites.google.com/a/jcp-consult.com/camion-wiki/
Funded by:	*EUROSTARS (CDTI in Spain)*
Contact Point:	Alberto Pineda (Fon)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 645124

5 Relevant organizations and standardizations bodies

5.1 CCSDS

Description: "*CCSDS* [20] *is a multi-national forum for the development of communications and data systems standards for spaceflight. Founded in 1982 by the major space agencies of the world, it is leading space communications experts from 26 nations collaborate in developing the most well-engineered space communications and data handling standards in the world. The goal? To enhance governmental and commercial interoperability and cross-support, while also reducing risk, development time and project costs. More than 700 space missions have chosen to fly with CCSDS-developed standards, and the number continues to grow".*

How it fits with UMOBILE: CCSDS focuses on the standardization of DTN elements and protocols for space data systems, while UMOBILE targets the exploitation of DTN elements for intermittent terrestrial and UAV communications. Both paradigms share the same concept of store-and-forward to tackle disruptions, and, thus, can use a similar set of protocols and solutions.

Possible liaison activities: UMOBILE project outcome, and in particular the impact of the delay-tolerant elements of the UMOBILE architecture, may be presented in the CCSDS meetings, to provide solutions that may fit into the space communications as well.

CCSDS	
Project website:	http://public.ccsds.org/
Contact Point:	tomg@aiaa.org

5.2 ICNRG

Description: *"The Information-Centric Networking Research Group (ICNRG)* [21] *is a research group within IRTF. Its main objective is to couple ongoing ICN research with solutions that are relevant for evolving the Internet at large. The research challenges for ICN include:*

- *Naming schemes for ICN, including scalable name resolution for flat names*
- *Scalable routing schemes*
- *Congestion control, QoS approaches, and caching strategies*
- *Metrics that make it possible to evaluate ICN implementations in a consistent manner*
- *Security and privacy, including scoping of information objects and access control to them*
- *Application/application-protocol design and APIs*
- *Business, legal and regulatory frameworks"*

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How it fits with UMOBILE: UMOBILE has in its core infrastructure the ICN networking paradigm, which is the main focus of ICNRG.

Possible liaison activities: We will participate in ICNRG meeting, present the advances in ICN architecture, introduced in the UMOBILE project, and receive feedback on ICN-related aspects.

ICNRG	
Project website:	http://irtf.org/icnrg
Contact Point:	Dirk Kutscher (dirk.kutscher@neclab.eu) Börje Ohlman (borje.ohlman@ericsson.com) Dave Oran (oran@cisco.com).

5.3 DTNRG Research Group

Description: *"The Delay-Tolerant Networking Research Group (DTNRG)* [22] *of IRTF is chartered to address the architectural and protocol design principles arising from the need to provide interoperable communications with and among extreme and performance-challenged environments where continuous end-to-end connectivity cannot be assumed. Examples of such environments include spacecraft, military/tactical, some forms of disaster response, underwater, and some forms of ad-hoc sensor/actuator networks.*
Among the challenges to be addressed are: large delay for transmissions resulting from either physical link properties or extended periods of network partitioning, routing capable of operating efficiently with frequently-disconnected, pre-scheduled, or opportunistic link availability, high per-link error rates making end-to-end reliability difficult, heterogeneous underlying network technologies (including non-IP-based internets), and application structure and security mechanisms capable of limiting network access prior to data transit in an environment where round-trip-times may be very large.
The group intends to build upon the extended "bundling" architecture created originally for the Interplanetary Internet. This architecture proposes an alternative to the Internet TCP/IP end-to-end model and employs hop-by-hop storage and retransmission as a transport-layer overlay. It provides a messaging service interface conceptually similar to electronic mail, but generalized for application-independence and supported by specialized reliability and routing capabilities.
The intended work products of the DTNRG include architectural descriptions (concept documents) a bundling protocol specification, and a series of one or more network-environment-specific "profile" documents. These profile documents will include descriptions of 'convergence layers' intended to adapt the overlying messaging architecture for use in specialized networking environments (space, water, sensor networks), and are expected to be created by the study teams described in the Membership section below. One study team output will be an "Internet profile" document, developed in concert with the architectural and protocol specification documents, giving suggested naming conventions and protocols to use for transport within the public Internet.

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Members of the DTNRG also intend to distribute source code of a reference implementation of the architecture and protocols developed."

How it fits with UMOBILE: UMOBILE leverages the delay-, disruption-, and disconnection-tolerance concept of the DTN architecture, in its scenarios.

Possible liaison activities: We will present in the DTNRG group advances in the DTN architecture introduced within the project, as well as various results of the projects that pertain to the DTN concept.

DTNRG	
Project website:	https://irtf.org/dtnrg
Contact Point:	Kevin Fall (kfall@acm.org) Jörg Ott (jo@netlab.tkk.fi).

5.4 Global Access to the Internet for All (GAIA) Research Group

Description: "*The Global Access to the Internet for All (GAIA)* [23] *is an IRTF initiative that aims:*
(1) to create increased visibility and interest among the wider community on the challenges and opportunities in enabling global Internet access, in terms of technology as well as the social and economic drivers for its adoption;
(2) to create a shared vision among practitioners, researchers, corporations, non governmental and governmental organisations on the challenges and opportunities;
(3) to articulate and foster collaboration among them to address the diverse Internet access and architectural challenges (including security, privacy, censorship and energy efficiency);
(4) to document and share deployment experiences and research results to the wider community through scholarly publications, white papers, presentations, workshops, Informational and Experimental RFCs;
(5) to document the costs of existing Internet Access, the breakdown of those costs (energy, manpower, licenses, bandwidth, infrastructure, transit, peering), and outline a path to achieve a 10x reduction in Internet Access costs especially in geographies and populations with low penetration.
(6) to develop a longer term perspective on the impact of GAIA research group findings on the standardisation efforts at the IETF. This could include recommendations to protocol designers and architects."

How does it fit with UMOBILE: The UMOBILE use cases involve a social extension in the access to networking services or the Internet. In this context, the scenarios' output as well as the project outcome can be of particular interest to the GAIA research group.

Possible liaison activities: We will participate in the meetings of the GAIA research group and present the outputs relevant to the group's concept.

GAIA Research Group

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Project website:	https://irtf.org/gaia
Contact Point:	Arjuna Sathiaseelan (UCAM), who is the chair of GAIA RG

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6 Liaison with local authorities

6.1 Greek authorities

DUTH has contacted the Intermediate Managing Authority of Eastern Macedonia and Thrace about the exploitation of the project results in the region. Several proposals have been made about applying the UMOBILE outcome in remote and urban areas of the regions, based on the scenarios that are being examined in the project. Further discussions and collaboration will follow during the next phases of the project.

6.2 Portuguese authorities

TEKEVER has established frequent contacts with Portuguese authorities such as NAV (Portuguese Air Traffic Controllers), INAC (Portuguese Civil Aviation Authority) and ANACOM (Portuguese Communications Authorities) which could enable an easy deployment of UAVs and other systems in the context of UMOBILE. TEKEVER closely cooperates with GNR (Portuguese National Guard) in multiple projects, namely Projecto VIANA, where TEKEVER is providing UAVs for forest fire surveillance and prevention in the Peneda Gerês National Park. This could be of interest for a UMOBILE Emergency Scenario demonstration.

6.3 Italian authorities

AFA Systems has met the National Civil Protection Department to illustrate the vision and the goals of UMOBILE project. Some hypotheses has been formulated on the possible exploitation of the project results, in order to take advantages of the novel architecture and services that will be deployed within UMOBILE.
Specifically, two different scenarios (based on the ones introduced in WP2 - task 2.1 and comprehensively defined in D.2.1) has been investigated during the meeting: the "Emergency Situation Scenario", mainly in remote-not connected-areas and the "Civil Protection Scenario", mainly in urban area.
A proposal to have a permanent demonstration session in a relevant area has been done and it will be evaluated during the next stages of the project.

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7 Sources of Information-references

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[9] http://www.uloop.eu/

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[11] http://rife-project.eu/

[12] http://cordis.europa.eu/project/rcn/193353_en.html

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[14] http://copelabs.ulusofona.pt/~citysense

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[21] http://irtf.org/icnrg

[22] https://irtf.org/dtnrg

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