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Universal, mobile-centric and opportunistic communications architecture

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Executive summary

Background: This report is written in the framework of Task 6.3 "Standardization report" of UMOBILE project. The deliverable envisions UMOBILE's main objectives in terms of standardization activities in the area of contributions and co-operation with various standardization bodies.

Objectives:
The main objectives of Work Package 6 are to cover the contributions of UMOBILE project in terms of dissemination, standardization, and exploitation of results. In the context of standardization, it is foreseen to consider i) standardization bodies; ii) technological platforms; iii) interexchange with other projects.

UMOBILE aims 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 as well as to promote user-centric networking in all its aspects.

The UMOBILE project has identified a set of relevant standardization bodies, mostly focused on the ICN, DTN and global Internet fields, that will be monitored to guarantee the alignment of the UMOBILE solution with the latest standards and to identify potential contributions to the ongoing standardization activities.

1. Introduction

The main objective of UMOBILE is to develop a mobile-centric service oriented architecture that efficiently delivers contents/services to the end users. The UMOBILE decouples services from their origin locations, shifting the host-centric paradigm to novel incorporated aspects from both information-centric and opportunistic networking with the ultimate purpose of delivering an architecture focused on: i) improving aspects of the existing infrastructure (e.g., keeping traffic local to lower OPEX); ii) improving the social routine of Internet users via technology-mediated approaches.

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

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In this context, we envision contributions to relevant standardization bodies as well as contributes to technological platforms, and knowledge/experience exchange with other projects, as described in detail in D1.2.

2. Plan for standardization activities – Monitoring

UMOBILE targets to play an active role in the international standardization bodies related to the area of interest to the project. The standardization activities will focus on contributing to (draft) specifications, and taking initiative in designing system and protocol aspects as applicable. As a general principle, the plan for each standardization initiative will cover the following subsequent activities:

- The project has identified the standardization bodies and specifications that could be interested/impacted by the UMOBILE research activity.
- The project focuses on liaison activities with the targeted standardization bodies in order to qualify and determine the appropriate course of action. UMOBILE partners are already in contact with the involved parties of every relevant group and collaborate towards the maximization of effort gain and exploitation of results, within the Future Internet context.
- The project follows a specific standardization plan for each impact area (i.e., research group, relevant technical area).
- UMOBILE consortium also participates in the review process, including assessment analysis and implementation of recommended outcomes from standardization bodies.
- The relevant UMOBILE standardization activities are to be disseminated through regular meeting of standardization bodies, international conferences and workshops.

The initial target standardization bodies, contributions and collaboration among partners in the key activities is presented in Table 1.

Entity	**Working Group**	**Expected Activities**	**UMOBILE Partners Involved**
IRTF	ICNRG	UMOBILE development guidelines	COPELABS, TECNALIA, UCL
	DTNRG	To provide interoperable communications with challenged environments where continuous end-to-end connectivity cannot be assumed.	ATHENA TECHNALIA
	GAIA	To develop sustainable solution and standardization for global Internet access	ATHENA, UCAM
	DINRG	To investigate open research issues in decentralizing infrastructure services	UCL

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Entity	Working Group	Expected Activities	UMOBILE Partners Involved
CCSDS		Dissemination of relevant outcomes on DTN	ATHENA
NetWorld2020		Technical discussion platform. Strong contribution platform, in the form of input to white papers addressing different aspects of networking technology.	Senception
WiFi Alliance		Deployment aspects; specification contributions	Senception

Table 1. UMOBILE initial mapping of the standardization entities and the involved partners.

3. Standard contributions

Several project partners are actively participating in various standardization bodies such as the Consultative Committee for Space Data Systems (CCSDS), NetWorld 2020, WiFi Alliance (WFA) and the Internet Engineering Task Force (IETF) as well as the Internet Research Task Force (IRTF). Within UMOBILE, we focus on novelty of the design architecture involved in many stages of research and development. Therefore, we believe that direct submission of results to IETF will not be fruitful due to the objectives and strategies of the project. However, IETF also maintains research branches such as IRTF, that is more open to innovations in communication architecture. Candidates for focused contributions are current efforts in the IRTF to position DTN and ICN as exploitable technologies. With both communities being somewhat disjoint at this point, the UMOBILE objectives in joining ICN with DTN concepts can directly influence the communities' thinking in both areas. We plan, for instance, to actively contribute to scenario and research challenge definitions, as well as position the UMOBILE functional components as a possible approach for traversing ICN, DTN and traditional IP deployments.

UMOBILE will focus on influencing research and development activities, which is particularly sensible as the innovative technology. UMOBILE will incorporate and propose standardization elements to achieve the necessary baseline interoperability across implementations.

3.1 IRTF Information-Centric Networking Research Group (ICNRG)

The Information-Centric Networking Research Group (ICNRG) 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

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- 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

3.1.1 UMOBILE Standardization Topics – Contributions

UMOBILE expected outcomes that may be promoted in IRTF are mostly related to the ICN. A preliminary analysis of the possible contributions in ICNRG has identified a list of potential contributions, as detailed in Table 2.

Standardization Element	Type of Contribution	Partner
Solving the congestion problem using ICN	Presentations to ICNRG meetings	UCL
Resilience in disrupted Information-Centric Networks	Presentations to ICNRG meetings	UCL
Keyword-based naming scheme in ICN networks	Presentations to ICNRG meetings	UCL
Native Content Distribution through Off-Path Content Discovery: A Proposal for a Downstream FIB	Presentations to ICNRG meetings	UCL
Keyword-Based Mobile Application Sharing through Information-Centric Connectivity	Presentations to ICNRG meetings	UCL
Adapting ICN to Function Execution for Edge Computing	Presentations to ICNRG meetings	UCL
ICN Research Challenges	Internet Draft and RFC standardisation	UCL
Information-centric Routing for Opportunistic Wireless Networks	Internet Draft	COPELABS, Senception, ATHENA

Table 2. Preliminary overview of potential UMOBILE standardization topics in ICNRG

3.1.2 Standardization efforts

UCL has already participated in most of the Interim meeting of the ICRNG group during the UMOBILE project. Dr Ioannis Psaras and Dr Vasilis Sourlas have represented UCL, where they discussed the on-going work at UCL related with the UMOBILE project and got feedback from the ICNRG group members, especially on the work related with the WP3

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about the UMOBILE ICN specifications of the architecture. In the ICN meeting in Prague (July 2015), UCL presented the "Solving the congestion problem using ICN"work, about congestion and flow control, related with the WP4 Task 4.1. UCL also presented the "Resilience in disrupted Information-Centric Networks" work, related with the WP3. In the ICNRG meeting held in Tokyo (October 2015), UCL presented the naming scheme that will be used in the UMOBILE architecture (WP3), based on a keyword-based naming scheme. In Berlin (July 2016) UCL presented the work related with the "Off-path Opportunistic Content Discovery" protocol proposed in the WP3. In the ICN meeting in Prague (July 2017), UCL presented the mobile computation sharing framework, presented in WP3 and, in Berlin (September 2017) UCL presented the work "Adapting ICN to Function Execution for Edge Computing".

COPELABS has being involved participating in the discussions around named-data networking (NDN) at ICNRG, namely related to the application of NDN to multi-hop wireless networks with intermittent connectivity. Based on this, COPELABS published a draft in ICNRG called "Information-centric Routing for Opportunistic Wireless Networks" (draft-mendes-icnrg-DABBER-00)[4], done together with Senception and Athena. This draft describes the Data reAchaBility BasEd Routing (DABBER) protocol, which has been developed to extend the reached of Named Data Networking based routing approaches to opportunistic wireless networks. By "opportunistic wireless networks" it is meant multi-hop wireless networks where finding an end-to-end path between any pair of nodes at any moment in time may be a challenge. The goal of Dabber is to assist in better defining opportunities for the transmission of Interest packets towards the most suitable data source. To the best of our knowledge this is the first ICNRG draft proposing a routing approach to NDN for wireless networks.

Standardizations and Internet drafts

- Through Dr Ioannis Psaras, UCL participated in the "ICN Research Challenges Internet-Draft", which summarises the group's activities in the area and outlines the priority areas of research value. The draft has been accepted as RFC 7927: Information-Centric Networking (ICN) Research Challenges [3]
- COPELABS, Senception and Athena has submitted a draft of **Information-centric Routing for Opportunistic Wireless Networks** to ICN research group [4]. This draft focuses on routing protocol for opportunistic wireless networks, called Dabber. This draft also encompasses some aspects of the integration of ICN and DTN.

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3.2 IRTF Delay Tolerant Networking Research Group (DTNRG)

The Delay-Tolerant Networking Research Group (DTNRG) 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. Members of the DTNRG also intend to distribute source code of a reference implementation of the architecture and protocols developed.

3.2.1 UMOBILE Standardization Topics – Contributions

UMOBILE leverages the delay disruption, and disconnection-tolerance concept of the DTN architecture, in several communication scenarios described in D2.1. Below, we summarize the expected contributions of UMOBILE consortium to the DTNRG.

Standardization Element	Type of Contribution	Partner
ICN-DTN architecture	Closely follow the outcomes of DTNRG meetings, workshops and Internet Drafts.	ATHENA
Integration of ICN and DTN	Internet Draft	ATHENA, TECNALIA

Table 3. Preliminary overview of potential UMOBILE standardization topics in DTNRG

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3.2.2 Standardization efforts

The DTNRG concluded its work in early 2016. The consortium focused its efforts on ICNRG-related standardisation activities.

3.3 IRTF Global Access to the Internet for All (GAIA)

The Global Access to the Internet for All (GAIA) is an IRTF initiative that aims:

- 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.
- to create a shared vision among practitioners, researchers, corporations, non governmental and governmental organisations on the challenges and opportunities
- to articulate and foster collaboration among them to address the diverse Internet access and architectural challenges (including security, privacy, censorship and energy efficiency).
- to document and share deployment experiences and research results to the wider community through scholarly publications, white papers, presentations, workshops, Informational and Experimental RFCs.
- 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.
- to develop a longer term perspective on the impact of GAIA research group findings on the standardization efforts at the IETF. This could include recommendations to protocol designers and architects.

IRTF: Internet Research Task Force, provides a suitable venue for evangelizing the vision and the solutions of UMOBILE towards a practitioner audience in the space of global access. Specifically, the GAIA working group is a key forum for UMOBILE, also due to the fact that Dr. Arjuna Sathiaseelan is the co-chair. During the duration of UMOBILE project we increase substantially the visibility of UMOBILE through several meetings, organizing workshops and informational Internet draft.

3.3.1 UMOBILE Standardization Topics – Contributions

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.

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Standardization Element	Type of Contribution	Partner
System design for universal communication architecture	Scientific article submission	ATHENA, UCAM, UCL, COPELABS, SENCEPTION
Information – Centric Multi Access Edge Computing Platform for Community Mesh Networks	Presentations to IRTF GAIA meeting	UCAM
UMOBILE architecture	Presentations to IRTF GAIA meeting	ATHENA
Alternative solution to provide affordable Internet in the developing regions.	Presentations to IRTF GAIA meeting	UCAM
Alternative Network Deployments: Taxonomy, Characterization, Technologies, and Architectures	Internet Draft and RFC standardisation	UCAM

Table 4. Preliminary overview of potential UMOBILE standardization topics in GAIA

3.3.2 Standardization efforts

The summary of activities and outcomes for IRTF GAIA standardization can be summarized as follows:

System Design for Universal Communication Architecture

The ATHENA, UCAM, UCL, COPELABS and SENCEPTION have collaborated and published an article summarised the UMOBILE architecture to the prestigious IEEE Communication magazine which has very high impact factor (10.435). The article presents the design of a unified UMOBILE architecture which tailors the information-centric communication model to meet the requirements of opportunistic communications, integrating those connectivity approaches into a single architecture[5]. The goal of this article is to tight the integration of opportunistic and delay-tolerant communications with the core of the network, extending its reach toward universal coverage and enhancing operational reliability when the network infrastructure is unavailable or impaired.

IRTF GAIA meetings

UCAM has already organized three GAIA meetings which invited practitioners, researchers, engineers and regulators from several developing countries including Africa, Asian and South America. The first meeting was organized at Queen Mary University, London on 30 November 2015[1]. Dr. Adisorn Lertsinsrubtavee also presented the results

[1] http://dev6.acmdev.org/gaia.php

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of socio-technical study carried out in rural community network in Thailand [1] as well as the solution to improve the connectivity with UMOBILE technology. The second workshop was organized at Computer Laboratory, University of Cambridge during 26 – 27 January 2017 [2]. In this meeting, Dr. Arjuna Sathiaseelan and Dr. Adisorn Lertsinsrubtavee also discussed with other participants from several developing countries to use UMOBILE technology in their community networks. The third meeting was organized in conjunction with IETF 101[3], Hilton London Metropole, London UK on 22 March 2018. In this event, Dr. Adisorn from UCAM gave a presentation about Information – Centric Multi Access Edge Computing Platform for Community Mesh Networks[6]. The talk was related to service migration platform and its evaluation mentioned in WP3 and WP5. In addition, Dr. Sotirios Diamantopoulos from Athena Research Center also presented and disseminated the UMOBILE outcomes to the GAIA community[7]. This presentation also included the UMOBILE architecture which has published in [5].

Standardizations and Internet drat

- Through Dr. Arjuna Sathiaseelan, UCAM has participated in the Internet draft on Alternative Network Deployments: Taxonomy, Characterization, Technologies, and Architectures. Currently this draft has been accepted to be published as the RFC 7962 [2]. This standardisation proposes the alternative solutions to provide the Internet connectivity in developing regions. The draft has been developed through the extensive discussions in GAIA workshops and GAIA mailing list.

3.4 Decentralised Internet Infrastructure" research group (DINRG)

The Decentralized Internet Infrastructure Research Group (DINRG) is a research initiative aimed at investigating open research issues in decentralizing infrastructure services such as trust management, identity management, name resolution, resource/asset ownership management, and resource discovery. The focus of DINRG is on infrastructure services that can benefit from decentralization or that are difficult to realize in local, potentially connectivity-constrained networks.

While intensive there is currently intensive research and development taking place around decentralized applications, the problem of decentralized infrastructure is receiving relatively less attention, despite the research challenges in this space. Some of these challenges include:

- Scalability - what are the problems that prevent decentralized infrastructure services from achieving global scale?
- Trust management in decentralized communication settings
- Privacy and targeted, verifiable disclosure
- Applicability of distributed ledger and related technologies to different use cases and environments
- Consensus algorithms for specific scenarios with a focus on Internet infrastructure services

[2] https://www.cl.cam.ac.uk/~al773/gaiaworkshop/
[3] https://datatracker.ietf.org/meeting/agenda.html

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- The ability of constrained nodes to benefit from elements of a consensus item that they cannot process or store as a complete set
- Distributed Trust and Delegated Computing
- Economic drivers and roadblocks for decentralizing network infrastructure
- Identification of common requirements and properties of selected technologies
- Design and implementation of one or more general-purpose infrastructure systems
- Deployment and operation of one or more actual implementations

3.4.1 UMOBILE Standardization Topics – Contributions

Dr Michal Krol, on behalf of UCL, presented the work about how to decentralize computing using NDN and network functions, and also how to verify decentralized computing using smart contracts.

Standardization Element	Type of Contribution	Partner
Decentralized Computing Environments	Presentations to DINRG meetings	UCL

Table 5. Preliminary overview of potential UMOBILE standardization topics in DINRG

3.4.2 Standardization efforts

No standardization actions have been done in this research group. However, during last phase of the UMOBILE project, UCL started the visibility of UMOBILE also in this research group, participating in the periodic meetings and through presentation of related work .

3.5 The Consultative Committee for Space Data Systems (CCSDS)

The Consultative Committee for Space Data Systems (CCSDS) was formed in 1982 by the major space agencies of the world to provide a forum for discussion of common problems in the development and operation of space data systems. It is currently composed of eleven member agencies, twenty-eight observer agencies, and over 140 industrial associates.

Since its establishment, it has been actively developing recommendations for data- and information-systems standards to promote interoperability and cross support among cooperating space agencies, to enable multi-agency spaceflight collaboration (both planned and contingency) and new capabilities for future missions. Additionally, CCSDS standardization reduces the cost burden of spaceflight missions by allowing cost sharing between agencies and cost-effective commercialisation.

During the last decade, CCSDS has been actively involved in the standardization of the Delay Tolerant Networking (DTN) architecture and its corresponding Bundle Protocol (BP) for interoperable space communications.

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3.5.1 UMOBILE Standardization Topics – Contributions

The outcomes of UMOBILE, and in particular the impact of the delay-tolerant elements of the UMOBILE architecture, can be of particular interest to CCSDS, since the proposed solutions may fit into the space communications as well.

Standardization Element	Type of Contribution	Partner
UMOBILE use cases in disconnected environments	Dissemination of relevant outcomes on DTN at the CCSDS regular meetings	ATHENA

Table 6. Preliminary overview of potential UMOBILE standardization topics within CCSD

3.5.2 Standardization efforts

Early in the project course, the consortium decided to employ UAVs to assist communications in remote, disconnected environments. As a result, the support of, and research on, satellite communications were not deemed necessary by the UMOBILE partners. Furthermore, research efforts by ATHENA were not related to the DTN layer itself, which would fall within the scope of CCSDS, but rather to the integration of the DTN and ICN network architectures rather. Subsequently, ATHENA did not actively seek to perform standardization activities within CCSDS, focusing instead on ICNRG activities, and culminating in the co-authoring of the DABBER protocol specifications draft [4]

3.6 NetWorld 2020

NetWorld2020 is the European Technology Platform for communications networks and services. Communications networks enable interaction between users of various types of equipment, either mobile or fixed. The NetWorld European technology platform gathers more than 700 players of the communications networks sector including industry leaders, innovative SMEs, and leading academic institutions. The mission of NetWorld is to strengthen Europe's leadership in networking technology and services so that it best serves Europe's citizens and the European economy.

UMOBILE expects to contribute to NetWorld2020 white papers, as well as to other efforts under development in the context of ICN and Device-to-device communications. At this stage, several partners of NetWorld2020 are monitoring the opportunities for disseminating UMOBILE results. This outcome has already been provided on the white paper “Beyond 5G”.

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3.6.1 UMOBILE Standardization Topics – Contributions

Standardization Element	Type of Contribution	Partner
Beyond 5G scenarios	Dissemination of aspects concerning taking advantage of proximity, e.g. in the context of device to device communications	Senception COPELABS

Table 7. Overview of potential UMOBILE standardization topics in NetWorld 2020

3.6.2 Standardization efforts

Senception and COPELABS are regularly disseminate the aspects of UMOBILE in this group. The topics that we are interesting are the advantages of proximity, for instance the context of device to device communications.

3.7 WiFi Alliance

The WiFi Alliance is a non-profit industry association that promotes Wireless LAN technology and certifies products if they conform to certain standards of interoperability. There are several programs launched by WiFi Alliance

The relevant standard with UMOBILE is Wi-Fi CERTIFIED Wi-Fi Direct®, a certification mark for devices supporting a technology that enables Wi-Fi devices to connect directly, making it simple and convenient for pervasive communications (i.e., printing, file sharing, data synchronisation and remote display)

UMOBILE relies on Wi-Fi direct to support user-centric networking, and the project originally expected to monitor and to provide contributions to Wi-Fi Peer-to-Peer Services technical specifications in particular concerning deployment and validation aspects.

Currently, there is no contribution to be provided. A relevant aspect developed in the context of the project and which may be explored afterwards concerns the capability of Wi-Fi Direct to assist in connectionless transmission of information during the "Service Discovery" phase of the Wi-Fi Direct Group establishment. Such aspect is relevant in the context of information-centric paradigms, as devices can exchange information relevant, for instance, to perform some form of negotiation before establishing a communication channel.

Senception is incorporating this aspect – exchange of context-aware weights – in the Contextual Manager module. This allows for different nodes to exchange weights computed by the Contextual Manager (Availability weight A and Centrality Weight C) as well as to assist in the computation of similarity aspects between nodes, as described in D4.5. Senception and COPELABS are developing a report which shall be released publicly and shall be sent to the Wi-Fi alliance, alerting for limiting aspects that have been found

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out during the implementation of the Contextual Manager, and of the interface to the routing module (NDN-Opp and DABBER).

3.7.1 UMOBILE Standardization Topics – Contributions

Standardization Element	Type of Contribution	Partner
Wi-Fi Direct	Monitoring of relevant aspects concerning Wi-Fi direct issues (e.g. issues in authentication) Release of a technical report detailing limiting aspects for data exchange during the Service Discovery Phase	Senception

Table 8. Overview of potential UMOBILE standardization topics in Wi-Fi Alliance

3.7.2 Standardization efforts

- In the context of the DABBER draft (IRTF ICNRG working group), partners COPELABS, Senception, and ATHENA have proposed an extension of the current NDN routing (link state) to opportunistic environments, based on contextual-awareness (node availability and centrality)and data reachability. COPELABS has contributed with the routing proposal, while Senception is contributing with the contextual aspects, including the interfacing to routing. ATHENA has provided the support for DTN-ICN integration. The draft shall be presented in the IRTF meeting in March 2018. The draft is currently under implementation and code shall be publicly available.
- Report on limitations of Data exchange during the Wi-Fi Direct negotiation phase. Wi-Fi Direct is an interesting instantiation of Wi-Fi, in particular in what concerns services that require some form of context-awareness derived from crowd analysis. Senception has been working with Wi-Fi Direct in the context of the contributions of UMOBILE, firstly in PerSense Mobile Light, and secondly in the Contextual Manager module. Derived from such learning, Senception shall release a technical report publicly, detailing the learning achieved for data exchange in a connectionless way. This report shall be provided to the Wi-Fi Alliance as well.

4. Conclusion

This report summarises the activities of UMOBILE in terms of standardization efforts. UMOBILE consortium have been actively contributed to the research related standardizations bodies such as IRTF ICNRG, IRTF GAIA and IRTF DINRG. The outcomes of UMOBILE activities have been delivered to three Internet drafts and two RFC standardizations [2, 3]. On top of that, during the project time, UMOBILE consortium have

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also participated in many presentation/invited talks in many preeminent events like IRTF and IETF meetings. Industrial partners also participated in many leading industrial standardization bodies such as NetWorld 2020, WiFI Alliance and CCSDS. Furthermore, the core of the UMOBILE architecture has been released as open source along with some use cases that show the potential of the project concept. As a result a significant contribution to the UMOBILE architecture, the consortium has published a research article in the IEEE communication which is the leading magazine to deliver the advances in key areas of communications combing practical, current implementations, and best industry practices [5].

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