User-centric Wireless Local Loop Framework

An Initial Perspective

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This White Paper provides an initial perspective on the EU FP7 ULOOP (User-centric Wireless Local Loop) project framework [4], detailing the underlying notions and main aspects to be worked upon. It has as motivation to disseminate ULOOP concepts and to raise awareness towards user-centric wireless networks both concerning their potential from a technical, and from a business perspective.

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Introduction

Today's end-user is connected to the Internet by means of a variety of broadband access technologies that usually do not directly reach the *end-user equipment (UE)*. Rather, this final segment of the *local-loop (last mile)* is provided by a number of short-range technologies, among which *Wireless Fidelity (Wi-Fi)* is the de facto solution. The growing popularity of Wi-Fi as a complementary technology to Internet broadband access is not due to its extraordinary technical aspects. Instead, it relates to its low-cost and worldwide availability, to the ease of use, and to the high interoperability that it is capable of sustaining, when interfacing with Internet broadband access technologies. Wi-Fi extends coverage of the most varied technologies (e.g. *Fiber-to-the-Home, FTTH*, UMTS), be it in enterprise or residential scenarios, allowing *Wireless Local Area Networks (WLANs*) to abound.

Having a last-hop of the Internet based on Wi-Fi introduces problems, but also some advantages in terms of Internet evolution and Internet wholesale models. On the one hand, having Wi-Fi as the last-hop technology introduces bottlenecks particularly if one considers broadband solutions such as FTTH. Moreover, by providing a WLAN for each Internet end-user, as complement of the broadband technology, Wi-Fi deployment becomes chaotic, particularly in highly populated areas. On the other hand, Wi-Fi is a highly flexible and easy to deploy technology, and thus appeals to the regular individual Internet end-user.

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It is due to such flexibility and also to the wide deployment as last-hop (complementary) technology, that Wi-Fi (as others forms of short-range wireless technologies) is giving rise to new models of Internet connectivity, and to a new way to perceive future Internet architectures.
In these new Internet access (*Internet connectivity*) models, the end-user is one of the key pieces and ceases to simply be a consumer of Internet services (be it connectivity or content), to become an active hop of the connectivity distribution chain.
ULOOP explores concepts to allow user-centric wireless local-loops to form autonomously. The term *user-centric* in this context is meant to express a community model that extends the reach of a high debit, multi-access broadband backbone from different perspectives (technical, business model). Such a model is expected to be beneficial both from an end-to-end and from an access perspective, given that it allows expanding high debit reach in a seamless, cooperative, and low-cost manner. Second,

ULOOP has as motivation to assist an autonomic deployment of user-*centric wireless local loops*, through the development of novel, self-organizing networking concepts and functionality.

ULOOP follows an evolutionary path to reach a Future Internet architecture, by building on existing work related to the recent trend of *Do-it-Yourself Networks (DIYN)*. A fundamental difference between such work and previous contributions on ad-hoc or mesh networking relates to the fact that ULOOP assumes that an infrastructure providing Internet access to specific locations is widely available, and users are simply willing to expand such infrastructure in a way that is user-friendly and plug&play. It also considers that within trust spheres, specific cooperation incentives can be provided in order for both the access and the end-user to cooperate and assist in further expanding the Internet. In order for that to happen, ULOOP considers four main functional blocks: **cooperation incentives and trust management**; **resource management**; **mobility aspects**; **interoperability aspects.**

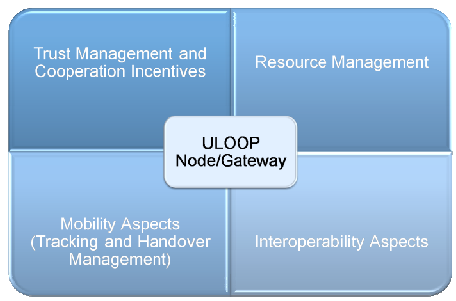
ULOOP Notions and Definitions

In ULOOP, there are two fundamental roles: *ULOOP node* and ULOOP *gateway*.

A **ULOOP node** concerns a role (software functionality) that a wireless capable device takes. Concrete examples of nodes can be specific user-equipment, access points, or even some management server.

A **ULOOP gateway** is a role (software functionality) that reflects an operational behavior making a ULOOP node capable of acting as a mediator between ULOOP systems and non-ULOOP systems – the outside world. This gateway role may or may not be owned and controlled by a ULOOP user: it may also be controlled by an access operator. The key differentiating factor of the role of gateway, in contrast to a regular ULOOP node, is the operational intelligence and mediation capability.

Similarly to ULOOP nodes, the ULOOP gateway functionality may reside in the user-equipment, in Access Points, or even in the access network. Hence, they exhibit a feature that is key in user-centric environments: their behavior as part of the network is expected to be highly variable. Gateways will be active or inactive based on several conditions such as users' wishes and network load.



Each ULOOP node has a unique owner assigned. An **owner** is an entity (end-user, operator, virtual operator) that is to be made responsible for any actions concerning his/her device. The term "responsible" reflects liability, i.e., from an operator's perspective the owner is the single responsible for the adequate/inadequate usage of the user's device within a specific, trust-bounded community.

A **community** in ULOOP is a set of ULOOP nodes that hold common interests (such as sharing connectivity or resources / peripherals) at some instant in time and space. In other words, nodes exhibit a space and time correlation that is the basis to establish a robust connectivity model. This is expected to be extrapolated by adequately modeling trust associations between nodes. We highlight that the notion of community does not have any relation whatsoever to an *Online Social Network (OSN)*, nor even to some specific OSN subset.

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An **interest** is here defined as a parameter capable of providing a measure (cost) of the "attention" of a node towards a specific location in a specific time instant. In other words, an interest is a parameter that provides a node with a measure of a specific time and space correlation. For instance, assuming that a user goes each Saturday morning to the coffee-shop on the neighborhood corner, an interest here could be "having a coffee". Other users in the same location (exhibiting a similar time and space correlation) are in the same place during an overlapping period of time. They all share an interest as they are all collocated in the same location for a specific period of time. The shared interest here is: attending the same coffee-shop. We highlight that owners may be complete strangers. Nonetheless they may be able to form a ULOOP community for a specific period of time, e.g. 2 hours every Saturday morning.

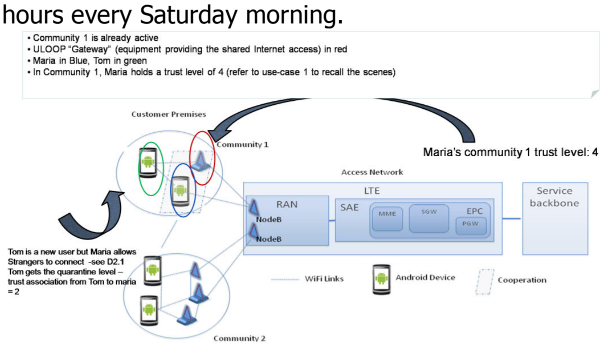


Figure 1: ULOOP communities notions applied to Use-case 1 [1], Expanded Coverage and Offloading.

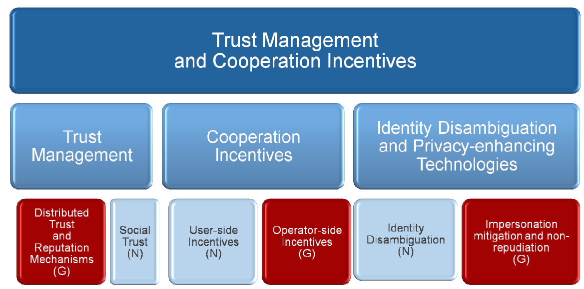
A second example for a ULOOP community relates to a set of persons that share an affiliation. Despite the shared affiliation, once they return to their households, the affiliation community, from a network perspective, is dissolved. In other words, a ULOOP community is active provided there is a time and space correlation as well as shared interests from a set of ULOOP nodes.
Figure 1 provides an illustration that backs up the described ULOOP concepts based on ULOOP Use-case 1 [1]. Two communities are present. At first only community 1 is active and the device highlighted in red has the role of a ULOOP gateway. Two users, Maria and Tom, belong to community 1. For instance Maria holds a trust level of 4 out of 5 thus justifying her as a highly cooperative user in her community.

Tom is a new user that takes advantage of the Internet access shared by Maria. Hence, when receiving Tom's request (be it directly or indirectly), Maria will put Tom into "quarantine" mode. This allows Tom to Google through Maria's device, but provides Tom with limited Internet access.

Trust Management and Cooperation Incentives

In ULOOP trust management aspects relate to understanding how to build networks of trust on-the-fly, based on reputation mechanisms able to identify end-user misbehavior and also to reward good behavior towards communities.

Trust management in ULOOP is the basis for the notions concerning self-organization and user-centricity.



Hence, the ULOOP trust management block comprises aspects that drive the modeling of communities. A first aspect addressed relates to the development of an automatic and seamless credentials/trust management token exchange ensuring that users will be able to create robust trust relations. This is to be achieved through a ***distributed trust and reputation* sub**-block which is expected to satisfy the automatic setup and update of communities; to assist users in terms of traceability and confidentiality whenever required; to be capable of defining the different levels of trust both between individuals and between communities.

Social trust is a second aspect to pursue under trust management. By maintaining trust within the social network of the ULOOP end-users, ULOOP mimics an important socio-economic aspect necessary for socio-economic sustainability. Strongly related to the development of distributed trust schemes, social trust deals with aspects such as social reputation, and OSN metrics (e.g., influence/social attractiveness, QoE). The aim is to derive trust metrics that can assist communities to evolve on-the-fly without disrupting the overall network operation. Such metrics should be attack resistant so that they can assist in establishing mutual trust relations between the different actors when combined with adequate distributed reputation architectures.

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Motivating Usage through Cooperation

Cooperation incentives in ULOOP are considered both from a specific technology perspective, as well as from a business perspective. Technical incentives may relate to natural features of the technology that result in a win-win match when cooperation is applied. Business incentives may related to micro-generation models based on the guidelines provided by WP2 (Task 2.2., Socio-economic Sustainability).

A concrete example of a technical incentive relates to potential improvements of the 802.11 MAC layer. ULOOP expects to engineer the MAC layer in a way that mitigates problems related with low data rate stations. Hence, when low data rate stations and high data rate stations cooperate, all elements are expected to take some advantage of such cooperation. While as for a business incentive, we can think of a specific peering scheme that may assist the access operators in understanding how to obtain revenue based on ULOOP architectures.

ULOOP addresses cooperation incentives both from an Internet end-user and operator perspective. ULOOP intends to explore incentives for good behavior.

As part of communities and also as individual nodes, cooperation must consider the willingness of owners/nodes in participating in communication. Willingness can be driven by different facts such as energy saving, low processing power, and/or lack of storage room. Although a node is not willing to share resources due to one of the aforementioned facts, the cooperation functionality should encourage such user in doing it so, as he/she can get an immediate return (e.g., more processing) while sharing that resource it has the most (e.g., storage). Instead of simply paying users with the same "currency", e.g., *you get more bandwidth if you give more bandwidth*, the cooperation functionality should reward involved entities with the type of resource the user wants and at the moment the user needs (i.e., immediately or later on).

Cooperation incentives contribute to the socio-economic sustainability of ULOOP: by providing cooperation incentives there are economic dynamics involved, encouraging Internet stakeholders to keep using ULOOP as they benefit from it.

The User Perspective

The lack of trust between users can influence their level of willingness and our belief is that motivation should be based on shared interests. Users sharing the same interest (e.g., movies), although being completely unknown to one another, can be easily encouraged in carrying information on behalf of others. A user interested in comedy movies surely won't mind to carry a copy of a movie destined to some other user if he/she is able to get a copy also. At this point, cooperation not only helps users disseminate information quickly and seamlessly (as the movie will reach different interested users other than the destination) as it also contributes to sparing resources from users who are not interested in that specific content.

Cooperation shall be easily encouraged if users share some social relationship. Thus, social ties have an important role in making cooperation among users even more reliable. Software functionality in ULOOP nodes is expected to track user expectations and service response. In this case, users are expected to cooperate in order to provide surrounding ULOOP nodes with information that not only can improve their own but also the other users' network experience. Users can exchange: i) SNR information, e.g., to aid in the handover process; ii) behavior information, to strictly penalize malicious/greedy users; iii) connectivity quality levels, to aid in load balancing and interference reduction.

The Provider Perspective

ULOOP will be a perfect solution for operators who are looking for higher density at limited cost, letting them to rely on created communities, in order to provide the required resources to demanding users at specific instants in time. This will offer an energy-efficient and cost optimized solution to increase density of the operators' networks.

Moreover, the subscription relation between the end-user and the access operator can be strengthened by having the access operator empowering the end-user with partial networking functionality, in a way that is completely transparent to the end-user. In other words: such cooperative model (based upon Internet service micro-generation) gives the means for the access operator to provide value-added services that are more appealing to the end-user and that go beyond regular subscriptions, common today both in the bundled and in Service Provider centric models such as the one embodied today by e.g. FON, when used in strong cooperation with access providers, give the means to access providers to offer Internet access

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subscriptions with worldwide wireless roaming included, which is a differentiating service towards competitors. ULOOP will explore new services and business opportunities, from a perspective where communities cooperate with the access.
Operators are expected to "own" and to control ULOOP nodes and/or communities.

Operator-based incentives are a highly relevant aspect in ULOOP as it is the project's belief that business-oriented entities will also benefit from the new models that ULOOP introduces.

For instance, access operators can take advantage of ULOOP capabilities to further expand its control towards the customer premises devices. Some reasons for ULOOP adoption (and hence for the relevancy of operator-based incentives) are: to provide adequate feedback to customers; to ensure an optimal network operation, where expanded coverage is also offered; to be able to deal with interference in dense areas; to provide residential areas with the same authentication/authorization model used in ULOOP coverage and thus, reduce CAPEX; to gain in reputation by supporting communities, following what is today common practice in open-source business models.

One of the central points for the successful integration of ULOOP from an operator's perspective is being able to deliver a well-designed licensing model for the technology to be produced.

An "Open Source" model with "some limitation" can favorite a win-win equilibrium between ULOOP and operator's competitiveness goals. Hence, operator's based incentives are expected to improve the potential of interoperability and of business opportunity for access and service stakeholders.

A Unique Way of Identifying Nodes

The first step towards building trust references in communities, i.e., from a ULOOP node to others, is to be able to uniquely identify owners of ULOOP nodes. Ideally, the recognition must be attack-proof. Hence the end-user must be able to authenticate her/himself. However, it is also important to protect the privacy of this end-user, so the trust management and cooperation incentives building block contains both identity management and *privacy-enhancing technologies (PETs).* To fit identity management to the distributed trust system required in the trust management block, identity management considers implementing appropriate identity management mechanisms for authentication and authorization, based on the concept of crypto-identifiers (*crypto-ids*). With such crypto-ids, the end-users can prove in a decentralized way and with cryptographic strength that they really own the secret linked to the crypto-id. Concerning privacy, creation and proof of ownership of crypto-ids does not require a centralized identity authority. Thus, end-users in ULOOP will protect their privacy through crypto-ids that they generate themselves and act as their pseudonyms not linked to their real world identity.

A second relevant aspect to be addressed relates to mitigating identity-based attacks based on novel identity disambiguation schemes, which will try to detect whether a ULOOP end-user is a fake end-user or not based, e.g., on real end-user information extracted from available real social networks.

Identity disambiguation is also dealt with by relying on OSNs, namely, information extracted from those social networks will be used to compile reputation evidence that will be in turn taken into account within ULOOP trust metrics, and heuristics.

Augmented Resource Management

As ULOOP relies on wireless infrastructures that are often deployed in an ad-hoc way, resource management optimization is a key aspect to pursuit. ULOOP has as purpose to assist in developing robust and high debit wireless local-loops in a way that meets current broadband access technologies debit as possible, and in a way that reduces the chances for bottlenecks to occur.

Throughput maximization is to be addressed across more than one hop by means of cooperative networking techniques of which one possibility is *relaying*. In regards to resource management, and to achieve a fair and self-organizing network usage, several aspects will be considered, such as the need to adequately and dynamically be able to control growth of ULOOP communities, dynamic fluctuations of the network both in terms of traffic due to stations joining and leaving frequently, as well as due to the movement of stations. Another aspect that is considered crucial is to develop cooperative and distributed mechanisms that assist the network in adequately selecting nodes that are willing to be

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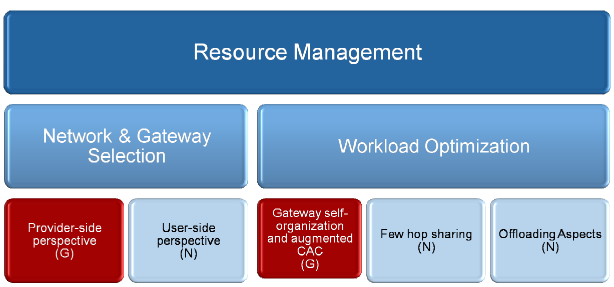
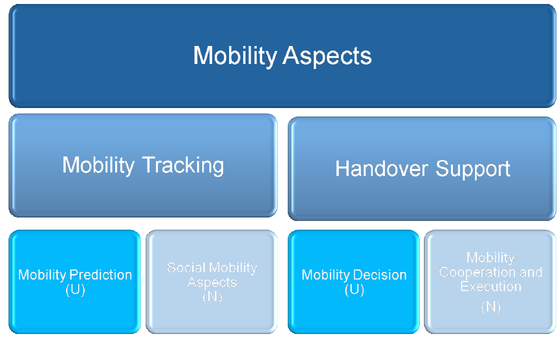
micro-providers. Such selection is to be performed in a way that considers not only throughput maximization, but also the lowest-cost in terms of energy-efficiency. This is to be performed by addressing node selection e.g. based on energy-efficient metrics.
The final aspect to tackle is congestion control. Being based on a self-organizing deployment purely related on the adoption of the technology and also cooperation incentives (as well as the willingness of users to share their subscribed Internet access), ULOOP users are expected to observe high interference and despite the fact that ULOOP will devise advanced network switching technology to assist in optimizing the wireless rates, there is still the need to optimize the network interests and the individual interests in order to achieve fairness. The user is expected to be able to cooperate based on a perceived QoE and also on individual expectations. The network will most likely provide a dissimilar resource allocation.



Dealing with and Estimating Mobility

In terms of mobility and adding to the currently available solutions, ULOOP is focused on two main aspects: mobility tracking and estimation, as well as handover support.

Ways of addressing patterns of node movement to estimate mobility patterns based on existing or novel social models is one aspect to be addressed. The purpose is to assist in improving the underlying connectivity model, and hence overall network operation.
Social mobility modeling is an aspect that shall assist in deriving algorithms and functionality that can anticipate the way nodes move based on analysis and tracking of node movement through time.



A final aspect to consider is to ensure that the functionality to be developed can assist in dealing with the unmanaged aspects of ULOOP architecture and should get rid of anchors in the network. This may be required, for instance, if a ULOOP community is not capable of providing a node with adequate mobility management e.g. due to trust aspects.

In ULOOP handover support is focused in attempting to mimic the handover operation available e.g. in cellular environments.

Being focused in Wi-Fi, the regular 250 meters range is small compared to the geographic distances that users are expected to travel in ULOOP scenarios. Hence, performing a complete handover would impose strong requirements on speed of message exchange. In ULOOP this is to be tackled by considering the regularity (routine) present in users' movement, which may assist in determining the place and type of resources that may be required to set up to assist seamless handovers. For example, based on movement analysis, the system may determine with a high probability that the user will handover towards the range of ULOOP gateway A or ULOOP gateway B. In this case specific functions may assist in defining the adequate next target, and how to handover to it. The challenge here is to identify with enough accuracy and reliability the gateways that a ULOOP node should connect to, while moving.

A Backward Compatible Solution

Interoperability in ULOOP relates with aspects essential to ensure interaction between ULOOP systems and non-ULOOP systems. This is of particular relevancy as ULOOP is expected to derive software functionality modules a resulting in an integrated software suite based on the individual modules addressed throughout Section [5].

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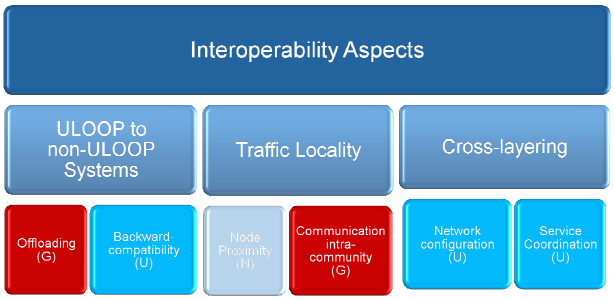
From an innovation perspective, interoperability in ULOOP deals with the following aspects: ULOOP to non-ULOOP systems interoperability; community interaction support; cross-layer aspects.



When dealing with unaware systems, i.e. systems that do not support ULOOP functionality, it is important to consider that a ULOOP device needs to be available to connect to a "legacy" network, and therefore, we must ensure proper backward-compatibility. This implies handing the interoperability aspects that deal with existing networking models and paradigms. Interoperability with legacy networks is especially important in the case where nodes roam through different types of networks, such as mobility between ULOOP and non-ULOOP networks with different technologies (e.g. Wi-Fi or Cellular architecture, 3G and beyond).

Interoperability also relates to *backward-compatibility*, i.e., assisting non-ULOOP devices to be able to participate in ULOOP communities in a regular way. Regardless of who supports the community information for the agnostic nodes, the connection, access must remain transparent (limitations can apply). Hence, when dealing with the interaction of ULOOP to non-ULOOP systems, two main aspects are to be considered: offloading and backward compatibility.

It is also important to consider how non-ULOOP nodes are able to participate in a ULOOP-enabled environment, impacting how ULOOP functionality and resources are provided to the participating nodes, as well as the overall trust management system. Therefore, by allowing legacy nodes to connect to a ULOOP supported community, the trust and resource management implications must be considered. Within these aspects, the solution greatly depends on how much interoperability is required, and at which phase should it be considered (either as design constraint or proxy/adaptation/add-on functionality). The impact on different functionalities can be substantial, depending on the type of integration/interoperability is required.

Offloading as a Mandatory Requirement

Offloading in ULOOP is addressed from the perspective that any intelligent offloading mechanism can be taken care of (also controlled) in non-ULOOP systems. An example is the guarantee that ULOOP nodes integrate capabilities that allow them to support offloading e.g. from cellular networks to Wi-Fi based networks.

Interacting in the Community

Community Interaction Support considers ways to optimize the network operation and hence network resources management based on the fact that users are normally placed in ULOOP communities. The idea is to be able to take advantage of source and destination proximity to optimize network resources, e.g., to prevent traffic from flooding the access, introducing the concepts of local-loop optimization and community interconnection. One aspect of community interaction support relates to being able to keep communication within a specific ULOOP community establishing not only connections to the outside network, but bridging the different technology local-loops. This bridging translates mostly into network information (e.g. network status, occupancy, signal-strength, etc.), but can also include peer interactions, such as two nodes communicating within the same (local) community through different access technologies (e.g. LTE and WiMAX). Such aspects can be tackled at a flow (individual) or aggregate (trunk from one community) level.

Cross Layering Aspects

Cross layer network configuration and service coordination, as a means for providing and supporting connectivity models required by the applications, as well as providing the interoperability between ULOOP services and existing networks.
From an interoperability perspective, it is important to understand how the different mechanisms (available at different levels in the network) interact, so that they can be properly aligned and integrated with the ULOOP provided functionality. An example of these issues relates to the capability of configuring link and network addresses transparently to the user, so that he can enjoy community-enabled services, without (many) additional requirements.

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Acronyms

3GPP	Third Generation Partnership Project
AAA	Authentication, Authorization, and Accounting
AP	Access Point
CAPEX	Capital Expenditures
CPE	Customer Premises Equipment
DSL	Digital Subscriber Line
FTTH	Fiber-to-the-Home
L2TP	Layer Two Tunneling Protocol
LTE	Long Term Evolution
MAN	Metropolitan Area Network
QoE	Quality of Experience
SNR	Signal-to-Noise Ratio
TTL	Time to Live
UCN	User-centric Networking
UE	User Equipment
ULOOP	User-centric Wireless Local Loop
VoIP	Voice over IP
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network

This involves several aspects of making communities work over existing networks that do not fall simply under the backward-compatibility hat, but require considering the link, connectivity and network aspects, align with the service provisioning related to the ULOOP community.
We focus on the availability of services in the network (considering different aspects such as network requirement and service discovery), on the integration between the supported technologies (such as authentication and resource management), the actual services advertised on the network, and finally on the consumption of the provided services. However, network interactions that require input from users should be minimized, creating a better user experience, without sacrificing any security or trust features.

In regards to service coordination, cross-layer cooperation will not only provides adaptive resource allocation, such as the adaptive channel assignment and spectrum management, but also select adaptively gateways for community according to QoE requirements from users and available resources measured from physical layers of users.

Conclusions

ULOOP envisions increasing the potential of the Internet by devising communication and networking technologies, which support:

- Creation of techno-social communities, providing a combination of information, communication and human elements, by relying on adequate modelling of trust associations and trust levels.
- Cost reduction for extending local loops, by relying on communication opportunities (e.g. sharing of Internet access and relaying resources) provided by end-users in cooperation with access operators.
- New services provided by communities as well as new business models for end-users and access operators (following an analysis of the expected impact on telecommunications markets and legislation).
- An increase in spectrum and energy efficiency in managing wireless communications.

References

[1] Valentin Moreno (Editor, FON Wireless Ltd.), ULOOP Consortium, *D2.1: ULOOP Use-cases*. EU FP7 IST ULOOP project (grant number 257418), March 2011.

[2] Alessandro Bogliolo (Editor, University of Urbino), ULOOP Consortium, *D2.2: ULOOP Socio-economic Sustainability Report*. EU FP7 IST ULOOP project (grant number 257418) deliverable, April 2011.

[3] Alessandro Bogliolo (Editor,University of Urbino), ULOOP Consortium, *WP03: Socio Economic and Regulatory Aspects of User-centric Wireless Local Loops*, EU FP7 IST ULOOP project (grant number 257418) white paper, September 2011.

[4] Rute Sofia (Editor, SITI/University Lusófona), ULOOP consortium. D2.3: ULOOP Overall Specification. EU IST FP7 project (grant number 257418), September 2011.

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