WILMA: An Open Lab for 802.11 HotSpots*

Extended abstract

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1 WILMA at-a-Glance

WILMA (Wireless Internet and Location Management Architecture) is an ongoing research project based in Trento, Italy, whose aim is the study of the management of 802.11–based HotSpot Networks and the value added services that can be provided through such an infrastructure.

The founding partners of WILMA [9] are ITC-Irst [10], the DIT [11] at the University of Trento, and Alpikom [12] a local telecom provider. One of the main achievements of the project is the creation of an Open Laboratory (Open Lab) where other institutions can join the experiments. For instance, an agreement with the Municipality of Trento was reached for the realization of several Hot Spots in the City buildings and historical center.

What makes WILMA different from other experimental 802.11 based services (see for instance projects like MegaBeam [13], Telia HomeRun [14] or Boingo [15]), is the stress on research, innovation and a new architectural concept. The WILMA network is based on a layered structure as shown in Fig. 1. The owners of the access points are not necessarily the content or Internet connectivity providers, indeed, they seldom are. Roaming is guaranteed throughout all the access points, independently from the infrastructure provider. The only similar ongoing project is, to the best of our knowledge, the Stockholm Open Network [16], where the service and network architecture resemble the one envisioned by WILMA, though many differences can be identified, such as, for instance, the different approach used for IP addresses management and authentication procedures.

2 Network Architecture

One of the main novelties of the project is the independence of the physical wireless infrastructure providers, the HSPs in Fig. 1, from the service and content providers, the ISPs. This is indeed one of the key issues from the point of

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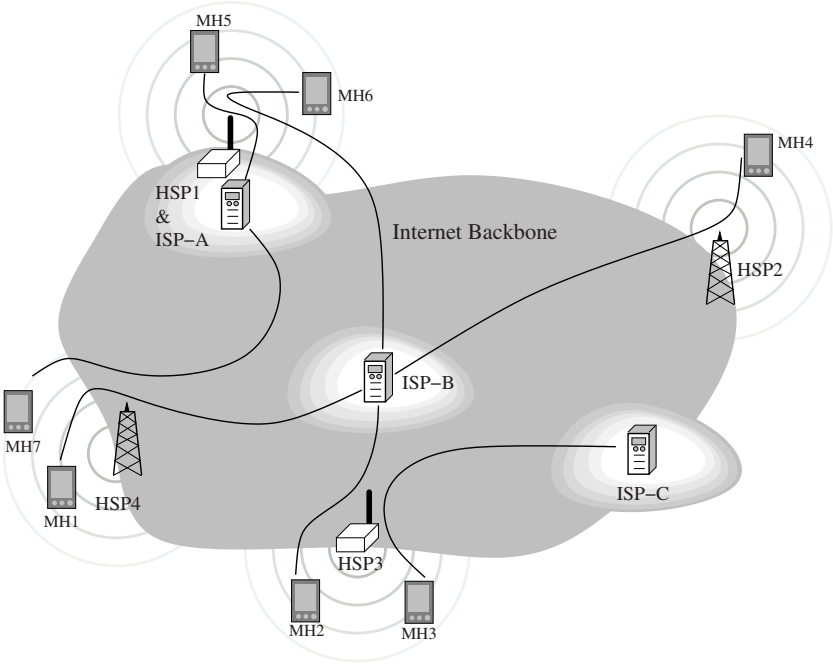

Fig. 1. Network and Service Architecture envisioned in the WILMA project

view of the network and service architecture, because it poses several new issues concerning security, privacy, AAA functions, pricing, etc.

The choice of this multi-actor infrastructure is not casual, but it is based on the deep belief that it is the only possible architecture that will ensure success to 802.11–based commercial networks. The Internet experience has shown that a clear separation between connectivity, which is technology related and can benefit from the quick pace of technology evolution, and services, which are software based and evolve with a much slower time scale, is a necessary condition for success in a competitive environment. The same Internet, on the other hand, has also shown that business without a pricing and investment strategy is not possible. The hundred and more years of telephony, fixed and mobile, teach the other part of the story: Pricing and planning strategies pays off, but service–specific networks cannot handle the burden of evolution. Besides, mobile networks have shown that only a standard, open solution as GSM can be really successful in the telecommunication market. One of the key points in GSM success is roaming, that guarrantees ubiquitous service and fosters competition, since it enables the ingress in the market of new operators without requiring the installation of a completely new infrastructure.

The challenges with wireless access on non-licensed bands go one step beyond both Internet and 2-3G cellular networks, since it is not possible for operators to furnish wide-scale access infrastructure with a constant quality. Hence, the idea

of a new architecture, bases on local HotSpot infrastructure Providers (HSP) and global Internet Service Providers (ISP), that can be the traditional telecom and Internet providers. HSPs are a large number, possibly privates covering specific sites (airports, trains and train stations, gas stations and rest areas on motorways, etc.), or municipalities offering coverage as a basic infrastructure on the territory, just like potable water or sewage. ISPs on the other hand are few and provide global coverage services. Mobile Hosts (MH) access the global infrastructure through an HSP, but the entity that ensure that the user is enabled to access the network are the global ISPs. This scenario is scalable, business oriented and conceptually appealing, but it raises a large number of still unresolved problems that must be studied and experimented.

3 Research Areas

The main research topics that are addressed in the WILMA project concern planning, security, protocols and innovative services. They can be summarized as follows (not necessarily in importance order).

Network Management. The management of complex networks includes many aspects, but when wireless networks are involved, mutual trust, authentication, authorization and accounting (AAA) are the top-list priorities. In a network scenario as envisioned by WILMA, where HSPs and ISPs are different entities, the management becomes of paramount importance.
Similarly to the Virtual Operators proposed in [1], ISPs in WILMA manage users accessing the network through the HSPs. In its present phase the project provides for a single ISP, played by the researchers at DIT, while IRST and Alpikom act as HSPs only. The connectivity between HotSpots is provided by Alpikom directly or is obtained through IP tunneling. The second phase of the project is open to other institutions that would like to experiment this role.
As already mentioned pricing plays a key role in the success of provisioned networks. In order to be competitive, both ISPs and HSPs need simple and effective mechanisms to control the congestion and guarantee the QoS, while keeping the business profitable. Price-based policy for the access control can be a means to enforce QoS and profit, for instance in [2] we explore a policy that controls the hot spot traffic by dynamically determining the access cost as a function of the current load in the hot spot.

Location Aware Services. In wireless networks, the physical location of a user is an important parameter, whose utility ranges from routing and content-delivery optimization, to location-dependent service provisioning. The estimation of the position of a mobile host by measuring the strength of beacon radio signals received by the network interface is a novel method open to research, that may make location independent, in some cases, from satellite based systems like GPS [3,4].
The WILMA city-wide open lab offers the chance of studying the benefits of new value-added services on a large scale, unavailable to purely indoors

implementations. For instance, cooperation with public institutions enables the experimentation of systems that support human decisions both in leisure environments (tourism, recreation) and in critical contexts (emergency management), while other subjects will collaborate in testing context-aware applications that adapt their behavior to the user's location (e.g., home or work).

In the prospected framework, access points serve a double purpose: they provide connectivity, and at the same time they are used to determine the location of the mobile systems, offering to the user a context-dependent interface even without being actually connected to the network.

An example application is PILGRIM (Personal Item Locator and General Recommendation Index Manager) [5,6], a system that provides a list of interesting web links to users, where the measure of interest to a link for a particular user depends on his position. The system is based on the *collaborative filtering* paradigm: the interest metric depends on previous user actions, and no parameters need to be set by the system manager.

Security. Security means both encryption of data and dependable resource use, hence interacting deeply with the network management. The main difference between security related topics and AAA and network management-related problems is that security is concerned with the semantics of data, while AAA operations are normally not concerned with it.

One of the key points within this project regards the study of service differentiation based on security needs. Most of the multimedia traffic (voice and video) generally require a mild security enforcement (GSM-like encryption is generally sufficient). On the other hand, security requirements of data traffic may range from zero (e.g., downloading of the information regarding the monument in front of you) to applications whose requirements go well beyond secrecy and privacy, like for instance all credit card based transactions, where the user must also be granted about the generalities of the counterpart.

Network Planning. W-LANs are being deployed widely, but rarely with careful planning procedures. Access points (APs) are placed where needed, with the only constraint that power and network plugs must be close by. While 'optimal' for fast bootstrap, this strategy will hardly lead to well organized Hot Spots. Within the WILMA project several fundamental issues are studied. Among them:

- Optimal positioning of APs as a function of the environment and traffic requirements;
- Dimensioning of the wireless and wired infrastructure;
- Interference between neighboring and/or partially overlapped systems;
- Planning for localization, i.e., with the additional constraint that APs positions should provide a good structure of the signal strength to support the positioning algorithms.

Protocols and QoS Provisioning. A carefully engineered network requires some form of admission control in order to provide some degree of QoS, and suitable protocols to provide, implement and negotiate QoS and SLAs. A

broadband wireless network will also support multimedia communications, with their different QoS requirements. To guarantee different QoS requirements in a wireless network one needs suitable scheduling and admission control algorithms [7]. Besides, differentiation is needed for pricing and accounting purposes, as a function of the traffic types [8], thus also complementing the researches on pricing carried out in the framework of network management.

WILMA is studying and addressing these topics with an incremental and experimental approach, tackling problems as they arise in the experimental phase, though also fundamental research on admission techniques and scheduling is carried out within the project.

4 Ongoing and Future Work

WILMA Open Lab presently consists of a first HotSpot within the University of Trento, and a second HotSpot at ITC-IRST that will be interconnected to the network management soon. In the next few months HotSpots scattered in the Trento area will be connected through the Alpikom infrastructure, supporting a seamless Open Lab where services are experimented, and data supporting research and incremental service deployment are collected and elaborated. Meanwhile, smaller scale experiments will start in selected areas, such as Trento Library, providing free public access to the Internet and allowing the collection of important measures and informations about user needs and habits.

One of the initial goals of the project is the experimentation of Open Software solutions to implement the functionalities identified above, both using and customizing existing tools and developing new ones.

Service differentiation experiments are medium term goals, allowing the study of viable business models that ensure both free (or very cheap) access to basic services and income-providing value added ones.

The long term goal is handling the infrastructure used for research and experiments, together with the expertise accumulated during the project, to private enterprises, thus paving the road for the widespread introduction of nomadic services based on standard and open architectures.

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URLs and Web Sites

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