

# Peer-to-Peer Wireless Network Confederation

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## Wi-Fi EVOLUTION

The Institute of Electrical and Electronics Engineers (IEEE) ratified the initial version of the standard for Wireless Local Area Networks known as IEEE 802.11 in 1997 (IEEE Standards, 2004). Belonging to the same family of standards as the Ethernet, it was labeled “Wireless Ethernet” and considered an appropriate networking technology for offices because it did not rely on cables. Although burdened by a lack of strong security (Fluhrer, 2001) and lower throughput compared to its wired equivalent, IEEE 802.11 was a success. The cost of manufacturing 802.11 chipsets fell quickly, and 802.11 found its way from desktop PCs to laptops and next generation cellular phones. Wi-Fi, a consumer-friendly moniker for 802.11, was adopted and the Wireless Ethernet Compatibility Alliance (WECA), a non-profit international association, was formed in 1999 to certify the interoperability of Wi-Fi products. WECA changed its name to the Wi-Fi Alliance in 2002 (Wi-Fi Alliance, 2004).

The two main components of Wi-Fi networks are the wireless clients and the Wi-Fi access points, which are the wireless equivalent of Ethernet hubs. Clients equipped with Wi-Fi can communicate wirelessly with nearby access points that link them to each other, to the local wired network and to the Internet. Clients can also communicate with each other without access points (assuming their radios are within range) in a so called “ad hoc” mode (IEEE Std. 802.11, 1999).

Newer IEEE specifications include 802.11g, which enables clients and access points to connect to each other at speeds of up to 54 Mbps; and 802.11i, which employs advanced authentication and encryption algorithms to protect against unauthorized users that attempt to gain access to private networks (IEEE Standards, 2004). Standard 802.11i also protects the confidentiality and integrity of wireless sessions, which are usually susceptible to eavesdropping and hijacking attacks.

The term “Wi-Fi hotspot” is now being used to describe any area where Wi-Fi connectivity is available via nearby access point. Public hotspots can be found in

airport lounges and shopping malls, in coffee shops and restaurants, and in hotels and exhibition centers. Wi-Fi users, which include business travelers as well as casual users, can use their portable devices in these hotspots to access e-mail, their corporate intranets and the Internet. Users can browse the Web, use instant messaging and location-based services, place cheaper voice-over-IP calls and conduct videoconferences. Nevertheless, such practice is still not commonplace (Stone, 2003).

## Wi-Fi PROVISIONING: ISSUES AND PLAYERS

Ubiquitous high-speed and cost-effective Internet access is not available today. However, in major cities, Wi-Fi technology combined with the widespread availability of broadband Internet links such as DSL and cable can help realize this goal. The low cost of Wi-Fi equipment compared to their cellular—2G and 3G—equivalents greatly assists in deploying Wi-Fi globally. There are factors, however, that work against such a deployment.

One such factor is the range of Wi-Fi hotspots, which is smaller than its cellular equivalent. To cover a given area, a greater number of access points are necessary compared to, for example, the number of CDMA or GSM base stations. The fact that Wi-Fi access points are inexpensive and that Wi-Fi operates in unlicensed frequency bands offsets this cost. Nevertheless, as with cellular base stations, there are still OA&M costs involved.

To share the costs mentioned above, providers establish roaming partnerships so that customers from one provider can use the infrastructure of other providers. For roaming to work in the cellular world, Mobile Network Operators sign roaming agreements with each other and standardize on the technology to use (GSM technology is well known for its success throughout Europe). However, even though the technology has already been decided with Wi-Fi networks, other types of provider “incompatibilities” leave Wi-Fi resources under-exploited. A factor working against the establishment of a global Wi-

Fi roaming partnership is that the various types of potential Wi-Fi providers are dissimilar. Four such types follow.

First, there exist today numerous private residential hotspots, owned and operated by households for private use. Due to the nature of Wi-Fi signals, it is not uncommon for Wi-Fi cells to cover a greater area than was intended, so residential hotspots, in general, can also be accessed by visitors in the area surrounding the household. This is seen as a security risk, and households typically use some form of authentication and encryption techniques to guard against it.

Second, there are organizational hotspots owned and operated by their respective organizations and offered as an amenity to the people associated with the organization. This category includes companies and their employees, schools with their students and faculty, even large transport vehicles such as trains, airplanes and ships.

Third, there are the nonprofit community hotspots. Municipalities and groups of hobbyists commonly operate these (Stone, 2003). They provide Wi-Fi Internet access (without security) to anyone within range. Security-conscious users use their own end-to-end security software in such hotspots.

Fourth, there are the for-profit public hotspot operators. Most operators partner with venues where people congregate (Boingo, 2004). Through these partnerships—and according to specific contracts—operators split the cost of installing and operating a broadband Internet link, as well as the cost of installing and administering Wi-Fi equipment and services. These hotspots require that users be authenticated with their subscription credentials before using the service. Users can also pay per session using their credit cards or by buying prepaid cards that correspond to a preset amount of connection time.

Today, there exist many public hotspot operators that handle a great number of user subscriptions. Some hotspot operators are also cellular and telecom providers. However, no single subscription can be used to access all these operators: The Wi-Fi market is still divided. Hotspot “aggregators” such as Boingo and iPass attempt to coalesce the resources of many smaller operators by taking over the handling of user subscriptions (Boingo, 2004; iPass, 2004). The aggregators also attempt to make peering agreements with large, established operators (one of the first such agreements involved iPass and the T-Mobile hotspot network; iPass, 2004) or with other aggregators. These efforts have varying degrees of success but, until now, result in a small coverage footprint even for the largest of aggregators, and roaming services are still costly for roaming users. These roaming agreements commonly ignore the first three types of potential hotspot providers.

## FULLY SELF-ORGANIZED PEERING OF Wi-Fi HOTSPOTS

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The various dissimilar providers mentioned in the previous section already cover useful territory in metropolitan areas. The Wi-Fi alliance’s Wireless Internet Service Provider roaming (WISPr) group is attempting to standardize technologies, protocols and behaviors among existing Wi-Fi providers in order to make Wi-Fi roaming as seamless as possible (Anton, 2003). Their efforts, however, focus on the established public hotspot operators and are modeled after existing cellular roaming schemes. Because these schemes involve administrative overhead for the roaming partners and legally binding agreements, they are not appropriate for many small public hotspot operators. Also, they are inappropriate for potential providers who are not already established corporate entities.

The Peer-to-Peer Wireless Network Confederation (P2PWNC) is a virtual community of Wi-Fi providers designed to unite all of these dissimilar providers into a seamless infrastructure for Wi-Fi roaming (Efstathiou, 2003). P2PWNC foregoes the complexity of roaming agreements and adopts flexible rules usually found in P2P file-sharing communities in order to control partner contribution and make better use of under-exploited resources found within this community. Contribution in the P2PWNC context means that providers share their Wi-Fi infrastructure and allow access to users associated with other providers within the same community. As a reward, their own users can receive service from other providers within the community. For example, if household hotspots participate in the P2PWNC community, members of such a household would be able to receive Wi-Fi service when roaming within the coverage area of any other P2PWNC household. If public hotspot operators were to participate in P2PWNC as well, P2PWNC users would be able to receive Wi-Fi service from these operators even if they did not subscribe to their services, because P2PWNC allows participants to make contributions “in kind.”

Unlike traditional roaming agreements (“provide access to all my users and I’ll provide access to all of yours”), which create imbalance if the partners are dissimilar, the participation rules of the P2PWNC virtual community are more flexible (Antoniadis, 2003). They are designed to provide the right incentives for contribution, since there are not only benefits but also costs involved with participating in the P2PWNC community. The obvious benefit is access to other P2PWNC hotspots. Costs can vary, and depend on the hotspot. One type of cost is the adverse effect on local traffic that visitor traffic causes; another is increased Internet fees, assuming the provider’s upstream connection is metered; other indirect costs include potential security risks involved in

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