Discussion:

A Real-World Observation of Wi-Fi

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Wi-Fi in the Real World

Recently, much has been written about Wi-Fi, the wireless local area network (LAN) technology running on the 802.11 standard, suggesting that it threatens the revenues of wireless network operators and the deployment of third-generation (3G) wireless services. Because of QUALCOMM's commitment to driving 3G products and services – particularly 3G data services – many industry observers have reflexively concluded that QUALCOMM is anti-Wi-Fi.

QUALCOMM has always viewed Wi-Fi, a wireless LAN technology, as complementary to 3G data services. The truth is that Wi-Fi, as it is today, cannot meet the wireless WAN needs addressed by 3G because it cannot provide the user with a truly mobile data-enabled experience. QUALCOMM recognizes the value of Wi-Fi in environments where large groups of people naturally congregate such as educational or office campuses, airports, train stations and libraries. The company has deployed almost 200 Wi-Fi access points on its own corporate campuses at an approximate cost of $300,000. QUALCOMM also recognizes the value of Wi-Fi for home networking. However, QUALCOMM does take issue with the supposition that the proliferation of public Wi-Fi hotspots will somehow moot the value of 3G mobile data in the wide area.

The purpose of this paper is to examine Wi-Fi as a wide area mobile data connectivity solution and make clear the facts about wireless WANs. Throughout this paper, keep in mind that QUALCOMM is addressing matters in the real world, not a lab where optimal conditions for radio waves prevail.

Lessons from the Past

Prior to the development of Wi-Fi, there were several attempts to deploy similar solutions for voice communications. For example, in the mid 1990s, CT-2 wireless services were sold in the U.K. (under the brand name Rabbit), France (Bebop), the Netherlands (Greenpoint), and Hong Kong (several services, including Pacific Link). CT-2 services were essentially low-powered voice-only hotspots.

With CT-2, the public could use a low-cost, low-power handset within 30 meters of an access point. These access points were not trials – they were broad deployments in the tens of thousands of base stations in hotel lobbies, bus stops, airports and convention centers. At the peak of its popularity, CT-2 had hundreds of thousands of users.

Can CT-2 services be found today? No. They only exist in Google™ Memory, since they were consigned to technological oblivion by second-generation (2G) wireless wide area voice networks such as GSM and cdmaOne™.

Another case is MobileStar. MobileStar was the Wi-Fi hotspot service provider that went bankrupt and was purchased by T-Mobile as the basis for its Starbucks Wi-Fi network. An April 2001 article about IBM and MobileStar, located at http://news.com.com/2110-1033-255733.html, sounds very similar to the promises and visions offered by Wi-Fi companies today. After reading the story, one might be prompted to ask, "What's changed?"

Finally, search for "Boingo 5000" in Google. One will find that Boingo announced in October 2003 that it achieved over 5,000 hotspots. Research this further to find that the company began predicting 5,000 hotspots in early 2002 and estimated that those 5,000 hotspots would be achieved by the end of that same year. Furthermore, Boingo's directory has a large overlap with the Wayport (another Wi-Fi provider) directory listing – something that calls into question the aggregate number of hotspots promoted by Wi-Fi public hotspot proponents.

The above examples have been presented so readers can see, with minimal research, that the concept and technology of Wi-Fi is not new nor is it cutting edge as it is often promoted. It is an intelligent concept that has made great progress and has evolved over time. Furthermore, these examples serve as valuable lessons for those who believe in learning from the past.

A European Wi-Fi Hotspot Experience

The best way for me to illustrate some important shortcomings of Wi-Fi hotspots is simply to tell you the story of my real-world Wi-Fi experience on a business trip in Europe in the spring of 2003.

In May 2003, I was scheduled to attend several press and analyst meetings in London, Stockholm and Helsinki. I carefully planned this trip and purposely selected hotels and meeting areas that offered Wi-Fi services.

After arriving in London, I took a cab to my Wi-Fi-enabled hotel and proceeded to check in. At the front desk, I purchased a Wi-Fi scratch-off pass card so that I could use the Liberty-i service. At the time, the hotel only had 2-hour pass cards available for £8 ($13.60). The concierge explained that soon, full 24-hour pass cards would be available for £16 ($27.20). Furthermore, because the service was new to the hotel and because Wi-Fi has a limited real-world range of about 100 feet, I had to stay on the fourth floor, in a specific wing of the hotel.

Underneath the scratch-off panel was a 17-digit alphanumeric numbered password. I went to the Wired Equivalency Privacy (WEP) page on my IBM ThinkPad™ and entered the 17-digit number. Nothing happened. I did it again. Again, nothing happened. After 20 minutes of trying and re-reading the enclosed instructions, I called the front desk only to find out that I had to first insert a Liberty-izone CD-ROM and install the Liberty-izone software. Unfortunately, my ThinkPad, with an embedded 802.11b modem, can only provide CD-ROM capabilities if I bring my docking station. To accommodate me, the hotel sent up its Dell 7500 laptop so I could perform browser-based email over Wi-Fi.

Upon further research, I found this on the Liberty-izone support page:

> Windows® 98 users must de-install the Liberty-i software after use, as all redundant ports (e.g. Ethernet ports) are disabled during a wireless Internet session. Uninstalling the software after you have used the WLAN card to access

the Internet will automatically re-enable all ports disabled during the session, leaving your PC as it was before.

Telling a customer to insert a CD-ROM in a company laptop and install/uninstall strange software is not user friendly nor is it encouraged by many corporate IT departments.

Relevant Web site: http://www.liberty-izone.com

The next stop was Stockholm. I selected the IVA Conference Center because it was part of the Telia HomeRun service. Telia HomeRun was more reasonable in its rates and only charged 120 SEK ($15.26) for 24 hours of service. Furthermore, it was all browser based – no CD-ROMs required. The Telia HomeRun service was good overall.

Relevant Web site: http://www.homerun.telia.com/eng/start/

In Helsinki, I attended meetings all day at the Hotel Kamp. The conference room was located on a specific floor and a specific wing so that Wi-Fi access was available. A room service employee delivered the Sonera wGate scratch-off pass card and told me that the cost was 50 Euros ($58) for 24 hours of service – three times the cost of the Telia Homerun service and twice as much as the unavailable 24-hour Liberty-i service. I sent the card back downstairs unused.

Later that evening, however, I was able to use the Finnish version of the Teliamobile Homerun service at one of the Scandic hotels in Helsinki for a more reasonable 15 Euros ($17.40).

Relevant Web sites:
http://www.hotelkamp.fi/en/Index/http://www.sonera.com/ (select business solutions, then select Sonera wGate)
http://www.homerun.telia.com/eng/start/

Returning to the U.S., I had a brief stay at the Westin Century Plaza in Los Angeles, where Wi-Fi service was not offered. However, there was a sign at the front desk offering "High Speed Internet Access" via a wired Ethernet for $9.95 for a 24-hour period. I could have used it but, because I was back in the U.S., I opted to use my ThinkPad and my CDMA2000 1X wireless WAN card. And because I was connecting to a wireless WAN, it did not matter which room or wing I stayed in.

At the conclusion of the trip, I added up my connectivity expenses as if I'd only had Wi-Fi for wireless data communications:

London:	$27 (for the unavailable 24-hour pass)
Stockholm:	$15
Helsinki:	$58 (during the day meeting, if I had not returned the card)
Helsinki:	$17 (during the evening, at my hotel)
Los Angeles:	$10 (for wired Internet, because Wi-Fi was not available)

Total: $127 to access the Internet, four via 802.11b and one via wired Ethernet.

For about five days of usage, Wi-Fi connectivity was not only expensive, it was not convenient: four different service providers, five different user interfaces, five different pricing schemes and five different instruction sets. And this was all in an environment where I took the time – valuable time – to plan ahead so that I could have access to Wi-Fi.

On a similar five-day trip in the U.S., using a wireless WAN card, I paid only $13.30, or $2.66 per day, based on a 30-day month and Verizon Wireless' $80 all-the-data-you-can-eat flat rate. (Note also that an entire month of wireless WAN costs less than those five days of Wi-Fi.) Furthermore, I used the services anywhere in the metro areas that I was visiting, for as long as I wanted.

Relevant Web site: www.verizonwireless.com

Wi-Fi Hotspot Proponent Responses and Reality

Proponents of Wi-Fi hotspots might dismiss my Wi-Fi experience as unscientific. QUALCOMM agrees. It is unscientific – it is a real-world experience. And that is very important to remember.

My experience did not take place in a lab under optimum conditions. It took place in everyday situations – situations that most people, who are exposed to Wi-Fi marketing claims everyday – may encounter. Wi-Fi is useful, but has its limits.

Following are three of the most common pro-Wi-Fi hotspot responses to my initial report on my European Wi-Fi hotspot experience. Many of these points are based on common Wi-Fi hotspot selling points created by marketers. And unfortunately for the public, these points are sometimes put out to the world without further examination. Each response is followed by information that QUALCOMM has documented in the real world.

1) *Wi-Fi is faster than wireless WAN*

True, Wi-Fi is faster than wireless WAN, but not nearly as much faster as Wi-Fi proponents want everyone to believe. During my European Wi-Fi hotspot experience, I found typical (i.e. real world) connection speeds in the high hundreds of kilobits per second, not the mythical 11 Mbps that Wi-Fi marketers tout. In fact, it is safe to say a typical user will never experience 11 Mbps in the real world because as with all Wi-Fi connections – whether the user is at a hotspot, a place of business or at home – speeds are limited by the backhaul.

The backhaul – in Wi-Fi terms – is the infrastructure behind the physical wireless access point. For example, at a Wi-Fi hotspot where there may be one or more access points, the physical access point is mounted on the wall. Behind the access point and the wall, is a data cable leading to a PC. From the PC there is almost always a wired connection,

typically a T1 or DSL, to the Internet. Everything behind the wall is "the backhaul." (Note that a hotspot may be made up of one or more access points.)

A T1 by definition, is 1.528 Mbps and costs anywhere from $600-$1,000 per month for the hotspot operator. DSL is less expensive but only provides 300-500 Kbps on average and presents some "grade of service" issues. Therefore, while a user is connected to the Internet via Wi-Fi, his laptop might be communicating over the air via 802.11 at peak rates of 11 or 54 Mbps (depending on which version of Wi-Fi is being used). But from the access point to the Internet, bit rates are limited by the T1 or DSL line. Think of the wireless connection between the laptop and the access point as a water main. And think of the data cable, PC and wired connection to the Internet as a garden hose. The water, or data, can only flow as fast as the garden hose, or backhaul, allows.

During some random, real-world testing in various cities around the globe, QUALCOMM found that Wi-Fi access was typically in the 400 Kbps to 1.2 Mbps range, with a midrange of 600-700 Kbps. In the U.S., the same random testing has shown that wireless WAN, specifically CDMA2000 1X, delivered in the 40-105 Kbps range (without compression), with typical performance being in the 70-80 Kbps range. Through dialup connections, users never receive 56 Kbps through a 56 Kbps dialup modem. A typical midrange experience with dialup in the U.S. is 35-42 Kbps. At some locations in the world, a user is lucky to get 9.6 Kbps.

To summarize QUALCOMM's findings:

- CDMA2000 1X is 1.5-2 times faster than dialup and is available almost everywhere in the U.S.
- Wi-Fi is 20-30 times faster than dialup and 7-15 times faster than CDMA2000 1X, but only available at limited locations

Looking into the future, one must consider how CDMA2000 1xEV-DO will alter the wireless WAN landscape. CDMA2000 1xEV-DO, which was recently launched by Verizon Wireless in Washington, D.C. and San Diego, offers peak rates of 2.4 Mbps and real-world rates of 300-600 Kbps. (Verizon Wireless is already planning to expand coverage into most major metropolitan areas across the U.S.) Assume by 2006 CDMA2000 1xEV-DO covers the U.S. just as CDMA voice service does today. The performance differential between Wi-Fi and wireless WAN changes dramatically:

- CDMA2000 1xEV-DO is 8-15 times faster than dialup and available in all the major metro areas of the U.S.
- Wi-Fi is 1.5-2 times faster than CDMA2000 1xEV-DO and is still only available at limited locations and is frequently even slower do to backhaul constraints

Returning to the present, CDMA2000 1X today provides a user experience that is faster than what most users get via dialup and consistent over large coverage areas. Let me relate the other five-day business trip I took in the spring of 2003, this one within the U.S. With my CDMA2000 1X card, I checked email, tracked world news, and connected to

QUALCOMM's corporate network via VPN through a wireless WAN connection. Admittedly, I did not download massive attachments or MP3s. But on average, I experienced speeds of 50-105 Kbps and 6-9 MB per hour of connection time. For what I was using it for, the wireless WAN connection was perfectly adequate.

The bottom line is that Wi-Fi can be faster than wireless WAN – but not nearly as fast as a lot of the marketing around Wi-Fi would lead the public to believe. And, because it does not offer mobile wide-area coverage, it is consistently less convenient than wireless WAN. Plus, the performance gap exists will only diminish over time.

2) There are many Wi-Fi hotspots

In reality, there are not that many hotspots. The number of hotspot locations is growing, but the majority of them are not located where mobile people who need real mobile connectivity need them.

For a list of hotspot locations, visit http://www.boingo.com, http://www.wayport.com, and http://www.tmobile.com/hotspot/default.asp?nav=hm.

If you look at these Web sites closely, you will see the following: Many of those hotspots are for lobby access only. And many of the locations listed on Boingo's site also appear on Wayport's site. Now contrast this reality with wireless WAN access in the U.S. Anyplace in a hotel where one can make a voice phone call on Sprint PCS or Verizon Wireless, there will be predictable access. And it is still faster than a dialup connection.

Now let us make a more critical examination. A hotspot covers – in reality and based on a general rule used by those that install Wi-Fi – about 25,000 square feet or approximately 2,500 square meters (Pi times the radius squared, on an access point radio coverage radius of about 90 feet or 28 meters). 25,000 square feet calculates out to about 1,000 hotspots per square mile of Wi-Fi coverage (or 400 per square kilometer). Therefore, the 100,000 hotspots we hear about being deployed in the U.S. will ultimately cover an area – in aggregate – the size of one or two suburban wide area cell sites. Gartner Group, an industry analyst firm, has projected upwards of 154,000 deployed hotspots worldwide by 2006.* For perspective, 154,000 hotspots reflect an aggregate coverage area of about 154 square miles out of the more than 3 million square miles of the U.S. Rhode Island alone, the smallest state in the U.S., covers 1,500 square miles.

While the number of hotspots continues to grow, the sort of coverage ubiquity that wireless WAN enables is not likely to come from this hotspot growth. Realistically, true wireless mobility requires a true wireless WAN technology.

3) All business hotels will have Wi-Fi installed

Not likely. Cometa, a venture of several U.S. tech companies, stated at a spring 2003 Lehman Brothers conference that an access point costs about $1,500 to install (all costs included) in a hotspot environment (which is consistent with QUALCOMM's cost for its Wi-Fi business campus network). This cost is not a substantial barrier to entry for a

coffee shop or a deli. However, when a business such as a hotel wants to move the Wi-Fi coverage beyond the lobby, the business center, or a block of rooms, the costs escalate exponentially.

Consider Wi-Fi deployment in a major hotel. Management will need to implement a site survey. RF and access point location planning must take place. Plans for routing power and data cable must be drawn. Decisions must be made about hardware and software, their compatibility and the inevitable support services that will be needed. Union labor must be hired in many cities. How much would deployment in a Sheraton on Seventh Avenue in New York cost? How much would the Venetian in Las Vegas cost? A Hyatt San Francisco? Or any key convention hotels in the 1,000-2,000 room range? These buildings are not made of "tilt-up" construction but massive amounts of concrete and rebar. The hotel would be installing hundreds, if not thousands of access points. For equipment and services, the costs will quickly escalate into the hundreds of thousands, if not millions, of dollars.

Now consider this from a practical business perspective. If hotels are already making a lot of money on in-room dialup connections, what are their managements' incentives to make massive capital outlays to install Wi-Fi throughout their buildings in today's business travel environment?

Proponents of Wi-Fi might argue that installing Wi-Fi access points is still more economical than erecting wireless WAN cell towers around the country. That is not true. What they overlook is that the infrastructure is already there and the carriers already own the spectrum.

The truth is not all hotels will be installing Wi-Fi in the near future.

A Glimpse into the Wireless Future

So what does the future have in store for Wi-Fi and wireless WAN?

Wi-Fi will continue to grow in the enterprise and in the home because it makes more sense, both economically, and for the user from a control and cost perspective.

Wireless WAN data service (already prevalent on PDA devices) will begin to expand rapidly in PCMCIA (Personal Computer Memory Card International Association) format for laptops and will begin to be embedded in more devices. Particularly as more people begin to use the services and recognize the utility and benefits the services can provide.

Creative pricing strategies will evolve, but ultimately consumers and professionals will want to pay a fixed rate for a bucket of services – no per-MB pricing. Wireless operators will offer fixed rates but will set contractual limits to prevent users from using more than their fair share of system capacity (i.e., no downloading of music all day).

The user experience will continue to improve as 3G networks and services, such as CDMA2000 1xEV-DO, begin to launch and grow around the world. Among the highly

mobile population such as mobile professionals, wide area wireless data will be the dominant method of connectivity, just as wide area wireless voice is the dominant method by which that group makes phone calls outside the office.

At places where people naturally would want to get wireless data – like an airport, a train station, or a convention center – a predictable process will evolve. If there is a lot of wide-area wireless data traffic, wireless operators will evaluate whether it will save them money to find a way for that data to be offloaded to Wi-Fi in these natural locations. While traveling, consumers will evaluate whether Wi-Fi saves them money, provides a fundamentally better user experience, or some combination of both. It will be the same process consumers went through with mobile phones for voice. Gradually, they all recognized the value of mobile phones and stopped using hotel room phones and pay phones when away from their homes. When they returned home, they used their wired lines to make phone calls. The same will happen with Wi-Fi and wireless WAN. On the road, consumers will use wireless WAN. When they return from a (pleasure or business) trip to their homes or offices, they will use their wired or Wi-Fi networks.

Keep in mind that everything QUALCOMM has described is applicable to laptops and PDAs connected to wireless WAN and Wi-Fi networks. Yet, by any metric, the global volume of these devices is very small when compared to the volumes of wireless handsets sold globally. And relatively few people have looked at what is really happening in the handset world. Handsets are getting smarter, being built with better screens, coming equipped with more memory and are capable of processing some amazing applications. Without doubt, as wireless handsets evolve, the wireless landscape will shift again.

Conclusion

For those who remain skeptical about the validity of my Wi-Fi experience and still believe that Wi-Fi can replace wireless WAN, QUALCOMM invites them to perform their own two-week real-world experiment:

Week #1, data wherever you can make a voice call:

For two weeks, whenever and wherever you take out your mobile phone to make a voice call, understand that you can get full wireless data access, at speeds much faster than dialup, with affordable flat-rate per month pricing. The proof exists today in the U.S. on both the Sprint PCS Vision[SM] service and Verizon Wireless NationalAccess[SM] service. It is also true in dozens of countries around the world that have launched 3G CDMA services, and will soon be true in Europe where an increasing number of UMTS (WCDMA) commercial networks are launching.

Week #2, voice only where you can get Wi-Fi:

For a different two-week experience, try to make a wireless voice call only where you can legally access and log onto an 802.11 Wi-Fi hotspot service network. You will have to do some research to find those hotspots. Note how many services you have to sign up for and add up the costs. And remember that you have to get on 802.11 using your laptop

or PDA before you can use your mobile phone. You will probably find the two weeks of this challenge to be very inconvenient and very expensive.

Once more, the purpose of this discussion is to examine Wi-Fi as a wide area *mobile* connectivity solution and make clear the facts about wireless WANs. QUALCOMM is not anti-Wi-Fi. Wi-Fi is an efficient technology when used in the home or where large numbers of people congregate in a limited area such as a business or educational campus, or at airports or train stations.

What QUALCOMM provides here is what we've found to be true in the real world. We encourage people to research for themselves the real-world usefulness of Wi-Fi hotspots compared to wireless WANs, and draw their own conclusions and use the combination of solutions that best serve their needs.

* Public WLAN Hot Spot Locations Worldwide by Region, 2001-2008. Gartner Group, Public Wireless LAN Hot Spots – Worldwide – 2002-2008, May 15, 2003.

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