

Municipal Wireless Deployment:

The Good, The Bad, and the Ugly

A BBP Staff Report

FOSE is the largest annual show for government contractors. We used it as a forum this spring, in cooperation with TIA, the Telecommunications Industry Association, to explore the issues surrounding wireless deployments.

famous in the fiber optics world. But less known is the city's commitment to WiFi, to handle the things fiber can't. **Sudeep Gupta**, from Alcatel, sees a bright future, and plenty of problems, for WiMAX. Will it replace WiFi or supplement it?

We are frankly nervous about municipalities making deals for "free" low-data-rate WiFi as a substitute rather than a supplement for true broadband. We also worry about municipalities trying to piggyback public safety tasks on an inherently insecure WiFi network.

We find an enormous amount of synergy between wireless and fiber. The two technologies could not exist without one another. But they do separate things. We are frankly nervous about municipalities making deals for "free" low-data-rate WiFi as a substitute rather than a supplement for true broadband. We also worry about municipalities trying to piggyback public safety tasks on an inherently insecure WiFi network.

To explore the issues, we brought four astute individuals together in front of an audience of government employees, many of whom are concerned about safety issues involving communication. **Mike Young** of Proxim Wireless talked first, about wireless technology. But to him, it is more than WiFi writ large. There is enormous opportunity for government to add wireless, but not merely through WiFi. **Hilda Legg** is an extraordinary evangelist for broadband everywhere. She's now living in Kentucky but traveling everywhere, consulting. Legg headed the Rural Utilities Service at USDA from late 2001 to 2005. **Jim Hettrick**, director of information systems for Loma Linda, is

We learned a lot – allaying some of our fears, exposing others, and charting a pathway for the future.

BONUS: Hear the actual presentations and get the Power-Point slides at www.broadbandproperties.com/fose.htm

Mike Young **Proxim Wireless**

What I want to talk about is the spectrum available for wireless. I am not going to limit myself to WiFi. There are two key issues. First, we have seen that customers want all kinds of applications; there is simply not enough RF spectrum to do what they want to do. The second is that the FCC limits the transmit power, especially in the license-free bands.

YOUNG: There are two key issues. First, we have seen that customers want all kinds of applications; there is simply not enough RF spectrum to do what they want to do. The second is that the FCC limits the transmit power, especially in the license-free bands. By the way, this is true for WiMAX systems as well as for WiFi.

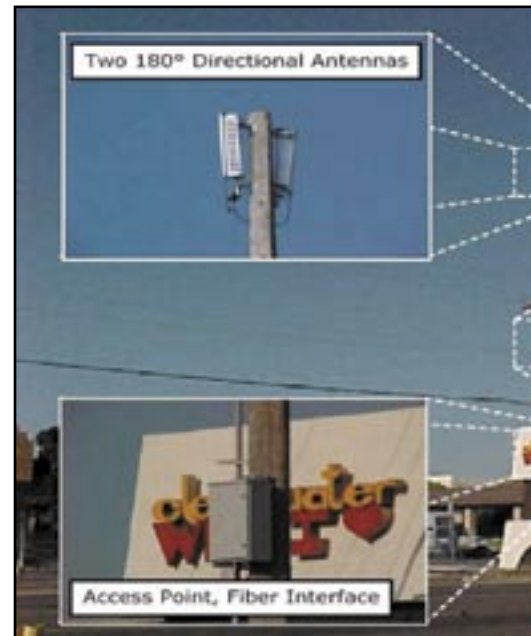
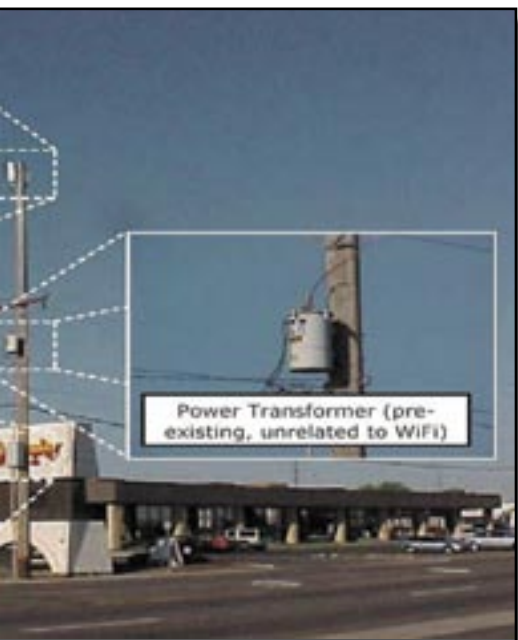


Figure 1: Typical WiFi access point; note down-focus (access points) and the interface for fiber backhaul.

2483.5 MHz band. That's the classic 2.4 GHz WiFi 802.11b/g/n band. We have the 5.25 to 5.35 GHz spectrum, which is the 802.11a band. We have the 5.725 to 5.850 GHz band. We have a 24 GHz license-free band, and a 60 GHz license-free band, both used for



ed antennas (to keep from interfering with nearby

point-to-point applications.

If you need a secure, reliable link with no interference, the 24 GHz and 60 GHz bands are something you should look into. Very few people even realize they're out there.

Figure 1 shows a typical installation, of a type we've been using for wireless networks for a long time. There are two 180-degree antennas to increase the bandwidth the access point can handle. If you focus the antennas straight to the horizon they interfere with the next pole, so we tilt them. The signal hits the ground.

By the way that's what they do on cell phone towers. You see those towers they have at buildings. They have the antennas down-tilted. That shrinks the coverage area, putting the signal out to the farthest customer and no farther.

That's the strongest signal we need for the customer. And you create a cell. Figure 2 shows a series of cells or access points going down the main street. You



Figure 2: A "municipal" WiFi network covering the area along a business street.

can have a laptop just about anywhere in here and get coverage. This coverage map was made while they were still being deployed. I think they've lit up more than this now. But this gives you an idea how municipalities can take 2.4 GHz WiFi outdoors.



Figure 3: Lightweight trailer carrying a WiFi access point—complete with backhaul antenna and its own gasoline generator.

Figure 3 shows an interesting equipment trailer a Proxim customer deployed after Katrina. He runs a wireless ISP company in northeast Louisiana. He brought the trailer down to New Orleans. It has the same basic two 180-degree WiFi-spectrum antennas, with

coax coming down to a box and a satellite link for the backhaul.

What's nice about this trailer is that you drive it to a location, set it up, and leave it there. Similar access points for emergency services are built into trucks. I saw a big Chevy Tahoe with an access point in New Orleans. But the expensive truck's stuck – you can't use it for anything else. Putting the access point on a simple trailer is a brilliant concept. In fact, this guy, Matt Jones of Invisiwire, is now starting to build these!

I don't know why every emergency department doesn't have one of these, because when the power goes out, phone lines go out, cell phones go out – you've got nothing. You crank up this access point and you have high-speed wireless; you have access to the Internet. You have email and you can all do it all under secure-network conditions. Yet cost of goods for these is in the low four figures.

Using the Public 4.9 GHz Band

The 4.9 GHz band is licensed to government agencies for public safety; police, sheriff departments and federal agencies and so forth can get a license for their area. The spectrum available is 4940-4990 MHz, giving just 50 MHz of bandwidth.

Why is that bandwidth number so important? The more bandwidth you have the more data you can push out.

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So the narrower the bandwidth you have available, the less information you can send or receive. Typically, vendors divide the band into 5, 10 and 20 megahertz channels. What can such channels carry? It does scale linearly. You get twice as much out of a 10 as you can a 5 and twice as much out of a 20 as you can a 10. But how much is that?

Just this morning, we were testing one of the radios and putting a high-definition video camera on it. Do you know how much data a VGA camera running 30 frames a second pushes out? We couldn't believe it – 7 Mbps. We're doing a project for the Virginia Beach Police. They want to put in video cameras on the 4.9 GHz band.

What can the band carry? We find that with typical equipment running OFDM we're getting about 10 Mbps for a 10 MHz channel, so it is about 1 Mbps per MHz because of the network overhead, packets, and acknowledgment of packet receipt.

Some people claim a lot more but they tweak the data. They find the optimal pocket size and that's what they run their tests on. But when you're running real data there isn't always an optimum size. So for planning purposes I tell people that for each megahertz of bandwidth they're going to get just that 1Mbps effective throughput, not 30 Mbps. The problem is that the marketing people don't like that. I tell them the customers will find out.

Thus, the 4.9 GHz band does not al-

low the high bandwidth and versatility wanted in most municipal RFPs. The classic one is the city of New York. It came out almost three years ago. They wanted to use 4.9 GHz for full-motion video in every police car and fire truck driving down the street. They wanted voice and video and data, all on the 4.9 GHz band. There's no way to do it. So they've done nothing. They've deployed nothing, because they asked for things that are not possible. With 7 MHz of bandwidth for each camera and only 50 MHz available, that's only 7 cameras.

Nevertheless, the band is attractive because there's no worry of interference – it's a licensed band. With WiFi, which is license-free, you can't control the spectrum. You can set up an access point in your grandmother's house on the top floor of this building and wipe out a 2.4 GHz WiFi system. And, 4.9 GHz is currently underutilized. The spectrum is pretty wide open.

Now the bad news. The propagation characteristics are much worse than for the 2.4 GHz WiFi band. The wavelength for 4.9 GHz is about 2.5 inches. That means if the beam hits anything metal or anything conductive about that size it's going to reflect, absorb or diffract the signal. This is about the size of a leaf. Just imagine a leaf wall. The signal isn't going to go through. At 2.4 GHz the wavelength is five inches and it manages to bend around. The 5.8 GHz band is worse.

Also, the FCC restricts the transmit

power based on the occupied bandwidth in an area with 4.9 GHz licenses. For 36 dBm (decibel referenced to a milliwatt of power) you get 4 watts. Every 3 dBm doubles the wattage needed so at 39 dBm you need 8 watts. This sounds like a fair amount of power but to get that you're going to have a very focused antenna.

Finally, for 4.9 GHz there's little standardization. Every vendor has its own proprietary equipment. This hurts agency-to-agency coordination in a region.

Proxim does make WiMAX equipment. Everyone's concentrating on the 3.5 GHz band overseas. WiMAX equipment on unlicensed bands is still far off. There are 50 or 60 companies making equipment. But the market isn't that big. There are only five or six companies making cell phone base stations today, for example, and they are supported by millions of customers.

There's lots of interest by vendors in WiMAX 802.16d and 16e. They use similar equipment but don't talk to each other although they are overlapping. My personal opinion is that 16e will eclipse 16d because the 16e, the mobile version, can be fixed; you can take a mobile system and put it on an antenna on a building and it will work just fine. But the fixed version can't be used mobile. By the way, there's also IEEE 802.20. It could eclipse 802.16. [IEEE temporarily suspended the 802.20 working group in June; see <http://grouper.ieee.org/groups/802/SA/SB%20802.20%20Suspension%20Announcement.pdf>.]

Question: You mentioned the 60 GHz band. As I remember, you can only get a couple hundred yards with it.

Young: It depends on the part of the country you're in. In Florida you better not plan on more than 600 meters. But if you're out in Utah you can probably do over a kilometer. When you plot attenuation versus frequency, there's a big bump at 60 GHz, so the FCC decided to give it to us for free. It's like shooting in a fog. The interesting thing is this is the band the military satellites use to talk to each other in orbit because

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the frequency doesn't penetrate down to earth. Links cost \$20-50 thousand depending on what you want. But if you look at the price of going across the railroad tracks or across the Interstate with a fiber cable it starts to make sense.

Hilda Legg
Consultant and
former head of the
Rural Utilities Service

I'm a former political appointee. You've seen us political appointees come and you've seen us go. As the former governor of Virginia once said "you know, I don't mind a political joke as long as it doesn't get elected." So as a political appointee I was wondering how I was going to talk about this – an issue very near and dear to my heart.

LEGG: When we take broadband to every American and help them to be able to afford to be on that Internet then in fact, we will be able to create a dynamic economy that I don't think we will be able to quite predict yet.

I'm not a vendor. My role is an advocacy role for broadband deployment. I am an evangelist for broadband. I am basically technology-neutral. But when it comes to broadband, I want you to have it. I have basically three points and a tip I want to share with you:

Number one, broadband must be ubiquitous. High-speed broadband deployments must be everywhere. The whole idea of the Internet will not work unless everyone has access to it. It must be in every tower, in every inner city. Our children must have access; our constituents must have access. It must be available and it must be affordable.

A couple of examples: Milwaukee decided to put in a wireless system supplying fiber backhaul through the sewers and using the city's infrastructure, the water towers and high-point buildings to get the wireless signal out there. It's a \$20 million investment to get every resident some access free, or for a small charge for various high-speed packages. No taxpayer dollars were used.

Number two, it must be in rural ar-

reas. Let me also take you out to Ulla and Morel in eastern Oregon. In Morel they don't even have a stoplight. That's in the entire county. That's more rural than where I come from in Kentucky.

However, they put in a WiFi network so all the police are connected to it. They treat it like a regular utility. The concept is not new. It's like water; it's like electricity. Only 70 years ago did we take electricity to rural America. When we electrified rural America, it became the breadbasket of the world. When we take broadband to every American and help them to be able to afford to be on that Internet then in fact, we will be able to create a dynamic economy that I don't think we will be able to quite predict yet.

At the RUS we never funded powerline broadband and we did not fund

wireless in our traditional infrastructure program. But at USDA there is over a billion dollars for small communities of 20,000 or less that don't have broadband. There are also some grants available for communities to connect. I think at least a third of the loans are in excess of a million dollars and some are for wireless applications.

The third issue involves applications and content. Broadband Properties did a summit last September. There will be another summit this September. Put it on your radar screen. We had people from all over the world. And RUS had some of our communities there and we were talking about how many applications they were running over the network.

In Sweden, one small community had 82 content providers and ISPs running on its network. American communities don't have even close to that. Folks, the way for the community to make more revenue is to drive the application process – putting in the fiber and wireless signals and all of that does not give anything unless people have a



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reason to be on line.

I believe that everything we do should have that connectivity. I want to see my son's Little League on the Internet. I want to be able to pay my parking ticket as well as my utility bill. I want to get my dog license. I want to get all kinds of government services on line.

Now at the USDA we had e-government initiatives. We put all our applications online. All of your funding applications and your grant applications. We must all be doing this. The content, the applications must be meaningful to the residents so they have a reason to pay a monthly fee.

LEGG: When I came on board at USDA in the fall of 2001 from Kentucky I brought my Palm Pilot and I thought I was coming to the big city. I was so excited. When I got up to the USDA they gave me my Blackberry. I just used it as a Rolodex because I couldn't get connected. This was the federal government in 2001.

When I came on board at USDA in the fall of 2001 from Kentucky I brought my Palm Pilot and I thought I was coming to the big city. I was so excited. When I got up to the USDA they gave me my Blackberry. I just used it as a Rolodex because I couldn't get connected. This was the federal government in 2001. I couldn't get connected to the Internet. I had that thing for 9 months before I could use it.

Finally I get on. What did it? On 9-11 when everything shut down, Blackberries worked in NY And the word Blackberry kind of caught on. Here I was coming from a rural community to an urban community and I thought I should be able to do it. But the government itself put barriers into the applications.

Two congressmen recently talked to me about pornography online. It was all about the negative. I don't know about you guys but one of the reasons I decided to go back to Kentucky was to spend more time with my little boy in a more quaint, slower-paced world.

It all came back to wondering how do we manage this great phenomenon, the Internet.

All of a sudden I could sit in front of my computer all day long and barely get all my emails read or clips or newspapers online. How do we begin to take this vast drama in this world and use it to enhance our lives, and not be an extra burden?

Here's the tip: The good Lord made us all equal in one way: There are only 24 hours in a day, for everyone. How do we use our time? There's (and I hate this word) a paradigm shift in the way we do business, state and local governments do business. How do we begin to manage this?

One way: One of the things I've gotten most interested in lately has been the social or community search. There are a number of products out there. It's the idea that whatever your needs are, whatever your issues are, instead of going through billions of items on the Internet, we can look at items in our own community.

Technology isn't going to replace us. It may give us new avenues for our cre-

ativity. You may be the first company in your town that has an Internet storefront, now that eBay's here. There are services that take your product's pictures and put them on eBay. No matter how technical we get, we can't lose the human connection.

Suddenly the people who have the same interest I have can use this social searching and special indexing to get together. For me it has managed the maze of information that's out there. Sometimes it seems as though technology gets in the way of living our lives. We can't let that happen. We must learn how to dominate it, how to manage it, how to control it, how to make it meaningful to us and not a problem.

So as I evangelize broadband I also try to get the feedback. What's the downside? What does it take away from our life? It's those communities and the individuals in those communities that are going to drive of the Internet. It's going to change our lives and the way we do business.

As those involved in government, serving a public constituency, your responsibility is to get the best bargain that you can. And I believe that if you are committed to the idea that everyone must have access and it must be affordable, if you look for the ways to make that happen in your communities, then you will contribute to a greater good.

We have to change everyday, ladies and gentlemen, in this information age. The technology that you've heard about is going to drive us as human beings. We must be willing to make those changes and accept those changes and not think we're going to do it the way sometimes in government that we've always done it.

You can do it in your communities. You can do it in your offices. And you will be part of the greater good.

Jim Hettrick
Director of Information Systems, Loma Linda, California

Loma Linda is an interesting place to live and to work. There are so many professionals in Loma Linda; 29 percent of its population has a graduate degree or higher. There are four hospi-

HETRICK: My children can't even fathom what it was like not to be connected. So think about what their worldview is like and what they expect when they have five methods to interact with anybody, anytime anywhere. What do you think their expectations will be for you and me as government employees 10 years from now?

tals within a mile of my office. One is a VA hospital; one is a private medical center; one is run by the university; and then there is Children's Hospital. There is a Ronald McDonald House. There is a terminally ill care facility building three miles away. And there's a new heart surgery hospital just going in.

In short, Loma Linda is about service. The nature of the city is about being proactive and innovative. I think residents realize some things early. There is the baby boomer generation, which uses technology at a level that they can adopt. Then there's the generation that I'm in that has somehow adopted technology at an early stage and kept up with the changes. So we remember what it was like not to have it. And then there are our children, who have no clue what life was like without the kind of connectivity there is today. My children can't even fathom what it was like not to be connected.

So think about what their worldview is like and what they expect when they have five methods to interact with anybody, anytime anywhere. What do you think their expectations will be for you and me as government employees 10 years from now?

If we don't do something today to set the stage to meet their needs into the future than we're the ones who are going to look like we are sleeping in our chairs. Those aren't issues we talk about in city council meetings; those are issues that are basically unspoken.

Loma Linda established a building code that said: If you build anything new it is going to have fiber and structured wiring built into it. We had our first broadband customer in nine months after the decision. So we became the first city to do that.

We want to install security cameras

for the parks and the schools and the local banks and we want to install traffic red light cameras and we want to do data acquisition for the homeland security department. We want to be able to do telemedicine. We want to be able to do remote sensing in education and business.

HETRICK: For wireless, we basically drop in a mesh network, tied to the fiber backbone, across areas that are difficult or already built but where there's a need for immediate solutions.

So the challenge was finding a way to integrate them in a way that I don't believe even the TIA said someone should do. You can basically pick what line you want your phone to be on. Imagine never again tearing apart a jack in a room. You just basically patch it across,

in a patch box in the closet. So if you understand how patching works you're set. If you don't it doesn't really matter because it's basically self-explanatory. And if you really don't want to touch it because you're afraid, you just go ask your neighbor, who has the same box in his house. Or ask a teenager or a 5-year old; she'll figure it out.

We realize that the fiber feeds really gave us control of those flows. It's a utility, just like water, just like sewer, just like everything else that cities build today. How many of you are in local government? We build things all the time. We manage crazy things and fiber is not as hard like some of the other things we're required to manage. So it's

a necessity, not a convenience, for the future. It creates a global competitive community.

The fiber is a foundation for a comprehensive infrastructure. Wireless is a piece of that. Broadband over powerline is a piece of that. There are many



Figure 4: Loma Linda, a pacesetter in fiber, also finds important tasks for WiFi. Here's a sample deployment within the city, in a park area.

HETRICK: We have one of the two proton accelerators in the world in town. Wireless doesn't really do too well. There's nine feet of concrete around it, and there are still interference issues. As things like that become more common for cancer treatment around the country, they will create dark bubbles for wireless.

technical solutions to getting over the hump. They enable the wireless technology to really function. Fiber is environmentally stable. You don't have to worry about the floods and the riots and fires. It requires very little maintenance.

But what is the cost justification for us to bring the fiber solution to get to every existing home? By doing the ordinance for new homes we took care of our future. But what's the redevelopment plan for the existing homeowners and how do we get them there? There are many steps to doing that and some of them are wireless.

Figure 4 shows the fiber backbone running around town. For wireless, we basically drop in a mesh network, tied to the fiber backbone, across areas that are difficult or already built but where there's a need for immediate solutions. We're using Firetide mesh to do this.

We then drop WiFi access points on top of that mesh, to create basically Internet free-access zones for people to come to parks or for the school district. At that point we said that's not enough. Let's drop reading of water meters, gas meters, electric meters and other controls into the mix. You bring it back across the mesh, across the fiber, and back to city hall.

Remember, you're getting your utility bill, you're getting water, sewer, gas, Internet, phone, TV all from us. Then you drop cameras on top of our mesh nodes and on top of fiber. And in doing that, our wireless and mesh solutions have been targeted at the applications we're going after and for what purposes they need it.

We use a lot of Proxim stuff, Tera-beam, and Firetide. The goal here for us as a municipality is to bring our mesh across the whole city, four square miles

of developed area. The cost if you built in today's dollars is about \$50 million with active WiFi gear and fiber. It is all underground construction.

We have a mesh network for public safety, but we're not using the 4.9 GHz band. We tried using WiFi 802.11a, at nearly the same frequency (about 5 GHz) in the parks, but the leaves and trees get in the way. We found 2.4 GHz much friendlier in a backhaul mode. To keep the throughput as high as possible, we have a two-hop rule. If the mesh requires more than two jumps between access points, we'll use fiber.

Question: Who were the resisters at Loma Linda when you proposed the original network?

Hettrick: The incumbents, Adelphia and Verizon, resisted when we did the ordinance. Verizon sent their lawyers to talk about what it meant for them. But because we hand off their service inside the house we enhance their service, so they really don't complain too much. And we invited them to use our fiber network. It's not as though it's a closed network at all. So there was really not any hostility.

Of course, there's always the type of people who come out and say it's not the government's role to be in telecom. They said that about electricity and about roads and sewers. They said it about everything except streets probably. You know what? It's the government's role to make sure the commercial interests of its citizens are met.

Also, Loma Linda made the decision that it's going to remain an ISP even after its service providers have joined the network, because there are certain services that we can provide to other government entities and to other private-public partnerships that will not be in the normal business portfolio.

Question: How about surrounding communities? How are they reacting to that?

Hettrick: We go to the perimeter of our city property. From there, if another town is proposing to have an interconnect with our network, we'll continue our network into their territory. It's staged for them so in the future if they want it, it is there.

Question: I spent more than my fair amount of time driving around in a vehicle with dark tinted windows checking for cellular interference. As you increase the density of the cell sites, you have to deal with your own interference from one access point to another. Not only is it the cell sites but the users, with omnidirectional antennas blasting at the cell site, hoping to talk to the site. And what about wireless for public safety?

Hettrick: We have one of the two proton accelerators in the world in town. Wireless doesn't really do too well. There's nine feet of concrete around it, and there are still interference issues. As things like that become more common for cancer treatment around the country, they will create dark bubbles for wireless.

Question: Did you have to fill gaps in the fiber system in Loma Linda, using wireless, though?

Hettrick: We used infrared free space optics as stopgap during our fiber network construction. A permit to cross the railroad tracks with fiber would have taken 16-18 months.

Sudeep Gupta Marketing Strategy Director, Alcatel

I want to talk mainly about WiMAX, and how we're envisioning fixed and mobile converging to change the way telecommunications looks today. First, you have the fixed operators who are doing broadband. That's what they're designed to do, and these days they do it very well.

Next, you have the mobile operators. Their key feature is, of course, mobility; that's what they're good at. That's what their business is all about. What we're starting to see is the mobile pro-

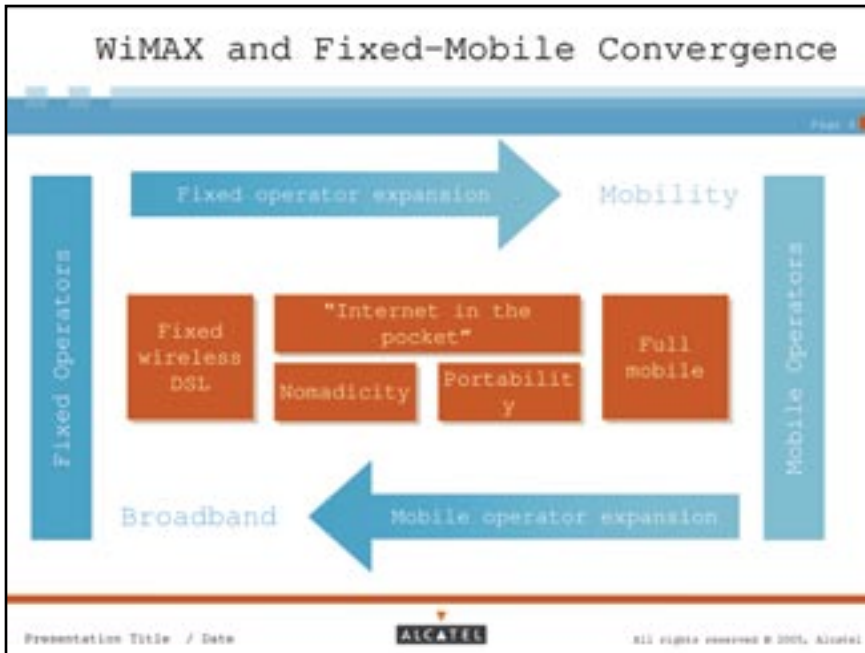


Figure 5: How Alcatel views the convergence of fixed and mobile operations.

viders and fixed providers migrating toward each other's business.

In areas where the fixed operators can not provide DSL-type connectivity for broadband, they now have the capability to do fixed wireless DSL through technologies such as WiMAX. That leads to what the industry is calling "nomadicy." You can move your user around, but it's not truly mobile. It's not like you're talking on the phone, but more like what you see with a laptop while traveling. This leads to portability, "Internet in the pocket."

We think WiMAX ties these two market segments together. WiMAX is the premiere technology for broadband wireless access. It fulfills the vision we have that broadband has to exist everywhere. It's not just about having it at your house, or having IPTV go into

your 50-inch plasma display. It's about taking the broadband Internet access anywhere.

Alcatel sees two major markets. First there's the next-generation mobile market. A lot of us probably have Blackberries. A lot of us are probably aware that GPRS is limited in access. Sometimes things don't respond that quickly with GPRS. The next generation of wireless and fixed users is going to change that because people are getting used to a broadband experience when they look at access. They want the instantaneous experience, no delay.

And what about the next billion users – the people who don't have Internet access today? We believe that wireless is obviously going to help those people because it is a lot cheaper to roll out wireless than to do fiber. It's easier to do that

not just for rural communities here in US but elsewhere in the world. You can provide Internet access in a cost-effective manner to the fishermen in India, for instance, who can now check market prices for fish before they pay for transport to bring their fish into town.

That sort of thing is enabled when you have ubiquitous Internet access, especially broadband access. Alcatel for the past two years has been behind the mobile standard for WiMAX, IEEE 802.16e, sometimes called 802.16e-2005; the standard was ratified in 2005. As was mentioned earlier, there is a fixed standard for WiMAX, 802.16d, that was completed earlier. They are not interoperable; they were not designed to be.

The mobile standard is not backward compatible to the fixed standard. I agree with Mike Young that regardless of whether you're doing fixed or mobile, the mobile standard makes more sense. The big benefits of that are lower costs (due to economies of mass production) and better interoperability with other vendors. As with WiFi, as a user when you've got mobility you've got to make sure you've got standardization – base stations, handsets, residential gateways, PCMCIA cards, or embedded chips that are put into laptops. All these things have to work together.

With more companies getting involved, mobility inevitably leads to lower costs because you have more competition. That's why we believe that even the fixed applications are better served by mobile WiMAX.

Alcatel is introducing a new WiMAX system; we're not the only ones. There is WiMAX equipment out there. We've been demonstrating our WiMAX system at trade shows all spring. We're also involved in several trials with WiMAX equipment at airports. There's a lot of interest in WiMAX out there, both with service providers and municipalities and a lot of people saying, "hey, this is the way to get broadband in a wireless manner more secure than WiFi but with more data throughput than cellular."

But what you're going to see is all these technologies being complimentary to each other; different types of devices

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will use a particular wireless method to access the Internet. We signed an agreement with Intel last year, as did many other partners working in this space, to make sure we can introduce interoperability to WiMAX. So you're going to see this same type of adoption and the same cost reduction we saw in WiFi.

Question: Why not expect all phone service to be VoIP in five years, rather than various types of cellular?

Gupta: If you look at the charts you'll see that traditional PBXs are moving away, and interfacing with wireless technology. For voice I don't see the bandwidth requirements that big. For video it's a debate.

Young: I don't know if you're going to see WiMAX displace any particular wireless network. The great example would be my house. I have a cable modem in my house, 3 Mbps. For video conferencing that's great. I can actually do multiple video conferencing sessions and I can I-chat. I'm a happy guy. But when I've got my Playstation2 on, at least running Starwars Battlefront, I can't videoconference anymore. I've got a lot of bandwidth going into my house by today's standards, but I simply can't do multiple services on top of it.

I think what you're going to find is that broadband access is going to become more available on specialized devices, which means you're not going to see everything collapse into a device you'll be holding. A great example of that: You see PDAs going away in favor of Blackberries and iPods. Those are two specialized devices. And they are very well done, which they can do because they are not trying to be everything to everyone.

When they have specialized devices out there, they're going to have different ways of connecting back to the Internet. So a 50-inch plasma display, you're going to go fiber with that. The next generation Playstation could be on WiMAX. So could a really tiny cell phone that needs to work deep in the interior of your house.

Young: The phone only needs about 9 Kbps. Shannon's Theory is that the higher the data rate you need, the better the signal-to-noise ratio you need, so the better signal you must have. Low data rates can get by with noisy signals, low-strength signals. At that low data rate, you can get a strong enough signal deep inside buildings. At 9 Kbps you can get signal levels which are very, very weak but will still work indoors. WiMAX, on the other hand, is megabits of data per second, so you need very strong signal levels, and you're not going to get that kind of coverage.

Question: In the house you have VoIP and maybe use it as a mobile phone off your laptop or with WiFi directly. Why can't you take it on the road and wouldn't that drive the WiMAX market?

Young: No, WiMAX is high data rate so you need strong signals for high bandwidth.

Gupta: The backbone will be WiMAX but the delivery technology will have four or five pathways to get to that backbone – cellular, VoIP, whatever. The other thing you're going to see is that the users produce a need to meet for wireless. But as the applications expand – telemedicine, better video, and so forth – bandwidth demand multiplies. That's why we justify fiber. **BBP**