Visions for 4G: Many Ways to Achieve Integrated Wireless Connectivity

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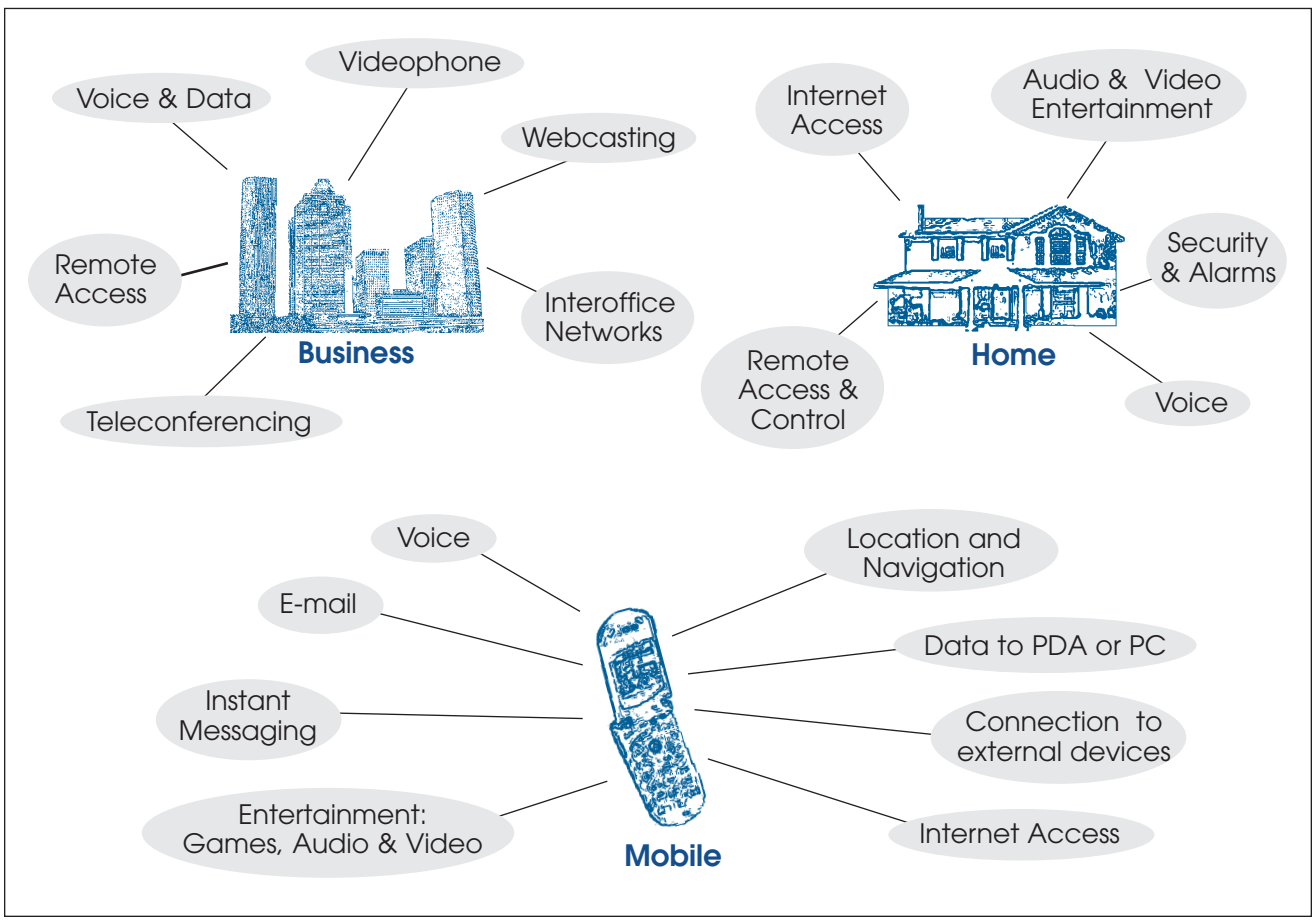
The next generation of wireless communications (4G) is the subject of much conjecture and debate. In simplest terms, 4G will be an integrated system of voice, data and image communications that will support a wide range of personal and business communications. Beyond that basic description, the view of 4G can be quite different depending on whose view is being presented.

First, let's review the evolution of wireless as successive generations of technology:

First generation (1G)—This is generally considered to be the first analog cellular systems and telephone capability over trunked radio services. A few commentators include cordless phones as part of 1G wireless.

Second generation (2G)—Digital-based cellular and PCS systems such as GSM, TDMA and CDMA. Some industry observers include Japan's Personal Handy Phone (PHP), Europe's DECT extended capability cordless phone technology, and unlicensed 900 MHz



What is 4G? This diagram shows many of the specific applications to be supported by a 4G integrated communications system.

and 2.4 GHz telephone and data services, mainly in the US.

Third Generation (3G)—This is the current generation of wireless technology, which is not yet fully deployed. The difficulty with defining discrete steps in wireless development is evident with 3G—a number of enhancements to wireless technology were even referred to as 2.5G. 3G's step forward is the addition of data communications to the familiar audio communications of a "wireless telephone." To be considered 3G, this data needs to be transferred at a useful rate for Internet and image communications.

Wireless Data (3G?)—Whether considered part of 3G or a parallel development, wireless data communications is definitely a precursor to 4G. This industry segment consists primarily of the various IEEE 802.11(*x*) WiFi standards, but also includes other less widely-used systems.

Competing Definitions of 4G

Beyond the basic description given in the first paragraph of this report, each industry segment has a different view of the path that will lead to 4G. Companies whose history is wireless telephony (cellular, PCS, GSM) consider the wide bandwidth extensions to their technologies to be the logical path to 4G. Proponents of wireless data—WiFi and WiMAX—see their technologies as being primary enablers for 4G. Ultra wideband (UWB) and ultra high data rate 60 GHz system developers believe that the capabilities of their technologies will be an essential part of 4G.

Even wireline broadband access providers are getting involved. DSL and cable providers already have significant penetration into homes and businesses. They argue that the integrated delivery system envisioned for 4G will be developed faster and more economically if their technologies are part of it. The still-developing fiber-to-home technology is receiving similar attention as a potential contributor to 4G.

At this time, 4G is experiencing the old-fashioned problem of "too many cooks in the kitchen." The diverging views of the road to 4G still need to be consolidated into a cohesive plan that can be presented to the marketplace.

Some of this work is already being done. In the organizational realm, mergers, acquisitions and partnerships among wireless and wireline companies are being implemented with future 4G markets in mind. In the technology realm, developers of WiMAX and other new high-capacity systems are proceeding with the assumption that they will be part of 4G, not just a standalone program delivery system.

4G System Architecture

One major challenge is matching the frequency, modulation and bandwidth with both the delivery method (fixed, portable or mobile) and the program content. In the mobile and portable environments, this process may be reversed, adapting program content to fit the available bandwidth. For example, the capabilities of 3G "mobile phone" technology are quite different than mobile WiMAX.

Of course, the nature of the communications devices plays a big role in this process, as well. For example, HDTV won't be much value on a 2" or 3" handset screen, so that type of video can be reformatted for lower resolution and less transmitted bandwidth.

On the other hand, as suggested by television commercials of a major wireless carrier, when that handset user arrives home, he or she may want to continue watching the same program on a big screen HDTV, with full quality and full bandwidth. That image must be sent separately, using a different transmission system.

The same scenario can occur in business communications. In a large meeting room, high quality video is desirable for video conferencing. But

a participant who is traveling may be using a handset, PDA or laptop PC, which require less resolution and less bandwidth.

4G will consist of a hierarchy of quality/bandwidth modes, organized somewhat like this:

- Voice, low-to-medium resolution images, moderate data rates. Current 3G "cell phone" technology and WiFi fit into this category.

- High quality audio, images with good quality on small screens (handset, PDA, laptop PC). This can be achieved with 802.11n, and WiMAX, with cable, satellite and DSL in supporting roles.

- Wide coverage with HDTV quality images, hundreds of Mbps data rates. Broadcast HDTV, digital cable, satellite and next generations of WiMAX/WiBro support this level of quality.

- Local distribution of HDTV quality images, hundreds of Mbps data rates. UWB, 60 GHz systems, and other developing technologies can address this application area.

Market Forces

At the bottom line is, well, the bottom line. Someone has to pay for new technologies—with nearly all revenue generated through fees paid by users of the programming that will be delivered.

With new technology, there is always some risk. Despite claims to the contrary, consumer demand rarely drives new technology, at least not directly. Using past consumer behavior and various forms of market research as a guide, promoters of new technology present consumers with new options to choose from. Some of those new services are accepted quickly, others more slowly, and some never become widely used (i.e., quadraphonic sound and video discs). Often, there is competition among similar, but incompatible technologies. Past examples include VHS and Betamax videotape and the first PC operating systems.

The priority assigned to each step in the development of 4G will be determined by a combination of the ability to develop the enabling technology—including both technical capability and the availability of investment capital—and the estimation of the size of the market for the new services it will support.

Technical Challenges

This report will conclude with a few of the technical issues that must be addressed in the near future to maintain progress toward 4G.

- Assure a robust backbone communications system to interconnect the wireless and wireline elements of 4G. Data must be routed efficiently to assure seamless transition from one mode of transmission to another.

- Complete the analysis and development of reliable high data rate transmission methods for the mobile environment. Much work has been done, but questions remain on the capabilities of mobile broadband systems as they operate at higher frequencies where propagation effects are more pronounced.

- Continue the search for an ideal handset form factor and feature set that will support voice, data, audio and video programming—and provide the necessary RF communications capabilities.

- Finally, and most important, continue the search for the optimal combination of program delivery technologies for each mode of operation—mobile, portable, home and business.

In our December 2007 issue, we will revisit 4G to report on progress in these and other areas of development.