What Lies Ahead for Cellular Technology?

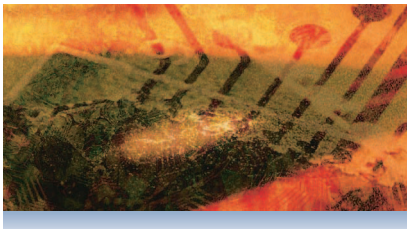
George Lawton

The ongoing goal of cellular services providers has been to make networks faster to enable new revenue-producing Internet-access and multimedia- and data-based broadband services, in addition to telephony. For example, carriers want to offer mobile Internet services as fast as those provided by cable- and DSL-based wireline broadband technologies.

This process has taken the industry through various generations of radio-based wireless service: After first-generation (1G) analog cellular service, they have offered 2G, 2.5G, and, since 2001, 3G digital technology.

However, 3G has disappointed many in the industry because of its high implementation costs and slow adoption and because its initial deployments didn't support services that carriers wanted to offer, said analyst Andy Fuertes with Visant Strategies, a market research firm.

As carriers upgrade their 3G offerings, they are looking perhaps five years ahead to 4G services, which would be based on the Internet Protocol and support mobile transmission rates of 100 Mbps and fixed rates of 1 Gbps. Presently the subject of extensive research, 4G would enable such currently unavailable services as mobile high-definition TV and gaming, as well as teleconferencing.



Wireless companies are thus preparing the transition to 4G from 3G, which could include 3.5G technologies, as the "Cellular Technology Hits the Road Again" sidebar explains. Some carriers are looking at new technologies such as IEEE 802.20.

Many providers, though, are simply upgrading the wireless technology they're already using, to avoid having to change their networking infrastructure.

However, this would continue the current problematic situation in which providers throughout the world work with incompatible cellular technologies. "It means more fragmentation, so roaming could be more difficult," Fuertes said. "Component makers would also lose some economies of scale."

FOUR CELLULAR PATHS

There are four categories of next-generation wireless technologies, typically implemented via chipsets, radio transceivers, and antennas.

GSM

The 2G Global System for Mobile Communications (GSM) technology, implemented in much of Europe and Asia, is based on time-division multiplexing. In GSM, TDM increases bandwidth by dividing each cellular channel into eight time slots, each of which handles a separate transmission. The channel switches quickly from slot to slot to handle multiple communications simultaneously.

GSM-based wireless services include 2.5G general packet radio service; 2.5G enhanced data GSM environment (EDGE); 3G wideband CDMA (WCDMA), used in the Universal Mobile Telecommunications System (UMTS); and 3.5G High-Speed Downlink Packet Access. All are currently in use except HSDPA, which is in trials.

"This year," said analyst Will Strauss with Forward Concepts, a market research firm, "we are forecasting that traditional GSM sales will be down by 20 percent in units and that UMTS- and EDGE-based technologies will be sharply up."

WCDMA, currently deployed in Europe and Japan, uses a 5-MHz-wide channel, which is big enough to enable data rates up to 2 Mbps downstream. The technology also increases GSM's data rates by using higher-capacity CDMA, instead of GSM's usual TDMA, modulation techniques. However, WCDMA uses different protocols than CDMA and is thus incompatible with it.

HSDPA uses a higher modulation rate, advanced coding, and other techniques to improve performance. Otherwise, HSDPA is similar to and can be implemented as just a software upgrade to a WCDMA base station, said Vodafone spokesperson Janine Young. Both technologies operate in the 2.1-GHz frequency range.

HSDPA offers theoretical and actual download rates of 14.4 Mbps and 1 Mbps, respectively. But, Visant Strategies' Fuertes noted, HSDPA addresses only downstream transmissions. HSDPA networks use existing

Published by the IEEE Computer Society

UMTS approaches for the network's uplink.

Thus, HSDPA supports applications that primarily require one-way high-speed communications such as Internet access but doesn't support two-way high-speed communications such as videoconferencing. High-Speed Uplink Packet Access technology will provide faster uplink speeds when finalized.

Carriers such as the UK's Orange, O2, and Vodafone; Japan's NTT DoCoMo; and the US's Cingular Wireless have already started trials of the technology on their networks. Fuertes predicts deployment will begin next year.

Telecommunications vendors such as LG Electronics and Nortel Networks are running trials of HSDPA equipment, such as base stations and handsets.

CDMA

The 2G code-division multiple-access technology, developed by Qualcomm and used primarily in the US, doesn't divide a channel into subchannels, like GSM. Instead, CDMA carries multiple transmissions simultaneously by filling the entire communications channel with data packets coded for various receiving devices. The packets go only to the devices for which they're coded.

CDMA-based wireless services include the 2G CDMA One and the 3G CDMA2000 family of technologies. All CDMA-based approaches operate at the 800-MHz or 1.9-GHz frequencies.

CDMA2000 1x, sometimes called 1xRTT (radio transmission technology), is at the core of CDMA2000. It runs over 1.25-MHz-wide channels and supports data rates up to 307 Kbps. While officially a 3G technology, many industry observers consider 1xRTT to be 2.5G because it's substantially slower than other 3G technologies.

CDMA2000 1xEV (Evolution) is a higher-speed version of CDMA2000 1x. The technology consists of CDMA2000 1xEV-DO (data only) and 1xEV-DV (data/voice).

EV-DO separates data from voice traffic on a network and handles the former. Initial versions support theoretical maximum rates of 2.4 Mbps downstream and 153 Kbps upstream. Recent revisions to EV-DO and EV-DV will support 3.1 Mbps downstream and 1.8 Mbps upstream theoretical maximum rates. Real-world rates are about half as fast, according to Forward Concepts' Strauss.

Vendors, led by Sprint and Verizon and joined by carriers such as Japan's KDDI and Brazil's Vivo, have supported EV-DO. This is driving down equipment costs, which should encourage further adoption. Carriers haven't yet started developing EV-DV.

The latest EV-DO revision reduces the maximum transmission latency from 300 to 50 milliseconds, making it more suitable for Internet telephony, which requires near-real-time responses. Strauss predicts the new revision won't be ready for implementation until 2008.

The International Telecommunication Union (ITU) recently approved the 3.5G CDMA2000 3x, also called CDMA Multicarrier. CDMA2000 3x would use a pair of 3.75-MHz-wide channels and is expected to provide high data capacity with transmission rates of 2 to 4 Mbps. No companies are deploying CDMA2000 3x yet.

WiMax and WiBro

WiMax (worldwide interoperability for microwave access) technology, based on the IEEE 802.16 standard, promises global networks that could deliver 4G performance before the end of this decade.

IEEE 802.16d, approved last year, has received support from numerous companies including Alcatel, Intel, and Samsung. However, the standard supports only fixed, point-to-multipoint, metropolitan-area-network technology that works via base stations and transceivers up to 31 miles away.

WiMax is fast in part because it uses orthogonal frequency-division multiplexing. OFDM increases capacity by splitting a data-bearing radio signal into multiple sets, modulating each onto a different subcarrier—spaced orthogonally so that they can be packed closely together without interference—and transmitting them simultaneously.

The IEEE 802.16e Task Group and companies such as Intel expect to finish work next year on 802.16e, which adds mobility to WiMax by using a narrower channel width, slower speeds, and smaller antennas.

The Task Group is still working on various aspects of the standard. Also,

Cellular Technology Hits the Road Again

Early mobile phones used first-generation (1G) cellular technology, which was analog, circuit-based, narrowband, and suitable only for voice communications. The dominant wireless-networking technology during the past few years has been 2G, which is digital and narrowband but still suitable for voice and limited data communications.

In response to disappointment with initial 3G approaches, network equipment vendors such as LG Electronics and Nortel Networks are developing faster 3G technologies. Carriers hope faster data rates will yield revenue from new services such as videoconferencing and mobile video and audio streaming.

Wireless carriers also hope to offer lucrative data services comparable to those provided by wireline networks but based on the lower-cost, wire-free infrastructure. The resulting lower prices could encourage more consumers to use wireless services for all communications.

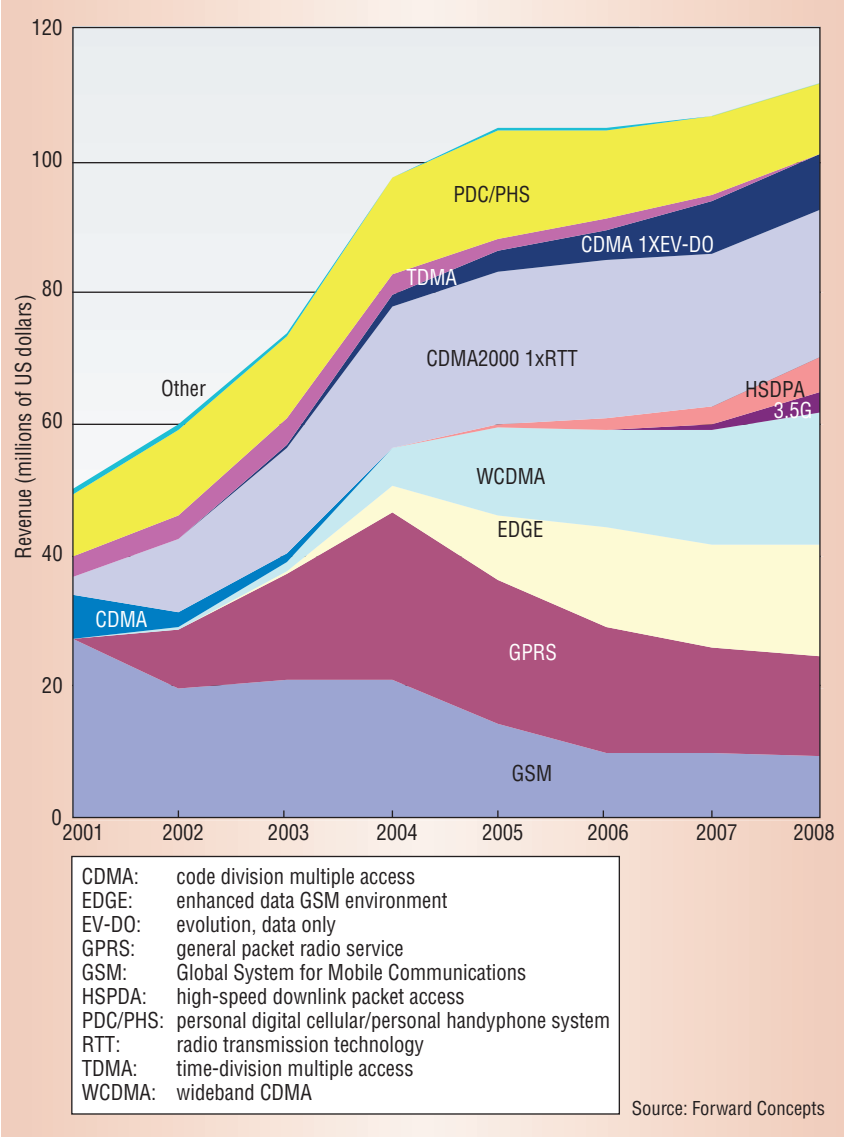


Figure 1. Future revenue generated by the sale of handsets that use the various cellular approaches will reflect the growing popularity of newer technologies, predicts Forward Concepts, a market research firm.

said Visant Strategies' Fuertes, "WiMax has yet to implement features, such as mobile authentication and handoffs, that are pivotal to a mobile network. This will take time and testing."

IEEE 812.16e will operate in the 2 to 6 GHz licensed bands and is expected to offer data rates up to 30 Mbps.

In South Korea, LG Electronics and Samsung have developed a technology called WiBro (wireless broadband), designed for use in the 2.3-GHz frequency band.

Proponents such as Samsung advocated basing IEEE 802.16e on WiBro. Intel and some other WiMax supporters opposed this because WiBro uses a different frequency band and carrier structure than IEEE 802.16.

An ongoing disagreement could have created two rival technologies, thereby splitting the market and inhibiting adoption. However, companies on both sides have agreed to merge the two technologies in IEEE 802.16e.

If the IEEE finishes work on 802.16e this year, said Intel spokesperson Amy Martin, "in the 2007 to 2008 time frame, we will see it in mobile phones and PDAs."

IEEE 802.20

An IEEE effort led by Flarion Technologies and supported by vendors such as Lucent Technologies and Qualcomm is developing a cellular standard—based on Flarion's Flash-OFDM—that could handle voice, multimedia, and data.

IEEE 802.20 will be a packet-switched technology operating between 400 MHz and 3.6 GHz that could offer optimal data rates of 6 Mbps downstream and 1.5 Mbps upstream.

Flash-OFDM, implemented primarily in Europe, works with OFDM and fast-frequency-hopping spread-spectrum technology, which repeatedly switches frequencies during a radio transmission. This sends a signal across a much wider frequency band than necessary, spreading it across more channels on a wider spectrum and increasing signal capacity.

In real-world systems, the average user would experience about 1 Mbps of downstream and 500 Kbps of upstream bandwidth, noted Ronny Haraldsvik, Flarion's vice president of global communications and marketing.

According to Fuertes, major vendors are presently focusing on other cellular technologies, which has put IEEE 802.20 on the back burner.

OTHER EFFORTS

NTT DoCoMo and Vodafone, the carriers that have invested most heavily in GSM-based technologies, have joined forces with companies such as Cingular and China Mobile to study a future WCDMA-based approach they call Super 3G. The Super 3G group says it will have specifications by mid-2007 and working systems by 2009.

The Radio Access Network Working Group of the 3G Partnership Project 2—a consortium of 200 wireless vendors and operators, including some in the Super 3G group—has begun studying a possible standard that supports wireless downlink speeds of 100 Mbps.

The 3GPP2—which develops 3G mobile systems based on the ITU's International Mobile Telecommunications-2000 (IMT-2000) project—expects to complete its study next year.

Industry observers predict that revenue generated by sales of handsets using various cellular technologies will reflect the increasing use of the newer approaches, as Figure 1 shows.

Nonetheless, the evolution toward 4G cellular technology is uncertain. According to Visant Strategies' Fuertes, 4G systems may well be based on an aggregation of network technologies, in part reflecting today's multiple cellular approaches.

Market-based, more than technology-based, considerations will drive broadband cellular's future, contended analyst Keith Nissen with publisher Reed Business. "In the long term," he said, "I see wireless broadband as an alternative to cable or DSL services."

Fuertes said 4G will be attractive for many services because carriers will want to move to an all-IP system that supports the many existing IP-based applications, such as videoconferencing, gaming, and wireless Internet telephony.

Meanwhile, he noted, carriers in countries such as China, India, Japan, and Korea are talking about developing their own new 4G standards, to give them control over the technologies used in their potentially lucrative mobile-communications industries.

In any event, proponents don't anticipate commercial deployment of 4G before 2010. ■

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