many of the approaches from 2G into a few key standards. IS-136, PDC, IS-95A, and EDGE all influenced the design of *UMTS*, a technology that uses *Wideband CDMA* (*WCDMA*). Meanwhile, IS-95B was extended to produce *CDMA 2000*.

Several competing standards evolved for third generation data services. *EVDO* and *EVDV* emerged at approximately the same time. Each of the two combines CDMA and frequency division multiplexing techniques to increase the overall performance. EVDO, which is either expanded to *Evolution Data Optimized* or *Evolution Data Only*, is the most widely deployed. EVDO comes in two versions that differ in the rate at which data is delivered: 2.4 Mbps or 3.1 Mbps. An alternative named *High-Speed Downlink Packet Access* (*HSDPA*) offers download speeds of 14 Mbps†. Of course, carriers charge more for services that offer a higher data rate. Figure 16.18 summarizes major 2G and 3G cellular standards.

Approach	Standard
GSM	GSM, GPRS, EDGE (EGPRS), EDGE Evolution, HSCSD
CDMA	IS-95A, IS-95B
TDMA	IDEN, IS-136, POC
WCDMA	UMTS, HSDPA
CDMA	1xRTT, EVDO, EVDV

Figure 16.18 Major second and third generation cellular technologies.

By the time fourth generation cellular technologies were being designed, smart phones had appeared, and it was clear that data would dominate cell phone use. In addition to downloading data and watching streaming video, users began sending files, images, and videos. To accommodate expected increases in data, the ITU published a specification for 4G cellular systems known as *International Mobile Telecommunications Advanced (IMT-Advanced).* IMT-Advanced specifies data rates of 100 Mbps while moving rapidly (e.g., in a train or car) and 1 Gbps while moving slowly (i.e., a pedestrian walking).

Vendors worked to create and deploy standards for 4G. Four early standards were *HSPA+*, *HTC Evo 4G*, *WiMAX* (described above), and a technology named *Long Term Evolution* (*LTE*). None of the early standards met the criteria specified by IMT-Advanced (e.g., LTE can only deliver 300 Mbps downstream and 75 Mbps upstream). However, the ITU decided that vendors would be allowed to advertise the systems as 4G. Therefore, vendors market LTE systems under the name *4G LTE*. Meanwhile, vendors developed standards that the ITU classifies as "true 4G": *LTE Advanced* and *WiMAX Advanced*. Figure 16.19 summarizes the 4G standards.

†A corresponding *High-Speed Uplink Packet Access* (*HSUPA*) protocol has also been defined, but has received less interest than HSDPA.