When all eight time slots of a GSM radio channel are dedicated to GPRS, an individual user is able to achieve as much as 171.2 kbps (eight time slots multiplied by 21.4 kbps of raw uncoded data throughput). Applications are required to provide their own error correction schemes as part of the carried data payload in GPRS. As is the case for any packet network, the data throughput experienced by an individual GPRS user decreases substantially as more users attempt to use the network or as propagation conditions become poor for particular users. Just as in the case of CDPD, and as described in Table 2.2, implementation of GPRS merely requires the GSM operator to install new routers and Internet gateways at the base station, along with new software that redefines the base station air interface standard for GPRS channels and time slots—no new base station RF hardware is required.

It is worth noting that GPRS was originally designed to provide a packet data access overlay solely for GSM networks, but at the request of North American IS-136 operators (see UWC-136 Air Interface in Table 2.3), GPRS was extended to include both TDMA standards. As of late 2001, GPRS has been installed in markets serving over 100 million subscribers, and is poised to be the most popular near-term packet data solution for 2G TDMA-based technologies. The dedicated peak 21.4 kbps per channel data rate specified by GPRS works well with both GSM and IS-136 and has successfully been implemented.

2.1.2.3 EDGE for 2.5G GSM and IS-136

EDGE, which stands for Enhanced Data rates for GSM (or Global) Evolution is a more advanced upgrade to the GSM standard, and requires the addition of new hardware and software at existing base stations. Interestingly, EDGE was developed from the desire of both GSM and IS-136 operators to have a common technology path for eventual 3G high speed data access, but the initial impetus came from the GSM user community.

EDGE introduces a new digital modulation format, 8-PSK (octal phase shift keying), which is used in addition to GSM's standard GMSK modulation. EDGE allows for nine different (autonomously and rapidly selectable) air interface formats, known as *multiple modulation and coding schemes* (MCS), with varying degrees of error control protection. Each MCS state may use either GMSK (low data rate) or 8-PSK (high data rate) modulation for network access, depending on the instantaneous demands of the network and the operating conditions. Because of the higher data rates and relaxed error control covering in many of the selectable air interface formats, the coverage range is smaller in EDGE than in HSDRC or GPRS. EDGE is sometimes referred to as Enhanced GPRS, or EGPRS [Noe01].

EDGE uses the higher order 8-PSK modulation and a family of MCSs for each GSM radio channel time slot, so that each user connection may adaptively determine the best MCS setting for the particular radio propagation conditions and data access requirements of the user. This adaptive capability to select the "best" air interface is called *incremental redundancy*, whereby packets are transmitted first with maximum error protection and maximum data rate throughput, and then subsequent packets are transmitted with less error protection (usually using punctured convolutional codes) and less throughput, until the link has an unacceptable outage or delay. Rapid feedback between the base station and subscriber unit then restores the previous acceptable air interface