Mobile phone measurement system based on robust industrial PC

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This article describes a modular measurement system to check the Quality-of-Service of mobile phone connections, using a robust industrial PC that can be flexibly adapted with various measuring modules.

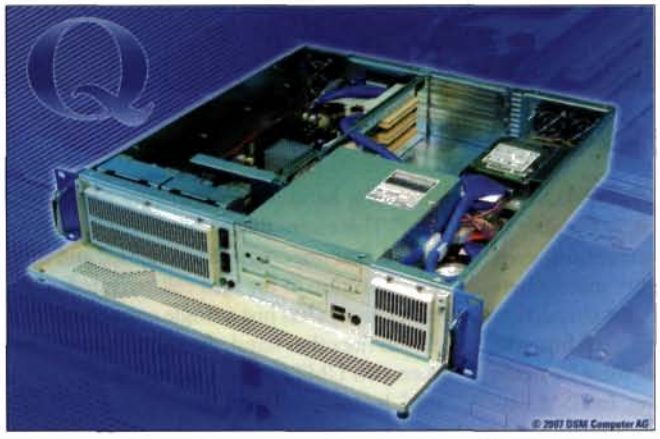

Figure 1. The modular construction of the robust Infinity M1584D industrial PC allows a wide range of measuring modules to be connected.

■ Irrespective of whether we use our mobile phone for business or private purposes, we expect it to function everywhere with full network coverage. Mobile phone operators must therefore give their customers the uninterrupted network availability of their assigned frequency bands. To ensure the quality of its network, the O_2 mobile phone company continually measures the quality of its phone connections and data transmissions. For this purpose, ten measurement vehicles equipped with sophisticated measuring equipment are constantly on the road, each vehicle annually covering over 60,000 kilometers in Germany.

Mobile phone signals are not transmitted at specific discrete frequencies, but over complete frequency ranges, or bands. The wider the assigned frequency band, the higher the data transmission capacity. To ensure broad coverage, the frequency band, and thus the data transfer rate, must be continually monitored. DSM Computers' robust Infinity M1584D industrial PC, which runs reliably even under harsh environmental conditions (figure 1), serves as a control computer for the mobile measurements. The modular construction of the compact 19-inch computer system, with many widely-used interfaces, allows to connect a wide range of different measuring modules, enabling the system to be easily adapted to the appropriate tasks. To ensure reliable operation in the vehicle, prior to delivery the CE-conformant industrial PCs were subjected to comprehensive tests and a 48-hour burn-in. The display mounted in the vehicle can be used to show immediately a topographical map with the recorded performance data (figure 2). Depending on the location, the measured data can be forwarded immediately to the mobile network planning office (figure 3).

Another important task for the mobile phone operator is to guarantee the stability of its installed network. The network planning, principally the antenna locations, must ensure that all geographic regions are optimally covered with signals. The network coverage area is determined by the completeness of all immediately neighboring and partly overlapping cells. A cell is designated as the coverage area of an antenna with its control and supply elements (base station).

For optimal reception not only the area coverage is important, but also the adaptation of the network capacity to the different regional requirements. For example, there are regions with a large number of users per area unit in inner-city areas or alongside motorways, and other regions with lower usage density per area unit in the countryside. A mobile phone user will however also want to make calls in isolated locations or inside buildings. This requires the optimisation of the cell size and capacity, because smaller cells permit higher usage density than large cells. If, for example, a mobile phone caller is traveling in a fast-moving car or train, the connection must be passed frequently from one cell to the neighboring cell. Structures with fewer, larger cells are favored for such cases.

Compared with GSM, the third mobile wireless generation UMTS has not only a higher data transmission speed but also a greatly improved transmission quality. UMTS uses the frequency bands 1920 to 1980MHz and 2110 to 2170MHz, whereas the GSM standard operates at 900 or 1800MHz. The technologies differ in the way in which the users share the transmission resources of a cell. For GSM, the available resource, the frequency channels and time slots, has a fixed assignment to a user. For UMTS, the mobile wireless subscribers share the signal power of a cell. This means they communicate within a cell concurrently with just one frequency. If a user exceeds the power levels assigned to them, the capacity of the cell for the remaining users reduces correspondingly. Because connections with different data rates and therefore power levels are continually being established or removed, the transmission conditions change continually within a cell. Additionally, the signals do not normally propagate directly, but rather the signals as received result from the superimposition of many

Figure 2. The mobile wireless measurement system with mobile wireless devices made by various manufacturers in a vehicle of the O_2 network operator.

Figure 3. The display installed in the vehicle provides a fast overview of the location-dependent transmitter power.

reflections from buildings or other objects. For a mobile phone connection, it is possible to move freely and without interruption, even over large distances. Because the mobile networks consist of individual cells, the connection must be passed to the neighboring cell from the cell it is leaving. This handover must be made without the subscriber noticing. In GSM networks, the handover is normally performed "hard". This means that within a very short time interval, first one connection is closed and then the connection to the next cell activated. Thus a caller always has just a single connection to a cell. On the other hand, the signal transfer between two UMTS cells is normally made as a "soft" handover. The reason is that a UMTS user is usually in contact not only with the nearest base station through a single connection, but is concurrently connected with one or even two neighboring cells. These multiple connections permit significantly better reception. This ensures good connection quality, and guarantees the ubiquity of the service even in remote areas or inner cities. ■