GSM System Approach
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Abstract
Within the Americas market there are three different digital technologies: GSM, CDMA and DAMPS, and a confusing array of technology choices. As the most deployed digital technology globally, GSM can provide the platform to cater for the challenges of user demands in the 21st century. Dr. Bhatia explains the GSM system design and discusses some of the value added services which will lead to differentiating multimedia services within the marketplace.

Since the beginning of large-scale deployment of cellular systems during the 1980's, the global wireless market has virtually exploded. Operators are now implementing completely digital second generation technology for the 1990's. Within the Americas market there are three different digital technologies: Global System for Mobile Communications (GSM), narrowband IS-95 Code Division Multiple Access (CDMA) and Digital Advanced Mobile Phone Service (DAMPS).

Central and Latin America face a similar future. The two regions are presently embroiled in the process of issuing licenses to new operators. Over the next two years, a rush of new operators will offer a confusing array of technology choices.

GSM: A Global Presence
The most deployed digital technology globally is GSM. With more than 200 GSM operators in 100 countries, its subscriber base has grown to more than 50 million worldwide in a matter of 5 years (see Figure 1). Served by three frequency bands (900 MHz, 1800 MHz, and 1900 MHz), GSM is a well-defined architecture that meets the needs of the different regions around the world.

GSM technology has been operational since 1992 and standardized for over a decade. The technological and evolutionary paths are stable and feature rich. GSM system architecture is well defined and continually updated with new market requirements by network operators and equipment manufacturers. The GSM groups in different regions are enhancing the GSM standard with new advances in data, coverage and capacity features demanded by end users.

Figure 2 describes the system architecture of GSM, comprising three network element subsystems: Network Subsystem (NSS), Base Station Subsystem (BSS) and Network Management Subsystem (NMS).

Designed to provide cost-effective coverage and capacity expansion, the Nokia GSM BSS is a proven technology for deployment ranging from rural coverage to high capacity applications. The BSS comprises three network elements: the Transcoder Submultiplexer (TCSM), Base Station Controller (BSC) and Base Transceiver Station.

The BSC is itself a switching platform based on a fault tolerant design. The key functions for this element are efficient call handling and optimization of the transmission network. The BSC provides a physical connection between the Mobile Switching Center (MSC) and the Base Transmitting Station (BTS). The Nokia BSC is designed to ensure reliability and availability enabling simplified control
Functionality. Flexibility in terms of remote installation is important as well.

Transmission efficiency is important in providing cost effective solutions. The TCSM is the element responsible for efficient transmission between the MSC and the BSC. Signals come from the BTSs into the BSC and are then passed along to the TCSM. The TCSM then concentrates the multiple signals in a four to one ratio and transmits the signal to the MSC. Remotely locating the BSC concentrates traffic as early as possible in the transmission link, thus providing maximum transmission efficiency.

Operators do, however, have the option of locating the BSC near the MSC. As operators have different coverage and capacity requirements, the configuration of base stations for specific conditions becomes an important issue. There are many different options and configurations to suit using either new microcellular technology or standard high capacity solutions.

The new microcellular type of BTSs, such as the Nokia PrimeSite Base Station, represent the next generation of GSM products and enables totally new deployment options for operators.

These base stations include a fully integrated single Transceiver (TRX), which has eight traffic and control channels and an integrated on-board antenna. Distinct advantages of the Nokia PrimeSite are its size, weight (55lbs) and ease of installation. In most cases, the pre-commissioned, pre-tested units can be installed by one person in about an hour.

Providing coverage within tunnels, shopping areas or a campus environment is a lot easier with microcellular technology. The PrimeSite can also be used as a regular base station for rural or difficult urban coverage.

The most widely used type of base station is a standard sized cabinet with a battery back-up support cabinet. These types of base stations can support up to 12 TRXs in a single cell within two BTS cabinets. These products incorporate the modular design techniques which give benefits in cost, expansion, installation and transmission efficiency.

Enhanced features, including frequency hopping, antenna diversity, multi-drop transmission configurations, dual duplexing and duplication of critical links, all add to the overall quality of the network.

Network Management Subsystem
At the core of the network is Nokia's NMS. Nokia's NMS/2000 and NMS/5000 have the ability to monitor the BSS, the NSS and also other important peripheral elements across a multi-vendor network.

In order to promote effective operations and maintenance, the management system provides the four following key elements over the lifecycle of the network: high-level view of the network; remote operations of the network; easy to use operations; and performance management tools. Nokia's NMS systems operate through a Graphical User Interface (GUI), which converts complex network management tasks into easy to see, easy to use operations.

The Nokia NMS provides overall network status information at a glance. The hierarchical user-
configurable network views provide a high level view of the operational status of the network elements. In a network element fault situation the operator will be able to trace and correct the problem quickly.

Many operations that are normally performed at a cell site can be done remotely from the NMS. Powerful tools for software, hardware and radio parameter management enable operators to have the correct information at their fingertips at all times. Changes to the network configuration can be made remotely from the NMS and time-consuming site visits are minimized.

The performance management tools help the operator with potential capacity or congestion problems in the network. A huge amount of performance data from the network elements are stored in the NMS database and can be post-processed with the tools provided by the NMS. Using the management reports from the NMS, operators can project expansion needs and implement network changes before capacity or coverage becomes a problem. All the performance reports created in the NMS are user-configurable.

**Network Subsystem**

There are two types of architecture philosophies for switching platforms in GSM 1900: either centralized processor based or distributed architecture. The centralized processor controls all functionality of the switching requirements with one processor or one processing unit.

Nokia's distributed architecture configuration has many processors throughout the network. Distributed architecture enhances the functionality of the network, creating a robust switching environment.

The switch can easily be reconfigured, and memory and processor requirements can be modified in individual units. Distributed systems allow easier expansion, redundancy, and specific customer orientated physical considerations such as power consumption, climate control and floor space.

The microprocessor embedded in the backbone of the processing capability and the software stability needs to enable fault tolerance, and an expansion path should be guaranteed, as processing power doubles in a relatively short time. The most obvious example is the Intel series of processors. These have increased from 25MHz to 100MHz in a couple of years.

The dimensioning and capacity of the switching platform and databases needs to be cost effective for all network sizes. For example, the Nokia DX200 platform allows a variety of configurations. Small systems would be based on a 10,000 subscriber MSC and a 75,000 subscriber Home Location Register (HLR). In this scenario the operator might expect a maximum of 9,000 busy hour call attempts (BHCA). Large systems would require a 150,000 subscriber MSC and a 300,000 subscriber HLR, equivalent to a maximum of 135,000 BHCA.

**GSM 1900 NSS Switching Elements**

The MSC and the Visitor Location Register (VLR) work together as a fully automatic switching system node. Although the MSCNLR are integrated on the same platform they are logically separate units. The MSCNLR is responsible for all the basic call handling and the interfaces to other switching elements both inside and outside the GSM network.

Generally, the three database elements are combined to provide comprehensive call information and
security for the network, consisting of the HLR, the Authentication Center (AC) and the Equipment Identity Register (EIR).

The AC and EIR handle security related issues. The AC maintains the subscriber identity-related security information together with the VLR. The EIR maintains the mobile equipment identity security information together with the VLR.

The open interface standard defines the A-interface and the Mobile Application Part (MAP) which allows the connectivity of multi-vendor equipment and the capability of roaming world-wide. Roaming is handled by the lower layers of SS7.

**Intelligent Network**

In order to provide new services in an efficient and cost effective manner, an intelligent network (IN) platform can be incorporated into the switching network architecture. IN must be incorporated with Short Message Service (SMS) and voice mail services. The main focus of IN is billing, call routing, or services features.

Advanced IN architecture will allow operators to create new services such as premium rating, calling cards, personal numbers, virtual private networks, family services and many others. The advanced tools offered to operators through IN services need to be flexible in order to produce unique end-user services and functionality.

The use of IN capabilities in the GSM network will enable operators to develop an exciting new generation of creative and innovative service packages. Such packages could include Family Service, Freephone, Calling Card, Personal Number and Virtual Private Networks, and other enhanced services. Customers will have the flexibility to choose from a package of services that closely correspond to their business needs and personal lifestyle. With the implementation of the IN solution, control of services is put in the hands of the subscriber. Subscribers will have the choice of handling calls differently based on the time, location or priority of the calling number.

Services could be accessed or barred depending on the same criteria, again placing the control directly into the hands of users. Subscribers will have access to an ever expanding pool of features and services that will make their life easier and, more importantly, generate additional revenue for operators.

**Value Added Services**

The GSM industry has progressed from radio modem pools to TCP/IP based data connectivity, and from the operators network to outside host computers. Nokia has in place, and is continuing to develop an array of wireless data solutions. The Data Communication Server (DCS), which is operational in many national networks, allows fast access to the Internet and corporate networks. The ability to bring data network connectivity to the market place takes an understanding of the integration issues, the two worlds of wireless networks and Internet/Intranet connectivity. Optimising the data path through wireless networks requires not only network design and deployment skills but also value added application skills.

Adapting existing applications for the wireless environment is not a simple process. Optimisation of the
underlying protocols need some development so that providers can quickly and easily support existing applications.

The GSM standard groups are working on High Speed Circuit Switch Data (HSCSD) and General Packet Radio services (GPRS) to enable their networks to cope with the demands of tele-video or the new data intensive applications. The market for value added services has not been specifically defined. However, the network infrastructure must be able to handle any type of data application requirements.

Internet connectivity is a fairly well defined transport to many new applications. Existing radio modem pools are unacceptable to mass users who expect similar 'instantaneous' connectivity through their wireless systems such as using optimised data servers like the DACS.

Summary
The GSM open standard interface policy has given operators the freedom to build multi-vendor networks. Open interface is a guarantee to operators of a competitive procurement market with continual development of features and services. The large number of operators and customers will ensure that features will be rich and focused on customer needs, throughout the world. The evolutionary nature of GSM and the strength of its core network will ensure that third generation networks requirements will be met by the development of its GSM standards.

The advances in IN capability and Nokia data solutions, and the continuing development of base station design ensure that GSM technology will continue to break new ground in wireless communications.

Conclusion
The GSM standard gives operators flexibility in the configurations of the network to meet desired traffic conditions. As traffic conditions change, the base station and switching platforms are easily expandable to accommodate the increased traffic and signalling requirements. The evolutionary path of these platforms should enable the operators to develop new services and features that will address the challenges of user demands in the 21st century.