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Swisscom Innovations' Programmes

WLAN-GPRS Integration: en Route to the 4th Generation Broadband Networks

The wireless cellular systems and the Internet are converging, as the demand for new services, increasing bandwidth and ubiquitous connectivity continuously grows. The next generation mobile systems will be based to a large extent on IP protocols. We are exploring some of the trends with the objective to offer seamless multimedia services to users who access an all-IP infrastructure via a variety of heterogeneous access technologies, meeting the demands of both enterprise and public environments anywhere and anytime.

The programme "Future Network Services" explores emerging technologies enabling wired and wireless, fix and mobile broadband services. A multitude of access technologies will coexist in the near future. Customers will be able to access the network, including voice services, through end devices supporting several access technologies, such as e.g. DSL, GSM, GPRS, UMTS, WLAN and Bluetooth. With its Innovation Programmes, Swisscom Innovations follows the objective of recognising early on the impact of technological developments, finding new business opportunities, promoting technical synergies, and developing concrete innovation proposals. Further, the expertise built up enables active engineering support of business innovation projects.

A user will in the future be able to work with his laptop or PDA anytime and almost anywhere. For example, he will be able to transfer data using WLAN when he is at the airport, and when coming into the train station

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he will automatically be switched to GPRS when losing the WLAN access. Applications on user's terminal equipment should not be affected by the change of technology. There are different solutions to cope with this bridging problem. They will be analysed in the following paragraphs.

Cellular Networks

The International Telecommunications Union (ITU) began its Third Generation mobile communications initiative in 1985 with the vision that there would be a single global standard. However, market conditions and drivers have proved to vary so widely in different regions that the ITU have now moved from the concept of one single system to a vision which accommodates a family of systems. The goal is now to establish global roaming among the various Third Generation technologies, with this task currently being led by 3GPP/3GPP2 forums. This family of systems is known as IMT-2000. In Europe, the technology choice is UMTS (Universal Mobile Telecommunications System) with UTRAN (UMTS Terrestrial Radio Access Network) defined as the air interface.

Global System for Mobile (GSM) is a second generation cellular standard that was developed to solve the fragmentation problems of the first cellular systems in Europe. It is the world's first cellular system to specify digital modulation and network level architectures and services. GSM was originally developed to serve as the pan-European cellular service and promised a wide range of network services inspired by ISDN (Integrated Services Digital Network). Its success has exceeded the expectations of everyone, and it is now the world's most popular standard for personal communications throughout the world.

The General Packet Radio Service (GPRS) is a carrier service for GSM that greatly improves and simplifies wireless access to packet data networks. It applies a packet radio principle to transfer user data packets in an efficient way between mobile stations and external packet data networks. In order to integrate GPRS into the existing GSM architecture, a new class of network nodes, called GPRS support nodes (GSN), has been introduced. GSNs are responsible for the delivery and routing of data packets between the mobile station and the external packet data network.

Quality of Service (QoS) requirements of typical mobile packet data applications are very diverse (consider real-time multimedia, Web browsing, and email transfer). Support of different QoS classes, which can be specified for each individual session, is therefore an important feature. GPRS allows defining QoS profiles using the QoS classes: precedence, reliability, delay and throughput.

Wireless Local Area Networks

A wireless LAN is an extension of a wired LAN. WLAN components convert data packets into radio waves or infrared (IR) light pulses and send them to other wireless devices or to an access point that serves as a gateway to the wired LAN.

The most used WLAN standard today is 802.11b. The equipment using this technology is quite cheap and offers relatively high data rates. Most 802.11 access points work as bridges between Ethernet 802.3 and 802.11.

The 802.11b standard considers no QoS, so a Medium Access Control (MAC) enhancement is required. The purpose of 802.11e is to enhance the current 802.11 MAC to improve and manage Quality of Service (QoS) requirements and support multimedia. Improvements in security and authentication mechanisms are in the scope of 802.11i. The 802.11i standard should be published by the end of 2003.

Handover and Roaming Concepts

Handover is the action of maintaining a path between the terminal equipment and the correspondent node when the terminal, in active mode, moves between cells of the same radio technology (horizontal handover), or between different radio technologies (vertical handover), with minimum interaction from the user. In the case of roaming, there should be mobility between administrative domains.

In order to make the transition from vision to reality, the mobile networks such as GPRS, WLAN, UMTS and beyond need to be based on solid technological and economical grounds.

The following three aspects need to be considered:

1. Support for mobile communications not only in terms of terminal mobility, as is currently the case, but also for session, service and personal mobility. Furthermore, this mobility should be available over heterogeneous networks, such as UMTS, WLAN and GPRS, as well as over fixed networks.
2. Integration of easy, yet efficient security, authentication, accounting and authorisation mechanisms with the service architecture. Without such integration, providers will not have the necessary means to control the services they provide and make revenue from users.
3. Support of flexible service creation architectures. Next generation networks will not only differ from current networks through higher bandwidth rates, but through a wider range of services. Such a variety of services can only be realised by using distributed, simple-to-use and enhanced service creation paradigms.

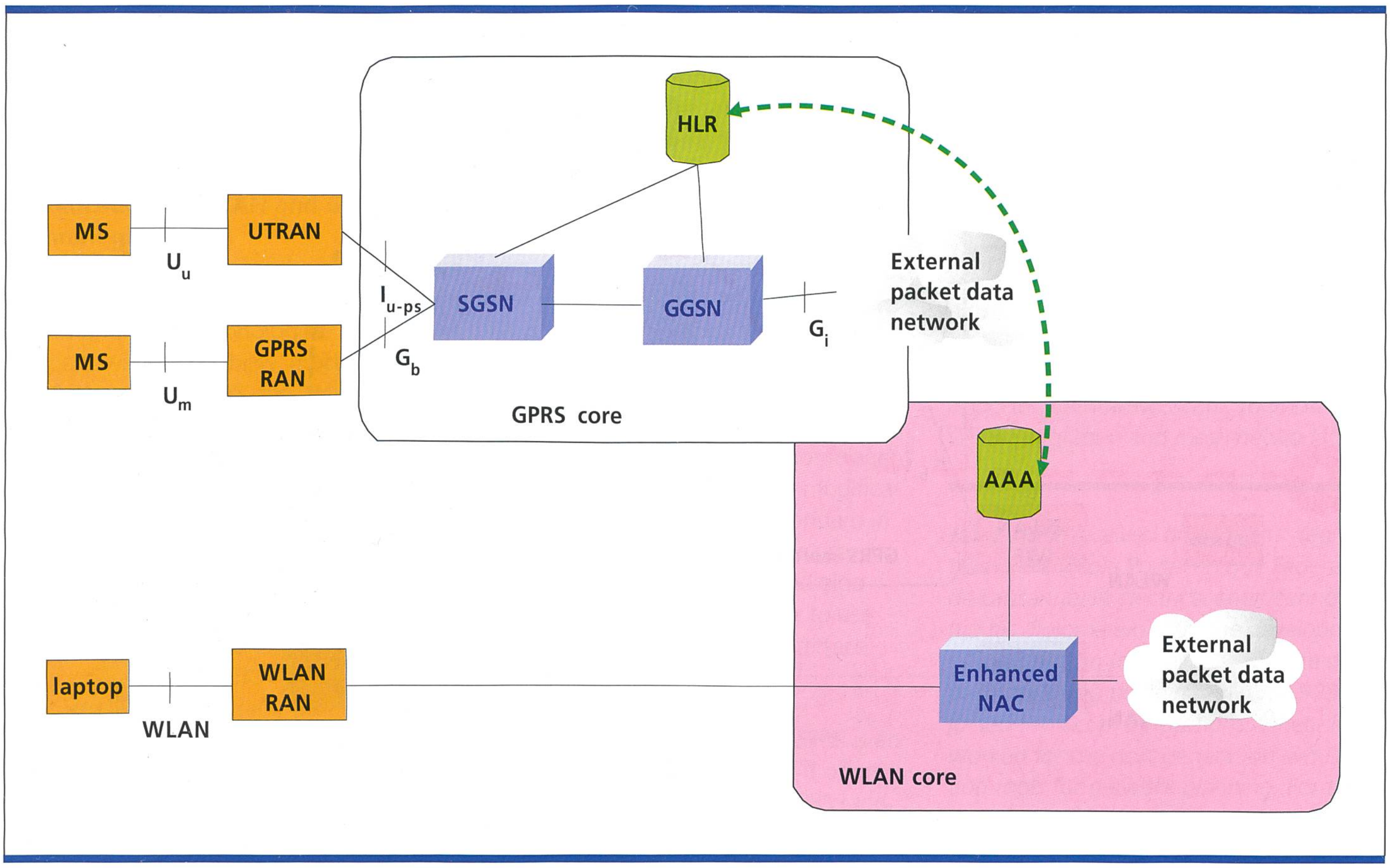

Fig. 1. Loosely coupled integration of WLAN and GPRS technologies.

The interworking between GPRS and WLAN is a foretaste of what UMTS will bring with higher data rates. An adequate implementation will offer the user both high coverage area with GPRS and high data rate with WLAN.

User Experience

With the large deployment of the cellular system, the notion to be always connected appeared and became common for most people. Roaming agreements between operators facilitate the use of mobile phones over the world and allow being reachable on the same number and still receiving one single bill.
Besides the voice services offered by the GSM technology, GPRS has been deployed to provide IP connectivity to the GSM users enabling mobile Internet services. Parallel to this new generation of services several access technologies have emerged, one of the most popular being WLAN, which took off extremely fast due to its numerous advantages (cheap, fast and easy). Thus, the user of such mobile technology will have the will to access data services with any wireless technology. He will want to be always connected in the same way he is always connected with his mobile phone today. The combination of the worldwide coverage of cellular systems with the high bandwidth of WLAN leads to the concept of being always connected optimally. For the realisation of this scenario a number of aspects need to be considered: relationships and agreements between operators and service providers, the always-on user experience concept and technical solutions in the terminal and network.
Mobile phones with traditional GSM/GPRS and CDMA technology will in the near future be improved with 802.11 technologies and enhanced by automatic switching of the network access point technology (3GPP R6).

Interconnection of WLAN and GPRS Technologies

Interconnecting two public networks can be done at several levels: authentication, data traffic and billing. The minimum interconnection level for a user is to be authenticated in the same way or with the same credentials in different networks. As far as WLAN-GPRS integration is concerned, this means the WLAN user can be authenticated with his mobile phone number. A further step of integration is not only to use the mobile phone number but the SIM card directly. It is quite easy to find a USB dongle (a device that is plugged on the USB port that can read SIM cards) where a SIM card is inserted. The SIM card is then used to authenticate the user on a WLAN network, and it brings the convenience of not having to enter a long login/password or mobile phone number, but simply the PIN (Personal Identification Number). For the operator, it also brings all the security mechanisms of the GSM SIM, and the IETF is currently finalising the standard for WLAN SIM authentication: EAP-SIM.
The EAP mechanism specifies enhancements to GSM authentication and key agreement, whereby multiple authentication triplets can be combined to create authentication response and encryption keys of greater strength than the individual GSM triplets. This mechanism also introduces network authentication, user anonymity and a reauthentication procedure. Such kind of authentication level integration is referred to as loosely coupled integration, and it is shown in figure 1.
One step further in WLAN-GPRS integration is to interconnect both data traffics:

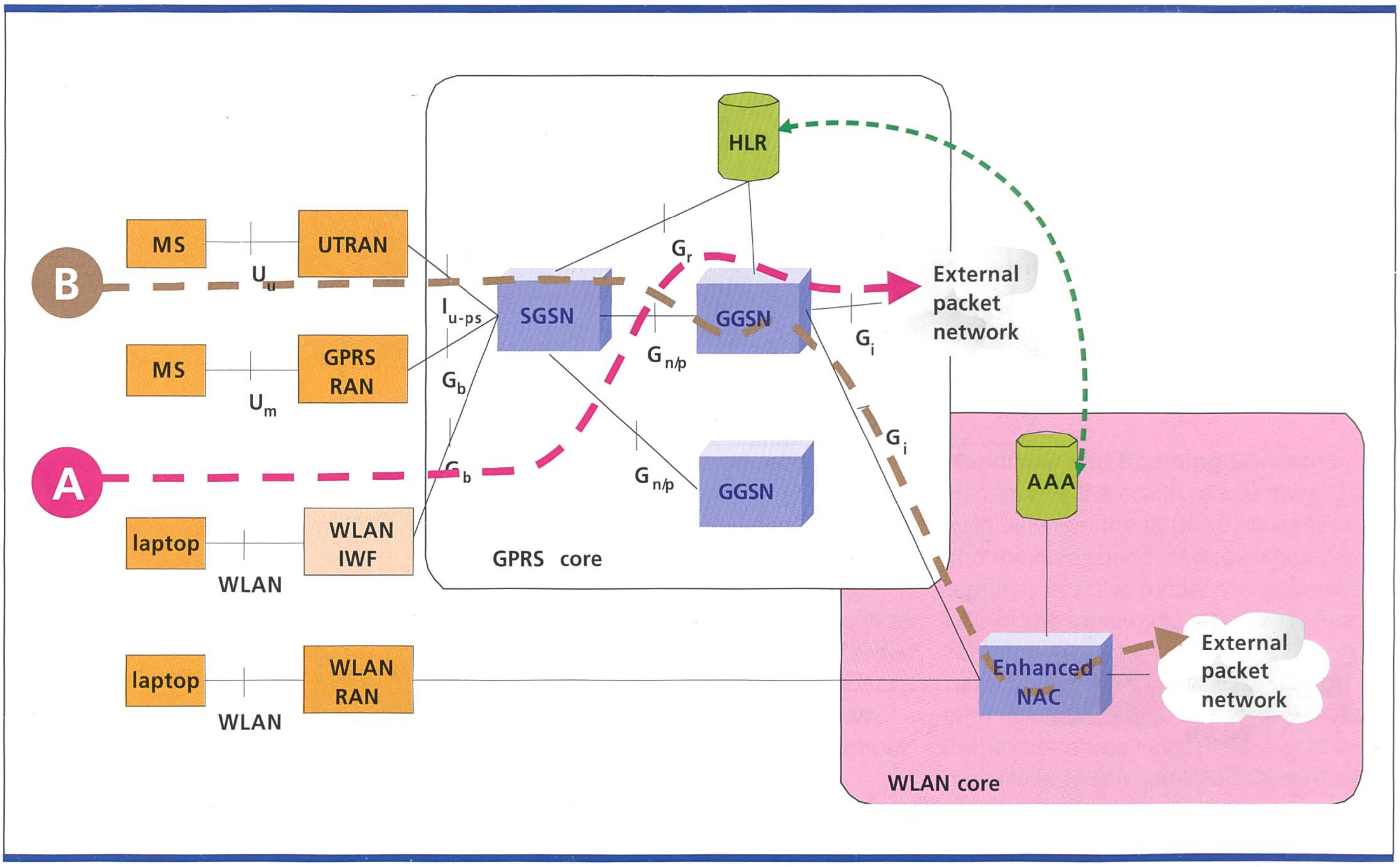

Fig. 2. Tightly coupled integration of WLAN and GPRS technologies.

either all WLAN traffic goes through the GPRS back-end infrastructure (fig. 2, path A) or all GPRS traffic goes through the WLAN back-end infrastructure (fig. 2, path B). The idea of connecting data traffics is to agree on the same services and user experience possible to be supported by both networks. This solution is called tight coupling.

In the case of the WLAN Radio Access Network (RAN) being connected to the GPRS infrastructure via an Interworking Function, the WLAN RAN is considered as another radio access method to the GPRS core (fig. 2, path A). The entire GPRS back-end infrastructure is then reused, minimising costs for new hardware.

In the case of the WLAN core being used to couple the GPRS infrastructure, most of the authentication and accounting of GPRS usage can be delegated to the WLAN back-end (fig. 2, path B). The GPRS infrastructure is then mainly used for GPRS mobility only.

In both cases such techniques easily allow billing the user on a single mobile phone bill. To do so, the traffic has to be monitored on a volume basis or time basis depending on the charging model chosen. Current platforms also allow content based billing. The authentication on both technologies is the first step to achieve for mobile subscribers. People having a GSM account are automatically registered to use GPRS infrastructure and they do not need special credentials to log on the Internet via their GPRS device (mobile phone device). Nevertheless, the WLAN user will use another terminal and will need new credentials to register on WLAN networks, especially on the public WLAN networks (PWLANs). This education is facilitated with the integration of WLAN in the GPRS thanks to the reuse of MSISDN and the SMS mechanisms, already well known by the cellular users. The benefit for the user is that he has the flexibility to use the same terminal for voice as well as for data services with the same subscription.

Mobility

Both GPRS and WLAN technologies enable mobility. GPRS standards define a broad mobility concept: from cell to countries. On the other hand, WLAN has a restricted mobility support based on switching from Access Point to Access Point, currently built on vendor proprietary mechanisms. The integration of the two networks can be considered as an advance if the indispensable measures are taken to seamlessly roam from one network to the other.

The simplest solution is to use Mobile IP: a Home Agent (HA) is installed in either the GPRS or the WLAN network, which is then called the Home Network (HN) and takes care of forwarding the IP packets to the other network, the Foreign Network (FN) for roaming. It either requires installing a Mobile IP client software on the user's laptop or a Foreign Agent in the Foreign Network. This solution is the Internet Engineering Task Force (IETF) answer to the mobility problem. But why not using the GPRS mobility capabilities?

The solution described hereafter applies in the case of tight coupling using the GPRS back-end infrastructure as described previously. In figure 2, the box named "WLAN IWF" is connected either to the GGSN or to the SGSN, so it simulates a SGSN or a PCU, respectively, for the GPRS network. WLAN users are considered by the GPRS network as any other GPRS users and the same mobility mechanisms can be applied; it either requires a client software on the user's laptop that will simulate the necessary GPRS mobility layers, or the WLAN IWF that fully takes care of the mobility and only recovers the IP packets from all the GPRS layers to deliver them to the WLAN user. Using client software facilitates IP addressing, whereas simply using the WLAN IWF can impose tough constraints to correctly route the traffic.

Demarcation of WLAN and GPRS Technologies

One of the difficulties for the operators is to provide dedicated services on both WLAN and GPRS technologies. Due to the bandwidth availability, much bigger in WLAN than in GPRS, the definition of the services portfolio should have some differences.
An important factor differentiating the two technologies is the Quality of Service (QoS). QoS is mandatory in the GPRS protocols but not present in the current WLAN standard (802.11b currently running for the majority of operators). The next generation of WLAN will have a bigger bandwidth and offer QoS.
For the user experience, QoS is not perceptible and often misunderstood. For instance, the definition of QoS is not only related to the bandwidth, which is often seen as a killer argument to deploy WLAN networks instead of the future generation of GSM telephony, UMTS. To guarantee the same quality level is a critical factor for the operators in order to give optimal performance for all its customers. But with the high penetration of the Internet access, more and more people are used to working with services based on best effort quality. The result is the success of WLAN technology.

Conclusions

Several different interworking architectures and approaches for the WLAN and GPRS integration have been proposed and explained, comparing their advantages and drawbacks. The European Telecommunications Standards Institute (ETSI) specifies two generic approaches for interworking: loose coupling and tight coupling. With loose coupling the WLAN is deployed as an access network complementary to the GPRS network. In this case, the WLAN utilises the subscriber databases in the GPRS network, but features no data interfaces to the GPRS core network. With tight coupling the WLAN is connected to the GPRS core network in the same manner as any other radio access network (RAN), such as GPRS RAN and UMTS terrestrial RAN (UTRAN). In this case, the WLAN data traffic goes through the GPRS core network before reaching the external Packet Data Networks.
All these solutions require some extensive challenges to be met for realisation. The largest problem seems to be related to the user equipment, which requires communication with lower level protocols on the Mobile Station for accessing SIM information. A complete implementation of these solutions should have the functionality to handle the mobility requirements efficiently, but at the price of an implementation complexity.
The IP level solutions are easier to implement. Implementation of the home agent and foreign agents requires no modification related to the mobile IP standard in most of these solutions, but the user equipment requires some added algorithm for the selection of either to use GPRS or the WLAN network interface.

Outlook

The integration of WLAN and GPRS is an important step towards UMTS. It offers the high coverage benefit of GPRS (and even a high data rate with UMTS in the future), and also provides the WLAN broadband potential at given hotspots. The way these two networks will be integrated is still under study and every predictable scenario opens a diversity of architectural issues.
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Abbreviations

3GPP	3rd Generation Partnership Project (www.3gpp.org/)
AAA	Authentication, Authorisation and Accounting
DSL	Digital Subscriber Line
EAP-SIM	Extensible Authentication Protocol – Subscriber Identity Module
FN	Foreign Network
FA	Foreign Agent
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GSN	GPRS Support Node
HA	Home Agent
HLR	Home Location Register
IETF	Internet Engineering Task Force
ISP	Internet Service Provider
ITU	International Telecommunications Union
IWF	Interworking Function
LAN	Local Area Network
MAC	Medium Access Control
MSISDN	Mobile Station Integrated Service Digital Network Number
NAC	Network Access Controller
PCU	Packet Control Unit
PDA	Personal Digital Assistant
PWLAN	Public Wireless Local Area Network
SGSN	Serving GPRS Support Node
USB	Universal Serial Bus
UTRAN	UMTS Terrestrial Radio Access Network
UMTS	Universal Mobile Telecommunications System
WISP	Wireless Internet Service Provider
WLAN	Wireless Local Area Network

Zusammenfassung

Heutzutage können Mobilnetzkunden als Ergänzung zu GSM-Sprachdiensten eine IP-Verbindung über GPRS mittels des Mobiltelefons erstellen. GPRS bietet sich somit als flächendeckenden mobilen Internet-Zugang an. Gleichzeitig hat sich seit einigen Jahren die WLAN-Technologie dank ihrer vielen Vorteile (schnell, billig, einfach) als weitere mobile (Internet-) Zugangstechnologie etabliert. Um den Kunden in Zukunft einen optimalen mobilen Internet-Zugang anbieten zu können, der die Flächendeckung von GPRS und die Bandbreite von WLAN vereint, müssen noch einige technologische Aspekte analysiert werden.
Im Projekt Atlantis werden unter anderem die Möglichkeiten untersucht, wie das öffentliche WLAN- (PWLAN) und das GPRS-Netz verbunden werden können. Dies kann auf drei Ebenen geschehen: Authentisierung, Datenverkehr und Verrechnung. Bei der IETF wird momentan an der Standardisierung für die SIM-basierte Authentifizierung in WLAN-Netzen (EAP-SIM) gearbeitet. Eine Verbindung der WLAN- und GPRS-Netze wird als «schwach gekoppelte Integration» bezeichnet (loosely coupled integration), wenn es sich weiterhin um zwei separate Datentransportnetze (WLAN und GPRS) ohne Interaktion auf Signalisierungs- oder Datenebene handelt. Eine stark gekoppelte WLAN-GPRS-Integration (tightly coupled integration) besteht dagegen aus einem gemeinsamen Datentransportnetz. Dabei kann der gesamte Datenverkehr über das GPRS-Datennetz oder über das WLAN-Datennetz geführt werden. Dadurch kann den Kunden eine einzige Rechnung für beide Netze gestellt werden.
Eines der grossen Probleme bei der Integration von WLAN und GPRS sind die Benutzerendgeräte. Eine komplett integrierte Lösung mit WLAN- und GPRS-Funktionalität sollte Protokolle für die SIM-Informationsbearbeitung sowie eine effiziente Handhabung von Mobilitätsanforderungen vereinen. Die Integration von WLAN und GPRS ist ein erster Schritt in Richtung UMTS.

FORSCHUNG UND ENTWICKLUNG

US Army bestellt tragbare GSM-Netze

Die US Army hat mit Cell-Tel Government Systems einen Vertrag über den Kauf von vorerst drei speziellen MilWave GSM-Netzen geschlossen. Cell-Tel vertreibt und integriert interWave-Hardware. Die Entscheidung stellt einen Rückschlag für die amerikanische Anti-GSM-Lobby dar. Darrell Issa, der republikanische Abgeordnete im US-Kongress, hatte mit einer Aktion gegen die «französisch-deutsche Technologie» GSM für internationales Kopfschütteln gesorgt. Der Politiker aus San Diego, wo sich die Zentrale von Qualcomm, Entwickler der konkurrierenden CDMA-Technologie, befindet, hatte gegen die Pläne zur Errichtung eines GSM-Netzes im Irak gewettert und «Hunderttausende amerikanische Jobs» in Gefahr gesehen. Nun dürfte aber gerade die Entscheidung des US Army Communications-Electronics Command, das «Network in a Box» (NIB) von interWAVE zu installieren, amerikanische Jobs sichern. Das NIB vereint ein komplettes GSM-Netz mit Mobile Switching Center (MSC), Base Station Controller (BSC) und Sendestation (BTS im 850, 900, 1800 und 1900 MHZ-Band) in einem Gehäuse etwa von der Grösse eines PC-Towers. Es kann von zwei Personen getragen werden und erfüllt damit eine wichtige Anforderung der Armee. Versprochen wird schnelle und einfache Inbetriebnahme, wobei das NIB als eigenständiges GSM-Netz oder zur Erweiterung bestehender Infrastrukturen eingesetzt werden kann. Auch die Anbindung an Satelliten, Kabel- oder Richtfunkverbindungen ist vorgesehen. Bis zu 100 Gespräche (Full Rate) können über ein NIB gleichzeitig abgewickelt werden. Die von Cell-Tel integrierten Zusatzlösungen ermöglichen sichere, verschlüsselte End-to-End-Kommunikation über öffentliche und private Fest- und GSM-Netze.

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