Interworking Between Mobile Cellular and Fixed Networks

SURF Communication Solutions

Today's global wireless communications infrastructure is probably best described as incompatible. North America, Europe, and Asia all followed different upgrade paths when they moved from 1st Generation (1G) analog to 2nd Generation (2G) digital technology. 3rd Generation (3G) Wireless intends to bridge the gaps that exist in todays 2 and 2.5G networks by defining a set of standards that will enable interoperability and backward compatibility with today's networks. This paper will give a brief background on 1G and 2G technology, and focus on the importance of the IWF (InterWorking Function) in 2.5G and 3G networks, showing that flexibility and forward compatibility is best achieved with software based solutions.

1st Generation Mobile

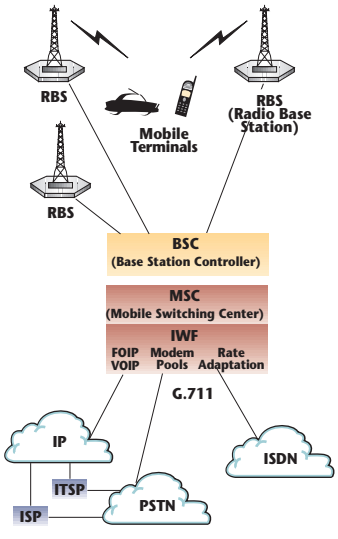
First generation mobile (1G) (e.g. AMPS , TACS, NMT) were based on analog air interface technology, and predominantly offered voice services.

The analog air interface meant that the voice signal was transmitted over the air (radio transmission) in an analog form. The conversion of the voice signal to a digital format was handled at the Mobile Switch (MSC - Mobile Switching Center) which connected to the Central Office (C.O.) via digital trunks (E1/T1).

Since the "killer application" of those times was mobile voice, data services over these networks were not really mainstream. In order to implement "mobile office" services (i.e. fax and modem) over the analog wireless network (which was designed specifically for voice), special subscriber units/devices had to be designed. These units allowed a connection of a fax/modem with a 2 wire interface or by means of some variant of an acoustic modem coupled with the mobile subscriber unit. This solution for transmitting data over the analog cellular system resulted in low rate transmissions which were very dependent on a good radio connection. Without the proper infrastructure to support it, data services would not be made widely available until 2G technology came along.

2nd Generation Wireless

2nd Generation Wireless (2G) systems (they are sometimes calld PCS - Personal Communication Systems, after the radio band allocated for them in the U.S.) are characterized by digital air interface technology, small handheld terminal units, and the data services that they support in addition to voice. 2G systems are currently the most widely deployed systems and are based on one of two air interface technologies: TDMA (Time Division Multiple Access) and CDMA (Code Division Multiple Access). There are three different system types based on the TDMA method: GSM (Global System Mobile) a European standard, TDMA IS-136 an ANSI Standard deployed in North America, and PDC, a Japanese TDMA standard. The CDMA systems are based on the American cdmaOne™ (ANSI IS-95) standard. Along with the development and proliferation of the 2G wireless systems came an increasing demand for data services by the common telephone network subscriber. Economies of scale brought fax machines and personal computers to nearly every household, and the Internet emerged as an integral part of communications. Most Internet users access the web via PSTN modems.



Mobile Wireless Network Configuration

The 2G IWF

Enabling access to PSTN data services from the mobile cellular networks introduced a new problem: 2G mobile cellular systems used narrow digital air interface channels. Voice is transmitted digitally using voice compression algorithms (Vocoders = low rate encoders decoders). Because these vocoders are specifically designed to transfer (compress) voice signals, analog modem signals do not pass well through these devices, and integrity is compromised.

The designers of the systems had two alternatives in order to enable the transmission of the commonly used data services (fax and modem) from the mobile units to the home via the PSTN.

The first alternative would be to add a 2-Wire analog interface and an internal modem to the mobile units, so that a regular fax machine could plug into the mobile unit the same way it plugs into the home POTS jack. This solution has the advantage of enabling the connection of a regular fax machine or PC modem to the mobile terminal, however it does not guarantee good data connections. The main drawback of such a solution is the additional cost and weight associated with the subscriber terminal due to the additional hardware components required.

The second alternative was to build a central translation unit at the mobile switch which would provide a translation layer between the air interface data format and the PSTN data format. This translation unit is called the IWF (InterWorking Function). Because the function was managed at the switch, it was only necessary to support a defined number of channels at any given time - an obvious advantage over having a dedicated device in every subscriber terminal. The disadvantage was that ordinary plain paper fax machines could not be used - only PC based fax machines or a specially built machine with a proper digital outlet to connect to the mobile could be used.

Since the number of fax and modem calls over cellular networks was small relative to voice calls, the IWF was not required to include a big bank of modems. The IWF units are built as a central modem bank or pool with printed circuit cards holding many individual modem chips. Data calls are diverted through the IWF where the data is modulated digitally in the direction to the PSTN and is demodulated in the direction from the PSTN.

Over the short period of time since the advent of the IWF, it has become necessary to upgrade IWF units based on advances in PSTN modem technology. The first IWFs implemented with hardware modem pools will need to be replaced by new units that can accommodate higher transmission rates as well as emerging technologies. Instead of using traditional dedicated modem hardware, companies are implementing software based universal ports, which will allow them to build increased flexibility into IWF platforms. By using Software Access Solutions (SAS), OEMs can offer a product that will be software upgradeable, and eliminate the need for the expensive “forklift” upgrade.

3rd Generation Wireless

3rd Generation wireless, or 3G, represents the next generation of mobile wireless systems and services. In the wake of the enormous economic success of 2G, there are great expectations and efforts to make a quantum leap between 2G and 3G.

There are many ongoing activities focused on the definition of standards for 3G. The efforts to harmonise all standards between different standards bodies, countries, and regions has only partially succeeded.

As with the 2G systems that preceded it, it is clear now that these efforts will not result in one standard, but rather in a set of standards.

For the Radio Transmission Technology (RTT) there will be at least 3 standards:

- WCDMA - a wideband CDMA system based on a joint European/Japanese effort.
- CDMA2000 based on ANSI IS-95/cdmaOne
- An RTT having downward compatibility with the TDMA ANSI IS-136.

The 3G systems will also be compatible with the 2G terminals. The mission of 3G is twofold:

1. Providing the user with new high bandwidth services anywhere anytime:

    Mobile data rates - up to 384Kbps (6 x 64Kbps).

    Fixed data rates - up to 2 Mbps (E1) per user.

2. A full Convergence of Voice, Data, Fax, Internet and Video services to the user.

2.5 G Wireless

Until 3G systems are ready for deployment (probably circa 2002) there are ongoing activities taking place to enhance the data transmission capabilities of existing 2G systems. The explosiveness of the internet is putting pressure on the providers of wireless systems to offer more bandwidth to the mobile user even before the 3G systems will be ready. It is well understood that achieving such a great leap between current mobile data rates and the intended 3G rates has to be, in some way, an evolutionary process.

The interim stage has been named, not surprisingly, 2.5G wireless. 2.5G wireless is an enhanced version of the 2G wireless systems, offering new data capabilities. These new data carrying capabilities are being implemented by introducing upgrades to the systems called:

HSCSD - High Speed Circuit Switched Data.

GPRS - General Packet Radio Services.

EDGE - Enhanced Data rate for Global Evolution.

HSCSD: (High Speed Circuit Switched Data) increases the speed of the Air Channel by changing the error correction code and aggregating channels. This method has first been implemented in Finland (Nokia) and in Singapore. HSCSD engages the air channel for the entire call duration (which appears wasteful but will be efficient for applications such as file transfer and video transmission).

GPRS: (General Packet Radio Services) transmits the data in packets over the air interface, thus being more suitable for connection to data networks, such as the internet. GPRS will provide the mobile customer with data speeds up to 115 Kbits (using data compression).

EDGE: (Enhanced Data rate for Global Evolution) will increas data rate on the air interface threefold by using a new modulation method 8PSK (3 bits/Symbol) instead of GMSK (1 bit/Symbol). This will allow data rates of up to 384 Kbps over the air (subject to favorable transmission conditions and major changes in infrastructure deployment). EDGE will be applied to HSCSD (ECSD) and to GPRS (EGPRS).

What is Driving the Requirements for Today's IWF?

Convergence. The explosion of Internet services and the trend of converging voice and data services on single networks are resulting in the rapid expansion of data networks (IP, FR and ATM) alongside the PSTN and ISDN.

Today's mobile networks will have to interoperate with all of these new networks. The mobile network will connect to the IP network through a gateway to send voice calls (VoIP) and faxes (FoIP). It may also require interworking functionality with an ATM or Frame Relay (FR) network. Certainly the mobile network will have to maintain its full interworking capability with the PSTN and ISDN data services.

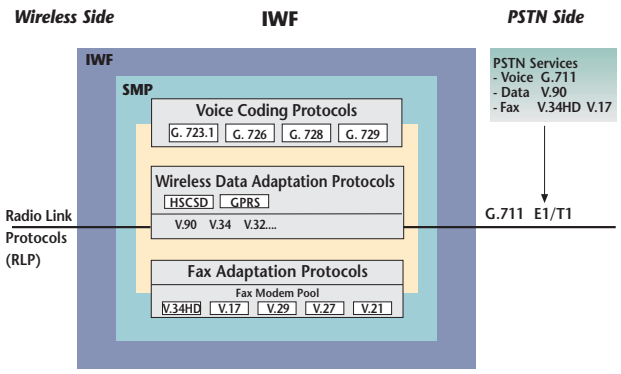
Although there is much talk about the impact of broadband connections to the home (cable modems, ADSL to VDSL, LMDS etc.), traditional dial up service (V.90, 56K) will remain a critical part of the communications infrastructure for the foreseeable future.

The Right Solution - Flexible, Scalable, Forward Compatible

The new IWF will be implemented using a generic platform that can support all connected networks and all services at the same time. It will be an intelligent software based system that can accommodate expansions for new functions and services. Because it will be based on a software-centric solution, the IWF will have a natural upgrade path that includes flexibility, scalability, and the ability to support new standards and technologies as they evolve.

The new IWF will be comprised of a multi-channel scalable interworking functionality resource pool. This resource pool will be built on multiple DSP units working in unison. This "DSP Farm" will behave as if it were one multi-channel multi-protocol multi-algorithm machine. In addition, today's DSP technology allows developers to pack more channels into less space with lower per-channel power consumption, reducing overall system cost. A lean (in terms of MIPS consumption) and agile resource manager will be needed to schedule and manage the concurrent protocol conversions that are critical to a dynamicly operating IWF.

This approach will help facilitate full convergence of voice, fax, PSTN modem, video and Internet services to any of the connected fixed networks.



Surf Multi-access Pool (SMP) is a generic building block for maintaining seamless interworking between wireless side & the PSTN services.

Surf's Solution for the New IWF

Surf Communication Solutions has developed a framework to address the requirements of the new IWF. Called SMP (Surf Multi-access Pool), the framework is the optimal building block for software multi access pools which are needed to build flexibility, scalability, and forward looking platforms.

The SMP is a resource manager specifically designed to manage real time protocols on a DSP. It manages many protocols concurrently and changes between the

managed protocols dynamically as required by the application.

The SMP is very efficient in terms of processing requirements. Its overhead consumes only a small fraction of the total power available on modern DSPs. For future DSPs the relative power needs for management will be reduced accordingly.

The SMP allows flexible introduction of protocols of different nature, enabling true convergence of Voice (vocoders), Data (PSTN modems) and Fax (fax modem data pumps and higher level protocols) running concurrently on the same DSP.

Several DSPs can be aggregated to operate as one pool of resources with Surf's Super SMP product. The Super SMP manages several DSPs as a single resource pool. Again, the DSP Farm is managed as one big resource pool, providing easy scalability of the system by allowing additional DSP resource boards to be added as necessary.

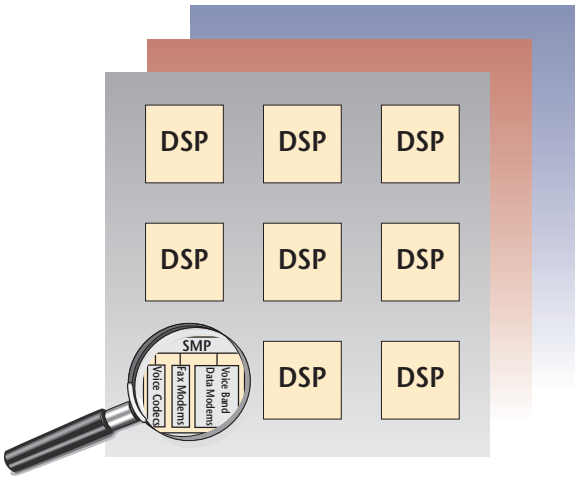
The SMP provides full data for statistics and management by means of SNMP management hooks to the systems central OAM&P unit.

New protocols can be added or older protocols can be replaced by means of code upgrades.

The SMP maps extremely well to the requirements of the new IWF:

- Management of multiple protocols running concurrently
- Dynamic allocation of different protocol algorithms on the fly
- Scalability
- Software enhancements and upgrades
- Extensive management data

Hardware Configuration



Surf Multi-access Pool (SMP) runs on each DSP
The IWF shelf is made of multiple DSP farms

Examples of IWF Related Implementation Using the SMP

2G IWF upgrades

2G IWFs are implemented using hardware with multiple single channel modem chips on boards. These modems usually cannot be upgraded without replacing the hardware. In addition the older modems offer very low density (i.e. one modem per chip). These boards are replaced with a software modem board containing DSP units running the SMP. The SMP simultaneously runs multi channels of fax and data modems at the highest rate the air link allows. (e.g. if the air link allows only a maximum rate of 9.6 Kbps the modem pool will operate at that maximum speed). In this case, each SMP running on a single DSP deals with a full E1 - 30 simultaneous channels. The same boards running the SMP can be upgraded (by code download) to act as an HSCSD IWF.

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HSCSD IWF

HSCSD aggregates several air channels and provides modem speeds up to 56Kbps. Surf has implemented An HSCSD IWF using its SMP software and DSP modem software.

GPRS Interworking

Even though GPRS is based on packets over the air, interworking with the PSTN is required. Surf together with customers is participating in a definition phase for implementing Surf's protocols for GPRS functions interworking with PSTN services.

Protocols that Are Currently Provided by Surf

Surf Communication Solutions has been a leading provider of DSP software for Telecommunications applications since 1996.

The suite of products includes:

- A full range of PSTN data modems (V.90 and all fallbacks) implemented on a range of DSP platforms.
- A full fax adapter (fax relay) for a mobile cellular network which includes all V.fax standards (V.34 HD, V.17, V.29, V.27ter, V.21) and GSM standard 3.45.
- Rate adaptation implementations for GSM and ISDN (V.110, V.120).
- A full set of ITU-T vocoders: G.711, G.723.1/A, G.726, G.728, G.729, G.729A/B, G.722, G.165, G.168
- The following control level protocols:

ECDC V.42b, V.42bis, MNP2-4,5

- Voice Jitter Buffer, RTP, RTCP support, Voice QOS.
- T.38 FoIP support

Surf is implementing its software modem for both HSCSD and GPRS IWFs using its unique SMP™ (Surf's Multi-access Pool) DSP resource management software. As important as our products is the commitment we have to ensuring the success of our partners. Customization and close integration of software is an integral part of the our solutions. By working with our partners from hardware and software design to product deployment, we are helping companies build next generation products while at the same time addressing time to market pressures.

Summary

Surf Communication Solutions has implemented software for 2G and 2.5G Mobile Cellular Systems and holds a full arsenal of software modems, vocoders and higher level protocols. Surf is well positioned to provide its customers with the full interworking functionality for current and future wireless and landline networks. By implementing Surf's unique SMP DSP resource management framework, Surfs customers can take advantage of the most efficient and cost effective solutions for the mobile wireless interworking functionality of present and next generation wireless systems.

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