

Satellite/Terrestrial Interoperation in Personal Communications Networks

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Abstract

The vision of Personal Communications Networks and Services that support personal and mobile operation in the many phases of our daily lives has been aggressively sold by market researchers and has been embraced by an enthusiastic user community. The question of how we are to plan and develop these services in the light of the current complexity of market, technology, and standards has no consistent answer. This paper addresses the single issue of how Satellite and Terrestrial components of PCS can be integrated into the transparent and ubiquitous network vision that the marketeers and users have embraced. The paper addresses this issue by walking through the current functional architecture for PCS and looking at issues associated with each functional element and interface. These issues are summarized and recommendations are made for areas of cooperation among the satellite and terrestrial communities.

1. Introduction

Personal Communications Services represent more than just a combination of radio, network and data technologies of which it is composed. These disciplines have evolved in largely independent communities and their fusion is neither obvious nor direct. Each has been spawned with separate technologies and in separate markets. It is only recently that combinations of these disciplines have been merged. Fig. 1 shows how the overlaps of these areas have combined in new techniques and markets.

Cellular telephones, for example, combine the Network switching and Radio technologies for voice applications, while ISDN combines Network switching and Data technologies. The integration of all three disciplines into Personal Communications Services combines the challenge of operating in the harsh radio environment with the sophisticated protocols required for data, and with the seamless services, switching, and transparency required of modern networks.

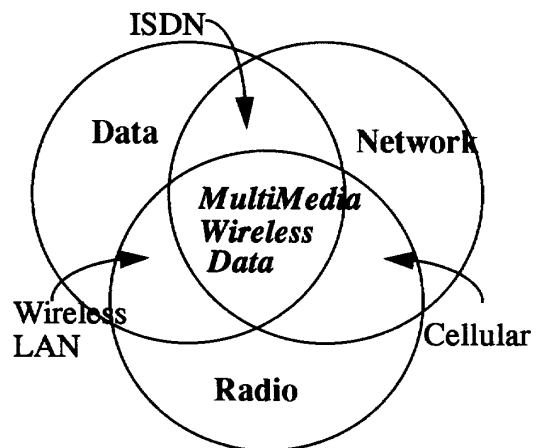
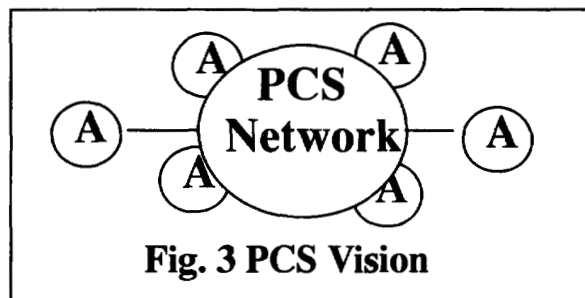
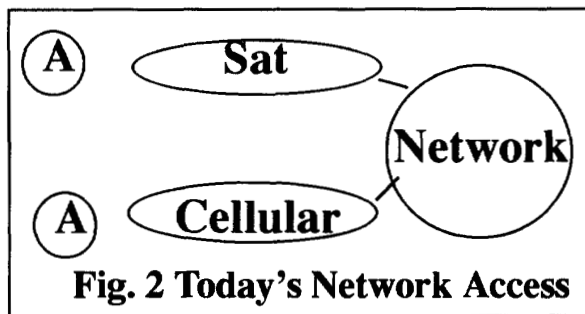


Figure 1. Technologies and Applications

The fusion of these disciplines is particularly challenging in light of the variety of access mechanisms that are possible, as with Cellular, Satellite, and Wireless LAN, each with a separate set of strategies, standards, and problems. While market forecasts for PCS are euphoric, the technical coordination and management problems facing PCS are formidable. Essential to real progress is first a clear understanding of the technical challenges and,

second, much greater cooperation among the independent communities of interest.

It is perhaps easiest to begin with a larger perspective of the problem we face. Today's wireless cellular and satellite systems represent a wireless enclave of application service (A) that is attached to the public network almost as a PBX supports users today. These users have network access but are not part of the networks. This notion as presented in Figure 2 is in stark contrast with the vision of a unified networks shown in Figure 3. Personal mobility in a multimedia environment demands that different networks transparently deliver a common set of services to the user independent of where he accesses the network.



In today's mobile environment the relationship of the user to the network is fixed and as a result it does not matter that the features and services are different. In PCS networks the relationship of the user to the network must adapt to fit the media to the user. This requires a degree of commonality of these networks or transparent translation of services.

2. Unified Terrestrial/Satellite Model

One strategy for identifying and addressing the issues is to step through each element in the

functional reference model and consider how service will be provided. The TIA TR46 reference model (1) for PCS will be used for this task. A variation of this model is shown in Figure 4 which shows both a satellite and terrestrial component in the network. This model identifies functional elements and interfaces that are the basis for TR46's work on standards. A description of selected interfaces and functional elements, and the identification of issues are as below.

User Identity Module (UIM) - This interface is not shown in the TR46 reference model but is under consideration for PCS applications. The UIM will carry the mechanism for user authentication, security, and key management. The European GSM cellular system currently supports the UIM function with a Smart Card which allows the user to migrate across service and geographic boundaries. A common UIM feature is critical for providing services to a user across the satellite/terrestrial boundary. Definition of common security algorithms and physical interface is also necessary.

Data Interface (Rm/Sm) - These interfaces are the interfaces to external data devices. A common data interface such as RS-232 or I430 and signalling schemes such as EIA 602 or Q.931 are the typical standards around which common choices might be made.

Personal Station/Radio (PS) - The PS is the radio terminal that will certainly vary from the satellite to terrestrial sector. Some elements within the PS however must have a common definition for PCS service. The choice of a common voice coder family would greatly facilitate service. Satellite developers will most likely want to operate at data rates of 2.4, 4.8, and 8 kbps because of power and bandwidth restrictions while the terrestrial developers will want to operate at 4, 4.8, 8, 13, and 32 kbps (2). Vocoder have traditionally been selected by manufacturers as hallmark features of their equipments. Cooperation will be required to support common performance criteria and choices to serve both communities. It appears possible to have as few as two core vocoders with variable rate coding schemes that will bridge the required satellite and terrestrial rates and service requirements.

Air Interface (Um) - The air interface is the current topic of interest in PCS because it is the fundamental ingredient in distinguishing radio manufacturers who are competing for a share of the PCS market. No one expects a single standard to emerge from the seven current candidates in the JTC. The key to success in PCS, however, is to isolate the PCS services from the variabilities of the air interface. A common set of services defined independent of the air interface will enable the remainder of the PCS network to be defined and developed. This strategy also fits well the needs to bridge the differences in satellite/terrestrial air interfaces that are necessary to support different radio channels. A subset of PCS services that function across the potentially different LEO, MEO, and GEO satellite air interfaces would serve to unite all these services. These might include voice, fax, short message, packet, asynchronous, and synchronous service as suggested in reference 3.

A Interface - The A interface is the connection between the Radio controller and the PCS switch. This is an important common interface between satellite terrestrial systems as shown in Figure 4. Unfortunately there is little consistency in the proposals for this interface. In most North American systems today this interface is imbedded into proprietary switches. The choice of the A interface is tied up in the decision on where to terminate the radio link protocol, vocoder and link encryption. The GSM system terminates these at the RPC and uses standard T1 trunk to backhaul traffic. North American systems prefer to multiplex the compressed radio protocols to the switch. Both approaches have advantages but a mix of techniques will significantly inhibit dual satellite/terrestrial service.

Interworking Function (IWF) - The IWF and the associated L interface are critical ingredients in supporting data services for PCS. The IWF is generally associated with the translation of data protocols across the wireless to wired boundaries for transparent service. This interface is also envisioned (3) to include the extension of data services through the L interface to third party service providers where file server, mail box, and general data interworking can be accommodated. A common definition of services and these functionalities will significantly

enhance the services provided to the satellite and terrestrial user.

Personal Communications Switching Center (PCSC) - The PCSC and the associated Di interface into other networks will be important ingredients in the integration of satellite services. As an ingredient in the Intelligent Network services supported by Signalling System 7, these components will manage the delay sensitive routing for satellite connections and insert echo control as necessary for voice connections.

Internetwork Signaling - Signalling between the PCS switched on the E interface and the C interface supports critical intersystem handoff and roaming. The choice of the North American IS 41 or GSM for this standard is the subject of current discussions in the PCS standards fora. Selection of a single scheme intersystem operation will enhance extension to satellite users.

Home Location Register (HLR)/Visitor Location Register (VLR) - These functions support the personal mobility of users in the PCS system. It is through the HLR/VLR data bases and associated signalling that authentication, service validation, and security features are provided. Serious questions exist today in the PCS standards community as to the basis for the signalling and security functions associated with the HLR/VLR. Two or more candidate schemes are likely to be standardized leading to considerable breakage in network transparency. The commonality of these functions are critical to the integration of satellite services into the network.

3. Common Satellite/Terrestrial Issues

When one looks across the issues associated with each component in the PCS reference model a handful of issues appear as pivotal in supporting satellite service in PCS.

Security Scheme - Privacy and Authentication is critical to personal mobility and the effects of these promulgate across several components in the network. The choice of algorithms, associated signalling, the User Identify Module, operation in handoff, and where these are terminated need to be consistent within PCS systems for the successful integration of satellite systems.

Common Service Definition - A consistent set of application and bearer services for PCS and a subset that can be supported by satellite systems is needed.

Vocoder Selection - The industry cannot continue to create new proprietary vocoder schemes for every new variation of mobile service. Common choices are necessary if a cohesive PCS service is to be provided. In addition the satellite community needs to agree on vocoder choices for 2.4 and 4 kbps rates.

Network Reference Architecture - The clear identification of functions and interfaces needs to be made. Decisions regarding the termination of RLP, vocoders, and security, and the intersystem signalling need to be unified.

Media Independent Components - PCS Networks need to be designed so as to isolate services from the variability of the radio technologies that support them.

4. Conclusions

This paper just scratches the surface in addressing the issues associated with the integration of satellite services into PCS. Many more issues lie beneath the surface. There is enough chaos in the PCS community today that few may want to venture into this already complicated landscape. It would be a serious mistake however not to address these issues now. More than anything else this paper is intended to show that there are substantial issues that need to be addressed in the integration of satellites into PCS. These issues are not currently being addressed in the PCS standards fora. Furthermore, satellite developers are traditionally independent competitors and have shown little interest in cooperating among themselves on common issues.

The market projections for PCS are predicated on personal mobility and service across the many variations of wireless networks. Large users such as the Federal Government have expressed the requirement for these services (4) which can only be realized with longer range vision and cooperation among the PCS and satellite communities.

REFERENCES

1. Telecommunications Industry Association PN 3169 *PCS Network Reference Model(s) for 1800 MHz*.
2. Bakhuizen M., *Multiple Speech Coder Signalling Support*, JTC (AIR) contribution 94.06.13-450, Toronto, Can
3. PCIA (Telocator) TE/93-09-10/378, *Data Standards Requirement Document for Personal Communications*, Sept 10, 1993
4. NTIA Federal Wireless Policy Committee, *Current and Future Functional Requirements for Federal Wireless Services in the United States*, 29 April, 1994

Fig. 4 Simplified TR46 Reference Model

