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Inmarsat Aeronautical Mobile Satellite System: Internetworking Issues

Jay R. Sengupta
Inmarsat
40 Melton Street
London, UK. NW1 2EQ
Phone: +44 71 387 9089
Fax: +44 71 383 0849

ABSTRACT

The Inmarsat Aeronautical Mobile Satellite System (AMSS) provides air-ground and air-air communications services to aero-mobile users on a global basis. Communicating parties may be connected either directly or, more commonly, via interconnecting networks to the Inmarsat AMSS, in order to construct end-to-end communication circuits. The aircraft earth station (AES) and the aeronautical ground earth station (GES) are the points of interconnection of the Inmarsat AMSS to users, as well as to interconnecting networks. This paper reviews the internetworking aspects of the Inmarsat AMSS, by introducing the Inmarsat AMSS network architecture and service concepts and then discussing the internetwork addressing/numbering and routing techniques.

INTRODUCTION

The Inmarsat AMSS has a distributed network architecture composed of multiple GESs, which cooperatively perform the network management functions. Nominated GESs in each satellite region are required to continuously broadcast network management information, for the benefit of AESs wanting to register with the AMSS. The initial system will operate without any central network control facility.

Log-in function

Individual aircraft equipped with AES are required to first log-on to any GES in the network, before they may avail of the communication services offered by the AMSS. Therefore, each GES along with the AESs logged-on to it essentially constitutes an independently operating sub-network within the global AMSS. GESs are required to cooperate with each other, by forwarding call setup requests for circuit-mode service connections intended to be handled by some other GES in the same satellite region.

AMSS SERVICE CONCEPTS

Service definitions in the Inmarsat AMSS have been developed based on the principles of structures and layered system design. It has also been an objective to maximize the degree of similarity with other Inmarsat standard systems, used for maritime and land mobile applications, without compromising the unique service requirements of the AMSS. The AMSS essentially offers two basic *bearer* services to the user, namely circuit-mode and packet-mode.

Circuit-mode bearer service

The circuit-mode bearer service has been designed to be compatible with the definition of the Integrated Services Digital Network (ISDN), in order to facilitate efficient interconnection with the terrestrial telecommunications networks of the future . The circuit-mode bearer service is supported by demand assigned single channel per carrier (DA-SCPC) operation. The bearer service essentially provides a connection oriented digital circuit, which is used to support a variety of teleservices such as telephony, facsimile and data transmission using the appropriate channel interface equipment.

Packet-mode bearer service

The packet-mode bearer service has been designed to be compatible with the Open Systems Interconnection (OSI) reference model, in order to facilitate provide a common interface for interoperability with diverse applications. The packet-mode bearer service is supported by random access / reservation TDMA and TDM channels, in the return and forward directions, respectively. The bearer service essentially provides a connection oriented packet communication circuit, which is used to support a variety of teleservices such as data and telex transmission using the appropriate channel interface equipment.

In addition to offering the benefits of efficient internetworking in the short/medium term, adherence to the above design objectives is expected to offer significant benefits in the longer term due to the convergent developments in ISDN and OSI standards in the support of multi-service telecommunication networks.

The internetwork traffic routing requirement, in order to effect end-end communications, is illustrated in Figure 1.

INTERNETWORK INTERFACES

Air-ground mobile satellite communications requires the interconnection of the AMSS with other subnetworks, in order to provide the required connectivity between the end users/systems. The Inmarsat AMSS facilitates this interconnection by supporting a variety of internationally standardized network interfaces. The AES and GES are the points of interconnection of the AMSS with avionics and terrestrial networks, respectively. The interfaces supported by the AMSS for interconnection with the various different network types is illustrated in Figure 2.

AES Interconnections

In the aircraft, the AES is required to be interconnected to the avionics network, with connectivity to both cockpit and cabin communication systems. The AEEC, which is responsible for the definition of avionics equipment interface characteristics, recommends the use of ISO 8208 (CCITT X.25 PLP) and CCITT Q.931 network layer interfaces for the interconnection of the AES with the cabin and cockpit systems, respectively.

GES Interconnections

On the ground, the GES is required to be interconnected to both private and public, packet-switched and circuit-switched networks. The ICAO and CCITT are responsible for the definition of recommended interfaces for the provision of ATS/AOC and APC communication services, respectively. The ICAO recommends the use of ISO 8208 (CCITT X.25 PLP) for interconnection to the future Aeronautical Telecommunications Network (ATN) terrestrial private subnetworks. The CCITT, on the other hand, recommends the use of CCITT X.75 for interconnection to the international public switched packet data network (PSPDN), and the use of CCITT No.7 (ISUP) for interconnection to the international public switched telephone network (PSTN) and integrated services digital network (ISDN).

The Inmarsat AMSS is capable of supporting each of the aforementioned interfaces in an efficient manner, since its service have been developed on the same ISDN and OSI design principles as these interfaces.

NUMBERING/ADDRESSING PLANS

The numbering/addressing plans for the Inmarsat AMSS have been developed to facilitate end-end communications, by accommodating the following aspects of diversity in the service requirements :

a) bearer service types - circuit-mode, packet-mode ;

b) interconnecting terrestrial networks - private, public; circuit-switched, packet-switched ;

c) user service categories - ATS, AOC, AAC, APC ;

In particular, the numbering/addressing plans are required to provide the means for the routing of different traffic types, as illustrated in Figure 2.

It has been necessary to adopt several different numbering/addressing plans as described below, since a single integrated plan could not satisfy all requirements.

Circuit-mode Service Numbering

Public network numbering plan. The Inmarsat AMSS numbering plan for public correspondence circuit-mode service, as defined in CCITT Recommendation E.215, is fully integrated into the international public network plan. Each Inmarsat satellite region has been assigned a distinct country code within the global numbering plan, and the Inmarsat-aero system is distinguished from other Inmarsat standard systems by a digit immediately following.

The international telephone number format for an Inmarsat AES is : CCC T $X_1 ... X_8$, where,
CCC = country code for Inmarsat satellite region;
T = Inmarsat system standard designnator;
X_n =Inmarsat (aero) mobile number.

With the implementation of the ISDN Numbering Plan in the international public terrestrial network in the year 1997, the length of the above number will increase by three digits and thereby provide the capability for *direct-dialling-in* to individual terminals on-board the aircraft. Moreover, in the interim period before 1997 Inmarsat intends to utilize spare capacity within the Inmarsat (aero) mobile number field for this purpose.

Private network numbering plans. The Inmarsat AMSS provides for either transparent or non-transparent support of private network numbering plans. In the former case, the AMSS performs routing based on a *Network Type* discriminator used within internal signalling messages, and simply transports the private network number to/from the point of attachment of the private network in a transparent manner. In the latter case it is possible, at the option of individual GES Operators, for the Inmarsat AMSS to perform routing based on the private network numbering plan and thereby be transparent to the private network user.

Packet-mode Service Addressing

Public network numbering plan. The Inmarsat AMSS addressing plan for public correspondence packet-mode service, as defined in CCITT Recommendation X.121, is fully integrated into the international public data network plan. Similar to the circuit-mode service case, each Inmarsat satellite region has been allocated a Data Network Identification Code (DNIC), and the Inmarsat-aero system is distinguished from other Inmarsat standard systems by means of a following digit.

The international data address format for an Inmarsat AES is : NNNN T $X_1 ... X_8$ D , where,
NNNN = DNIC for Inmarsat satellite region;
T = Inmarsat system standard designator;
X_n = Inmarsat (aero) mobile number;
D = on-board terminal identifier (optional).

This addressing plan provides a limited *direct-dialling-in* capability to address individual terminals on-board the aircraft. The impact of the implementation of the ISDN Numbering Plan in the public terrestrial network in 1997, is currently under study.

Private network numbering plans. The Inmarsat AMSS provides for either transparent or non-transparent support of private network addressing plans. In the former case, the private network address is simply carried as higher layer *user data* between the private network's points of attachment. This transparent mode will be applicable for the support of Network Service Access Point (NSAP) addresses, which will be used in the future ATN. In the latter case, at the option of GES Operators, the private network address could be integrated into the AMSS DTE Addressing Plan described below.

In order to facilitate the interconnection of multiple private networks, a *Subnetwork DTE Addressing Plan* has been defined for the Inmarsat AMSS. This addressing plan is used to uniquely identify all data terminal equipment (DTE) that are directly attached to the AMSS.

INTERNETWORK ROUTING

Internetwork routing in the aeronautical mobile environment is primarily characterized by the requirement to manage the mobility of aircraft in flight. The internetwork routing techniques must therefore incorporate methods to manage the mobility of the AESs in the AMSS, which is a mutli-region distributed network. The Inmarsat AMSS is capable of supporting three different routing regimes as described below, although only the first method is currently implemented; the latter two techniques require the implementation of some form of mobile location registration facility, and the network interconnections required are illustrated in Figure 3.

Mobility management by calling users

This routing management technique does not require the AMSS or any other interconnecting subnetwork to perform any mobility management functions. It requires the calling terrestrial user to be aware of the location (region) of the called AES; the call attempt simply fails if the called AES is absent from the chosen region. This routing technique is supported by the current Inmarsat AMSS public correspondence numbering/addressing plans, which require the selection of a particular AMSS satellite region by the calling party.

This routing technique is acceptable when there are a small number of AMSS regions. However, it carries the risk of significant penalty in the proportion of unsuccessful call attempts and associated decrease in network traffic handling capacity, due to the absence of the called AES from the selected AMSS region, if the number of regions within the AMSS were to increase.

Mobility management by AMSS

This routing management scheme would require the implementation of a *Location Register* within the Inmarsat AMSS as illustrated in Figure 3, which would register the current location (satellite region) of all AESs currently logged-on to the AMSS. The Location Register would be updated by every GES, whenever an AES newly logs-in or is logged-out by it. Direct signalling links would exist between major nodes in the terrestrial networks (Network 1 in Figure 3) and the Location Register, to query the current location of the called AES. The connection would then be routed to a GES serving the appropriate AMSS satellite region. In cases where direct signalling links do not exist between the terrestrial network nodes and the Location Register the connection could first be routed to a default GES, which would then query the Location Register and reroute the connection to some other AMSS satellite region if necessary.

The signalling links and location registration functions can be implemented using CCITT No.7 (MSAP) protocols and procedures, which are currently under definition. Having implemented a central database for mobility management purposes, the same facility and signalling/control procedures can be used to accommodate other network management and value-added services, such as calling user authentication and private virtual networking.

It should be noted that, currently, there are no firm plans to implement this method of mobility management in the Inmarsat AMSS.

Mobility management by interconnecting subnetworks

This routing management scheme places the responsibility of AMSS network mobility management, on the interconnecting subnetwork. Signalling links would exist between the GESs and nodes in the interconnecting subnetwork, as depicted by Network 2 in Figure 3. The AMSS would be required to convey any changes in AES log-on status, either from the AES or the GES to their respective interconnected subnetwork node. The location registration function may be implemented either as a standalone facility, or be integrated into the routing tables of the nodes within the interconnected subnetwork.

This method of internetwork routing management has been proposed for the interconnection of the Inmarsat AMSS to the future ATN, for the purposes of

ATS/AOC/AAC packet-mode services. In this case, the Inmarsat AMSS will also support the ATN requirement of transparent transfer of Internet Protocol (IP) packets, which are used to disseminate routing information between the ATN nodes.

CONCLUSION

This paper has presented a brief description of the internetworking capabilities of the Inmarsat AMSS. The internetworking capabilities of the Inmarsat AMSS will continue to be enhanced as required, to accommodate evolutionary changes in subnetwork architectures and user service requirements. Inmarsat actively participates in the international fora to promote the development of standard methods of internetworking.

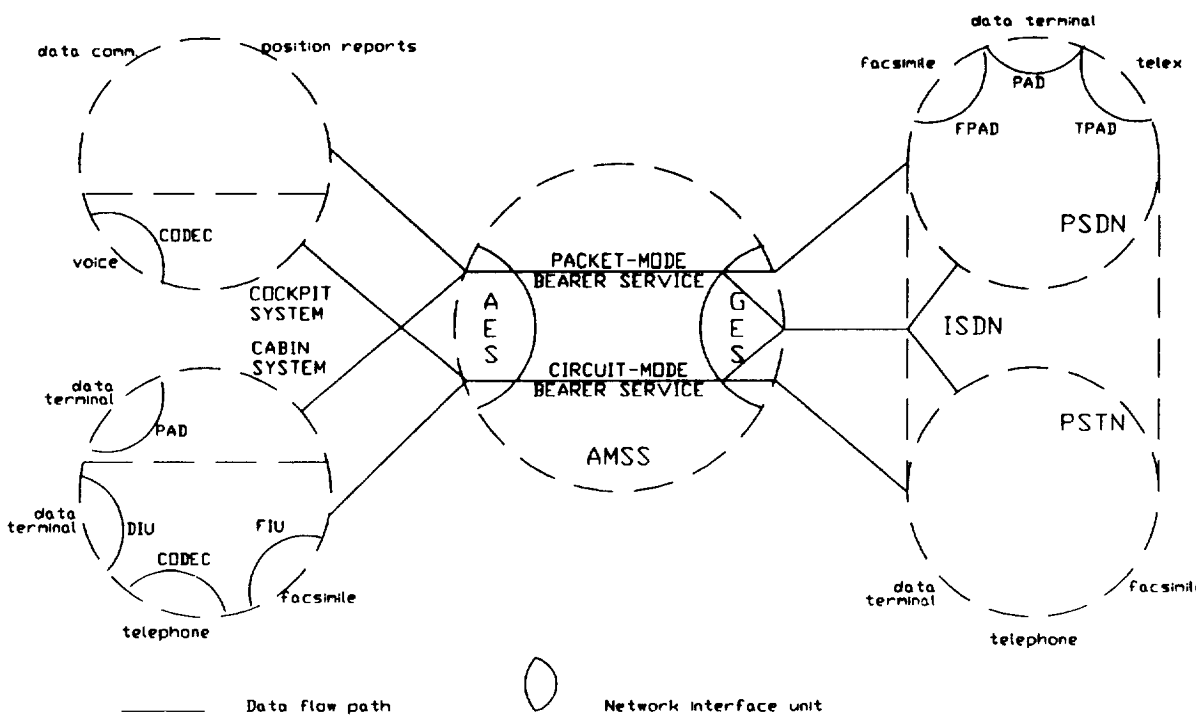

Fig. 1. Traffic Routing Requirements

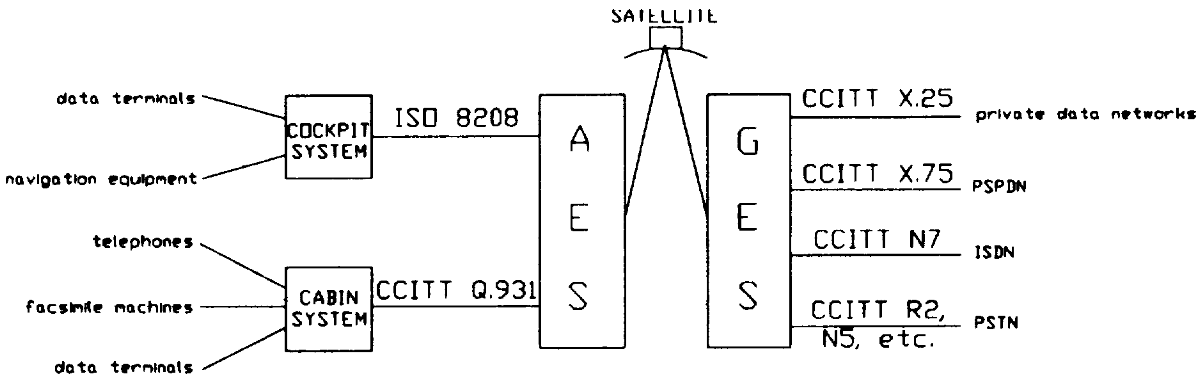

Fig. 2. Network Interconnection Scenario

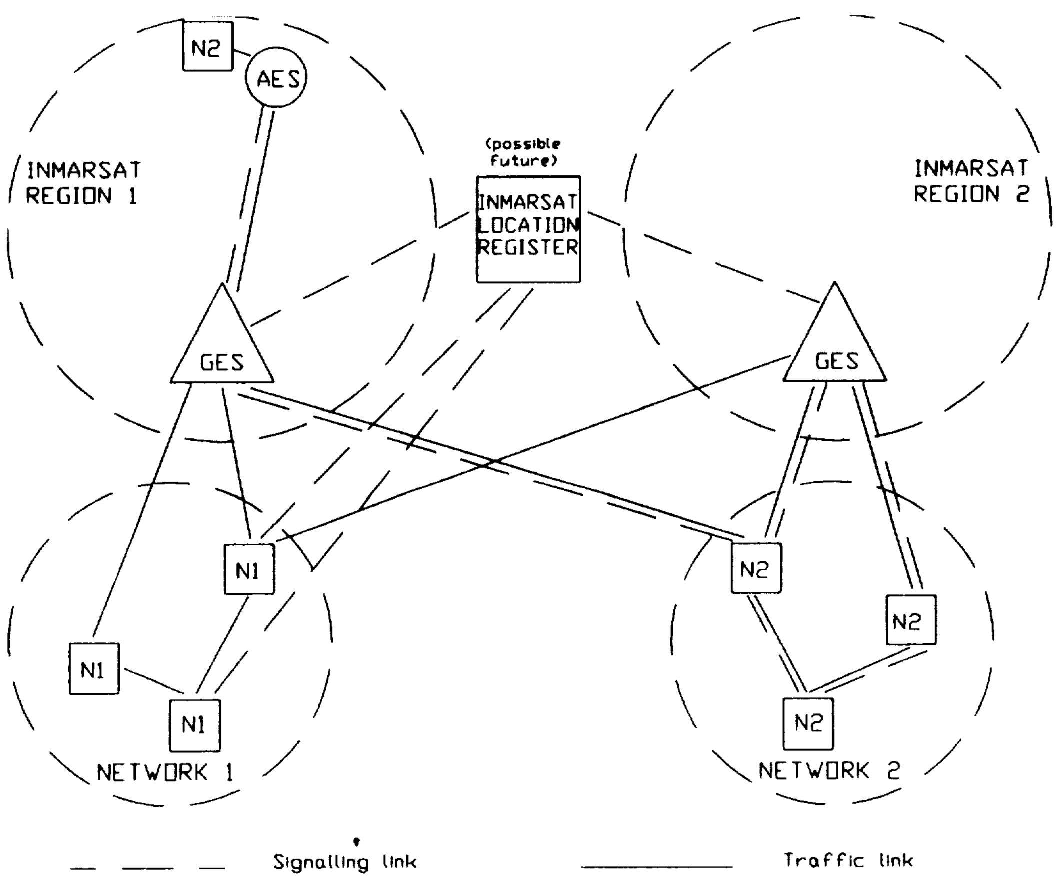

Fig. 3. Mobility Management in the Internetwork