The AMSC Network Control System

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AMSC will be constructing, launching and operating a satellite system in order to provide mobile satellite services to the United States. AMSC will build, own and operate a Network Control System for managing the communications usage of the satellites, and to control circuit switched access between mobile earth terminals and feeder-link earth stations. This paper provides an overview of the major Network Control System functional and performance requirements, the control system physical architecture and the logical architecture.

FUNCTIONAL REQUIREMENTS

The Network Control System (NCS) will provide centralized control, management and administration of all services utilizing the AMSC satellites. From the NCS perspective, satellite use is divided into two major categories, Full Period and Demand Period. Full Period services are those services which make use of dedicated satellite bandwidth and power that is administered by a control system that is essentially independent of the NCS. Examples are aviation safety service networks that operate to FAA standards, packet data networks that do not make use of circuit switched type access, or networks that are operated by independent service providers. Demand Period services are those services which use satellite power and bandwidth on demand and which are directly controlled by the NCS. Demand Period services are provided through circuit switched, full duplex, two-point circuits set up between Mobile Earth Terminals (METs) and Feeder-link Earth Stations (FESs) by the NCS. All satellite use, whether Demand Period or Full Period, will be under the ultimate control of the NCS.

Demand Period Services

Groups of METs and FESs using Demand Period Services can be set-up into separate networks with customized routing, communications channel types and customized calling services. Networks may be configured for interconnection to the public circuit switched networks or to private circuit switched networks. A universal numbering plan will be used that will permit universal calling.

MET Access Management

All METs will be subject to a number of requirements designed to insure that they are capable of operating correctly, that they are authorized for access to the system and that they continue to operate properly once operational. In addition, the control system will be able to exert positive control to manage congestion, abnormal operation or to invoke preemption on behalf of safety services.

METs must be type approved prior to being allowed to be registered in the system. Type approval will be used to verify that the particular model of MET meets minimum performance and operational specifications required to operate successfully within the network.

METs must undergo commissioning before being allowed to use the network for the first time or after being decommissioned. The commissioning process will verify that the MET is type approved and capable of operating in a satisfactory manner through measurement of key performance parameters and the exercising of appropriate control and signalling sequences.

Each time a request is placed by a MET to enter or use the network, it will be subject to an authentication and authorization procedure. This procedure will verify that the MET ID is authentic and that the MET is authorized to use the system. The procedure will verify that the MET is registered to a legitimate owner and that the owner has current administrative approval to use the system.

Once commissioned, METS will be subject to performance verification testing under the control of the NCS. These tests will be designed to verify that an individual MET operates properly and to minimum performance standards.

All METs using the services of the NCS will be under positive control while operating in the system. Positive control means that the NCS can issue commands at any time directed to one or groups of METs (and associated FESs) that must be acted upon immediately. A primary use for this mechanism is to be able to preempt satellite channels already in use for reassignment to Aeronautical Mobile Satellite (Route) Services, AMS(R)S, upon demand. This is expected to be a relative rare event. Another use is to shutdown METs that have been identified as malfunctioning and that might cause disruption to other users of the satellite. Another use is to implement source control of access when congestion or abnormal operation require limitation on how and when access is permitted.

Network Management and Administration

Management and administration of the network will be centralized with appropriate backup. The NCS will allocate system resources such as satellite spectrum and power to various uses, respond to preemption demands by safety services and insure that they are carried out, manage service restoral and failure recovery, and establish and maintain system databases and configuration control processes. The NCS will provide status monitoring and control support for maintenance and network operations functions. It will collect call records and usage data, generate service status information and reports, provide network performance analysis data and support customer service activities related to status and performance. It will interface to the network control systems of other (non-AMSC) systems for the purposes of intersystem coordination and operation. Examples of other systems are those of Telesat Mobile, Inc. and INMARSAT.

System Sizing

The AMSC system will eventually be comprised of several satellites in several orbital locations. The satellites will each have multiple beams on the service-link (mobile) side. Initially there will be single beams on the feeder-link side although long term there may be multiple beams as well. The first generation system is expected to be able to service at least 0.5 million METs of various types, with long term projections into the several millions. Feeder-link Earth Stations are expected to number into the hundreds minimum, possibly into the thousands. Each orbit slot and it's associated satellites may support several thousand individual communications channels. The NCS must be able to administer and manage the total resources of all these assets.

Availability and Reliability

The NCS must have availability and reliability commensurate with its central and essential role in managing the system.

METs and FESs will be assigned to Control Groups. There may be several Control Groups, each managed separately within the NCS. The availability of a Control Group is specified as 0.999 in the worst month, while the availability of at least one Control Group operative in the NCS is specified at 0.9999 in the worst month. The reliability of an individual Control Group has been provisionally selected as no more than four outages in excess of 30 seconds in any 24 hour period.

The NCS must be designed so that there is no single point failure, since a single point failure might cause unacceptably long outages.

Circuit Switched Connection Performance

It is expected that Grade of Service requirements will vary from one group of users to another. Accordingly, the NCS must be able to efficiently service call blocking rates ranging from 1% to 15% in a nonqueued mode, and optionally be able to provide call queueing with a variable wait delay before blocking. Connection holding times are expected to average from about 20 seconds for dispatch type services to several minutes for general telephone use. The NCS must be able to handle connection requests at an average rate of at least one per 20 seconds per circuit and to service large groups of channels within a Control Group at that rate. The average connection time under clear path conditions should be no more than 2.5 seconds, with 90% of connections completed in less than 5 seconds. The connection time may be longer under poor propagation conditions. Disconnect time should average no more than two seconds.

Signalling and the Radio Link Environment

The signalling between the NCS and the METs and FESs must be robust and reliable to insure a high probability of successful control communication. The service link side will be subject to multipath, shadowing and path blockage as the METs move. The motion will also introduce doppler, and doppler spreading if multipath is present. The feeder-link side will be subject to occasional flat fading caused by hydrometers (rain, snow, ice) that must be compensated for either by adequate link margins, power control, or transfer between feeder-link earth stations. The NCS feeder-link path must be especially robust as it may serve large numbers of users.

PHYSICAL ARCHITECTURE

The Network Control System makes use of several physical facilities as illustrated in Figure 1. The AMSC owned facilities are the Network Operations Center, Network Control Centers and the satellites (not shown). Also, logically part of the NCS are the controllers in the METs and FESs that interwork with the NCS. The Network Operations Center will consist of computer facilities, related peripherals and network operator consoles that support overall network administrative, management and operational needs. It may be colocated with one of the Network Control Centers. The Network Operations Center will be backed up by another suitably equipped facility. There will be two geographically separate Network Control Centers. Geographic redundancy will be used to guard against catastrophic failure of a facility, to provide a means for continuing operations when maintenance or upgrades or modifications require taking down an Network Control Center, or to provide access diversity when the other Network Control Center is subject to propagation induced outages. A Network Control Center will consist of an RF terminal to work with the satellite on the feeder-link side, signalling channel units for working through the satellite to the METs and FESs, computers and related peripherals for using the signalling channels and interfacing to the Network Operations Center, and such other equipment as is typically required to run an earth station complex. The Network Control Centers do the real-time management of satellite access.

Each Network Control Center will provide at least one set of bidirectional signalling channels for use in each beam. The METs will use these signalling channels for obtaining access to the system. Forward channels will be continuously broadcast with signalling information packet multiplexed into them. Included in these channels will be periodic system configuration and status information required by METs to enter and use the network, or to inhibit access or use if necessary to maintain the integrity of the control system. The return signalling channels will permit random access by the METs to the control system.

Each Network Control Center will have bi-directional signalling channels through the satellite for use by the FESs. There will be at least two channel sets for redundancy. The forward channel will operate in a continuous broadcast packet multiplexed mode. The return channels will operate in a TDMA mode, with possibly a random access mode for low usage FESs. The communications protocol will be based on a well established standard. An alternate interconnection path using either leased line or telephone dial backup facilities will be supported at the Network Control Centers.

The MET signalling channels and FES signalling channels will be used to assign a specific circuit to an MET-FES pair. Once assigned, the MET and FES will establish contact with one another through the communications channel. Present thinking is to require METs to continuously receive an NCS control channel even when using a communications channel, and to use this channel for control purposes. This approach would permit the NCS to directly control certain aspects of MET operation required for system protection (improper operation, system failure and recovery, preemption for AMS(R)S). It would also support the provisioning of custom calling services such as call or message waiting.

The Network Operations Center will provide interconnections to the control centers of Full Period service providers or to other systems such as TMI and INMARSAT. These interconnections will use either X.75 or X.25 Gateway communications protocols.

LOGICAL ARCHITECTURE

The logical architecture is hierarchical in nature. At the top of the hierarchy is the Network Operations Center. The NOC is the ultimate authority in the system. It partitions and assigns resources to Control Groups, manages priority and preemption, generates databases for use of the Control Groups in the carrying out of their functions, provides the interface to external systems, and generally provides the overall management of the system.

Reporting to the NOC are one or more Control Groups. There will be at least one Control Group per satellite. Control Groups are groups of METs and FESs that share in some fashion a collection of space resources (circuits, geographical access), and a Group Controller that manages the Control Group. Group Controllers reside in Network Control Centers. The top level logical relationships within a Control Group are illustrated in Figure 2.

Group Controller

A Group Controller logically consists of a Group Resource Manager, Network Access Processor and one or more Virtual Network Managers.

The Network Access Processor handles all those functions related to the transmission and reception of access and signalling messages between the Group Controller and the METs and FESs. It services all signalling channel sets in all beams served by the Control Group, operates the access protocols over the signalling channels, passes service requests and responses between the METs or FESs and the Virtual Network Manager or Group Resource Controller as appropriate.

The Virtual Network Manager serves a specific set of METs and FESs forming a Virtual Network. Normal requests for service by a member of a Virtual Network are handled by the associated Virtual Network Manager. The VNM contains a database listing all of the attributes, routing algorithms and permitted services associated with each member of the Virtual Network and of the Virtual Network as a set. Using this information, the VNM determines the type of connection to be made (if permitted), which MET/FES pair to connect and the priority to be given. It requests an appropriate circuit assignment from the Group Resource Manager which returns a specific circuit assignment, if available, to the VNM. The VNM passes the assignment on to the MET and FES involved via the Network Access Processor. At the completion of a call, the Virtual Network Manager returns the circuit to the Group Resource Manager.

The Group Resource Manager manages the Control Group as a whole. It maintains the circuit assignment pool used by the Virtual Network Managers, assigning and deassigning circuits as needed. It obtains the members of the circuit pool from the NOC as the NOC dictates. It manages priority and preemption within the Control Group. It conducts commissioning and performance verification testing of METs. It collects call records and status information for periodic transfer to the NOC. It provides status monitoring, alarming and diagnostics for the Group Controller, and supports network operator access and intervention.

Because the Virtual Networks are likely to support a variety of Demand Period services and capabilities, the NOC and its associated Group Controllers must be able to support a wide range of configuration options from which Virtual Networks may be constructed. The categories of configuration options are circuit configuration options, connection routing options and address screening options.

Circuit configuration options define a specific set of standard communication circuit types that will be assignable by the NCS. Each type will have a specified signal format, modulation, channel spacing and power settings associated with a class of METs or FESs.

Connection routing options define the specific methods available for selecting MET/FES connections for each call. The NCS will be capable of establishing connections for either MET originated or FES originated calls. There will be a general purpose routing structure available that can be tailored to specific Virtual Network needs. The structure will support either public or private network inter-working. It will support preassigned routing, alternate routing, unrestricted routing and addressed based restricted routing. The ability to form routing algorithms which can do "least cost routing" is also highly desirable. Least cost routing will be applicable to Virtual Networks that interconnect into public networks where tariffs vary depending on routing.

Address screening options define how an individual call is handled based on source and destination addresses associated with the call. Address screening will be used for routing purposes, but it will also be used to restrict or permit different types of connections based on preestablished custom calling subscriptions. Examples are one-way calling in which calls can be placed in one direction but not the other, restricted destination calling in which a particular source can call only a selected set of destination addresses, and closed user group calling in which calls can be placed between, and only between, a limited set of addresses.

SUMMARY

The functional requirements, physical architecture and logical architecture of the AMSC Network Control System have been described. The system will be designed, developed, built and installed in time for operations to begin through the satellites in late 1993.

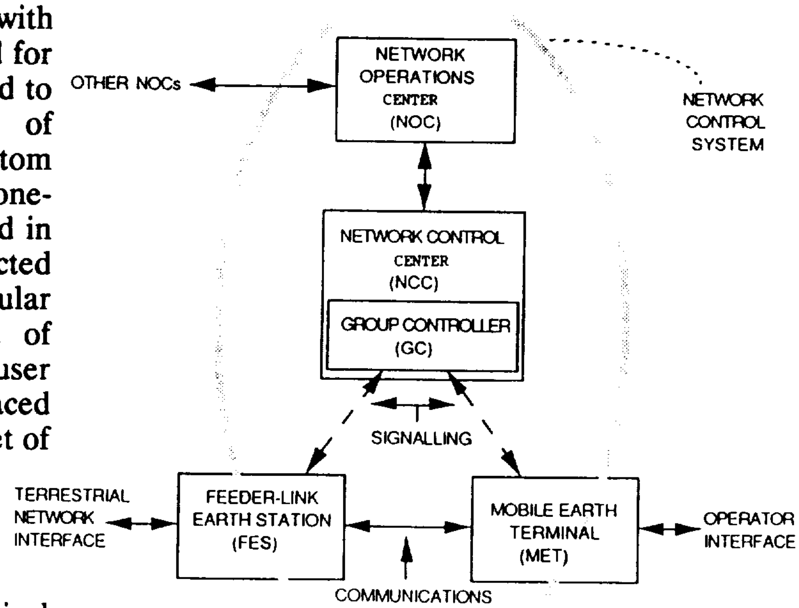

Figure 1. The Network Control System

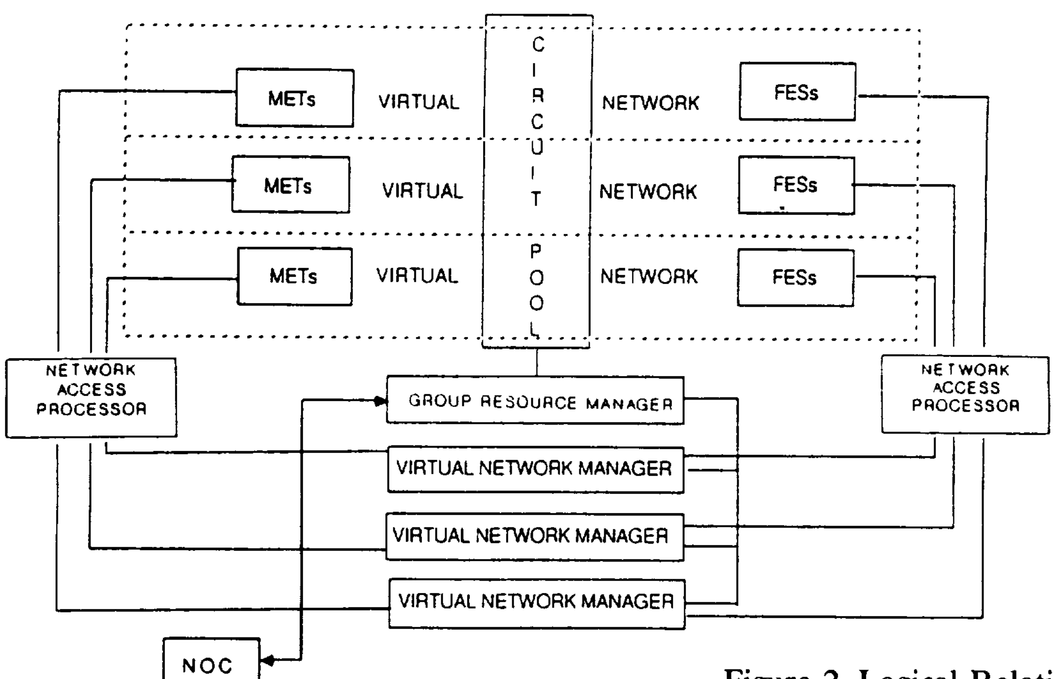

Figure 2. Logical Relationships Within a Control Group