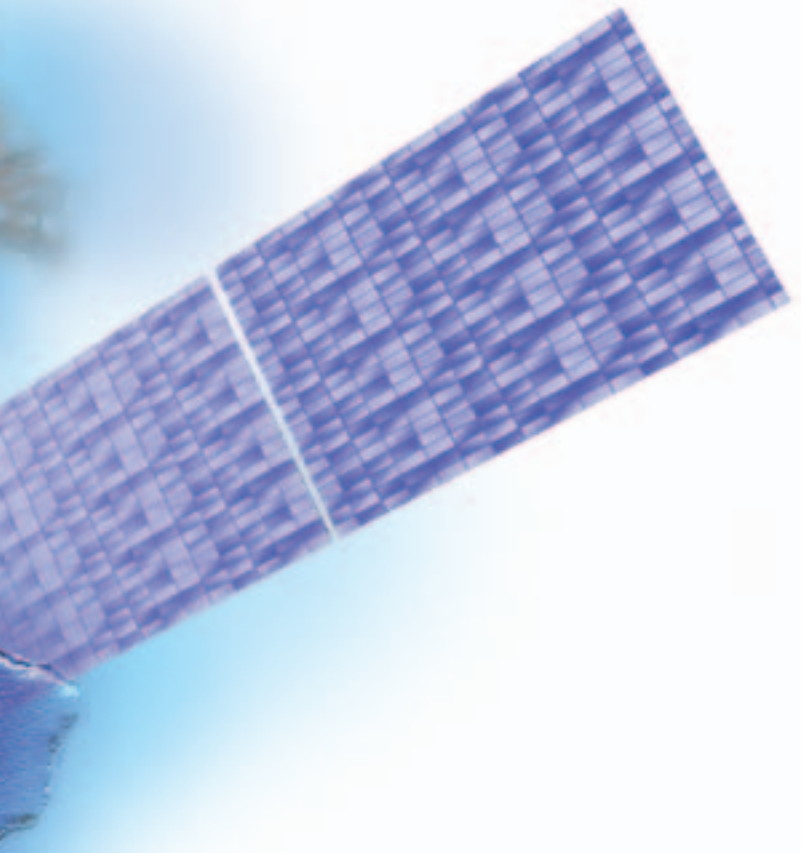
AmerHis: The First Switchboard in Space



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Satellite telecommunications has now reached an advanced stage of maturity with nearly 40 satellite operators controlling around 250 satellites in geostationary orbit. The services that those operators provide range from backbone trunk networks in the telephony and data fields, to the distribution and broadcasting of thousands of TV channels to hundreds of millions of viewers around the World.

Successful as they are today, satellite systems are on the brink of yet another major revolution that will doubtless also have a significant impact on our daily lives in the near future. This revolution will be brought about by the provision of a new generation of cost-effective broadband interactive services, initially to larger corporations, later to small and medium-sized enterprises, and eventually to private homes.

Introduction

The basis for the introduction of these new services lies firstly in the availability of precisely targetted multiple spot-beam coverage from satellites, allowing greater optimisation of the use of the satellite's resources in terms of power and frequency spectrum, and secondly in the consolidation of open standards based on the successful DVB-S/DVB-RCS suite. Designing around such open standards guarantees that the receiving

Good wishes to Amazonas, on the fairing of the Proton launcher

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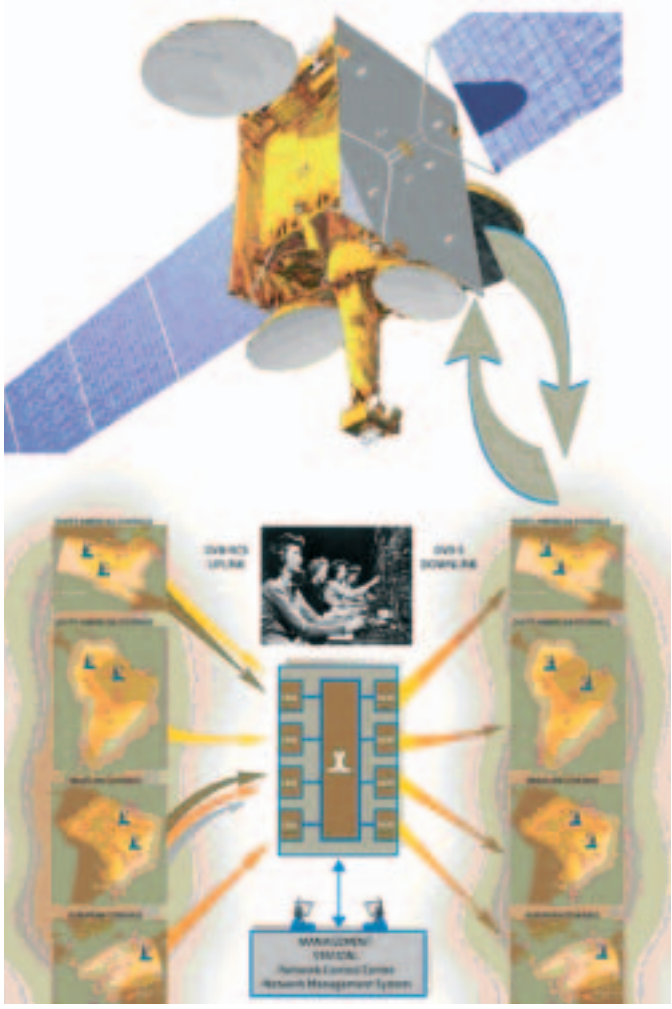
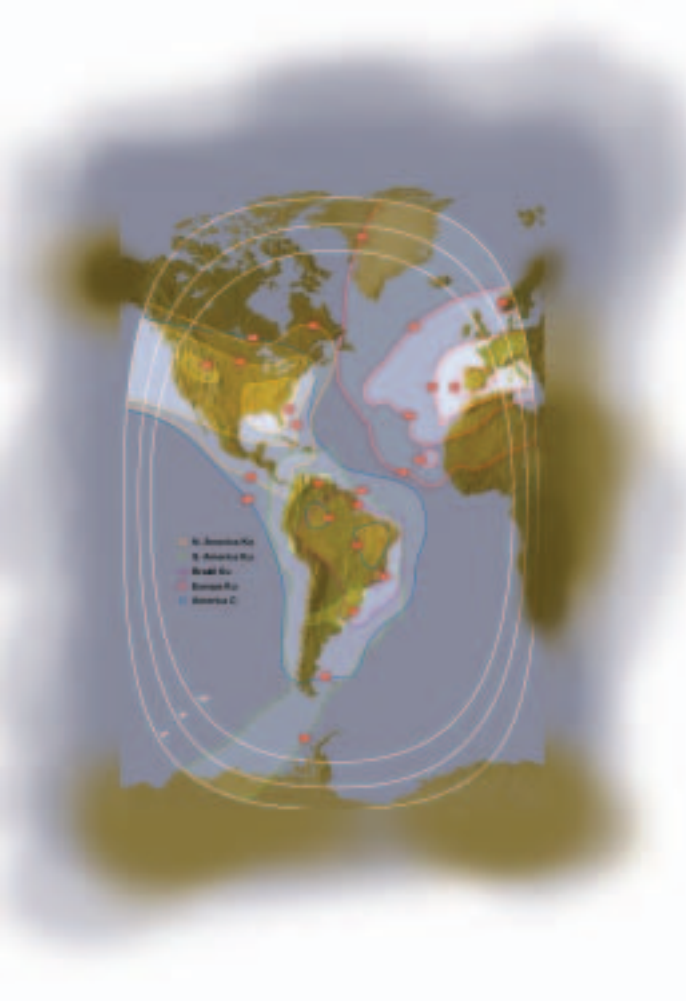
terminals and services will be available from many vendors, which is fundamental to the creation of an open competitive market and the delivery of economies of scale.

The consolidation of the DVB-based open-standard approach has paved the way for the introduction of a new satellite payload and system architecture, whereby a number of transmitting/receiving transponders on the same satellite can be interconnected via an onboard digital switch. In this way, the network topology becomes star-like in form, centred on the node constituted by the satellite and its



The AmerHis switchboard in space



The Amazonas coverage zones

transponders. This new architecture allows optimisation of the resources assigned to each individual transponder in terms of coverage, power and bandwidth.

The ESA Telecommunications Long-Term Plan foresees greater cooperation with telecommunications operators in order to foster the introduction of new payload technologies and services. As part of this process, ESA entered into an agreement with the Spanish company Hispasat, with the cooperation of Spain's CDTI (Centro para el Desarrollo Tecnológico Industrial), for the implementation of a regenerative multimedia system, known as the 'AmerHis System', onboard Hispasat's 'Amazonas' satellite, which was launched on 5 August 2004.

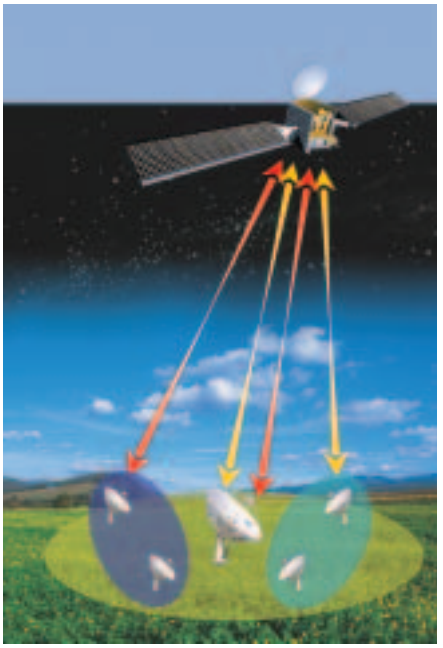
The AmerHis System

AmerHis is an advanced satellite communication system based around Alcatel's 9343 DVB On-Board Processor. This processor has the demodulation, decoding, switching, encoding and modulation capabilities needed for the four transponders on Amazonas. Each transponder covers one of the four geographical regions served by the satellite - namely Europe, Brazil, North and South America.

The complete AmerHis system consists of:

– The regenerative payload onboard Amazonas.
– A network management system, containing the Network Control Centre (NCC) and associated management control, responsible for managing the onboard resources and the user terminals.
– User terminals (Return-Channel Satellite Terminals, or RCSTs) oriented towards the commercial demonstration of new services.
– Gateways (RCST Satellite Gateways, or RSGWs) that provide the system with access to terrestrial networks.

With AmerHis, the satellite operator is able to offer broadband connectivity via a single hop to users anywhere within the four geographical areas covered by Amazonas. This is a great improvement compared with existing satellite-based networks, which require a double hop via a ground-based hub. The AmerHis concept puts that hub onboard the satellite, saving the delay of about 250 milliseconds caused by the additional second hop. The regenerative payload thereby enables real-time broadband connections between small user terminals.



AmerHis provides connectivity between spot-beam coverage areas without the need for double hops between ground and spacecraft

This unique combination of onboard processing and full compatibility with the open standards of DVB-S (downlink) and DVB-RCS (uplink) gives an AmerHis-equipped telecommunications satellite unprecedented potential compared with its rivals relying on conventional system architectures.

In summary, the key advantages of AmerHis for the user are:

– Provision of direct 'end-to-end' connectivity between any two users in different regions via a single satellite hop. This allows real-time voice and video services, as well as reducing bandwidth usage.
– Full flexibility both for the interconnection of coverage areas and payload-capacity management, allowing optimum exploitation of available onboard resources. Thanks to the dynamic resource-allocation process, the system supports predictable symmetric up- and downlink traffic, as well as intermittent 'bursty' traffic generated by a large number of users.
– The regenerative nature of the AmerHis payload, and the utilisation of DVB-S saturated carriers on each downlink, provide substantial improvements when using the AmerHis-enabled transponders. These improvements are reflected both in the enhanced throughput capacity and the reduced receive-antenna size requirements for the users.

These features, combined with the use of standard low-cost and high-performance broadband interactive user terminals, represent a major qualitative step forward in the successful development of interactive multimedia services via satellite.

The Services Offered by AmerHis

The great flexibility for managing and selling AmerHis capacity is such that all of the main telecommunications players will benefit from this advanced technology. Real- and non-real-time multimedia services and applications can be provided on readily available DVB-S/DVB-RCS compatible terminals. The system permits the assignment of resources to different subnetworks in a very flexible manner and allows user transmission rates ranging from 512 kbit/s to 8 Mbit/s. The system supports Internet Protocol (IP) based as well as native MPEG-based services, with efficient mechanisms for the provision of uni- and multicast services, and the possibility to define various quality-of-service levels to meet different user needs.

AmerHis supports mesh connectivity and star connectivity, in both cases with just one satellite hop. Unidirectional or bidirectional point-to-point connections are possible in both cases. These types of connections can either be established on demand by the terminals and the gateways, or by the Management System. A given connection can be assigned one of three priorities within AmerHis - low priority,

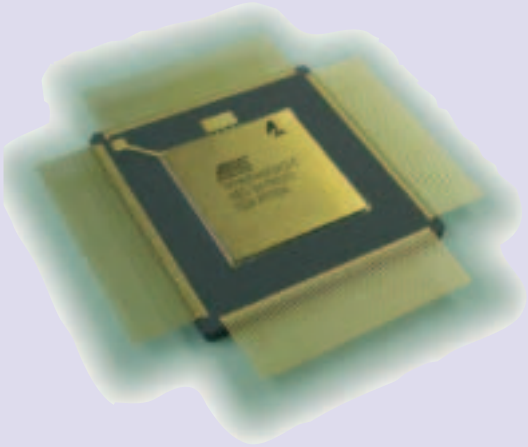
The AmerHis Elements

Space Segment – The regenerative payload

The AmerHis payload is made up of a novel set of On-Board Processing (OBP) technologies, which are being flown for the first time on the Amazonas satellite. The key feature of AmerHis is that the payload is regenerative and provides unique connectivity possibilities via its 'switchboard in the sky' functionality.

The uplink format to the OBP is MF-TDMA according to the DVB-RCS standard (MPEG-2 option), with up to 64 carriers per transponder. Data rates of 512 kbit/s, 1, 2, 4 and 8 Mbit/s can be combined in the same transponder. The downlink format is according to the DVB-S standard, with a maximum data rate of 55 Mbit/s per transponder. The OBP, which relies on complex digital signal-processing functions implemented in ASICs, offers full routing flexibility between uplink and downlink channels using dynamic capacity management.

The AmerHis payload installed on Amazonas consists of eight boxes: the down converter, the onboard processor, four modulators and two Ku-band filters.



One of the AmerHis ASICs

Ground Segment

The AmerHis ground segment consists of user terminals to access the system, gateways interfacing to terrestrial services and a management system to configure and manage the network.

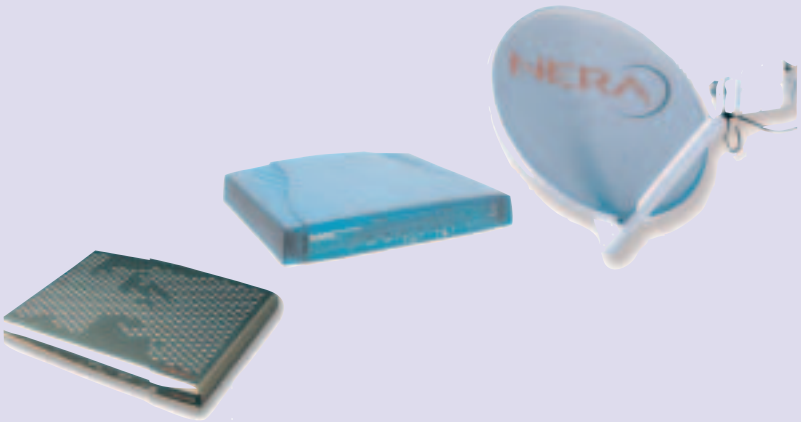
User Terminals

A Return Channel Satellite Terminal (RCST) provides access to other users, as well as external access to terrestrial networks and Service Providers. The peak uplink data raw bit rates for different terminal classes are:

- 512 kbit/s for Class-1
- 1.036 Mbit/s for Class-2
- 2.073 Mbit/s for Class-3
- 4.417 Mbit/s for Class-4.

The antenna and Solid-State Power Amplifier (SSPA) sizes vary from 1.2 to 3 metres and 2 to 8 Watts, respectively, depending upon the class type and coverage area.

An RCST can support both guaranteed rate and delay and best-effort classes of service. The network quality-of-service mechanism in the RCST performs prioritisation of IP flows and selects the most suitable transmission parameters for the application in question. This provides priority to mission-critical data transactions or video or voice transmissions, which require faster turnaround, while providing lower priority to less-time-sensitive traffic such as e-mail and web surfing.



AmerHis user terminals (RCSTs) manufactured by NERA (Norway) and EMS Technologies (Canada)

These terminals are based on standard DVB-RCS products and are already available from two companies. The point-to-point connectivity provided by the AmerHis regenerative payloads requires a call-handling protocol, which is now being considered for DVB-RCS standardisation. The AmerHis RCSTs from different vendors are interoperable, i.e. both terminals can work with the same hub, and have a call-handling procedure implemented.

Gateways

An RCST Satellite Gateway (RSGW) provides AmerHis users with internetworking capabilities to external networks (PSTN, ISDN, Internet). In effect, the RSGW is the hub in an access network with a star topology. It incorporates a standard low-cost and slightly modified RCST, which is an attractive solution for medium to small service providers. It has been designed to share its satellite and terrestrial bandwidth resources with a large number of simultaneous active subscribers.

An AmerHis gateway

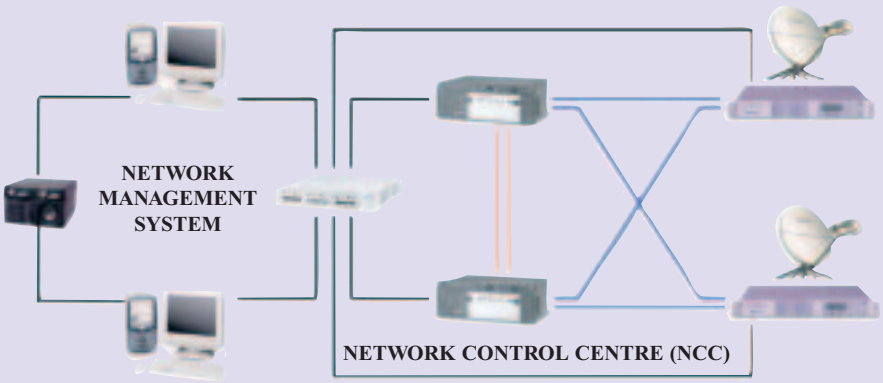
The gateway support commonly used interfaces to the terrestrial networks such as ISDN, Ethernet and ATM. To support the delivery of business-class data services, the RSGW is able to provide service guarantees to subscribers based on different quality-of-service criteria for the different subscription levels.

The peak uplink transmission raw bit rate of the RSGW is at least 8 Mbits/s (2 x 4 Mbit/s terminals). The RSGW maximum downlink throughput at IP level is at least 8 Mbit/s. In order to offer low-cost RSGWs targeted specifically at small Internet Service Providers (ISPs), a standard RSGW can be simplified by not offering voice/video services and reducing the peak uplink rate to 2 Mbit/s.

Management System

The Management System consists of a Network Control Centre (NCC) and a Network Management Centre (NMC). The NCC controls the interactive network, services satellite access requests from users and manages the OBP configuration. An NCC Return-Channel Satellite Terminal (RCST) provides terminal access to the satellite. The NMC handles the system configuration and manages the AmerHis network elements, supporting remote configuration and monitoring of the NCC, user terminals, gateways and OBP, as well as providing fault, configuration, performance and security features for all elements.

Connection-control management functions both support permanent connection set-ups and handle on-demand connection requests, such as call establishment, call modification and call release.



The AmerHis management system

high priority or high priority jitter-sensitive - each of which is associated with a specific set of traffic parameters. An admission-control function ensures optimal use of the available capacity and provision of the best possible service for the different types of application.

The physical capacity of AmerHis is distributed over Virtual Private Networks (VPNs). Each VPN can be allocated a dedicated set of logical capacity, reflecting the service provider's needs, or it can share a set with other VPNs. Any VPN can also take advantage of the AmerHis broadcast capability.

AmerHis is therefore creating a new era for relationships between Internet Network Access Providers (INAPs), service providers and customers by offering much greater flexibility than any other satellite-based system so far. Being a connection-oriented system, it allows full control over the applications crossing the network and the amount of resources allocated to those applications. In this way, over-provisioning can be avoided and billing is triggered only when applications are really using the network. This opens the door for new business models, reflected in turn in the Service-Level Agreement (SLA) between the INAP and service provider or service provider and customer.

The following are some typical AmerHis application scenarios:

Internet Service Providers

In this scenario, the Internet Service Providers (ISP) manage their own low-cost gateway and provide reliable Internet access to subscribers. Value-added services, such as Voice over IP (VoIP) or video conferencing based on the ITU H.323 standard, can be provided to individual customers via a simple configuration. ISPs can choose to offer their own SLAs, be they flat-rate, volume-based or based on a certain quality-of-service profile.

The AmerHis gateways are intended to be low-cost and have minimum infrastructure requirements. The ISPs therefore have the flexibility to locate their gateways in different AmerHis coverage regions and thereby offer more reliable Internet access and/or more attractive tariffs.

The AmerHis in-orbit testing (IOT) station, antenna and shelter and (right) the ground-support equipment used for IOT

A novel feature of AmerHis is the support it provides for multicast services, allowing streaming contents to be delivered to a large number of subscribers simultaneously. The AmerHis gateways support all of the necessary functionality for implementing these services according to the latest IETF (Internet Engineering Task Force) standards. The AmerHis network can support all of the various deployement methods currently used by ISPs, such as private and public IP addressing support, NAT (Network Address Translation), authentication and billing support.

Corporate Services

Companies with multiple branch offices in Europe, Brazil, North and South America can easily set up their own Virtual Private Networks (VPN) and share their allocated capacity between all offices.

An important feature of the AmerHis system for corporate communications is the high quality of service that can be offered for business-grade video and voice conferencing and the possibility of always reaching each branch office with a single satellite hop. In addition, access to the ISDN and POTS terrestrial networks is provided via the AmerHis gateways.

The AmerHis system allows the scheduling of specific connectivity requirements, such as the daily distribution of newspaper copy to printing facilities in different geographical regions.

Video Services

The AmerHis payload offers multiplexing and de-multiplexing of MPEG-2 transport streams and is therefore not only capable of offering IP services over MPEG-2, but also allows the routing of video. Contributions can be made from different uplink stations

and, depending on the onboard switch configuration, duplicated and sent to multiple destinations if necessary, using the DVB-S standard for direct-to-Home (DTH) services. Business television services, occasional-use services and video contributions from smaller terminals can all be supported more easily by exploiting these capabilities.

Early AmerHis Operations

The Amazonas satellite was launched on 5 August 2004 from Baikonur in Kazakhstan by a Proton launch vehicle. One of the first tasks in the Amazonas in-orbit testing (IOT), which started on the 11 August, was to upload the initial settings for the onboard processor via the telecommand link. The AmerHis payload's performance was verified from Hispasat's Arganda ground station, southeast of Madrid, and a signal emitted by a station in Brazil was received. After extensive testing it was concluded that the AmerHis regenerative payload had survived the launch and was performing as expected.

All of the network elements required for the first AmerHis pilot operations are currently available. The intention is thus to verify the whole AmerHis network's operation and performance starting in 2005 and to provide the Amazonas satellite operator Hispasat with a pilot network for early commercial customers.

In addition to this commercial use of AmerHis capacity, ESA is also planning several projects geared to further technology and application development, including:

– Technology projects to look into the characteristics of the current system, propose and perform additional tests, and address further enhancements of the ground segment.
– Application projects are expected to use typical AmerHis features such as quality-of-service, multicasting and demonstrate that applications will benefit from these. Such trials will exploit AmerHis's functionality to convince service providers of the added value of onboard processing and an advanced ground segment.

One potential pilot project is to provide communications capabilities to hospitals in the Amazon rainforest region. An EU-sponsored telemedicine network is being established and some of the hospitals are several thousand kilometres away from well-populated areas in Brazil. Only satellite links can provide reliable communication capabilities. The important feature of AmerHis is being able to provide a single-hop link, for example to a hospital in Portugal for medical-specialist consultation in the event of an emergency occurring at a hospital in the rainforest.

Conclusion

The onboard part of AmerHis has been proven to function as expected in orbit, with a first videoconference between three sites in Europe taking place in early February 2005. The technology offered by AmerHis provides the means to help to bridge the digital divide in developing regions of the World, with a special emphasis on institutional applications such as telemedicine.

In addition, the regenerative onboard payload concept is also well-suited to serving communications scenarios for security, civil protection and emergency applications, which typically have demanding requirements in the areas of mesh connectivity and quality of service.

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