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*ITU-D Regional Development Forum for the Africa Region:  
"NGN and Broadband, Opportunities and Challenges"  
Lusaka, Zambia, 18-19 May 2009*

## **ITU-R Standards Development on Broadband Wireless Access (BWA)**

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## **ITU-R Standards on Terrestrial BWA**



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## ITU-R studies

- Studies on terrestrial BWA in ITU-R are carried out in **Study Group 5**:
- **Working Party 5A** – non- IMT BWA (fixed and mobile)
- Working Party 5C – FWA systems not related to public access systems for potentially mass market coverage (e.g. P-MP fixed systems)
- **Working Party 5D** – IMT systems

## Some key publications on terrestrial BWA

- **Rec. ITU-R F.1763** - Radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz
- **Rec. ITU-R M.1801** - Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz
- **Handbook on Land Mobile** (including Wireless Access) Volume 1: Fixed Wireless Access
- **Handbook on deployment of IMT-2000 systems** (and Supplement 1)
- Many more! - addressing system characteristics, frequency band channeling, sharing, performance, ...

## ITU-R texts on terrestrial BWA

Type		Num	Rev	Approved	Title	WP
Recommendation	F	<b>757</b>	3	01-Feb-03	Basic system requirements and performance objectives for fixed wireless access using mobile-derived technologies offering telephony and data communication services	5A
Recommendation	F	<b>1399</b>	1	01-Feb-01	Vocabulary of terms for wireless access	5C
Recommendation	F	<b>1400</b>	0	01-May-99	Performance and availability requirements and objectives for fixed wireless access to public switched telephone network	5C
Recommendation	F	<b>1401</b>	1	01-Jan-04	Considerations for the identification of possible frequency bands for fixed wireless access and related sharing studies	5C
Recommendation	F	<b>1402</b>	0	01-May-99	Frequency sharing criteria between a land mobile wireless access system and a fixed wireless access system using the same equipment type as the mobile wireless access system	5C
Recommendation	M	<b>1454</b>	0	05-May-00	E.i.r.p. density limit and operational restrictions for RLANS or other wireless access transmitters in order to ensure the protection of feeder links of non-geostationary systems in the mobile-satellite service in the frequency band 5 150-5 250 MHz	5A
Recommendation	M	<b>1457</b>	7	19-Oct-07	Detailed specifications of the radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)	5D
Recommendation	SF	<b>1486</b>	0	01-May-00	Sharing methodology between fixed wireless access systems in the fixed service and very small aperture terminals in the fixed-satellite service in the 3 400-3 700 MHz band	SG4, 5C
Recommendation	F	<b>1488</b>	0	01-May-00	Frequency block arrangements for fixed wireless access systems in the range 3 400-3 800 MHz	5A
Recommendation	F	<b>1489</b>	0	01-May-00	A methodology for assessing the level of operational compatibility between fixed wireless access and radiolocation systems when sharing the band 3.4-3.7 GHz	5A
Recommendation	F	<b>1490</b>	1	01-Sep-07	Generic requirements for fixed wireless access systems	5A
Recommendation	F	<b>1499</b>	0	01-May-00	Radio transmission systems for fixed broadband wireless access based on cable modem standard	5A
Recommendation	F	<b>1518</b>	0	01-May-01	Spectrum requirement methodology for fixed wireless access and mobile wireless access networks using the same type of equipment, when coexisting in the same frequency band	5A

## Current studies on terrestrial BWA

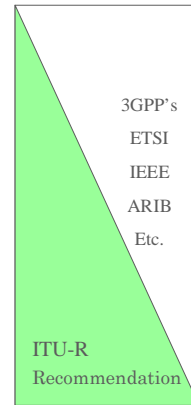
- Update of Rec. ITU-R M.1801 (MBWA < 6 GHz);
- Draft new (Recommendation/Report) - Mobile wireless access systems providing communications to a large number of ubiquitous sensors and/or actuators scattered over wide areas in the land mobile service;
- Draft new Recommendation - Performance and availability requirements and objectives for wireless access systems;
- Draft new Report – Studies on compatibility of non-IMT Broadband wireless access networks (in the mobile service) and fixed-satellite service networks in the 3 400-4 200 MHz band;
- Land Mobile Handbook - Volume 5 -Broadband Wireless Access Systems.

# Scope of BWA Standardization

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Protocol stack		Specified items
Higher Layer	Application	-
	TCP	
Network layer (IP)		<ul style="list-style-type: none"> <li>• Network routing</li> <li>• Mobility management</li> </ul>
Data Link Layer	DLC Sub-layer	<ul style="list-style-type: none"> <li>• Send-receive flow control</li> <li>• ARQ control</li> <li>• QoS control</li> </ul>
	MAC Sub-layer	<ul style="list-style-type: none"> <li>• Medium access control</li> <li>• Error detection &amp; correction</li> </ul>
Physical Layer (PHY)		<ul style="list-style-type: none"> <li>• Radio frequency arrangement</li> <li>• Modulation/Demodulation</li> <li>• Transmission bit rate</li> <li>• Necessary bandwidth</li> <li>• Frequency sharing criteria</li> </ul>



TCP : Transmission Control Protocol IP : Internet Protocol  
 MAC : Media Access Control DLC : Data Link Control

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# Fixed BWA

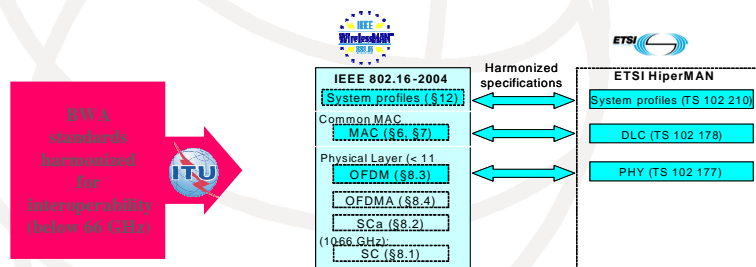
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## Rec. ITU-R F.1763 - Radio interface standards for broadband wireless Access systems in the fixed service operating below 66 GHz

The Recommendation identifies specific radio interface standards for BWA systems in the FS, addressing profiles for the recommended interoperability standards.

The **interoperability** standards referenced in the Recommendation include the following specifications: system profiles; PHY layer parameters, i.e. channelization, modulation scheme, data rates; MAC layer messages and header fields; conformance testing methods:



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# ITU-R Standards on Satellite BWA



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## ITU-R studies

- **Studies on satellite BWA in ITU-R are carried out in Study Group 4:**
- **Working Party 4A** – Efficient orbit/spectrum utilization for FSS and BSS
- **Working Party 4B** – Systems, air interfaces, performance and availability objectives for FSS, BSS and MSS, including IP-based applications and satellite news gathering
- **Working Party 4C** – Efficient orbit/spectrum utilization for MSS and RDSS

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## Some key publications on satellite BWA

- **Rec. ITU-R S.1782** - Possibilities for global broadband Internet access by fixed-satellite service systems;
- **Rec. ITU-R S.1709-1** - Technical characteristics of air interfaces for global broadband satellite systems;
- **Rec. ITU-R S.1711** - Performance enhancements of transmission control protocol over satellite networks;
- **Rec. ITU-R S.1783** - Technical and operational features characterizing high-density applications in the fixed-satellite service;
- Others addressing system characteristics, maximum emission requirements and off-axis e.i.r.p. densities.

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## Current studies on satellite BWA

- Draft revision of Recommendation ITU-R S.1711;
- Draft new Report – Transmission control protocol (TCP) over satellite networks;
- Draft new Recommendation and Report – Quality of service (QoS) architectures, mechanisms and their provisioning in IP-based satellite networks;
- Draft new Report – Studies on compatibility of non-IMT broadband wireless access networks (in the mobile service) and fixed-satellite service networks in the 3 400-4 200 MHz band.

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## RECOMMENDATION ITU-R S.1782

### Possibilities for global broadband Internet access by fixed-satellite service systems

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- **Satellite telecommunication technology has the potential to accelerate the availability of high-speed Internet services in developing countries, including the least-developed countries, the land-locked and island countries, and economies in transition;**
- **FSS frequency allocations can be used in the short, medium and long term for the global provision of high-speed Internet services;**
- **Studies into possibilities for providing global access to the Internet at a high data-rate via satellite have been carried out and are contained in ITU-R standards.**

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- **First example:** suitable fixed-satellite service (FSS) bands are identified and up and downlink characteristics are developed for direct satellite links from user terminals with 30 cm antennas;
- **Second example:** up and downlink characteristics are developed for a system that would provide direct satellite links for user terminals with 1.2 m antennas;
- **Third example:** the characteristics are developed of an example system based on user access via terrestrial radio links to “community” earth stations and thence via a satellite to a single central earth station.

## Possibilities for global broadband Internet access by FSS systems designed for ultra small earth station antennas



## Frequency band considerations

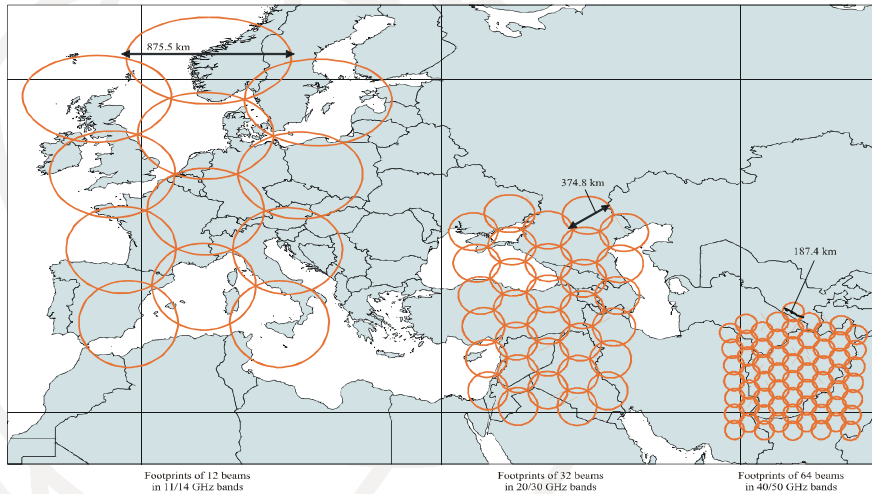
- **4/6 GHz:** not suitable for low cost, very small antennas and already heavily used;
- **11/14 GHz:** already heavily used;
- **20/30 GHz:** most suitable in the near term, technology reasonably well developed;
- **40/50 GHz:** technology still not well developed.

## Possible technical characteristics

- Use of ultra-small aperture terminals (USATs) of 30 cm diameter at the user end;
- Satellite spot-beam characteristics selected

FSS frequency range	11/14 GHz	20/30 GHz	40/50 GHz
Gain at beam centre (dBi)	42	50	55
-3 dB beamwidth (degrees)	1.4	0.6	0.3
Number ( <i>n</i> ) of dual-polar transmit/receive beams per satellite	12	32	64

## Examples of beam arrangements for FSS satellites that could provide high-speed Internet access



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## Example link parameters

- User 30 cm USATs communicating via satellite with large base stations interfacing with the Internet;
- QPSK modulation with rate  $\frac{3}{4}$  FEC, C/N = 8.5 dB;
- User bit rate of 2 Mbit/s.

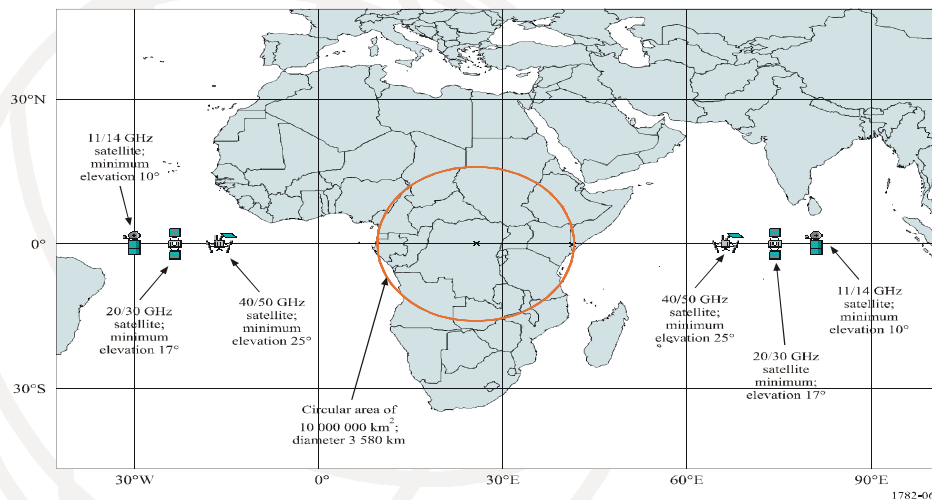
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## Capacity per satellite

- QPSK modulation with rate  $\frac{3}{4}$  FEC;
- 11/14 GHz: 3 024 Mbit/s;
- 20/30 GHz: 8 960 Mbit/s;
- 40/50 GHz: 16 128 Mbit/s.

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## Potential overall capacity Example Equatorial area of 10 million km<sup>2</sup>



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## Potential overall capacity

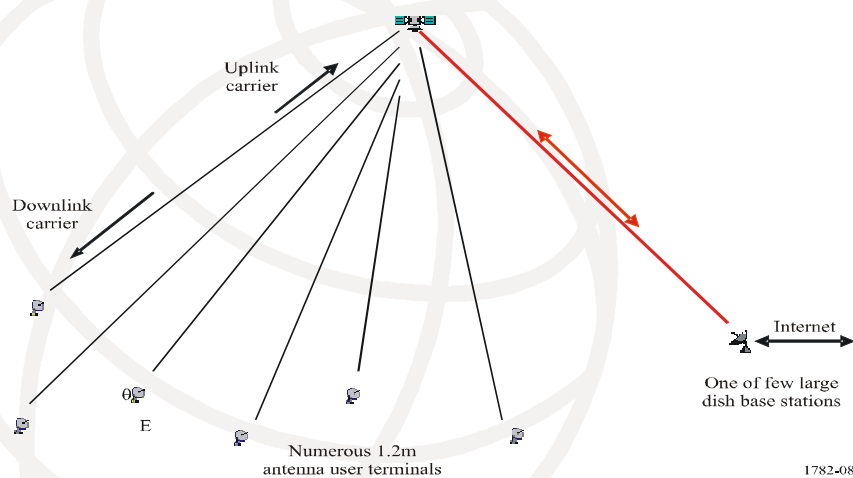
- QPSK modulation with rate  $\frac{3}{4}$  FEC;
- 11/14 GHz: 71 Gbit/s;
- 20/30 GHz: 706 Gbit/s;
- 40/50 GHz: 4 400 Gbit/s.

## Possibilities for global broadband Internet access by FSS systems designed for larger earth station antennas

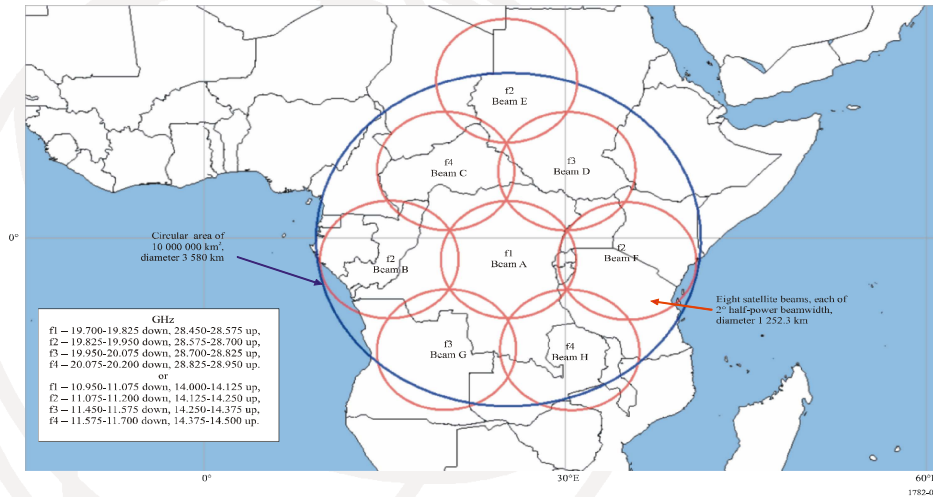
## Example link parameters

- User 1.2 m VSATs communicating via satellite with large base stations interfacing with the Internet;
- QPSK modulation with rate  $\frac{1}{2}$  FEC, C/N = 7.5 dB;
- User bit rate of 2 Mbit/s.

## Link arrangement for broadband Internet access via satellite using VSATs



## Example satellite beam arrangement for broadband Internet access via satellite by user stations with 1.2 m antennas



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## Broadband Internet access via satellite by user stations with 1.2 m antennas

### Capacity per satellite

- 11/14 GHz: 1 408 Mbit/s;
- 20/30 GHz: 1 280 Mbit/s.

### Potential overall capacity

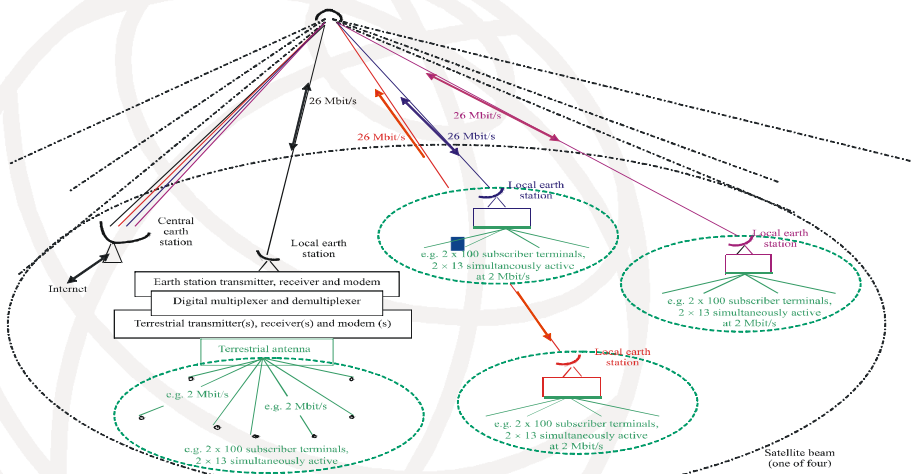
- 11/14 GHz: 77.44 Gbit/s;
- 20/30 GHz: 61.44 Gbit/s.

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## Example of global broadband Internet access by an FSS system designed for “community” earth station antennas and local terrestrial distribution

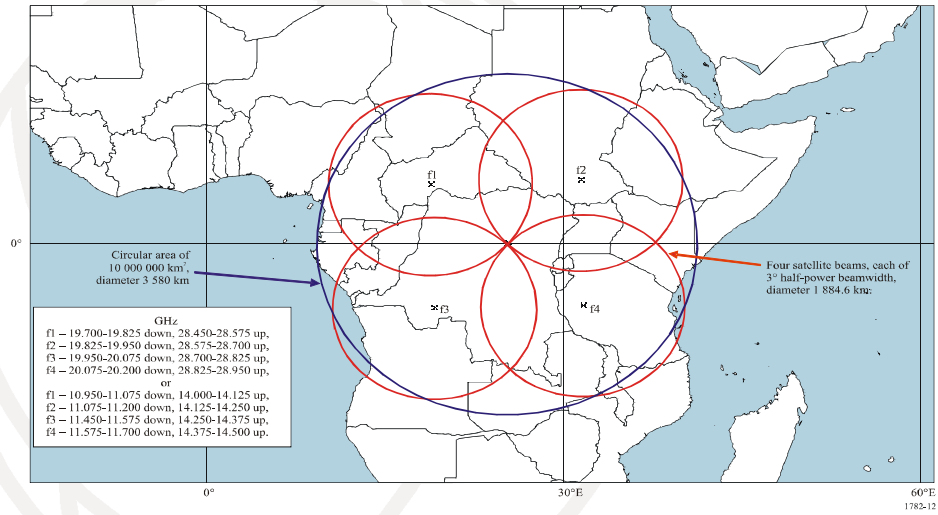
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## Example architecture for broadband Internet access via local terrestrial radio networks plus satellite



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### Example satellite beam arrangement for broadband Internet access via satellite plus local terrestrial radio network



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## RECOMMENDATION ITU-R S.1709-1

### Technical characteristics of air interfaces for global broadband satellite systems

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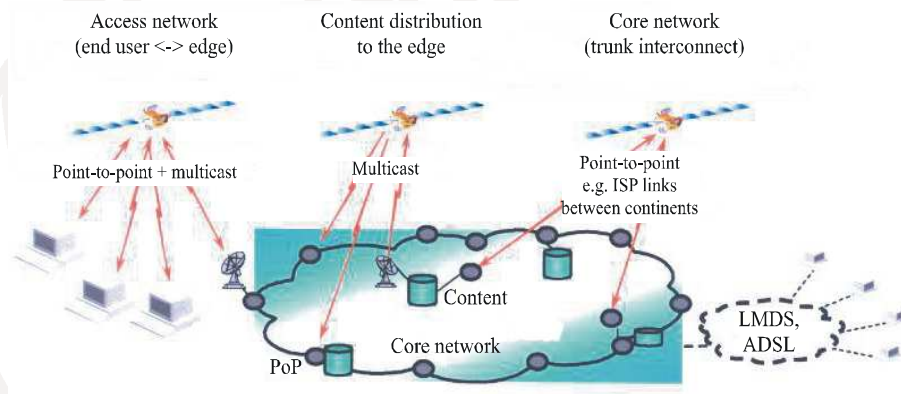


- **satellite telecommunications technology has the potential to accelerate the availability of broadband communications both on a global and regional basis;**
- **several different types of architectures are used in broadband satellite systems;**
- **these varying uses have led to the development of various air interface standards in order to allow seamless transportation of broadband signals over different networks.**

## **Generic network architecture for global broadband satellite systems**

- **The inherent characteristics of satellite communications, that is their wide-coverage, broadcast mode of operation and multicasting, make them capable of providing high-speed Internet connection and multimedia long-distance transmissions;**
- **There are many possible implementations of broadband by satellite, however, certain fundamental features such as protocol stacks, satellite dependant and independent functions, user-access to the system and air interface are very similar.**

## Global broadband satellite network scenarios



ADSL : asymmetric digital subscriber line  
LMDS: local multipoint distribution system  
PoP : point of presence

1709-01

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## Services

- **Point-to-point;**
- **Multicast/broadcast;**
- **Content distribution.**

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## Broadband applications

- **Entertainment**
  - Video-on-demand;
  - TV distribution;
  - Interactive games;
  - Music applications;
  - Streaming.

## Broadband applications

- **Internet access**
  - High-speed Internet access;
  - Electronic messaging;
  - Multimedia applications;
  - Distance learning;
  - Telemedicine.

## Broadband applications

- **Business**
  - Videoconferencing;
  - Business-to-business;
  - Home security.
- **Voice and data trunking**
  - IP-transport;
  - Voice-over-IP;
  - File transfers.

## Satellite architecture

- A non-regenerative architecture refers to a single architecture, commonly called a "bent-pipe architecture". This architecture does not terminate any layers of the air interface protocol stack in the satellite – the satellite simply transfers the signals from the user links to the feeder links transparently;
- A regenerative architecture is the range of other architectures that provide additional functionality in the satellite. In these architectures, the satellite functions terminate one or more layers of the air interface protocol stack in the satellite.

## RECOMMENDATION ITU-R S.1711

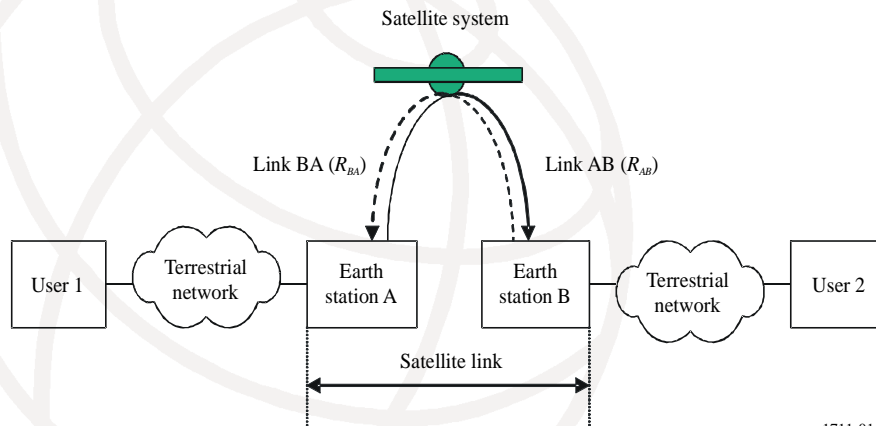
### Performance enhancements of transmission control protocol over satellite networks

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- **satellite systems are being used increasingly for Internet Protocol (IP) packet transmissions, in particular providing broadband applications directly to users in addition to their role as backbone links;**
- **Most of the current IP transmissions use transmission control protocol (TCP) as transport protocol. However, the performance of TCP may suffer from degradation due to long satellite transmission delay, which affects the quality of service of end-users' applications;**
- **The enhancement of TCP performance is therefore critical in designing satellite links to carry IP packets. Various techniques, collectively referred to as "TCP performance enhancements" were developed to overcome satellite link limitations due to propagation delay and link errors.**

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## Reference model for a point-to-point link including a satellite link



1711-01

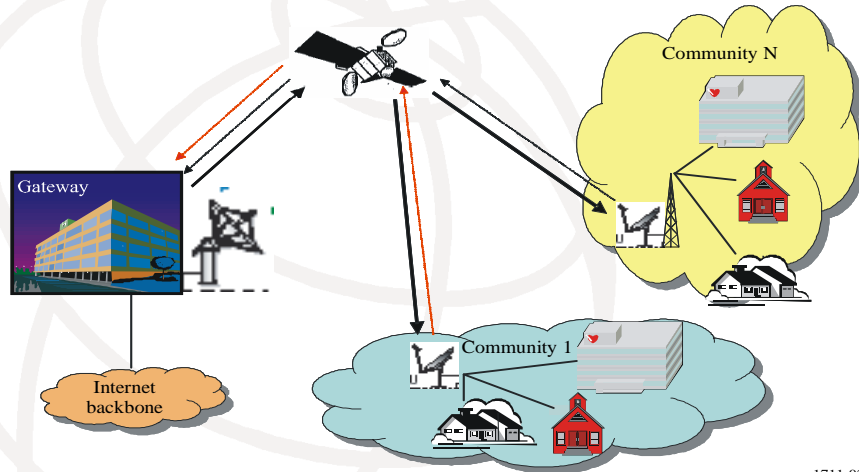
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## Topologies

- A star network topology is defined by the star arrangement of links between the hub station (or Internet access point) and multiple remote stations. A remote station can only establish a direct link with the hub station and cannot establish a direct link to another remote station;
- A mesh network is defined by the mesh arrangement of links between the stations, where any station can link directly to any other station. The star topology can be considered as one special case of the mesh topology.

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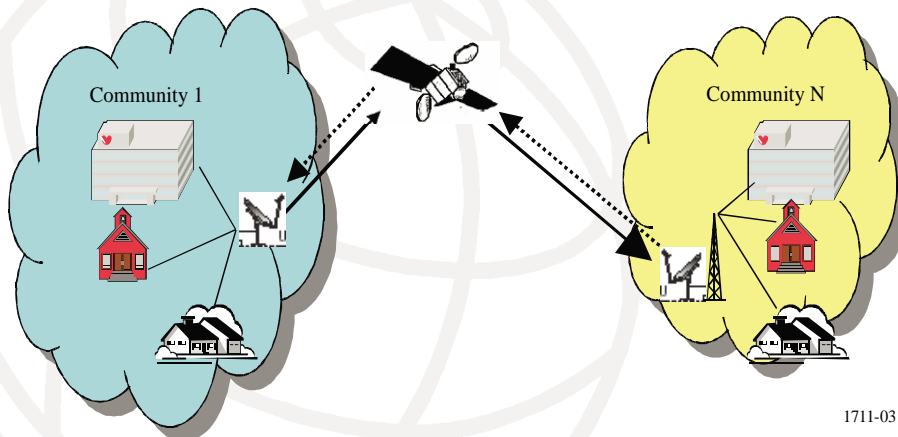
## Star topology



1711-02

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## Mesh topology



1711-03

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## RECOMMENDATION ITU-R S.1783

### Technical and operational features characterizing high-density applications in the fixed-satellite service

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## Features relating to HDFSS

- flexible, rapid and ubiquitous deployment of earth stations;
- large numbers of earth stations deployed with high-geographical density;
- urban, suburban and rural earth station sites;
- wide range of telecommunications applications;
- different systems may employ GSO or non-GSO satellites.

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**Thank you!**