SATELLITE COMMUNICATIONS NETWORK OF EXCELLENCE

Trials and Applications

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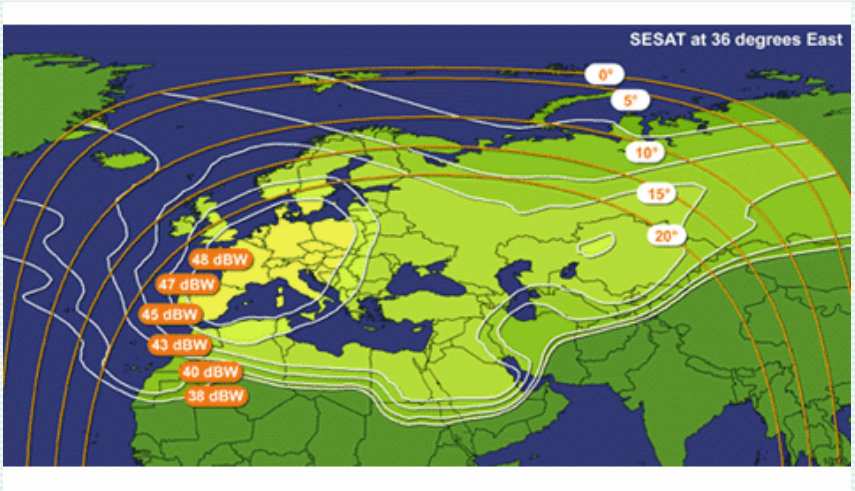
CONTENTS

- Advantages of Satellite Communications
- Technology
- TV Distribution
- Internet via Satellite
- Emergency Communications
- Tele-Medicine
- Tele-Education
- Further Developments
- Summary

ADVANTAGES OF SATCOMS

- Wide coverage
- Broadcast capability
- High communications capacity
- Flexibility in network set-up
- Mobility
- Rapid deployment
- Reliability
- Economic solutions available

COVERAGE (SESAT)



TECHNOLOGY

VSAT TECHNOLOGY

- **Antenna sizes**
  - 1.2/ 1.5 m for transportable units
  - 2.4 m for fixed stations
- **Ku-band**
  - 12 / 14 GHz
- **Ka- band**
  - 20 / 30 GHz

Fly-away terminal

FIXED GROUND STATION

Antenna sizes:
1.5… 2.4 m

RF Power: typ. 16 W

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TRANSPORTABLE TERMINAL

Car trailer

400 kg

Operational within
30 min.

SYSTEM ASPECTS

- **User rates up to 4 Mbit/s per terminal**
- **Fade adaptation possible**
  - ➔ Variable transmission rate
  - ➔ Variable code rate

    Short preamble:
    - minimise overhead
    - prerequisite for IP optimised system
- **MF-TDMA access scheme**
  - ➔ dynamic assignment of capacity
  - ➔ guaranteed QoS

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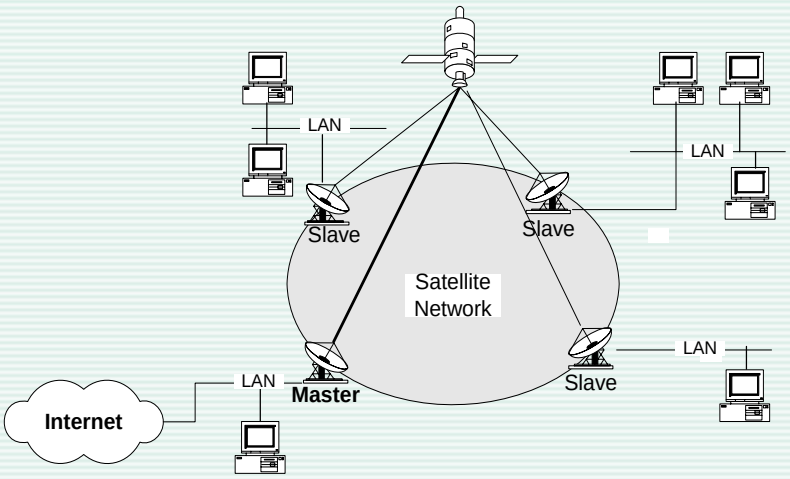
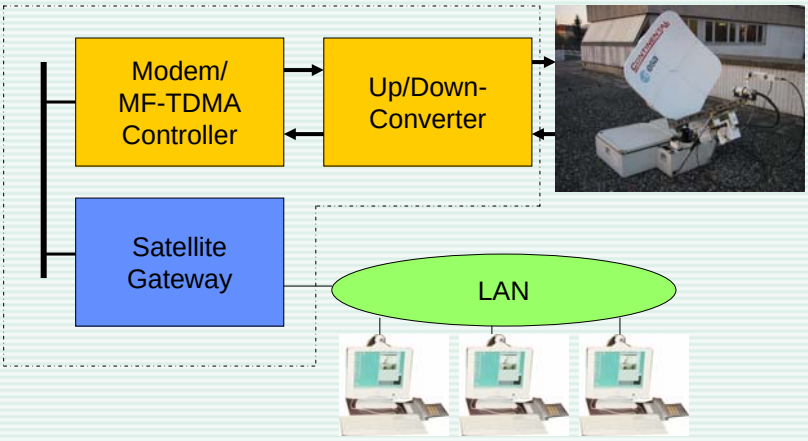
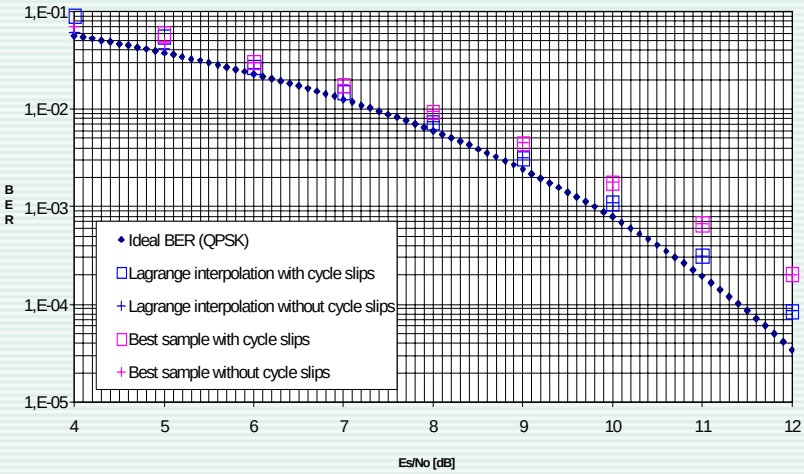
NETWORK ARCHITECTURE



TERMINAL ARCHITECTURE



PERFORMANCE



IMPLEMENTATION

- Modem integrated in Linux PC
- FPGAs for
  - modulator
  - demodulator
- FEC (Turbo) entirely in software

FPGA CARD

FEC

- **Turbo principle**
  - ➔ low complexity
- **Method found to reduce error floor with less iterations (patent)**
- **Code rate variable (1/2, 2/3, 3/4)**

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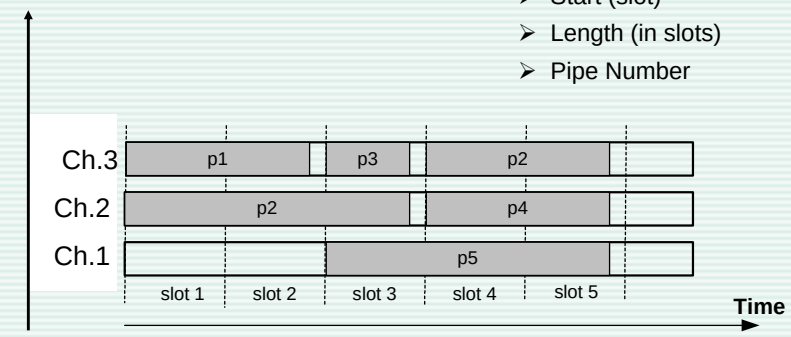
ACCESS SYSTEM

- **Multi-Frequency TDMA (MF-TDMA)**
  - ➔ capacity assigned in time and frequency
  - ➔ centralised control by master station

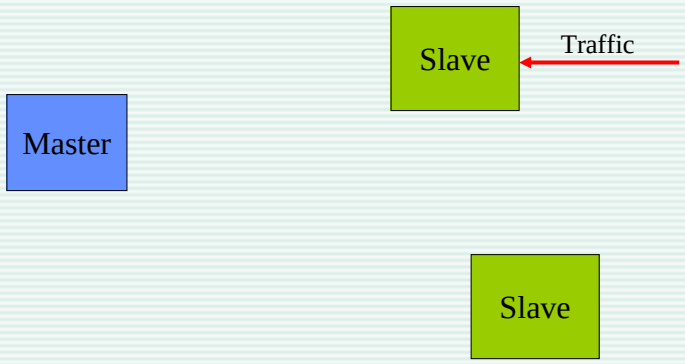
MF-TDMA

Burst description:

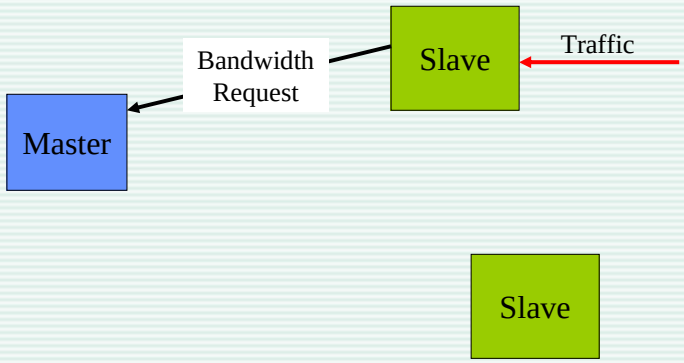
- RF Channel Number
- Start (slot)
- Length (in slots)
- Pipe Number



RESOURCE ALLOCATION



RESOURCE ALLOCATION



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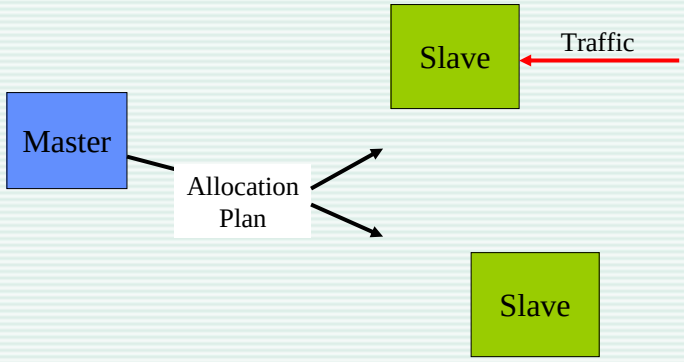
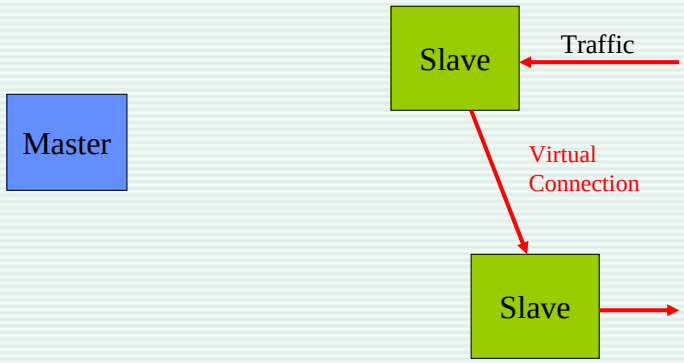
RESOURCE ALLOCATION



RESOURCE ALLOCATION



QoS CLASSES

Guaranteed assignment of bandwidth

Constant bandwidth allocated, stringent delay requirements

Guaranteed available bandwidth

Bandwidth guaranteed, assigned only on request

Best effort - high priority

No bandwidth guarantee, fair distribution

Best effort - low priority

Like best effort high priority QoS class, but low priority

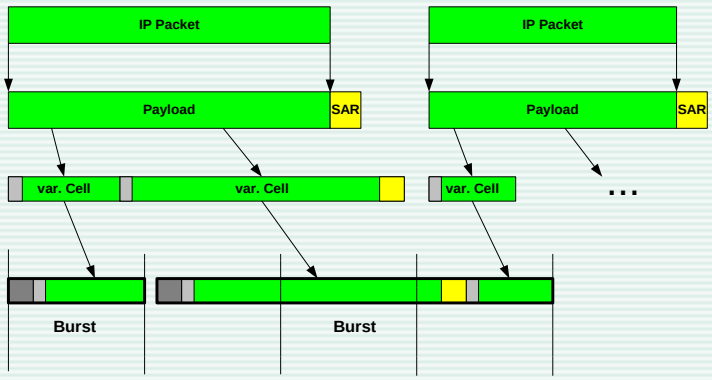
Bulk transfer

No guarantees, low priority, long delay

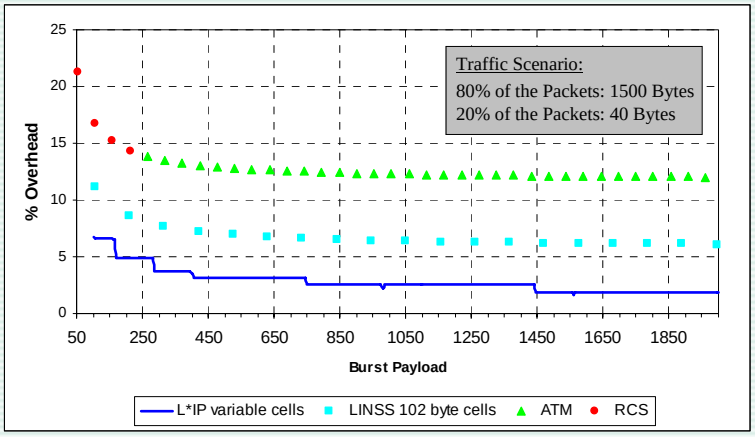
ENCAPSULATION

- **Satellite multimedia systems based on**
  - ➔ ATM cell (53 byte, 48 byte payload)
  - ➔ MPEG-II transport cell (188 byte, 184 byte payload)
  - ➔ frame relay
- **IP traffic dominant: overhead!**

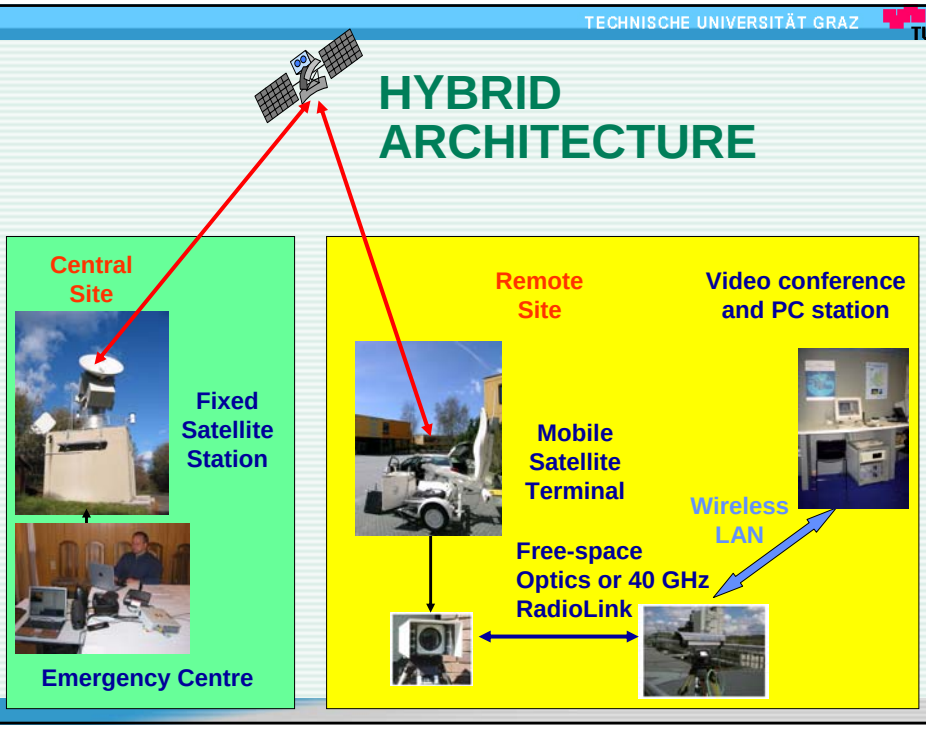
EFFICIENT ENCAPSULATION



OVERHEAD COMPARISON



HYBRID ARCHITECTURE

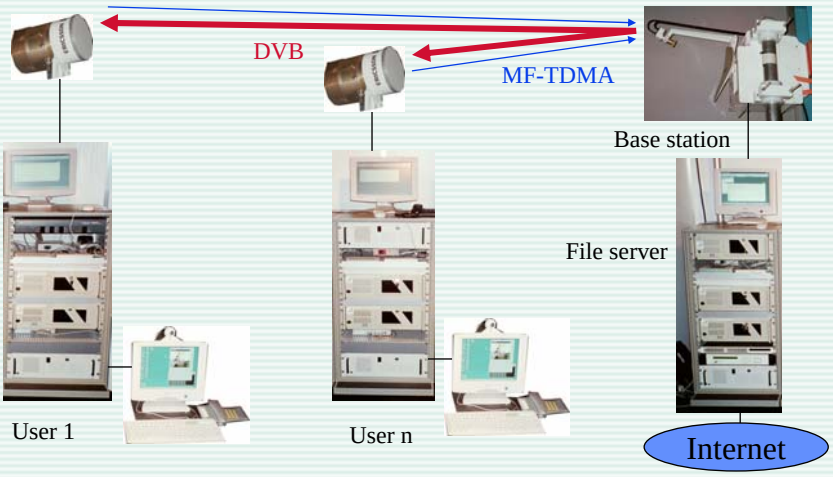


FREE-SPACE OPTICS / WLAN

- **FSO**
  - Up to 1.5 km
  - LED / Laser systems
  - Ethernet interface

- **WLAN (802.11b/g)**
  - For last 30…50 m
  - Directive antennas

TERRESTRIAL BROADBAND WIRELESS (40 GHz)



„ALL IP“ NETWORK

- **Protocol family of Internet dominant**
- **System uses exclusiveley IP protocols (IP/TCP / IP UDP)**
  - ➔ LAN – LAN interconnection
  - ➔ Fast Internet / Intranet access
  - ➔ Voice over IP
  - ➔ Video over IP
- **Quality of service guarantees**
- **All standard local computer applications possible**

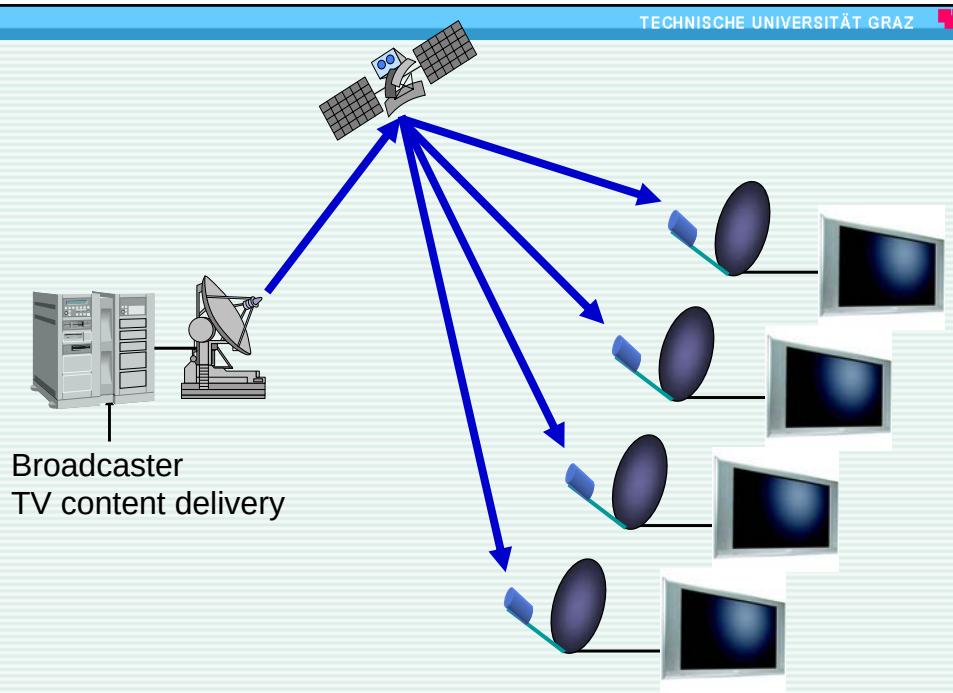
VIDEO CONFERENCE

- **Commerical system:**
  - ➔ Polycom ViewStation:
    - Max 768 kbit/s Video
    - 64 kbit/s Audio
    - Ethernet/LAN Interface
  - ➔ H.323 standard
    - Video over Internet Protocol (IP)
- **Alternative: software video conference systems (e.g. Netmeeting)**
  - ➔ Usually lower quality

CASE 1: TV DISTRIBUTION

TV DISTRIBUTION

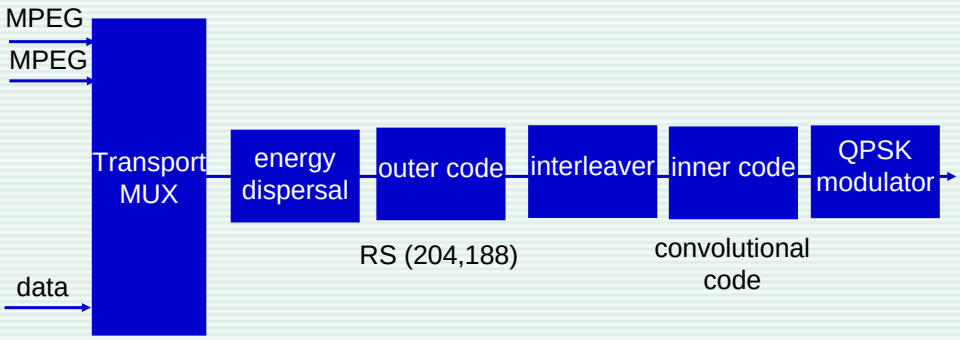
- **Oldest, but most important application**
- **Exploitation of broadcast capability of satellite**
- **Services:**
  - ➔ One-way
  - ➔ Two-way (interactive TV, MHP)
- **Analog (FM)**
  - ➔ phasing out
- **Digital (DVB-S, DVB-S2 standard)**



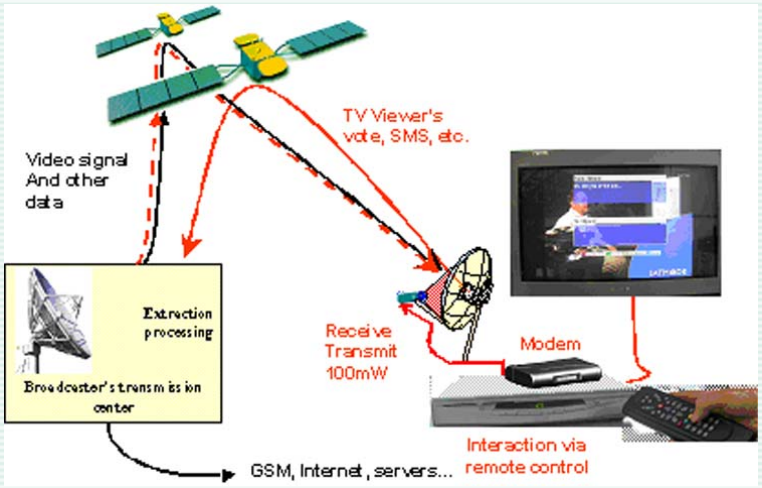
DVB-S

- Digital Video Broadcast standard
- MPEG transport stream defined, 188 byte cells, 4 byte header
- multiplex of MPEG-II video and IP packets

DVB-S TRANSMITTER



INTERACTIVE TV

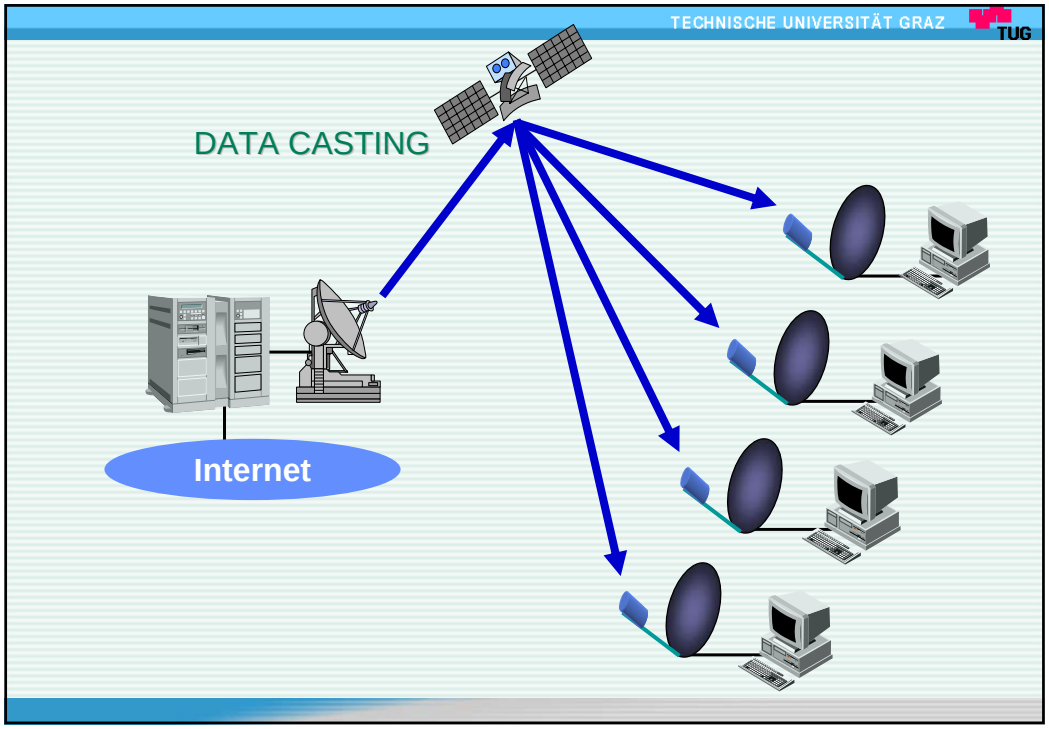


Source: ESA

CASE 2:
INTERNET VIA SATELLITE

SATELLITE INTERNET ACCESS

- **Transport of IP packets via DVB (forward link)**
- **Return link**
  - ➔ via terrestrial networks
  - ➔ via satellite
- **Improvement of telecom infrastructure in rural areas**
- **Low-cost solutions**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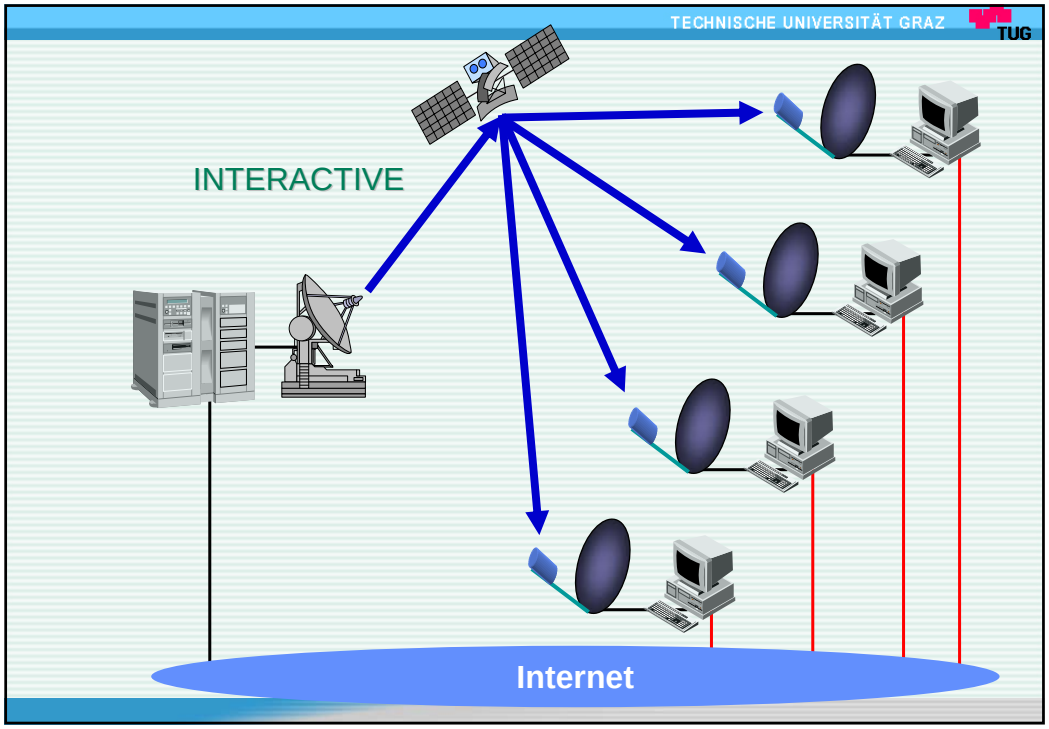
TUG
DATA CASTING
Internet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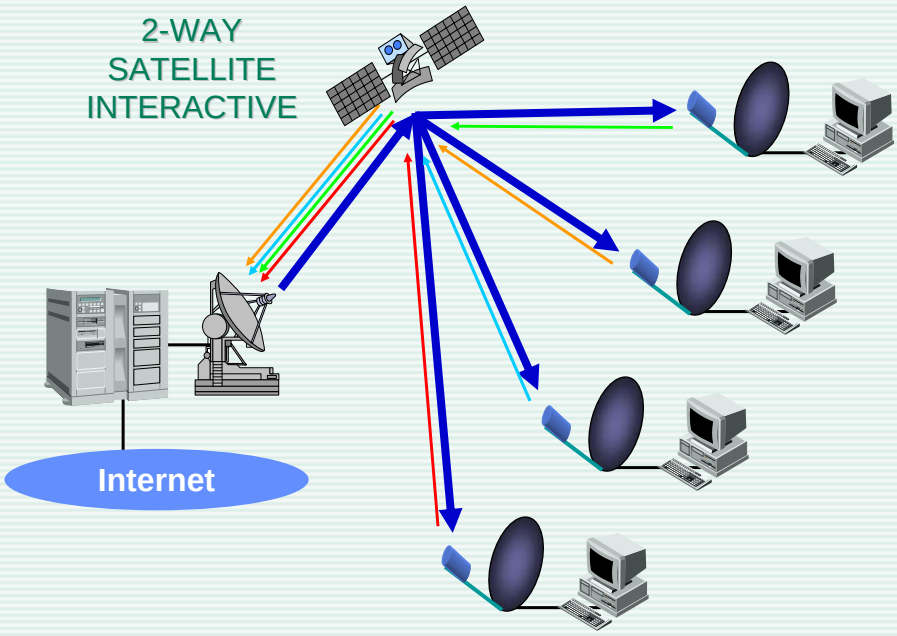
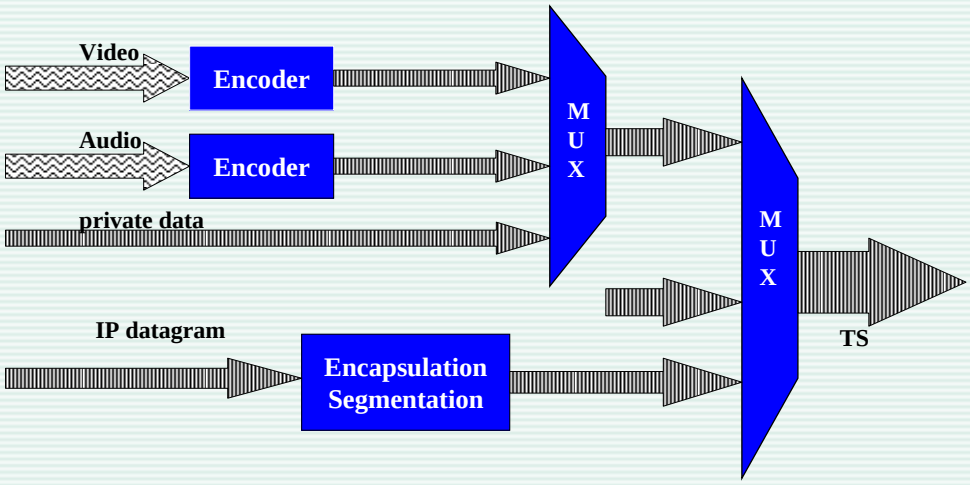
TUG
INTERACTIVE
Internet

2-WAY SATELLITE INTERACTIVE



MULTIPLEXING



DATA RATES

- bit rate after MUX: 41.57 Mbit/s
- bit rate after RS code: 45.108 Mbit/s
- outer code rate: 7/8
- symbol rate: 45.108 / 2 * 8/7 = 25.776 Msymb/s
- BW/Rs = 1.28
- BW = 25.776 * 1.28 = 33 MHz (3 dB bandwidth of transponder)
- C/N = 8.4 dB for quasi-error free channel (BER= 10^{-11})

DATA RATES

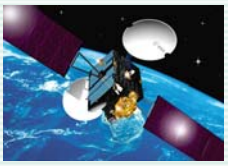
- bit rate after MUX: 23.754 Mbit/s
- bit rate after RS code: 25.776 Mbit/s
- outer code rate: 1/2
- symbol rate: 25.776 / 2 * 2 = 25.776 Msymb/s
- BW/Rs = 1.28
- BW = 25.776 * 1.28 = 33 MHz
- C/N = 4.1 dB for quasi-error free channel

CASE 3:
EMERGENCY COMMUNICATIONS AND DISASTER MANAGEMENT

EMERGENCY COMMUNICATIONS

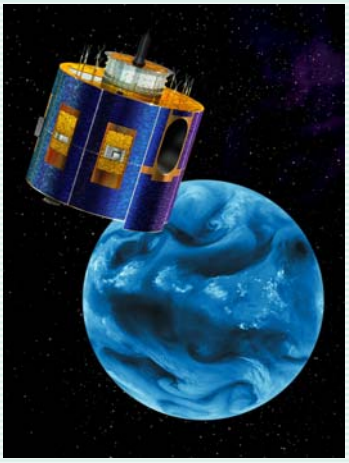
- **Satellites provide ideal communications tools**
  - ➔ in case of natural or man-made disaster
  - ➔ in areas with inadequate infrastructure

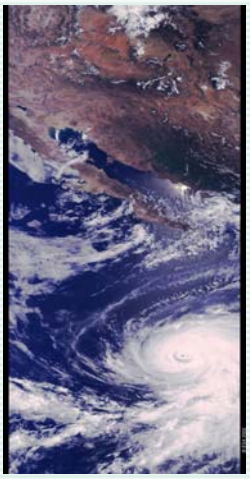
APPLICATIONS



- **Data collection**
- **Data dissemination**
- **Interconnection of remote areas with management centers**
  - Voice (telephony)
  - Video (video conference)
  - Data (Intranet/Internet, database access)

METEOROLOGICAL SATELLITE IMAGES





www.esa.int

REMOTE SENSING IMAGES

SYMMETRICAL NETWORK

GEO Satellite

fixed station

air-transportable terminal

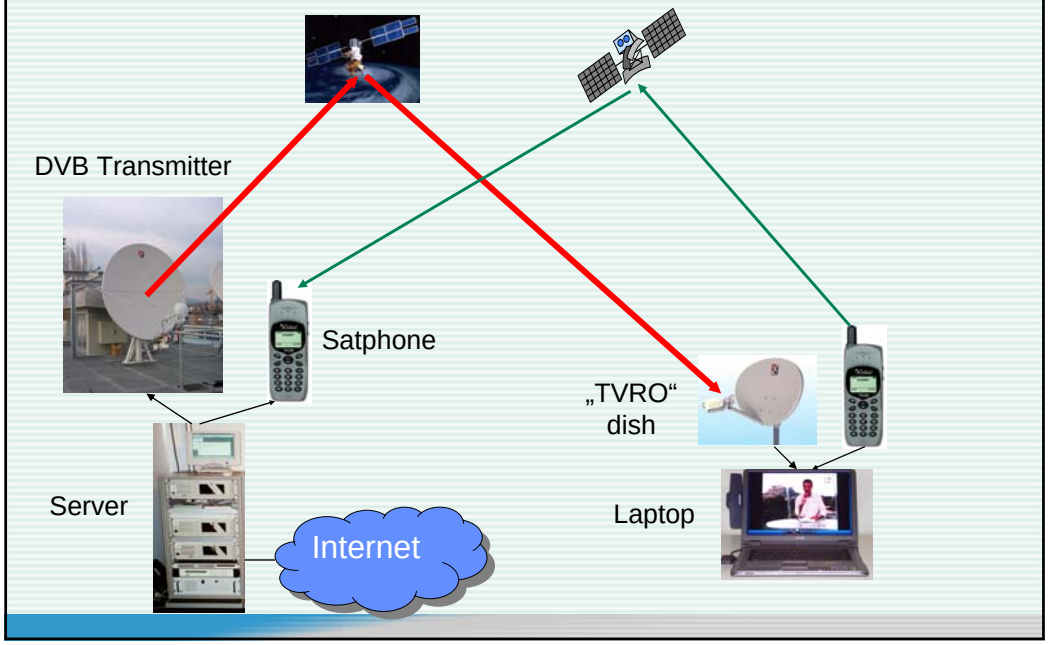
road-transportable terminals

ASYMMETRICAL NETWORKS

- **Meshed VSAT powerful, but more expensive**
- **Digital Video Broadcasting (DVB-S, DVB-S2) widespread, low cost**
  - Forward link system
  - High data rates: ~ 40 Mbit/s
- **Satellite phone (GLOBALSTAR, THURAYA)**
  - Return link system
  - Data rates: ~ 9.6 kbit/s
- **Efficient multicast protocols**
  - Low capacity in return link sufficient

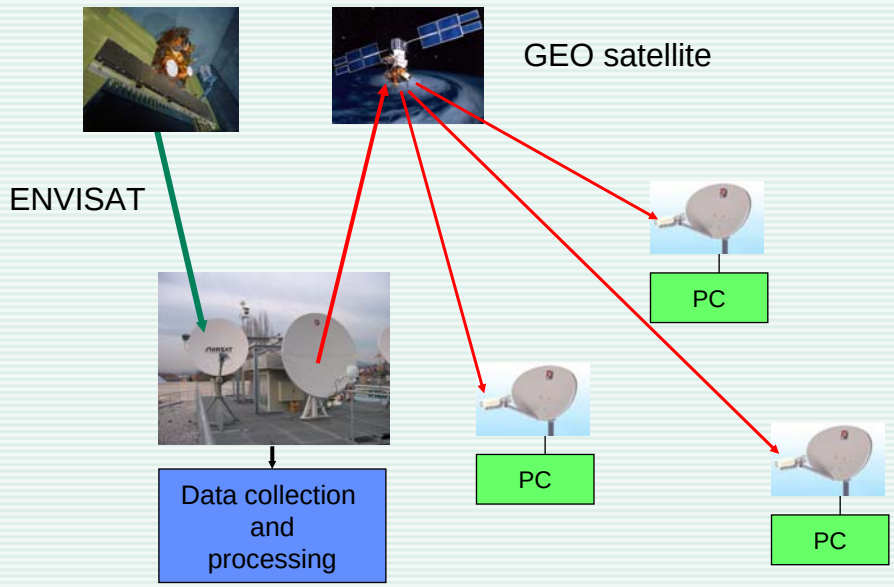
SUPPORTED APPLICATIONS

- **Delivery of high quantities of data (multicast)**
  - Image transfer
  - Situation maps
  - Intranet / Internet access (downloads)
- **Email**
- **Voice**



ENVISAT Data Dissemination

- DVB technology to transfer ENVISAT processed images at high speed
- Satellite TV dish
- PC with DVB card
- Return link not required
- 25 stations active in Europe



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SERVICES

- **High-speed file transfer**
  - ➔ Meteorological, remote sensing images
- **Database access**
- **Intranet / Internet access from remote areas**
- **Email**
- **IP Video conference services among experts and decision makers**
- **IP telephony**
- **Integrated decision support system**

CASE 4: TELE-MEDICINE

TELE-MEDICINE SERVICES

- **Transfer of patients' vital data at high speed**
  - electronic X-ray and CT images
  - Ultrasound scanner data, etc.
- **Provision of video conference and telephony services between a remote hospital and an expert centre**
  - Tele-consultancy among physicians
  - Second opinion

TELE-MEDICINE

- **Interconnection of hospitals via satellite**
  - Remote hospitals linked with expert centres
- **Fast transmission of CT, radiology images, ultrasound scanner data**
- **Consultancy of medical experts via video conference**
  - Fast decision about further treatment of patients
  - Second opinion
- **Monitoring of surgery in broadcast TV quality (MPEG-2)**
- **Tele-Training of medical personnel**

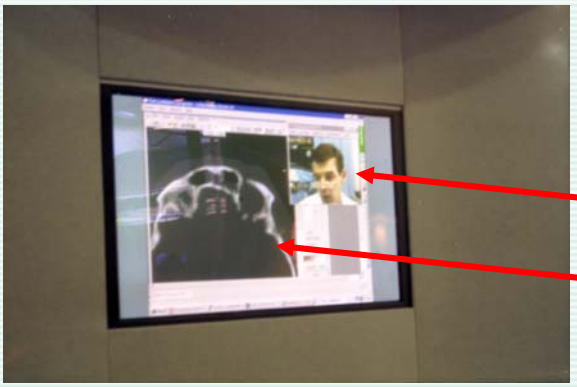
ESA‘s TELEMEDICINE PROJECT

TELE-MEDICINE TRIAL

3D computer tomography workstation

connected with satellite terminal

TELE-MEDICINE



Video conference

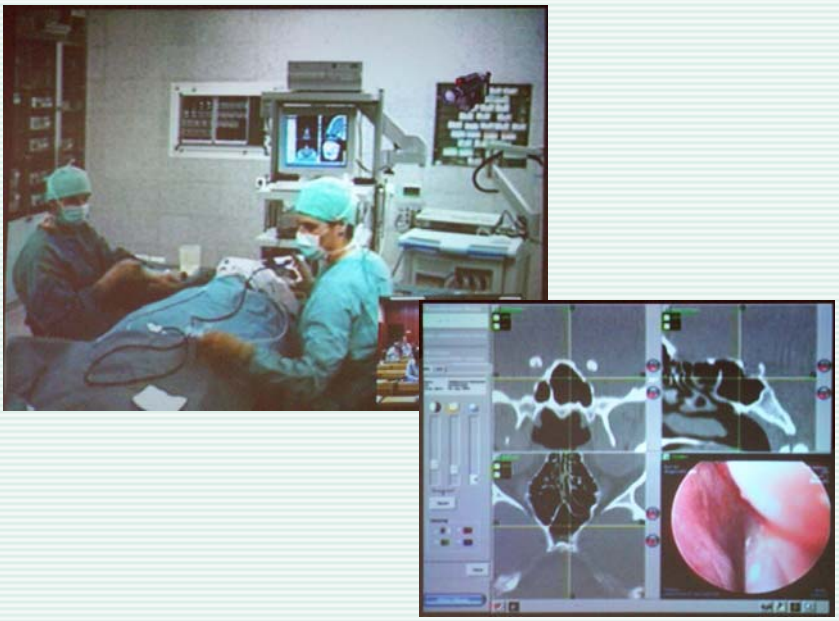
3D- CT-Image

TELE-MEDICINE APPLICATION

Demonstration at
UNCOPUOS Meeting
June, 2003

Live surgery: interactive medical
Training

Graz – Munich
Graz – Rochester (Mayo Clinic)



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TELE-CONSULTANCY

PILOT DEMONSTRATIONS

HEART MONITOR

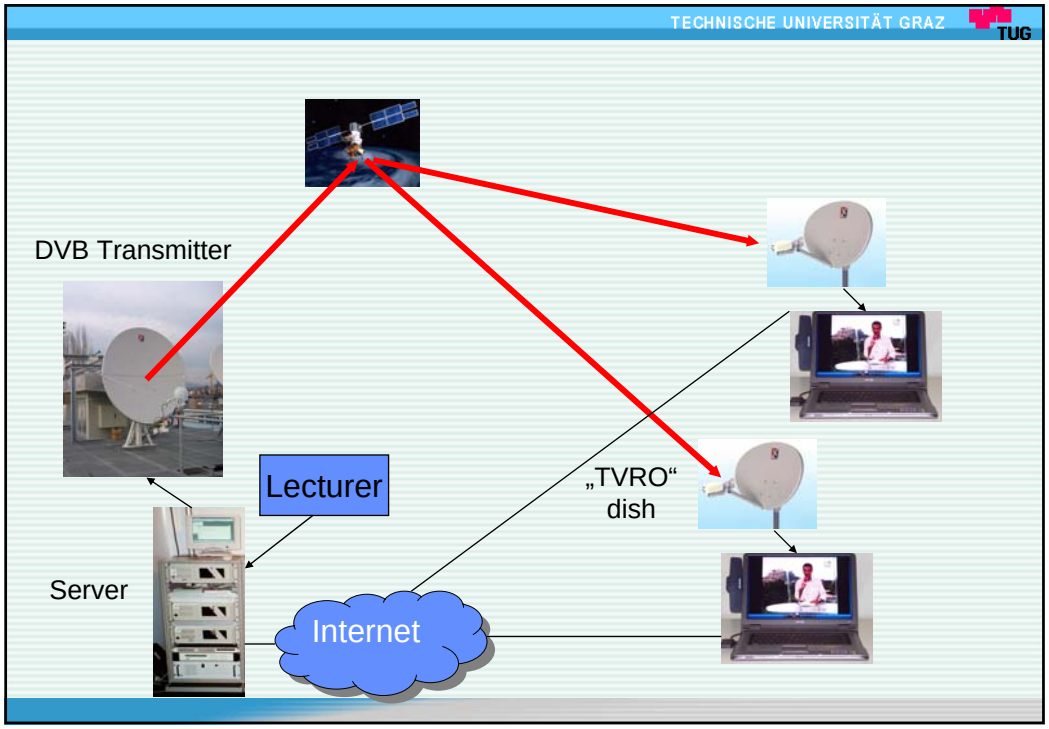
Heart monitor data transferred in parallel to video conference

CASE 5:

TELE-EDUCATION

TELE-TEACHING

- **Lecturer has camera, microphone, PC**
- **High-quality outbound video and audio**
  - ➔ MPEG-2
  - ➔ MPEG-4
  - ➔ H.323
- **Application sharing for electronic slides**
- **Interactivity**
  - ➔ by video conference or audio only return link
  - ➔ Minimum: text (chat function)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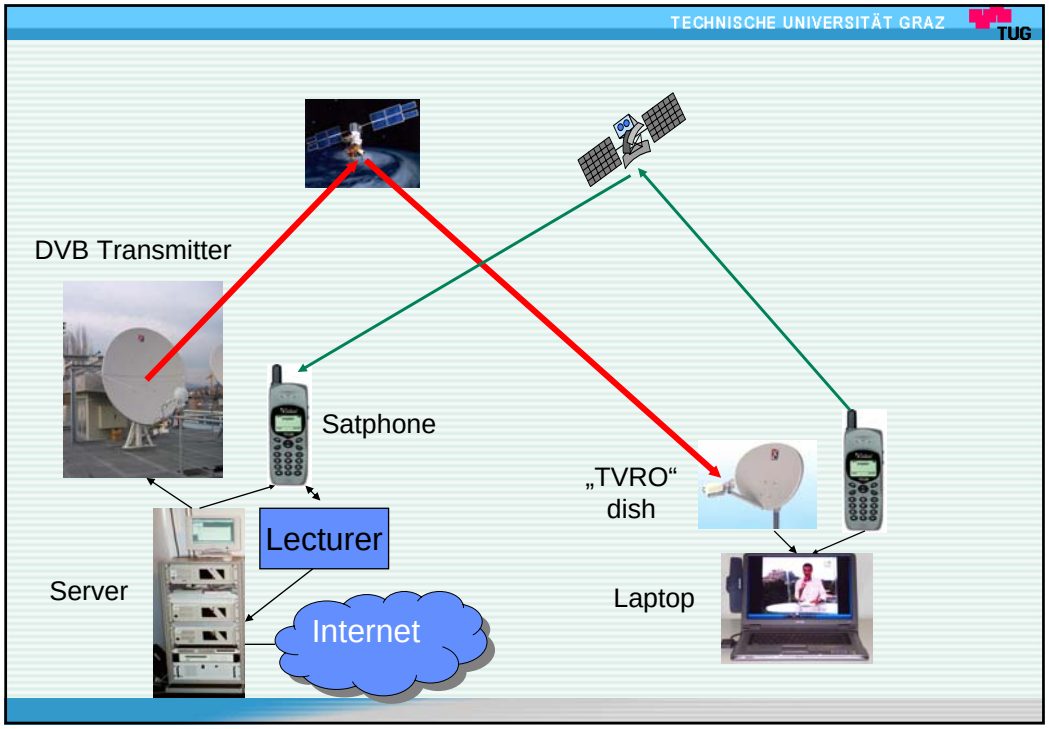
TUG
DVB Transmitter
Lecturer
„TVRO“
dish
Server
Internet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TUG
DVB Transmitter
Satphone
„TVRO“
dish
Lecturer
Server
Laptop
Internet

REMOTE LECTURE

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SATNEX PLATFORM

- **Based on DVB-S forward link**
- **Hub station at Fraunhofer Institute**
- **Content delivery via terrestrial Internet**
- **Return link via Internet**
  - Video conference
  - Chat
  - VoIP
- **Multipoint feature provided by conference server**

OTHER DEVELOPMENTS

- **SKYPLEX**
  - DVB technology
  - Multiplexing on board of satellite
  - Spot beams
  - Small terminals for uplink
  - Standard DVB receivers
- **Adapted DVB-RCS terminals (SIT)**

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SIT – INTERACTIVE TERMINAL

- **DVB – RCS (Return Channel System)**
- **Digital Video Broadcasting Technology (DVB-S,-S2)**
  - forward link Ku-, C-band
  - High bit rates: several Mbit/s
  - typ. in Ku-band (normally used for TV distribution)
- **Return link**
  - C-, Ku- or Ka-band
  - Data rates 144, 384, 2048 Mbit/s
- **Star network, large number of terminals**
- **Designed for high-speed Internet access in areas without DSL or cable connectivity**

SIT

- **Dish sizes: 75, 90, 120 cm**
- **Small transceiver front-end**
- **Small indoor equipment**
- **Lower cost compared to traditional VSATs**
  - ➔ Terminal: around $ 1500
- **Self-aligning dish (azimuth, elevation, polarization) needed for emergency communications**

www.emssatnet.com

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NETWORKING ASPECTS

- **Suitable for**
  - ➔ High-speed data transmission (remote sensing images)
  - ➔ Intranet / Internet access
  - ➔ Data collection (larger volumes)
- **Direct terminal – terminal communications limited due to double hop**
- **Solution: On-board processing**
  - ➔ „switching in the sky“
  - ➔ HISPASAT AMAZONAS satellite (South American coverage)

SUMMARY

- **Satellite communications indispensable tool for**
  - High-speed data collection & dissemination
  - Voice/video/data when othe communications links are disrupted
  - Integrated decision support systems
  - Tel-medicine
  - Tele-education
- **Symmetrical and asymmetrical solutions**
- **„All IP“ networks facilitate integration**
  - Satellite
  - FSO / Microwave links
  - WLAN

SUMMARY (2)

- **Provision of services in remote areas**
- **Rapid deployment**
- **Reliable systems**
- **Low-cost solutions available using DVB technology**

WEB SITES

- www.joanneum.at/ias
- www.iks.tugraz.at