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Satellite Services for Disaster Management and Security Applications

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1. Introduction

Satellites can be a vital communications element in case of emergencies or natural disasters. This is not only true for developing countries, but also for highly developed regions. As the example of the floods in Central Europe in 2002 have shown, even basic telecommunications services can become unavailable. During natural or man-made disasters, access to data from meteorological and remote sensing satellites is extremely important for assessing the situation.

Using very small aperture terminal (VSAT) technology, it is possible to provide broadband connectivity to disaster sites by communications equipment, which can be, for instance, flown in by helicopter.

The transfer of remote sensing and meteorological images, aerial photographs and situation maps can be carried out at high speed. In parallel, voice (telephony) and videoconferencing services may be utilized by decision makers. Furthermore, the emergency teams get connection to the Internet as well as Intranets to access databases, which are vital for their work. This implies that the satellite network and its terrestrial tails should ideally all support the Internet protocol suite. Data services, these days, are by definition using the IP protocols. Telephony is supported by voice over IP (VoIP), video services are also provided on top of IP. The advantages are a homogeneous network architecture and a single interface (Ethernet).

2. Network Architecture

2.1 Symmetrical Meshed Network

The network is based on a hybrid architecture, consisting of a satellite backbone and wireless local network islands. The satellite network uses low-cost VSAT technology. The topology is meshed, therefore any station can communicate with any other. The network control however, is centralized. Capacity is requested by the remote stations on demand. The central master station then assigns capacity depending on the type of traffic, priority and quality of service requirements. The multiple access scheme is multi-frequency TDMA (MFTDMA). This has the advantage of a very high degree of flexibility and scalability without the need of changing the transmission parameters (EIRP, G/T). Data rates of 4…8 Mbit/s can be supported per station. The networks as such may accommodate in principle up to 500 stations. Typical antenna sizes range from 1.2…1.8m for the transportable units and typically 2.4m for fixed installations. In the system developed by JOANNEUM RESEARCH and Graz University of Technology trailermounted and flyaway terminals are utilized for temporary set-ups.

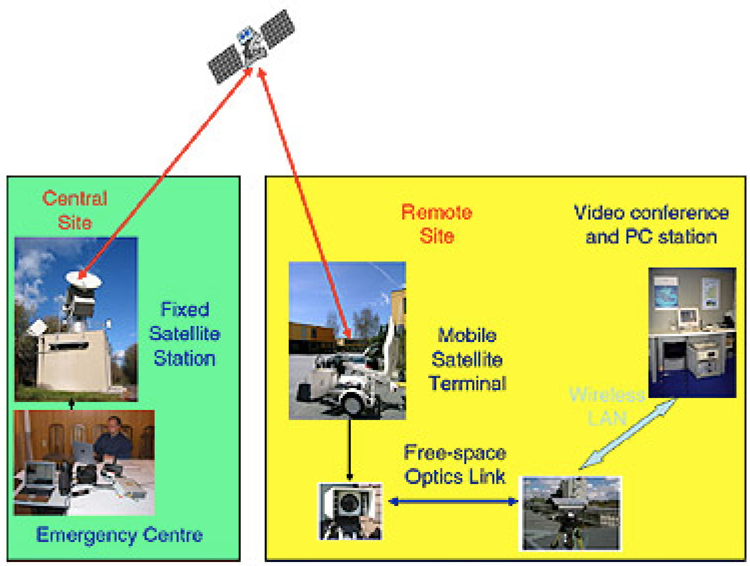

Figure 1: Point-to-point scenario.

In order to facilitate a rapid deployment of the communications infrastructure in case of emergencies, the local networks are also wireless. Three different technologies are in use to connect the outdoor satellite terminal with the indoor network components (PCs, workstations, videoconference terminals, VoIP telephones):

- A broadband microwave point-to-point system for distances up to 2.5 km is employed (40 GHz LMDS-local multipoint distribution system). It supports data rates of about 50 Mbit/s.
- To bridge distances up to 1.5 km free-space optics (FSO) transceivers are utilized, providing data rates between 10 and 155 Mbit/s.

For short-range communications and indoor networking low-costWLAN technology (802.11 b and 802.11 g) are used.

Figure 2: Multi-point scenario.

The combination of FSO (link from satellite terminal to buildings) and WLAN (for links inside buildings) has proven to be very effective. No cabling is necessary. Therefore, installations can be made very quickly and even in difficult terrain. Fig. 1 shows the network architecture for point-to-point links, Fig. 2 a multipoint scenario, Fig. 3 the transportable unit and Fig. 4 the flyaway terminal. The latter consists of four smaller boxes, which can be checked in as aircraft luggage. It also fits into a Jeep-type car or helicopter. The antenna is composed of four segments and has a diameter of 1.2 m.

Figure 3: Transportable VSAT.

Figure 4: Fly-Away Terminal.

The trailer-type station uses a 1.5m antenna, which is positioned horizontally on the trailer, yielding a height of about 1m. The indoor communications equipment is integrated in a flight case and comprises the satellite modem/gateway, an IP-router and -switch, the L-band converter and an uninterruptible power supply (Fig. 5). The outdoor unit can be powered by a small generator. The VSAT power requirement is about 400W.

Figure 5: Indoor-Unit of the VSAT.

2.2 Asymmetrical Networks

The symmetrical VSAT network infrastructure provides broadband interconnectivity among all active stations. The technology is mature and robust. However, the equipment is not very small and involves costs of about 20,000 US-$ per site. For some applications small low-cost equipment is desirable. For this purpose a different scenario has been evaluated. For broadband communications from the emergency centre to the remote terminals digital video broadcasting (DVB) technology is utilized. Data rates up to 40 Mbit/s can be accommodated. The expensive equipment is concentrated at a single site. All remote stations use very cheap DVB receivers. High-quality video transmission is straightforward. In addition, IP packets can be encapsulated into the DVB transport stream. For the return link satellite telephones with data rates of a few kbit/s are used, such as GLOBALSTAR or THURAYA. Using multicast protocols the required return link capacity may be very low for ftp downloads (basically only requests are transmitted on the return channel). For voice communications the satellite telephone is adequate. This system is suitable for delivering high volume data to the The symmetrical VSAT network infrastructure provides broadband interconnectivity among all active stations. The technology is mature and robust. However, the equipment is not very small and involves costs of about 20,000 US-$ per site. For some applications small low-cost equipment is desirable. For this

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3. Services

The overall network uses exclusively the IP-protocol. This has the advantage that all standard PC applications can be easily supported. In a multiservice network like this quality of service guarantees are essential. The satellite and terrestrial wireless systems have been designed to support QoS [1-6]. The following services are supported:

- High-speed file transfer.
- Data base access.
- High-speed internet/intranet access.
- E-mail.
- IP videoconferencing (using dedicating videoconference units or PC-based videoconference packages).
- Video over IP (transfer of high-quality video material, coded in MPEG-2 or MPEG-4).
- VoIP telephony.

The file transfer service allows to disseminate situation maps, remote sensing satellite images, and aerial photographs from disaster sites. The high-speed Internet/ Intranet access is important for emergency teams to retrieve information from their home bases. Videoconferencing facilitates ad hoc discussions between decision makers. Furthermore, the possibility to relay highquality video material from the emergency site to an operation centre, allows better assessment of the situation by the decision makers. Telephony is still a very important application. VoIP gateways to the public network provide voice interconnectivity from the remote sites to any telephony subscriber.

4. Pilot Demonstrations

The communications facilities described before have been extensively tested and demonstrated in various field trials. One important application clearly is the improvement of medical services in case of natural or man-made disasters.

Telemedicine is a means to provide this. In cooperation with European Space Agency, United Nations and several medical expert centres the hybrid satellite/terrestrial system has been successfully demonstrated. The transfer of CT and electronic X-ray images has been carried out at high speed. In parallel videoconferences were conducted between physicians to exchange opinions concerning patients' treatments. Using broadcast quality MPEG-2 transmission on-going surgery could be monitored. This is also a useful feature for medical expert training (Fig. 6).

Figure 5: Telemedicine Demonstration.

In the framework of a large emergency exercise in the province of Styria in Austria the system was successfully employed and received very positive feedback. The local civil emergency centre in Graz was equipped with a transportable satellite terminal. The trailer-mounted units were driven on demand to different simulated emergency sites. The assumption was that the traditional communications means like fixed and mobile telephony lines had become unavailable. Videoconferencing between civil and military authorities and transfer of situation reports and maps were the most often used services.

The combination of satellite communications and local wireless networking by FSO and WLAN proved to be extremely efficient. Typical set-up time at a site was about 30 min. The system was very reliable. All services showed excellent availability.

5. Further Developments

Two additional satellite systems are currently under evaluation. The disadvantages of the meshed VSAT approach are to some extent equipment costs and size. A hybrid DVB/satphone system is low cost, but very limited in return link capacity. Uploads of videos or videoconferencing cannot be provided.

Under contracts by European Space Agency industry has developed the DVB-RCS (Return Channel System) terminals. The topology is star. The instantaneous transfer rate from a central hub to client terminals can reach several 10 Mbit/s. The return link capacity is up to 2 Mbit/s. The main application of DVB-RCS is fast Internet access in areas where terrestrial broadband services are not available. The terminals are much cheaper than traditional VSATs (around US-$ 2000). The dish size ranges between 60 and 90 cm. The frontend is very compact. Currently these terminals are only available for fixed installations which rules out most emergency communications scenarios. However, using self-aligning pedestals, which optimize azimuth, elevation and polarization angles of the front-end, based on information from a GPS receiver, an electronic compass and a field strength indicator from the terminal, would allow "nomadic" operations.

If all communications are between a communications centre and remote terminals the DVB-RCS architecture is suitable. Interactive applications between remote terminals cannot be sufficiently supported due to the double hop. The Amazonas satellite by HISPASAT with its on-board processing (OBP) payload avoids this, but has limited coverage.

Another possibility is the SKYPLEX payload by EUTELSAT. All terminals are DVB compatible. Both MPEG video and IP data can be transmitted at data rates up to 6 Mbit/s. Due to the OBP payload double hops are avoided. By now, low-cost SKYPLEX terminals are available. At JOANNEUM RESEARCH and TU GRAZ these possibilities are currently under assessment.

6. Summary and Conclusions

Satellite communication systems are indispensable tools for emergency communications and securityrelated applications. Transportable meshed VSAT terminals in combination with various wireless network technologies, such as WiMAX, FSO and WLAN facilitate a rapid deployment of the equipment in areas where normal telecommunication services are disrupted. As a very low-cost solution the combination of a DVB forward link with a satphone return channel is adequate when the traffic flow is highly asymmetric. An "all IP" network is beneficial, because only a single interface needs to be supported and all existing computer-based applications including voice and video are available. Alternative solutions exploiting OBP will provide even smaller terminals at lower costs.

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