SOLVING PROBLEMS WITH DISSEMINATION OF REMOTE SENSING DATA VIA SATELLITE BROADCASTING

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ABSTRACT:

Dissemination of remote sensing data via traditional techniques like websites and FTP can face problems when reaching out to users in remote areas like Siberia or areas with poor internet connectivity like Africa. Sending out loads of CDs, DVDs or tapes is often considered an expensive and time-consuming alternative. To resolve those problems, an innovative method of data dissemination via commercial telecommunication satellites was implemented by EUMETSAT and ESA. This method, often referred to as satellite broadcasting or Digital Video Broadcasting by Satellite (DVB-S), is in essence the same system that people use to watch satellite TV. The only difference is that the digital data stream doesn't contain audio and video, but scientific data products. The biggest advantages are of course that the data stream can reach out very fast and simultaneously to very large geographical areas, provided that sufficient reception stations are installed.

The EUMETCast system was originally designed to distribute meteorological data and added value products, mainly from the MSG (Meteosat Second Generation) satellite, but also from other satellites, to end users in Africa. The geographical coverage of EUMETCast has recently been extended to cover also parts of North-, Central- and South-America.
ESA's Data Dissemination System or DDS is not intended to provide added value products to end users. Instead, it focuses on delivering near real time data from ESA's famous Envisat and ERS-2 environmental satellites to scientific users, mainly in Europe, to circumvent the troublesome data delivery via FTP or fixed media (DVD, tape). Both EUMETCast and DDS systems are fully operational and are regularly expanded to include other data products.

At VITO, we have recently started to use satellite broadcasting both for data delivery and reception (VGT4AFRICA project, see http://www.vgt4africa.org) , using both EUMETSAT's EUMETCast and ESA's DDS system. In the presentation, we will thus be looking at issues such as the requirements and costs of data reception, reliability and speed of data transmission and how to provide data, all based on practical experience.

Figure 1. EUMETCast reception antenna
at VITO (left) and DDS reception antenna (right)

1. INTRODUCTION

The aim of this paper is to describe one of the latest technologies in data dissemination, namely the use of satellite broadcasting. To be precise, we'll cover topics such as the history of the technology, it's main benefits and drawbacks, but also it's performance, reliability and costs, all based on practical and hands-on experience at VITO.

Hopefully, this introduction into the satellite-based data dissemination technology will inspire scientists to use it for their own purposes. This will then in turn lead to an increase of support for these new systems, to further development of this emerging technology and eventually to a broader community of scientific data users, especially in remote and difficult to reach parts of the world.

2. BRIEF HISTORY

Conventional data dissemination techniques such as distribution of CDs, DVDs or tapes or file transfer over the internet via FTP (File Transfer Protocol), face problems when reaching out to wide user communities (i.e. large costs and time consumption) or when disseminating data to for instance developing countries, where internet access is far from common.

To resolve these issues, EUMETSAT and the European Space Agency, well-known for their satellite technology, both came up with the idea to use satellite telecommunication mechanisms, similar to those used for Digital Video Broadcasting over Satellite, or DVB-S, which is known to bring digital television into consumer homes, for fast dissemination of scientific data over large geographical areas.

ESA's DDS, or Data Dissemination System, started in 2001 and operational since 2002, provides data from the well-known Envisat and ERS-2 satellites to scientific users in Europe. Today, this system is used for disseminating large volumes of data, not only across Europe, but also to African users and in the future also to North- and South-America.

EUMETSAT's EUMETCast system started off in 2002 and extended it's coverage over Africa in 2003 already. From the start of this year, EUMETSAT is also conducting trial disseminations over North- and South-America and plans to extend EUMETCast into a larger, global GEONetCast system. Whereas EUMETCast was originally designed to spread Meteosat Second Generation (MSG) data, it now transports data from many other satellites as well, including data from SPOT-VEGETATION.

Of course, the expansions of both systems to new geographical areas and to new data products, has also lead to a steady increase in satellite bandwidth over the years, from less than 1 megabit per second in the early days, to 3 to 4 megabits per second today.

3. METHODOLOGY

As shown in figure 2, the satellite broadcasting system, sometimes called multi-casting in view of it's well-defined amount of receivers, consists of the following elements:

- One or more data providers, that typically process and archive scientific data. The data providers transfer their data, usually via FTP, to the satellite uplink servers of ESA or EUMETSAT.
- Those uplink servers, based in Europe, transmit the data to geostationary satellites with coverage over Europe, such as the HotBird 6 platform in the case of EUMETCast and the EUTELSAT W1 platform in the case of DDS.
- European users can then downlink the data from those satellites, in the so-called Ku-band (downlink frequency of 10.854 GHz for EUMETCast and 12.678 GHz for DDS).
- Intermediary stations, for instance based near the Mediterranean, also downlink the data from the satellite in Ku-band and bounce it back up in C-band to other satellites, with coverage for instance over Africa or America.
- African and American users can then receive the data from those satellites, also in C-band. Because of the lower frequency of C-band with respect to Ku-band, users in Africa will require significantly larger satellite dishes than those in Europe.

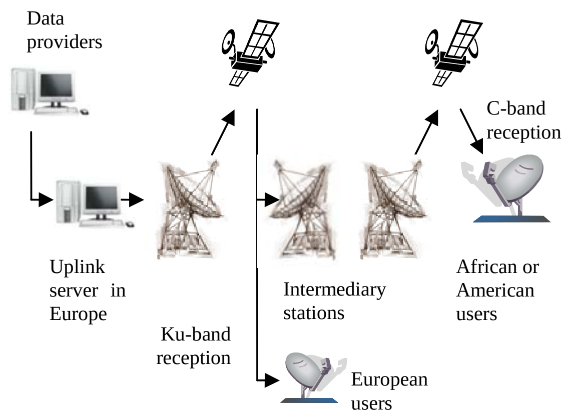

Figure 2. Schematic of data dissemination via satellite broadcasting

4. DATA RETRIEVAL: REQUIREMENTS & COSTS

At the European reception stations, the setup typically consists of:

- a satellite dish with a diameter of about 1 meter or more for Ku-band reception;
- a Low Noise Block (LNB) that filters the noise and down-converts from the Ku-band frequency (10-13 GHz) to a frequency more suitable for computer communications over coax cables (i.e. 1-3 GHz).
- a receiving computer, connected to the LNB via the coax cable, that decodes the signal via DVB reception hardware and stores the data on disk.

Such a reception station setup is very similar to the setup that is needed to watch satellite TV, which implies that most of the hardware can be bought at everyday electronics and television stores.

Because of the large volumes of data that are handled, a fast computer, with a relatively high amount of RAM and fast disk access is strongly recommended for any DVB receiving station.

4.1 EUMETCast reception

At VITO, we opted to install a Windows-based PC with a standard skystar2 DVB card, to mimic the setup of the EUMETCast stations in Africa that are used by the end user of the products we provide in the framework of the VGT4AFRICA project. Linux installations are now also possible (EUMETSAT, 2006). The requirements and costs of a typical setup are summarized in table 3.

Requirement	*Estimated cost*
Satellite dish (diameter depends on the location)	Around 100 euros maximum
Universal Low Noise Block (LNB) down converter	< 50 €

High-quality coax cable	< 50 €, depends on length and quality
Windows PC	< 1500 €
PCI DVB-card "skystar"	< 100 €
Hardware key (EKU)	40 €
2met! ® software	Free (for VGT4AFRICA project), can be quite expensive otherwise.
Data access (registration fee), incl. other software like tq®-tellicast	Essential data: free Licensed data: EKU 60 € External data: to be discussed with data provider

Table 3. Requirements and costs for EUMETCast reception

Installation and pointing of the dish, installation of the coax cable and of the reception computer were all taken care off by VITO staff and amounted to around 2 days work in total. The installation was quite easy and straight-forward.

For data access, EUMETSAT distinguishes 3 types of data: essential, free data for which an EKU is not required, licensed data for which a license fee may need to be paid and an EKU (unique USB hardware decryption key) is needed to allow access, and data from external services, for which you need approval from the data provider.

4.2 DDS reception

For DDS reception, ESA offers a few types of systems: a fairly cheap, commercial Windows-based kit, similar to the setup for EUMETCast described above, Linux-based rack units or Linux-based shuttle PCs. The Linux-based systems are quite a bit more expensive than the Windows system, but they are controlled remotely by ESA to monitor the reception performance and thus offer a higher reliability.

At VITO, it was decided to go with a Linux-based, dedicated shuttle PC, ordered from Global Communication & Services (GCS) GmbH in Austria, who works closely together with ESA. GCS and ESA actually pre-configured the computer for DDS reception and for the remote monitoring by ESA, which is carried out mostly at ESRIN, Italy, each day.

Requirement	*Estimated cost*
Satellite dish (diameter depends on the location and is at least 1m)	Around 100 euros maximum
Universal Low Noise Block (LNB) down converter	< 50 €
High-quality coax cable	< 50 €, depends on length and quality
Computer	<1500 € for the commercial Windows-based kit, <5000 € for the remotely monitored systems
Software	Free for the Linux-based systems
Data access	Access to ESA data from Envisat or ERS-2 typically requires an ESA funded project, for instance a Cat-1 or explicit approval from ESA.

Table 4. Requirements and costs for DDS reception

Installation of the dish and cables were again carried out by VITO staff. The installation of the pre-configured system was quite easy but required significant changes to the network configuration to support the remote monitoring by ESA.

5. DATA RETRIEVAL: PERFORMANCE & RELIABILITY

The only major drawback of data reception via satellite, in comparison to the traditional data reception via FTP or on fixed media, is the fact that it's reliability also depends on weather conditions or the vicinity of other transmitters. Heavy rain and snow can have a negative impact on data reception, especially for Ku-band reception like in Europe, due to the higher frequencies of Ku-band with respect to C-band. C-band, on the other hand, is more affected by nearby radar or television transmitters, but this can be overcome by installing a band pass filter (EUMETSAT, TD15, 2006). If timely arrival of the data is critical and reliability must be 100%, then a backup solution, preferably FTP, is recommended. For most end-user applications, such backup solutions are however not needed.

5.1 EUMETCast reception

Even without any backup solution or remote monitoring, practice has shown that, once the EUMETCast reception station is properly configured, it can obtain a high degree of reliability under typical Belgian weather.

For instance, 3 times each month, VITO provides, in the framework of the VGT4AFRICA project, several scientific data products to EUMETSAT for dissemination via EUMETCast. After more than 6 months in operation, the reception station has received all those products, without any problem whatsoever.

On the other hand, the reception of data that arrives more frequently has shown problems and data loss, but only for short periods of time. An example of this is the reception of MSG high rate data. A practical test has shown that reliability of such data is around 90%. As documented (EUMETSAT TD 15, 2006), this may be due to insufficient memory or disk speed in the reception computer.

As for data transfer speed, the EUMETCast receiving station at VITO easily reaches 400 kilobits per second, with spikes up to 600 or 700 kbps, but limitations on speed can be configured to limit disk usage.

Because data is received 24 hours each day, the total data volume received is still very big. For example, VITO's system, which does not have access to all the disseminated data, regularly receives more than 2 gigabytes of data per day.

5.2 DDS reception

Tests have shown that, partly because of the remote monitoring by ESA, the reliability of data retrieval for the DDS system can be estimated at 98 to 99%.

To ensure even higher reliability, for instance in cases of failing DDS reception due to snowfall, and to ensure the fastest, near-real time data retrieval for processing, VITO decided to install an FTP-based download system as backup of DDS.

The data transfer speeds for DDS, with a theoretical maximum of around 2 megabits per second, currently reaches similar speeds as the EUMETCast setup, i.e. around 500 to 700 kbps.

The volume of transported data, again keeping in mind that VITO's system does not have access to all disseminated files, amounts to 10-12 gigabytes per day.

In fact, ESA reports to have disseminated over 50 terabytes of data since the start of the operational DDS disseminations in 2002.

6. DATA PROVISION

Before you can start disseminating data via either EUMETCast or DDS, you first need to make the necessary arrangements with EUMETSAT and ESA. These arrangements, often formalized in a document, describe:

- the FTP access to the uplink server;
- the necessary points of contact, on both sides, used to announce delays or failures in data production or dissemination, for instance due to computer maintenance;
- and the data to be disseminated.

For instance, it is important to estimate the size and frequency of the data you wish to provide, so that EUMETSAT or ESA can accurately assess the required satellite bandwidth, in relation to the total amount of bandwidth at their disposal and the bandwidth required for other data products.

VITO has made such arrangements to provide SPOT-VEGETATION data over EUMETCast in the framework of the VGT4AFRICA project (http://www.vgt4africa.org) and over DDS in the framework of the ESIT project.

The file format is irrelevant, because the DVB technology supports all file formats. There are some minor restrictions on file naming, mainly for technical reasons related to the uplink system.

Performance tests have shown that the delay between provision of the data via FTP and the actual dissemination is typically around 1 to 2 hours maximum, for low priority products like the ones provided by VITO.

As an experiment to get an idea of the delay on Envisat products, the total time duration between the start of the acquisition and the dissemination of a MERIS level 2 product on DDS was calculated to be less than 24 hours, with typical times between 5 and 15 hours. Taken into account that this includes the full level 0 to level 1 and level 1 to level 2 processing, such a delay is very reasonable.

The reliability of the data transmissions is monitored by ESA and EUMETSAT regularly and was verified by VITO for the EUMETCast system by setting up a reception station and comparing the received data with the originally provided data. This comparison showed that the Ku-band transmission does not alter the data in any way and is thus considered fully reliable.

7. OUTLOOK ON FUTURE

Both DDS and EUMETCast systems are constantly expanding, as well in their geographical coverage, in the number of products provided as in the total amount of bandwidth allocated on the commercial telecommunications satellites.

EUMETCast, for instance, forms the basis of GEONetCast, a world-wide system for provision of environmental data in support of the Global Earth Observation System of Systems (GEOSS) and Global Monitoring for Environment and Security (GMES) initiatives. As part of this, EUMETSAT has started conducting trial disseminations over the American continents in the beginning of 2006.

DDS, on the other hand, has recently been expanded over Africa and also has foreseen an extension to the American continents.

8. CONCLUSIONS

To conclude, we can say that the new mechanism of data dissemination via satellite broadcasting, developed in the last 5 years by both EUMETSAT and ESA, adequately solves problems that traditional dissemination techniques face, like the poor internet connectivity in developing countries and the difficulties in reaching out to remote areas.

The only drawback in comparison to traditional data transfer techniques is the dependency on weather conditions (Ku-band reception) or the vicinity of radar and television transmitters (C-band) which may necessitate an FTP-based backup system for applications where fast and 100% reliable data retrieval is a must. For most basic applications by end users, however, the offered reliability is more than adequate.

Data providers can, after agreement with EUMETSAT or ESA, disseminate their data over the existing systems by uploading it via FTP to uplink servers. Important restrictions in data provision are the amount of satellite bandwidth required, which limits the data volume that can be provided and the priority of the product, which may affect delivery times.

In view of the fact that this technology is very recent and constantly being expanded to new geographical areas and to other scientific data, we can conclude that satellite broadcasting is a useful and practical new way for data dissemination, both now and in the future.

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