"SeismoSAT" Project State of the Art: Connecting Seismic Data Centers via Satellite

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ABSTRACT. Since 2002 the OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale) in Udine (Italy), the Zentralanstalt für Meteorologie und Geodynamik (ZAMG) in Vienna (Austria), and the Agencija Republike Slovenije za Okolje (ARSO) in Ljubljana (Slovenia) are using the Antelope software suite as the main tool for collecting, analyzing, archiving and exchanging seismic data in real time, initially in the framework of the EU Interreg IIIa Italia-Austria project "Trans-national seismological networks in the South-Eastern Alps" (Bragato et al., 2004 and Bragato et al., 2010). The data exchange has proved to be effective and very useful in case of seismic events near the borders between Italy, Austria and Slovenia, where the poor single national seismic networks coverage precluded a correct localization, while the usage of common data from the integrated networks improves considerably the overall reliability of real time seismic monitoring of the area. At the moment the data exchange between the seismic data centers relies on internet: this however is not an ideal condition for civil protection purposes, since internet reliability is poor. For this reason in 2012 the Protezione Civile della Provincia Autonoma di Bolzano in Bolzano (Italy) joined OGS, ZAMG and ARSO in the Interreg IV Italia-Austria project "SeismoSAT" (Progetto SeismoSAT, 2012) aimed in connecting the seismic data centers in real time via satellite. As here illustrated, the general technical schema of the project has been approved, data bandwidths and monthly volumes required have been quantified, the common satellite provider has been selected, the hardware has been purchased and installed, and the all SeismoSAT project is in testing phase.

The border region of Slovenia, Austria and NE Italy has experienced several destructive earthquakes in the past. Different seismic networks are operating in the area supporting monitoring, alerting and research. The example of recent strong earthquakes demonstrated that the integration of services provided by the neighboring networks is essential for a rapid and efficient intervention.

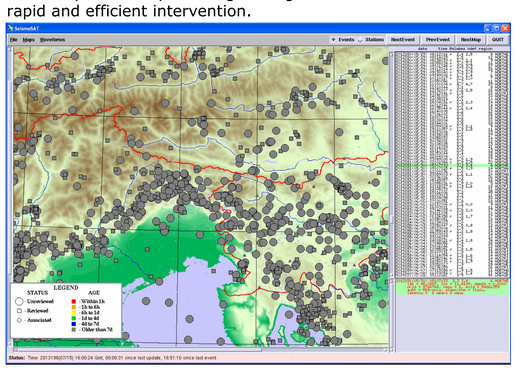

Fig. 1 Seismicity map in the years 2011-2012 of the border region between Northeast Italy, Austria and Slovenia. In the map the events with magnitude ML > 1.5 are shown.

Fig. 2 SeismoSAT map with seismic stations in red and data centers in blue

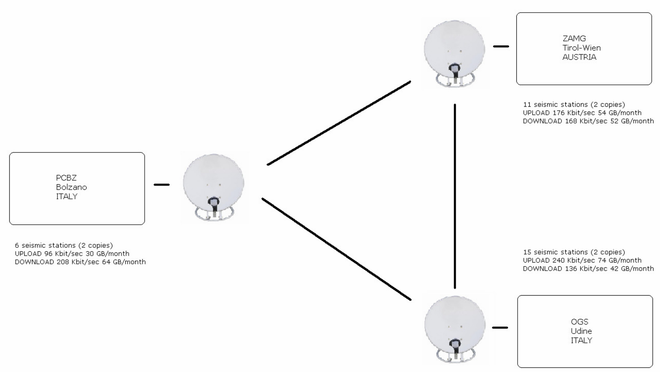

Fig. 3 SeismoSAT schematic diagram with data bandwidth requirements

Fig. 4 - The Eutelsat KA-BA satellite terminal from the Austrian SOSAT (http://www.sosat.at/) has been selected and is currently in testing phase.
Its main characteristics are:
• 18432kbit/s download, 6144kbit/s upload
• 1 public IP address
• 60GB data volume
• Annual link availability >99,5%
• RTTs Satellite round trip time < 600 ms
• Lan/Ethernet Data Interface
• Security: Time Division Multiple Access (TDMA)

The average station (**Fig.2**) bandwidth required indicated in Pesaresi et al., 2013 for the seismoSAT project is 2.46 Kbit/second. This number is calculated on a normal seismic noise mode, where data compression is quite efficient, which is not true in case of seismic event. In order to accomplish enough bandwidth for transmitting seismic data also in harsh conditions like in case of a big earthquake, we fixed a bandwidth requirement of 8 Kbit/sec per each seismic station.
Total bandwidths required per network are then:
NI OGS 120 Kbit/sec
OE ZAMG 88 Kbit/sec
SI PCBZ 48 Kbit/sec
Each data center has to upload to the satellite network 2 copies of his network data, one for each of the other 2 data centers.
Total upload bandwidth required are therefore:
OGS 240 Kbit/sec
ZAMG 176 Kbit/sec
PCBZ 96 Kbit/sec
While download bandwidth required are:
OGS 136 Kbit/sec
ZAMG 168 Kbit/sec
PCBZ 208 Kbit/sec
Satellite contracts often includes 'fair policy' limiting total amount of data transmitted per month. Therefore expected monthly data bandwidth for SeismoSat are:
OGS 74 GB/month upload, 42 GB/month download
ZAMG 54 GB/month upload, 52 GB/month download
PCBZ 30 GB/month upload, 64 GB/month download

The Antelope software suite has the capability to exchange data in real time among data centers: for this purpose the standard "orb2orb" software module is used. It uses a proprietary protocol and a point-to-point client/server architecture to exchange data. The last release of the Antelope software suite contains a more sophisticated version of this data exchange module: it is named "orbxchange". "orbxchange" is a multithreaded version of "orb2orb" which supervises multiple "orb2orb" copies specified in a parameter file; it has the option of switching to alternate servers when no data is being copied from the primary. A distributed real time seismic database has been so established by connecting ZAMG, CRS/OGS, DST/UTS and ARSO Antelope servers with "orbxchange" modules (Horn et al., 2007). A test of the above described "orbxchange" features has been conducted artificially shutting down the Antelope servers and/or the data links between them: the results in the data coverage of the multiple copies of the distributed database showed an improvement in data availability that will be very useful for the institutional activities (like rapid earthquake location with magnitude estimation) of the institutions involved, but moreover its natural extension will be in more mission critical applications, like in public civil protection applications and rapid notification of inherent authorities like in the SeismoSAT Project (**Fig. 3**).

Fig. 5 - As an alternative to the software automatic routing switching offered by the Antelope suite, the automatic switching between the default internet and the back-up satellite data links could be done with the usage of a Virtual Private Network (VPN).
For this reason we selected the Cisco 2921 illustrated in Figure 5 above:
http://www.cisco.com/c/en/us/products/routers/2921-integrated-services-router-isr/index.html)
Its main features are:
• 3 Integrated 10/100/1000 Ethernet ports with 1 port capable of RJ-45 or SFP connectivity
• Embedded hardware-accelerated VPN encryption
• Secure collaborative communications with Group Encrypted Transport VPN, Dynamic Multipoint VPN, or Enhanced Easy VPN
• Integrated threat control using Cisco IOS Firewall, Cisco IOS Zone-Based Firewall, Cisco IOS IPS, and Cisco IOS Content Filtering
• Identity management: Intelligently protecting endpoints using authentication, authorization, and accounting (AAA), and public key infrastructure

Note and Acknowledgements
ARSO is an "associated partner" of the SeismoSAT project. ARSO benefits from the improved robustness of the data exchange between the other data centers, while eventually fully taking part in the project if other sources of funding will be available.
The authors wish to thank the Interreg Italia-Austria (2007) Authority for the financial support on the ERDF (2000) Fund and all the colleagues of OGS, ZAMG, Protezione Civile della Provincia Autonoma di Bolzano and ARSO not explicitly mentioned here for their support to the SeismoSAT Project.

REFERENCES
•European Regional Development Fund (ERDF): http://ec.europa.eu/regional_policy/thefunds/regional/index_en.cfm, last access: 18 April 2014, 2000.
•Interreg IV Italia-Austria: http://www.interreg.net/, last access 18 April 2014, 2007.
•Progetto SeismoSAT: http://www.crs.inogs.it/seismosat/, last access: 18 April 2014, 2012.
•Bragato, P.L., Costa, G., Fitzko, F., Horn, N., Priolo, E., Kobal, M., Suhadolc, P., and Živčić, M.: The INTERREG IIIA Project: "Trans-National Seismological Networks in the South-eastern Alps", ESC XXIX General Assembly, Potsdam, Germany, 13-17 September 2004, 2004.
•Bragato, P.L., Costa, G., Horn, N., Pahor, J., Pesaresi, D., Lenhardt, W., and Živčić, M.: The usage of Antelope for acquiring end exchanging data in South-Eastern Alps: present configuration and future perspectives, ESC XXXII General Assembly, Montpellier, France, 6-10 September 2010, 2010.
•Horn, N., Pesaresi, D., Costa, G., and Živčić, M.: Testing the Antelope software suite to realize a distributed seismic database among Austria, Northeastern Italy and Slovenia, EGU General Assembly 2007, Vienna, Austria, 15-20 April 2007, 2007.
•Pesaresi, D., Lenhardt, W., Rauch, M., Živčić, M., Steiner, R., Fabris, P., and Bertoni, M.: The Interreg IV Italia-Austria "SeismoSAT" Project: connecting Seismic Data Centers via satellite, EGU General Assembly 2013, Vienna, Austria, 7-12 April 2013, 2013.