Centro di Ricerche Sismologiche

ISTITUTO NAZIONALE DI OCEANOGRAFIA E DI GEOFISICA SPERIMENTALE

Acquiring seismic data in the North-East of Italy: the OGS-CRS experience in using the Antelope software suite

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1. The INTERREG project

Since 2002, the Centro di Ricerche Sismologiche (CRS, http://www.crs.inogs.it) of the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS) is involved in the EU INTERREG IIIA project "Trans-national seismological networks in the South-Eastern Alps" (Bragato et al., 2003) together to other four institutions monitoring the area (department DST of the University of Trieste and Civil Protection of Regione Autonoma Friuli-Venezia Giulia, Italy, ARSO, Slovenia, and ZAMG, Austria, see Fig. 1.1). The Antelope software suite has been chosen as the common basis for near real-time data exchange, rapid location of earthquakes and alerting.

At CRS we have developed hardware and software solutions to integrate our heterogeneous instrumentation in the common virtual network. Furthermore, the "orb2orb" Antelope program is used to exchange data in near real-time with the other Institutions. In collaboration with the other partners, we are setting up the automatic procedures to locate earthquakes occurring both locally and worldwide, estimate their magnitude, dispatch alert messages and update web pages describing the observed seismicity.

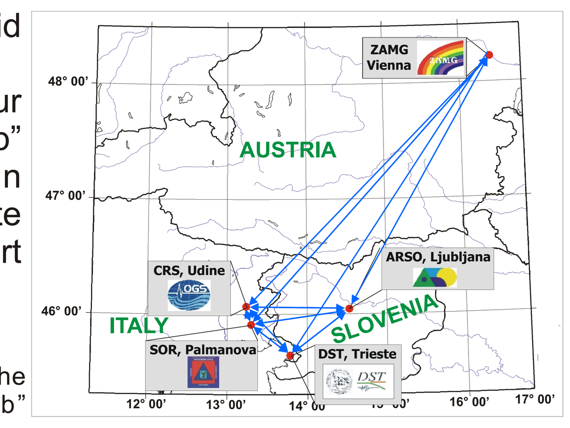

Fig. 1.1: Institutions involved in the INTERREG project and "orb2orb"

2. Seismometric stations

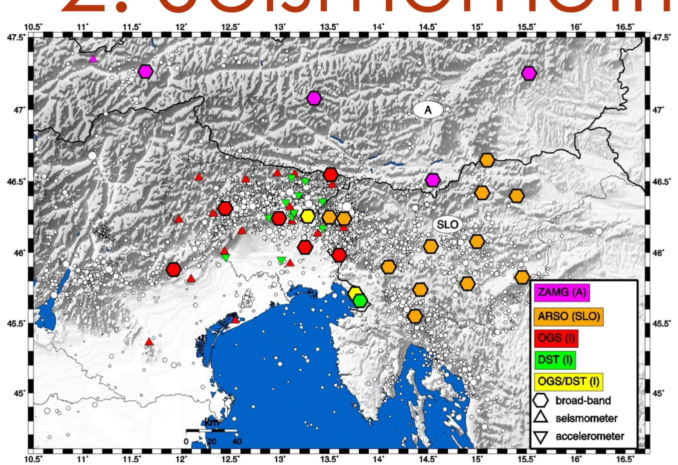

Fig. 2.1: Station currently acquired at CRS in the framework of the project "Trans-national seismological networks in the South-Eastern Alps"

Broad-band, high dynamics

The CRS manages 8 broad-band stations (red and yellow hexagons in Figure 2.1): 3 are property of OGS, 2 are jointly-owned by OGS and DST; 3 are owned by the *Civil Protection* of the *Regione Autonoma Friuli-Venezia Giulia* and are operated by OGS in the framework of the INTERREG project described above. They are mainly installed in natural caves (3 stations) or old military sites (3 stations, e.g. the bunker in Fig. 2.2). They are equipped (Fig. 2.3) with a broad-band sensor (5 Streckeisen STS2 and 1 STS1, 1 Guralp CMG-40 and 1 CMG-3T), and, with one excpetion, with an accelerometer (4 Kinemetrics Episensor FBA ES-T and 3 Guralp CMG-5T). The data loggers are Quanterra Q4120 (4 station), Quanterra Q330 (3 stations), and Lennartz M24 (one station). All are sampled at 100 sps. Seven stations are acquired at CRS in real time (see the details in the following boxes), while one is acquired in dial-up mode.

Fig. 2.2: Borad-band station of Acomizza (code ACOM).

Fig. 2.3: Sensors at the broad-band station of Acomizza (ACOM).

Fig. 2.4: Short-period station of Zoufplan

Short-period

Since 1977 the OGS operates a network of short period stations in NE Italy (Priolo et al, 2005). At present it includes 15 stations in Friuli-Venezia Giulia, property of OGS, and 6 in Veneto, owned by *Regione Veneto* (red triangles in Fig. 2.1). They are mainly installed in mountainous and piedmont low-noise sites (Fig. 2.4). In the typical configuration (Fig. 2.5), they include a 1-Hz three-component Lennartz LE-3D seismometer, a Lennartz MARS88 data logger (120 dB dynamic range, sampling rate 62.5 or 125 sps), GPS or DCF receiver for time synchronization. Events detected based on an STA/LTA mechanism are transferred to the central station by means of the MARS88/RC acquisition system, using the radio links described in the next box.

Fig. 2.5: Deployment of a short-period station.

Low cost accelerograph

Dense networks of inexpensive digital accelerographes are useful for the rapid generation of detailed shake maps. We are installing a prototype network of 4 devices GeoSIG IA-1 (Rosenberg et al, 2004) to monitor in real-time at CRS the area of a small village. The IA-1 (Fig. 2.6) is constituted by single-board PC running LINUX with Ethernet port, a 16 bit A/D converter and an MMS accelerometer with full scale 4g. It is suitable for recording earthquakes of magnitude greater than 3 up

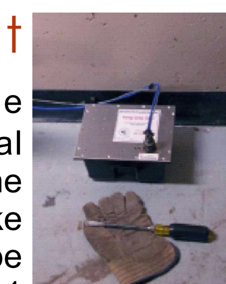

Fig. 2.6: The GeoSIG IA-1 accelerograph.

Stations from other Institutions

Currently we are receiving data from 29 stations managed by ARSO, DST and ZAMG (Fig. 2.1). Much of them are broad-band and high dynamics (i.e., seismometer+accelerometer) with various models of Quanterra data loggers. We receive their data within some seconds through the INTERNET using the "orb2orb" Antelope program. Using "orb2orb" we also receive data from a number of strong motion stations connected to DST in dial-up mode.

3. Broad-band radio links

With a few exceptions, the seismometric stations are connected to the acquisition center at CRS by means of spread-spectrum radio links (Fig. 3.1). The communication network includes a backbone (Fig. 3.2), and several links seismic station/backbone.

The backbone is implemented using radio devices Alvarion BreezeNET B14, transmitting at about 6 Mbps in the 5.47-5.725 GHz frequency band. The connections station/backbone are implemented by the less expensive devices WiLAN VIP 110-24 (2Mbps in the 2.4 GHz frequency band). All the devices have bridging capabilities, so that remote stations are seen as IP nodes of a private network. For the serial devices, like the Lennartz MARS88 data loggers, we use the serial to Ethernet converter MOXA NPort Express DE-211. Spread-spectrum is also used to connect CRS to the emergency room of the Civil Protection of Friuli-Venezia Giulia (about 15 km apart).

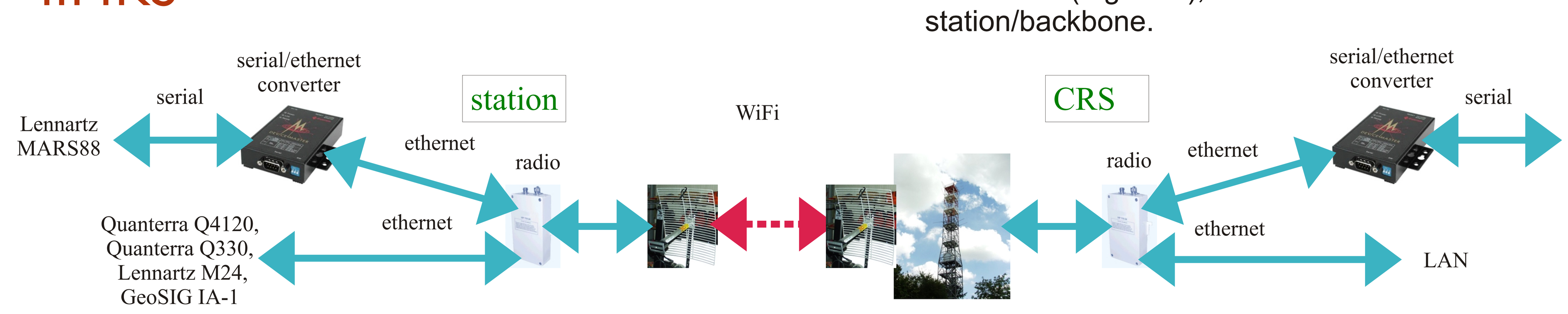

Fig. 3.1: IP and serial connections through spread-spectrum radio links.

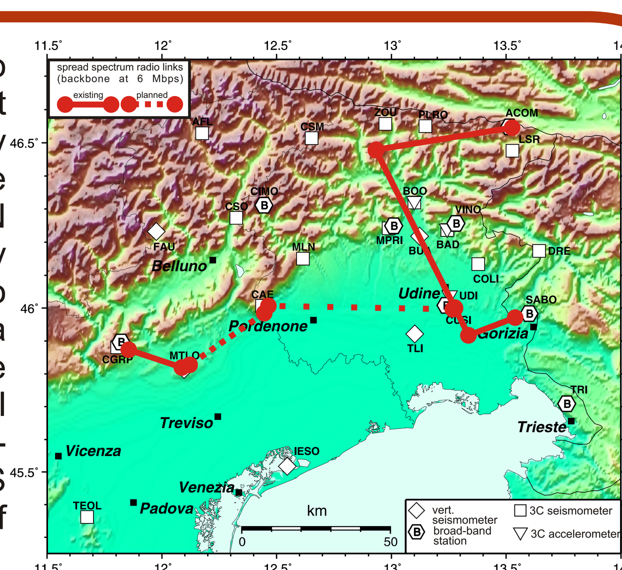

Fig. 3.2: Backbone of the radio network.

4. Connecting stations to Antelope

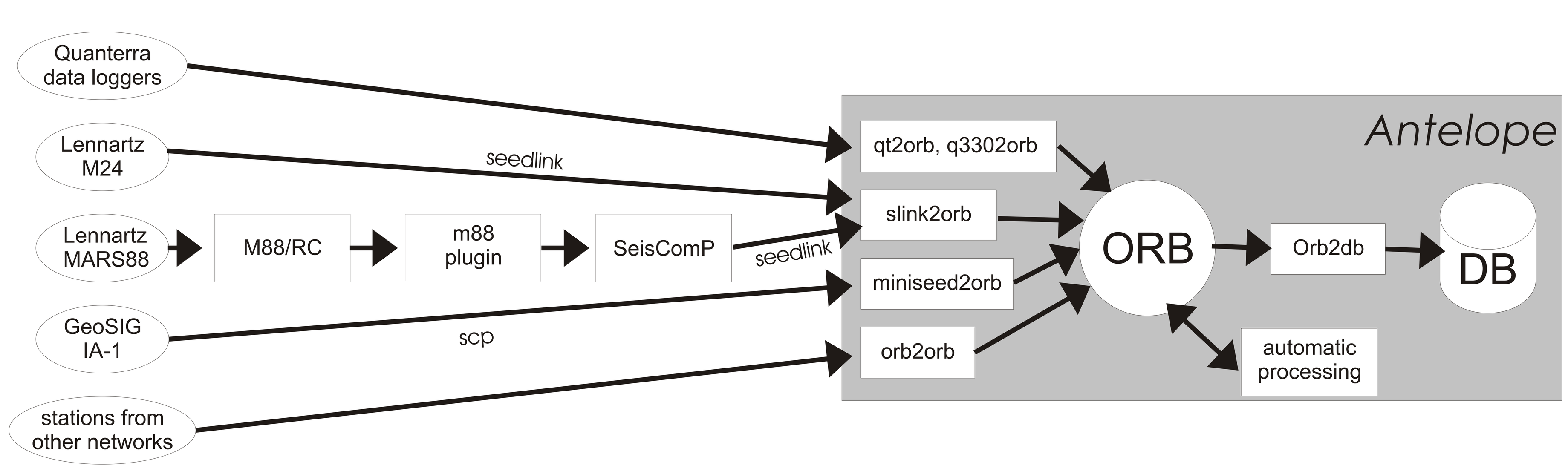

Fig. 4.1: Connection of various data loggers to Antelope

The connection of the different data loggers to Antelope is depicted in Fig.4.1. The waveform data are inserted in the Antelope ORB (Object Ring Buffer) by means of various interface programs and then made available to the automatic processing tools that detect and locate the earthquakes. Furthermore, they are definitively recorded in the Antelope database with the program *orb2db*. The Quanterra data loggers are connected to Antelope by means of the programs *qt2orb* and *q3302orb*. The Lennartz M24 has a SeisComP server installed and sends its data using the *seedlink* protocol. Such data are inserted in the ORB by means of the Antelope program *slink2orb*. The data from short-period stations recorded by the Lennartz MARS88 data loggers are collected at the central station by means of the acquisition system Lennartz MARS88/RC running on a SUN machine with Solaris. Such data are passed to a SeisComP server by means of the *m88plugin* and then sent to the ORB using the *seedlink* protocol and the Antelope program *slink2orb*. The low-cost accelerograph GesoSIG IA-1 produces MiniSEED files that can be downloaded using the standard UNIX program *scp* and sent to the ORB with the Antelope program *miniseed2orb*. Data from the other networks are gathered from the respective data centers using the program *orb2orb*. The automatic earthquake location processing in Antelope is carried out by the *orbdetect*, *orbtrigger* and *orbassoc* programs (Pesaresi and Horn, 2003). The *orb2orb* program is also used to exchange data with the other data centers involved in the INTERREG IIIA project.

5. Automatic data

Both local and teleseismic earthquakes are currently automatically detected and located by the Antelope system at CRS: such tasks are performed by means of the programs "orbdetect" and "orbassoc". The set-up and tuning of the location procedure in use at CRS has been performed mainly at DST (http://www.dst.units.it/). Different types of magnitude are estimated (ML, mB and Ms) using the program "orbampmag" developed at ZAMG (http://www.zamg.ac.at/) by Niko Horn. The performances of the automatic location system are discussed in a companion poster "Performances of two automatic earthquake location systems in the North-Eastern Italy" by S. Gentili et alii (ECEES-2006, session SC-B 0). Fig. 5.1 is a snapshot of the Antelope locations database. Locations are disseminated via web (Fig. 5.2), email (Fig. 5.3) and Short Message System (SMS, Fig. 5.4), allowing rapid alert of operators.

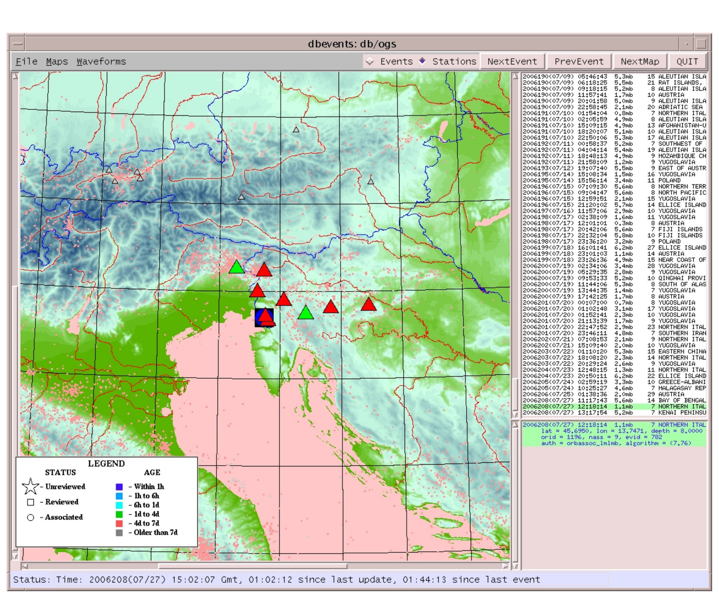

Fig. 5.1

Fig. 5.2

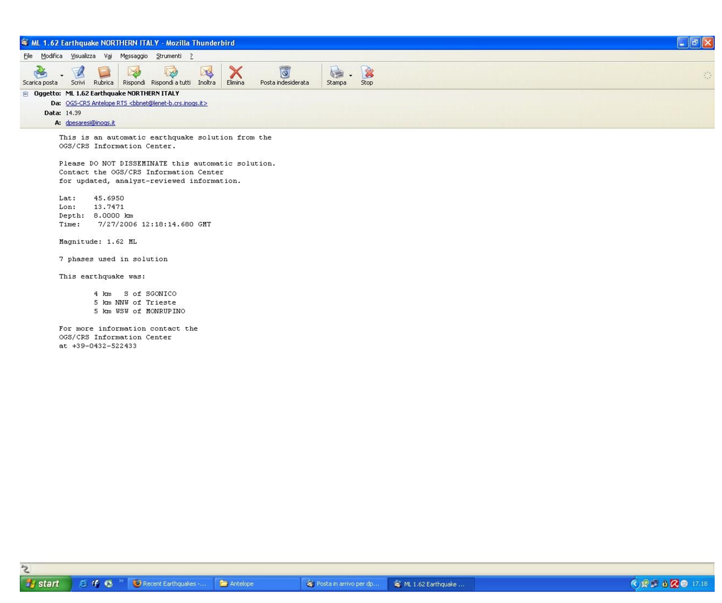

Fig. 5.3

Fig. 5.4

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