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Romanian complex data center for dense seismic network

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ABSTRACT

In 2002, the National Institute for Earth Physics started the development of its own real-time digital seismic network. This now consists of 86 seismic stations, of which 32 are broad-band sensors, 52 stations are equipped with short-period sensors, and two seismic arrays, all of which transmit data in real time to the National Data Center (NDC) and the Eforie Nord (EFOR) seismic observatory. EFOR is the back-up for the NDC, and it is also a monitoring center for Black Sea tsunamis. The seismic stations are equipped with Quanterra Q330 and K2 digitizers, broad-band seismometers (STS2, CMG40T, CMG 3ESP, CMG3T) and Episensor Kinemetrics acceleration sensors (±2g). SeedLink is a part of Seiscomp2.5 and Antelope, which are the software packages used for data acquisition in real time and data exchange. Communication from the digital seismic stations to the NDC in Bucharest and EFOR is assured by five providers (GPRS, VPN, satellite, radio and internet). AntelopeTM 4.11 is used for acquisition and data processing at these two data centers for the reception and processing of the data, which runs on two workstations: one for real-time processing and the other for off-line processing. A Seiscomp 3 server works as the back-up for the Antelope 4.11. This acquisition and analysis systems for the seismic data produce information about the local and global parameters of earthquakes. In addition, Antelope is used for manual processing (e.g. association events, creation of a database, sending seismic bulletins, and calculation of magnitude and peak ground acceleration and velocity), generation of ShakeMap products, and interactions with global data centers. The NDC has developed tools to make all of this information easily available across the internet, and also to lay the grounds for a more modular and flexible development environment. This will enable centralizing of the data from software such as Antelope, which is using a dedicated database system (Datascope; a database system based on text files), to the more general-purpose database, MySQL. This acts like a hub between the different acquisition and analysis systems used at the NDC, while also providing better connectivity at no expense to security. Mirroring certain data to MySQL also allows the NDC to easily share information with the public, via the new application that is being developed, and also to mix in data collected from the public (e.g. information about the damage after an earthquake, which can be used to produce macroseismic intensity indices that are then stored in the database and also made available via the web application). For internal use, there is also a web application that uses the data stored in the database to display earthquake information, like location, magnitude and depth, in semi real time, thus aiding the personnel on duty. Another use for the data collected is to create and maintain contact lists to which the datacenter sends notifications (SMS and email), based on the parameters of an earthquake. For the future development, one of the NDC plans is to develop the means to cross-check the data generated between the different acquisition and analysis systems (e.g. comparing data generated by Antelope with data generated by Seiscomp).

1. Introduction

The National Institute for Earth Physics (NIEP) operates a real-time seismic network that is designed to monitor the seismic activity in the Romania territory, which is dominated by the Vrancea intermediate-depth (60-200 km) earthquakes.

The ability to reduce the impact of earthquakes on society depends on the existence of a large amount of high-quality observational data. The development in the last few years of the seismic network and of an advanced acquisition system are essential factors to achieve this goal.

Starting in 2002, the modernization of the Romania seismic network was based on the installation of new seismic stations operating in real time. This network consists of digital seismic stations that are equipped with acceleration sensors (EpiSensor) and velocity sensors (broad-band: STS2, CMG3ESP, KS2000, CMG40-T; or short period: MP, SH-1, S13, Mark Product).

2. Real-time data system

The real-time digital seismic network consists of 86 seismic stations with three components, including two arrays: BURAR with 12 elements and PLOR with 7 elements. All of the data recorded by this network are transmitted in real time to the NIEP for automatic data processing, analysis and dissemination. The seismic station locations and equipment characteristics for the real-time Romania Seismic Network are given in Table 1.

Station code	Latitude (°N)	Longitude (°E)	Elevation (m)	Recording equipment type
ARCR	47.085	24.353	385	Q330 + MARMOT, STS2 + Episensor
ARR	45.365	24.633	871	Q330, CMG3ESP + Episensor
AMRR	44.610	27.335	67	Q330 + MARMOT S13, SH1 + Episensor
BANR	45.382	21.137	80	Q330 + MARMOT, KS200 + Episensor
BAPR	44.405	26.119	103	K2 Digitizer, Mark + Episensor
BMR	47.672	23.496	294	Q330, CMG40T+ Episensor
BSTR	44.445	26.098	125	K2 Digitizer, Mark + Episensor
BTMR	44.437	26.106	140	K2 Digitizer, S13, SH1 + Episensor
BUC	44.410	26.093	82	K2 Digitizer, Mark + Episensor
BUC1	44.347	26.028	77	K2 Digitizer, Mark + Episensor
BURAR	47.644	25.200	1216	9 SP - GS21, 1 BB - KS5400, 5 CMG40T
BVCR	44.430	26.101	112	K2 Digitizer, Mark + Episensor
BZS	45.618	21.640	260	Q330, STS2 + Episensor
CFR	45.178	28.136	52	Q330 + MARMOT, CMG40T + Episensor
CIOR	44.448	25.879	138	Q330 + MARMOT, Mark + Episensor
CJR	46.713	23.598	750	Q330 + MARMOT, CMG3ESP+ Episensor
CNCR	44.43	26.61	105	K2 Digitizer,+ Episensor
CRAR	44.325	23.799	125	Q330, CMG3ESP + Episensor
CVD	44.351	28.039	153	Q330, Mark + Episensor
CVD1	44.320	28.062	50	Q330, CMG40T + Episensor
DEV	45.887	22.898	250	Q330, CMG40T + Episensor
DOPR	45.967	25.388	526	Q330 + MARMOT, STS2 + Episensor
DRGR	46.791	22.711	921	Q330, KS2000 + Episensor
EFOR	44.075	28.632	103	Q330 + MARMOT, Ranger + Episensor
GIUM	45.485	28.208	106	K2 Digitizer ,CMG40T + Episensor
GRER	45.380	26.974	276	Q330 + MARMOT, S13, SH1 + Episensor
GHRR	46.060	27.408	212	Q330 + MARMOT, CMG3ESP + Episensor
GOLR	44.843	24.981	301	Q330 + MARMOT, S13, SH1 + Episensor
GZR	45.393	22.776	850	Q330 + MARMOT, STS2 + Episensor
HARR	44.689	27.930	118	Q330 + MARMOT, S13 + Episensor
HUMR	44.528	24.980	247	Q330 + MARMOT, CMG40T + Episensor
IAS	47.193	27.553	160	Q330 + MARMOT, KS2000 + Episensor
INCR	44.441	26.161	88	Q330, MARK + Episensor
ISR	45.118	26.543	750	Q330 + MARMOT, CMG3ESP + Episensor
KIS	46.997	28.817	185	Q330, CMG40T + Episensor
LEOM	46.473	28.246	52	K2 Digitizer, CMG40T + Episensor
LOT	45.446	23.769	1240	Q330 + MARMOT, STS2 + Episensor
MANR	43.816	28.587	71.9	Q330 + MARMOT, MARK + Episensor
MDB	46.149	24.376	375	K2 Digitizer, MARK + Episensor
MILM	46.918	28.812	64	Q330 + MARMOT, STS2 + Episensor
MLR	45.490	25.945	1360	Q330, STS2 + Episensor
MSAB	44.089	27.826	124	Q330, CMG40T + Episensor
MTUR	45.234	25.073	1018	Q330 + MARMOT, S13 + Episensor
ODBI	45.763	27.055	181	Q330, RANGER + Episensor

Station code	Latitude (°N)	Longitude (°E)	Elevation (m)	Recording equipment type
PETR	45.723	27.231	86	K2 Digitizer, KS2000+ Episensor
PGOR	44.919	26.976	98	Q330 + MARMOT, S13, SH1 + Episensor
PLAR	44.914	26.027	146	Q330 + MARMOT, MARK + Episensor
PLSP4	45.851	26.649	672	Q330, GS21
PLOR	45.851	26.649	657	Q330, STS2, 6 CMG40T + 4 Episensor
PRAR	47.361	26.227	451	Q330 + MARMOT, MARK + Episensor
RMGR	44.662	22.692	113	Q330 + MARMOT, MARK + Episensor
RMVG	45.036	24.284	260	K2 Digitizer, MARK + Episensor
SECR	45.035	26.067	417	K2 Digitizer, S13, SH1 + Episensor
SIRR	46.265	21.663	480	Q330 + MARMOT, CMG40T + Episensor
SIBR	45.809	24.175	463	Q330, S13 + Episensor
SRE	44.660	23.203	335	Q330 + MARMOT, MARK + Episensor
SORM	48.135	28.351	64	Q330, CMG40T + Episensor
SULR	44.677	26.252	73	Q330, KS2000 + Episensor
TESR	46.511	26.648	372	Q330 + MARMOT, STS2 + Episensor
TIM	45.736	21.221	88	K2 Digitizer, S13, SH1 + Episensor
TLB	44.585	28.041	60	Q330, CMG40T + Episensor
TNR	45.652	24.273	519	Q330, S13
TIRR	44.458	28.412	77	PS6-24, STS2 + Episensor
TLCR	45.186	28.815	73	Q330 + MARMOT, MARK + Episensor
VOIR	45.437	25.049	969	Q330, STS2 + Episensor
VRI	45.865	26.727	472	Q330, STS2 + Episensor
ZIMR	43.657	25.365	74	Q330, Ranger + Episensor

Table 1 (continues from previous page). Seismic stations and instrumentation. All of the stations listed have real-time data transfer modes.

The remote seismological stations have three-component seismometers for weak motion and three-component accelerometers for strong motion.

In cooperation with the Kishinev Institute of Geophysics and Seismology, Republic of Moldova, three seismic stations have been installed in the Republic of Moldova. These seismic stations were installed at Leova (LEOM), Giurgiulesti (GIUM) and Milestii Mici (MILM). Also, in collaboration with the same institute, two more seismic stations have been installed in Kishinev (KIS) and Soroca (SORM).

All of the data from the seismic stations installed in the Republic of Moldova territory are received in real time at the NIEP Data Centre using seedlink connections.

The primary goal of the real-time seismic network is to provide earthquake parameters from more broad-band stations with a high dynamic range, for more rapid and accurate computation of the locations and magnitudes of earthquakes. The Seedlink and Antelope™ program packages are used for this real-time data acquisition and exchange.

The real-time digital seismic network developed by the NIEP is illustrated in Figure 1. The near-future strategies include installing additional broad-band stations in the central and western parts of Romania, and another 40 strong-motion stations in Bucharest city.

A completely automated Antelope seismological system [BRTT 2011] (Figure 2) is run at the Data Center in Magurele. The Antelope data acquisition and processing software is run on two workstations for real-time processing and post-processing. The Antelope real-time system provides automatic event detection, arrival picking, event location, and magnitude calculation. It also provides graphical displays and automatic location within near real time after a local, regional or teleseismic event has occurred [Neagoe and Ionescu 2009].

SeisComP 3 is another automated system that is run at the NIEP and which provides the following features: data acquisition, data quality control, real-time data exchange and processing, network status monitoring, issuing event alerts, waveform archiving and data distribution, automatic event detection and location, easy access to relevant information about stations, waveforms, and recent earthquakes [SeisComP3.org 2011a, 2011b] (Figure 3).

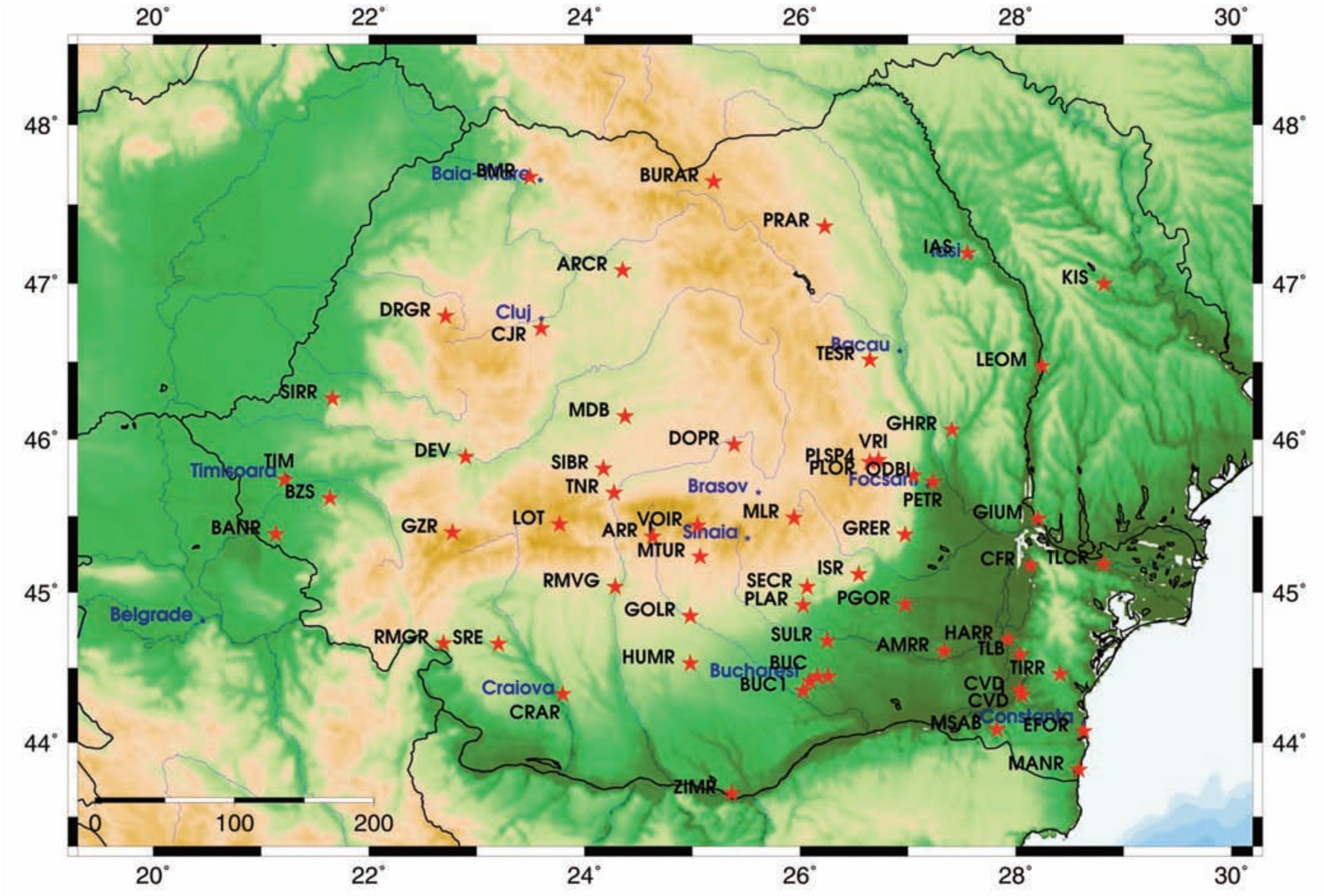

Figure 1. The real-time digital seismic network developed by the NIEP.

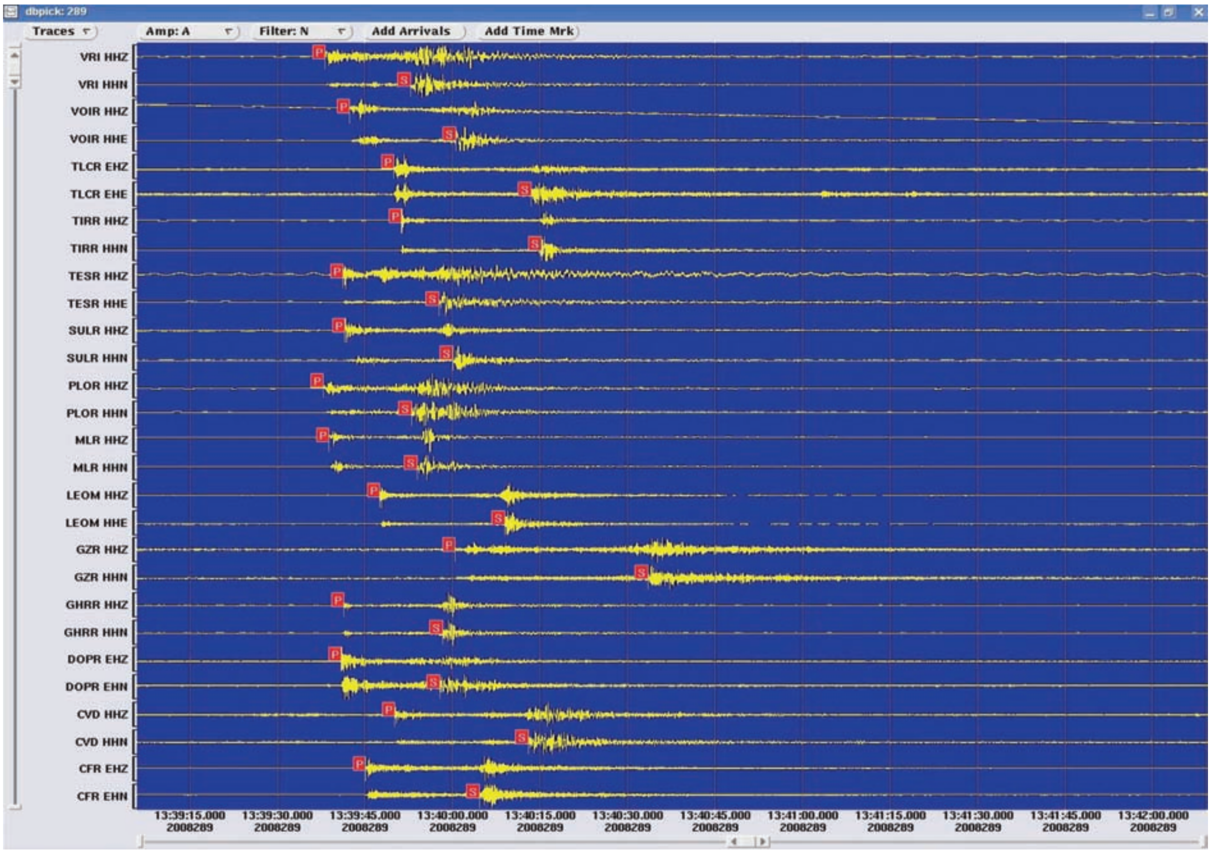

Figure 2. Example of the manual data-processing with Antelope software.

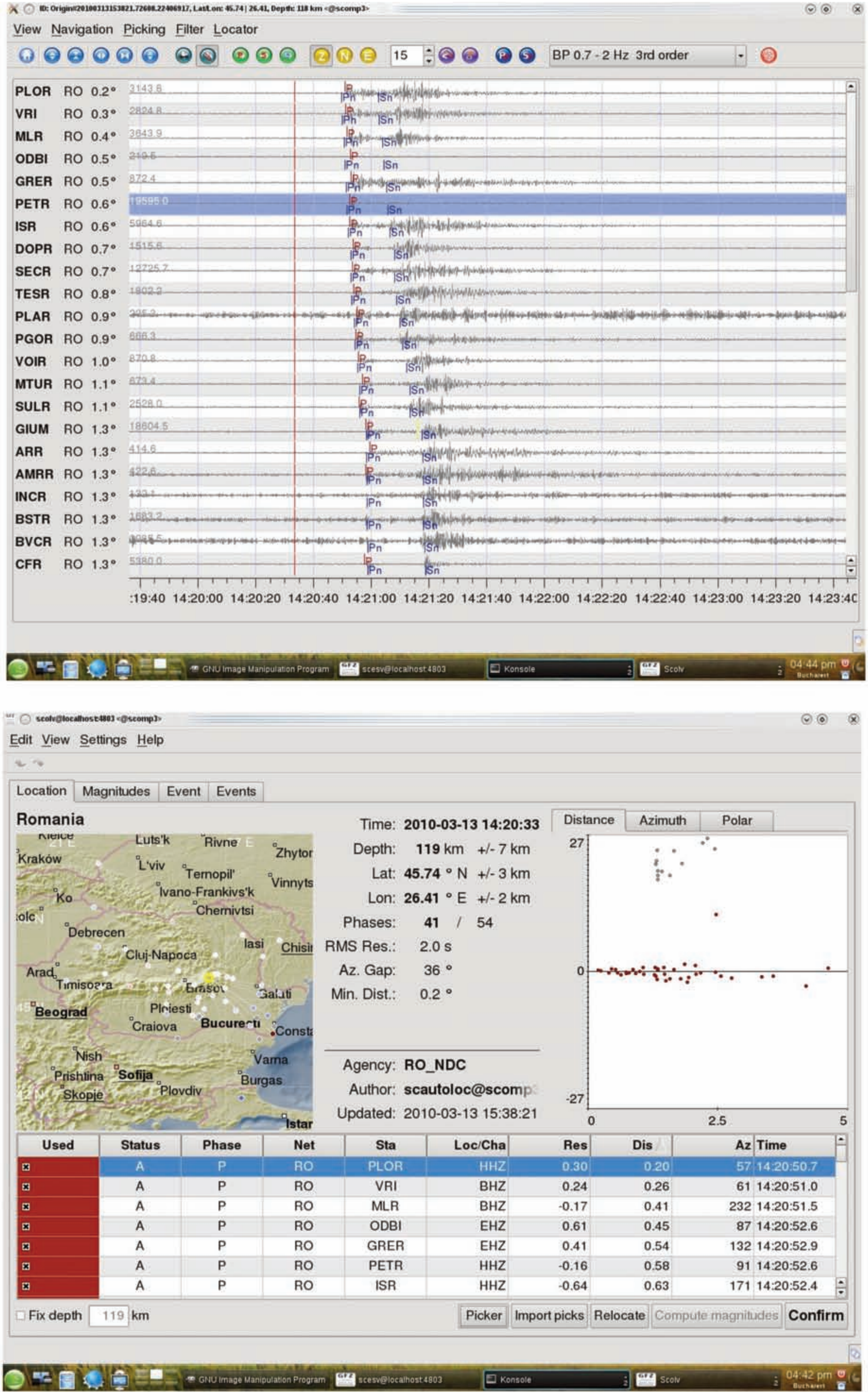

Figure 3. Automatic detection (top panel) and seismic data processing (bottom panel) using the SeiscomP 3 software.

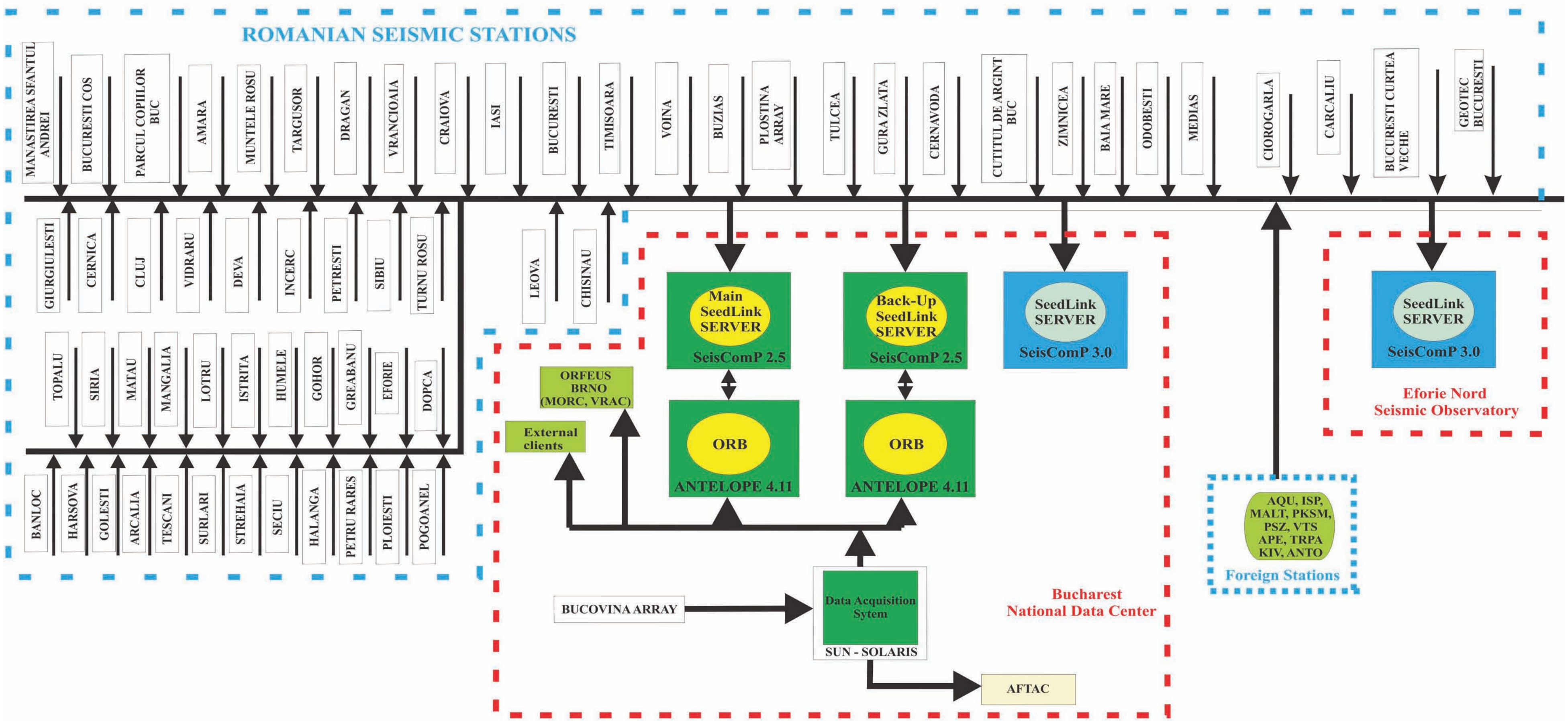

Figure 4. The data flow at the Romania Data Center.

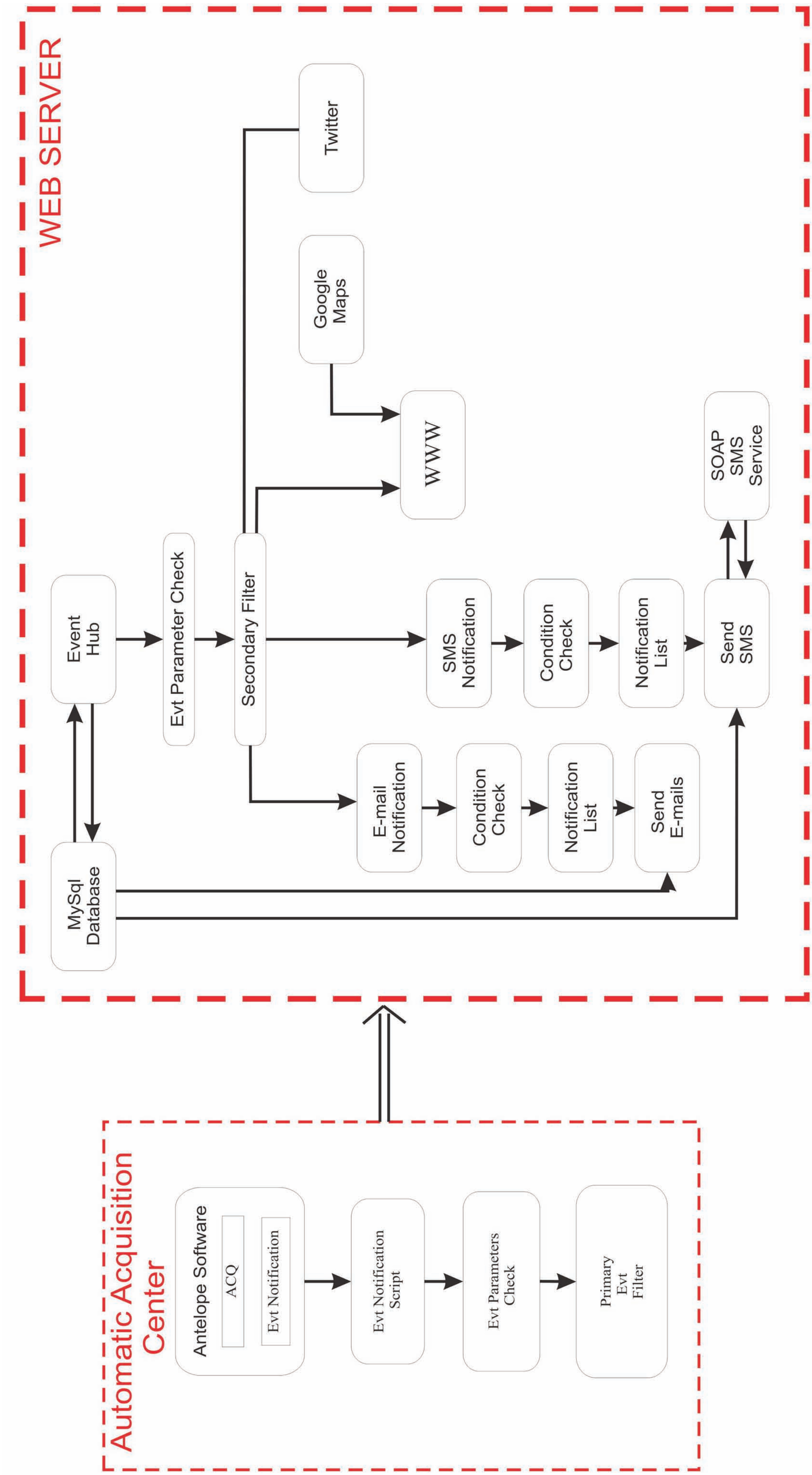

Figure 5. The web server configuration.

The Romania Seismic Network exchanges data with international organizations like ORFEUS and IRIS and with data centers from other European countries via the internet. The data provided consist of near-real-time waveform data from six broad-band stations: Iasi, Dragan (DRGR), Craiova (CRAR), Bucharest (BUC1), Vrincioaia (VRI), Muntele Rosu (MLR) and the Bucovina (BURAR) array (Figure 4).

3. Real-time analysis

Both the acquisition and analysis of seismic data systems produces information relating to the local and global parameters of earthquakes. In addition, Antelope is used for manual processing (e.g. association events, magnitude computation, database, sending seismic bulletins, calculation of peak ground acceleration and velocity), generating ShakeMap products, and interacting with international data centers.

To make all of this information easily available across the internet, and also to lay the grounds for a more modular and flexible development environment, the NDC has developed tools to enable the centralizing of the seismological data.

As Antelope is using a dedicated database system (Datascope, a database system based on text files), we have moved the data to a more general-purpose database, MySQL, which acts like a hub between the different acquisition systems used in the NDC. The MySQL database also provides better connectivity at no expense to security (Figure 5).

Mirroring certain data to MySQL also allows the NDC to easily share information with the public via the new application that is being developed, and also to mix in data collected from the public (e.g. information about damage after an earthquake that can be used to produce macroseismic intensity indices, which are then stored in the database and also made available via the web application). For internal use, there is also a web application that uses the data stored in the database to display earthquake information in semi real time, like location, magnitude and depth.

Another use of the data collected is to create and maintain contact lists to which the data center sends notifications (SMS and email) based on earthquake parameters.

5. Future developments

The Romania Seismic Network will be enlarged by the installation of new stations that will provide seismic data in real time to the NDC. The up-graded network will provide new data for site effect studies and microzonation purposes, and it will be used for developing and evaluatiing shake maps for all of the country, and in particular in the Bucharest area.

Among the various aspects of the future development, the NDC plans to develop the means to cross-check the data generated between the different acquisition and analysis systems (e.g. comparing data generated by Antelope with data generated by Seiscomp).

References

BRTT (2011). Evolution of the Commercial ANTELOPE Software; http://www.brtt.com/docs/evolution.pdf.

Neagoe, C. and C. Ionescu (2009). Toward a dense real-time seismic network, Romanian Rep. Phys., 61, 359-366.

SeisComP3.org (2011a). Introduction and scope; http://www.seiscomp3.org/wiki/doc/introduction-and-scope.

SeisComP3.org (2011b). Software architecture. http://www.seiscomp3.org/wiki/doc/software-architecture/.

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