Using wireless point-to-point connections to improve volcano monitoring: a feasibility study of the wimax technology applied to the Campi Flegrei volcanic area (Southern Italy)

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IEEE 802.16 standard, commonly known as WiMAX (Worldwide Interoperability for Microwave Access Forum), is one of the most promising broadband wireless access technology for next generation all-IP networks. This access technology allows reaching high bit rate (up to 75 Mbps) and covering large areas (up to 50 km) with a single Base Station (BS). Thanks to these features, IEEE 802.16 opens the way for the use and the introduction of wireless technologies in particular emergency scenarios, like volcano monitoring.

In particular, this paper focus on a novel solution, designed within the IST FP6 EU "WEIRD" (WiMAX Extension to Isolated Research Data networks) Integrated Project, to perform volcano monitoring using the features offered by IEEE 802.16 networks in order to improve transmission on-demand of data acquired by temporary seismic stations deployed during emergencies. The temporary seismic stations, deployed to enhance both the network geometry and the quality of the recorded data, are generally characterized by continuous local recording on removable media. The local recording system agrees with the necessity of a quick improvement of the monitoring system in case of emergency. On the other hand, the use of stand-alone temporary stations has some limitations: in fact, the local recording needs a periodic maintenance to retrieve the data and therefore the data itself are not available in real-time. The need to create a communication link between temporary seismic stations and the Acquisition Centre puts new challenging requirements that have to be taken into account. This feature has several advantages:

- scientists do not move to reach all the temporary seismic stations to download collected data spending useful time.
- scientists can analyze in real-time current volcano status and activate any action;
- the problem related to the finite storage capacity of the temporary seismic stations is eliminated.

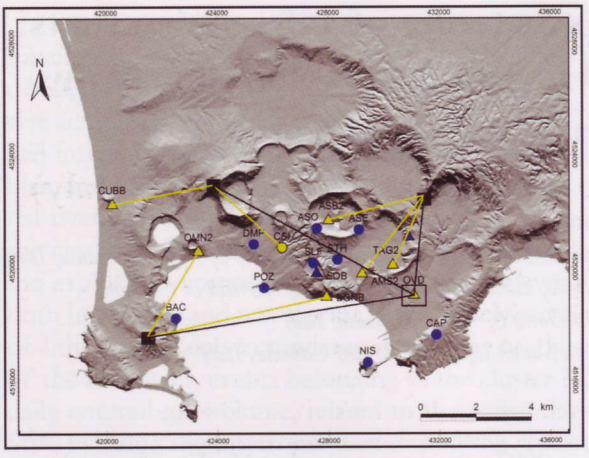

Fig. 1. Scenario for the Campi Flegrei seismic monitoring system. Yellow symbols represent the Temporary Seismic Stations. Blue symbols show the Permanent Seismic Network. Yellow lines represent the link between Temporary Seismic Stations and an access point (filled black squares), black lines are the links with the Acquisition Centre (empty square).

Moreover, the need to collect seismic data on-demand requires wide wireless area coverage together with broadband features, even in NLOS (Non Line Of Sight) conditions. Finally, the need to support also voice and video communications, as they are needed during a volcanic crisis for the communication between scientists in the field and scientists in research centre, introduces Quality of Service (QoS) requirements.

A test was made using a 24-bit portable digital seismic station Lennartz M24 equipped with a Lennartz LE-3Dlite seismometer. The Lennartz M24 seismic station is characterized by stand-alone recording as well as remote data retrieval via serial line (RS-232) or TCP/IP protocol on a Web-based interface. The seismic station was installed about 5 km from the local acquisition center in LOS configuration. With the WiMAX communication, based on TCP/IP protocol, the test showed that the download of five minutes of seismic signal was completed in just five seconds, allowing a near real-time processing of the data and their fast integration with the permanent seismic network data.

To check the performance of the WiMAX data transmission in a real case, we have simulated the WEIRD system in the Campi Flegrei volcanic area, where a Temporary Seismic Network, composed by seven broadband and one short-period stations, has been deployed during the recent 2004-2006 emergency and still operating (Fig. 1).

In this situation, the NLOS transmission allows the link between each Temporary Seismic Station and the Acquisition Center. However, the link can be obtained also through a sequence of radio links (repeaters) in order to reach stations not directly visible (Fig. 1). With only three access points configured as repeaters, it is possible to cover the entire area and to link the Temporary Stations to the Acquisition Centre.

The work presented in this paper demonstrates that the use of new TCP/IP-based broadband wireless communication technologies, in particular WiMAX, brings benefits in emergency scenarios and highlights the importance of the diffusion and the deployment of such technologies.