Optimizing GNSS CORS networks at remote locations

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SUMMARY

The installation and maintenance of GNSS CORS at remote locations poses extra difficulties due to issues concerning data transfer and monitoring. Access to reliable local electrical power and internet access can be very difficult or even impossible. In addition, the security of the installation is also a major criterion at such places.

SEGAL (Space & Earth Geodetic Analysis Laboratory), a collaborative scientific venture between University of Beira Interior and Institute Geophysical D. Luíz, Portugal, has being installing several systems at very remote locations, particularly in Africa, that suffer with the mentioned problems. In recent years, several of these systems have been installed in collaboration with National Mapping Agencies (e.g., OSGOF – Nigeria; CENACARTA – Mozambique) and Research Institutions (e.g., Air Force Research Lab, USA, JPL/NASA – USA).

We present here our recent developments concerning hardware and software. We also discuss how to optimize such systems in order to be used by different scientific and technical applications, which is quite often relatively simple and it does not demand extra resources if properly planned in advance.

Our technical solutions in terms of software network management both at server and stations are adapted to the existing conditions available at many countries where the communication technologies are still advancing (and still have high costs). Such solutions can be implemented with significant fewer costs than the solutions presented by commercial companies. In addition, we developed web services that are a reliable alternative for data management (acquisition, storage, and maintenance).

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1. INTRODUCTION

SEGAL (Space & Earth Geodetic Analysis Laboratory – http://segal.ubi.pt) has been installing GNSS (Global Navigation Satellite Systems) all over the world in the last decades in the framework of dedicated projects or in collaboration with local or international partners. These partners include National Mapping Agencies (e.g., OSGoF – Nigeria; CENACARTA – Mozambique) and Research Institutes (e.g., JPL and AFRL – USA; AIT – Thailand). Figure 1 shows the partial distribution of the stations installed using SEGAL support in the last years (some stations, e.g., Dili – East Timor, Suva – Fiji) are not shown.

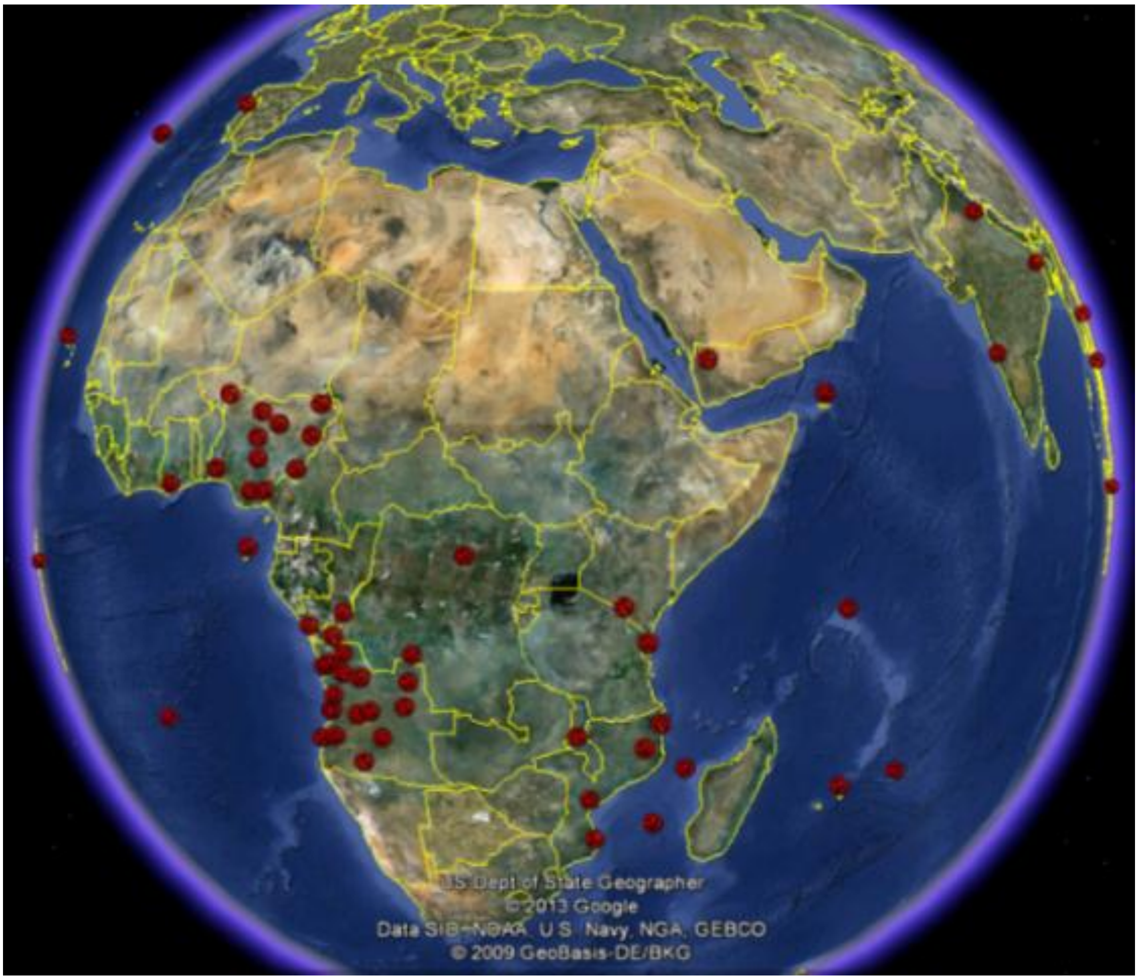

Figure 1 – Distribution of stations installed by SEGAL in the last decade

Due to the different partnerships, one of the major characteristics of the network installed by SEGAL is that it is not based in a single brand. In fact, the network shown in Figure 1 comprises GNSS systems from five different brands: Leica, Topcon, Trimble, Novatel, and Javad. This forced us to develop systems to optimize the integration with any model making our design independent of brands/models.

Another major characteristic is that our systems were developed to be installed at very remote locations where local support can be very limited due to lack of human support and/or expertise. Such locations can also lack reliable infra-structures in terms of power and communications. Therefore, out systems were developed thinking to be completely autonomous of the local conditions. In this respect, they do not need to use local power (although it can be used as alternative source) and the communications can be done using not only mobile networks (preferable approach) but also landlines or satellite links. Finally, our systems can be configured to locally storage as much data as necessary, which also makes it independent of the installed GNSS receiver (which additional memory can still be extremely expensive).

The field systems are supported by a central application, MGN – Monitoring GNSS Networks, which has been developed with the goals of permanent monitor the network status and data transfer, and also make easily available the data to the involved organization(s) and/or final users.

2. SEGAL SYSTEM

Figures 2 and 3 show details of the developed setup for the system that includes:

a) monument (cf. Figure 2) – this installation has been done on the ground using a foundation of more than $1m^3$. This was possible because it was ensured by the local partners the necessary security (further warranted by the technical box that stores all the components with the exception of the solar panel(s) and GNSS antenna). However, at many locations, the alternative is to install the system in the roof tops if the building is stable enough.

b) power management (cf. Figure 2) - there is redundant power supply. The receiver and router work both on solar panel and on electrical grid (when available). The radios (used to stream RTK corrections) work on the electrical grid (however, they can also work only on the installed batteries for short periods if necessary).

c) receiver (cf. Figure 3) - the system was developed in order to be independent of the receiver used (currently, the system is working with different models from five different vendors).

d) router (cf. Figure 3) - this equipment manages all local processing and the communications using mobile communications (UTMS or EDGE). The collaboration with some partners intends to also develop systems that can be used by different applications simultaneously: if the limit for surveying is 1Hz, seismic and ionospheric applications imply data acquisition at high frequencies (>=50Hz) that it is impossible to transfer using available communications at many worldwide locations. Therefore, local processing is required. The goal is to use the most efficient device in terms of components and power consumption. Currently, the option is a router but other options (e.g., FitPC) are being investigated.

Figure 2 – Example of a system installed by SEGAL (Nigeria)

Figure 3 – Example of a system installed by SEGAL (Angola)

SEGAL continues to developing tools that permit to establish 2-ways communications with the remote systems using mobile communications. In particular, SEGAL is using VPN tunnels in order to access the remote systems. In countries like Nigeria, mobile communications are using NAT protocols which prohibit any external access since no unique IP is attributed to the system. Therefore, it is the router that needs to initiate any communication by establishing a permanent VPN tunnel.

The SEGAL firmware for the communications is reaching a stable phase of development. The stations having the last version are working with no major issues even where the available bandwidth is very limited.

3. MGN

SEGAL is not limiting the development of GNSS infrastructures to the field installations. One of our goals is to also develop computer applications that can interact with the installed networks in order to efficiently monitor and manage them. In this respect, SEGAL is developing an application – MGN – that intends to achieve such goals. Three major characteristics support its development: versatility, simplicity, cost.

In fact, most of the existing applications in the market are extremely costly and are not very versatile. They normally have characteristics that are not real necessary for most of the organizations (but that they are forced to acquire in the entire package). Furthermore, it is common that they cannot work with other brands or models due to interconnectivity issues (which in many cases is not even true but stated due to marketing reasons).

MGN intends to be independent of the installed GNSS receivers and implemented communications. In fact, it can accept several different types of receivers inside of the same network communicating with the central server (where MGN is installed) using different type of communications. MGN has been also developed as a web-service, which means that is accessed using any web browser. This also permits to create different levels on the application: the MGN Pro version is only to be accessed by the administrators (cf. Figures 4 and 5) where all different parameters concerning the monitoring and management of the application are defined. In addition, there is a second version, called MGN lite, implemented to provide to any user access to visualize and download the data (if authorized). Figure 6 shows a detail of this application where the existing data for a station can be directly checked and observed.

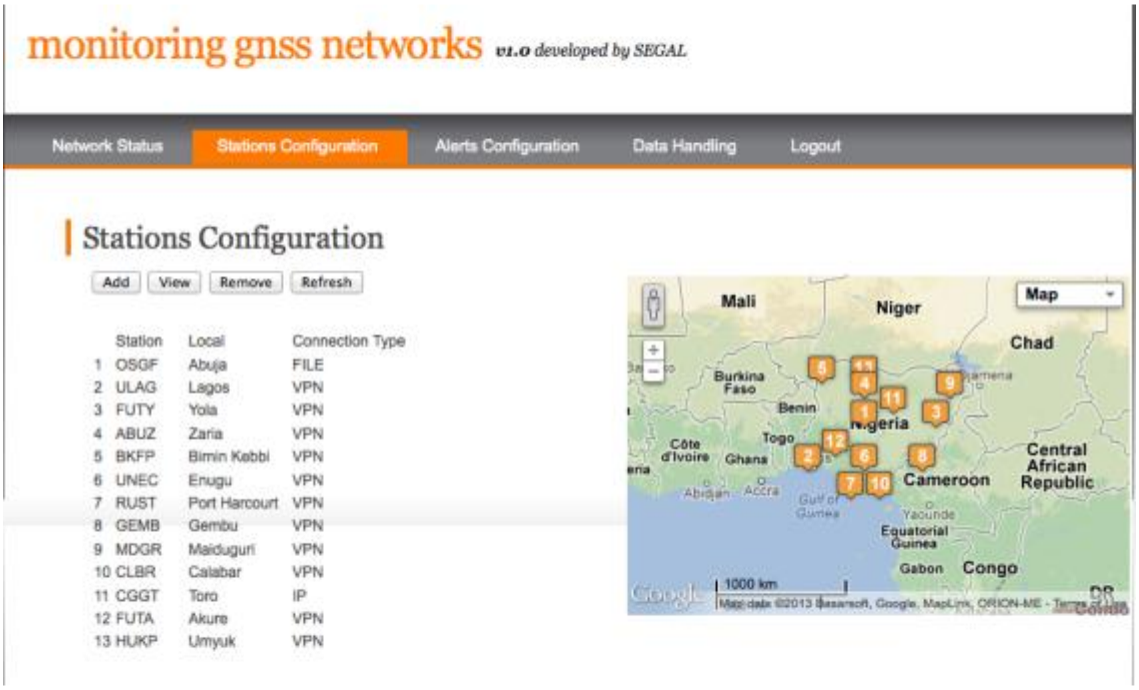

Figure 4 – Example of MGN Pro configuration – NIGNET network.

Figure 5 – Example of MGN Pro configuration – Addition of a new station to the network.

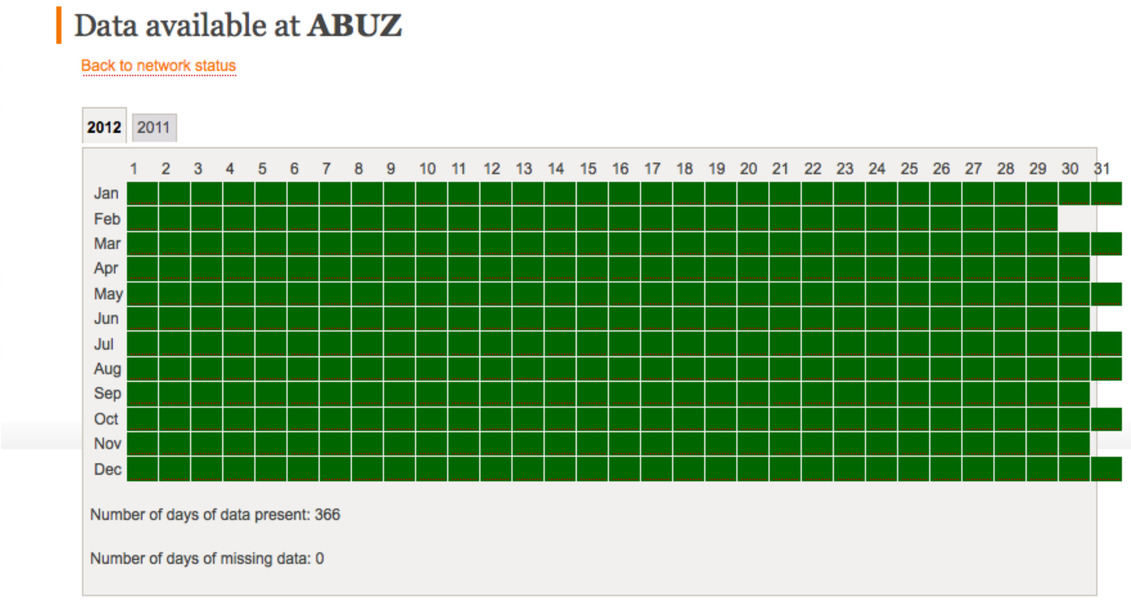

Figure 6 – Example of data holdings shown by MGN Lite. The daily files can be directly downloaded by selecting the appropriate square.

4. CONCLUSION

The SEGAL GNSS integrated system and the MGN application has been already tested at several networks around the world and they are proved to be efficient and robust alternatives to other systems being offered in the market. Being developed with the aim to support the most demanding applications in terms of accuracy and stability – one of the core research areas of SEGAL is the use of GNSS observations for seismic and geodynamic applications, they also serve other GNSS applications, namely surveying.

Other major advantage is that each installation (hardware and software) can be tailored to the needs of the organization instead of the alternative approach where the organization has to adapt their needs to the features offered by the existing systems applications.

Finally, SEGAL is not a commercial organization. Therefore, it is possible to make available the developed products at reasonable costs. In fact, they are free when the umbrella project has exclusively research objectives.

BIOGRAPHICAL NOTES

Rui M. S. Fernandes is Assistant Professor of University of Beira Interior and Associated Researcher of Center of Geophysics of University of Lisbon / Institute Geophysical D. Luíz. He obtained the MPhil in Geomatics Engineering by University of Coimbra, Portugal (1990) and he has the Ph.D. in Earth and Space Sciences by Technical University of Delft, The Netherlands (2004). His current research topics are focused on the application of Geodetic Space techniques to Geodynamics and Reference Systems. He belongs to some organizations like American Geophysical Union and is member of IAG (International Association of Geodesy), EUREF (European Reference Frame) and AFREF (African Reference Frame) technical working groups.

João Apolinário and **Hugo Valentim** are young researchers at SEGAL.

Pedro Venâncio and **Nuno Gonçalves** are former young researchers at SEGAL.

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