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Designing and Developing a Web Server for Real Time GPS Data Processing for Internet of Things Applications using Gamit/Globk

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Abstract IOT (*Internet of Things*) type of application is an important challenge. It can be developed for a large variety of fields. However, each thing (*device*) should be smart device. It is very important in many fields to obtain high-precision positions through an automated GPS (*Global Positioning System*) data processing; one of these techniques is GAMIT/GLOBK software (*Global positionning system At Massachusetts Institute of Technology, Global Kalman filter*). All results obtained by Gamit/Globk are satisfied. However, its manipulation and requirements (software and hardware) is difficult, which lead us to adopt a web-based approach for GPS data processing.

The aim of this paper is to design and implement a new way (*especially for Algerian users*) of processing and analyzing of GPS data based on Web services. The users or experts whom desire processing their confidents GPS data by using their models instead of the global existing models can submit data of one or more sessions, and receive the results with the highest accuracy in the real time. In our case and through this solution as a test we will quantify the movements of some GPS permanent stations installed in the North of Algeria, which situated in the boundary of tow tectonic plates: Africa and Eurasian.

Keywords: *GPS Data Processing, IoT, Web Based Application, Gamit/GlobK.*

1.INTRODUCTION

The Internet of Things enables physical objects to see, hear, think and perform jobs by having them talk together, to share information and to coordinate decisions **[14]**. Today's applications need the collaboration of many kinds of smart devices. For mobile device, the position is an important aspect; it can be given by GPS.

In the last few years, Global Positioning System (GPS) has been used effectively in almost engineering applications (*ex. Geographic Information System*), studies and multiple disciplines. Many of these applications need to improve the accuracy of their GPS data by using the post-processing techniques, where GPS observations data are obtained from continuously stations. The user can move from the initial decimeter magnitude to the sub-centimeter or even millimeter level precision.

Nowadays, with GAMIT/ GLOBK, Bernese, GIPSY and other scientific GPS data post-processing software **[13]**, the level of GPS data processing improved quickly.

An automated processing system becomes an important key for processing and analyzing the data gathered by a network of GPS stations. However, Gamit/GLOBK and other software still much difficult to install and to manipulate, because it requires high performance hardware and also knowledge of a lot of commands to configure and use them, because it does not have an easy interface, this led us to think and suggest a Web-based online solution to make the Post-processing easily always and the results are with high level precision. In general, smart grid communication technologies can be grouped into five key areas: advanced components, sensing and measurement, improved interfaces and decision support, standards and groups, and integrated communications **[15]**.

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The rest of this paper is organized as follows. Section II gives a background and related works; we describe in particular the GPS data processing by Gamit and Globk. Section III describes the designed and proposed architecture. Section IV describes the implementation and results. Finally, we conclude and give some future works..

2. Background

In this sub-section, we present a background on the GAMIT/GLOBK system, particularly the data processing phase.

A. GAMIT/GLOBK vs Other Softwares

There are various GPS research analysis software (TABLE I) such as GAMIT/GLOBK, GIPSY, and Bernese **[11]** that are used in post-processing and analyzing GPS data. In our case, we have adopted GAMIT/GlOBK software (developed by Massachusetts Institute of Technology) for several reasons: it is one of the performant GPS positioning orbit software; and by using the precise ephemeris the relative accuracy of short baseline is better than 1 mm **[1]**. This free and open software is characterized also by its high operation speed, short update cycle and higher degree of processing automation.

TABLE I. Comparative table between the three software

Software	mode	approach	Commercial
Gamit /Globk	*Stati,kinematic*	DD[a]	Free and Open-source
Bernese	Static	DD	Commercial
Gipsy	Static	PPP[b]	Free Software

a: Double Difference; b:Precise Point Positioning

B. Advantages of GPS data processing by a Web Server

The advantages of data processing on the Web that motivate this work are **[2]:**

- The user is not obliged to use other systems to process its confident data,
- It is a good solution for companies that need such processing manner (*ex. Sontrach in Algeria*),
- No software installation is required for the user,
- All software updates can be done in a single server,
- The software can automatically determines the necessary parameters for a particular circumstance,
- The program remains on an independent platform to the user,
- The web server is accessible to multiple users at the same time.

C. Data Processing Using Gamit

GAMIT **[3]** is a set of programs to process phase data and estimate three-dimensional relative positions of ground stations and satellite orbits, and earth orientation parameters. The software is an open source and designed to run under any UNIX operating system.
In the following, we present the main steps of Gamit processing: data preparation and batch processing**:**

1) Creating Satellite and Stattion Clock Files

In order to account properly for clock effects in the observations phase, additional information has to be supplied about the behavior of the satellite and station clocks.

It is done using the MAKEJ "**Fig. 1"** function that uses the RINEX (*Receiver Independent Exchange Format*) navigation file to make the satellite clock file.The formula (1) used to calculate the SV (Space vehicle)clock offset is:

$$\Delta t_{s}=t_s-t_s'=a^{(0)}+a^{(1)}\left(t-t_0^{(c)}\right)+a^{(2)}\left(t-t_0^{(c)}\right)^2 \quad (1)$$

Where t_s' is the time read by the satellite's clock and t_s is "true" GPS time.

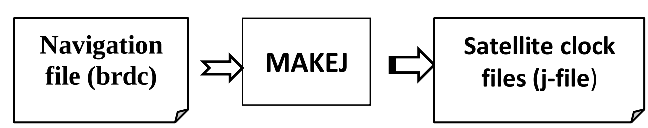

Figure 1. Makej Model

The two models *MAKEX* and *MAKEK* are shown in "Fig. 2", they generate a station clock offset file (K-file) and observation X-files for each station in the session. It takes such input :the scenario file (*session.info*), station information file (*station.info*), satellite clock (J-) file, broadcast ephemeris (*RINEX navigation*) file, station coordinates (L-) file, raw data files (*in RINEX format*) and creates X- and K-files **[4]**.

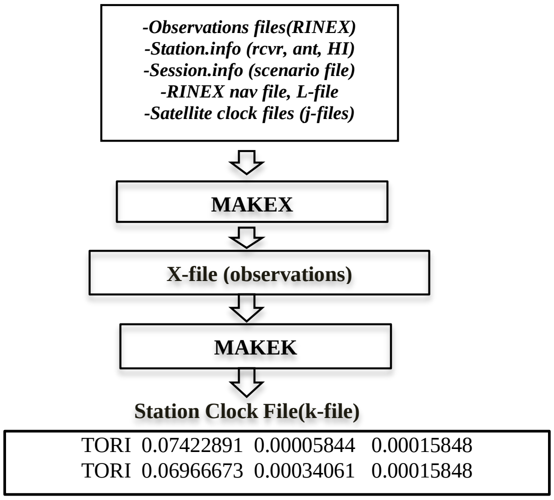

Figure 2. Section from a Station Clock File (k-file).

2) *Automatic Batch Procesing*

The final solution is obtained by the following modules:

MODEL "Fig. 3" computes the theoretical values of the observations ("observables") and partial derivatives of these observations with respect to the parameters to be estimated, and writes them in an output (C-) file. *AUTCLN* performs automatic (*batch*) editing of cycle slips and outliers in the phase observation. The *CFMRG* module writes a (M-) file defining the way observations are to be combined, and *SOLVE* performs the least squares analysis, writing the output in Q-file and the adjustments and covariance matrix in H-file and also the sky plots . With Automatic Batch Processing option, the time can be saved for the treatment of important data.

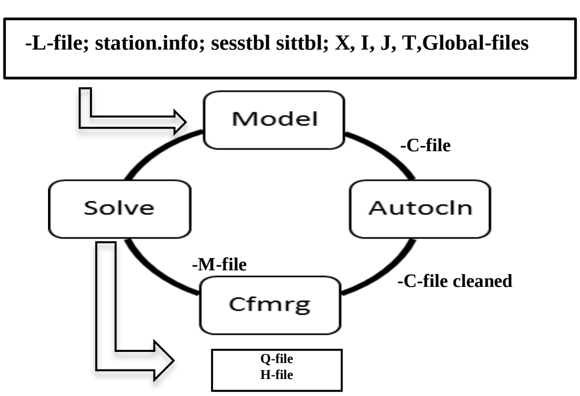

Figure 3. The different Steps of Gamit processing.

3) *Data Processing by GLOBK*

GLOBK (1980) is a set of programs that combines solutions (*based on Kalman filter*) from different kind of data (*ex: GPS data*) and from different software solutions in order to estimate other parameters such as **[5]:**

- Site velocities,
- Temporal derivative of position (mm/yr),
- Time series of measurements,
- Satellite orbit adjustments ,
- Other parameters

There are three common modes, or applications, in which

Globk is used:

- Combination of individual sessions (*e.g., days*) of observations to obtain an estimation of station coordinates average over a multi-day experiment.
- Combination of experiment-averaged from (*individual sessions*) estimation of station coordinates obtained from several years of observations to estimate station velocities.
- Independent estimation of coordinates from individual sessions to generate time series assessment of measurement precision over days or years.

At the beginning of processing, we have a set of quasi - observation (h-file). The first step is to convert the ASCII quasi-observation files into binary h-files that can be read by Globk. This is accomplished via the program *htoglb* "*Fig. 4*". The second step is usually to run *Glred* -The script *sh_glred*, described in **[1]** combines these initial steps, invoking in turn htoglb, glred, and plotting of time series- for all of the (*binary*) h-files from a session or period of continuous observations- to obtain a time series of station coordinates, which can then be plotted and examined for outliers to obtain reasonable uncertainties. When outliers are found, we may need to repeat our processing of the primary observations (*e.g., using GAMIT*) for certain days or to remove the h-files from these days from further analysis. Since we have obtained a clean data set, we repeat the processing, this time with *Globk* instead of glred, to combine the daily h-files into a single h-file that represents the estimate of station positions for the session or a period of continuous observations.

- Once we have estimates the h-files of station coordinates for continuous observations, we can run glred and globk again, using these combined h-files as input to obtain a time series (*from glred*) and/or estimates of station velocities (*from globk*) for the entire period spanned by the data .

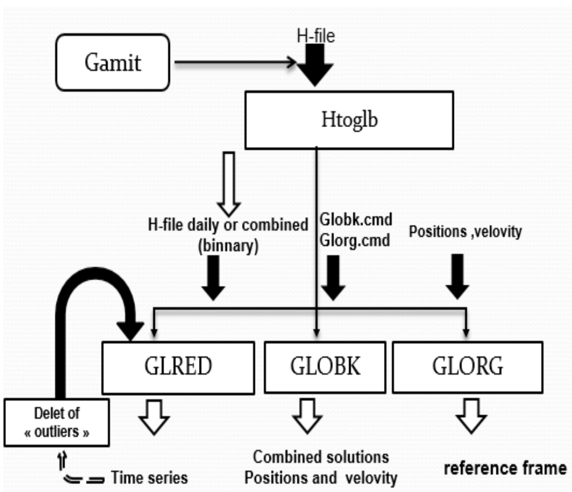

Figure 4. The different Steps of Globk processing

3. Related Works

There are different online Global Positioning Systems processing services that provide GPS processing results to the users **[12]**, in our study we can cite:

A. *Online Positioning User Service (OPUS)*

Online Positioning User Service (OPUS) [9] is a service that set up by the American National Ocean Atmosphere Association (NOAA), the "PAGES" software is used By NOAA to calculate the coordinates. After uploading the GPS data collected in the field, type and height of the antenna were also introduces to the system with the help of the easy-usable interface. OPUS calculates the coordinates by taking the results from three independent base vectors. The results are sent to the e-mail address. For a single station, the process lasts approximately 15-20 minutes **[6]**.

B. *Australian Online GPS Processing Service (AUSPOS)*

AUSPOS **[8]** is an online GPS data processing service prepared by the Geoscience Australia Association. In this system, the coordinates are determined with the help of the three nearest IGS (*International GPS Station*) stations. In the processing stage, IGS precise orbit information, earth rotation parameters and speed vectors of IGS stations are taken into count. For these evaluations, GPS survey software is used, it is named Microcosm. Users can be reached to the AUSPOS processing service through the service's interface screen; users start the survey process by entering their data, type and height of antenna. Users can install the data via both interface and ftp server. The results are sent via e-mail. The survey file of a single day can be processed in approximately 15 minutes**.**

C. *Auto-Gipsy of JPL (Jet Propulsion Laboratory)*

Unlike the two other systems, Auto-Gipsy **[10]** has no web interface to interact with the user. It is a mail-in service where a user with an email account can access to an anonymous ftp server to store the GPS data. The user simply needs to send an email to "*ag@cobra.jpl.nasa.gov*", titled "Static" and, in the body of the email, the ftp address to the server hosting the relevant data. A reply email with the title "Output" will be sent to the user within 5 - 10 minutes, depending on the number of jobs in the queue. The body of the email contains the ftp addresses of the results file. The users are warned that the results are only available for a few days **[7]**.

In our study, we are based on GAMIT/GLOBK packages for several reasons: firstly, it thoroughly estimates almost all the parameters affecting positioning by GPS observations. Secondly, we use globk to combine solution files generated by other GPS software, as well as for terrestrial and SLR (*Satellite Laser Ranging*) observations.

Furthermore, our System presents two different features (Table II): in one hand, the user can upload its control files (*session file, site file…etc.*) and data directly via the web interface. In other hand, in addition, that the system can sent the results by e-mail, also, the user can show the results (*summary files and plots*) in the real time if he has not much data. As opposition to JPL, there is no need to specify an FTP location, which implements the '*Auto Gipsy*' software. A user can upload the RINEX observation and navigation files through the web browser

TABLE II. COMPARATIVE TABLE BETWEEN DIFFERENT ONLINE POST-PROCESSING SYSTEMS

Service	Based Software	Correction Products	Processed Frequency	Access and results
OPUS	Pages	Orbit/Network	Static	Internet
AUSPOS	Bernese	Orbit/Network	Static	E-mail
Auto-Gipsy	GIPSY	Orbit/Clock	Static	E-mail
Our solution	Gamit/Globk	Orbit/Network	Static/ Dynamic	Internet

4. ARCHITECTURE OF THE PROPOSED SYSTEM

There is no unique definition available for Internet of Things that is acceptable by the world community of users. In **[19]**, it is defined as: "*An open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment*"

The term "Internet of Things" has come to describe a number of technologies and research disciplines that enable the Internet to reach out into the real world of physical objects **[16]**. Devices used in Internet of Things can be accessed, monitored and controlled using different built-in wireless and wired communications protocols such as ZigBee, Wi-Fi, RFID, Bluetooth, general packet radio service (GPRS), Home-plug, RS485, I2C, SPI and power liner carrier (PLC) **[17]**. Sensors are largely used in IoT **[20]**. The large-scale implementation of IoT devices promises to transform many aspects of the way we live **[18]**. However, this implementation needs to be optimized in particular for decentralized applications. Furthermore, we have chosen client server type of application. In this context, we propose a new system for automatic data processing collected given by GPS.

Our system allows user to upload the RINEX observation and navigation files into precise orbit files to obtain high-precision coordinates. The main function of our system can be summarized as shown in "Fig. 5".

- User Authentication and Creating an Experience Directory,
- Preparing for processing and uploading data,
- Configuring and starting processing,
- Presentation of the results (*solution files*) to the user in the digital format (*display or download*) and in the graphic format.
- Preparation and processing using Globk,
- Presentation of the results (*positions and velocity*) to the user in both digital and graphic format (*display or download*).

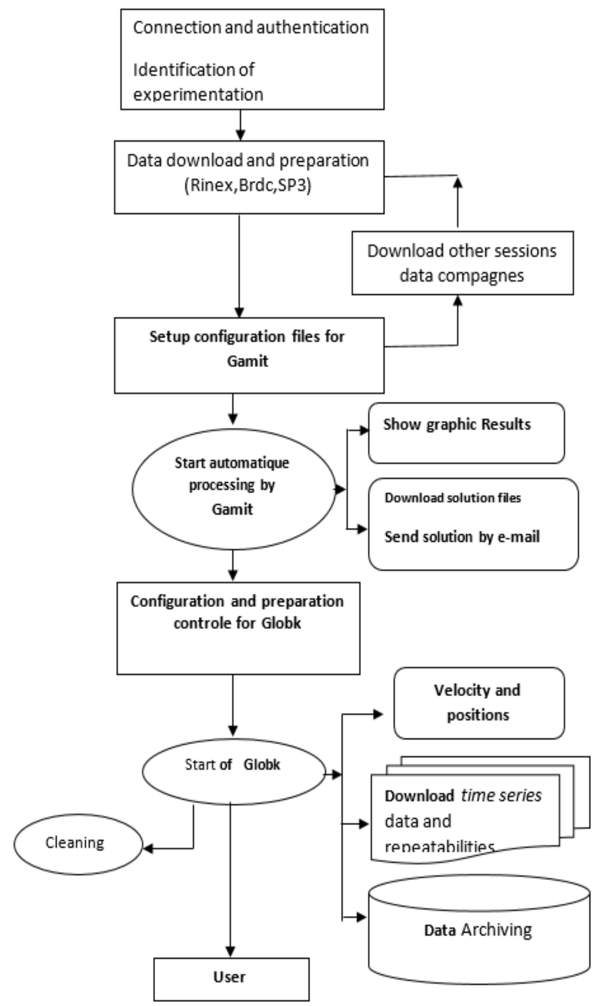

Figure 5. The proposed Flow chart summarizing the architecture of online automated processing system by Gamit/Globk.

A. Configuration of the processing server

Since the data is processed with Gamit/Globk, we have installed the latest version 10.35. The specifications of hardware compatibility to install Gamit's environment and to control the data is rather immense. Once the server is installed, it is necessary to configure it in order to use directories somewhere on the disk as a root user. On the user side, the GUI is designed to avoid dependency on the installed platform (*Mac OS, Windows, and Linux, etc.*).

B. Development Environment and Implementation

Various technologies and methods have been used for the development of the system. The used tools are shown in (Table III).

TABLE III. THE DIFFERENT TECHNOLOGIES USED TO DEVELOP THE PROCESSING SERVER

Modules	Used Technologies
Designing Method	UML (Unified Modeling Language)
Operating System and web server	Linux Feodra 14, Web Apache V.4.3.0
Browser and Application server	JavaScript , Mozilla Fire fox, PHP, Shell
Data processing	Gamit/Globk 10.40,GMT 4.5.6

1. IMPLEMENTATION AND RESULTS

In this section, we discuss the essential steps of automatic GPS data processing through our system.

A) User Authentication, Data Preparation: First, the user log on to the automated processing system. New users can create a new account using "*Register a new user*". Once the user has logged in with the server, he can enter an experiment name and his email. The server creates a directory with the experiment name where all data can be transferred. This allows the user to upload a number of Rinex files “Fig. 6” and control files “Fig. 7”.

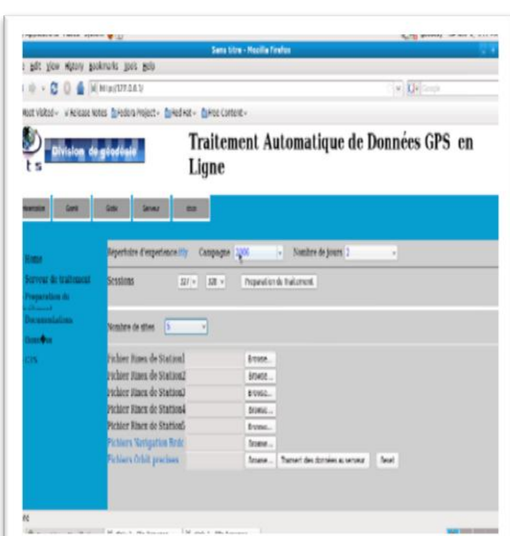

Figure 6. Preparing for processing and downloading data

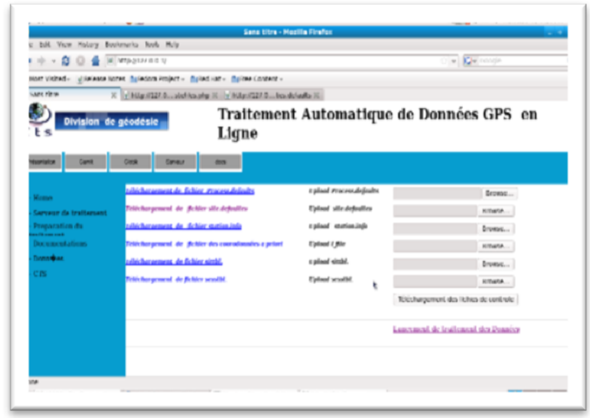

Figure 7. Configuring and starting processing

B) Results of processing by Gamit server: Once the user downloads the data and the control files to the server, it can initiate processing “Fig. 8”. When the server completes the processing successfully, the page containing the daily results is displayed to the user. For each session processed, we can find:

- *File of execution*”Fig. 8.c,Fig. 8.e”*: log, status, warning, fatal*
- *Process control file* ”Fig. 8.a,Fig. 8.d”
- *: autoclean.sum the sky plots*
- *Solution file* ”Fig. 8.b”*: q-file, h-files*

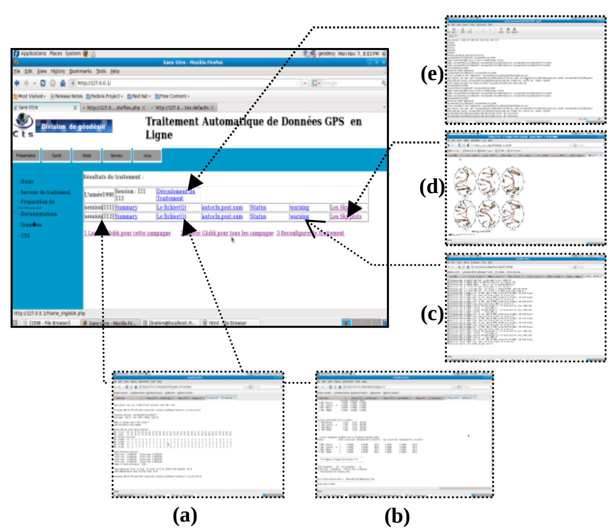

Figure 8. Displaying processing results obtained by the server

C) Determination of positions and velocity of stations

The results are time series of positions per station, as well as a position and a *velocity*. The SUM. * and VAL. * Files contain the daily velocity, coordinates for each station the results are displayed to the user in tables, and graphs "Fig. 9":

- *File of execution*"Fig 9.e"*: log, status, warning, fatal*
- *Time series (VAL.ensum file)* "Fig 9.b"
- *Combined position and velocity solutions (SUM.-file)* "Fig 9.a"*;*
- Time series and station displacement graphs "Fig. 9.d,9.c"

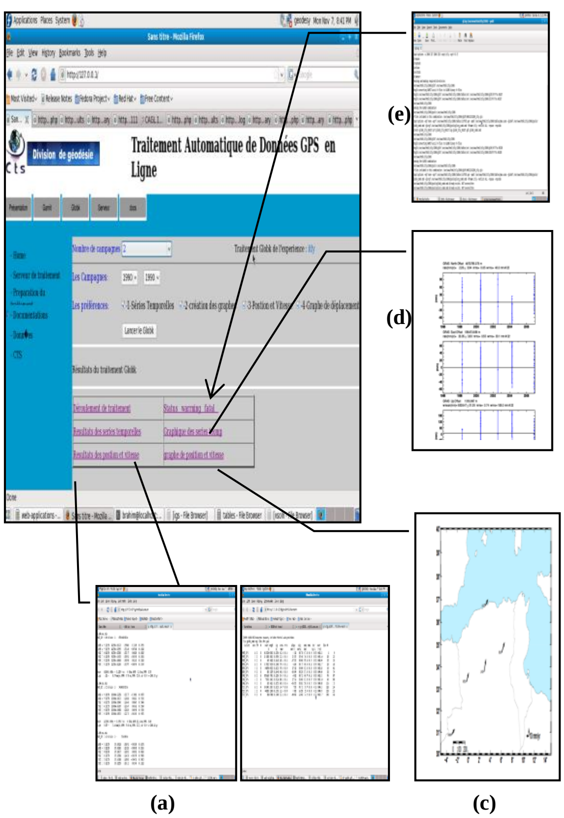

Figure 9. Displaying and downloading results of Globk processing (positions and velocity).

The map "Fig. 10" shows the results of the calculation Velocity displacement of Algerian stations (*Algeonet*), it shows only five stations between 2001 and 2005 because the common data for the other stations were unavailable. The velocity field presents a sense of displacement from the north to the east, and generally this deformation is generally interpreted by the convergence of Africa – Eurasia. However our study doesn't discuss the velocity displacement of Algerian station but it focuses on the way of processing any kind of GPS data.

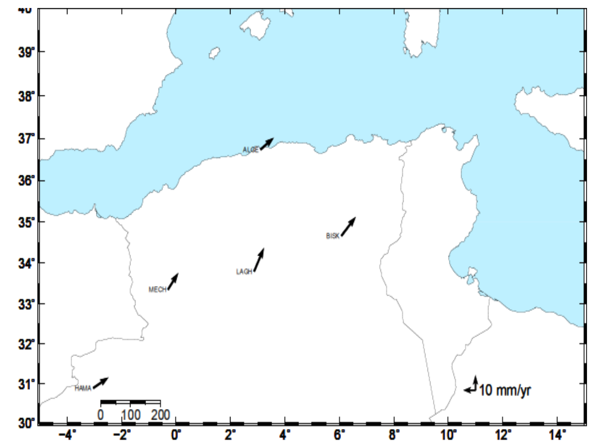

Figure 10. velocity displacement of stations map using ALGEONET (Algerian Geodynamical Network)) stations between 2001 and 2005.

2. CONCLUSION AND FUTUER WORK

In this study, we have described a web solution that helps experts, researchers and companies whom need processing their GPS data easily with highest accuracy, we find this solution more flexible user interface, remote processing, the user can test own models, and more confident where the users doesn't oblige using other services. However, it still needs more improvements in the short term.

As a future work, we envision in one hand improving our proposed solution; we propose the following appropriate enhancements:

- Energy consumption optimization of GPS permanent station,
- Integrating the GPS network stations in the WASN and IOT networks,
- Using "Cron" commands that allows Linux to processing the GPS data at a specific time or at regular intervals,
- Improving the system by using TRACK module (*GAMIT Kinematic GPS processing*), where the processing suggests that one or more GPS stations are moving (*e.g., car, aircraft*).

In other hand, we envision to develop an application that consists of finding the stolen children. These last should have to wear smart device.

Referencee

[1]: E Dongchen, Zhan Biwei, Jiang Weiping, Zhang Shengkai. *High—PRECISION GPS DATA Processing BY Gamit/GLOBK*, CHINESE JOURNAL 0F POLAR RESEARCH, 17(3): 174-182, Sept, 2005.

[2]: S.Sirri Maraş, Ismail Şanlioğlu and Bahadir Aktuğ, *Design and testing of a web-based automatic high precision GPS data processing environment*, International Journal of the Physical Sciences Vol. 6(9), pp. 2294-2302, May, 2011.

[3]: Herring T., R. W. King, S. C. McClusky, *Introduction to GAMIT/GLOBK, Release 10.6*, Department of Earth, Atmospheric, and Planetary Sciences Massachusetts Institute of Technology. Book, 2015

[4] Herring T., R. W. King, S. C. McClusky : Book: *G A M I T Reference Manual Release 10.6*, Massachussetts Institute of Technology, Cambridge, 2015 .

[5]: Herring T., R. W. King, S. C. McClusky: *Global Kalman filter VLBI and GPS analysis program 10.6* Massachussetts Institute of Technology, Cambridge, Book, 2015.

[6]: Weston ND, Soler T, Mader GL, *Rover station positional accuracies from OPUS as a function of reference station spacing and rover station occupation time*. Proc. FIG Working Week, Eilat, Israel, 3-8, p. 11,May, 2009.

[7]: Kouba, J. Book: *A guide to using International GNSS Service (IGS) products, Geodetic Survey Division Natural Resources Canada*, May 2009,

[8]: Online GPS Processing Service (AUSPOS) web page. URL: http://www-b.ga.gov.au/bin/gps.pl (15.02.2017).

[9]: Online Positioning User Service (OPUS) web page. URL: http://www.ngs.noaa.gov/OPUS/ (15.02.2017).

[10]: Online Positioning User Service (JPL) web page. URL:http://igscb.jpl.nasa.gov/components/usage.html 15.02.2017).

[11] : HAN F., CHENG C., WANG X, *A Study of Automatic GPS Data Processing System Based on Bernese GPS Software*, Bulletin of Surveying and Mapping, vol. 56, Issue 11, pp. 8-10, 2011.

[12]: Reza G.,Peter D., *Online GPS processing services: an initial study* , doi:10.1007/s10291-005-0147-5, 2006.

[13]: Jian L.,Hongjiang Z.,Tao F., *Post-processing Procedures for Passive GPS based Travel Survey*, Procedia - Social and Behavioral Sciences, 13th COTA International Conference of Transportation Professionals (CICTP 2013), 2013

[14]: Ala Al-Fuqaha, Mohsen Guizani, Mehdi Mohammadi, Mohammed Aledhari, Moussa Ayyash, *Internet of Things: A Survey on Enabling Technologies, Protocols and Applications*, IEEE Communications Surveys & Tutorials, DOI 10.1109/COMST.2015.2444095.

[15]: Kalpana Shete, Dr. Govind U. Kharat, *An Intelligent Self-Adjusting Sensor for Smart Home Services Based on Smart Grid System A Review*, International Journal of Innovative Research in Computer and Communication Engineering, Vol. 4, Issue 5, May 2016, pp. 8163- 8168, DOI: 10.15680/IJIRCCE.2015. 0405010

[16]: Twinkle Gondaliya, *A Survey on an Efficient IOT Based Smart Home*, International Journal of Review in Electronics and Communication Engineering, Vol. 4, No 1, pp. 6-9, February 2016

[17]: Ayesha Hafeez, Nourhan H. Kandil, Ban Al-Omar, T. Landolsi, and A. R. Al-Ali, *Smart Home Area Networks Protocols within the Smart Grid Context*, Journal of Communications Vol. 9, No. 9, pp. 665-671, September 2014.

[18]: Syeda Butool Fatima, Sayyada Fahmeeda Sultana, Sadiya Ansari, *Survey on Energy Efficient Protocols and Challenges in IOT*, International Journal of Advanced Research in Computer and Communication Engineering, Vol. 5, Issue 8, pp. 257-260, August 2016,

[19]: Somayya Madakam, R. Ramaswamy, Siddharth Tripathi, *Internet of Things (IoT): A Literature Review*, Journal of Computer and Communications, 2015, vol.3, pp.164-173, http://dx.doi.org/10.4236/jcc.2015.35021

[20]: *Lamia Cheklat, Mourad Amad, Abdellah Boukerram*, Wireless Sensor Networks, State of Art and Recent Challenges: A Survey, *in SENSOR LETTERS JOURNAL, Vol. 15, pp. 1–23, American Scientific Publishers, 2017*

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