Geomatics applications on mobile telephony

VINCENZO BARRILE (*), GIUSEPPE M. MEDURI (*), GIULIANA BILOTTA (**)
* DICEAM - Faculty of Engineering
"Mediterranea" University of Reggio Calabria
Via Graziella Feo di Vito 89100 Reggio Calabria, Tel +39 0965 875301
** Ph.D. NT&ITA – Dept. of Planning - University IUAV of Venice
Santa Croce 191, Tolentini 30135 Venice
ITALY
vincenzo.barrile@unirc.it, ing.giuseppemariameduri@gmail.com, giuliana.bilotta@iuav.it

Abstract: - The diffusion of new mobile terminals (smartphones, tablets), combined with the availability of data transmission networks faster and/or to the capillary diffusion of wireless systems, have enabled the exponential growth of information services and the creation of thousands of applications (Apps) offering to the end user the ability to search for specialized information.
In this paper two multi-platform applications are proposed; both platforms have interesting aspects concerning infomobility. The first application, of a cultural nature, can play the role of dynamic and interactive guide to the terminals, in order to offer to the visitor and/or citizen a set of value-added information on the territory. The second of a scientific nature that can be helpful to the professional or to workers in the field of telephony/communications that may provide information regarding the location, characteristics and data related to antennas transmit/receive data and have an indication of the extent and distribution of the field.

Key-Words: - Infomobility - Cultural applications - Assisted GPS - Archaeological maps - Electromagnetic fields

1 Introduction

Element common to both infomobility platforms proposed is the map, made navigable and searchable on multiple levels of accuracy.

After careful evaluation of wireless location technologies that enable a mobile device to detect its position in terms of geographical coordinates, we proposed the use of A-GPS or Assisted GPS. The use of Global Positioning System (GPS) and generally technology of Global Navigation Satellite System (GNSS), in conjunction with the data obtained from the mobile data network, increases the efficiency of the positioning system [1,2,3,4].

In Fig.1 you can see a representation of the network architecture of the proposed system.

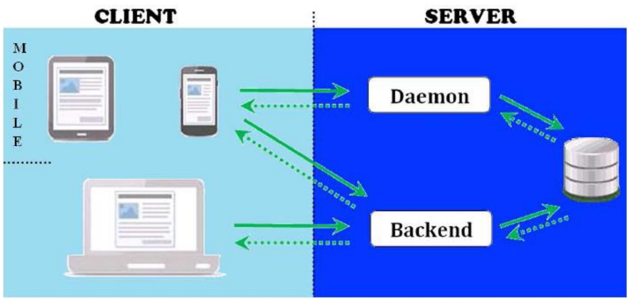


Fig.1: Client-Server network architecture.

A client/server model is especially recommended for networks that require a high level of reliability because the server is at the centre of the whole architecture and allows managing common resources with multiple clients. It avoids the problems of incoherence and inconsistency, and access to data is more secure, because it is through a single point of access, and it is possible to remove and add clients without disturbing the operation of the system.

The communication between the client and the Android Java Daemon takes place by means of a protocol specially made. At the level of the network are initiated communication socket on IP protocol; the daemon has a socket always active listening for connections, thanks to multithreading and the Java ServerSocket class, which realize a system capable of serving multiple clients simultaneously.

At transport level, communication uses the Transmission Control Protocol (TCP), which ensures the correct reception of messages, sequencing and retransmission in case of error. Because of the nature of the non-persistent connection, TCP offers better delivery guarantees of messages [5,6,7].

The high-level protocol, designed for the request and the transmission of multimedia content, uses the Extensible Markup Language (XML) for defining the structure of the communication messages.

Between the transport layer and the application is located a sub-layer that deals with the compression and decompression of messages.

From the transmitter side XML messages are encapsulated in compressed bundles which are forwarded to the lower level of transport; at the receiver the data follows the opposite direction, and then from the transport layer to the sub-level of compression that takes care of decompressing the messages before sending them to the application layer.

The procedure is described visually in the diagram of the levels present in Fig.2.

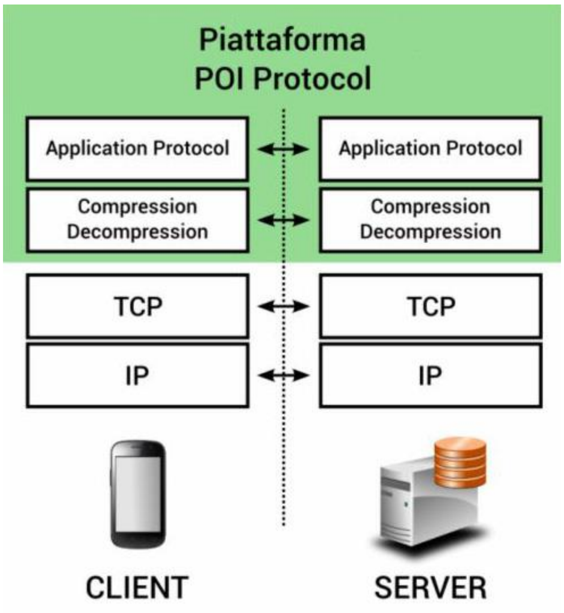


Fig.2: Structure of the levels of protocol.

Compression reduces the time and resources necessary to communication, favoring mainly mobile devices plagued with disconnections due to the movement and characterized by limited energy resources.

The Android application makes use of multiple communication interfaces present on smartphones for:

- Identifying the location of the device;
- Establishing a communication with the server ;
- Receiving daemon georeferenced data not yet in possession;
- Repeating the procedure following a significant change in position.

The client is characterized by a variable mobility; for example, the user may be pedestrian or can move on board a means of transport, in both cases, the application needs to update in real time the information to be presented to the user. The refresh rate must, however, be a function of the speed of movement of the user; updates with a frequency to be determined would be in the best of cases unnecessary connections to the server.

Leaning to the Application Programming Interface (API) (Google Developers) of the Android platform has been possible to tie location updates to the distance traveled since the last survey, so the client will contact the server only when the user's movement is such as to require new information about what surrounds him.

Following are two prototype applications that demonstrate the potential of the proposed platforms.

2 Cultural/Informative Application

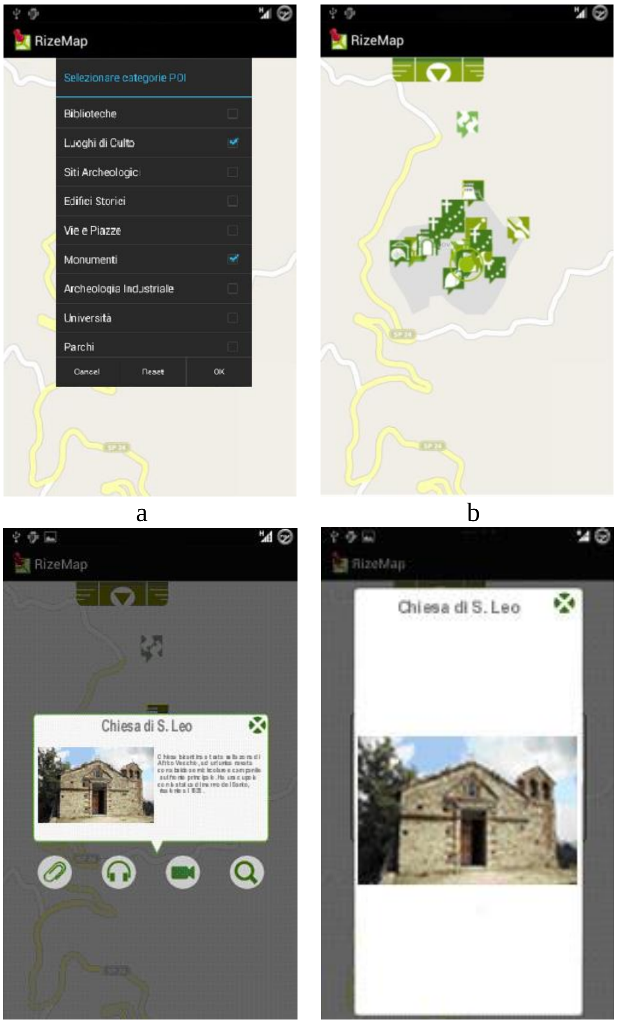
The development involved the design and subsequent implementation of a platform for InfoMobility that has allowed us to make accessible archaeological and artistic/cultural information [8].

We make use of a vector for pervasive spreading as the smartphone, that allows to achieve a high portion of the population, and very varied targets for ages and interests. The main purpose of the proposed platform is to promote knowledge of the area, making the information available to value added, while providing immediacy and intuitiveness in the recovery and presentation [9,10,11].

The infomobility platform we proposed has allowed us to make easy, on any mobile device (smartphone, tablet), the display of Points of Interest (POI) located nearby service user, through a geo-referenced map, based on open-source cartographic systems.

The demonstrative prototype initially displays a map centered on the current location of the user, and the POI (Point of Interest) in the surrounding area . To avoid overcrowding of icons in certain areas of considerable interest, it has been developed a system of selective filtering of POIs which, according to user preferences, allows to choose which types of POI are to display on the map (Fig.3).

Each POI on the map is selectable by the user and allows the display of a window that contains descriptive information about the selected POI. In addition to the description there is a picture related to the POI, which can be maximized by selecting the icon of the magnifying glass in the description window (Fig.3).



a b c d

Fig.3: a) Select the category of interest, b) POI, c) Detail POI, d) Zoom Photo.

It is possible to correlate each POI with other multimedia content, such as a link to a website containing more information, a short audio clip and a short video clip.

2 Scientific Application

2.1 Implementation of GIS software

The geographic information system was realized in various steps and has demanded much time is for to get the data employed and for the implementation of the instrument survey necessary for to know the coordinates of some sites and the electric field values [12,13].

In the first place, the first phase was dedicated to the collection of the necessary data in order to know the exact positioning of the systems installed on the municipal territory of Reggio Calabria. For being able to realize the calculation in the area of study (sited in Piazza della Libertà) had to be known radio electric characteristics of the installed systems.

The relative data for registering the systems have been supplied from three of the four main providers of mobile telephony, while has been possible to have all the characteristics of the systems sited in buildings adjacent to “Piazza della Libertà”. In table 1 is indicated the total number of installations in the territory of Reggio Calabria for every provider.

Provider	BTS number
1	51
2	30
3	42

Table 1: Number of BTS in Reggio Calabria for every provider.

2.2 Software features and functionality

For evaluating the levels of electrical field through the far-field expression, we created a calculation software still in experimentation phase.

This software will allow us to collect information and the database built-up stores the collected information.

It was in fact necessary to create a database that stores the information to manage, allowing at the same time of having a centralized cadastre of sites, beyond to the archives on used GIS.

2.3 Database structure

This database was realized through applicative SQL Server Enterprise Manager that has allowed to create some tables then related creating a classic entity-relations model.

The main entity of the database is the table ANTENNA, with its id as primary key. In the table antenna there are also the attributes related to the gain and an attribute in order to allow the insertion of the images of the system available and the id of other tables ANTENNA MODEL, POLARIZATION, FREQUENCY, ELECTRICAL WORKER in which are attributes, beside id and code, also numerical value and the sign for the polarization.

These tables are connected with relations many to one to the table ANTENNAS (that is for every antenna are a single value of frequency, one only of tilt, one only of polarization). In the table ANTENNA MODEL there are the relative attributes as code model and the id of the constructor, further than the description of the antenna type. Therefore, connected to it with relation one to one, there is the table CONSTRUCTOR with just id and code, corporate name, address, etc.).

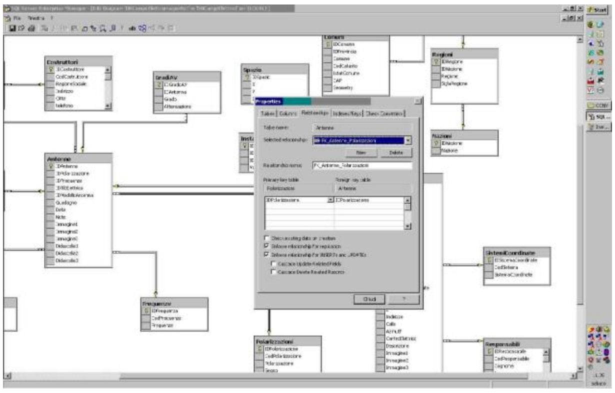


Fig.4: Building the diagram in SQL Server Enterprise Manager.

Moreover to the table ANTENNAS, the tables are related DEGREE AO and DEGREE AV (relation one to one), than beyond to id the degree and to id the antenna contain the attributes degree and attenuation in order to insert the values associated.

The table INSTALLATION concurs to estimate for every antenna all the characteristics on localization (Address, section, sheet, attached, particle, X,Y, and Z coordinates etc.) and radio-electric (power, tilt mechanic, number of cell, height centre electrical, azimuth, etc.) (Fig.4).

To it connected with relation one to one we have the COORDINATE tables SYSTEMS (Id, Code, Coordinate system) and RESPONSIBLES (Id, Code, Name, Address, etc.) in order to characterize the type of used coordinates and the provider of the system.

Moreover, connected to the table INSTALLATION there is that MUNICIPALITY (Municipality Id, Provinces Id, Municipality, Zip Code, etc), with in its turn connected the tables PROVINCES, REGIONS, NATIONS, all between they tied from relation one to one.

Finally in order to concur the calculation of the values field generated from various installations we created table INSTALLATIONS-SPACE (Id, Id Space, Id Installations, Value) with the attribute Value that takes the value of field estimated from the software for the single installation.

To table INSTALLATIONS-SPACE the relative table is tied SPACE of the calculation grid of the electric field who then allows to consider the values generated in the point with appropriate coordinates and to carry out the quadratic sum.

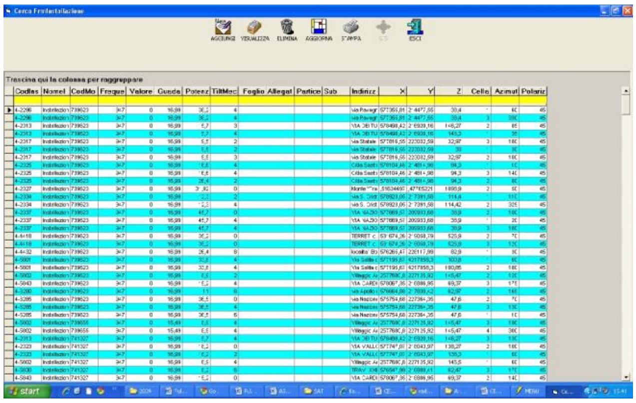


Fig.5: Final database

2.4 Structure of the software

Contextually has been planned a software that allows to use this database like source from which reaching the necessary data in order to operate a control on the levels of pollution produced from the telecommunication systems.

For the realization of a software that answers to the requirements before indicated is devised a tool personalized that allows to carry out simulations and at the same time to work on the territory.

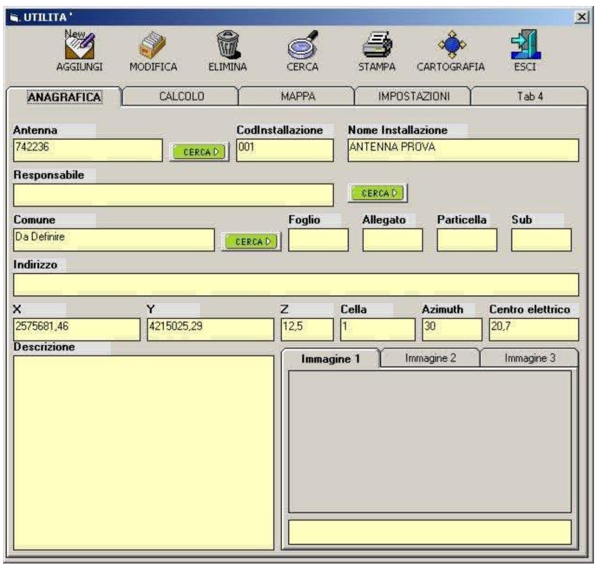


Fig.6: Mask with key accounts and geographic information.

For this aim we developed the software in Visual Basic editor, that it allows to carry out modeling simulation in conditions of far away and free field without considering the contributions of reflections and diffractions by orography of the land and the systems inhabited, mainly precautionary situation. The points of strength of the plan are essentially two: the database on which it supports the software and the digital map, containing the information on the territory. The procedure for the calculation is as follows:

- Insertion in the archives of the identifying and geographic data of the site and all the technical data of the cells;
- Identifying of the site in the area inside the georeferenced archive;
- Preparation of a plan of theoretical appraisal of the electric field irradiated through selection of the studied sites.

For this purpose the graphically sites are selected on the hosting systems (on the same site can coexist more systems). To every site are connected the information of the georeferenced telephony systems with their technical data necessary for the appraisals.

From the code of the antenna type and from the frequency, the polarization and tilt electrical for the antenna in the installation site, the software search inside of database the selected antenna type and finds the values of horizontal attenuation and vertical of the chosen antenna associated to the calculation point. Therefore, it is possible to visualize the attenuation diagrams by means of image.

2.5 Program output

Actually calculated values of the electromagnetic fields can be visualized in shape of values of electromagnetic field with punctual esteem of the effective value of the field electrical in correspondence of identified buildings or particularly interesting places.

We got manually distances, height and angle formed on the plan between direction of maximum radiation and direction of the calculation point, by redrawing the municipal cartography. Instead, the angle on the vertical plan between direction of maximum radiation and direction of the calculation point and the punctual value of the field was calculated directly from the software.

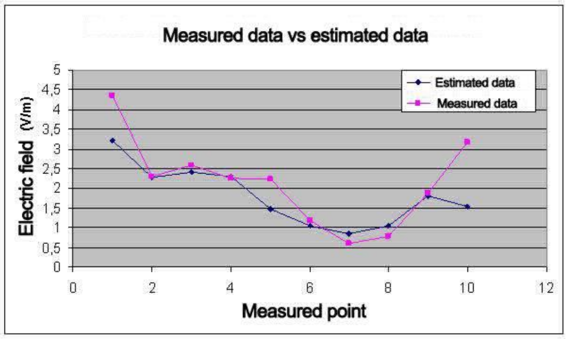


Fig.7: Measured data vs. estimated data.

The measured values and predicted values have good correlation, but the differences between them have a considerable variability [14], because between the different points were different conditions in which the measures were carried out, with regard to:

- Presence of barriers at some points of measurement;
- Presence of reflective surfaces between the different points;
- Fluctuations in the power of the plant.

It is in phase of experimentation and definition the realization of horizontal maps of the effective value of electric field overlapped to the topography of the zone selected in which the area of calculation is subdivided in cells (grid) and the software calculates the value of field at the centre of the cells.

In future the developments of the software will be able to produce:

- 3D maps of the effective value of electric field in the direction of maximum radiation;
- geographic information on the sensitive areas (destination of built up use city);
- geographic database showing various thematic maps of the level of electromagnetic pollution;
- possibility three-dimensionally to visualize the solid of total irradiation and overlay to the surrounding city environment, using the new cartography of the communal territory.

In the case study were placed four systems, one for every single provider. In the application the characteristics of this systems are visible, that is the 2D geographic coordinates, the elevation of the electrical center as regarding the ground as on the sea level, the identifying number of the field, the direction of these fields regarding the north, the frequency, the gain and the usable maximum power in escape to the antenna connector.

In the orthophoto in the GIS can be identified electromagnetic field and the relative sector cells of irradiation organization of the analysis zone, with the sources and the positioning of the points of instrumental measure of the electric field. It is proceeded therefore to the calculation of the contributions of field for every source on the points considered [15,16,17].

Moreover, although as said the software is in phase of definition, it is shown a demonstrative application of the realization of the horizontal maps of field in the area of study, considering two of the four present systems.

The demonstrative prototype, operating and experimentally due to further testing proposal also today on smartphones, initially shows a map with the ability to choose the place of interest through the address, coordinates or GPS locator, in case the device will be equipped with, and possibly the filter providers to consider. (Fig 8).

Fig.8: Data selection site.

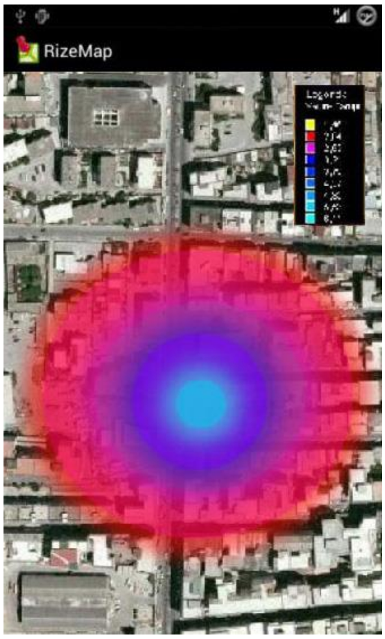


Fig.9: Output effects of EM field on cartography.

In Fig.9 for a demonstrative aim is proposed a map of field for an area of 200 meters from sources, than however it does not represent the real distribution of the field values: it makes only the idea of how they will be out, once defined the software, and how are featured on this website. The conducted model simulations on the interest points was compared with the results of the References: instrumental measures with the comparison between [18] the esteem and the "traditional" experience in measurement with probes of wide band.

3 Conclusions

It seems clear, as already noted, that the diffusion of new mobile terminals (smartphones, tablets) together with the availability of data networks faster and/or widespread dissemination of wireless systems have enabled the exponential growth of information services and the birth of thousands of applications (apps) that offer to end user the ability to search for specialized information.

Particularly interesting though still in the testing phase and beating the two seem to validate cross-platform applications: proposed in this note.

The integration with other sources of information related to territory/environment may allow in the future, once properly implemented in a single model, to offer the tourist and/or a citizen a set of value-added information on the territory autonomously fast and interactive.

References:

[1] P. Misra, P. Enge, *Global Positioning System: Signals, Measurements and Performances*, Ganga-Jamuna Press, 2001.

[2] B. Hofmann-Wellenhof, H. Lichtenegger, J. Collins, *Global Positioning Systems: Theory and Practice*, Springer; 2001.

[3] A. Cina, *GPS. Principi, modalità e tecniche di posizionamento*, Torino, Celid, 2000, pp. 9-23.

[4] A. Cina, A. Manzino, M. Piras, M. Roggero, *Reti GPS per il tempo reale: le informazioni contenute nel segnale di correzione differenziale*, Bollettino SIFET, Vol. 4, 2004, pp. 9-27.

[5] N. Walsh, *A Technical Introduction to Xml*, 1997.

[6] R.I. Pfeiffer, *Xml Tutorials for Programmers*, 1999.

[7] F. Boumphrey, *Xml Tutorial*, 2000.

[8] T. Caracciolo, V. Marra, G. Calabretta, M. Sisca, F. Teti, *Un prototipo WebGIS per l'interoperabilità e la condivisione dei dati geografici fra gli Enti della Regione Calabria*, 8° Conferenza Nazionale ASITA, 2004.

[9] V. Barrile, G. Bilotta, G.M. Meduri, *Archaeological investigations with TLS and GPR surveys and geomatics techniques, 33rd EARSeL Symposium*, Matera, Italy, 3-6 June 2013, pp. 857-864.

[10] V. Barrile, G.M. Meduri, G. Bilotta, *Un WebGis per i percorsi archeologico culturali*, XVII Conferenza Nazionale ASITA, 5-7 novembre 2013, Riva del Garda, 2013, pp. 103-109.

[11] V. Barrile, G. Bilotta, G.M. Meduri, *An open GIS for the significance analysis of displacements arising from gps networks repeated over time: an application in the area of Castrovillari*. Wseas Transactions on Signal Processing, Vol.10, ISSN: 1790-5052, pp. 582-591.

[12] V. Barrile, G. Bilotta, F. Di Capua, GIS for calculating electromagnetic field, *Recent Advances in Urban Planning and Transportation*, *Proceedings of the 2nd WSEAS International Conference on Urban Planning and Transportation (UPT '09)*, 2009, pp. 117-124.

[13] V. Barrile, G. Armocida, G. Bilotta, *GIS supporting the Plan of BTS (Base Transceiver Stations) for mobile network in urban context*, Wseas Transactions on Communications, Vol.8, No.8, August 2009, pp. 775-784.

[14] F. Andolfato, A. Schiavinato *Esempio di valutazione dell'incertezza nella misura dei campi elettromagnetici a radiofrequenza con sonda a banda larga*, ARPAV – DAP Treviso.

[15] A. Ammoscato, R. Corsale, G. Dardanelli, A Scianna, B. Villa, *Metodologie di rappresentazione 3D di campi elettromagnetici mediante tecniche GIS open source* SIFET 2006.

[16] A. Ammoscato, R. Corsale, G. Dardanelli, A. Scianna, B. Villa, "*GPS-GIS integrated system for electromagnetic pollution*", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVII. Part B1. Beijing 2008, pp. 491-498.

[17] Z. Zhongyuan, L. Guishu, Cui Xiang, "*The calculation of the 3D-electromagnetic fields in GIS using the numerical electromagnetic code*", Environmental Electromagnetics. CEEM 2003. Proceedings. Asia-Pacific Conference on, 4-7 Nov. 2003, pp. 360-366.

[18] P. Bevitori, *Inquinamento elettromagnetico ad alta frequenza. Aspetti tecnici, sanitari e normativi. Campi elettromagnetici generati da sistemi fissi di telecomunicazione e dispositivi elettronici*, Maggioli Editore, 2000, pp. 25-50.