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1 Abstract

Our goals today, through the updated POLESAT project (version 2) are to improve the usability of the e-health geomatic platform with the help of a geo-medical e-Atlas and an innovative and modern methodology: a graphic language called "medical knowledge visualization", dynamic and interactive web pages orchestrated by relational management database system, web and map servers. Results: this new prototype offers an example of three georeferenced public hospitals (Dunkerque, Lille and Valenciennes) and its medical information system statistics and associated mapping. The Nord - Pas-de-Calais e-Atlas is displayed and accessible by users thanks to an advanced and secured web-mapping technology. Discussion-conclusion: thanks to geographical access with the map, a medical graphic language (by clicking on PiNoKio's anatomy linked to hospital activity) and modern geographic information system architecture, we responded to the first critical assessments. The next version of e-Atlas will evolve into a whole open source environment and will be the subject of a future campaign whose goal will be a programmed medical choice.

POLESAT, an innovative e-health geomatic platform in decision-making based on: geographical approach, medical knowledge visualization and geographic information system & web-mapping architecture

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1 Abstract

Our goals today, through the updated POLESAT project (version 2) are to improve the usability of the e-health geomatic platform with the help of a geo-medical e-Atlas and an innovative and modern methodology: a graphic language called "medical knowledge visualization", dynamic and interactive web pages orchestrated by relational management database system, web and map servers. Results:

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2 Key words

e-Health geomatic Platform; **decision-making; programmed medical choice;** e-Atlas; geographic information system (GIS) **& web-mapping architecture;** medical visualization knowledge (VCM); program for the medicalization of information systems (PMSI).

3 Introduction

For the last 10 years, we have demonstrated the various usages that medical databases offer especially through the French national "programme de médicalisation des systèmes d'information" (PMSI) (in English: program for the medicalization of information systems) [1]. The PMSI is related to the French casemix system and concerns medico-economic databases which are used as epidemiological or planning tools in geo-epidemiology, sanitary

planning and geomatics applied in health [2]. For this last topic, we presented the geomatic platform1 and its first tool, the e-Atlas of health within the framework of the POLESAT project. The main goal of POLESAT's geo-platform was to improve information and decision-making for professionals and the general public, for example: assistance in making a programmed medical choice. In tandem with each user's rhythm, we will provide access, transmission, communication and information of the geographical studies through the e-Atlas [3, 4]. The aims of the geomatic platform2 are to provide a revisited e-Atlas, taking into account the first critical assessments of several partners such as URPS, which especially concern indicators and user usability as explained hereinafter. By making reference to the concept of optimization of the ease of use (usability) of new health technologies [5, 6], in our new prototype we seek to improve user usability in this geo-medical e-Atlas by means of an innovative methodology through a geographical approach, a medical iconic language called visualisation des connaissances

médicales (VCM) (in English: medical knowledge visualization) [7, 8], dynamic and interactive web pages orchestrated by a relational database management system (RDBMS) and web and map servers (web-mapping) [9-11]. Consequently, we offer a logical scheme of thinking based on geography and cartography, PiNoKio 's anatomy linked to hospital activity in order to easily find the focused medical-surgical setting activity: medical terminology is directly gathered depending on the selected anatomic part.

We will present below the stages of development of the e-Atlas: materials and methods, results and discussion/conclusions.

4 Materials

The platform is hosted on a secure Linux server protected by a firewall and under a general public license (GPL) which means "is not Unix: (GNU)". It interacts by means of a "reverse proxy" with the associated Windows server®.

4.1 Software and language

The software used is as follows: the Géoconcept desktop®: a geographic information system (GIS); Géoconcept internet server® (GCIS):

running on Windows; the Apache/PHP® server; MySQL®: the RDBMS server and an open source (OS) package that runs on Linux®; Philcarto®: a mapping application; Adobe Illustrator® CS4: a drawing application which includes Flash technology; Nagios®: a computer system monitor, network monitoring and infrastructure monitoring software application and Microsoft Visual Studio C++®: that is an integrated development environment (IDE) from Microsoft. POLESAT®: the e-health geomatic platform project; the puppet PiNoKio®: a VCM medical iconic language which concerns anatomy linked to medical terminology of hospital activity targeting professionals and the general public.

The computer languages used are JAVA, PHP, HTML/xHTML, C++/Visual and C++.

4.2 Databases

The databases used concern (i) GeoFla® administrative levels covering all the Nord - Pas-de-Calais region, (ii) the specific activity of orthopedics-rheumatology for the year 2007 according to the PMSI and the tool for PMSI analysis (OAP®: V 5.2) terminologies. The

PMSI includes the French "homogeneous group of patient disease" (GHM) which is equivalent to the diagnosis related groups (DRG). OAP enables DRG grouping by specific activity (23 activity segments) and product lines.

5 Methods

5.1 Architecture of the dynamic website

Architecture of the dynamic website (Figure 1) [12]: with regard to the server, data is managed by MySQL RDBMS and used by the Apache server. For the display of dynamic web statistics (performed in real-time and/or updated), we used PHP5 and HTML languages (included inside Apache) in interaction with the MySQL RDBMS. With regard to the client, an application launched by the web browser will enable access to the e-Atlas and its web pages depending on user profiles.

5.2 The GCIS architecture, mapping server

The GCIS architecture, mapping server (Figure 2): the map data, as well as part of the geocoded PMSI data are stored in the GIS desktop for processing, and afterwards, choropleth mapping outcomes are provided by product lines. The maps are created with the Jenks natural breaks

classification method (minimum of variances within classes and maximum between classes). These maps are then stored in the GCIS server until a "request client" generate the display of the requested maps. Then the dynamic website architecture will directly provide all expected results except for mapping. Mapping distribution will indirectly be performed but in a transparent manner by the Linux server (hosting the dynamic website (Figure 1)) by querying the Windows server (hosting the GCIS map server (Figure 2)) by reverse proxy which is a sort of proxy server that extracts resources on behalf of a client from one or several servers.

5.3 Regarding the VCM medical iconnic language

We were inspired by the work and advice for the development of the puppet PiNoKio in Flash technology [8, 13]. Following the selection of the desired anatomical part of PiNoKio, the user will discover the hospital activity linked to the anatomy (thanks to the medical terminology targeted) and therefore the underlying disease will be easier to find. There are 23 activity segments which will be partially or fully

displayed, depending on links with selected anatomy, and will be represented in the resulting table of hospital activity.

5.4 Security and state of servers

An alarm called "incident" is activated by Nagios. From our extranet, access to the e-Atlas is given to researchers and partners located beyond the network through a web interface. Secure access is performed by password (.Htaccess). The HTTPS protocol used makes it possible to secure the transport of HTTP requests and responses and encrypt passwords.

6 Results

From a web browser, we perform a secured Linux server connection then we arrive at the first webpage (Figure 3) of the prototype which represents an interactive Flash technology map of the Nord - Pas-de-Calais region from which we select one of three public hospitals displayed on the map from west to east which are respectively: Dunkerque, Lille and Valenciennes. Click on the circle, then Dunkerque hospital is pre-selected. The second webpage (Figure 4) shows PiNoKio. Click on one of PiNoKio's arms and the table of activity

segments is displayed (Figure 5). On the third webpage, once the administrative and statistical information has been observed and analyzed, click on the interactive link of the activity segment: "AB-Orthopedics, Rheumatology" and one arrives at (Figure 6) product lines related to the activity segment. Click on the second product line "AB02-Amputations" and one gets the choropleth map of hospital activity of Dunkerque (from raw values ranging from 1 to 7 for amputations) (Figure 7).

7 Discussion

7.1 Data and confidentiality

The PMSI data becomes anonymous and fictive after reprocessing followed by a random drawing in order to carry out a test set that is different from the reality. This test set makes it possible to test the entire software program without coming to real conclusions vis-à-vis a health-care establishment's real operations because the simulation is limited to three institutions and not to the entire region.

7.2 VCM medical iconic language

We show here, once again, another use applied to the health sector of the VCM medical iconic

language which was originally intended to provide knowledge of the drug [8, 13] and which is enriched thanks to applications for electronic health records (EHR), decision support systems and search engines.

7.3 Geomatic platform2

To our knowledge, there is no similar work in medical informatics. Thanks to the geographical approach, the VCM medical iconic language of PiNoKio (anatomy-hospital activity) and a modern GIS architecture (containing confidentiality, privacy and security for data), on the one hand, we have optimized user friendliness (the usability concept) of the e-Atlas environment and consequently we have responded to the first critical assessments of the geomatic platform2 of the POLESAT project [6, 14]. In order to achieve better usability of e-Atlas usages:

- * we bring a geographical approach starting with a regional map which allows us to discover the health-care supply in the territory and in order to select a medical or surgical department for scheduled medical care.

- * consequently, we bring a more logical approach in terms of e-Atlas usability in order to choose a health care provision through geography.

- * we facilitate the task with a puppet named PiNoKio in order to find the hospital activity related to the corresponding anatomy.

- * OAP offers a synthetic view of hospital facilities by specific medico-surgical activity (specialties).

Thus, in version 2 of the prototype, the geo-medical e-Atlas offers for three geo-referenced hospitals (Dunkerque, Lille and Valenciennes), their PMSI statistics and associated mapping according to user profiles. The e-Atlas is web-accessible and distributed thanks to a more advanced and secured web-mapping technology.

7.4 Development perspectives

Development perspectives: (i) concerning client-server interactivity: e-Atlas will give the user access to data sets which lead to additional mapping online. (ii) the next version of e-Atlas will evolve into a whole open source environment [15]. (iii) in terms of development, improvement and of industrialization of the e-

health geomatic platform, it depends firstly: on the results of the next communication campaign "assistance in making a programmed medical choice" and secondly, on the political orientation and on the market study in progress led by the centre for research and industrial innovation (CR2i) of Montpellier, concerning the e-health geomatic platform project: its services and its tools on offer in the domain of biotechnology.

8 Conclusions

Pending the emergence of the e-health geomatic platform with the help of a partnership between Lille University Hospital and the CR2i of Montpellier, it should be noted that many articles highlight the interest of information technology (IT) in geomatics such as GIS and other spatial analysis systems coupled with data-mining for the health sector [16, 17]. It should also be remembered that in France compared with Anglo-Saxon countries and French Canada, we are far behind, especially with regard to the e-atlas and open-data in the health sector. In France, a debate and petition

are in progress with regard to open-data stakes for the general public and our future society.

9 Acknowledgements

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10 Competing interests

The authors have not declared any conflict of interest.

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12 Figures

12.1 Figure 1: A dynamic website architecture:

PHP-MySQL

“FIGURE1-b.tif” in TIFF format.

12.2 Figure 2: The GCIS architecture,

mapping server

“FIGURE2-b.tif” in TIFF format.

12.3 Figure 3: Template of the e-Atlas

prototype from west to east: Dunkerque, Lille,

Valenciennes

“FIGURE3-b.tif” in TIFF format.

12.4 Figure 4: the interactive Puppet

"PiNoKio" and its anatomic terminology table

“FIGURE4-b.tif” in TIFF format.

12.5 Figure 5: The activity segment table and

its statistical PMSI indicators

“FIGURE5-b.tif” in TIFF format.

12.6 Figure 6: Table of segment "AB-

Orthopedics, Rheumatology": product lines

and PMSI statistics

“FIGURE6-b.tif” in TIFF format.

12.7 Fig.7: AB02-Amputations: hospital

activity (raw numbers)

“FIGURE7-b.tif” in TIFF format.

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1 Key words

e-Health geomatic Platform; decision-making; programmed medical choice; e-Atlas; geographic information system (GIS) & web-mapping architecture; medical visualization knowledge (VCM); program for the medicalization of information systems (PMSI).

Figure1

[Click here to download high resolution image](#)

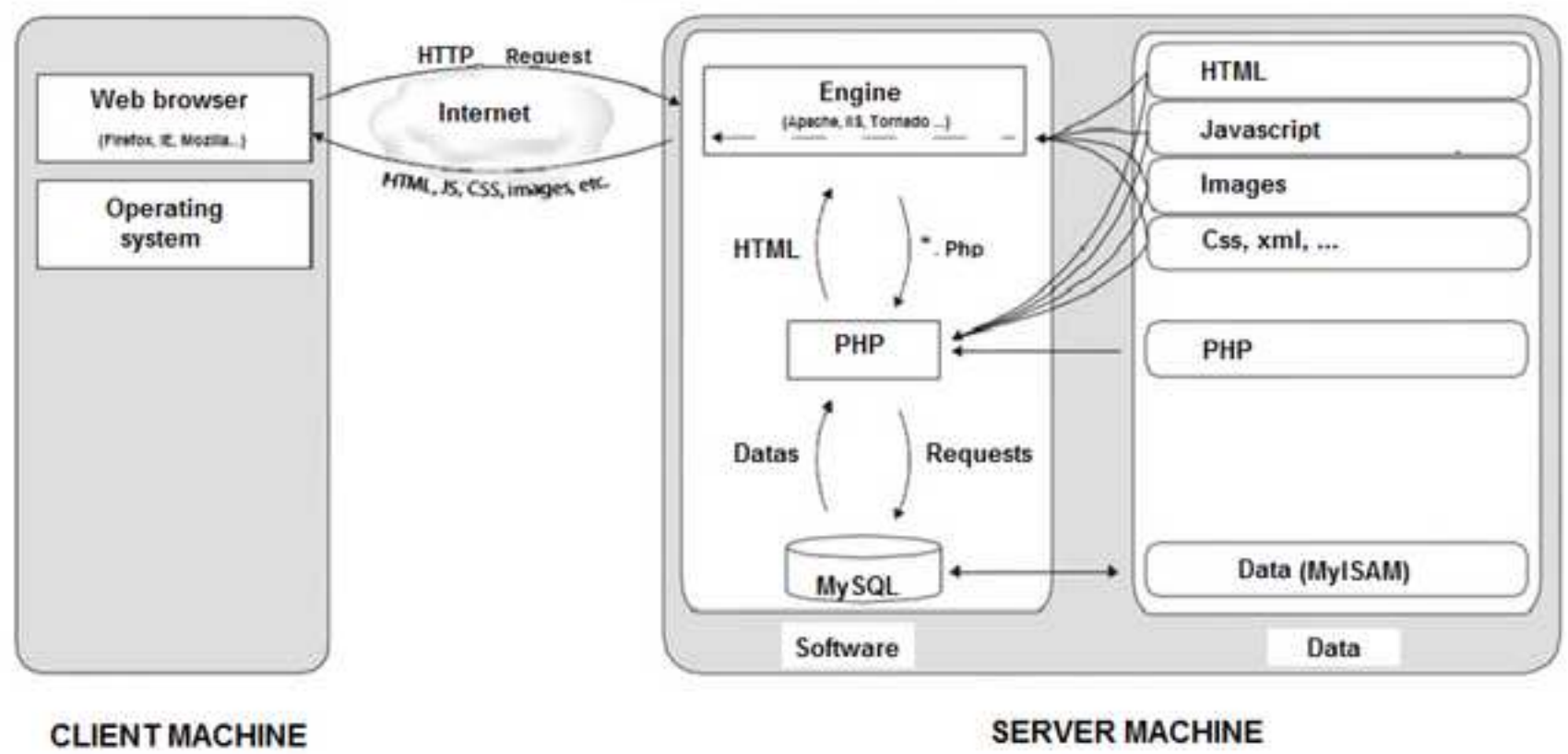


Figure2

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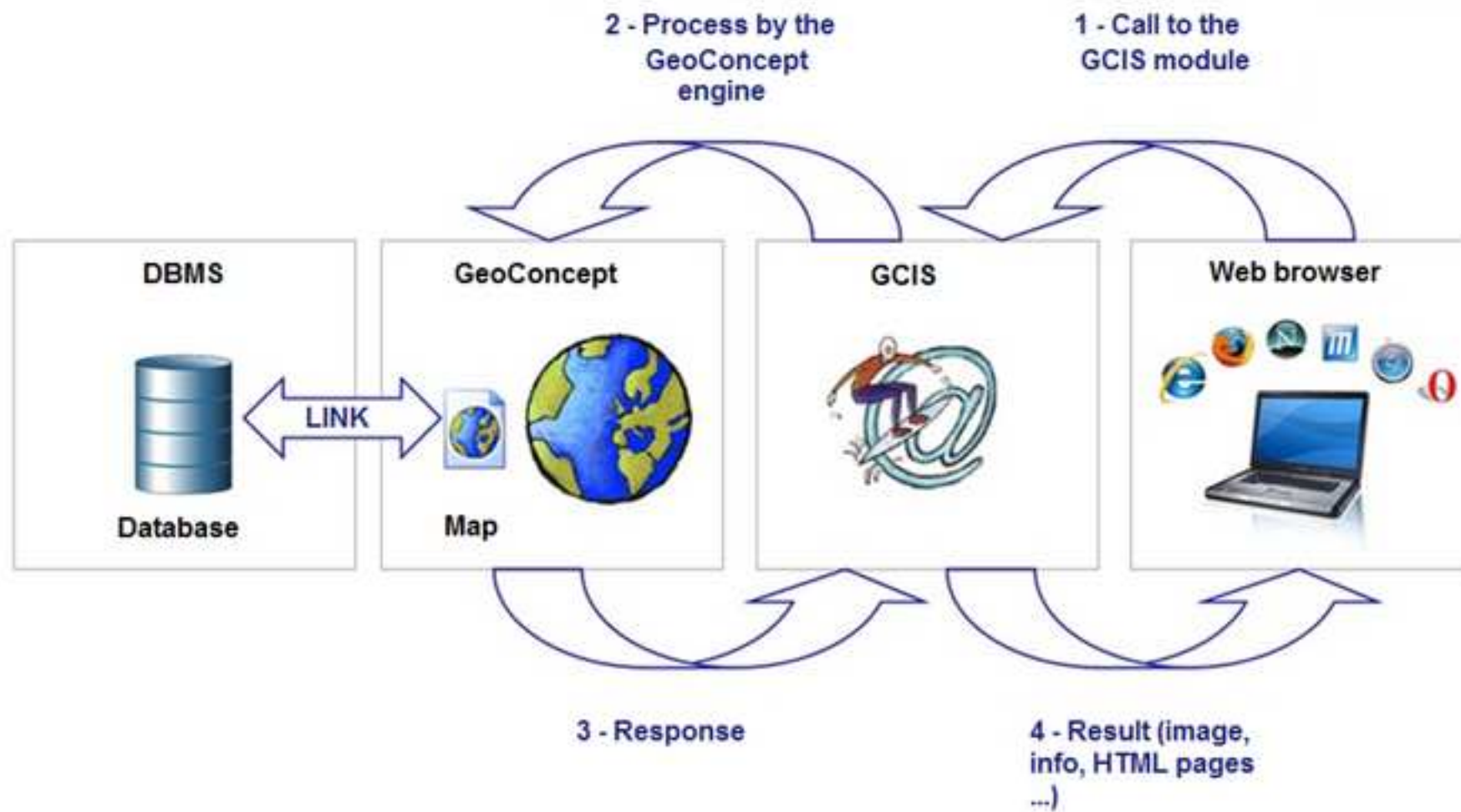


Figure3
[Click here to download high resolution image](#)

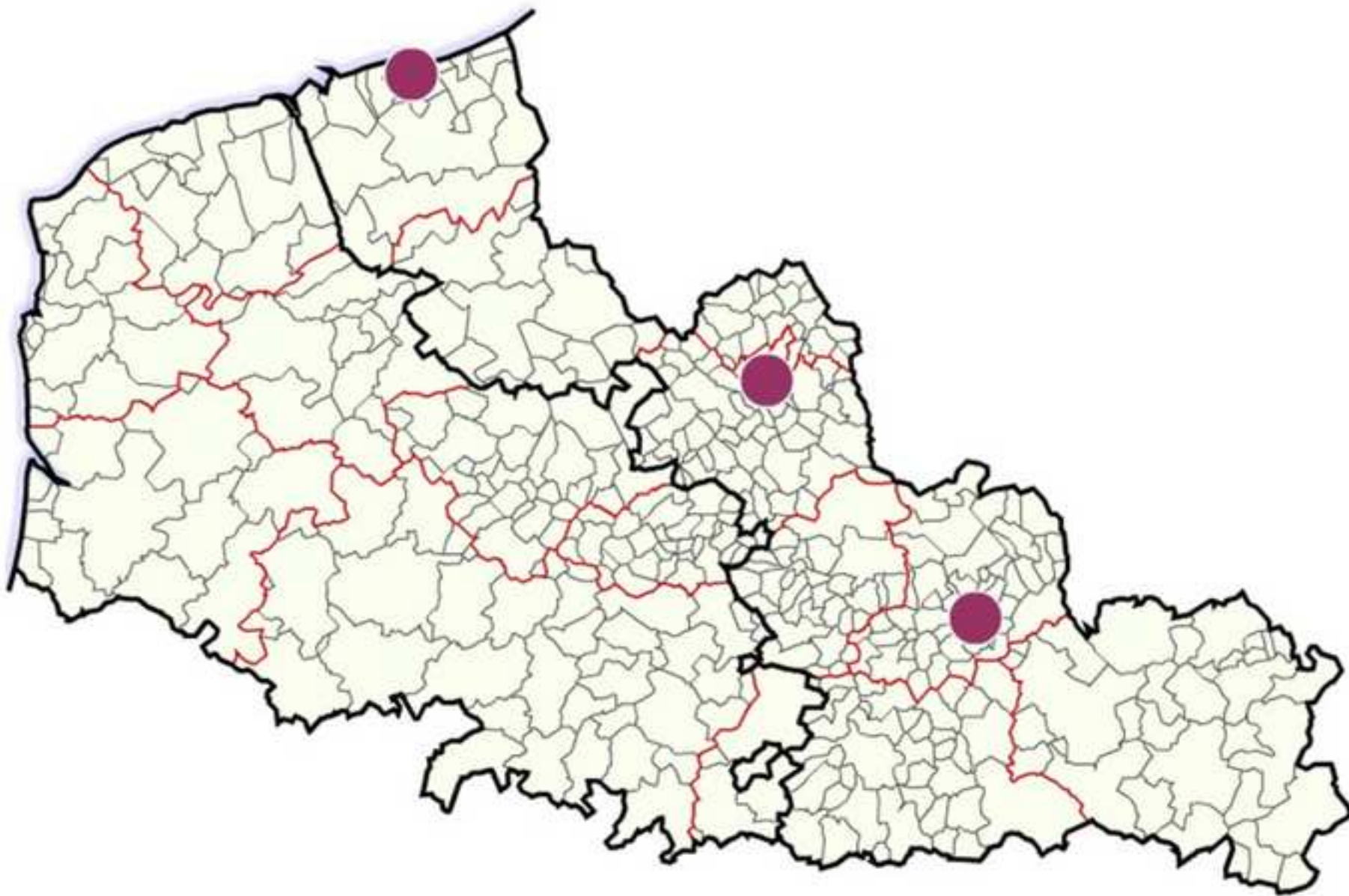


Figure4

[Click here to download high resolution image](#)



SKULL-THROAT	EYES
NOSE	MOUTH
RIGHT EAR	LEFT EAR
SHOULDERS	ARMS
ELBOWS	FOREARMS
WRISTS	HANDS
CHEST	HEART
PELVIS_ABDOMEN	UROGENITAL SYSTEM
THIGHS	KNEES
LEGS	ANKLES
FEET	

Figure5

[Click here to download high resolution image](#)

DUNKERQUE PUBLIC HOSPITAL

Address: 130 AVENUE LOUIS HERBEAUX
59140 DUNKERQUE
Postal address: 59355 DUNKERQUE CEDEX 1
Tel: 03 20 28 50 00
Fax: 03 20 28 57 41
Web address:

Hospital activity mapping:
e-Atlas access => Following page

Table of selected activity segments (OAP - Version 5.2) from the puppet PINoKio and statistic indicators

Source: extract of the regional database (DB) for the year 2007 (fictive data).

Method: only one dynamic activity segment linked to DB => "AB - Orthopedics, Rheumatology"

Statistics by activity segment (AS)

Click on OAP_V5.2: link to a table of 23 activity segments and their subdivisions in product lines (PL)

Legend: OAP => Tool for PMSI analysis, NR => Non Renseigné (English: Nil => no information), DMS => Durée Moyenne de Sejours (English: HSA => hospital stay average)

Total Regional Death DB (Activity Segment - only AB) : 469
Total Regional Hospital Stay DB (Activity Segment - only AB) : 127407

**Access to a detailed table of product lines (PL) CLICK (below)
on links: activity segment code & labels**

• AB - Orthopedics, Rheumatology

Hospital Stays by activity segment (AS) : 2440

Hospital Stays by AS (%) : 1.92

Local Hospital Stay Average (HSA) : 5.23

National HSA : 4.46

Hospital Deaths by AS : 22

Hospital Deaths by AS (%) : 4.69

Figure6

[Click here to download high resolution image](#)

DUNKERQUE PUBLIC HOSPITAL

Address: 130 AVENUE LOUIS HERBEAUX
59140 DUNKERQUE
Postal address: 59385 DUNKERQUE CEDEX 1
Tel: 03 28 28 59 00
Fax: 03 28 28 57 41
Web address:

The selected activity segment: 'AB - Orthopedics, Rheumatology'

Product line table of the selected segment & statistic indicators

Source: extract of the regional database (DB) for the year 2007 (fictive data)

Method: statistics by activity segment & product lines

Click on [OAP_V5.2](#) : link to a table of 23 activity segments and its subdivisions in product lines

Legend: AS => activity segment, PL => product lines, NI => no information, HSA => hospital stay average

Total Regional Death DB (Activity Segment: "AB only"): 469
Total Hospital Deaths (Activity Segment: "AB only"): 22
Total Hospital Stays (Activity Segment: "AB only"): 2440

**Hospital activity mapping =>
access to the e-Atlas by Click (before) on links:
product line code & labels**

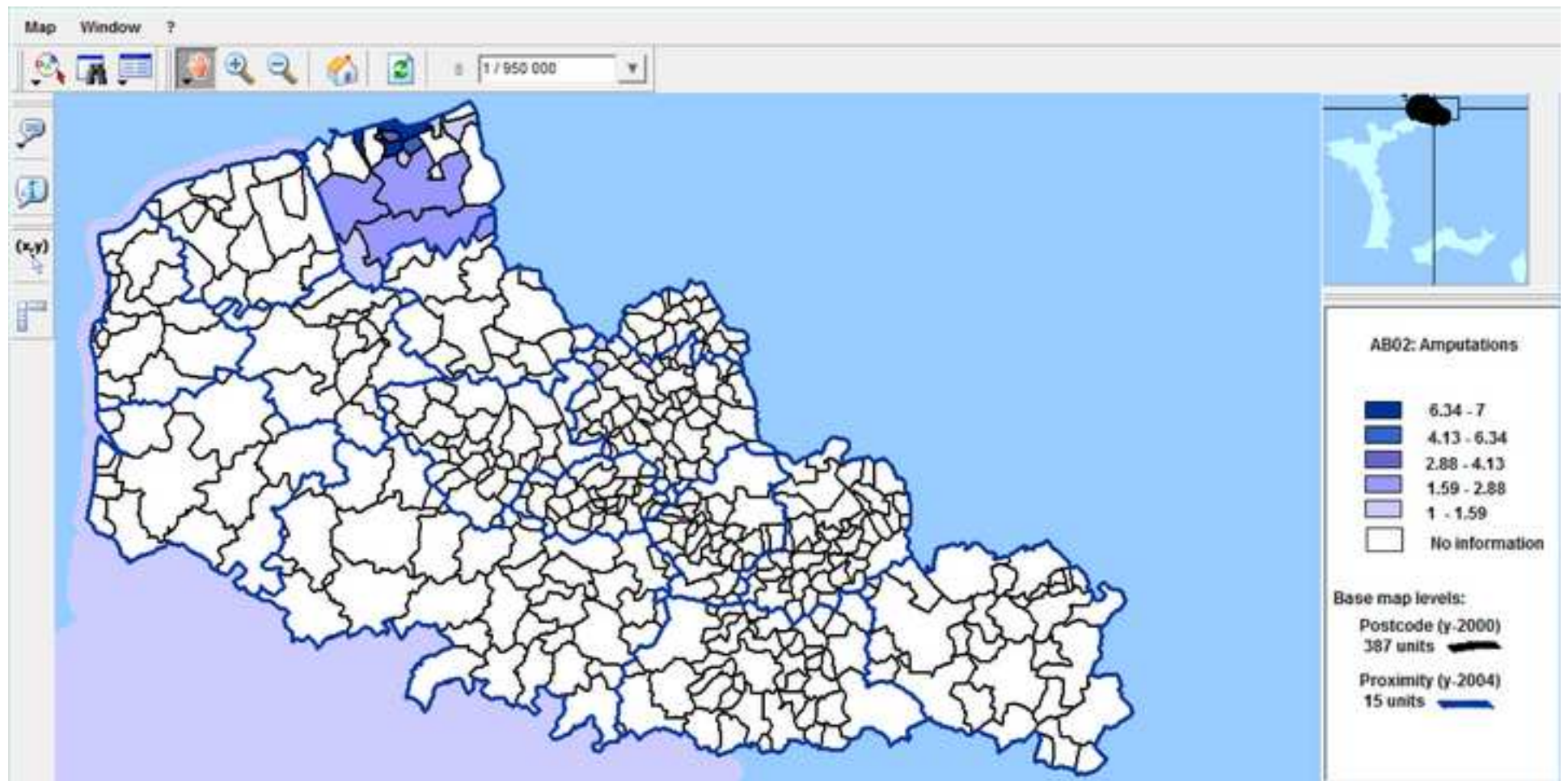
AB01 - Withdrawal of osteosynthesis material

Hospital Stays by product line (PL): 219
Hospital Stays by PL (%): 8.975
Hospital Deaths by PL: NR
Hospital Deaths by PL (%): NR
Local Hospital Stay Average (HSA): 2.53
National HSA: 1.14

AB02 - Amputations

Hospital Stays by product line (PL): 30
Hospital Stays by PL (%): 1.23
Hospital Deaths by PL: 3
Hospital Deaths by PL (%): 13.64
Local Hospital Stay Average (HSA): 22.47
National HSA: 25.47

Figure7
[Click here to download high resolution image](#)



List of changes of the revised manuscript

Corresponding author: Anne Quesnel-Barbet, Ph.D.,

In the revised manuscript the changes appear in yellow

Page 1: title has been changed:

POLESAT, an innovative e-health geomatic platform in decision-making based on: geographical approach, medical knowledge visualization and geographic information system & web-mapping architecture

Page 2: Key Words have been added

e-Health geomatic Platform; decision-making; programmed medical choice; e-Atlas; geographic information system (GIS) & web-mapping architecture; medical visualization knowledge (VCM); program for the medicalization of information systems (PMSI)

Page 3: ref [7] has been changed

Page 8: [7] Lamy JB, Venot A, Bar-Hen A, Ouvrard P, Duclos C. Design of a graphical and interactive interface for facilitating access to drug contraindications, cautions for use, interactions and adverse effects. BMC Medical Informatics and Decision Making. 2008;8(21):1-11.

Pages 8 & 9: the file names have been changed (FIGURE1-b.tif to FIGURE7-b.tif), and we have again uploaded all figures (from 1 to 7) with a best resolution.