Web-services for monitoring the resistance to antibiotics of pathogen germs

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Abstract: - The occurrence and spread of bacterial strains resistant to antibiotics is considered an issue of great concern in our days. Resistance to antimicrobials represents a natural phenomenon, accelerated by a variety of factors, especially by a wide use and misuse of antibiotics in the therapy of human infections. Many studies have been conducted in order to establish the evaluation of germ prevalence and distribution in hospitalized patients. All the results have concluded the necessity of the surveillance of the resistance to antibiotics and of the determination of the optimal prophylaxis and therapy. Several new solutions and medical technologies are available in order to address some of these challenges, but often their access is prohibited due to the associated costs.

The aim of our study is to implement a modern solution that will address this issue with a low cost and in the same time to make it available and easy accessible to all decisional factors: specialist doctors, epidemiologists, management and other.

Implementing this solution as a web-service brings all the advantages offered by this technology (interoperability, easy to access and to integrate, reusability) and will also support the categories mentioned above in taking the correct and appropriate decision.

Key-Words: - Web services, resistance to antibiotics, monitoring system

1 Introduction

Antimicrobial resistance is an unavoidable consequence of the selective pressure of antibiotic exposure, excessively used in different socio-economical domains for the prophylaxis and therapy of human, animal and plant infections. [3, 7]

This is usually associated with significant morbidity, longer hospitalization, excess costs and mortality. [6]

Resistance to antimicrobials represents a natural phenomenon, accelerated by a variety of factors, especially by the wide use and misuse of antibiotics in the therapy of human infections.

The therapy of infectious diseases is often problematic because the selection of antibiotic resistant strains. [2] This makes the empirical treatment of infections more difficult.

In this context, each specialist needs to be informed about the pattern of resistance to antibiotics for the pathogenic germs isolated in his hospital and especially in his department. Also, the evaluation of germ prevalence in hospitalized patients needs to be monitored and updated permanently.

The graphic of antibiotic usage needs to be known not only by specialist doctors but also by management staff. A known history of the resistance patterns will help a lot in determining the appropriate antibiotic prescription, with immediate consequences in reducing the hospitalization duration. Indirectly, this also reduces the risk of resistance spread due to misuse of antibiotics. [6]

Several new solutions and medical technologies are available in order to address some of these challenges, but often their access is prohibited due to the associated costs.

The aim of our study is to implement a modern solution that will address this issue with a low cost and in the same time to make it available and easy accessible to all decisional factors: specialist doctors, surveillance specialists, epidemiologists, and management staff.

The chosen software and technology: MySQL database [5] and a Java-based Web service running on a JBoss application server [4] were also done in this respect, of benefiting from the leader open source IT technologies with minimal costs.

2 Subjects and methods

The subjects are patients hospitalized in the medical and surgical departments of the Clinical County Emergency Hospital of Brașov, for which a bacteriological examination has been performed.

All the resulted data were stored in a database in order to be used later on in determining the resistance patterns.
2.1 Design considerations

In designing the database we had to take into account:
- all information available regarding the patient (age, gender, registration no., occupation);
- the department(s) where the patient was hospitalized;
- list of pathological products;
- list of isolated germs;
- list of tested antibiotics according to the recommendations of the Clinical and Laboratory Standards Institute (CLSI) [1];

The database schema is presented in Figure 1.

The data entry process was performed in the department of bacteriology of the previously mentioned medical unit, based on the medical form for biological samples and the results obtained from the bacteriological examination (identified strains and antibiogram).

A screenshot of the user interface used for data storage is presented in Figure 2.

The personal data form is the same in all cases while the results of the antibiograms are filled in using specialized forms since every isolated germ needs to be tested to different antibiotics according to CLSI.

2.2 Data entry process

In designing the web service we have taken into account the needs of specialists and management as presented below:
- identification of germs isolated in a specific department and their antibiotic resistance patterns;
- determining the antibiotic resistance patterns for a specific germ based on the department and pathological product;
- determining the pattern of germs that are isolated in the hospital during a defined period of time;
- determining the prevalence and distribution of MRSA (Methicillin Resistant Staphylococcus aureus) strains based on pathological product, department and timeframe;
- determining the prevalence and distribution of ESBL (Extended Spectrum Beta Lactamases) strains based on pathological product, department and timeframe;
- monitoring the pathogen germs etiologically implicated in nosocomial infections.

2.3 Web service

Web services provide the ability for applications to interact with others through XML-based messaging over the internet or intranet. In the case of this particular application, XML [10] and XML based technologies are used. They are based on industry standards, are not the property of any particular vendor and include XML itself, SOAP [8] (simple object access protocol) and WSDL [9] (Web services description language). This makes our application easy to access from any hardware or software platforms and easy to integrate with other medical applications.

The web service contains specialized methods in order to be able to retrieve an XML response based on the requests mentioned at point 2.1. The XML response is then transformed using XSL [11] based
technologies like XSL-FO, XSLT and XPath, to be finally presented to the user as a PDF report.

3 Implementation Aspects

The proposed implementation is an asynchronous Web service solution as shown in Fig 3.

![Application architecture diagram](image)

Fig. 3 – Application architecture

The user sends a request to a servlet using an html form (1).

The servlet generates a report id and a link to the document (not yet present on the server), that will be used later on for report visualization (1a). The response got by the user is a html page with a link to the report.

The business to build the appropriate report seats in the web service. The servlet builds an xml requests and queries the Web service in order to build a response in form of an xml (2).

A call to the DB is then performed (3) and the appropriate XML response in sent back to the servlet.

Since an xml response does not make to much sense to the end user, this is then transformed into a more readable form meaning into a PDF ‘report’ document (4). The name of the PDF report is the one received from the servlet so that the link is already available to the requestor.

3.1 Reporting

All web-service methods have a double task. One is to query the database to build the appropriate XML response. The second task is to send the response to a “transformer” servlet running on the JBoss application server, responsible to use XSL-FO, and XPath to transform it into a PDF document. The PDF will be then stored in a common location on the application server so that it can be accessed by the user via HTTP.

The application can provide two types of reports. The first type includes user specific reports, requested by a specific user and is of limited interest (for ex. a report regarding the resistance to antibiotic of a specific germ in a specific pathological product). Such a report is presented in figure 4. The other type includes reports that are of large interest. These kinds of reports are automatically generated by a batch process and made available to all the departments.

4 Conclusion

The proposed implementation takes advantages of using the top open source standards and platforms. Being a low cost solution, this makes it affordable to a large category of doctors and health specialists and also easy to integrate with further systems that might be used.
The proposed solution reflects the needs of having this kind of reports in place so that they can be easily accessed, having also the opportunity to do a permanent update.

Implementing this solution will support specialist doctors, epidemiologists and management in taking the correct and appropriate decision for antibiotic prescription, prevention of nosocomial infections, leading to a reduced hospitalization stay and cost.

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