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CZECH TECHNICAL UNIVERSITY IN PRAGUE
FACULTY OF INFORMATION TECHNOLOGY
DEPARTMENT OF SOFTWARE ENGINEERING



Bachelor's thesis

Specialized Information System Maintaining Patients Participating in Epileptosurgical Programme – Reporting Module

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To begin with, I am deeply grateful for the support and guidance of Mr. Ježdík with whom I have a possibility to cooperate for past two years. Thanks to him, I could work on such an interesting topic as an implementation of an information system for a the biggest hospital in the Czech Republic.

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Finally, but first in my heart, my parents and my brother are due my deep gratitude for their continued moral and financial support throughout my studies. The broad education that I was able to enjoy while growing up has proven invaluable.

Declaration

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In Prague on 8th May 2014

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Abstract

Epilepsy is a brain disorder that affects approximately 1% of the population. Of these, approximately 10 % of the patients suffer from a pharmacoresistant form of epilepsy which can not be treated by the standard medical procedures. This paper deals with the analysis, design and implementation of a reporting module to GENEPI Information System, which was developed for the Faculty Hospital Motol by the students of FIT ČVUT, and is a key tool for the management of patients, involved in epileptosurgical programme. Currently in the epileptosurgical programme are involved 150, mostly children, patients and its beginning dates back to 2000. GENEPI IS, and thus the reporting module is software that was developed from the beginning according to the specific requirements of doctors, who use it. Given that it stores unique information, which also may contain sensitive information, the resultant product was developed under special claims. Among those included robustness, reliability and safety aspects.

Keywords export of data, access according to the user roles, data anonymization, reporting module

Abstrakt

Epilepsie je onemocnění mozku, které postihuje přibližně 1% populace. Z toho přibližně 10% pacientů trpí farmakorezistentní formou epilepsie, při které se nedají použít standardní léčebné postupy. Tato práce se zabývá analýzou, designem a implementací reportovacího modulu do Informačního Systému GENEPI, který byl vyvíjen na zakázku pro Fakultní Nemocnici Motol studenty FIT ČVUT, a který je klíčovým nástrojem pro správu těchto pacientů zapojených do epilepticko-chirurgického programu. V současné době je do epilepticko-chirurgického programu zapojeno na 150, převážně dětských, pacientů a jeho začátek se datuje do roku 2000. GENEPI IS, a tím pádem i reportovací modul, je software, který byl od začátku vyvíjen na základě specifických požadavků lékařů, kteří jej používají. Vzhledem k tomu, že uchovává unikátní data, která zároveň mohou obsahovat citlivé údaje, tak byly na výsledný produkt při vývoji kladeny zvláštní nároky. Mezi ty patřila robustnost, spolehlivost a především bezpečnost.

Klíčová slova export dat, přístup na základě uživatelských rolí, anonymizace dat, reportovací modul

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Introduction

The reporting module, part of the GENEPI - the information system, adds an important functionality to this software. Thanks to this module the user will be able to export data saved in the system to sundry formats. This is useful for the doctors that take care of patients with epilepsy, as well as for the researchers that make analysis above the data from this system. The goal was to extend the IS with another functionality without letting the user to notice he's even using any extension. Therefore the reporting module was delicately worked into the existing source code of the GENEPI IS, using the same design patterns and approaches as the rest of the IS.

GENEPI IS should replace the original information system that was used in the Faculty Hospital Motol in Prague for maintaining patients in epileptosurgical programme. The main reasons for replacing the original information system was a fact, that it didn't comply with the current requirements of the medics, contained bugs and its design wasn't optimal. Because of the uniqueness of stored data and because of the special requirements on the system itself, there was no free software available that would be suitable and thus it was needed to create bespoke information system.

I chose to participate this project, although I knew it will not be easy. The main reasons that led to selection of participation on the development of the GENEPI IS were facts, that it is a software that will be deployed in the production environment, will be used by real users and can help to improve the health state of real people.

In the following chapters will the reader get familiar with the GENEPI IS, the process of analysis, design and realisation of the reporting module, as well as with the process of testing and a will see a few examples of exports done by the reporting module.

Current status

That the reader could fully understand the functioning of the reporting module, first of all it is needed to introduce the information system that it extends. GENEPI - the information system was being created within the subjects BI-SP1 and BI-SP2 on the Czech Technical University, Faculty of Information Technologies in the school year 2012/2013 as a student's project. You may find these projects with full documentation on enclosed CD.

GENEPI IS is being developed in the java programming language, using frameworks¹ Spring 4.0.2 and Hibernate 4.3.4. Front end part is realized via JSP, using HTLM5, JavaScript and CSS. Libraries that were used to ease the programming of the front end were Twitter Bootstrap 3.3.1 and jQuery 2.1.0. As a database has been chosen MySQL 5.5 and as an application server Apache Tomcat 7. All of the used software and libraries are distributed under some kind of free license. GENEPI IS is a bilingual software due to the expected deployment in the Miami Children's hospital in Florida, the United States of America. Languages that are currently supported, are czech and english, nevertheless thanks to the suitably implemented localization it is easy to extend the application and add any other language. During the whole period of the programming of the system, the team consulted the approach often and regularly with contracting authority, to fully meet the needs of the medics.

¹An abstraction in which software providing generic functionality can be changed by code additionally added by a programmer

2.1 Functional Requirements

A functional requirement defines a set of inputs, the behavior, and outputs of a system or its component. Functional requirements may be data manipulation and processing, data validation, implemented features such as searching, export, etc.

- Patient evidence
- Evidence of medical records of patients
- Advanced Search according to given parameters
- Export of the records to sundry formats
- Verification of patients
- Managing users and roles
- Quicksearch in patients card index
- Validation of patients
- Versioning database changes
- Hiding patients and their medical records instead of deleting

2.2 Non-functional Requirements

A non-functional requirement is a requirement that specifies criteria that can be used to judge the the system. Usually those are security, accessibility or reliability.

- Role-based access control
- Robustness
- Reliability
- Solution based on free technologies
- Security
- Responsive design²

²Design that provides optimal viewing experience on any kind of device

2.3 Used back end technologies

1. Java 7

Java is the foundation for virtually every type of networked application and is the global standard for developing and delivering embedded and mobile applications, games, Web-based content, and enterprise software. Java is designed to enable development of portable, high-performance applications for the widest range of computing platforms possible. By making applications available across heterogeneous environments, businesses can provide more services and boost end-user productivity, communication, and collaboration—and dramatically reduce the cost of ownership of both enterprise and consumer applications.[?]

2. Apache Tomcat application server

Apache Tomcat is an open source software implementation of the Java Servlet and JavaServer Pages technologies. Apache Tomcat is developed in an open and participatory environment and released under the Apache License version 2. Apache Tomcat powers numerous large-scale, mission-critical web applications across a diverse range of industries and organizations.[?]

3. MySQL Community Server

The MySQL software delivers a very fast, multi-threaded, multi-user, and robust SQL database server. MySQL Server is intended for mission-critical, heavy-load production systems as well as for embedding into mass-deployed software.[?]

4. Spring Framework The Spring Framework provides a comprehensive programming and configuration model for modern Java-based enterprise applications - on any kind of deployment platform. A key element of Spring is infrastructural support at the application level: Spring focuses on the "plumbing" of enterprise applications so that teams can focus on application-level business logic, without unnecessary ties to specific deployment environments.[?]

5. Spring MVC

Spring's Web MVC framework is designed around a DispatcherServlet that dispatches requests to handlers, with configurable handler mappings, view resolution, locale and theme resolution as well as support for upload files.[?]

2. CURRENT STATUS

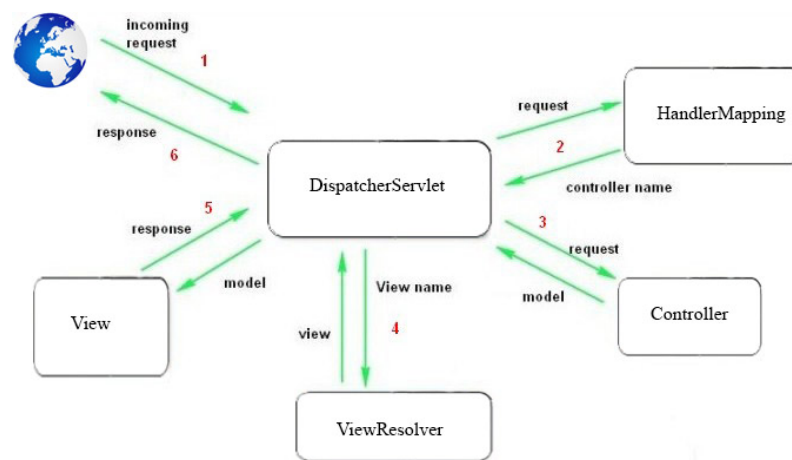


Figure 2.1: Spring MVC web-flow

6. Spring Security

Spring Security is a powerful and highly customizable authentication and access-control framework. It is the de-facto standard for securing Spring-based applications.[?]

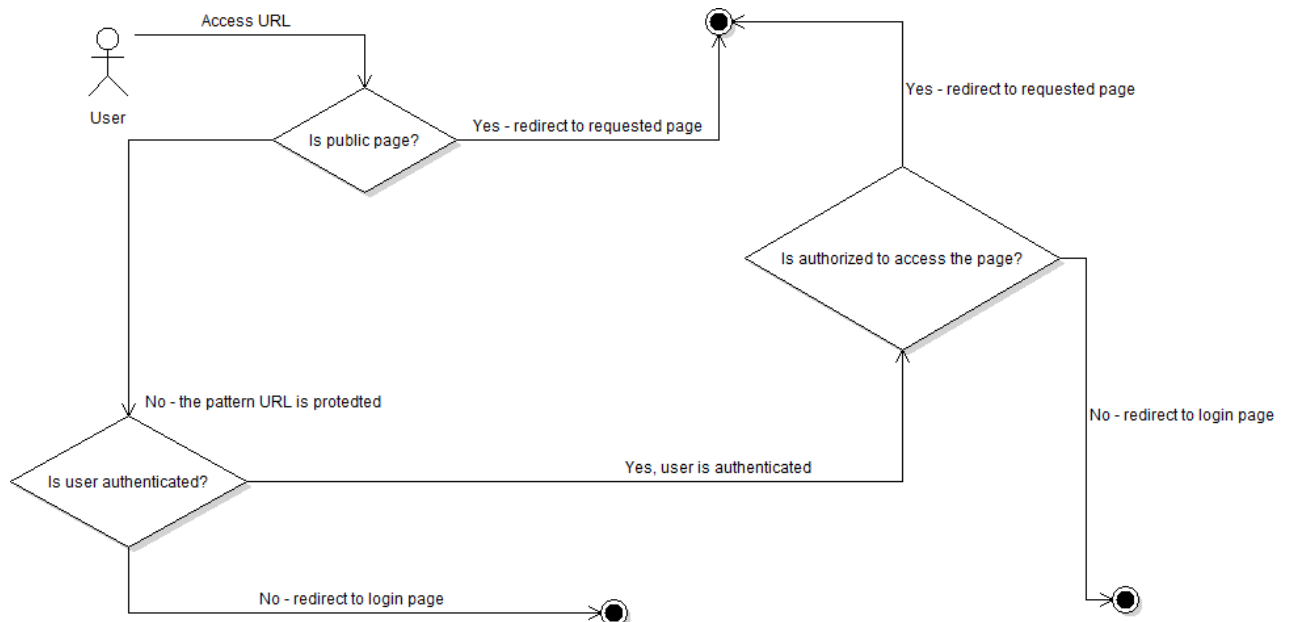


Figure 2.2: Authentication and Authorization flow

7. Hibernate

Hibernate takes care of the mapping from Java classes to database tables, and from Java data types to SQL data types. In addition, it provides data query and retrieval facilities. It can significantly reduce development time otherwise spent with manual data handling in SQL and JDBC. However, unlike many other persistence solutions, Hibernate does not hide the power of SQL from you and guarantees that your investment in relational technology and knowledge is as valid as always.[?]

2.4 Used front end technologies

1. HTML5

HTML5 contains powerful capabilities for Web-based applications with more powerful interaction, video support, graphics, more styling effects, and a full set of APIs³. HTML5 adapts to any device, whether desktop, mobile, tablet, or television.[?]

2. JavaScript

JavaScript (often shortened to JS) is a lightweight, interpreted, object-oriented language with first-class functions, most known as the scripting language for Web pages, but used in many non-browser environments as well such as node.js or Apache CouchDB. It is a prototype-based, multi-paradigm scripting language that is dynamic, and supports object-oriented, imperative, and functional programming styles.[?]

3. CSS

Cascading Style Sheets (CSS) is a simple mechanism for adding style (e.g., fonts, colors, spacing) to Web documents.[?]

4. JSP

JavaServer Pages (JSP) technology enables Web developers and designers to rapidly develop and easily maintain, information-rich, dynamic Web pages that leverage existing business systems. As part of the Java technology family, JSP technology enables rapid development of Web-based applications that are platform independent. JSP technology separates the user interface from content generation, enabling designers to change the overall page layout without altering the underlying dynamic content.[?]

³A set of functions, classes or protocols of a library that can be used by a programmer

2. CURRENT STATUS

5. Twitter Bootstrap

Twitter Bootstrap is the most popular front-end framework for developing responsive, mobile first projects on the web. [?]. It is build with HTML, CSS and JavaScript. Thanks to this framework it was much easier to create responsive front end with pleasant and ergonomic look and feel.

6. jQuery

jQuery is a fast, small, and feature-rich JavaScript library. It makes things like HTML document traversal and manipulation, event handling, animation, and Ajax much simpler with an easy-to-use API that works across a multitude of browsers. With a combination of versatility and extensibility, jQuery has changed the way that millions of people write JavaScript.[?]

Goals

The goal of my bachelor's thesis was to create the reporting module for the GENEPI IS, that would meet the requirements of the medics and researchers that will use it.

Since the GENEPI IS is accessed by more types of users, it was needed to adapt the reporting module to this fact. One of the request therefore was, that the data has to be able to be exported to more formats. Specifically, the formats pdf, docx, xls, csv and txt.

Among the important requirements was also included, that it has to be able to modify the scope of the exported data based on user needs, save and load exports configurations, automatic and optional data anonymization and user-friendly interface.

Of course there has to be data security to prevent access to sensitive patient data to users without proper permission.

The main goals consequently are:

- Implement export to pdf, docx, xls, csv and txt format
- Implement export configuration
- Let the user to save and load customized configuration
- Let the user to anonymize exported data
- Anonymize exported data automatically if the user doesn't have sufficient privileges

Analysis and design

The reporting module, as well as the whole information system, was designed given the requested robustness, accessibility, reliability and the cleanness of the source code. GENEPI IS has a three-tier architecture driven by Spring MVC module, uses access according to the roles of the users via Spring Security module and thanks to the optimized data layer that uses Hibernate framework, it saves the computing resources and eases the developers to understand and extend the source code.

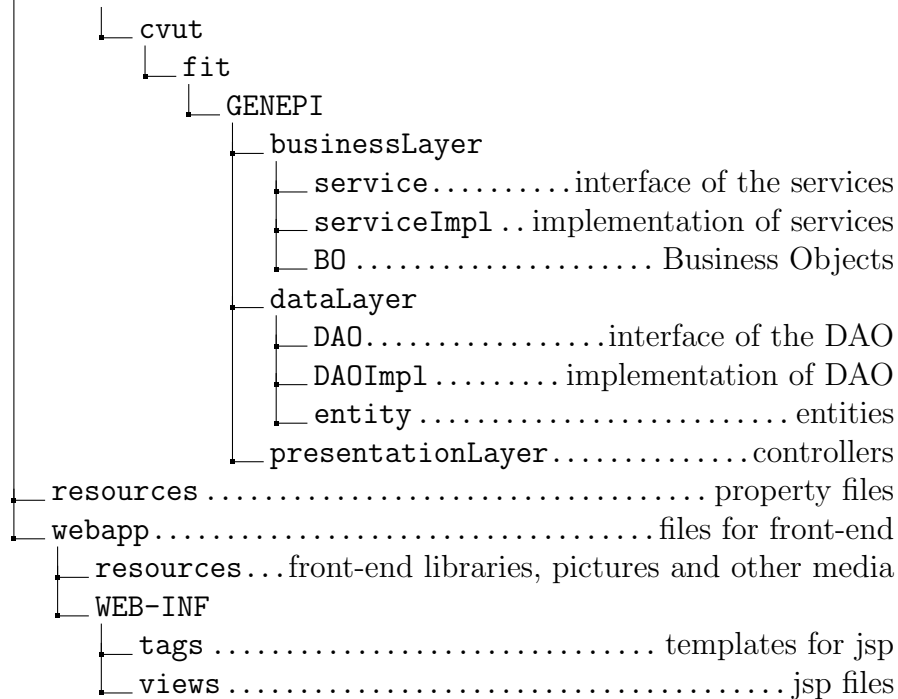
Due to the fact, that users, who should work with the exported data, have different levels of access and different requirements on the format of the exported data, there was a need to make the module to be able to anonymize sensitive data as well as to export data to different formats. The contracting authority also requested that the user could choose which data does he want to export.

4.1 Design of the reporting module

Architecture of the reporting module doesn't differ from the architecture of the rest of the information system. Thanks to this, I could guarantee the robustness and the security of this module. It has also provided me an easy and elegant way to access the other components in the system.

In this tree diagram you may see the parts of the IS, that concern the reporting module:

```
Backend
├── src
│   ├── main
│   │   ├── java.....java classes
│   │   └── cz
```



4.1.1 Design of the back end part

Back end part of the reporting module was designed to follow the three-tier architecture of the rest of the system. Thus the classes that this modul uses, are devided into three different packages. Every package contains classes that belong to the same tier. These packages are called Presentation layer, Business layer and Data layer.

4.1.1.1 Presentation layer

In the presentation layer there is a controller - a Spring MVC compon-ent that calls function according to the HTML request and its URL that is mapped to a particular function. This function executes simple oper-ations such as verification of passed parameters and calls to the other layers. The results of the functions from other layers may be saved to a `org.springframework.ui.Model` object and passed to front end. This layer never executes any more complicated actions, as those should be done within the Business layer nor doesn't access the database as this should be done within the Data layer. Functions of a controller usually return the name of a view - a .jsp file - that should be displayed to a user.

4.1.1.2 Business layer

There are three packages in in this tier - concretly those are service, serviceImpl and BO.

Service contains interfaces whereas serviceImpl contains classes that implement those interfaces from service package. It is analogical as in the Data tier which I will describe in great details in the next paragraph.

In serviceImpl classes there is usually implemented some more complicated logic, that shouldn't be implemented within Presentation layer, like adjusting of BOs, sorting of lists of objects under some conditions and many other actions.

The third package - BO - contains classes, that are used to transform classes from a form in which the data come from the database - in the entity classes - to a form, that is more propriate for work within Business tier.

4.1.1.3 Data layer

This layer contains three packages - DAO, DAOImpl and entity. In the DAO package, there are interfaces of the data access objects, in DAOImpl are the classes that implement the interfaces from DAO package and finally in entity package, we can find the entity classes.

In DAOImpl classes you can find the functions, that are used to access the database and to get some data from it. There is a direct use of hibernate functions or queries in HQL.

In entity classes is described, how the structures of the tables in the database look like. Every entity contains a property for every single column of the table. The type of this variable must match the type of the column of the table. If these conditions wouldn't be satisfied, the database query would fail and the AS would throw out `org.hibernate.MappingException`.

Every property has to have a getter and a setter as well. Thanks to annotations from `javax.*` and `org.hibernate.validator.constraints.*` it is possible to check the requirements for attributes of the input that should be saved to the database, ie. minimal or maximal size, regexp pattern or if the input may be blank or NULL.

Mandatory is also a Hibernate annotation `@Column`, as it describes the mapping of the property to the certain table in the database.

I would like to point out the generic `GenericDAO` and `GenericDAOImpl` classes that have been implemented. These are abstract classes that were implemented to ease the process of programming of the other DAO and DAOImpl classes.

In the GenericDAOImpl class there are implemented the most used methods, that may be used by any service such as save, delete, getCount, getCountOfUnhidden, findByID and many other. The GenericDAO class is interface of GenericDAOImpl class, as it is usual in the rest of the project.

The other DAO and DAOImpl methods extend these generic classes so then it wasn't needed to implement these basic functions to every single class and the programmer had to programme only those functions, that were unique for that certain class.

4.1.2 Design of the front end part

As well as the back end part, the front end had to follow the style and design of the rest of the system. If I wouldn't do so, the work with reporting module could be confusing for users. On the basis of these facts, it was needed to implement frontend based on the same technologies as the rest of the GENEPI IS. Thanks to this approach the User Experience⁴ from work with this module is positive and user accepts reporting module as a casual part of the IS.

⁴User's behaviors, attitudes, and emotions about using a system or service

Realisation

In this chapter, I would like to describe how was the export, its customization and security implemented. I would also like to describe the inner logic used while performing these actions. In the end, it is also needed to familiarize the reader with the form of the front end and describe its sections individually.

The standard approach when performing an export is following:

1. The user chooses in the export view the properties that he wants to include to the exported file, the format, anonymization option and hits the export button
2. PatientExportPOST method in PatientController class is called and according to the given parameters is calls method to export the data to the right format. It also checks if the data should be anonymized and if the user isn't authorized to see sensitive data, then it sets the anonymize flag to true automatically. All given parameters with all those informations are passed to called export function in the Bussines tier.
3. In this step we've moved from Presentation tier to Business tier, where are called method from Data layer to get pateint's data. Then one of the methods for export to certain format is called. This is the part, where the data is being written to the file itself. The program iterates through all the patients that user wanted to export and gradually prints out their data. At first the patient's header is printed out. This header contains information about patient such as his age, gender, age at the beginning of the epilepsy and other important data. It may also contain sensitive data such as his name, address or other contact information.

5. REALISATION

4. In the last step is the user redirected to an URL of the newly created file with exported data to download. This file persists on the server and can be repeatedly downloaded. The time that is this file accessible depends on the setting of the server CRON, as this should regularly delete old files in the directory dedicated for export files.

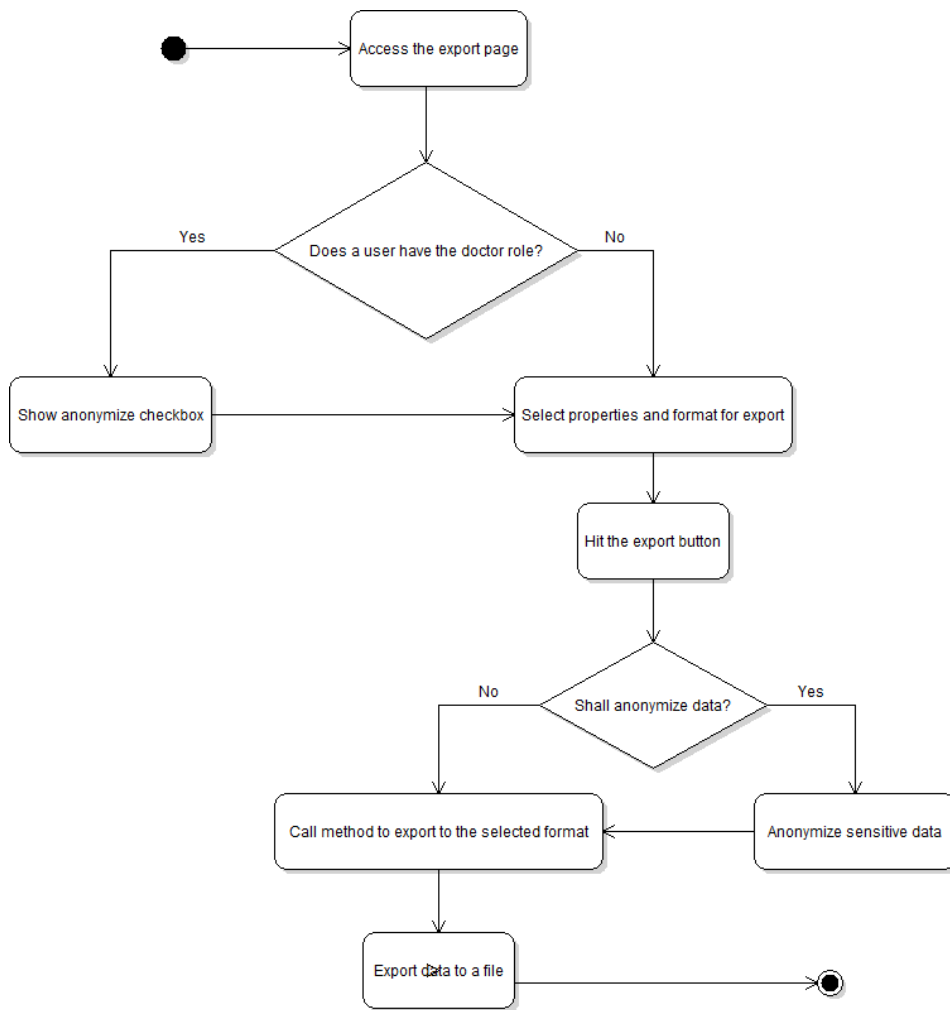


Figure 5.1: Export activity diagram

The goal was to make the whole process secure, reliable and easy to understand for programmer who would read the code, as well as for the user that would use the reporting module. Thanks to the chosen design and implementation approach, were these requirements satisfied.

5.1 Customization of the export

There was a strong demand from the contracting authority to create a module that would let the user to customize the report. Every patient can have filled in fifteen cards. This means circa 340 properties that can be stored for every single patient. Nevertheless not all of them are needed to be exported in certain situations. Therefore was needed to implement some solution, that would allow a user to select only those cards or properties of those cards, that should be exported. Due to a high amount of those properties, it was quite challenging to create solution, that would meet the requirements and will be user-friendly at the same time. I've chosen a treeview on the front end and a special entity on the back end.

On the front end there was implemented a customized treeview, where every item has a checkbox. Patient's cards are represented by the nodes, whereas porperties of these cards can be represented by the leaves of this tree or nodes as well. They may be nodes, if they denote some category that can hold some properties that couldn't exist withou their parent category. By checking and unchecking these items, the user can choose, what all should be involved in the exported data. When unchecking the node, also all leaves of this node are deselected. On the other hand, by selecting even a single leaf from an unselected branch, the parent node is selected as well. Here I attach a simple example of the treeview I was writting about:

```
Anamnesis.....anamnesis card
├─ Anamnesis property
├─ Another anamnesis property
├─ Seizures.....seizure card
│   ├── Seizure property
│   └── Another seizure property
├─ ...
├─ ...
├─ Neuropsychology.....neuropsychology card
│   ├── Neuropsychology inner node
│   │   ├── Neuropsychology property
│   │   └── Another Neuropsychology property
│   ├── Another Neuropsycholgy inner node
│   │   └── Neuropsychology property
│   └── Neuropsychology property
├─ ...
├─ ...
└─ Outcome ..... outcome card
```

After confirming the export form, the state of the treeview is saved to an instance of an entity called `ExportParams`. This entity has a boolean property for every single value from the treeview in the export form. Thanks to this, I am able to determine, which properties the user wanted to export and which didn't. It gives me another advantage - I can save the current setting of the treeview for a later usage, but I will write about this feature later.

5.2 Export to the particular formats

During the programming of the classes that procure the logic of the reporting, I was trying to use the fact, that there already exist java libraries that can export data to docx, pdf, xls and csv formats. I also avoided the duplication of the code by transforming data from one format to another. Thanks to these measures, it is much easier to do changes in the code of the classes that handle export itself and it also eases the understanding of the code for anybody, who would read it.

5.2.1 txt

Export to the text format is realized by components from `java.io.*` package. Specifically `java.io.FileOutputStream`, `java.io.OutputStreamWriter` and as last `java.io.BufferedWriter`. Output is encoded to the UTF-8 format. Every property is printed out to a new line, sections are delimited by dash lines, star lines or empty lines.

5.2.2 docx

Export to the docx format was not as easy as to the txt, so I decided to look up suitable libraries, compare them and use that one, that would best suit my needs. After researching the possible solutions I ended up with two libraries - Apache POI and docx4j.

I've chosen to use docx4j because it has provided me more functionalities and clearer API then Apache POI could. The main problem I had with Apache POI was the forming of the cells, when I wanted to format data to the tables. I could hardly adjust the size of the cells and redefine my own styles of headers and text. Docx4j provided me a really easy and elegant way to solve these issues.

5.2.3 xls

As well as for the docx format, I used the fact that there already were programmed libraries for export to xls. I've chosen to use Apache POI library, as this library provides me anything I could need to export data to an xls file, such as merged cells, creating of new lists and changing the background color of the cells.

5.2.4 pdf

There are of course java libraries that provide you some way to export data to pdf format as well, nevertheless I've chosen different approach. While I already had implemented the export to docx, I've chosen not to implement export to pdf, but to create file with data exported to docx and using the classes from `apache.poi.xwpf.converter.*` package convert this file to pdf. Thanks to this approach I didn't duplicate the code because the only logic needed to format and print out the data for export was already implemented in the export to docx. After transforming docx file to pdf, the original docx file is deleted and only the newly created pdf file persists.

5.2.5 csv

Before I started to implement the export to csv format, I was also thinking, if I should implement whole logic of export to csv, but then I decided to proceed similarly as in the case of implementation of the export to pdf. Nevertheless in this case I don't use a file with data exported to docx, but a file created by export to xls, as this format can be easily transformed to csv and vice versa. During the export to csv I create at first an xls file with exported data and then I walk through this file and print out the values to the file via the classes from `java.io.*` package. These are the same classes, that have been used in the export to txt. Based on the requirements of the contracting authority, the comma, as a standard delimiter in csv format, has been replaced with semicolon. The main reason of this change was a fact, that every card, that patient may have, contains comment, which is a text, which may also contain commas. As the semicolon is a much less used character in the sentences, it was decided to use it as a delimiter. Otherwise the report could look confusingly for the user.

5.3 Security and anonymization

In GENEPI IS there are 5 main levels of an access, according to the visibility of the patient's data.

1. Users

User role is a basic role that every new user gets from the system by default. This role allows you to access the homepage and your user profile. Without any further role, the user is not allowed to perform any further actions.

2. Administrators

Administrators don't have any access to the patient's data. They are not even able to access the URL to view or export these data. They're the only users who may create new users and edit user's roles. They may also edit user's details and change passwords.

3. Researchers

Researchers have limited access to patient's data - they are not allowed to see sensitive data. Nevertheless they are still able to see lists of users, with limited options use advanced search and anonymized export data. Researchers are not allowed to modify patients's data.

4. Doctors

Doctors have full access to patient's data, they are allowed add new patients and modify their data. Nevertheless after every change, the patient is set as unverified. This means, that those changes weren't checked by an authorized person, can't be with certainty trusted and shouldn't be included to any research. Doctors by default doesn't have authority to verify patients whose data were changed and are set as unverified.

5. Superdoctors

Users with role Superdoctor have the same privileges as users with role Doctor. Moreover they have the right to verify unverified patients.

Because of this fact, it was needed to implement some way, how to anonymize the exported data. To reporting module I have implemented two types of anonymization - optional and mandatory.

Optional anonymization is accessible for doctors and superdoctors only. Before they commit the export, they can decide if they want to anonymize the exported data. This could be useful for example in situations, when the doctor needs to provide the data to somebody, who normally doesn't have an access to the system and can't see the sensitive informations at the same time. On the other hand, the doctor still has a possibility to export unanonymized data, which might be useful for the medical purposes.

Mandatory anonymization is done automatically, when somebody, who doesn't have sufficient access level, wants to export data. This feature will prevent anybody unauthorized from seeing the sensitive data of the patients. Anonymized data will be mostly used by researchers, who make analysis upon the data and don't need to know the names and addresses of patients, because they can distinguish them according to their IDs, which is a mandatory property that is printed out for every patient in every export.

5.4 Custom configurations

Customization of the configuration of exported data, was one of the key features of this module. Due to the fact, that there are several types of users who work with this IS, it's needed to count with that, that the ways how they need to use it differs. Researchers usually do some analysis above some part of the data from the IS, whereas doctors usually need some more complex report about patient's health state and the process of the treatment.

It is obvious, that settings of these configurations will be needed regularly, as it is not expected that users would need to create unique configuration for every single export he'd like to perform. Because of this, it was decided that users should have an option to save their adjusted configuration for a later use. Reporting module for GENEPI IS distinguishes two types of saved configurations.

First of them is configuration saved by a user with the Superdoctor role. This configuration may be set as generic. That means that the user chose to let his configuration to propagate through the system, so other users may see and use it.

The other type are user's private configurations. Every user with sufficient access level to access the export view is allowed to create and use them. These are configurations that were created by a user himself and are available for him only. The other users are not able to use these configurations, nor to see them.

Deleting of configurations is possible as well. Private configurations can be deleted by a user that can see them in his list of private configurations

list and not by anybody else.

On the other hand generic configurations are visible to all users in the system, therefore it is needed to determine, if a user who wants to delete some generic configuration, has even the right to perform this action. To delete a generic configuration, the user has to own a Superdoctor role. Then he's allowed to delete any generic configuration created by any other user. If user doesn't have the Superdoctor role, then the delete button for generic configurations is not even displayed to this user in the export view. On the following pictures you can see the activity diagram of saving and then deleting of a configuration from the point of view of the user.

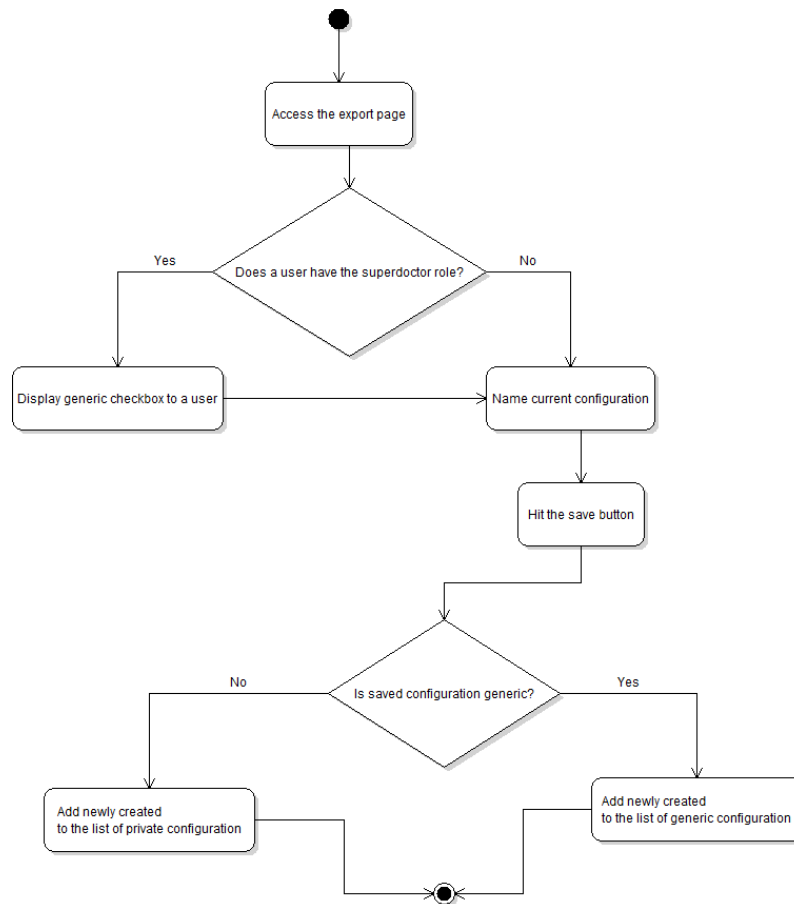


Figure 5.2: Create configuration activity diagram

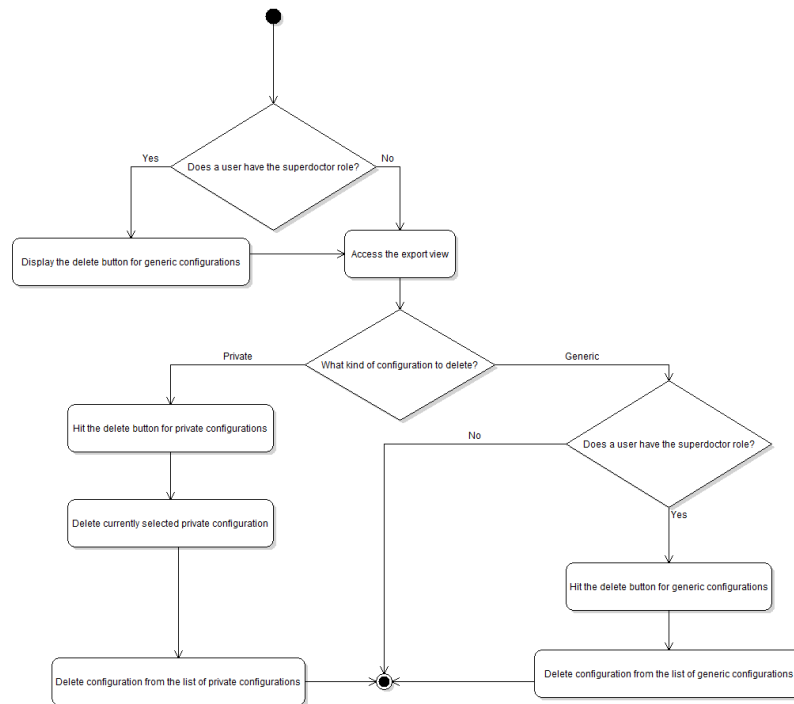


Figure 5.3: Delete configuration activity diagram

5.5 Graphical user interface of the reporting module

On the following pictures I'll explain all components, that are used to control the export view. During the phase of design and implementation of the view, I had to take into account the fact, that users of this module need a user-friendly interface that could provide them all tools that they could need to customize exports.

On the first picture, you can see the interface for loading and deleting of custom configurations. In the first row, there is a combobox with generic custom configurations which the user may load or even delete, if he's a creator of this configuration.

On the next picture there is displayed a section for export itself. Firstly there is a list of IDs of patients that are prepared for an export. The user may access the patient's overview by clicking his ID. Next it's needed to choose the format for export via several radiobuttons. In the case, that user chooses as a format docx or pdf, a checkbox appears and lets him to choose if exported data should be formatted into tables or as a text. If the

5. REALISATION



Figure 5.4: Loading and deleting of a custom configuration

user has the Doctor or Superdoctor role assigned, then he's able to see a combobox, that allows him to let to anonymize exported data.

On the last picture you can see the interface for saving custom configurations. There is a textfield for naming the configuration and if the user has the Superdoctor role, then he may check the checkbox to make the configuration generic.

5.5. Graphical user interface of the reporting module

Export

Patients to export

1906 1917 1935 1939 2002 2004 2015 2024 2089 2093 2095 2105 2122 2126 2188 2189 2192 2212 2235
2248 2293 2302 2303 2320 2334 2356 2370 2404 2412 2455 2456 2460 2497 2503 2561 2696 2735 2746
2794 2831 2939 2979 3038 3067 3112 3126 3234 3241 3242 3266 3271 3279 3337 3338 3380 3381 3382
3392 3398 3399 3401 3405 3406 3407 3409 3410 3411 3560 3567 3581 3589 3590 3592 3593 3594 3595
3596 3597 3600 3601 3602 3609 3629 3630 3631 3633 3634 3636 3637 3638 3639 3643 3644 3645 3646
3647 3648 3654 3651 3652 3653 3655

Settings

Choose format ☒ pdf ☐ xlsx ☐ docx ☐ txt ☐ csv

☐ Export as a table

☒ Anonymize

Export

Parameters

☒ Check/Uncheck all

- + ☒ Anamnesis
- + ☒ Seizures
- + ☒ Pharmacotherapy
- + ☒ Neurological finding
- + ☒ Neuropsychology
- + ☒ Neuropsychology - old
- + ☒ Diagnostic test - Scalp EEG
- + ☒ Diagnostic tests - Neuroimaging test
- ☐ Invasive Test ECoG
 - ☐ ECoG done
 - ☐ ECoG coverage
 - ☐ ECoG patterns
 - ☐ ECoG After resection
 - ☐ Comment
- ☒ Invasive Test - iEEG
 - ☒ EEG done
 - ☒ Intracranial electrodes
 - ☒ localization intracranial electrodes
 - ☒ EEG Slow
 - ☐ Interictal EEG spikes
 - ☐ Localization invasive EEG interictal spikes
 - ☒ Invasive EEG status epilepticus
 - ☒ Ictal EEG patterns
 - ☐ Localization ictal EEG pattern
 - ☒ Comment
- + ☒ Invasive test - Cortical mapping
- + ☒ Operation
- + ☒ Histology
- + ☒ Complication
- + ☒ Outcome

Figure 5.5: Selection of format and customization of an export

5. REALISATION

Save parameters

Name ☐ Generic

Figure 5.6: Saving of a custom configuration

Testing and Examples

Testing of the reporting module as well as the GENEPI IS itself was being performed during the development by the developers themselves and by a member of the team who held the position of a tester. After key functionalities were implemented, Ing. Ježdík Ph.D got the access to the system and tested it on usual use cases. He of course had many change requests that could enbetter the application or found bugs that should be fixed. Nowadays the GENEPI IS with reporting module should be deployed on produciton servers in the Faculty Hospital Motol and fully replace the existing applicaiton. As in the most of the cases from commercial sector, it is awaited, that users will also have some change requests. But those are expected to be minor change requests, mostly on a front end and should be implemented within a few MD.

On the following screenshots the reader may see a few examples, how the export files created by the reporting module look like. I also enclose a simple example of analysis made on the base of data from GENEPI IS, that were exported do xls. All these examples spring from the real data, that are currently saved in the IS, but they were anonymized of course. You may find these files enclosed on CD as well.

6. TESTING AND EXAMPLES

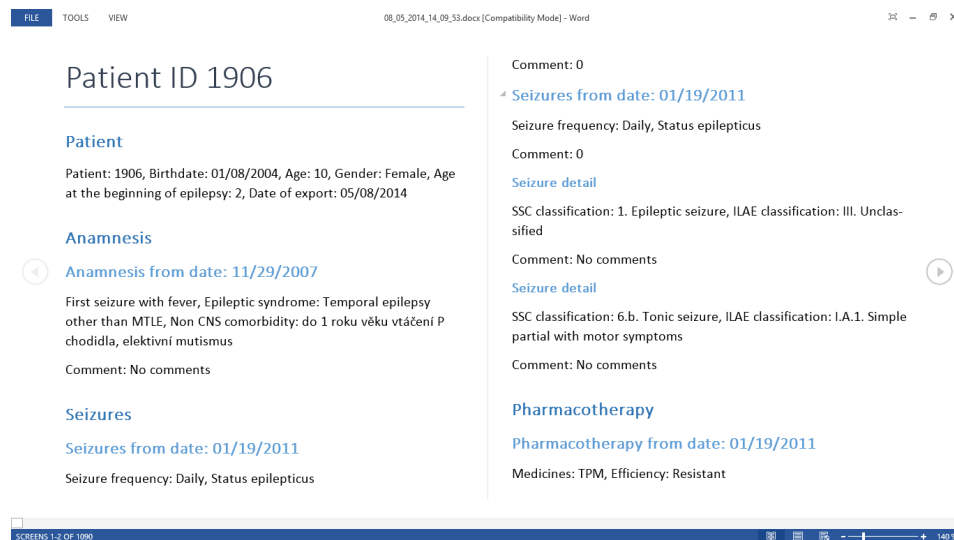


Figure 6.1: Screenshot of an export of all patients to docx

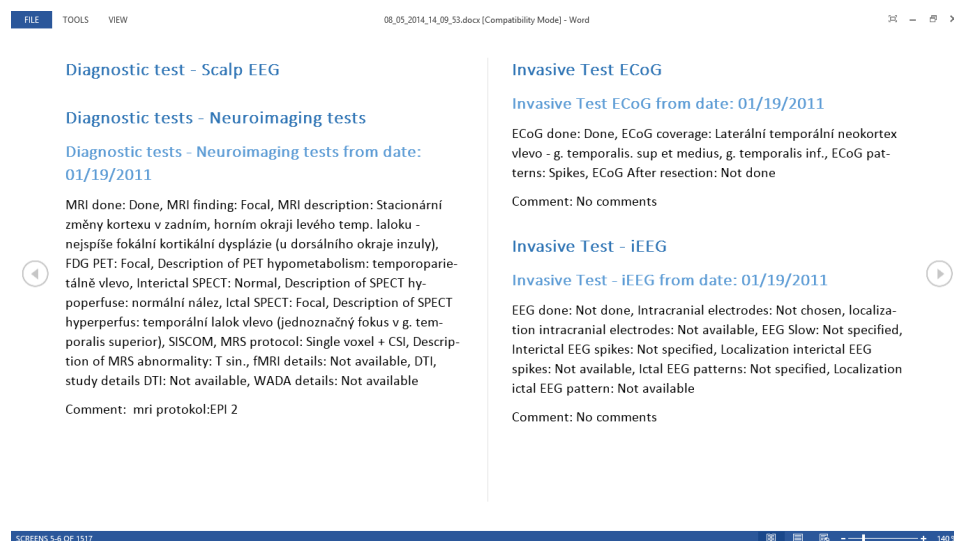


Figure 6.2: Screenshot of an export of all patients to docx

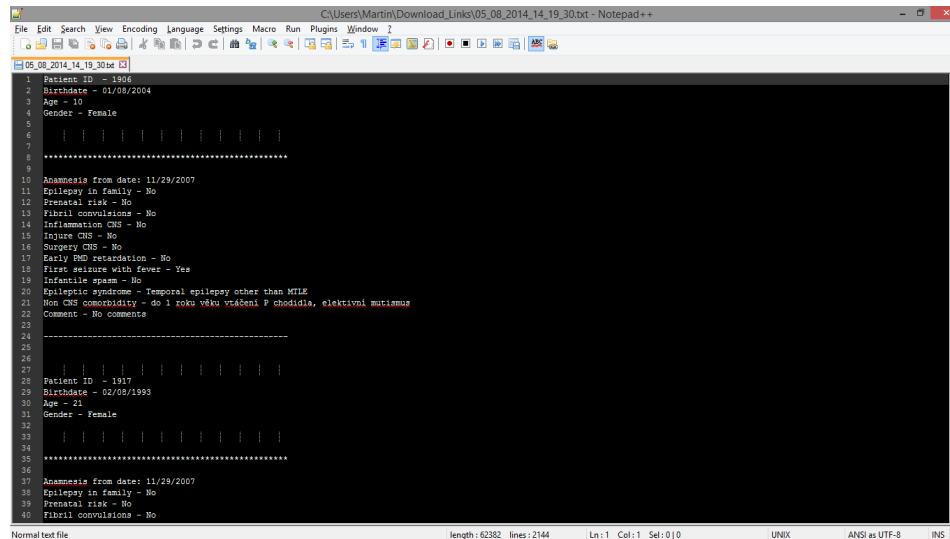
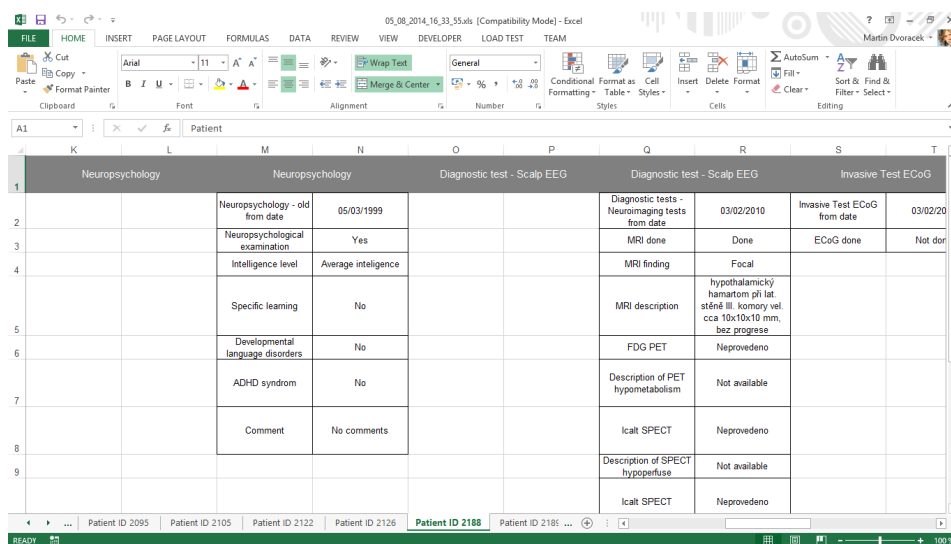


Figure 6.3: Screenshot of an export of all female patients to txt

Patient		Anamnesis		Seizures		Pharmacotherapy		Neurological finding	
ID	2188	Anamnesis from date	11/29/2007	Seizures from date	03/02/2010	Pharmacotherapy from date	03/02/2010	Neurological finding	03/02/20
Birthdate	07/17/1991	Epilepsy in family	No	Seizure frequency	Daily	Medicines	VGB	Hemisphere dominance	Right-han
Age	22	Prenatal risk	No	Secondarily generalized seizure	No	Efficiency	Resistant	Abnormal neurological finding	No
Gender	Female	Fibril convulsions	No	Status epilepticus	No	During surgery	No	Hemiparesis	No
Age at the beginning of epilepsy	2	Inflammation CNS	No	Comment	0	Comment	No comments	Visual field defects	No
		Injure CNS	No					Comment	lehká asymet nasolabální ry norm. neuro
		Surgery CNS	No	Seizures from date	03/02/2010	Pharmacotherapy from date	03/02/2010		
		Early PMD retardation	No	Seizure frequency	Daily	Medicines	VPA		
		First seizure with fever	No	Secondarily generalized seizure	No	Efficiency	Resistant		

Figure 6.4: Screenshot of an export of all patients older then 5 years to xls

6. TESTING AND EXAMPLES



Neuropsychology		Neuropsychology		Diagnostic test - Scalp EEG		Diagnostic test - Scalp EEG		Invasive Test ECoG	
1		Neuropsychology - old from date	05/03/1999			Diagnostic tests - Neuroimaging tests from date	03/02/2010	Invasive Test ECoG from date	03/02/20
2		Neuropsychological examination	Yes			MRI done	Done	ECoG done	Not done
3		Intelligence level	Average intelligence			MRI finding	Focal		
4		Specific learning	No			MRI description	hypothalamický hamartóm pfi lat. sténé III. komory veľ. cca 10x10x10 mm, bez progresie		
5		Developmental language disorders	No			FDG PET	Neprovedeno		
6		ADHD syndrom	No			Description of PET hypometabolism	Not available		
7		Comment	No comments			Icalt SPECT	Neprovedeno		
8						Description of SPECT hypoperfuzie	Not available		
9						Icalt SPECT	Neprovedeno		

Figure 6.5: Screenshot of an export of all patients older then 5 years to xls

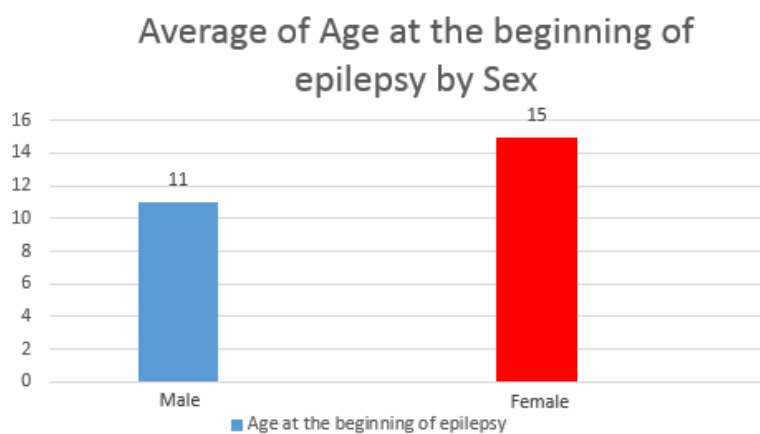


Figure 6.6: Example of an analysis from exported data

Conclusion

I've created a tool that greatly extends the possibilities, that GENEPI IS could provide to doctors and researchers, who would use it. Without the reporting module, GENEPI IS would be only a tool to store and look up informations about patients. But now it become a tool, that can provide to users structured and customized reports. Those reports may be used as a source of important informations about the patient's health state and about the process of his treatment during the surgery as well as the source of data for analysis and researches.

Thanks to the possibility to customize exports, the doctors can select to export only those data, that are important for given medical intervention. As it is expected that the set of requested informations to given interventions will not change frequently, the doctors can also use the feature of the module to configure the export once, then save the configuration, and then just load it anytime they would need it, without any need of further configuration.

Another possibility of using the reporting module are analysis made by researchers. Researchers shouldn't usually be allowed to see sensitive data about patients. Thus there comes in handy the feature of automatical anonymization of the patient's data. Also a possibility to export unlimited count of patients during one export to one file is usefull, because researchers need larger amount of data to make any analysis. Exporting every single patient to separated file one by one, would be really user-unfriendly solution. It is also awaited, that researchers will use diffirent formats than doctors. Whereas doctors are awaited to use mostly docx or pdf format, researchers will probably use xls, csv or txt. These formats can be easily parsed and processed to other software for further analysis.

These all were the reasons why in the end it is possible to execute export

CONCLUSION

to 14 sundry formats. Those are 5 basic formats, 5 more in anonymized variant. Docx and pdf export can be also formatted to tables. With anonymized variant we get 4 more formats. This should be sufficient solution to meet the needs of any user of GENEPI IS.

To sum up, all goals that were stated in the beginning of this thesis, were satisfied. Moreover I've added some features that may ease the work with the reporting module such as generic configurations or more types of formatting when exporting to docx and pdf.

I must say, that I'm really satisfied with the software I've created on the basis of the requests of the doctors from the Faculty Hospital Motol in Prague. I believe that it will serve doctors and researchers well and make their work and research much easier. This all should lead to an improvement of the treatment of the patients with epilepsy.

I'm proud, that result of my bachelor's thesis will be deployed in the biggest hospital in the Czech Republic and will be there used to help real patients. I also believe that that my work will have its share on helping the mankind to understand such as insidious disease which epilepsy is and maybe even to save somebody's life.

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Acronyms

API Application Programming Interface

AS Application Server

BO Business Object

CI Continuous Integration

DAO Data Access Object

GUI Graphical User Interface

HQL Hibernate Query Language

IS Information System

JDBC Java Database Connectivity

JSP JavaServer Page

MD Manday

MVC Model View Controller

XML Extensible Markup Language

Contents of enclosed CD

To my bachelors thesis I enclose a CD, that contains all important data, that are needed to start your own Apache Tomcat AS, MySQL database and depoloy GENEPI IS. It also contains source codes of GENEPI IS and libraries that it uses. In the Database directory is also enclosed model for MySQL Workbench, where the reader may see the structure of the database. In the same folder you can also find migration scripts. These are important when migrating from the information system that was previously used in the Faculty Hospital Motol to GENEPI IS. Migration scripts allow you to copy data from previously used database to the databse that is being used by the GENEPI IS. Thanks to this, the reader should be able to administrate or even modify GENEPI IS without any larger problems. If the reader would like to use enclosed Apache Tomcat AS and/or MySQL database, he has to agree and follow the licence agreements that are enclosed in the same directories as the software, that is being distributed under them.

Next important directory is the directory with samples of exported data. This folder contains 14 files with all possible formates of exported data - pdf, docx, xls, csv, txt - all of these formates in both anonymized and unanonymized variants (sensitive data were changed) and both printed as a plain text and formatted to a table for pdf and docx as well.

The reader may also find useful directory that contains deployment packages of the results of the previously mentioned projects from the subjects BI-SP1 and BI-SP2. The documentation to these projects is included in that directory.

I would also recommend to become familiar with the content of the directory Documentation, where you may find user and admin documentation for GENEPI IS.

Another content of enclosed CD is text directory, that contains this this

B. CONTENTS OF ENCLOSED CD

	readme.txt	the file with CD contents description
	Apache Tomcat	the directory that contains Apache Tomcat
	Database ...	the directory that contains MySQL database and database scripts
	MySQL	the directory that contains MySQL database
	data ..	the directory that holds model of the database and migration scripts
	Documentation	the directory of GENEPI IS documentation
	war	the directory with war file
	Backend	the directory of a maven project
	src	the directory of GENEPI IS source codes
	main	
	java	
	cz	
	cvut	
	fit	
	GENEPI	the directory of source code of an implementation
	resources	the directory configuration files
	webapp	
	resources	the directory of librarires for front end
	WEB-IF	
	spring	the directory for spring context file
	tags	the directory of templates for jsp pages
	views	the directory of jsp pages
	test	the directory of source codes of unit tests
	Previous projects	the direcotry of results of BI-SP1 and BI-SP2
	BI-SP1	the directory of the BI-SP1 project
	BI-SP2	the direcotry of the BI-SP2 project
	Sample Data	the directory that contains samples of exported data
	Text	the thesis text directory
	thesis.pdf	the thesis text in PDF format
	thesis.ps	the thesis text in PS format

theis in pdf and ps format and readme.txt file, where is in great deatails described the content of the CD.