A MVC BASED USER INTERFACE DESIGN FOR CLINICAL RESEARCH DATA EXTRACTION

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Abstract- One of the research orientedintegrated data repository, Biomedical Translational Research Information System (BTRIS),developed by US National Institutes of Health, providesthree kinds of data sets (demographic, laboratory, and pathology) to other research departments for clinical studies through the BTRIS HL7 web service.In order to decrease the learning curve and adoption barrier of using BTRIS HL7, this research study developed an Integrated Data Repository (IDR) query web application (IQWA) to query BTRIS more efficiently.We adopted the Model-View-Controller (MVC) design pattern framework to design a well decoupledIQWA to access BTRIS.The IQWA has aneasy user query interface for clinical researchers to submit the query criteria.The navigation logic of the IQWA Controllertriggers the data access business logic (BTRIS access functions) basedon the Model by the query criteria and presents the query results on the View to the researchers' browser.

Keywords- BTRIS, HL7, MVC, Clinical Research.

I. INTRODUCTION

The wide spread adoption of Electronic Health Records (EHRs) in health providers and facilities presents an opportunity of secondary use of the clinical data in clinical research. It also give rise an opportunity in the research protocols to accelerate the data collection, prevent the duplicate data collection, reduce the costs, and avoid human errors, etc.[1-12].Toencourage the secondary use of EHRs in the research, NIH provided some monetary incentive [2, 13]such as Clinical and Translational ScienceAwards (CTSA) to build the research infrastructure [13-17]. Some of the research institutions or the health providers start to integrate EHRs from several sources to provide research oriented data warehouse, called integrated data repository (IDR) or clinical data warehouse (CDW)[12, 14, 18]. BTRIS (Biomedical Translational Research Information System)is one of the IDR developed by U.S. National Institutes of Health[12, 19-21].BTRIS has its own terminology system, "Research Entities Dictionary" (RED)[19, 21]provides a web service interfacefor accessing data, which supports the HL7(Health Level Seven) Version 2.6 message[22]for users to request three types of data sets; demographic, laboratory, and pathology.

In our previous study[12],we built a HL7 interface engine application program interface (API) to generate the BTRIS HL7 query messages to query the data from BTRIS. However, the product of our previous work is an API component; it is suitable for the batch retrieving data from BTRIS or serves as a component/moduletoother programs to facilitate BTRIS data access, butit is not applicable for the clinical research fellows to inquire about the data. Therefore, developing a user friendly interface for the clinical researchers to generate BTRIS HL7 querieswould be ideal and more efficient. The clinical researchers neither needing to taketime to understand HL7 messages nor having to buildthe program to invoke the HL7 API, and retrieved the data from BTRIS.

In order to develop the user query interface, we should figure out what kind of BTRIS data sets and criteria we need through the user query interface, and then ask the HL7 API to generate the corresponding BTRIS HL7 query messages.Thus, there would be logic rules needed to determine what kind of BTRIS HL7 query messages should be generated by users' query parameters. Model-View-Controller abbreviated as MVC [23-28] is a programming design pattern;it separates a program into three sub modules by its functions. The View provides the user interface, the Controller module supports the navigation rules and dispatch rules, and the Model module holds the business rules and data access functions. Consequently, this design pattern conforms to our requirements to develop the BTRIS IDR query web application (IQWA), which includes the user query interface, the logic rules, and the data access function (invoking our previous product, HL7 API, to access the BTRIS). In this study, we provided a framework thatadopts the MVC design pattern to accomplish the IQWA development.

II. MODEL VIEW CONTROLLER (MVC)

MVC is a framework of system design pattern in software engineering. MVC separates the system in to three modules (Model, View, and Controller) and organizes the interaction among these three modules.MVC is originally introduced by a Smalltalk developer, Trygve Reenskaug in 1979 at Xerox Palo Alto Research Center[23-28].Some large traditional software project includedmixture of data persistent function, data access function, business logic function, and user presentation function. The different functional codes were coupled tightly, and it could cause several issues. The first issue is hard to maintain or extend the software, the mixtureof functional codes easily get confusing to the code maintainers.Second, the codes are difficult to reuse because they depend on many other classes,this causes strong ripple effects whenever a change is made anywhere[24]. Third, it's hard to subdivide the developing work for different specialties programmers, such as user interface developers, data persistent function developers, business logic developers, etc. Therefore, MVC design pattern is a solution since it separates the software project into three interconnected parts depend on their functionality to achieve well decoupling.MVC successfully isolated user interface, request dispatcher function, and business logic function, each part is able to be maintained separately without affecting each other.

MVC pattern is not only used in the desktop application, but the Model 2 MVC[23, 25, 26]pattern is also developed for the design of web applications. There are manywell-known Model 2 MVC frameworks, such as Struts2[29], Spring MVC[30], etc.

Figure 1 describes how each part of the Model 2 MVC interact.

1. The end users send a HTTP request through their web browser to the web application, then the Controller module of web application blocks the request.
2. The navigation logic of Controller module dispatches the request to the relative business logic on the Model module.
3. The Model module contains the function of business logic, algorithms, and data access, etc., while the Model processesthe request through the related business logic; returninga result to the Controller module dispatcher.
4. The Controller module dispatched result then indicates which web pages (html, jsp, php, etc.) should be present to the client.
5. The View module renders the result to the client browser.

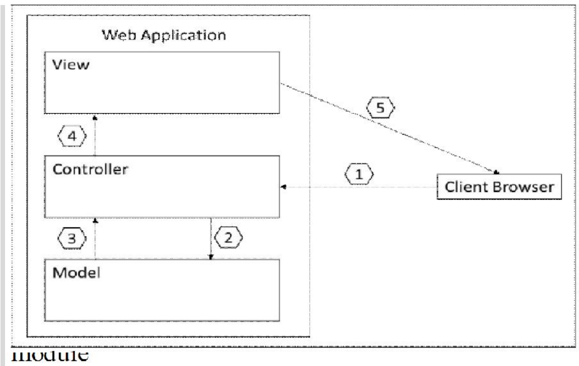


Fig.1. Model 2 MVC workflow

III. SYSTEM IMPLEMENTATION METHODOLOGY

In this section, we describe how we adopted MVC design pattern as our IQWA system framework, and the methodology of components' deployment.The development of the IQWA is made by java programming language with jdk7.As shown in Figure 2, the entry point of IQWA is a "btrisQuery.jsp" Java Server Page (jsp)generated web page. The user query interface is presented to the users to send the BTRIS query parameters. We used struts2 framework as the MVC framework of IQWA, and the components built were deployed on each of its layer. First of all, the Controller module includestwo required components of struts2;struts.xml file and Action class. The struts.xml file works on the dispatch function, and the Action class provides the navigation logic. Second, the Model module includesthe business logic and java bean to invoke the HL7 API to access BTRIS.Third, there are three jsp web pages (Lab.jsp, Demographic.jsp, and Pathology.jsp)provided to present the query results to the user. Finally, we deploy the IQWA on Apache Tomcat 7 web application server, and all the transaction arethrough HTTPS.

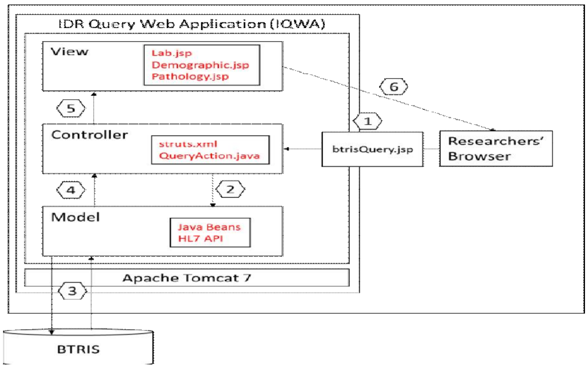
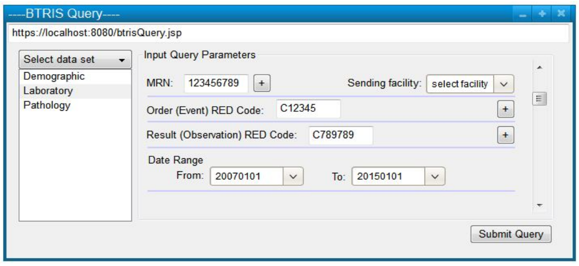


Fig.2. System Implementation

IV. SYSTEM WORKFLOW AND IMPLEMENTATION RESULT

In this section, we follow the workflow of IQWA, and combine IQWA system screenshot and core code to present implementation results.

(1) The first step in Figure 2 shows that clinical research staff can access the btrisQuery.jsp (Fig. 3) web page of IQWA through their browser.The btrisQuery.jsp web page is the entry point of IQWA and provides the interface for the clinical researcher to set the query parameters (criteria). For example, the criteria would includespecific BTRIS data set (Demographic, Laboratory, or Pathology), patient data (indicated by MRN (Medical Record Number)), etc. Once the clinical research staff has filled out the query parameters and pressed the submit Query button, the query parameters would be embedded in struts tag (Fig. 4) and sentto the Controller of the IQWA.



----BTRIS Query----

https://localhost:8080/btrisQuery.jsp

Input Query Parameters

MRN: 123456789

Sending facility: select facility

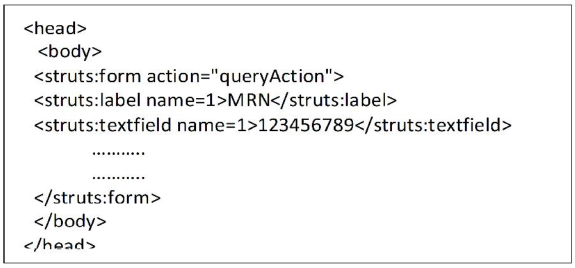
Order (Event) RED Code: C12345

Result (Observation) RED Code: C789789

Date Range

From: 20070101 To: 20150101

Fig 3.btrisQuery.jsp on the client's browser



```
<head>
  <body>
 <struts:form action="queryAction">
 <struts:label name=1>MRN</struts:label>
 <struts:textfield name=1>123456789</struts:textfield>
          ..........
          ..........
 </struts:form>
 </body>
</head>
```

Fig 4.btrisQuery.jsp

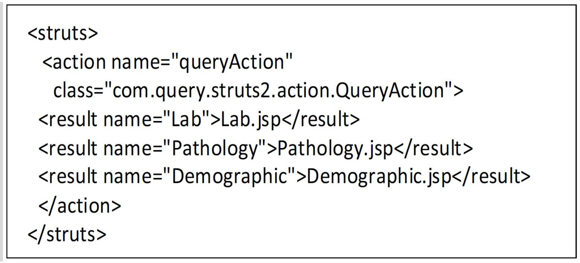
(2)The configurations of the Controller module were settled in struts.xml file (Fig. 5).The struts.xml file is actually a request dispatcher. The "queryAction" action class in Fig 4 would map to "queryAction" of struts.xml in Fig 5, then struts.xml dispatchs the parameters to the QueryAction.java class (a navigation logic, refer to Fig. 6) to process. The QueryAction.java invokessome business logic (includingthe data access function) on the Model to process the request parameters.

(3)The QueryAction.javaclass (Fig. 6)invokesthe data access function on Model(e.g., HL7API.LabQuery(String[]) is used to initiate theBTRIS query function of the Lab data set).

(4)The data access results arereturned to the QueryAction.java class on the Controller model.

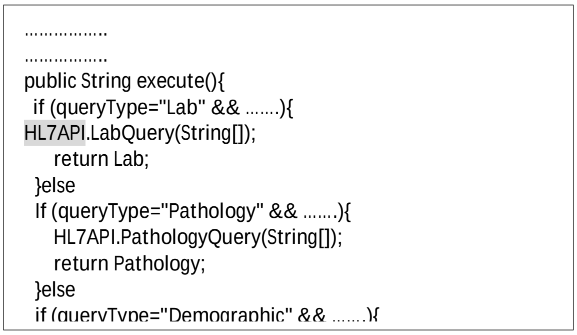
(5) The QueryAction.java class returns the "Lab" string as a navigation index, and struts2 looksup the struts.xml and finds"<result name="Lab">Lab.jsp</result>." The "Lab" string allows the query results tobe presented on the Lab.jsp web page inthe researchers' browser.

(6) The View modulepresentsthe Lab.jsp web page with the query results to the researchers' browser (refer to Fig. 7).



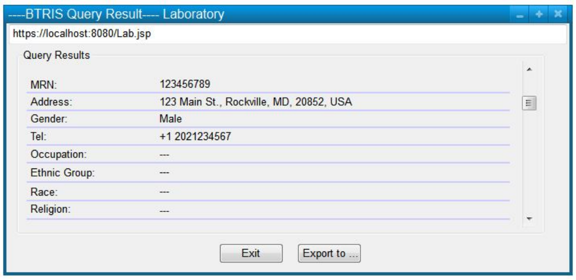
```
<struts>
  <action name="queryAction"
    class="com.query.struts2.action.QueryAction">
 <result name="Lab">Lab.jsp</result>
 <result name="Pathology">Pathology.jsp</result>
 <result name="Demographic">Demographic.jsp</result>
 </action>
</struts>
```

Fig 5.struts.xml



```
................
................
public String execute(){
 if (queryType="Lab" && .......){
HL7API.LabQuery(String[]);
     return Lab;
 }else
 If (queryType="Pathology" && .......){
     HL7API.PathologyQuery(String[]);
     return Pathology;
 }else
 if (queryType="Demographic" && .......){
```

Fig 6.queryAction.java



----BTRIS Query Result---- Laboratory

https://localhost:8080/Lab.jsp

Query Results

MRN:	123456789
Address:	123 Main St., Rockville, MD, 20852, USA
Gender:	Male
Tel:	+1 2021234567
Occupation:	---
Ethnic Group:	---
Race:	---
Religion:	---

Fig 7.Lab.jsp query results

CONCLUSIONS

In order to decrease the learning curve of the BTRIS HL7 query message for clinical researchers, this study developed an IDR query web application (IQWA), which provides a friendly user query interface to query the BTRIS by HL7 message more efficiently.The IQWA triggersthe business logic to generate corresponding BTRIS HL7 query message by using the query parameters from the user query interface.

To integrate the previous research end product (the HL7 API) to IQWA for the user interface to generate the BTRIS HL7 query message, we adopted the MVC design pattern. The IQWA has a user query interface for clinical researchers to submit the query criteria. The navigation logic of the Controller module takes responsibility of triggering the data access business logic on the Model module by using the query criteria, and presenting the query results on the View module to the researchers' browser. The future work of this research should focus on the semantic mapping to different clinical terminology system, e.g., to map LOINC and SNOMED to RED, to see how itcould increase the data reusable capability.

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