

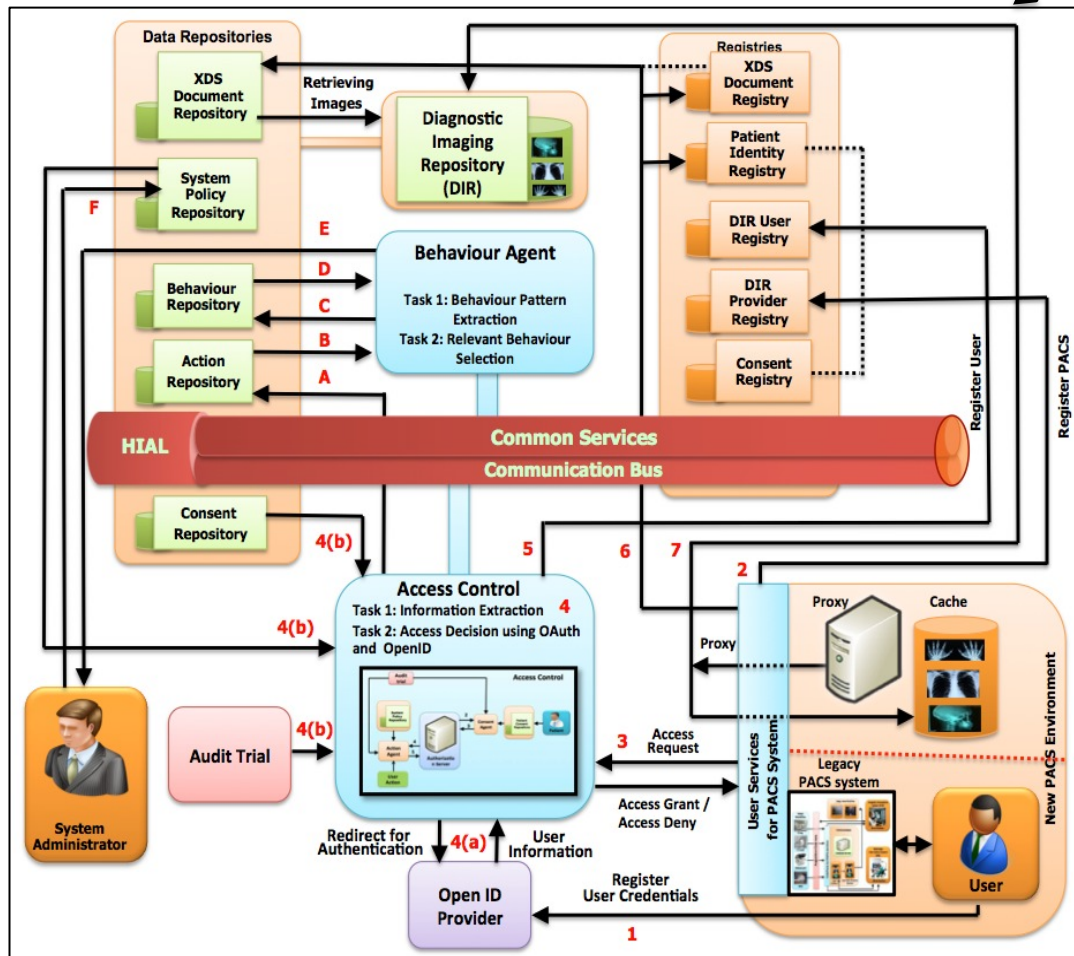
IBM Rhapsody Simulation of Distributed PACS and DIR systems

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System Architecture

All Registries and Repositories are represented in **MySQL DB**

System Behavior is simulated using **Rhapsody**



Retrieving Images using XDS-I Technology

Authenticating and Authorising the user using OpenID and OAuth technologies respectively

Main functionalities of the system

- Each PACS is integrated with the **common infrastructure** for **access control**
- PACS users are **authenticated** against the common infrastructure using **OpenID protocol**
- Access to patient medical images within the DIR is controlled based on **consent directives** and other user **access controls policies** defined in the common infrastructure
- Images are retrieved by using **XDS-I profile** proposed by IHE

Thesis Contribution

Simulation in Rhapsody to verify the following functionalities of the system:

1. User Authentication using **OpenID**
2. Looking into the consent repository to make **consent decision**
3. Based on the consent decision, looking into the **system security policy** to make authorisation grant decision
4. Once the user is granted access permission, retrieving the image details from **XDS document registry** and **XDS document repository** and later access the image from **DIR**

Thesis contribution contd..

5. Limiting the number of access allowed for a user per day

Scenario : Initially we set a threshold value to 3

Each time the user sends access request to the system, attribute values submitted by the user is recorded in MySQL Database.

If the system finds that the user is trying to access the same image of the same patient for more than 3 times a day, system will deny the user from further accessing the image.

Thesis contribution contd..

6. Tracking the behavior of the user from the access pattern

Scenario :

The system keep track of the access requests made by the user. We analyze the data recorded for a period of time (a week or two) in the MySQL DB

We find out the most frequently occurred attribute values in the tuple to figure out the behavior of the user

Overview of Rhapsody Tool

- Rational Rhapsody **implements solution from design diagrams**
- Automatically **generates code** that is optimized for target environment and thereby help the user to analyze the intended **behavior** of the application
- In Rhapsody we can draw UML diagrams that provide Structure and Dynamic behavior views of the system

Structure views:

Use case diagram

Object model diagram

Structure diagrams

Component diagram

Deployment diagram

Dynamic behavior views:

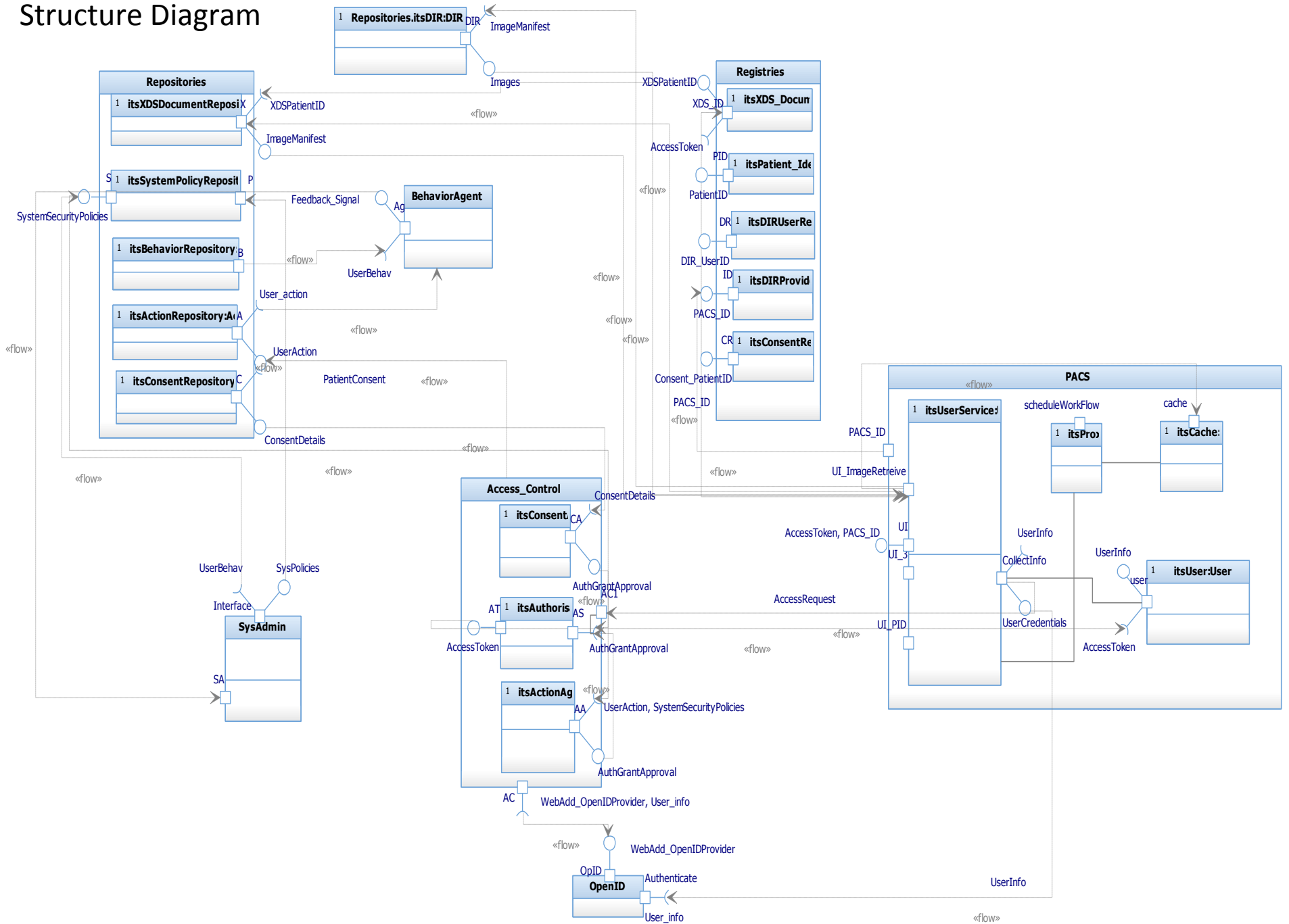
Statechart

Activity diagram

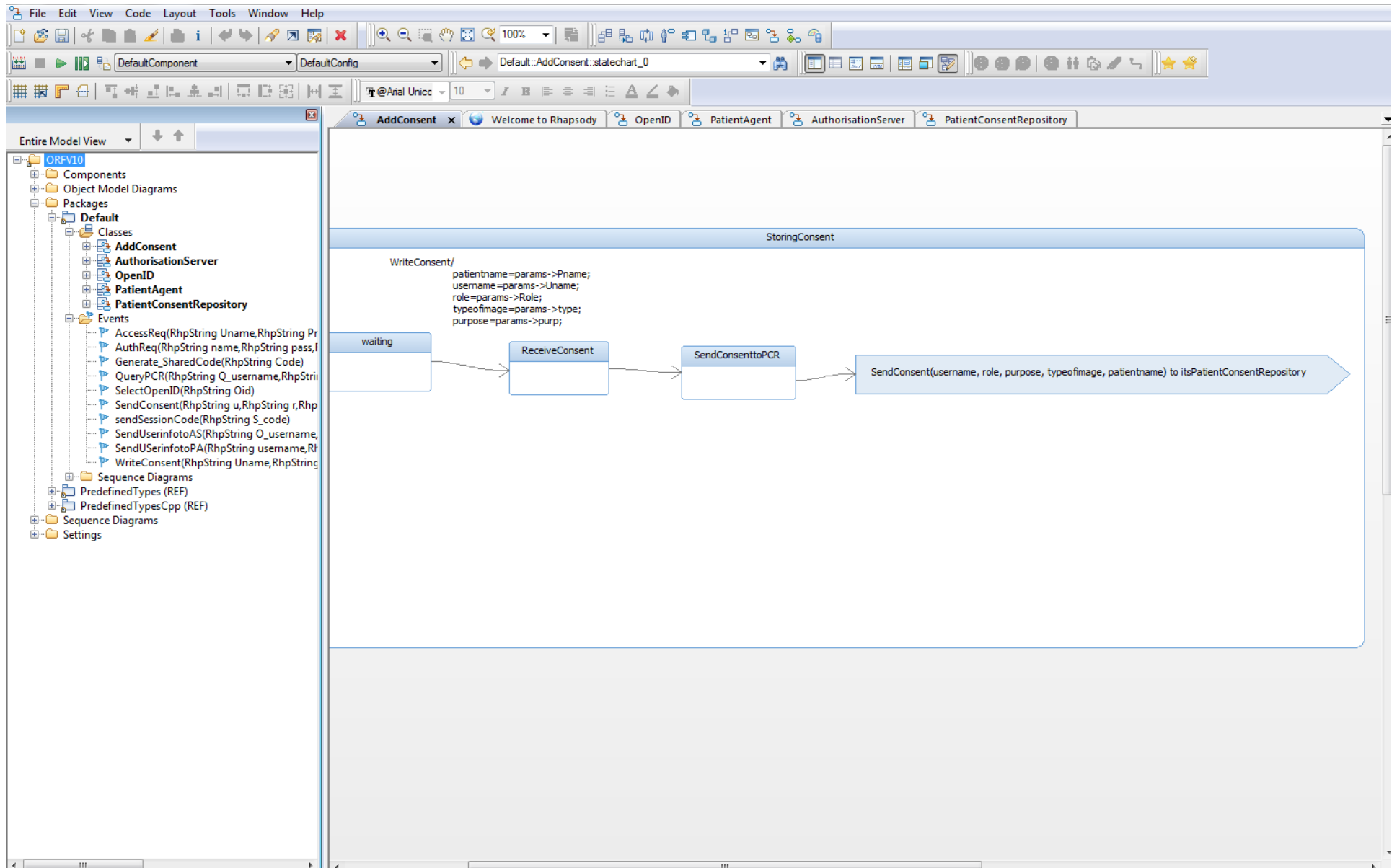
Sequence diagram

Collaboration diagram

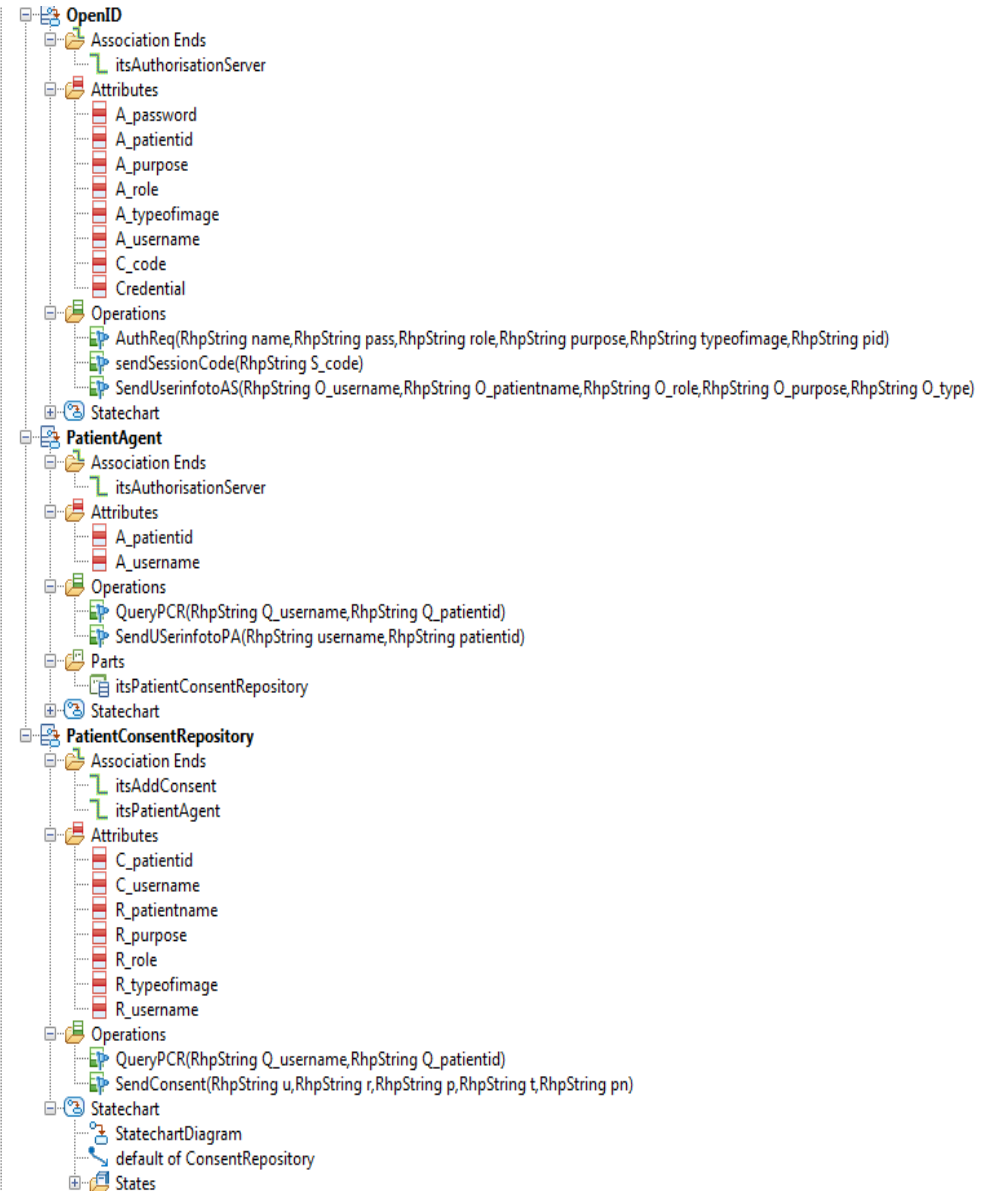
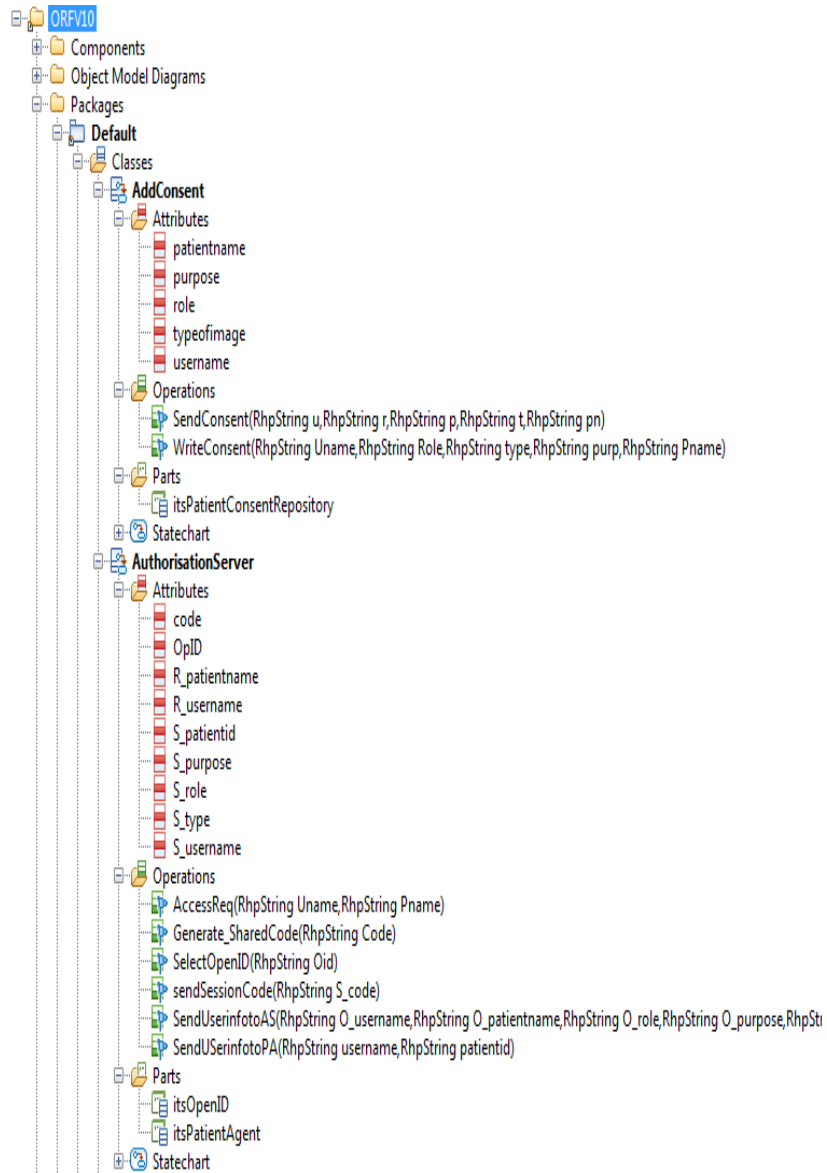
Structure Diagram



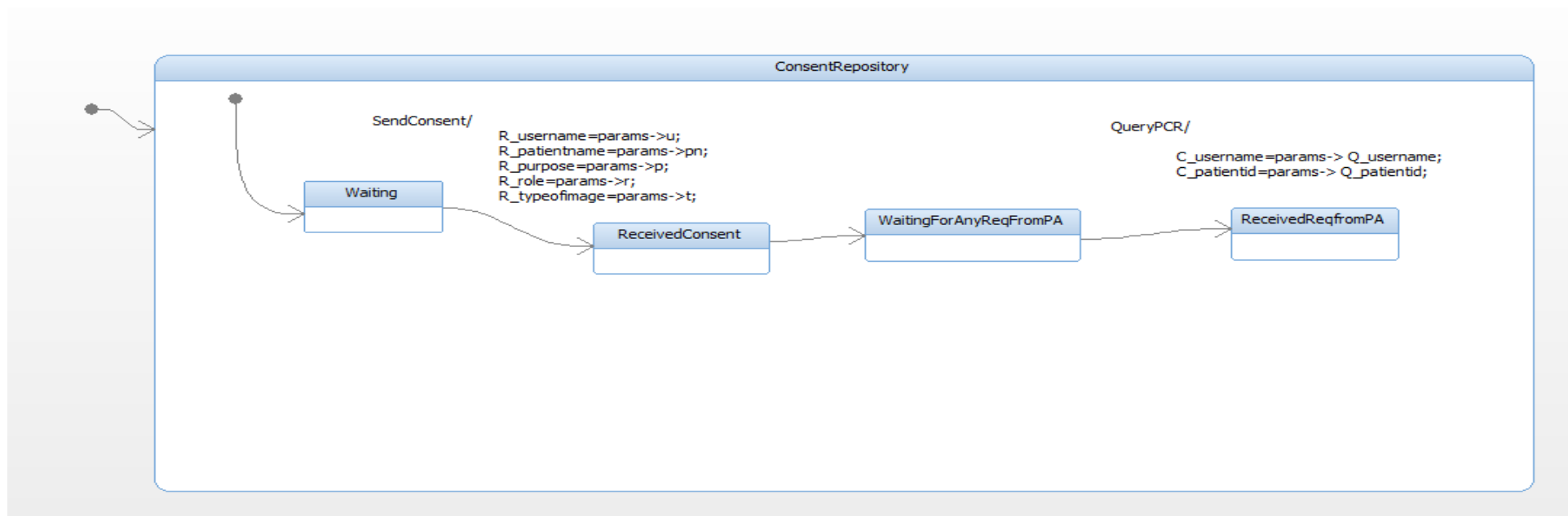
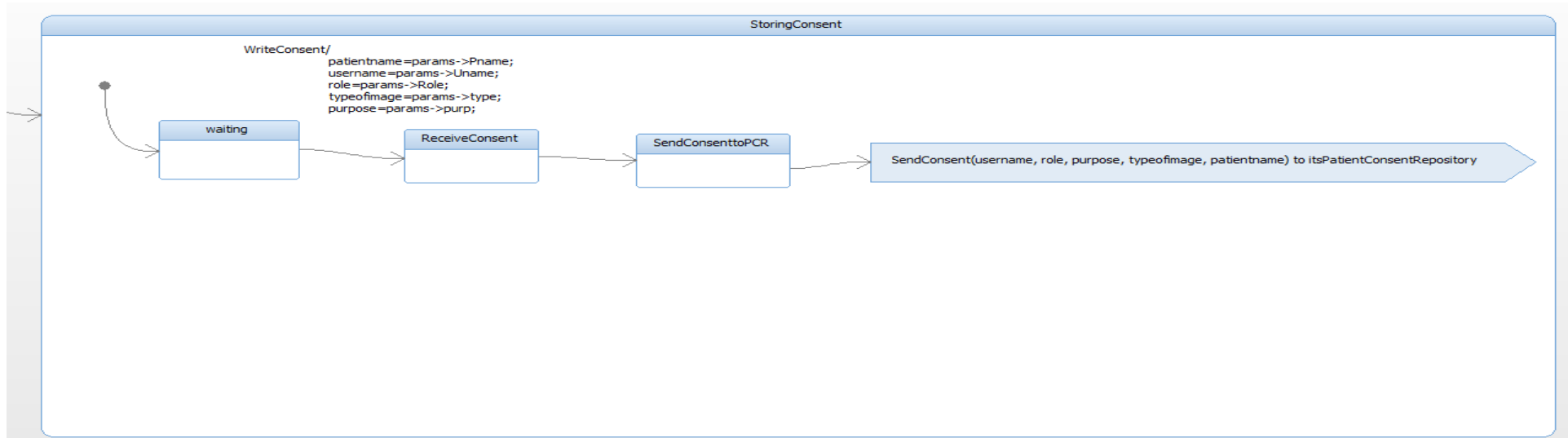
Rhapsody working Environment



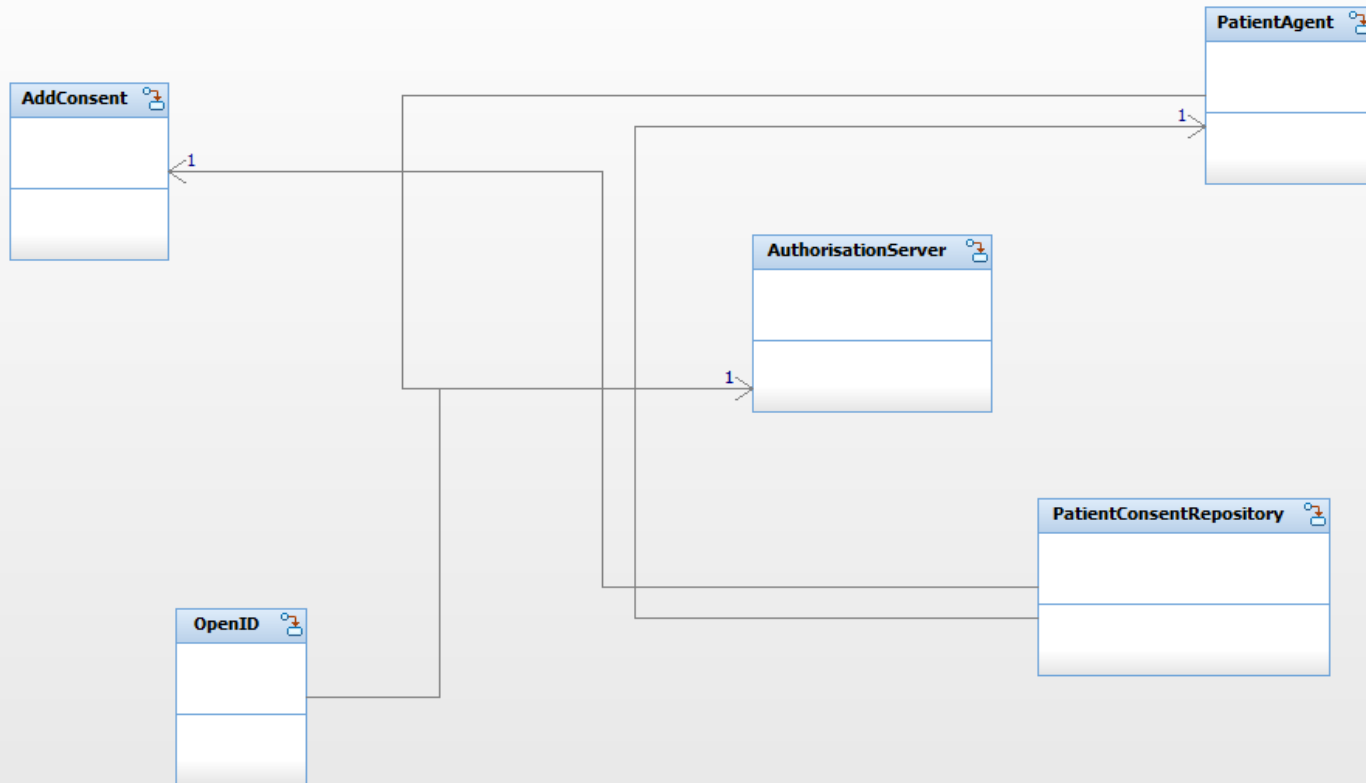
Rhapsody Browser



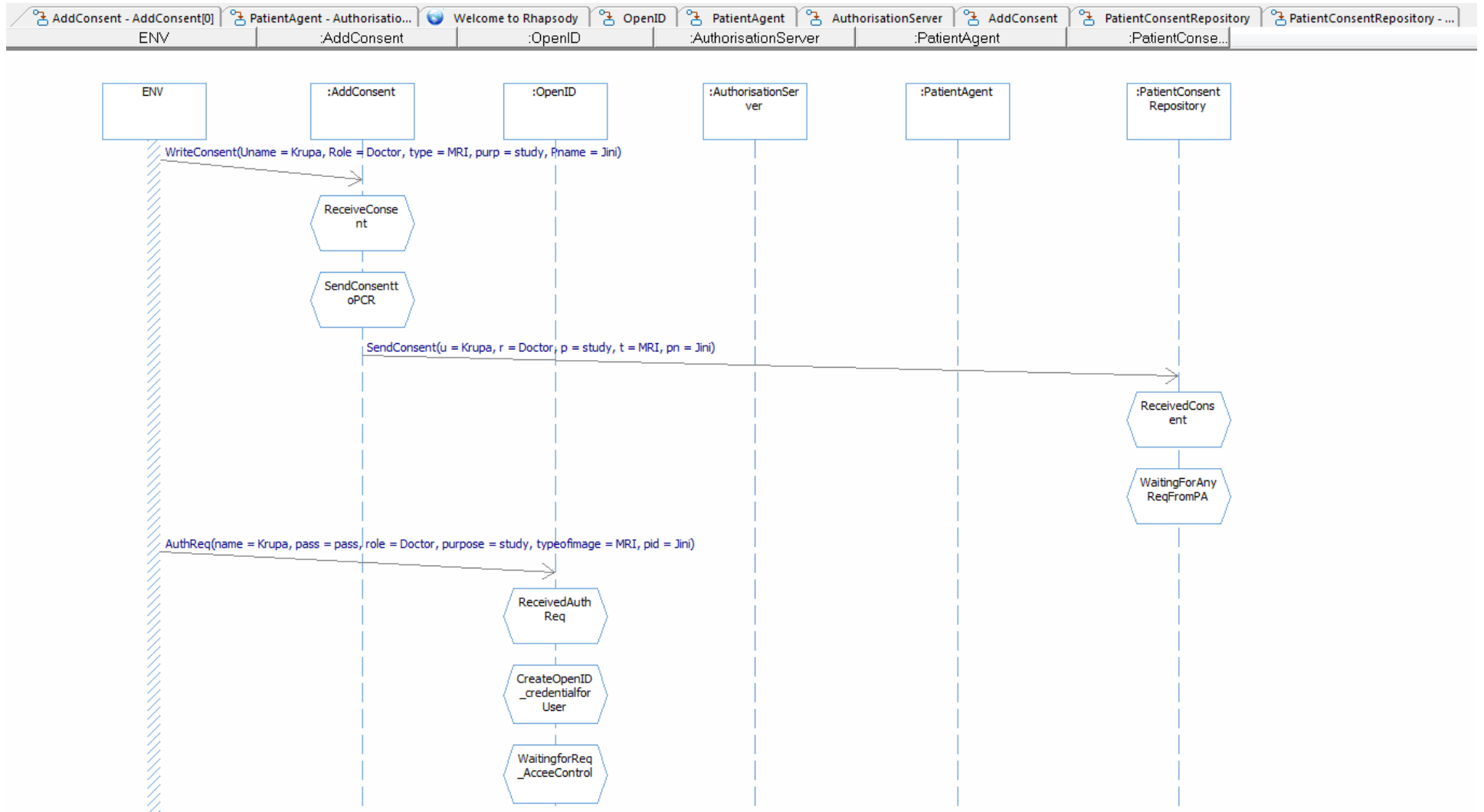
Example to show Classes and associated State Chart



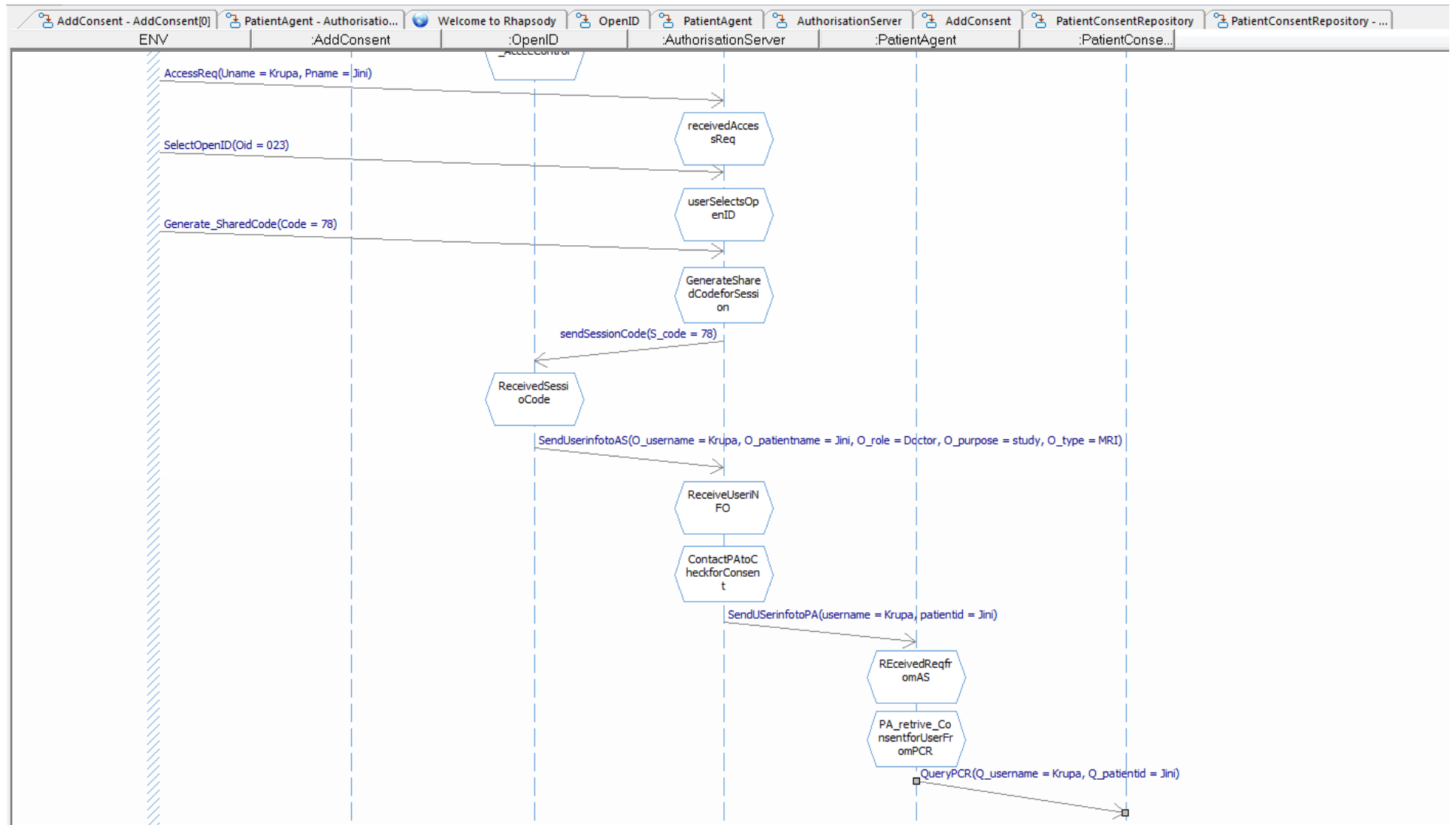
Object Model Diagram



Sequence Diagram

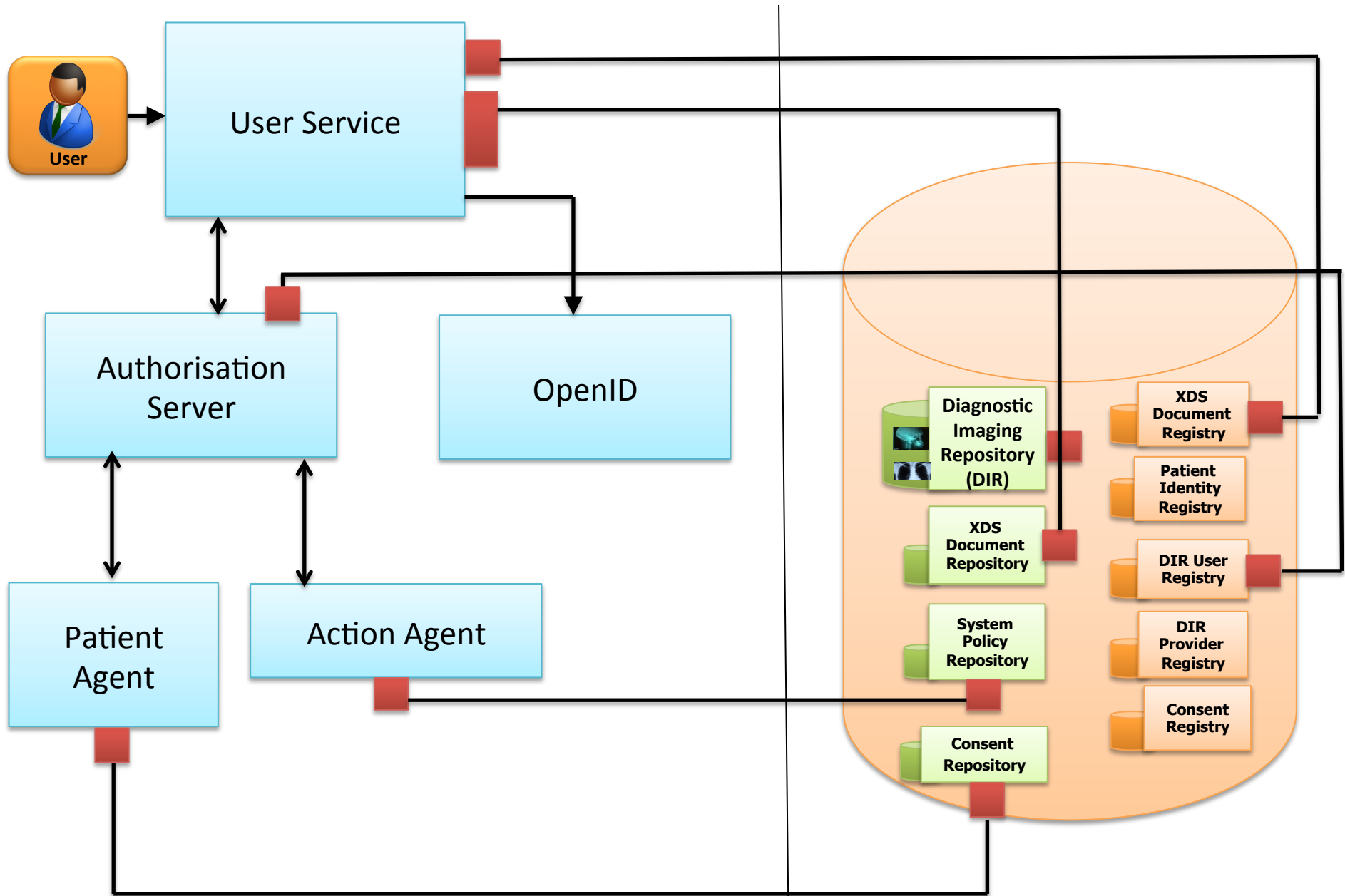


Sequence Diagram Continued



Current Status of Thesis

- Recreating the state chart in Rhapsody **Java Version**
- Creating **classes and associated state charts** for the major modules in the architecture
- Creating API using **Java codes** to connect Rhapsody with the all registries and repositories in **MySQL Database** to do the necessary functionalities of the system

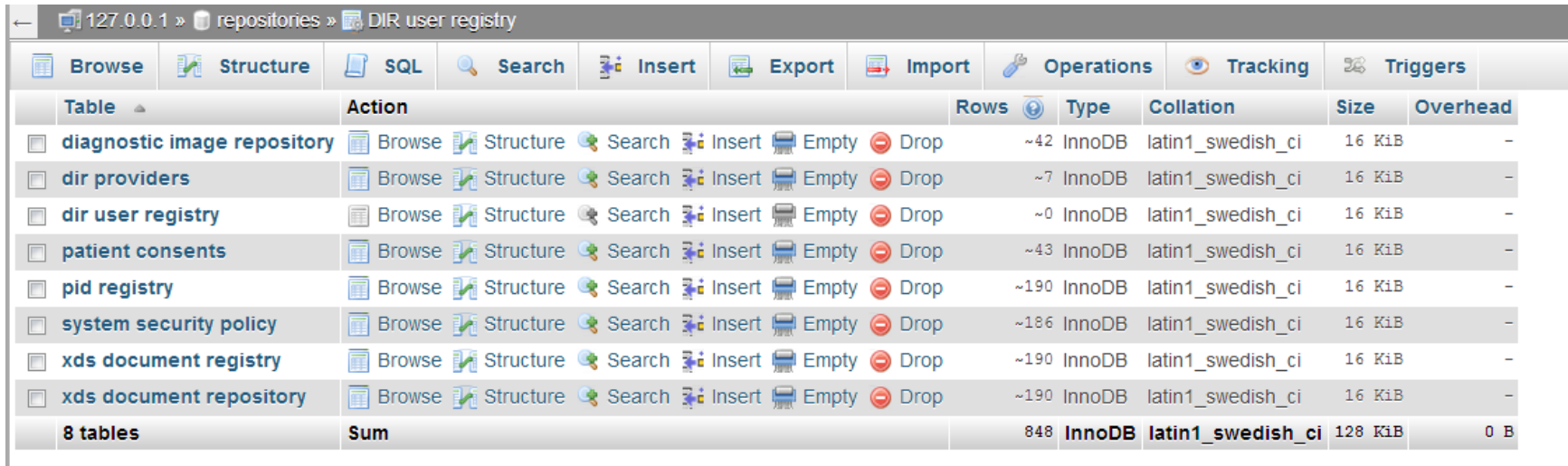


Rhapsody Classes

■ DB connections

MySQL Database

MySQL Database : repositories



The screenshot shows the MySQL Enterprise console interface. The breadcrumb navigation at the top indicates the path: 127.0.0.1 » repositories » DIR user registry. Below the navigation are several tabs: Browse, Structure, SQL, Search, Insert, Export, Import, Operations, Tracking, and Triggers. The main area displays a table list with columns: Table, Action, Rows, Type, Collation, Size, and Overhead. The table list includes eight tables: diagnostic image repository, dir providers, dir user registry, patient consents, pid registry, system security policy, xds document registry, and xds document repository. A summary row at the bottom indicates there are 8 tables in total, with a total of 848 rows, InnoDB engine, latin1_swedish_ci collation, and a total size of 128 KiB.

Table	Action	Rows	Type	Collation	Size	Overhead
diagnostic image repository	Browse Structure Search Insert Empty Drop	~42	InnoDB	latin1_swedish_ci	16 KiB	-
dir providers	Browse Structure Search Insert Empty Drop	~7	InnoDB	latin1_swedish_ci	16 KiB	-
dir user registry	Browse Structure Search Insert Empty Drop	~0	InnoDB	latin1_swedish_ci	16 KiB	-
patient consents	Browse Structure Search Insert Empty Drop	~43	InnoDB	latin1_swedish_ci	16 KiB	-
pid registry	Browse Structure Search Insert Empty Drop	~190	InnoDB	latin1_swedish_ci	16 KiB	-
system security policy	Browse Structure Search Insert Empty Drop	~186	InnoDB	latin1_swedish_ci	16 KiB	-
xds document registry	Browse Structure Search Insert Empty Drop	~190	InnoDB	latin1_swedish_ci	16 KiB	-
xds document repository	Browse Structure Search Insert Empty Drop	~190	InnoDB	latin1_swedish_ci	16 KiB	-
8 tables	Sum	848	InnoDB	latin1_swedish_ci	128 KiB	0 B

System Policy defined for various participating “roles” and “hospitals”

User Role	Access for Diagnosis	Access for Discharge	Access to Modify	Access for Study	CT images	MRI	US images	X ray	SMH Server	RMC Server	SJH Server	HHC Server	RVHS Server	LRH Server
Physician	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Anesthesiologist	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cardiac electrophysiologist	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cardiologist	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cardiovascular surgeon	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Colon and rectal surgeon	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Critical care medicine specialist	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dermatologist	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Developmental pediatrician	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Diagnostic radiologist	1	1	1	1	1	1	1	1	1	1	1	1	1	1

XDS Document Repository

Patient Identifier	MRI Image availability	MRI Captured Location	Date_MRI	MRI Image No .	US Image availability	US Captured Location	US Date	US Image No	x ray Image availability	Loc xray capture	x-ray Date	x-ray image No	CT image availability	CT Captured location	CT Date	CT image no
1245	available	2389	01/04/2005	23	available	2390	12/12/2006	300	available	2366	10/06/2008	500	available	2366	04/08/2209	700
1250	available	2389	02/04/2005	24	available	2390	13/12/2006	301	available	2366	11/06/2008	501	available	2376	05/08/2009	701
1255	available	2389	03/04/2005	25	available	2390	14/12/2006	302	available	2366	12/06/2008	502	available	2376	17/06/2168	702
1260	available	2389	04/04/2005	26	available	2376	15/12/2006	303	available	2366	13/06/2008	503	available	2376	24/11/2147	703

DIR Provider Registry

Organisation code	system ID
SMH	2389
RMC	2376
SJH	2390
HHC	2366
RVHS	2345
LRH	2309

Patient Identity + Consent ID Registry

Patient Last Name	Patient First name	Health Card No	DIR Patient ID	Consent ID
Adhikary	Jessey	100491564	399491575	798983150
Ahsan	Adib	100479656	399479667	798959334
Alagarasa	Prasath	100317216	399317227	798634454
Alakeel	Abdullah	100445285	399445296	798890592
Alam	Muhammad	100498034	399498045	798996090
Anderson	William	100485632	399485643	798971286
Aranan	Archun	100505521	399505532	799011064
Ashar	Mihir	100506456	399506467	799012934
Ata	Charles	100488131	399488142	798976284
Athaide	Jonathan	100488471	399488482	798976964
Azevedo	Paul	100461439	399461450	798922900
Baig	Asad	100483458	399483469	798966938

XDS Document Registry

Patient Last Name	Patient First name	DIR Patient ID	Patient XDS ID
Adhikary	Jessey	399491575	1245
Ahsan	Adib	399479667	1250
Alagarasa	Prasath	399317227	1255
Alakeel	Abdullah	399445296	1260

XDS Document Repository (Contains Meta Data of Images)

Patient Identifier	MRI Image availability	MRI Captured Location	Date_MRI	MRI Image No .	US Image availability	US Captured Location	US Date	US Image No	x ray Image availability	Loc xray capture	x-ray Date	x-ray image No	CT image availability	CT Captured location	CT Date	CT image no
1245	available	2389	01/04/2005	23	available	2390	12/12/2006	300	available	2366	10/06/2008	500	available	2366	04/08/2209	700
1250	available	2389	02/04/2005	24	available	2390	13/12/2006	301	available	2366	11/06/2008	501	available	2376	05/08/2009	701
1255	available	2389	03/04/2005	25	available	2390	14/12/2006	302	available	2366	12/06/2008	502	available	2376	17/06/2168	702
1260	available	2389	04/04/2005	26	available	2376	15/12/2006	303	available	2366	13/06/2008	503	available	2376	24/11/2147	703
1265	available	2389	05/04/2005	27	available	2376	16/12/2006	304	available	2390	14/06/2008	504	available	2376	02/05/2127	704
1270	available	2389	06/04/2005	28	available	2376	17/12/2006	305	available	2390	15/06/2008	505	available	2376	08/10/2106	705
1275	available	2389	07/04/2005	29	available	2376	18/12/2006	306	available	2390	16/06/2008	506	available	2376	15/03/2086	706
1280	available	2389	08/04/2005	30	available	2376	19/12/2006	307	available	2389	17/06/2008	507	available	2376	21/08/2065	707
1285	available	2376	09/04/2005	31	available	2376	20/12/2006	308	available	2389	18/06/2008	508	available	2376	27/01/2045	708
1290	available	2376	10/04/2005	32	available	2376	21/12/2006	309	available	2389	19/06/2008	509	available	2376	05/07/2024	709
1295	available	2376	11/04/2005	33	available	2376	22/12/2006	310	available	2389	20/06/2008	510	available	2376	12/12/2003	710

DIR

Image ID	Image
23	Image 1
24	Image 2
25	Image 3
26	Image 4
27	Image 5
28	Image 6
29	Image 7
30	Image 8

1. Patient Consent Table -->

Patient Last Name	Patient First Name	Date of Birth	Healthcard Number	Last Name User	First Name User	UserID	Role	Location of Server	CT image	MRI	X ray	US image	Access for Diagnosis
Adhikary	Jessey	04-Apr-87	100485632	Roy	Jesse	100504769	Physician	SMH	1	1	1	1	1
Adhikary	Jessey	04-Apr-87	100485632	Ruchlemer	Isaac	100486175	Physician	RMC	1	1	1	1	1
Adhikary	Jessey	04-Apr-87	100485632	Russell	Brett	100504146	Nurse	SJH	1	1	1	1	1

Scenario

Access Request :

User : Jesse Roy

Role : Physician

Location: SMH

Patient Name : Adhikary Jessey

Date of Birth : 04-04-87

Health Card No: 100485632

Type of Image : MRI

Purpose : Diagnosis

2. System Policy

User Role	Access for Diagnosis	Access for Discharge	Access to Modify	Access for Study	CT images	MRI	US images	X ray	SMH Server
Physician	1	1	1	1	1	1	1	1	1
Anesthesiologist	1	1	1	1	1	1	1	1	1
Cardiac electrophysiologist	1	1	1	1	1	1	1	1	1
Cardiologist	1	1	1	1	1	1	1	1	1
Cardiovascular surgeon	1	1	1	1	1	1	1	1	1

3. XDS Document Registry

Patient Last Name	Patient First name	DIR Patient ID	Patient XDS ID
Adhikary	Jessey	399491575	1245
Ahsan	Adib	399479667	1250
Alagarasa	Prasath	399317227	1255
Alakeel	Abdullah	399445296	1260

5. DIR

Image ID	Image
23	Image 1
24	Image 2
25	Image 3
26	Image 4
27	Image 5
28	Image 6
29	Image 7
30	Image 8

DIR Provider Registry

Organisation code	system ID
SMH	2389
RMC	2376
SJH	2390
HHC	2366
RVHS	2345
LRH	2309

4. XDS Document Repository

Patient Identifier	MRI Image availability	MRI Captured Location	Date_MRI	MRI Image No .	US Image availability	US Captured Location	US Date	US Image No	x ray Image availability	Loc xray capture	x-ray Date	x-ray image No	CT image availability	CT Captured location	CT Date	CT imag no
1245	available	2389	01/04/2005	23	available	2390	12/12/2006	300	available	2366	10/06/2008	500	available	2366	04/08/2209	700
1250	available	2389	02/04/2005	24	available	2390	13/12/2006	301	available	2366	11/06/2008	501	available	2376	05/08/2009	701
1255	available	2389	03/04/2005	25	available	2390	14/12/2006	302	available	2366	12/06/2008	502	available	2376	17/06/2168	702
1260	available	2389	04/04/2005	26	available	2376	15/12/2006	303	available	2366	13/06/2008	503	available	2376	24/11/2147	703

Thank You