Freie Universität Berlin

SYNTHESYS

D 1.2 Develop authentication services for system access

REPORT

A documented operational component integrated in the system

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Abstract

This document contains the milestone report M22 of objective D1.2 of the project SYNTHESYS from the European Sixth Framework Programme. As agreed in annex I of the document "Description of work for SYNTHESYS" for contract number RII3-CT-2003-506117, this document reports about the following task:

- A documented operational component integrated in the system

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1 Preface

This document contains the milestone report M22 of objective D1.2 of the project SYNTHESYS from the European Sixth Framework Programme. As agreed in annex I of the document “Description of work for SYNTHESYS” for contract number RII3-CT-2003-506117, this document comprises of the following task:

- A documented operational component integrated in the system.

The start date of the project SYNTHESYS was February 1, 2004. The agreed duration for this deliverable amounts to twenty-two months. So the closing date for this deliverable is November 30, 2005. We started our work concerning this activity after the delivery of the milestone report M6 on August 01, 2004.

This document first gives an account about our activities regarding the scientific output of our work. Next, an overview of the milestone progression is presented. Subsequently, a documentation of the implemented software includes the system architecture, the user documentation and installation instructions.

Finally, this document closes in with a comparative discussion of the concepts elaborated in milestone M6 and the software realisation described in this document. Additionally, an outlook towards useful future development steps in is given.

2 Report

This section presents an overview of the scientific output and the progression of this milestone. Thus, the following sections report about the publications, presentations and milestone progression made within the context of this task.

2.1 Publications

We submitted papers to the following conferences:

Submitted at	Submission title
D-A-CH Security 2005 15/16 March 2005, Darmstadt, Germany, http://syssec.uni-klu.ac.at/DACH2005/	Designing XML Security Services for Biodiversity Networks
SICHERHEIT 2005 05-08 April 2005, Regensburg, Germany http://www.sicherheit2005.de	Integration of XML security services in a biodiversity information system

Regarding D-A-CH Security 2005, our paper has been published within the proceedings of the conference [TSL05].

Unfortunately, we have not been accepted at SICHERHEIT 2005.

2.2 Presentations

We used the following opportunities to present our project or report about the progression of our work:

Presented at	Presentation title
BITS - Berliner IT-Sicherheit 30. September 2004, Berlin, Germany, http://bits.informatik.hu-berlin.de/	XML-Sicherheitsdienste für das Netzwerk der Global Biodiversity Information Facility GBIF
Workshop GBIF-D-IT-Fachgruppe 28/29. October 2004, Berlin, Germany, http://132.180.63.25/GBIF-ITFG/Workshop_02/ws02vo91.html	XML Sicherheitsmechanismen für den Datentransfer in GBIF-D
GBIF-D Status Meeting 6/7.December 2004, Bonn, Germany, http://www.gbif.de/gbif- de/aktuelles/gbif-de/aktuelles/statusseminar_04	XML-Sicherheitsmechanismen
TDWG-Meeting 2005 11-18 September 2005, St.Petersburg, Russia, http://www.tdwg.org/2005meet/TDWG_2005_Intro.html	Access rights management and access control for BioCASE

Additionally, we have been previewed as backup-referent at:

Backup referent at	Presentation title
D-A-CH Security 2005 (15/16 March 2005 in Darmstadt, Germany, http://syssec.uni-klu.ac.at/DACH2005/)	“Designing XML Security Services for Biodiversity Networks”

Finally, we presented the software implementation as computer demonstration at:

Computer demonstration at	**Presentation title**
TDWG-Meeting 2005 11-18 September 2005, St.Petersburg, Russia, http://www.tdwg.org/2005meet/TDWG_2005_Intro.html	Access rights management and access control for BioCASE

2.3 Milestone Progression

Beginning at 01 August 2004, we passed into the first software design and development phase. The objective was the development of a minimalist, but continuous and working prototype to demonstrate the general feasibility of the requested access control and rights management components. With the end of December 2004, we reached a proof of concept state confirming the general feasibility of authentication, access control and access rights management within the BioCASE scenario.

Starting in January 2005, we developed a first prototype of the authentication and rights management service components and presented and discussed the solution at the BGBM with Markus Döring and Anton Güntsch on 06 April 2005. As a result, we agreed about a feature list regarding the requirements of the final version.

Furthermore, we agreed to present a demonstrator of the solution, integrated in the current BioCASE provider software, at the TDWG 2005 Meeting from 11 to 18 September 2005 in St.Petersburg, Russia. The implementation of the demonstrator was successfully presented within two computer demonstration sessions at the TGWG 2005 meeting.

Since the end of the meeting, we act on some suggestions got from demonstration attendees and worked on further improvements regarding the system configurability and the flexibility of the specification of access rights policies. The current state is delivered as final version of the software implementation.

3 Software Documentation

3.1 System Architecture

The system architecture bases on the preconditions and concepts already described within our first milestone report [TSL04]. Thus, the solution builds up on the current BioCASE provider infrastructure as for general access. Our concept developed during the last milestone, envisaged to locate the BioCASE provider logically behind the authentication and access control component to be implemented. The goal of this approach is that the client continues to drive the provider application with his web browser as before and that the provider software is subject to minor changes only. Additionally, the solution uses current XML security standards. The eXtensible Access Control Markup Language (XACML) [MOS05] was figured out to be suitable for access control. Furthermore, an X509 Public Key Infrastructure (PKI) [IET05] is drafted to fit the requirements of a mutual authentication between clients and providers.

During the implementation of the first prototype, it turned out that implementing the concept behind the Security Assertion Markup Language (SAML) [HM04], providing a single-sign-on authentication scheme to realise forwarding of client authentication information from one provider to another, is not only very complex to install for most providers, but exceed the available resources regarding its implementation. On this account, we decided to fall back to the second solution already proposed within the last milestone report, to use the Secure Socket Layer (SSL) [THE05a] to protect client-server communications.

Another unanticipated circumstance, turned out during the implementation phase, leads us to make minor modifications regarding our concept. We came to the point that the whole BioCASE provider application needs to be driven through the access control component, and not only the communication with the PyWrapper. Thus, we considered, that the access control component responds not only to requests originating from the client, but from the provider application also. Consequently, the communication protocol has been adopted, as such as requests are not redirected to the PyWrapper until the provider application recalls the access control layer at least for the second time after the request was initiated by the client first.

The next sections present an overview of the primary and the access control enhanced system architecture and describe the components working together to realise authentication and access control mechanisms for the BioCASE scenario. A more detailed description concerning the configuration and execution of these components can be found in section (see clause 3.3.1). The installation is described in section (see clause 3.4).

3.1.1 Overview

The starting point of the system architecture represents the current BioCASE scenario. Within this scenario, the client uses a common web browser to control a BioCASE application located at the provider's web server (see figure 1). This application communicates with the PyWrapper whenever access to the provider's Unit Database is required. Usually, the PyWrapper also runs on this web server.

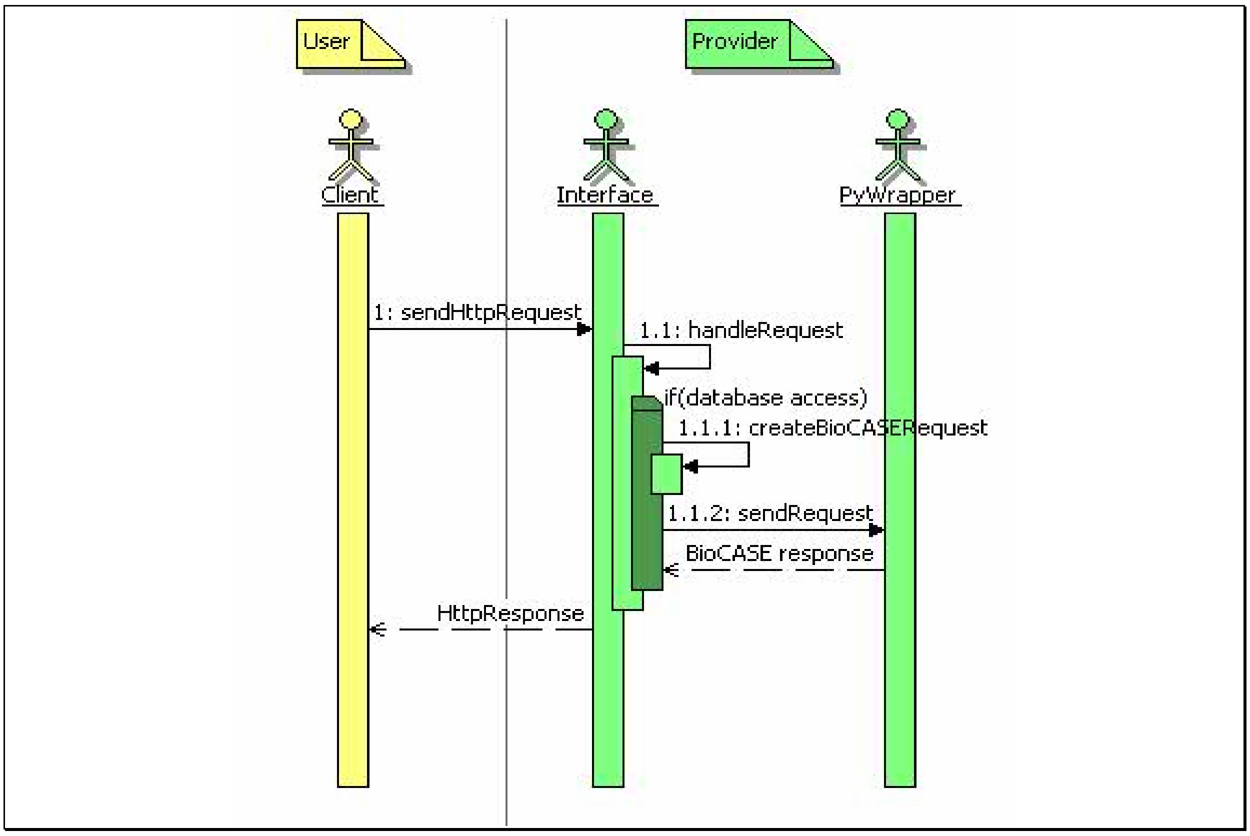


figure 1 Overview primary BioCASE protocol

To realise authentication and access rights management, an additional access control layer was introduced, filtering the communication between the client and the application. So, the filter acts like an, so called, application level firewall. This means, it scans the client-provider communication for relevant BioCASE protocol messages and evaluates correspondent access control policies defined according to the RBAC Profile of XACML v2.0 [AND05]. This may result in blocking client BioCASE requests completely or filtering out XML elements of the content of the provider's BioCASE response on a permitted client request. Any permitted request is redirected unchanged to the relating BioCASE provider host.

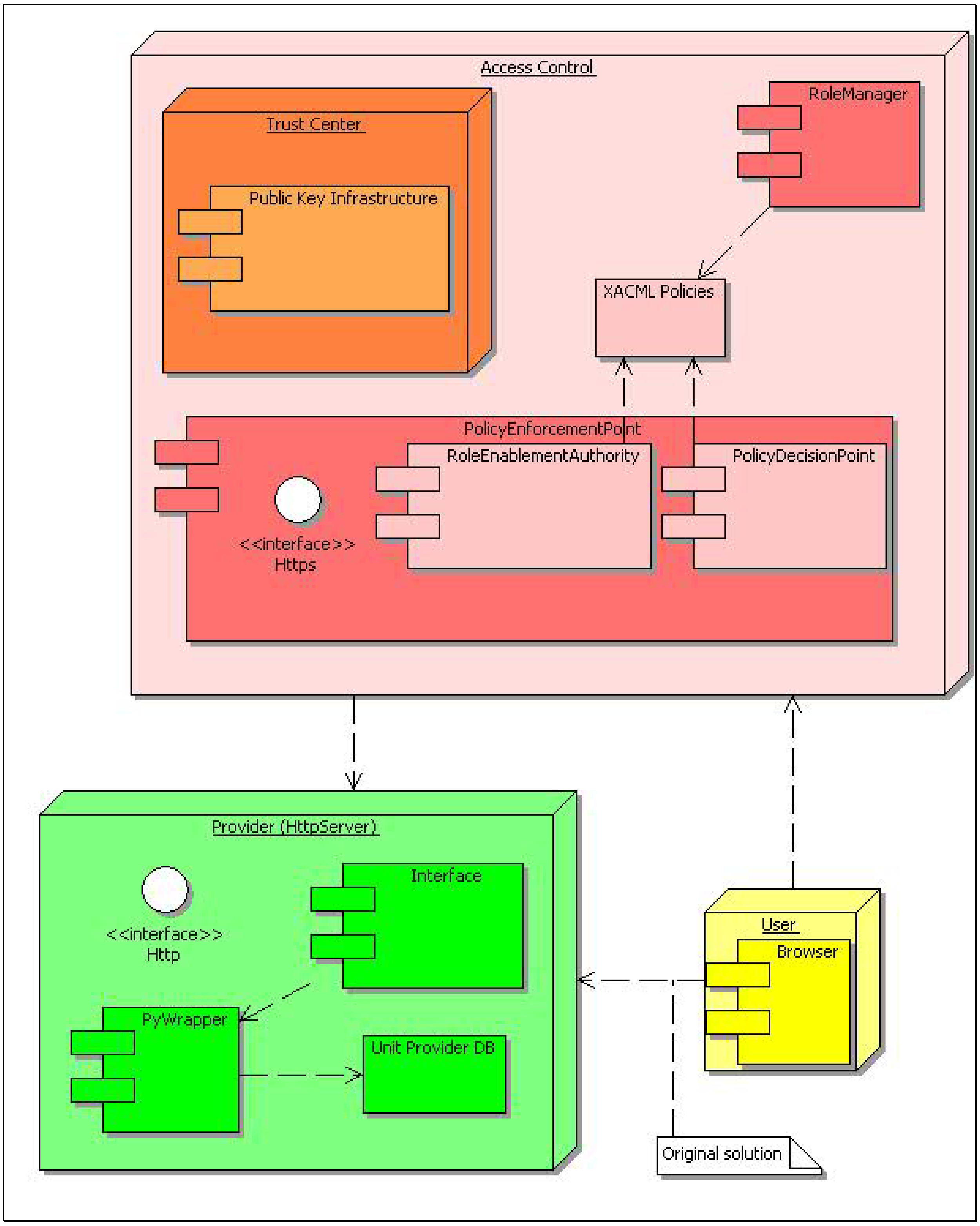


figure 2 Overview system components

Further, the implementation of the access control layer founds on several components sub dividable to handle the two main tasks authentication and access rights management (see figure 2). First, there is the Trust Center component responsible for the management of the Public Key Infrastructure (PKI). The main task of the provider's Trust Center is the issuance of certificates required for the mutual authentication between clients and servers. Second, the Policy Enforcement Point (PEP) realises the application level firewall functionality and enforces a set of XACML based role bases access control policies defined by the provider. To support system administrators managing these policies, the Role Manager component was introduced.

For security reasons, it is very important to emphasize, that it must be assured, that the provider's web server can not be reached from the internet or other unauthorised networks directly. The only access point to outside clients should be the Policy Enforcement Point. Otherwise, any of the measures to implement authentication and access control mechanisms may be bypassed easily by communicating with the provider application directly.

The implemented components are described in more detail in the following sections. To enlighten the interaction between these main components, the next paragraphs describe the main collaboration scenario. figure 1 and figure 3 illustrate the components interactions of the original BioCASE protocol and the access control enhanced system architecture described below.

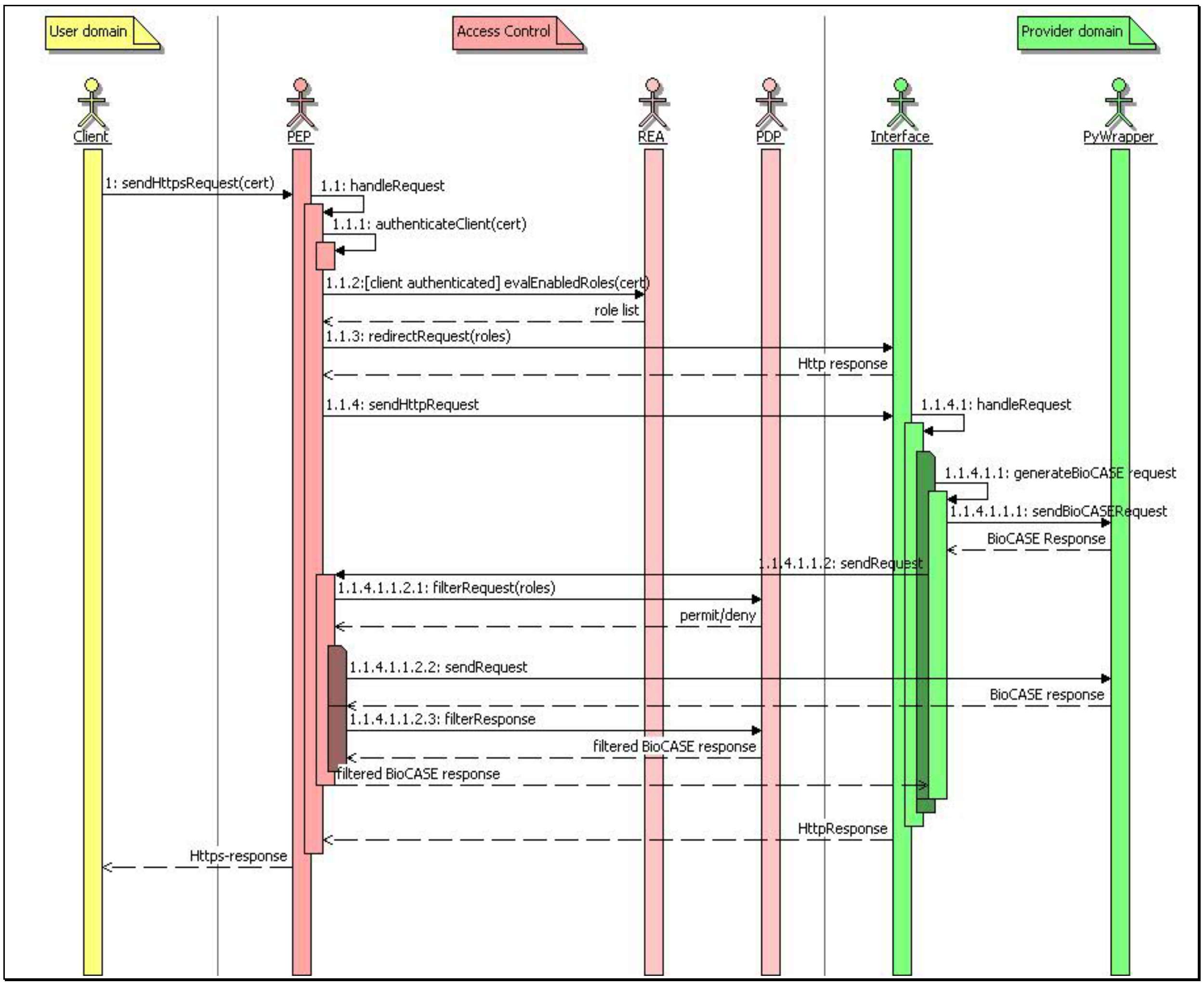

User domain
Access Control
Provider domain
Client
PEP
REA
PDP
Interface
PyWrapper
1: sendHttpsRequest(cert)
1.1: handleRequest
1.1.1: authenticateClient(cert)
1.1.2:[client authenticated] evalEnabledRoles(cert)
role list
1.1.3: redirectRequest(roles)
Http response
1.1.4: sendHttpRequest
1.1.4.1: handleRequest
1.1.4.1.1: generateBioCASE request
1.1.4.1.1.1: sendBioCASERequest
BioCASE Response
1.1.4.1.1.2: sendRequest
1.1.4.1.1.2.1: filterRequest(roles)
permit/deny
1.1.4.1.1.2.2: sendRequest
BioCASE response
1.1.4.1.1.2.3: filterResponse
filtered BioCASE response
filtered BioCASE response
HttpResponse
Https-response

figure 3 Overview access control enhanced BioCASE protocol

Within the original scenario (see figure 1) the user selects the URL of the provider's application web interface in his browser. Clicking on an interactive element, such as a button, he sends an Http-request to the web server, which is handled by the application interface. Whenever the request requires access to the provider's unit database, the interface creates an adequate BioCASE request and sends this request to the PyWrapper. The PyWrapper queries the unit database, builds the BioCASE response and sends this response back to the application interface. The application interface formats a web page from this response and returns the data to the client.

The starting point within the access control enhanced system architecture remains the same (see figure 3), except that the URL of the provider begins with "https". Furthermore, the client must import his certificate on his web browser. Otherwise, the PEP assigns to him the guest role, defining minimal access rights to the system only. In this scenario, the PEP, located at the provider's access control layer, receives the client request. Then, the PEP authenticates the client verifying its certificate got from the SSL handshake with the client browser. If the client can not be authenticated, then the PEP also assigns to him the guest role. When the client is authenticated, the PEP requests the Role Enablement Authority (REA) subcomponent, to evaluate all roles enabled for this client within the Role Assignment policies defined by the provider's system administrators. Then, the PEP adds this list of client roles and the internal URL of the PEP as parameters to the original client request and forwards it to the provider's application interface. The application interface proceeds the request as described for the primary BioCASE scenario. If the interface needs to access the PyWrapper, then the interface uses the URL received as request parameter from the PEP before. So, the Interface connects to the PEP and sends the generated BioCASE request to him. When no database request is required, then the application interface responds the request from the PEP as described for the primary BioCASE scenario and the PEP returns this response to the client.

When the PEP receives a request for the PyWrapper, its PEP subcomponent evaluates this request using the role list evaluated before (appended to the request from the interface as additional Http-request parameter). The Policy Decision Point (PDP) evaluates the BioCASE request against the defined XACML Role Permission policies for each of the evaluated roles. If the request is permitted for one of these roles, the PDP returns a permit decision to the PEP. If the request is denied, then the PEP creates a BioCASE error response and returns this response to the application interface.

Otherwise, the PEP forwards the BioCASE request unchanged to the PyWrapper. Then, the PyWrapper's BioCASE response is evaluated against the defined XACML Role Permission policies also. If the PDP denies the access to any of the sub elements or element attributes of the content of the BioCASE response, then the PDP also eliminates this element (and all its attributes and sub elements) or the attribute from the content element of the BioCASE response respectively.

Finally, the BioCASE response filtered by the PDP is returned to the provider's application interface, which proceeds the response as normal. The application interface returns its final Http-response to the PEP returning this final response directly to the client.

3.1.2 Components

The following sections describe the components presented in the overview in more detail, such as the

- BioCASE Provider
- Public Key Infrastructure
- Web Browser
- RoleManager
- Policy Enforcement Point

3.1.2.1 BioCASE Provider

To support the access control enhancements, the original BioCASE scenario [BIO05] has been subject to some minor modifications already suggested above. The enhanced scenario should be supported in the provider software starting with version 2.31. This version has been implemented for the computer demonstration at the TDWG 2005 meeting in September 2005. The following paragraphs describe the required modifications.

First, the provider software must store the role list sent from the PEP included since the initial request forwarded to the application interface (see clause 3.1.1). The role list is sent within the Http-parameter *role*. The provider interface must include this parameter to any PyWrapper request (redirected to the PEP). This indicates to the PEP, that the request was initiated from the PyWrapper and intended for the PyWrapper.

Next, for the redirection of PyWrapper-requests initiated by the provider's application interface, the PEP uses the already defined Http-parameter *wrapperURL* for any *Http-POST* requests or *url* for any *Http-GET* requests respectively. For that, the PEP must be configured with its own (PyWrapper)-URL, such it can be connected from the internal network, i.e. the web server hosting the provider's application interface (see clause 3.3.1.2.3).

3.1.2.2 Browser

Within the BioCASE scenario, the web browser usually serves as graphical user interface enabling the client to interact with the provider software. To be suitable for the enhanced access control environment, the client's web browser must support the Https-protocol (e.g. Mozilla Firefox [MOZ05], Microsoft Internet Explorer). Furthermore, the user must install its own X509 certificate and, to verify the authenticity of the provider host, the certificate of the provider. Both certificates should be available from the provider's Trust Center.

3.1.2.3 Trust Center

The main task of the provider's Trust Center is reliable authenticity management. Therefore, the Trust Center ensures the authenticity of entities by generating key pairs and issuing certificates for these entities. With the issuance of certificates (see clause 3.3.2), it guarantees that the owner of the corresponding private key is the entity described within the certificate's attributes. The Trust Center must also ensure to hand out the related private key to the correct entity. An entity may be a person, like a system user, but may also be a system, such as the provider's Policy Enforcement Point.

Usually, a Trust Center provides further information services allowing to query for certificates of given entities or to provide information about the current state of a certificate (valid, revoked, and expired) [SS04]. But in the current scenario, the Trust Center just serves as a secure user or server registry on behalf of the provider. So, it creates key pairs for registered clients and server hosts of this provider and issues the corresponding certificates. Then it ensures to hand out the key pairs and certificates to their correct owners, i.e. the registered system user or the server administrator respectively. Finally, the provider has to publish the relevant server certificates, such as to make possible to authenticate the provider servers to the client. For that, the client just has to install its private key and certificate, and the server certificates within its security enabled web browser (e.g. Firefox, Internet Explorer).

This project provides a basic Trust Center solution based on the OpenSSL project. The implemented Public Infrastructure should be suitable not only for single providers, but for providers belonging to the same security domain or hosting multiple provider databases also. The solution should be extensible to more complex infrastructures. Very useful information about the construction of Public Key Infrastructures gives [DFN00]. The following section shortly describes the provided Public Key Infrastructure.

3.1.2.3.1 Public Key Infrastructure

The Public Key Infrastructure bases on the X.509 standard [IET05] and realises the mutual authentication between client and provider within the Policy Enforcement Point of the Access Control Layer using the Secure Socket Layer (SSL) protocol. Every X.509 PKI founds on a Root Certification Authority (RootCA), which must be at the same time the most trustworthy and most secured entity in the whole security infrastructure. The RootCA provides certificates for Registration Authorities (RA) thus enabled to issue certificates for users or servers. We established two RAs: a ServerCA, issuing certificates for provider servers and a UserCA issuing certificates for users. Both issue certificates on request of the provider administrators, when a new provider host shall be setup, or the provider's system administrators, when they register a new client. The following figure illustrates the hierarchy of the demonstration scenario, where keys and certificates for one provider and three clients were issued. As stated above, this infrastructure may be easily extended to support several provider or providing hosts and the addition of an arbitrary amount of users. The definition of roles and the assignment of users to these roles bases on the issued X509 user certificates and is supported by the RoleManager tool.

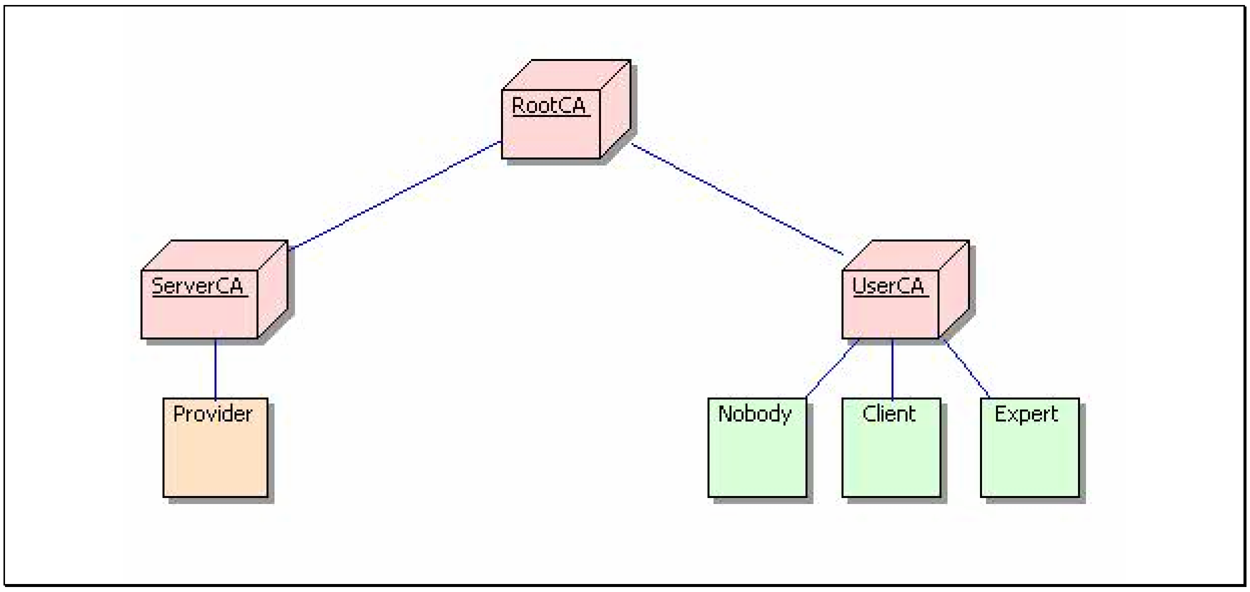


figure 4 Public Key Infrastructure

3.1.2.4 RoleManager

The RoleManager is a small command line application permitting the

- definition of roles
- assignment of users to roles
- definition of permission policies
- assignment of permission policies to roles
- definition of permissions
- assignment of permission to permission policies

The RoleManager supports the provider's system administrators to manage and configure an adequate XACML policy hierarchy according to the XACML Role Based Access (RBAC) profile [AND05]. The detailed commands and parameters are described in clause 3.3.3. The policies defined with the RoleManager are stored as XML files in a special configuration directory on the file system (see clause 3.3.1.1). Configured with the same policy directory location, the Policy Enforcement Point (PEP) and its subcomponents Role Enablement Authority (REA) and Policy Decision Point (PDP) evaluates the enabled roles or access rights for a given action and resource from these policy files respectively.

3.1.2.5 Policy Enforcement Point

As its name suggests, the Policy Enforcement Point (PEP) represents the system entity enforcing authentication and access control on behalf of a given provider. Thereby, the PEP becomes the only access point to the provider's application interface and/or PyWrapper respectively.

To realise the authentication, the PEP accepts all incoming requests on behalf of the provider using the SSL-protocol (https). For the realisation of the Role Based Access Control, the PEP involves two subcomponents:

- Role Enablement Authority (REA)
- Policy Decision Point (PDP)

The REA's task is to evaluate a list of enabled roles for a given client identified by its X.509 certificate. The REA is a special instance of an XACML PDP, focusing on Role Assignment Polices only (see clause 3.3.3.1) and specifying user-to-role assignments. To process the request the REA requires a X.509 certificate. The REA evaluates all roles specified within the Role Assignment Policies and evaluates for each role, if this role is enabled for the client authenticated by the given X.509 certificate. Finally, the REA returns the resulting list to the requester, i.e. the PEP.

If the authentication of the client fails, then the PEP creates a role set containing the predefined role guest only.

The PDP's task is to evaluate access rights for a given set of roles, on a given resource with a given action. Therefore, the PDP just focuses on Role Policy Sets, referencing the Permission Policies defined for a given role (see clause 3.3.3.1). Permission Policies include of a set of Permissions specifying resources enabled for a given action. Thus, the same policies can be referenced from different roles.

Within the BioCASE environment, we have to distinguish request and response policies. Within request policies, resources are defined as paths to concepts, which may be subject of a scan or search request. Unlike request policies, resources are defined as paths to elements or attributes within the XML document included in the content sub element of a BioCASE response. Actions are defined on each of the specified BioCASE protocol method, such as *capabilities*, *scan* and *search*. To allow the definition of permissions for requests and responses, the suffixes "*-request*" or "*-response*" has to be appended to the method names within Permissions. So, the PDP needs at least a role, a resource and the related BioCASE request method to evaluate if access to the given request or a response content element may be granted or not.

After a successful client authentication, the PEP gets the client's certificate and queries the REA for the set of enabled roles. When receiving a request designated to the PyWrapper, the PEP analyses this BioCASE request and generates an evaluation request to the PDP with the role set evaluated by the REA as subject, the requested concept(s) as resource(s) and the request method as action. If the PDP permits the request, the PEP forwards the request to the PyWrapper. After receiving the BioCASE response from the PyWrapper, the PEP examines the resulting content document and creates an evaluation request to the PDP with the role set as subject and the response method as action for each element or attribute path in this content document. If the PDP does not permit the access to any of the content's sub elements, then the PEP eliminates this element and all its attributes and sub elements from the BioCASE response. If access is denied for an attribute, the PEP eliminates this attribute only. All access control decisions are reported in the Diagnostics of the BioCASE response.

More details about the integration of the PEP in the BioCASE protocol have been described in the clause 3.1.1).

3.2 System Requirements

The following sections include an overview of the system requirements needed to install and run the software. Currently the following third party or open source components are indispensable to run the system:

- Java Runtime Environment (Version 1.4.2)
- OpenSSL
- Ant
- bash-shell

The Java section also contains a list of open software projects, which libraries have been used to implement the system.

3.2.1 Java Platform

The software implementation builds up on the Java 2 Platform, Standard Edition (J2SE) Version 1.4.2 [SUN05a]. The current release number is 10. Furthermore, the Java Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy Files 1.4.2 are required, enabling to use third party JCE provider on the Java Platform.

The Java Platform is available for all popular Windows, Linux and Solaris operating systems. Using the Java Platform, the software implementation uses the following open source third party software components:

- Bouncy Castle JCE provider[TAU05]
- Sun’s XACML Implementation[SUN04]
- Jetty Java Http Servlet Server [MOR05]
- Apache Jakarta Subproject Commons [THE05b] components:
  - CLI
  - Collection
  - Configuration
  - IO
  - Lang
- Log4j project [APA05]

See the installation guide (see clause 3.4) for further information.

3.2.2 OpenSSL

The OpenSSL Project [THE05a] offers an Open Source implementation of the Secure Sockets Layer (SSL)/Transport Layer Security (TLS) protocol and a general purpose cryptography library. OpenSSL is used in this system to provide the Trust Center functionality such as the generation of Public Key pairs and X.509 certificates.

Binary distributions of OpenSSL are included in most popular Linux distributions and for Microsoft Windows. During the implementation of this system, the OpenSSL package included in Cygwin (see clause 3.2.3) was used to build up a test PKI. In the course of the development, some a basic OpenSSL configuration has been developed, supporting the creation of the PKI (see 3.3.2).

3.2.3 Cygwin

Cygwin is a Linux-like environment for Windows providing a collection of useful Linux/Unix tools like the bash-shell or the OpenSSL package [RED05]. The software distribution contains some useful bash-scripts to install the software and run the PEP and RoleManager application. Thus, the software should run under the Windows Operating System, it could be time-saving to start working with Cygwin first.

3.2.4 Ant

The Apache Ant Project [THE05c] provides a Java-based build tool. Ant is used within this project to

- compile a distribution zip-file
- compile the distribution’s source code
- generate the JavaDoc-based developer documentation from the distribution’s source files
- install the software from the unzipped distribution

It is quite comfortable to use ant from the eclipse platform IDE [ECL05]. Please, refer to the project pages for current installation instructions.

3.2.5 BioCASE Provider

Of course, to see the system working, a BioCASE provider is needed. The system should cooperate with the BioCASE provider version 2.3.1 [BIO05]. This is the version used for the computer demonstration at the TDWG 2005 Meeting in September 2005. If the version is not available on the web page, please contact the BioCASE developers for support.

3.2.6 Web Browser

The web browser is required to drive the provider's application interface and manage the Public Key Pair of the client and the certificates of the provider host running the PEP during the authentication. The web browser of choice must support the https protocol, X.509-certificates and PKCS#12 key pair files. The software has been developed using the Mozilla Firefox Browser [MOZ05] and has been tested with the Microsoft Internet Explorer version 5.x or higher included in Windows XP.

3.3 User Documentation

This section of the document contains the user documentation of the implemented system components. It shall support system administrators to configure the software and define XACML policies. The documentation starts with a description of the configuration issues of the implemented components. Then it explains the policy management structures and shows how to set up the PKI using OpenSSL. Next it provides a user manual of the Role Manager component and concludes with a detailed description of the BioCASE system integration of the PEP.

3.3.1 Configuration (general)

The configuration of the RoleManager, the Policy Enforcement Point and the Role Enablement Authority is build up on the subproject Commons Configuration of the Apache Jakarta Project (http://jakarta.apache.org/commons/configuration/). The configuration consists of the file "config.xml" specifying the configuration objects to load. We decided to use an XML based configuration object, which is stored in an XML file to be configured within the attribute "fileName" of the element "xml" in the config.xml.

```
<?xml version=”1.0” encoding=”ISO-8859-1” ?>
<configuration>
     <xml fileName=”PEPconfig.xml”/>
</configuration>
```

Currently, there is no DTD or XML schema to describe the format, neither from the Commons Configuration project, nor from us. So, the relevant parameters will be explained in the configuration sections of the correspondent component. (see clauses 3.3.1.1, 3.3.1.2 and 3.3.1.3).

Generally, the root element is ignored, so the configuration of a component starts with its corresponding element name such as RoleManager, PolicyEnforcementPoint or RoleEnablementAuthority. The distribution's file PEPconfig.xml contains the configuration scheme for the example scenario (see clause 3.4.5).

3.3.1.1 RoleManager

The configuration largely represents the class architecture of the RoleManager's software architecture. The aim of the RoleManager's configuration framework is to keep the configuration of the RoleManager's components as flexible as possible. So, any of the particular components implementing classes may be interchangeable whenever wanted.

The RoleManager element has two attributes:

Attribute	Function
Class	The class of the RoleManager implementation to be loaded.
defaultDomain(required)	The default domain specifies the domain to be used, when the command line interface is invoked without the -D option.

Furthermore, the RoleManager element must contain a PolicyManager element described in clause 3.3.1.3.1.

As an example, look at the example RoleManager configurations delivered with this distribution (see also clause 3.4.5).

```
<RoleManager class=”nbi.xmlsec.xacml.profile.rbac.RoleManager”
defaultDomain=”biocase” >
     <PolicyManager class=”nbi.xmlsec.xacml.profile.rbac.PolicyManager”
policyBaseDir=”./policies”>
          <PolicyFinder>
               <PolicyFinderModule
class=”nbi.xmlsec.xacml.profile.rbac.finder.RBACPolicyFinderModule”
policyBaseDir=”./policies” >
                    <SuffixFileFilter>.xml</SuffixFileFilter >
               </PolicyFinderModule>
          </PolicyFinder>
      </PolicyManager>
</RoleManager>
```

If the specification of any class attribute is omitted, the implementation loads the default classes of this distribution. Anyway, for comfort reason you should define the default domain and the policyBaseDir within the PolicyManager element as default values. Otherwise, you will be forced to state the options *-D* and —`policyBaseDir` in every command invoked (see clause 3.3.3.2).

3.3.1.2 PolicyEnforcementPoint

The configuration largely represents the configurable objects of the PolicyEnforcementPoint’s software architecture. The aim of this configuration framework is to keep the configuration of the components as flexible as possible. So, any of the particular components implementing classes may be interchangeable whenever wanted.

The PEP element has one optional attribute:

Attribute	Function
Class	The class of the PEP implementation to load

Furthermore, the RoleManager element must contain a Filter element. The Filter implements the filtering of incoming requests and responses. Currently, this filter builds up on the HttpServer implementation of the Jetty Project [MOR05]. Thus, Jetty’s software architecture determines the items to be configured, such as

- Context path
- Listener
- Handler

The context path simply specifies the path on the HttpServer, where the PolicyEnforcementPoint is attached. The Listener waits for connections on a specific IP-address and port and needs SSL parameters to be specified. Finally, the handler processes the incoming Http- requests and responses and therefore sets up the Role Enablement Authority and Policy Decision Point used to grant access or not.

3.3.1.2.1 Context Path

The context path simply specifies the path on the HttpServer, where the PolicyEnforcementPoint to be attached. If the context path is set to "\", then the PEP is accessible on the root level of the server.

The ContextPath element has the following attribute:

Attribute	Function
Path	The path of the PEP on the server

3.3.1.2.2 Listener

The Listener awaits connections to the PEP. To do that, a host name and port number must be configured. The default scenario provides to use the SSL protocol for the authentication of users and to protect the connection against tampering. Therefore, the Listener contains a sub element SSL, where specific parameters such as a key store, containing the private key of the PEP, its type and passwords for the key and key store may be specified.

The Listener element has the following attributes:

Attribute	Function
class	The class of the Listener implementation to load
host	The PEP's host name
port	The PEP's port number

The Listener's SSL sub element has the following attributes:

Attribute	Function
needClientAuth	Yes or no. Signals if SSL client authentication is needed.
wantClientAuth	Yes or no. Signals if SSL client authentication is wanted.

Furthermore, the SSL element has the sub elements KeyStore and Key. The element KeyStore defines the key store, where the private key of the PEP is stored into. It has the following attributes:

Attribute	Function
file	The key store's file path
Type	The type of the key store (e.g. PKCS12)
password	The password needed to access the key store

The element Key only specifies the password for the PEP's private key.

Attribute	Function
password	The password needed to access the PEP's private key

Finally, the Listener's sub element ThreadPool allows to define the minimum and maximum amount of threads started by the Listener to serve requests. This can be configured with the following attributes:

Attribute	Function
minThreads	The minimum number of threads to be started
maxThreads	The maximum number of threads to be started

3.3.1.2.3 Handler

The handler proxies incoming Http-requests and responses and act's like an application level firewall by blocking requests and filtering the content of responses returned from the BioCASE provider. To communicate with the provider, the handler needs the URLs of the provider's application interface and database wrapper. This may be done within the sub elements Proxy and Wrapper.

The Handler's sub element Proxy has the following attributes:

Attribute	Function
url	The url of the provider's application interface

The Handler's sub element Wrapper has the following attributes:

Attribute	Function
url	The url of the provider's database wrapper

The sub elements RoleEnablementAuthority and PolicyDecisionPoint are largely configured by the specification of their classes and the configuration of their policy managers. Thus, both consist of the following attribute:

Attribute	Function
Class	The class of the RoleEnablementAuthority or PolicyDecisionPoint implementation to load respectively

Both include the sub element PolicyManager to configure the policies to be included within the policy evaluation processes. The configuration of the PolicyManager describes clause 3.3.1.3.1.

3.3.1.2.4 Example

As an example for the complete configurations of the PEP component, look at the PEP's example configuration part delivered with this distribution (see also clause 3.4.5).

```
<PolicyEnforcementPoint class="nbi.xmlsec.PEP">
  <Filter class="org.mortbay.http.HttpServer">
    <Context path="/" />
    <Listener class="org.mortbay.http.SslListener" host="localhost"
port="443">
      <SSL needClientAuth="false" wantClientAuth="true">
        <KeyStore file="./keystore.p12" type="PKCS12" password="provider"
/>
        <Key password="provider" />
      </SSL>
      <ThreadPool minThreads="5" maxThreads="100" />
    </Listener>
    <Handler class="nbi.xmlsec.PEPHandler" domain="biocase">
      <Proxy url="http://localhost:8080" />
      <Wrapper url="https://localhost" />
      <RoleEnablementAuthority
class="nbi.xmlsec.xacml.profile.rbac.RoleEnablementAuthority">
        <PolicyManager class="nbi.xmlsec.xacml.profile.rbac.PolicyManager"
policyBaseDir="./policies" >
          <PolicyFinder >
            <PolicyFinderModule
class="nbi.xmlsec.xacml.profile.rbac.finder.RBACPolicyFinderModule" policyB
aseDir="./policies" >
              <SuffixFileFilter >.xml</SuffixFileFilter >
            </PolicyFinderModule>
          </PolicyFinder >
        </PolicyManager>
      </RoleEnablementAuthority>
      <PolicyDecisionPoint class="nbi.xmlsec.xacml.profile.rbac.RBACPDP">
        <PolicyManager class="nbi.xmlsec.xacml.profile.rbac.PolicyManager"
policyBaseDir="./policies" >
          <PolicyFinder >
            <PolicyFinderModule
class="nbi.xmlsec.xacml.profile.rbac.finder.RBACPolicyFinderModule"
policyBaseDir="./policies" >
              <SuffixFileFilter >.xml</SuffixFileFilter >
            </PolicyFinderModule>
          </PolicyFinder >
        </PolicyManager>
      </PolicyDecisionPoint>
    </Handler>
  </Filter>
</PolicyEnforcementPoint>
```

3.3.1.3 Policy Management

The policy management is processed by the component PolicyManager, which must be configured to identify the policies to be included within the policy evaluation processes. This is done by the subcomponents PolicyFinder and FileFilter. The following sections describe their configurations.

3.3.1.3.1 PolicyManager

The PolicyManager's objective is to keep track of all defined policy types and may be described the following attributes:

Attribute	Function
`class`	`The class of the PolicyManager implementation to load`
`policyBaseDir`	`The path to the base directory, where the policy file structure is located`

.
Next, the PolicyManager element must contain a PolicyFinder element.

3.3.1.3.2 PolicyFinder

The PolicyFinder is used by the SunXACML library to retrieve the policies to be evaluated. For that, the policy finder has to specify at least one PolicyFinderModule, which does that work for him. Each policy finder module is configured within a PolicyFinderModule element and has the following attributes:

Attribute	Function
`Class`	`The class of the PolicyFinder module implementation to load`
`policyBaseDir`	`The path to the base directory, where the policy file structure is located`

The policy base directory defined here replaces any previously configured, higher-levelled policyBaseDir definition (e.g. within the PolicyManager's configuration.

Additionally, each PolicyFinderModule may contain several FileFilter elements, filtering out the files to be identified as policy files.

3.3.1.3.3 FileFilter

A FileFilter filters out the files to be identified as policy files. Currently, only a SuffixFileFilter is implemented, but this feature may be extended in future versions.

The value of a SuffixFileFilter determines the suffix of matching filenames, such as "*.xml*".

3.3.1.3.4 Example

As an example, look at the example PolicyManager configurations delivered with this distribution (see also clause 3.4.5).

```
<PolicyManager class=”nbi.xmlsec.xacml.profile.rbac.PolicyManager”
policyBaseDir=”./policies” >
  <PolicyFinder>
    <PolicyFinderModule
class=”nbi.xmlsec.xacml.profile.rbac.finder.RBACPolicyFinderModule”
policyBaseDir=”./policies” >
       <SuffixFileFilter >.xml</SuffixFileFilter >
     </PolicyFinderModule>
   </PolicyFinder >
</PolicyManager>
```

3.3.2 Public Key infrastructure

All client identification issues base on an X509-Public Key Infrastructure (PKI). The following sections describe how to build up a PKI consisting of a RootCA and the RA’s ServerCA to register servers and UserCA to register users (see clause 3.1.2.3.1). Furthermore, the generation of server and user X.509 certificates is explained and the prepare key and certificate files to be imported by browsers.

The software distribution contains a subdirectory *CA*, where the OpenSSL configuration file *openssl.cnf* should be found. This file (and this how to too) assumes, that *CA* is the current working directory where OpenSSL is called. All preconfigurations in *openssl.cnf* are defined relative to that directory. In particular, the distribution should have created the directory structure. If not, the following directory structure should be created. The examples below are created using the Cygwin bash-shell.

3.3.2.1 Create the directory structure

Create the subdirectories RootCA, ServerCA and UserCA within the CA directory (command *mkdir*). Copy the *openssl.cnf* file into the CA directory (command *cp*). Then, the directory listing should look like this:

```
$ ls -la CA
total 8
drwxr-xr-x+ 5 lusu None    0 Mar 21 11:07 .
drwx------+ 7 lusu None    0 Mar 21 10:20 ..
drwxr-xr-x+ 6 lusu None    0 Mar 21 11:06 RootCA
drwxr-xr-x+ 6 lusu None    0 Mar 21 11:07 ServerCA
drwxr-xr-x+ 6 lusu None    0 Mar 21 11:07 UserCA
-rwxr-xr-x  1 lusu None 7730 Mar 21 11:03 openssl.cnf
```

In each subdirectory (*RootCA*, *ServerCA* and *UserCA*) create the subdirectories *certs*, *crl*, *newcerts* and *private*. Additionally, create the file *index.txt* and *serial* using the following commands:

```
$ touch ...CA/index.txt
$ echo “01” >...CA/serial
```

Now, the content of each subdirectory should look as follows

```
$ ls -la CA/RootCA
total 1
drwxr-xr-x+ 6 lusu None 0 Mar 21 11:06 .
drwxr-xr-x+ 5 lusu None 0 Mar 21 11:07 ..
drwxr-xr-x+ 2 lusu None 0 Mar 21 10:48 certs
drwxr-xr-x+ 2 lusu None 0 Mar 21 10:48 crl
-rw-r—r--  1 lusu None 0 Mar 21 11:06 index.txt
drwxr-xr-x+ 2 lusu None 0 Mar 21 10:48 newcerts
drwxr-xr-x+ 2 lusu None 0 Mar 21 11:17 private
-rw-r—r--  1 lusu None 3 Mar 21 11:04 serial
```

Finally, is it possible to create own random files for each CA creating the file *.rand* in each subdirectory *private* of each of *CA* subdirectories (*RootCA*, *ServerCA* and *UserCA*). If it is not present, OpenSSL will create own random numbers during key generation. When done, each private subdirectory should look like this:

```
$ ls -la CA/RootCA/private
total 3
drwxr-xr-x+ 2 lusu None    0 Mar 21 11:17 .
drwxr-xr-x+ 6 lusu None    0 Mar 21 11:06 ..
-rw-------  1 lusu None 1024 Mar 21 10:47 .rand
```

3.3.2.2 Adopt openssl.cnf

There are only a few points where modifications should be taken without being confident with the configuration of the OpenSSL software. For other modifications, please refer to the official OpenSSL documentation [THE05a] or [DFN00].

Set the *$HOME* variable within openssl.cnf or the *CA_HOME* environment variable (`export CA_HOME /some_dir` using bash) to an absolute path, if OpenSSL is usually called from another working directory than *CA*.

Set the default_ca variable in the section *[ca]* to e.g. *UserCA*, if the keys and certificates for the *ServerCA* and *UserCA* are created, and only user key pairs and certificates shall be created.

Adopt the default values proposed during the generation of a certificate’s X.500 Distinguished Name, so that they are suitable for your organisation. This may be done within the section *[req distinguished name]* changing the entries with the suffix *_default*.

3.3.2.3 Generate the Private key of the RootCA:

The following command creates a 2048 bit RSA Private Key for the RootCA. OpenSSL requests to enter a pass phrase for the key. Remember that pass phrase, but keep that secret very safe!

```
$ openssl genrsa -aes256 -out RootCA/private/RootCA.key.pem -rand
RootCA/private/.rand 2048
1024 semi-random bytes loaded
Generating RSA private key, 2048 bit long modulus
..................+++
.....................+++
e is 65537 (0x10001)
Enter pass phrase for RootCA/private/RootCA.key.pem:   (your_pw)
Verifying - Enter pass phrase for RootCA/private/RootCA.key.pem: (your_pw)
```

3.3.2.4 Generate the RootCA’s certificate

The following command creates a self-signed certificate of the RootCA, valid for five years and with the serial number 0. Therefore, OpenSSL requests to enter the pass phrase of the RootCA’s private key. The proposed values for the Distinguished Name may be modified. Anyway, a unique *Common Name* must be entered.

```
$ openssl req -config ./openssl.cnf -set_serial 0 -new -x509 -days 1827 -
key RootCA/private/RootCA.
key.pem -out RootCA/RootCA.cert.pem
Enter pass phrase for RootCA/private/RootCA.key.pem:
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
```

```
For some fields there will be a default value,
If you enter ‘.’, the field will be left blank.
-----
Country Name (2 letter code) [DE]:
State or Province Name (full name) [Berlin]:
Locality Name (eg, city) [Berlin]:
Organization Name (eg, company) [FU-Berlin]:
Organizational Unit Name (eg, section) [NBI]:
Common Name (eg, YOUR name) :RootCA NBI
Email Address :
```

3.3.2.5 Verify the certificate

```
$ openssl x509 -in RootCA/RootCA.cert.pem -text
```

3.3.2.6 Copy the certificate to the place configured within openssl.cnf

The location of the certificate is indicated within the section *[RootCA]* in the variable certificate, the location of the private key in the variable *private_key*:

```
certificate    = $dir/cacert.pem
private_key    = $dir/private/cakey.pem
```

Now, copy both files to the right location.

```
$ cp RootCA/RootCA.cert.pem RootCA/cacert.pem
$ cp RootCA/private/RootCA.key.pem RootCA/private/cakey.pem
```

3.3.2.7 Link the RootCA’s certificate within the directory structure configured in openssl.cnf

The certificate must be copied in the RootCA’s subdirectory *certs*, renamed with the serial number and linked with its hash value:

```
$ cp RootCA/RootCA.cert.pem RootCA/certs/00.pem
$ cd RootCA/certs/
$ ln -s 00.pem ‘openssl x509 -hash -noout -in 00.pem‘.0
```

Now, the certificate of the RootCA is ready for working. Continue creating the Registration Authorities for servers und users, *ServerCA* and *UserCA*.

3.3.2.8 Generate the ServerCA and UserCA and generate the Private Key for the Server CA

The generation of a key pair is analogous to the RootCA. You will also be requested to enter a pass phrase. Remember it and keep it secret!

```
$ openssl genrsa -aes256 -out ServerCA/private/ServerCA.key.pem -rand
/usr/lib/ssl/ServerCA/private/.rand 2048
```

3.3.2.9 Generate the certificate request (to be signed from the RootCA later)

The following command creates a certificate request for the ServerCA to be signed from the RootCA later. Therefore, OpenSSL requests to enter the *pass phrase* of the *ServerCA*’s *private key*. The proposed values for the Distinguished Name may be modified. Anyway, a unique *Common Name* must be entered.

```
$ openssl req -new -key ServerCA/private/ServerCA.key.pem -out
ServerCA/ServerCA.req.pem
Enter pass phrase for ServerCA/private/ServerCA.key.pem: (your_pw)
You are about to be asked to enter information that will be incorporated
```

```
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter ‘.’, the field will be left blank.
-----
Country Name (2 letter code) [AU]:DE
State or Province Name (full name) [Some-State]:Berlin
Locality Name (eg, city) :Berlin
Organization Name (eg, company) [Internet Widgits Pty Ltd]:FU-Berlin
Organizational Unit Name (eg, section) :NBI
Common Name (eg, YOUR name) :ServerCA NBI
Email Address :


Please enter the following ‘extra’ attributes
to be sent with your certificate request
A challenge password :server
An optional company name :
Sign the certificate request
```
Using the *RootCA*’s *private key*, the following command signs the Server CA’s certificate request and generates the ServerCA’s certificate.

```
$ openssl ca -name RootCA -config ./openssl.cnf -in
ServerCA/ServerCA.req.pem -out ServerCA/ServerCA.cert.pem
Using configuration from ./openssl.cnf
Enter pass phrase for ./RootCA/private/cakey.pem: (your_pw)
Check that the request matches the signature
Signature ok
The Subject’s Distinguished Name is as follows
countryName          :PRINTABLE:’DE’
stateOrProvinceName  :PRINTABLE:’Berlin’
localityName         :PRINTABLE:’Berlin’
organizationName     :PRINTABLE:’FU-Berlin’
organizationalUnitName:PRINTABLE:’NBI’
commonName           :PRINTABLE:’ServerCA NBI’
Certificate is to be certified until Mar 21 11:03:17 2006 GMT (365 days)
Sign the certificate? [y/n]:y
1 out of 1 certificate requests certified, commit? [y/n]y
Write out database with 1 new entries
Data Base Updated
```

3.3.2.10 Copy the ServerCA certificate to the place configured within openssl.cnf

First, the newly created certificate was stored in the *newcerts* subdirectory of the RootCA. From there, it must be moved to the subdirectory *certs* and linked with its own *hash value*:

```
$mv RootCA/newcerts/01.pem RootCA/certs/
$cd RootCA/certs/
$ln -s 01.pem ‘openssl x509 -in 01.pem -hash -noout‘.0
```

3.3.2.11 Repeat the last steps to create the UserCA

```
$ openssl genrsa -aes256 -out UserCA/private/UserCA.key.pem -rand
UserCA/private/.rand 2048 (pw user)
$ openssl req -new -key UserCA/private/UserCA.key.pem -out
UserCA/UserCA.req.pem
$ openssl ca -name RootCA -config ./openssl.cnf -in UserCA/UserCA.req.pem -
out UserCA/UserCA.cert.pem
$ mv RootCA/newcerts/02.pem RootCA/certs/
$ cd RootCA/certs/
$ ln -s 02.pem ‘openssl x509 -in 02.pem -hash -noout‘.0
```

3.3.2.12 Create Browser compatible certificate files

To import these certificates in common browsers, all characters within the certificate files created above between the lines

```
-----BEGIN CERTIFICATE-----
```

and

```
-----END CERTIFICATE-----
```

must be stored into a file with the suffix “*.crt*”. Use a text editor and create the files *RootCA.crt*, *ServerCA.crt* and *UserCA.crt*. These files may also be published (together with the fingerprints) online, so that users can download and use them.

3.3.2.13 Generation of a server certificate

Now, the ServerCA is prepared to generate server certificates. Server certificates do not require pass phrases, because the have to use their Private Key without human interaction. This can be achieved omitting the OpenSSL pass phrase encryption algorithm parameter when generating the Private Key. Server certificates will be signed from the ServerCA with the following command sequence:

```
$ openssl genrsa -out ServerCA/provider.key.pem -rand
ServerCA/private/.rand 2048
$ openssl req -config ./openssl.cnf -new -key ServerCA/provider.key.pem -
out ServerCA/provider.req.pem
$ openssl ca -config ./openssl.cnf -name ServerCA -in
ServerCA/provider.req.pem -out ServerCA/provider.cert.pem
$ mv ServerCA/newcerts/01.pem ServerCA/certs/
$ cd ServerCA/certs
$ ln -s 01.pem ‘openssl x509 -hash -noout -in 01.pem‘.0
To import these certificates in a browser, it must be transformed in the
X.509(crt) file format as described above.
```

3.3.2.14 Generation of a user certificate

Unlike server certificates, the generation of user certificates requires pass phrases to protect the user’s private key against unauthorised usage. Thus, use the following command sequence to generate a user key pair and certificate. User certificates will be signed be the UserCA.

```
$ openssl genrsa -aes256 -out UserCA/client.key.pem -rand
UserCA/private/.rand 2048
$ openssl req -config ./openssl.cnf -new -key UserCA/client.key.pem -out
UserCA/client.req.pem
$ openssl ca -config ./openssl.cnf -name UserCA -in UserCA/client.req.pem -
out UserCA/client.cert.pem
$ mv UserCA/newcerts/01.pem UserCA/certs/
$ cd UserCA/certs
$ ln -s 01.pem ‘openssl x509 -noout -hash -in 01.pem‘.0
```

To import these certificates in a browser, it must be transformed in the X.509 (*.crt*) file format as described above.

3.3.2.15 Export keys and certificates to the PKCS#12 format

The following command exports the server keys and certificate to the PKCS#12 format and name it *BioCASE Provider 2048 Bit Zertifikat*.

```
$ openssl pkcs12 -export -inkey ServerCA/provider.key.pem -in
ServerCA/provider.cert.pem -name “BioCASE Provider 2048 Bit Zertifikat” -
out ServerCA/provider.p12
```

The following command exports the server keys and certificate to the PKCS#12 format and name it *BioCASE Client 2048 Bit Zertifikat*.

```
$ openssl pkcs12 -export -inkey UserCA/client.key.pem -in
UserCA/client.cert.pem -name “BioCASE Client 2048 Bit Zertifikat” -out
UserCA/client.p12
```

3.3.2.16 Configuration of the JSSE trust manager

The Java Secure Socket Extension (JSSE) trust manager determines whether the authentication credentials presented by the client should be trusted, when a client connects to the PEP. This is done using a so called trust store which stores all CA-certificates required, to build a trustable certification chain to the presented client certificate. The trust store equals to a Java Key store, which can be created using the Java keytool. Regarding the PKI developed above, the certificates of the RootCA and the UserCA must be added to that trust store.

To create such a trust store use the following commands:

```
$ keytool -import -trustcacert -alias RootCA  -file Keys/RootCA/RootCA.crt
-keystore jssecacert

$ keytool -import -trustcacert -alias UserCA  -file Keys/UserCA/UserCA.crt
-keystore jssecacert
```

You will be prompted to set a password. Press enter to omit that password. If you decide to set a password, the password must be configured using the Java system property *javax.net.ssl.trustStorePassword* (`java -Djavax.net.ssl.trustStorePassword=your_pw`)

The trust store file jssecacert must be copied to the *lib/security* subdirectory of your Java Runtime Environment (see 3.4.4). If you like to define another location, this must be configured using the Java system property *javax.net.ssl.trustStore* (`java -Djavax.net.ssl.trustStore=path_to_truststore`).

3.3.3 RoleManager

The RoleManager component supports the organisation of roles and policies. It offers a command line interface providing several commands to process the most important role and policy management tasks (see clause 3.1.2.4).

The RoleManager organises the role management policies according to the RBAC Profile of XACML v2.0 [AND05]. Additionally, it introduces domains allowing to specify policy sets for different environments or other purposes.

The following sections elucidate the policy management basics and the commands and options of the RoleManager’s command line interface. For configuration issues refer to clause 3.3.1.1. The RoleManager may be started using the distribution’s bash-script *RoleManager* or running the Java class *nbi.xmlsec.xacml.profile.rbac.RoleManager.* The commands and parameters of this command line interface describes clause 3.3.3.2).

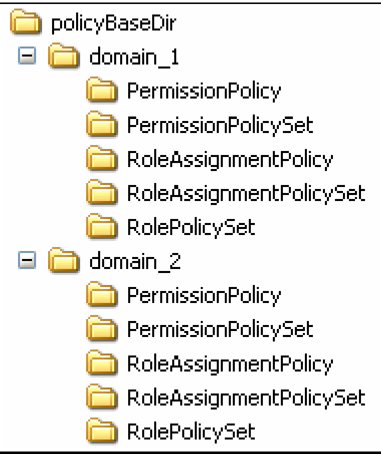
3.3.3.1 Policy management

The policies managed by the RoleManager are stored in a file system structure according to the policy structure described in the RBAC Profile of XACML v2.0 [AND05]. That is, every policy (set) described there will be stored in a XML-file within a subdirectory named after its policy type. The policy file name corresponds to the label of its policy (set) appending the file suffix “.xml”. The RBAC Profile of XACML v2.0 specifies the following policy types:

- RoleAssignmentPolicySet
- RoleAssignmentPolicy
- RolePolicySet
- PermissionPolicySet
- PermissionPolicy

In addition, we introduced a simple domain concept, allowing the composition of policies for specific objectives like different providers or databases. This domain feature is provided in the file system reserving one directory for each domain. These directories are labelled after the name of the domain and include the subdirectory structure stated above.

All these domain directories must be subdirectories of a so called policy base directory. This directory comprises the access control configuration of the whole system used by the RoleManager, the Policy Enforcement Point and the Role Enablement Authority. As a matter of course, all these files must be protected by system administrators against unauthorised access. The following figure shows a possible directory hierarchy including two domains (see figure 5).



```
policyBaseDir
  domain_1
      PermissionPolicy
      PermissionPolicySet
      RoleAssignmentPolicy
      RoleAssignmentPolicySet
      RolePolicySet
  domain_2
      PermissionPolicy
      PermissionPolicySet
      RoleAssignmentPolicy
      RoleAssignmentPolicySet
      RolePolicySet
```

figure 5 Directory structure for RBAC XACML policies

3.3.3.1.1 Domains

The main idea behind the domain concept is to provide a measure to differentiate role sets for different application or policy domain specifics. So, e.g. a server hosting different providers or databases may start a PEP instance for each provider or database hosted. Configuring the PEP to use the policies defined within a domain for each provider eases the maintenance of the policies. Nevertheless, you must specify at least one domain, even if you are serving just one domain.

3.3.3.1.2 Identifier

The XACML standard requires that every type of policy element must have an identifier [MOS05]. Furthermore, it requires that no two policies have the same identifier, which may be achieved following a predefined URN or URI scheme. Therefore, we extended this requirement to XACML Rule elements also, resulting in an identical naming convention for all relevant policy elements. Thus, we defined a scheme for our RBAC policies and rules as follows:

- urn:<domain_label>:<policy_type>:<policy_label>.

The accepted values for <*policy_type*> are

- RoleAssignmentPolicySet
- RoleAssignmentPolicy
- RolePolicySet
- PermissionPolicySet
- PermissionPolicy.

The values for <*policy_label*> and <*domain_label*> describe the name of the policy or denote the name of the domain, which the policy element belongs to.

The current implementation maps this naming scheme onto the file system. For that, all ":" of the naming scheme are replaced by the path separator of the underlying operating system. The policy file name is built concatenating the value of <*policy_label*> and the XML file suffix ".xml". The result is a relative file path unique within the system's policy base directory.

```
Example:

The identifier "urn:domain_1:RolePolicySet:role_1" is mapped to the
relative file path "domain_1/RolePolicySet/role_1".
```

By this way, all policy types can be unambiguously stored and retrieved from the file system. Note, that because domain and policy labels must be representable in the file system, the syntax for labels is restricted to the Namespace Identifier Syntax as defined in RFC 2141 [MOA97].

3.3.3.1.3 RoleAssignmentPolicy(Set)

As defined in [AND05], a RoleAssignmentPolicy or RoleAssignmentPolicySet determines which users are enabled to which roles and under which conditions. These policies are used be the Role Enablement Authority to determine whether a subject - identified by an X509 certificate - has a particular role attribute value. The RoleManager organises role assignments as follows:

The RoleAssignmentPolicySet includes RoleAssignmentPolicies using PolicyReferences to support combining role assignments from different sub roles or the construction of hierarchical role sets. The RoleManager assigns one RoleAssignmentPolicySet per domain, where each RoleAssignmentPolicySet supports referencing of several RoleAssignmentPolicies determining the individual roles. A RoleAssignmentPolicy determines the real user to role assignments according to [AND05]. The assignments consist of multiple subjects, identified by its X.500 Distinguished Name, a *role_value* resource storing the role label and the predefined action *enableRole*. See the next table for detailed XACML values and data types.

Element	**Value**	**XACML data type**
`Subject`	`X500 Distinguished Name`	`urn:oasis:names:tc:xacml:1.0:data-type:x500Name`
`Resource`	`<domain_label>:role_value:<role_label>`	`http://www.w3.org/2001/XMLSchema#anyURI`
`Action`	`urn:oasis:names:tc:xacml:2.0:`	`http://www.w3.org/2001/XMLSchema#anyURI`

	`actions:enableRole`	

The RoleManager supports the following XACML PolicyCombiningAlgorithms for a RoleAssignmentPolicySet:

- *urn:oasis:names:tc:xacml:1.0:policy-combining- algorithm:permit-overrides*

The RoleManager supports the following XACML RuleCombiningAlgorithms for a RoleAssignmentPolicy:

- *urn:oasis:names:tc:xacml:1.0:rule-combining- algorithm:permit-overrides*

3.3.3.1.4 RolePolicySet

A RolePolicySet associates users with particular role value attributes to a PermissionPolicySet. This PermissionPolicySet contains the permissions associated with the given role. According to [AND05], each RolePolicySet references at most one corresponding PermissionPolicySet. The XACML target limits the applicability of the RolePolicySet to subjects with the given role value attribute.

The RoleManager supports the following XACML PolicyCombiningAlgorithms for a RolePolicySet:

- *urn:oasis:names:tc:xacml:1.0:rule-combining- algorithm:permit-overrides*

3.3.3.1.5 PermissionPolicySet

A PermissionPolicySet references the PermissionPolicies describing the resources and actions that subjects with a particular role value attribute are permitted to access. [AND05] also specifies the inheritance of PermissionPolicySets as junior roles. Unfortunately, this is currently not supported by the RoleManager but may be added in future versions.

The RoleManager supports the following XACML PolicyCombiningAlgorithms for PermissionPolicySets:

- *urn:oasis:names:tc:xacml:1.0:policy- combining- algorithm:permit-overrides*
- *urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:deny- overrides*

3.3.3.1.6 PermissionPolicy

A PermissionPolicy describes the resources and actions that subjects are permitted to access. These Permissions are determined by Rules contained in a PermissionPolicy. [AND05] also specifies the addition of further conditions to the application of such permissions.. Unfortunately, this is currently not supported by the RoleManager, but may be added in future versions.

The RoleManager only supports the following RuleCombiningAlgorithms for a PermissionPolicy:

- *urn:oasis:names:tc:xacml:1.0:rule-combining- algorithm:permit-overrides*
- *urn:oasis:names:tc:xacml:1.0:rule-combining-algorithm:deny-overrides*

3.3.3.2 Commands

The RoleManager offers a command line interface to the user providing several commands supporting the most important role management task. Currently, the interface implements the commands *add*, *remove*, *list* and *help*. Each command may be parameterised by several options. The following sections explain the available commands in detail.

3.3.3.2.1 Add (-a, --add)

This command adds or updates policy elements. If necessary, it creates any missing policy elements needed to process the command. The add command may be used to

- add users to a role
- add permission policies to a role
- add permissions to a permission policy

3.3.3.2.1.1 Add users to a role

When adding users to a role, this means that an Assignment will be added to a RoleAssignmentPolicy (Set). Currently, users are represented by their X509 certificates. Thus, to process the command, the following arguments are needed:

Option	Description
`-D`	`domain label`
`-R`	`role label`
`-U`	`list of X.509 certificate file paths of users to add`

If the domain or the RoleAssignmentPolicySet and RoleAssignmentPolicy relying on the given role are inexistent, they are created.

Examples
The following command adds the user with the X509Certificate stored in *./CA/UserCA/user_1.crt* to the role *users* of the domain *domain*

- `a -D domain -R users -U ./CA/UserCA/user_1.crt`

The following command adds the users with the X509Certificates stored in *./CA/UserCA/user_1.crt* and *./CA/UserCA/user_2.crt* to the role *users* of the domain *domain.*

- `a -D domain -R users -U ./CA/UserCA/user_1.crt ./CA/UserCA/user_2.crt`

3.3.3.2.1.2 Add PermissionPolicies to a role

When adding PermissionPolicies to a role, this means that a PermissionPolicy will be added to a PermissionPolicySet. Thus, a PolicyReference to the PermissionPolicy will be added to the PermissionPolicySet for the given role The command requires the following arguments:

Option	Description
`-D`	`domain label`
`-R`	`role label`
`-P`	`list of PermissionPolicies to add`

If the domain or the PermissionPolicySet and RolePolicySet or PermissionPolicy relying on the given role are inexistent, they are created.

Examples
The following command adds the PermissionPolicy *userperm_1* to the role *users* of the domain *domain*

- `a -D domain -R users -P userperm_1`

The following command adds the PermissionPolicies *userperm_1* and *userperm_2* to the role *users* of the domain *domain*.

- `a -D domain -R users -P userperm_1 userperm_2`

3.3.3.2.1.3 Add Permissions to PermissionPolicies

When adding permissions to a PermissionPolicy, this means that the Rules representing the Permission will be added to the given PermissionPolicy. The command requires the following arguments:

Option	Description
-D	domain label
-P	List of PermissionPolicies to update
-p	List of Permission labels to add
-d	Flag setting the permission effect to deny (otherwise permit)
-y	list of resources to be added to the permission
-z	list of actions to be added to the permission

If the domain, PermissionPolicy or Permission to be updated is inexistent, it will be created.

The syntax scheme to define target resources or actions of permissions describes clause 3.3.3.3.9.

Examples
The following command adds the Permission *perm_1* which effects to *permit* to the PermissionPolicy *userperm_1* of the domain *domain*

- `a -D domain -P userperm_1 -p perm_1`

The following command adds the Permission *perm_1* which effects to *deny* to the PermissionPolicy *userperm_1* of the domain *domain*

- `a -D domain -P userperm_1 -p perm_1 -d`

The following command adds the Permission *perm_1* which effects to *permit* to the PermissionPolicy *userperm_1* of the domain *domain* and defines that the action must be equal to the string "*action_1*".

- `a -D domain -P userperm_1 -p perm_1 -z string-equal[action_1]`

The following command adds the Permission *perm_1* which effects to *deny* to the PermissionPolicy *userperm_1* of the domain *domain* and defines that the action must be equal to the string "*action_1*" and matches any string resource containing the string "*resource*"

- `a -D domain -P userperm_1 -p perm_1 -d -y string-match[resource] -z string-equal[action_1]`

3.3.3.2.2 Remove (-r, --remove)

This command removes policy elements. The *remove* command may be used to

- remove users from a role
- remove permission policies from a role
- remove permissions from a permission policy
- remove roles completely
- remove domains completely

3.3.3.2.2.1 Remove users from a role

When removing users from a role, this means that an Assignment will be removed from a RoleAssignmentPolicy(Set). Currently, users are represented by their X509 certificate. Thus, to process the command, the following arguments are needed:

Option	Description
`-D`	`domain label`
`-R`	`role label`
`-U`	`list of X.509 certificate file paths of users to remove`

This command removes the corresponding Assignments from the given RoleAssignmentPolicy. If there are no users left, the RoleAssignmentPolicy will not be deleted!

Examples

The following command removes the user with the X509Certificate stored in *./CA/UserCA/user_1.crt* from the role *users* of the domain *domain*

- `r -D domain -R users -U ./CA/UserCA/user_1.crt`

The following command removes the users with the X509Certificates stored in *./CA/UserCA/user_1.crt* .and *./CA/UserCA/user_2.crt* from the role *users* of the domain *domain*

- `r -D domain -R users -U ./CA/UserCA/user_1.crt ./CA/UserCA/user_2.crt`

3.3.3.2.2.2 Remove PermissionPolicies from a role

When removing PermissionPolicies from a role, this means that a PermissionPolicy will be removed from a PermissionPolicySet. For that, the PolicyReference to the PermissionPolicy will be removed from the PermissionPolicySet for the given role. The command requires the following arguments:

Option	Description
`-D`	`domain label`
`-R`	`role label`
`-P`	`list of PermissionPolicies to remove`

If there are no PolicyReferences left, the PermissionPolicySet will not be deleted!

Examples
The following command removes the PermissionPolicy *userperm_1* from the role *users* of the domain *domain*.

- `r -D domain -R users -P userperm_1`

The following command removes the PermissionPolicies *userperm_1* and *userperm_2* to the role *users* of the domain *domain*.

- `r -D domain -R users -P userperm_1 userperm_2`

3.3.3.2.2.3 Remove Permissions from a PermissionPolicy

When removing permissions from a PermissionPolicy, this means that the Rules representing the Permission will be removed from the given PermissionPolicy. Furthermore, actions or resources can be removed from Permissions. The command requires the following arguments:

Option	Description
-D	domain label
-P	list of PermissionPolicies to update
-p	List of Permissions to remove
-d	Flag setting the Permission’s effect to deny (otherwise permit)
-y	list of resources to remove from the Permissions
-z	list of actions to remove from the Permissions

For the syntax scheme to define resources or actions for permission see clause 3.3.3.3.9.

Examples
The following command removes the Permission *perm_1* from the PermissionPolicy *userperm_1* of the domain *domain*.

- `r -D domain -P userperm_1 -p perm_1`

The following command removes the action equalling the string “*action_1*” from the Permission *perm_1* of the PermissionPolicy *userperm_1* of the domain *domain*.

- `r -D domain -P userperm_1 -p perm_1 -z string-equal[action_1]`

The following command removes the action equalling the string “*action_1*” and the resource matching the string “*resource*” from the Permission *perm_1* of the PermissionPolicy *userperm_1* of the domain *domain*.

- `r -D domain -P userperm_1 -p perm_1 -y string-match[resource] -z string-equal[action_1]`

3.3.3.2.2.4 Remove roles completely

This command removes the *RoleAssignmentPolicySet*, *RoleAssignmentPolicy*, *RolePolicySet* and *PermissionPolicySet* of the given role. All the related files are deleted from the file system. The command requires the following arguments:

Option	Description

`-D`	`domain label`
`-R`	`List of roles to remove`

Example
The following command removes the role *users* of the domain *domain* completely.

- `r -D domain -R users`

3.3.3.2.2.5 Remove domains completely

This command removes the given domain completely from the file system. All corresponding policy files are lost. The command requires the following arguments:

Option	Description
`-D`	`domain label`

Example
The following command removes the domain *domain*.

- `r -D domain`

3.3.3.2.3 List (-l, --list)

The list command prints defined Roles, Users and Permissions to the screen.

Examples
The following command lists all available *domains*.

- `-l`

The following command lists all available *RoleAssignmentPolicySet and RolePolicySet* labels of the domain *domain* to the screen.

- `l -D domain`

The following command lists all available Assignments and PermissionPolicies of the role *role* of the domain *domain* to the screen.

- `l -D domain –R role`

The following command lists all available Permissions including all subjects, resources and actions of the PermissionPolicy *permPolicy* for the role *role* of domain *domain* to the screen.

- `l -D domain –R role –P permPolicy`

3.3.3.2.4 Help (-h, --help)

The help command prints a short command description of the RoleManager to the screen.

Example
The following command prints the command description to the screen:

- `h`

3.3.3.3 Options

The commands offered by RoleManager need several parameters to operate. These parameters are given to the RoleManager's command line using options. See the following table for supported options.

Name	Long Name	Arguments	Commands
	`--policyBaseDir`	`<dir path>`	`all except help`

`-d`	`--Deny`		`add permissions,`
			`add permission policies`

`-D`	`--Domain`	`<label list>`	`all except help`

`-P`	`--PermissionPolicy`	`<label list>`	`add/remove permissions,`
			`add/remove permission policies`

`-p`	`--Permission`	`<label list>`	`add/remove permissions,`
			`add/remove permission policies`

`-R`	`--Role`	`<label list>`	`all except help`
`-U`	`--User`	`<cert file list>`	`add/remove users`
`-y`	`--targetResource`	`<datatype-matchfunc[value]>`	`add/remove permissions`
`-z`	`--targetAction`	`<datatype-matchfunc[value]>`	`add/remove permissions`

The following sections explain the available options in detail.

3.3.3.3.1 PolicyBaseDir (--policyBaseDir)

This option specifies the policy base directory for the given command. This option overwrites any default setting from the configuration file (see clause 3.3.1).

3.3.3.3.2 Deny (-d, --Deny)

Sets Permission's effect to *deny* or sets the combining algorithm of a PermissionPolicy or PermissionPolicySet to *urn:oasis:names:tc:xacml:1.0:policy-combining-algorithm:deny-overrides.*

3.3.3.3.3 Domain (-D, --Domain <label list>)

This option specifies at least one domain name for the given command. Multiple domain parameters are supported for the command *remove domains completely* only (see clause 3.3.3.2.2.5). This option overwrites any default setting from the configuration file (see clause 3.3.1).

3.3.3.3.4 PermissionPolicy (-P,--PermissionPolicy <label list>)

This option specifies at least one PermissionPolicy for the given command. When adding or removing permissions (see clauses 3.3.3.2.1.3, 3.3.3.2.2.3) only the first label from the list is evaluated.

3.3.3.3.5 Permission (-p,--Permission <label list>)

This option specifies at least one piece of Permission for the given command. When adding or removing target actions or resources (see clauses 3.3.3.2.1.3, 3.3.3.2.2.3) only the first label from the list is evaluated.

3.3.3.3.6 Role (-R,--Role <label list>)

This option specifies at least one role value for the given command. Multiple role value parameters are supported for the command *remove roles completely* only (see clause 3.3.3.2.2.4).

3.3.3.3.7 User (-U,--User <cert file list>)

This option specifies at least one path to an X.509 certificate file.

3.3.3.3.8 TargetResource (-y,--targetResource <datatype- matchfunc[value]>)

This option specifies at least one XACML resource target. The syntax scheme of the arguments describes clause 3.3.3.3.9.

3.3.3.3.9 TargetAction (-z,--targetAction <datatype- matchfunc[value]>)

This option specifies at least one XACML action target. The syntax scheme of the arguments describes clause 3.3.3.3.9.

3.3.3.4 Target syntax scheme description

The syntax scheme to define resources or actions for permission is defined as follows:

- datatype-matchfunc[value]

Currently the following data types are supported:

Data Type	**Description**
`string`	`declares the value as a string`
`Anyuri`	`declares the value as a URI`
`x500Name`	`declares the value as a X500Principal`

The datatype may be combined with the following match functions:

Match Function	**Description**
`Equal`	`equals the value`
`Match`	`match the value as regular expression (string and x500Name)`

Example
To match the string "*pattern*" within Permission targets uses the following target declaration:

- String-match[pattern]

3.3.4 Policy Enforcement Point

The task of the PEP is to await BioCASE-requests, evaluate the access rights related to the requesting entity and process the request according to these access rights. The BioCASE-requests are embedded within the Https-protocol, which uses the SSL authentication protocol to determine the authenticity of the requesting client. For that, each client must own an X509-certificate.

The Policy Enforcement Point (PEP) encapsulates two components:

- Role Enablement Authority(REA)
- Policy Decision Point(PDP).

The REA evaluates the roles assigned to an authenticated client. The evaluation process founds on the Role Enablement Policies defined for the REA's security domain. If the client's authenticity can not be verified, then the REA assigns the predefined guest role to this request (see clause 3.1.2.5).

Parameterised with the evaluated roles for the request, the PDP decides on the further processing of the request. Requests may be blocked completely or redirected to the protected BioCASE-provider.

BioCASE-responses returned from the provider are filtered according to the XACML policies defined using the RoleManager. Within this filtering process, parts of the XML-structure of the provider's response content may be eliminated in the final response delivered to the PEP (see clause 3.1.1). Finally, the PEP embeds the remaining BioCASE- response in a Https-response and returns the latter to the requesting client.

The configuration details for the PEP describes clause 3.3.1.2), The PEP may be started using the distribution's bash-script *PEP* or running the Java class *nbi.xmlsec.PEP*. The command has no parameters.

3.3.4.1 BioCASE Integration

The current implementation of the PEP (PDP) supports the BioCASE protocol version 1.3 [BIO05]. The integration of the BioCASE-protocol within the XACML architecture needed some adaptation efforts. Namely, the BioCASE protocol specifies three commands (capabilities, scan and search), each requiring a separate processing. A different processing is required for BioCASE request and responses also. Therefore, some rules must be respected when defining policies using the RoleManager. Furthermore, some commitments concerning the handling of some protocol operators must have been taken. Both are subject of the next sections.

3.3.4.1.1 Policy Definition Rules

The BioCASE protocol provides three request methods (*capabilities*, *scan* and *search*) and each requires special processing regarding the PDP's policy evaluation. Additionally, because requests can only be blocked and responses can only be filtered, the PDP uses two processing chains for each method - one for requests and one for responses.

3.3.4.1.1.1 Request processing

Due to the fact that methods are the active components within a BioCASE-request, the method names are considered as actions, whereas the path used within the filter element of the search request and the value of the concept element of the scan request are interpreted as resources. Regarding the capabilities method, requests can only be permitted or denied based on the request method. Thus, for the evaluation of requests a Permission's action target must be defined using the RoleManager according to the following pattern:

`String-equal[<method>-request]`	`where as <method> may be replaced by one of the strings “capabilities”, “scan” or “search”`

Example:

`String-equal[search-request]`	`matches a search request`

Furthermore, several paths or concepts can be added as resources to a permission for scan or search requests. During the request evaluation process, the PDP evaluates the defined PermissionPolicies by looking up for matches between the actual request and the PermissionPolicies defined with the RoleManager.

As stated above, if the evaluated request type is *scan*, than the PDP looks for matches within the value of the concept element of a scan request.

If the request type equals to *search*, then the path attribute of the filter sub elements of the search request is evaluated by the PDP.

In both cases, the PDP tries to match string values represented by the concatenation of the request format and the path or concept value of the request. So, if a scan or search request permission for the ABCD resource *`/DataSets/DataSet/Units/Unit/Identifications/Identification/TaxonIdentified/NameAuthorYearString`* shall be defined, then the following string must be added to the target resources:

`http://www.tdwg.org/schemas/abcd/1.2/DataSets/DataSet/Units/Unit/Identifications/Identification/TaxonIdentified/NameAuthorYearString`

Currently, you can define the match functions *string-equal* and *string-match* only.

`Example:`

`string-equal[http://www.tdwg.org/schemas/abcd/1.2/DataSets/DataSet/Units/Unit/Identifications/Identification/TaxonIdentified/NameAuthorYearString]`	`matches the given ABCD concept if equal`
`string-match[http://www.tdwg.org/schemas/abcd/1.2/DataSets/DataSet/Units/Unit/Identifications/Identification]`	`matches all ABCD sub concepts of Identification (regular expression)`

3.3.4.1.1.2 Response processing

Analogous to the processing of BioCASE-requests, method names are considered as actions within BioCASE-responses also. But this time, the pattern to be used for the definition of the action target of Permissions should be defined as follows:

`string-equal[<method>-response]`	`where as <method> may be replaced by one of the strings “capabilities”, “scan” or “search”.`

Example:

`string-equal[search-response]`	`matches a search response`

When the PDP evaluates the BioCASE-responses, it considers the value of the content element as XML-document, the namespace of this document and the response format from the related BioCASE-request. First, the PDP checks the access permissions for every sub element and attribute of this XML-document. If permission is denied for an element of the response’s content document, access is also denied for any attributes and sub elements of this element. All elements stated above will be eliminated from the final response to the requesting client. If permission is denied for an element’s attribute, only this attribute will be eliminated from the final response to the client. Therefore, the PDP also verifies for each sub element and attribute, if the namespace of the XML-document matches the response format requested. Thus, unlike the description of request processing above, the permissions for scan or search responses must define resource target defined using the RoleManager applicating the following rules:

If *search* response permission for the *ABCD* resource *`/DataSets/DataSet/Units/Unit/Identifications/Identification/TaxonIdentified/NameAuthorYearString`* shall be defined, then the following string must be added to the target resources:

`http://www.tdwg.org/schemas/abcd/1.2/DataSets/DataSet/Units/Unit/Identifications/Identification/TaxonIdentified/NameAuthorYearString`

If *scan* or *capabilities* response permission shall be defined, then the response format equals the namespace of the *BioCASE-* protocol:

`http://www.biocase.org/schemas/protocol/1.3`

To match the values of a scan response, the following string must be stated in the match function:

`http://www.biocase.org/schemas/protocol/1.3/scan/value`

Attributes to be matched shall be given by appending “@” and the attribute name to the related element path, such as

`http://www.tdwg.org/schemas/abcd/1.2/DataSets/DataSet/Units/Unit/Identifications/Identification/TaxonIdentified/NameAuthorYearString@attribute`

Currently, you can define the match functions *string-equal* and *string-match* only.

`Examples`

`string-equal[http://www.tdwg.org/schemas/abcd/1.2/DataSets/DataSet/Units/Unit/Identifications/Identification/TaxonIdentified/NameAuthorYearString]`	`matches the given ABCD element and all sub elements if equal.`
`string-match[http://www.tdwg.org/schemas/abcd/1.2/*/Identification]`	`matches all ABCD Identification sub concepts within the response document (regular expression)`

3.3.4.1.1.3 Combining algorithms deny-overrides vs. permit-overrides

Using the RoleManager's option –d (see clause 3.3.3.3.1), the combining algorithm of an XACML PermissionPolicy can be determined. The combining algorithm *deny-overrides* determines, if only one Permission within a PermissionPolicy evaluates to *deny*, then the result of the whole evaluation is *deny*. Vice versa, the combining algorithm *permit-overrides* determines, if only one Permission within a PermissionPolicy evaluates to *permit*, then the result of the whole evaluation is *permit*.

Note, that the combining algorithm possibly influences the intended effect of the permission evaluation process. Let's demonstrate the effect on the following simple example.

Say, the following two resources are defined for a search response.

`string-match[http://www.tdwg.org/schemas/abcd/1.2/*]`	`permit all elements of an ABCD document`
`string-equal[http://www.tdwg.org/schemas/abcd/1.2/DataSets/DataSet/Units/Unit/Identifications] -d`	`deny all ABCD elements below /DataSets/DataSet/Units/Unit/Identifications`

If the combining algorithm is defined to permit-overrides, then the PDP would permit a request on the resource *`http://www.tdwg.org/schemas/abcd/1.2/DataSets/DataSet/Units/Unit/Identifications/Identification/TaxonIdentified/Name`*.

But if the combining algorithm is defined *deny-overrides*, the same request would be evaluated by the PEP to *deny*.

Nevertheless, the availability of both algorithms provides to determine access policies as “black lists” or “white list” and may be helpful to save unnecessary typing efforts when defining permission policies.

3.4 Installation

The following section provides a small guide through the installation process of the software distribution and some third party products required to run the PEP and RoleManager. The guide includes the following aspects:

- Web Browser X.509 Certificate Installation
- OpenSSL
- BioCASE provider
- Access control software distribution

Finally, the example scenario also included in the software distribution is described. It may be helpful testing the correct installation of all required software components.

3.4.1 Browser Certificate Installation

To install the web browser, please refer to the installation instructions of your favourite browser. As an example, the installation of the X.509 certificates for clients is described within the following sections for the popular web browsers

- Mozilla Firefox
- Microsoft Internet Explorer

3.4.1.1 Firefox

To install the user certificates, open FireFox's certificate manager following the menu entry *Tools/Options/Advanced/Certificates* and pushing the button "*Manage Certificates*". Click on the tab "*Your Certificates*" and then on the button "*Import*". Now, choose the certificates files to install. Example user certificates for the users *nobody*, *client* and *expert* can be found in the unzipped distribution subdirectory *CA/UserCA*. The have the suffix "*.p12*" and are PKCS#12-files. The passwords for this example files equals to their *user names*(e.g. *expert*).

To install the certificate of the RootCA, import the file *CA/RootCA/RootCA.crt* from the distribution under the tab "*Authorities*". To install the certificate of the ServerCA, use the file *CA/ServerCA/ServerCA.crt* under the tab "*Web Sites*".

3.4.1.2 Internet Explorer

To install the user certificates, open Internet Explorer's Certificates dialog following the menu entry *Tools/Internet Option* and pushing the button "*Certificates*". Next, click on the tab "*Personal*" and then the button "*Import*". Now, choose the certificates files to install. Example user certificates for the users *nobody, client* and *expert* can be found in the unzipped distribution subdirectory *CA/UserCA*. The have the suffix "*.p12*" and are PKCS#12-files. The passwords for this example files equals to their *user names*(e.g. *expert*).

To install the certificate of the RootCA, import the file *CA/RootCA/RootCA.crt* from the distribution under the tab "*Trusted Root Certification Authorities*". To install the certificate of the ServerCA, use the file *CA/ServerCA/ServerCA.crt* under the tab "*Intermediate Certification Authorities*".

3.4.2 OpenSSL

For OpenSSL installation instructions please refer to [THE05a].

To build up a PKI and generate keys and certificates for client and servers refer to clause 3.3.2.

3.4.3 BioCASE Provider

The BioCASE provider software version 2.31 should be available from the BioCASE Secretariat [BIO05]. A detailed installation instruction is provided on [DOE05].

3.4.4 Software distribution

To install the software distribution, unzip the content of the zip-file in a suitable system directory. Ensure that no unauthorized users have access to that directory.

The distribution contains an Ant-file (build.xml). The second line of the build.xml defines the property "*dir.jdk*". Please modify the value of this property, so that it points to the directory, where the Java Development Kit to be used for the software is installed. Then, using the ant target *install*, ant installs the required files for the Java environment automatically (*ant install*).

If automatic installation does not work, then execute the following instruction to install the software manually. Using the JDK's (J2SE 1.4.2) default installation, Java should be located in the directory "*C:\Program Files\Java\j2re1.4.2_xx*". Please copy the files of the subdirectory *j2sdk1.4.2/jre/lib/security* of the unzipped distribution zip-file to the directory "*C:\Program Files\Java\j2re1.4.2_xx\lib\security*". If the JDK 1.4.2 is installed into another, non default location, then the files must be copied in the subdirectory *jre/lib/security* of the JDK's home dir.

The installation copies the Java Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy Files 1.4.2 (see 3.2.1) and configures Bouncy Castle as JCE Provider within this Java VM. Furthermore, the file *jssecacerts* file contains the certificates of the example PKI's RootCA and UserCA. This file is expected there by the Java Secure Socket Library (JSSE) [SUN05b] (see also clause 3.3.2.16) .

Finally install the example keys and certificates in your browser as described in clause 3.4.1.

Before starting the PEP, adopt the *host* and *port* of the PEP within the Listener configuration and the URLs of the BioCASE provider application interface and the PyWrapper (see 3.3.1.2). The latter must be set to the URL of the PEP, as it must be reachable from the BioCASE provider domain. The distribution includes an example scenario and configuration files, assuming that a BioCASE provider is installed locally (see clause 3.4.5). Please try this default configuration first, before setting up complex scenarios.

Next, to run the scenario with a locally installed BioCASE provider running on *http://localhost:8080*, you can use the predefined values in the default configuration files (see clause 3.3.1.2), such as

```
<Listener class="org.mortbay.http.SslListener" host="localhost" port="443">
to configure the Listener listening on the https port 443,
```

```
<Proxy url="http://localhost:8080" /> and
<Wrapper url="https://localhost" />
to configure the Handler redirecting the PyWrapper through the PEP.
```

There are two possibilities to start the PEP, first using the ant task *run* ("ant run") using the distributions *build.xml* file, second, using the distribution's bash-script *PEP*. Please adopt the property *dir.jdk* (ant), or the *PATH* and JAVA_HOME export variables (bash) in the file *java-classpath* respectively, so that they point to the correct directory. The file *java-classpath* is also included in the start scripts *RoleManager* and *provider-setup*, to start the RoleManager or reset the example policies (see clause 3.4.5). To start the RoleManager, the ant task *runRoleManager* may be used. To reset the example policies, you can also use the ant task *reset-policies*. For that, please adopt the property *bash* within *build.xml* so that it points to the bash executable file. Whenever the policies have changed, *PEP* must be restarted to enforce these new policy definitions.

Assuming that the path, where the provider software application interface is installed on the web server equals to “*/biocase*” and the provider software is running locally, use the web browser where you imported at least one of the client certificates, and browse to the URL “*https://localhost/biocase*”. If you have more than one client certificate installed, you may be prompted to select one of them. Furthermore, you should be prompted to accept the PEP’s example server certificate. Next, you should see the starting page of the BioCASE provider application interface and may start to use it as usual. Depending on the selected user identity, especially for the users *nobody* and *client* you should consider the restrictions imposed by the example scenario, as described in clause 3.4.5.

Additionally, the ant script *build.xml* supports the tasks *compile* and *javadoc*. The first compiles the source code from the *src* sub directory and (re-)creates the *xmlsec.jar* library in the *lib* sub directory. The latter rebuilds the javadoc documentation from the source files into the *doc/javadoc* sub directory of the distribution. Please adopt the ant property *dir.ext.javadoc* and/or the properties starting with *javadoc.* to configure the path to external javadoc directories of the used third party libraries (see clause 3.2.1).

3.4.5 Example scenario

The distribution provides an example scenario based on the BioCASE provider software 2.31 and supporting the BioCASE protocol version 1.2. The example scenario defines the roles *guest*, *client* and *expert* within the domain *biocase* and assigns these roles to the users *nobody*, *client* and *expert* respectively. The role *guest* is also assigned, when an unauthenticated request was received by the PEP.

The role *guest* is restricted to the concepts defined as “required” within the ABCD schema version 1.3, such as

```
/DataSets
/DataSets/DataSet
/DataSets/DataSet/OriginalSource
/DataSets/DataSet/OriginalSource/SourceInstitutionCode
/DataSets/DataSet/OriginalSource/SourceName
/DataSets/DataSet/OriginalSource/SourceLastUpdatedDate
/DataSets/DataSet/DatasetDerivations
/DataSets/DataSet/DatasetDerivations/DatasetDerivation
/DataSets/DataSet/DatasetDerivations/DatasetDerivation/DateSupplied
/DataSets/DataSet/DatasetDerivations/DatasetDerivation/Supplier
/DataSets/DataSet/Units
/DataSets/DataSet/Units/Unit
/DataSets/DataSet/Units/Unit/UnitID
```

All scan or search requests are denied, which are not covered by the above list. Furthermore, all ABCD elements of the BioCASE response content are eliminated by the PEP, when not part of this list. All capabilities requests and responses are permitted.

Using the *client* role, only those scan and search requests concepts and response content elements are denied or eliminated, when they include ABCD locality information or images, such as

```
/DataSets/DataSet/Units/Unit/UnitDigitalImages
/DataSets/DataSet/Units/Unit/Gathering/GatheringSite
```

Using the *expert* role, unlimited access is granted to any request.

The bash script *provider-setup*, called from the ant task *reset-policies* also, resets this scenario whenever needed. This script is a good and commented example source, how to call the RoleManager to assign users to roles and how to specify permissions and assign them to the permission policies of a given role. Feel free to use this as a basis for your own experiments defining access control policies for your own PEP configuration (see clause 3.3.3).

This example scenario presumes that the BioCASE provider is running locally on port 8080, i.e. under the URL http://localhost:8080/biocase. If not, modify the related values in the configuration files as described in clause 3.3.1.

3.5 Developer Documentation

The software distribution described was implemented in Java. The preferred documentation scheme for Java developers is the maintenance of JavaDoc entries in the source code. From these JavaDoc tags, the documentation needed by Java developers may be generated using the javadoc tool of the J2SE.

The software distribution includes the generated HTML-JavaDoc documentation for all implemented classes in the subdirectory *doc/javadoc*. It may also be reconstructed from the source code using the ant task *javadoc* (ant javadoc) in the distributions directory.

4 Conclusion

The present software implementation complies with the concepts drafted in milestone M6 considering the requirements evaluated regarding authentication services and access rights management. Based on an easy to use and flexible Public Key Infrastructure, it enables secure, mutual authentication of clients and servers based on the widely accepted SSL protocol. Furthermore, this authentication system can be used with the most popular web browsers. Thus, clients do not need to change their common provider interface.

Because the access control component is located between the client and the BioCASE provider, the BioCASE provider software has been subject to a small set of modifications only. So, unauthorized requests are already rejected in the Policy Enforcement Point and are not transmitted to the provider. In addition, the responses from the BioCASE provider are exclusively processed and filtered by the PEP according to the provider’s access control policies. Above all, the policy control remains under the control of each single provider, as required from many providers.

To ease the development of access rights policies, the solution includes the Role Manager Tool hiding the complexity to edit XACML policies from system administrators. Also, it focuses on the applicability within the BioCASE environment. Further efforts may extend its applicability for XACML RBAC policies in general. Moreover, our solution justifies the selection of XACML as XML standard to realise access control.

The realisation of other concepts drafted in the last milestone, which were coupled on the selection of other XML security standards proved to be too complex, too expansive and/or just too ambitious in relation with the available project resources. The usage of the XML Key Management Specification (XKMS) suffers on the unavailability of an open source server implementation. Even if available clients are free, there usage is coupled with fees concerning the generation of keys and certificates for users or servers. We also revised our primarily concept to use SAML authentication messages to realise a single-sign-on functionality within the BioCASE community. The complexity is too high as each small provider could stem it. Also, the implementation of these feature would be too expensive for the given project resources.

However, the present implementation paves the way to integrate confidentiality, integrity and authenticity of information using the planned XML standards XML-Signature and XML-Encryption. Within the project GBIF, also based on the BioCASE scenario, we reuse and enhance the present solution to realise features such as fine granular encryption and signing of BioCASE response content elements.

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