Full Prototype of the AmI-MoSES Service Platform

AmI-MoSES Project

Ambient-Intelligent Interactive Monitoring System for Energy Use Optimisation in Manufacturing SMEs

FP7-ICT-224250

Public Project Report

Project Facts:	**Duration:**	**36 Months (September 2008 – August 2011)**
	Programme:	**FP7 – ICT**
	Website:	**http://www.ami-moses.eu**

The AmI-MoSES Project is co-funded by the European Commission under the Information and Communication Technologies (ICT) theme of the 7th Framework Programme (2007-2013)

This publication was completed with the support of the European Commission under the 7th Framework Programme. The contents of this publication do not necessarily reflect the Commission's own position.

Authors and AmI-MoSES Project Partners

	**ATB** **Institut für angewandte Systemtechnik Bremen GmbH** **http://www.atb-bremen.de**	**Bremen** **Germany**
	**TECNALIA** **http://www.tecnalia.com**	**Derio** **Spain**
	**RIFOX – Hans Richter GmbH Spezialarmaturen** **http://www.rifox.de**	**Bremen** **Germany**
	**Vicinay Cadenas Sociedad Anonima** **http://www.vicinaycadenas.com**	**Bilbao** **Spain**
	**MB Air Systems Limited** **http://www.mbairsystems.co.uk**	**Wishaw** **United Kingdom**
	**Reimesch Kommunikationssysteme GmbH** **http://www.reimesch.de**	**Bergisch-Gladbach** **Germany**
	**Disseny I Subministres Tecnics, S.A.** **http://www.distec.org**	**Girona** **Spain**
	**Solvera Lynx d.d.** **http://www.solvera-lynx.com**	**Ljubljana** **Slovenia**
	**Valtion Teknillinen Tutkimuskeskus** **http://www.vtt.fi**	**Espoo** **Finland**

Summary

The AmI-MoSES project is about realising an innovative, beyond the state-of-the-art solution for Energy Efficiency optimisation in manufacturing companies. The solution is based on the one hand on a novel approach to energy consumption monitoring by introduction of so-called Ambient Intelligence parameters and on the other hand on combination of so extended data set with Knowledge Management technologies to realise a decision support system as an innovative extended Energy Management System. Viability of the AmI-MoSES system functionalities is currently being proved in three typical manufacturing companies, within three business cases (BC) defined as a baseline for the project realisation.

This document presents a short description of the implemented full prototype of one AmI-MoSES subsystem – Service Platform and belonging services. The full prototype is developed according to the specification, refined and completed based on the early prototype testing and comments from the project reviewers and User Interest Groups members. Testing and justification of the system concepts are running, facilitating gathering of additional requirements and ideas for the ICT system improvement. The full prototype is currently in the initial phase of the demonstrators' creation and collection of ideas for the prototype refinement on the way to the commercial product.

The document comprises, similar to the early Prototype description, a tabular comparison of the EP functionalities vs. FP, followed by the workflow of the Full Prototype for the sake of facilitating following of the whole system ideas and the following text. Technical details of the platform architecture and used software tools, as well as description of the user authentication and basic platform set-up, are presented in chapter 4, illustrated by screen-shots of the GUIs enabling access to implemented functionalities. The same approach of presenting implemented functionalities, using screen shots of the corresponding GUIs, is applied for description of the developed services, where they have a GUI, as can be seen in chapters 5 (MSI services) and 6 (KM services). In the case of implemented system components which do not have a GUI, i.e. which are to be accessed by the system administrator, such as Common Repository in chapter 7, there is short description of the structure with examples of class diagrams for several classes. Chapter 8 is dedicated to the concluding remarks.

The full prototype of the Service platform briefly presented here is currently being tested and assessed, partly as a separate part (AmI-MoSES subsystem) and partly within the integrated full prototype of the AmI-MoSES ICT system, i.e. in the three demonstrators.

Table of Contents

Abbreviations

AmI	Ambient Intelligence
API	Application Programming Interface
ASCS	Application Specific Collaborative service
ATB	Institute for applied Systems Technology Bremen GmbH
BC	Business Case
BU	Business Units
CBR	Case Based Reasoning
CR	Common Repository
DBMS	Database Management System
ECD	Energy Consumption Data
EE	Energy Efficiency
e.g.	exempli gratia = for example
EP	Early Prototype
etc.	et cetera
EU	European Union
EUP	Energy Use Parameters
FP	Full Prototype
GUI	Graphical User Interface
ICT	Information and Communication Technology
i.e.	id est = that is to say
JAX-WS	Java API for XML-Web Services
JPA	Java Persistence API
JSF	Java Server Faces
KM	Knowledge Management
KR	Knowledge Repository
MSI	Management of Social Interactions
RBR	Rule-based Reasoning
SOA	Software Oriented Architecture
UML	Unified Modeling Language
XML	Extensible Markup Language

1 Introduction

This document is part of the AmI-MoSES deliverable D4.4 and presents a short description of the software implemented as Full Prototype of the AmI-MoSES Service Platform. Main part of the deliverable D4.4 is the actual implemented software. This document comprises a brief description of the implemented functionalities as well as of the platform architecture and software tools, followed by description of the AmI-MoSES Common Knowledge Repository.

The following describes application of the AmI-MoSES platform in BC3 – Vicinay, whereby description of application within BC2 – RIFOX is presented in the D3.4 since the main difference of these two BCs is actually in the energy consumption context and monitored EUPs, which is elaborated in D3.4. Application of the platform in BC1 – MBAS is described in the example of the collaborative problem solving during manufacturing system ramp-up phase and is indicated by description of the corresponding EE service Installation and Ramp-Up Support in deliverable D5.3 - AmI-MoSES Full Prototype.

1.1 Objective of the document

The objective of this document is to provide basic technical facts about the developed full prototype and an overview of the functionalities. Its purpose is to support the prototype testers either as end users or independent testers and to facilitate collection of feedback from the testers.

The document presents the current status of the AmI-MoSES full prototype system development, and does not represent documentation of the software developed or to be developed in the scope of the project.

1.2 Document Structure

The document structure is in compliance with its objectives i.e. the a.m. content is divided in following chapters:

- Chapter 1, as seen above, presents introduction
- Chapter 2 gives an overview of the functionalities covered by the Full Prototype Implementation
- Chapter 3 provides description of the workflows of the Full Prototype
- Description of the Service Platform architecture, software tools used in the implementation and user authentication with basic set-up procedure is provided in Chapter 4
- Chapters 5 and 6 are dedicated to description of the generic core services for Management of Social Interactions (MSI), and Knowledge Management (KM), respectively[1]
- Chapter 7 provides a description of the AmI-MoSES Common Knowledge Repository structure in the form of class diagrams
- Chapter 8 presents short conclusions about the implemented system prototype

[1] Full prototypes of the Energy Efficiency services are presented within the description of the integrated full prototype in deliverable D5.3 - AmI-MoSES Full Prototype.

2 Functionalities covered by the Full Prototype

Full Prototype functionalities are developed based on the D4.1 Specification of the AmI-MoSES Service Platform, results of the early prototype testing presented in D5.2 Early Prototype Assessment and on the comments and suggestions from reviewers, documented in the Technical Review Reports from the three Review Meetings.

The list of the Full Prototype functionalities against those realised in the early prototype is presented in Table 1.

Table 1: Functionalities of the Early and Full Prototype

No	System Component - Functionality	Early Prototype	Full Prototype
1	**AmI-MoSES Platform**	• Basic version of the SOA platform • Security Service for Authentication • Data Management Services	• Service execution environment, • Full security framework, • External measurements systems integration.
2	**Knowledge Repository**	• Initial version - main features completed, but still open for modifications to come during full prototype implementation	• Complete CR • Data Management Services
3	**Generic Core Services – MSI**	• Limited Resource Discovery Service functionality • Limited Selection of Comm. Services functionality • Basic GUIs for the implemented functionalities • Notification Service, limited to e-mail • Tracking of user interaction, no retrieval/presentation	• Resource Discovery Service • Selection of Commination Services • Full set of GUIs for the implemented functionalities • Notification Service, for the implemented functionalities • Tracking of user interaction, incl. retrieval/presentation
4	**Generic Core Services – KM**	• Case-based Reasoning • Knowledge Provision for product/process	• Case Based Reasoning (CBR) – complete • Rule Based Reasoning (RBR) – complete • Knowledge Provision – Retrieve Knowledge
5	**Application-Specific Core Services**	• Basic problem solving service • Limited number of AmI Data Adapters (only for BC-specific devices) • Context set-up	• Problem solving service • AmI Data Adapters for BC-specific devices • Context set-up
6	**EE Services**	• Rudimentary version of Condition-based Energy Consumption Warning Service • Full Prototype of 2 Energy Efficiency services: for On-line Diagnostics of Energy related Problems and Continuous Improvement	• Condition-based Energy Consumption Warning, On-line Diagnostics, Installation and Ramp-up Support, Continuous Improvement
7	**AmI-MoSES system**	Early prototype components integrated	Full system integration in the scalable platform

3 AmI-MoSES Full Prototype Workflow

Shortly described AmI-MoSES (full) system workflow comprises the following steps, as described in the D1.4 AmI-MoSES Concept and presented in Figure 1:

1. Platform set-up
2. Monitoring of EUPs' values, based on ECD and AmI data, and – by overriding defined alarm thresholds – starting:
    a. If the cause for alarm belongs to the group "Known", service for Condition Based Warning is activated
    b. If the cause for alarm belongs to the group "Unknown", service for Online Problem Diagnostics is activated
3. Service for Continuous Improvement of the Energy Efficiency starts, triggered by overriding of a predefined number of problems or by a system user, and
4. By commissioning of a new plant or a new plant subsystem/component, service for Installation and ramp-up support is used

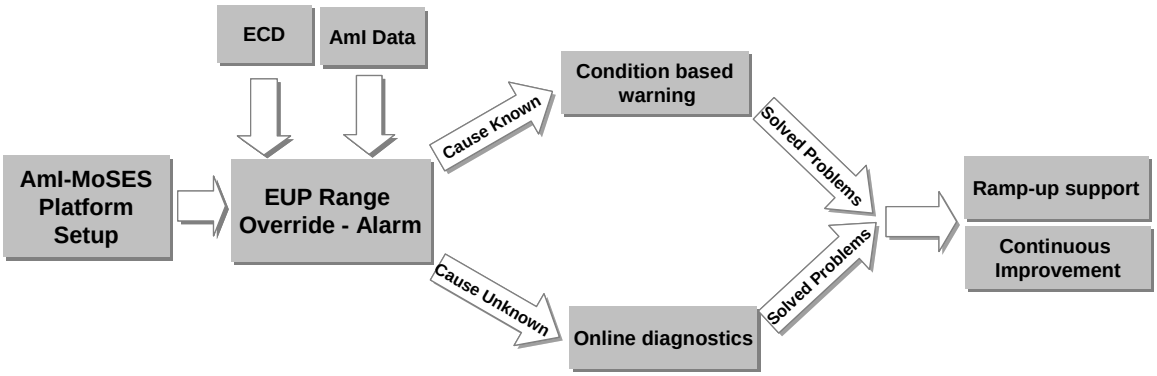


Figure 1: AmI-MoSES Full Prototype workflow

4 AmI-MoSES Service Platform

4.1 Platform description

Based on SOA principles the platform allows for building different software services, which will, among other functionalities, interactively provide suggestions of the appropriate actions for problem elimination and energy efficiency optimisation. This decision support is realised applying reasoning mechanisms on data coming from energy consumption measurement and so called ambience parameters measurement.

SOA platform is aimed at:

- acquisition of information/knowledge needed to optimise energy use in Manufacturing Systems over the life cycle
- usage of this information/knowledge for:
  - derivation of Life-cycle related Energy Use Parameters (EUP) and decision support to optimise energy use, and
  - provision of an open set of energy efficiency services for optimal energy use in MS in different life-cycle phases.

The AmI-MoSES system is energy neutral, meaning applicable to Energy Efficiency optimisation in MS, independent of the kind of the energy used.

The main assumption of the AmI-MoSES project is that such a platform can be effectively built based on AmI systems integrated in manufacturing environments (within machines, equipment, but also in the manufactured products).

The AmI-MoSES system, presented in Figure 2, based on the here described platform includes centralized Monitoring and advisory system to enable a holistic assessment/analysis of energy efficiency in MS during lifetime and provision of energy efficiency services. The platform can be interfaced to different measurement systems over an Information middleware. These measurement systems can be decentralized, and can capture energy consumption data (ECD) and energy related ambiance – process and environmental – data for intelligent processing and computation of (life cycle) EUPs.

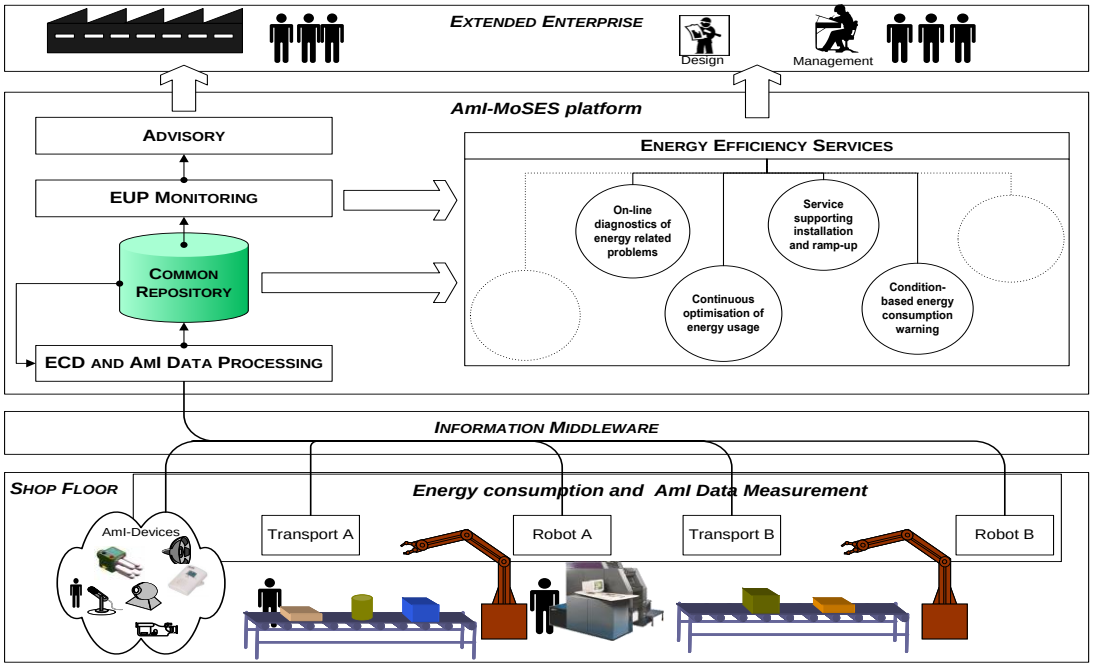


Figure 2: AmI-MoSES System Concept

4.2 Implementation Architecture

The architecture implementation was done, as can be seen in Figure 3, according to the approach presented in the system concept.

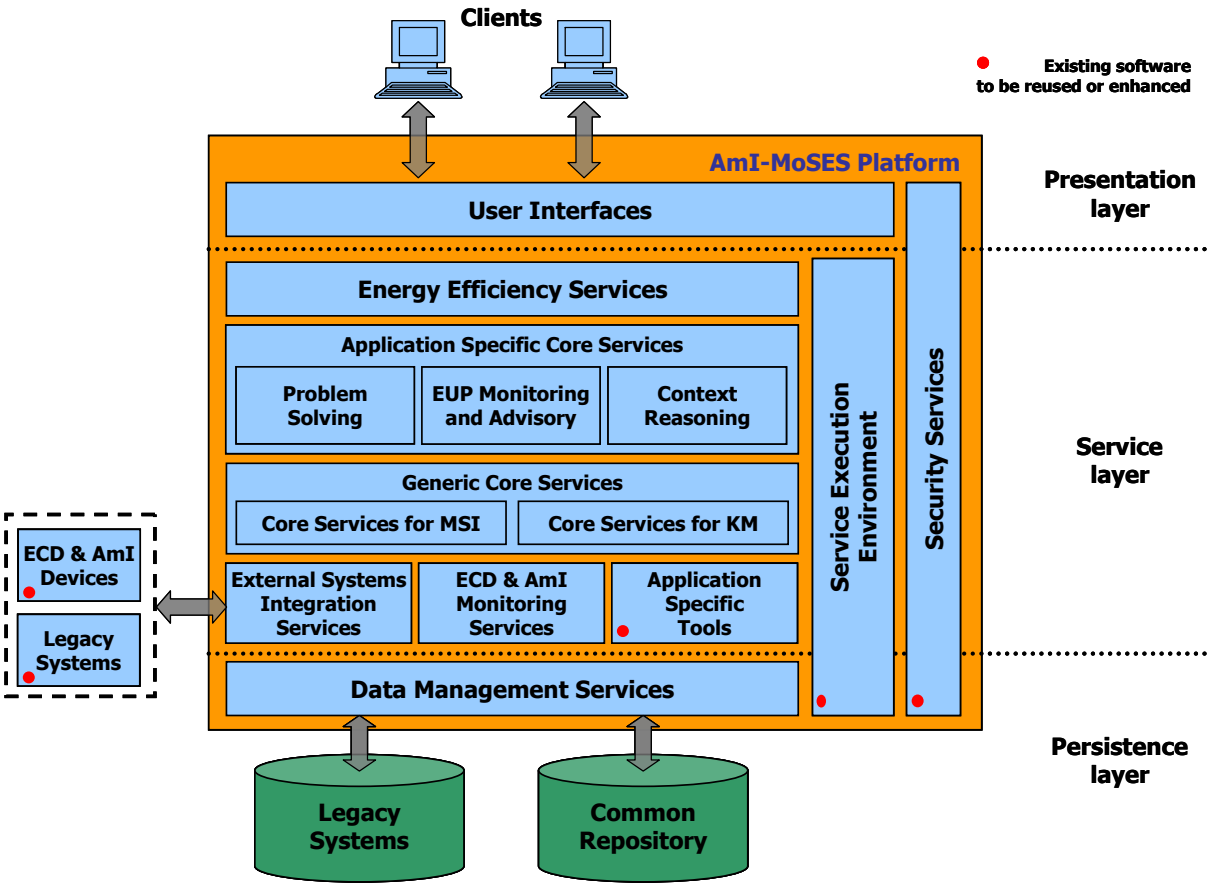


Figure 3: AmI-MoSES Full Prototype Implementation Architecture

Based on the basic versions of components that had been implemented for the early prototype all system components presented in the figure above have been further extended and adapted for the AmI-MoSES full prototype.

4.3 Software Tools

The development environment was selected following considerations from the system conception phase, i.e. primarily relying on open source software tools for development.

The tools used are listed in Table 2 below (for more detailed description see D1.4 AmI-MoSES Concept).

Table 2: Software tools used for AmI-MoSES full prototype development

Function	Software Tool
Database Management System (DBMS) / Common Repository	MySQL
Application Server	JBoss AS
Persistence Framework	JBoss Hibernate / Java Persistence API (JPA)
Web Services	JBoss Web Service Framework/Java API for XML Web Services (JAX-WS)
Case-based Reasoning	JColibri

Function	Software Tool
Charting / Reporting	JasperReports / Eclipse BIRT
User Interface	JBoss Seam/Java Server Faces (JSF)
Programming Language	Java
UML Modelling	No Magic MagicDraw UML
Project Management and Build Automation	Apache Maven and Apache Ant
Model-driven Architecture	AndroMDA (for Common Repository only)
Integrated Development Environment	Eclipse IDE
Version Control System	Subversion
Bug tracking system	Mantis BT

4.4 Platform functionalities

4.4.1 Log-in

After accessing the AmI-MoSES system address a user has to authenticate himself. Figure 4 presents Mr Jens Ahlering from RIFOX logging in to the AmI-MoSES system.

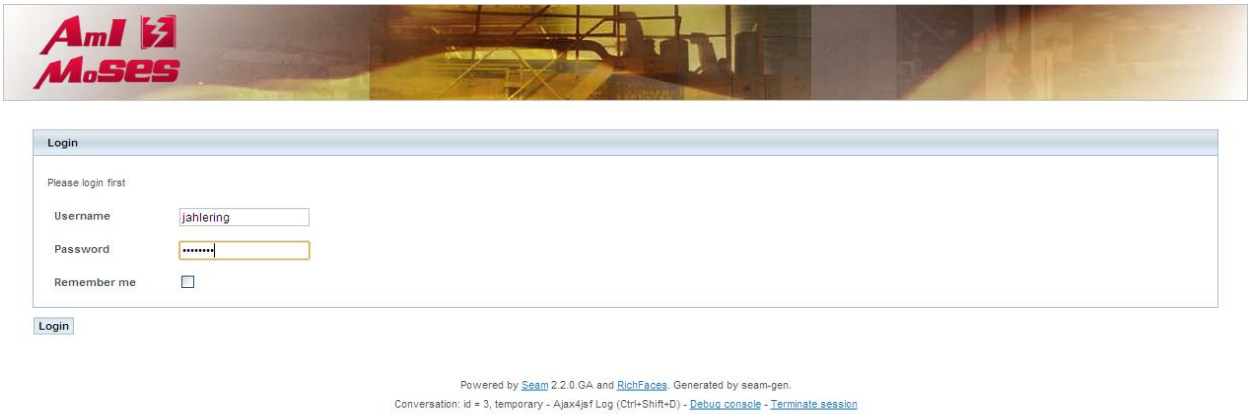


Figure 4: AmI-MoSES Log-in

After logging in the AmI-MoSES home screen is displayed, as shown in Figure 5. It contains the main menu – granting access to the different AmI-MoSES platform functionalities – on the left, as well as a welcome message and status message about pending alarms in the main area.

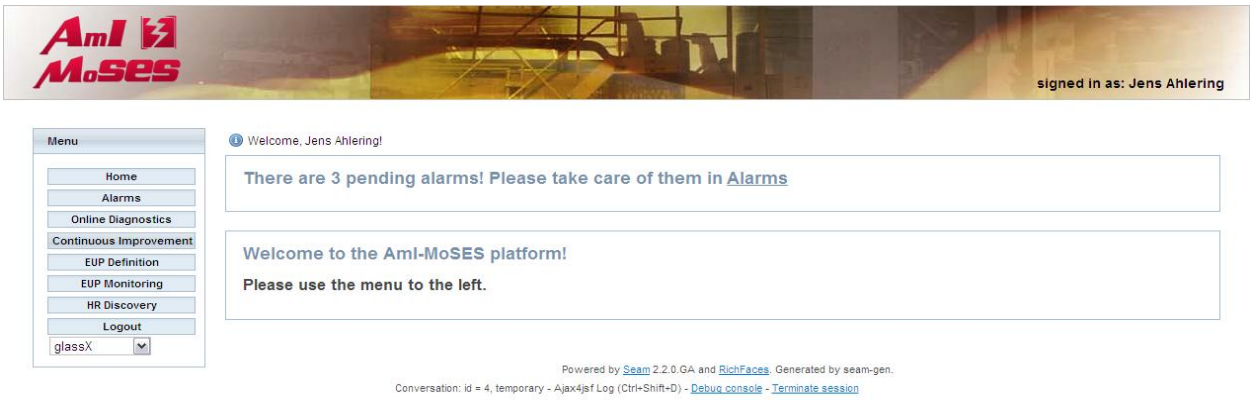


Figure 5: AmI-MoSES home screen

4.4.2 Platform Set-up

As described in the system concept, platform set-up comprises enterprise model insertion by definition of enterprise constructs in form of an XML file that complies with an XML Schema, which is derived from the AmI-MoSES Knowledge Repository structure.

Information about master data like business unit structure, employees, production units, product parts, process steps, existing ECD measuring devices, etc. is encoded into such an XML file, and uploaded into the AmI-MoSES platform by users with the appropriate access rights (i.e. administrators). This facilitates initial set-up of the AmI-MoSES platform's Knowledge Repository with needed master data.

Uploading data into the Knowledge Repository is depicted in Figure 6. Defining/editing production units and product parts (other data model entities can be accessed in a similar way) is shown in screen shots in Figure 7 and Figure 8, respectively.

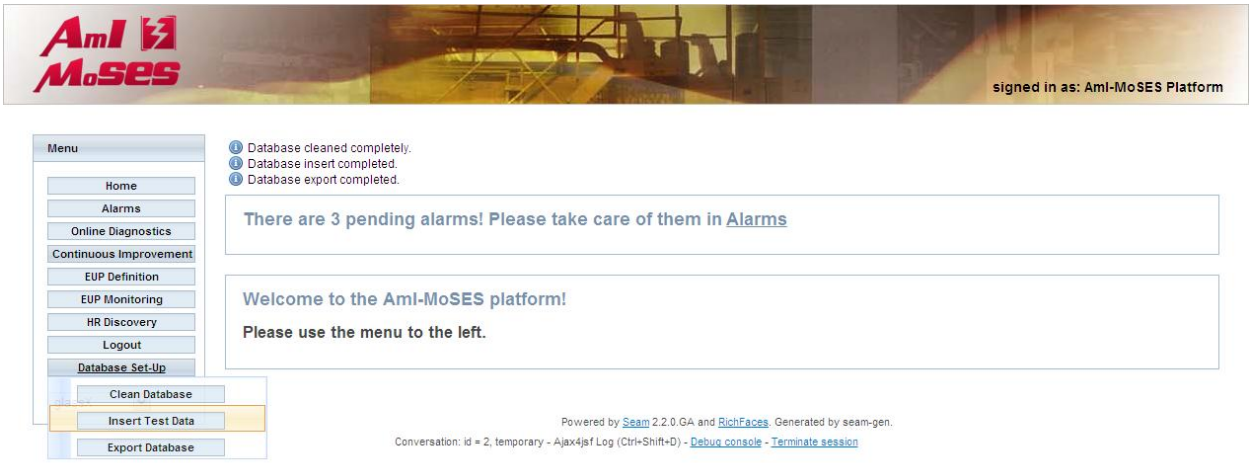


Figure 6: AmI-MoSES platform set-up

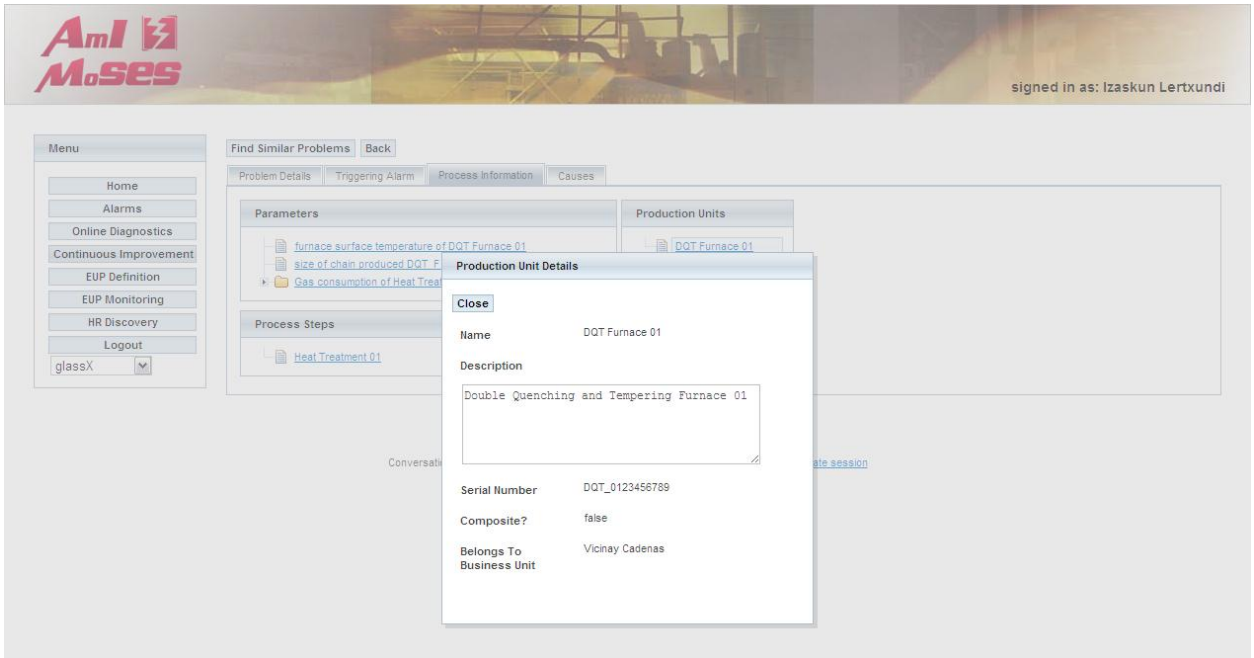


Figure 7: Production unit description

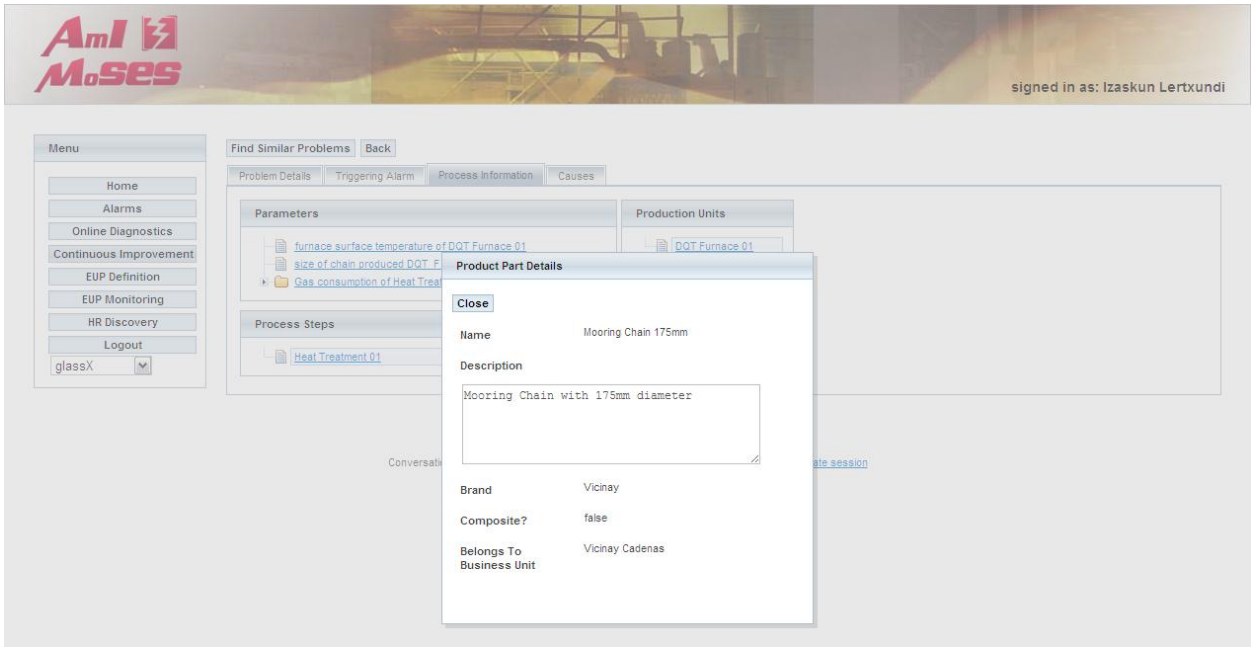


Figure 8: Product part description

5 Generic Core Services for Management of Social Interactions

5.1 MSI Service for Resource Discovery

As described in the system concept, the "Resource Discovery" service is used for finding experts possessing predefined expertise within an Extended Enterprise. As it can be seen in Figure 9, the search criteria, related to the specific expertise and the availability can be selected from a set defined in the common repository.

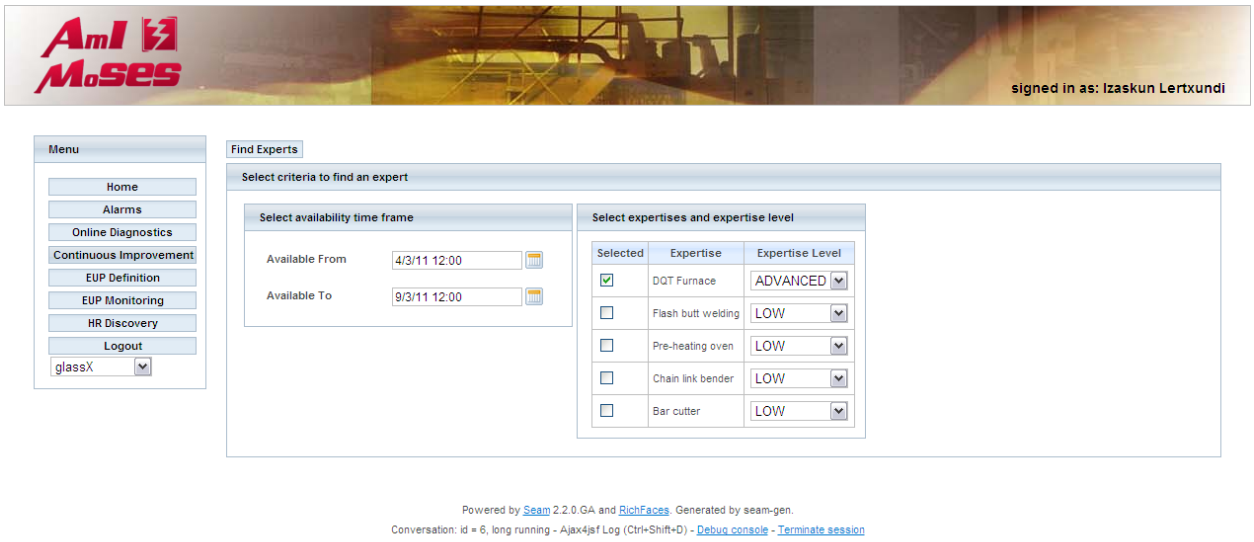


Figure 9: Expert search criteria

The search results are shown in the GUI as presented in Figure 10.

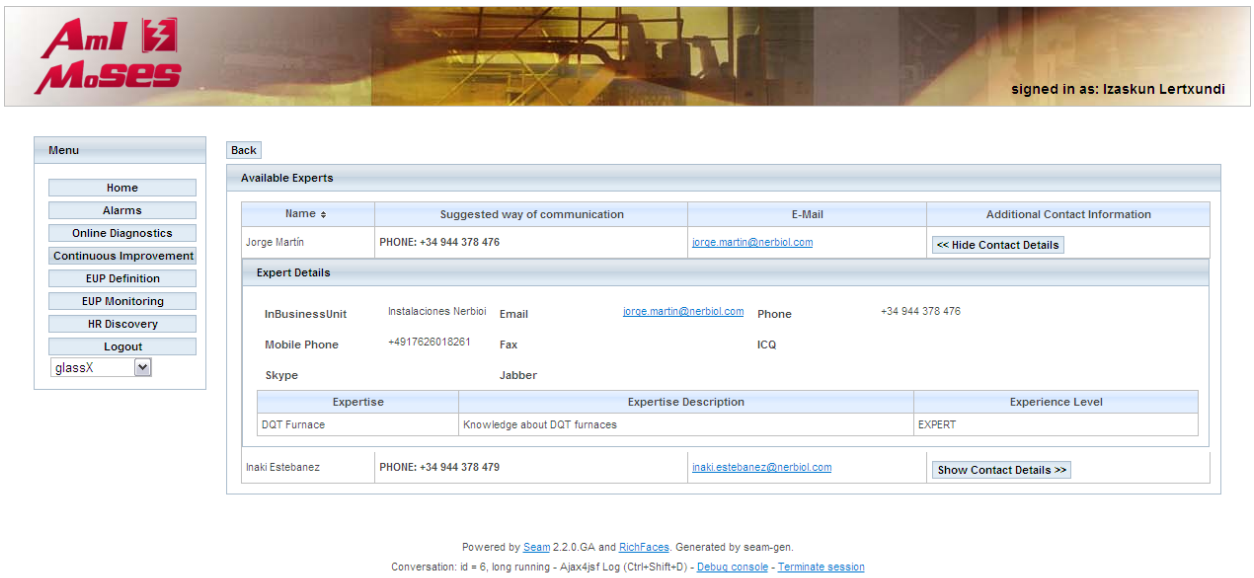


Figure 10: "Resource discovery" search results

5.2 MSI Service for Selection of Communication Services

Among the predefined search criteria in addition to sought expertise and availability and employed collaboration pattern, there is also criterion of the personal communication preference within the available communication means/company policies regarding communication. Search result based on all these criteria can be seen in Figure 10 for each selected expert.

5.3 Collaboration Tracking & Tracing Service

The Collaboration Tracking & Tracing Service allows keeping track of user actions performed on the AmI-MoSES platform. Its functionality includes collecting and storing user activities in the Common Knowledge Repository as well as retrieving tracked activities from the Knowledge Repository. Figure 11 shows the result list of tracked activities that have been collected from users working on solving a particular energy efficiency problem. Each line of the table lists the activity type, when it was performed and by whom. Furthermore, contact details of the user who performed the activity can be seen.

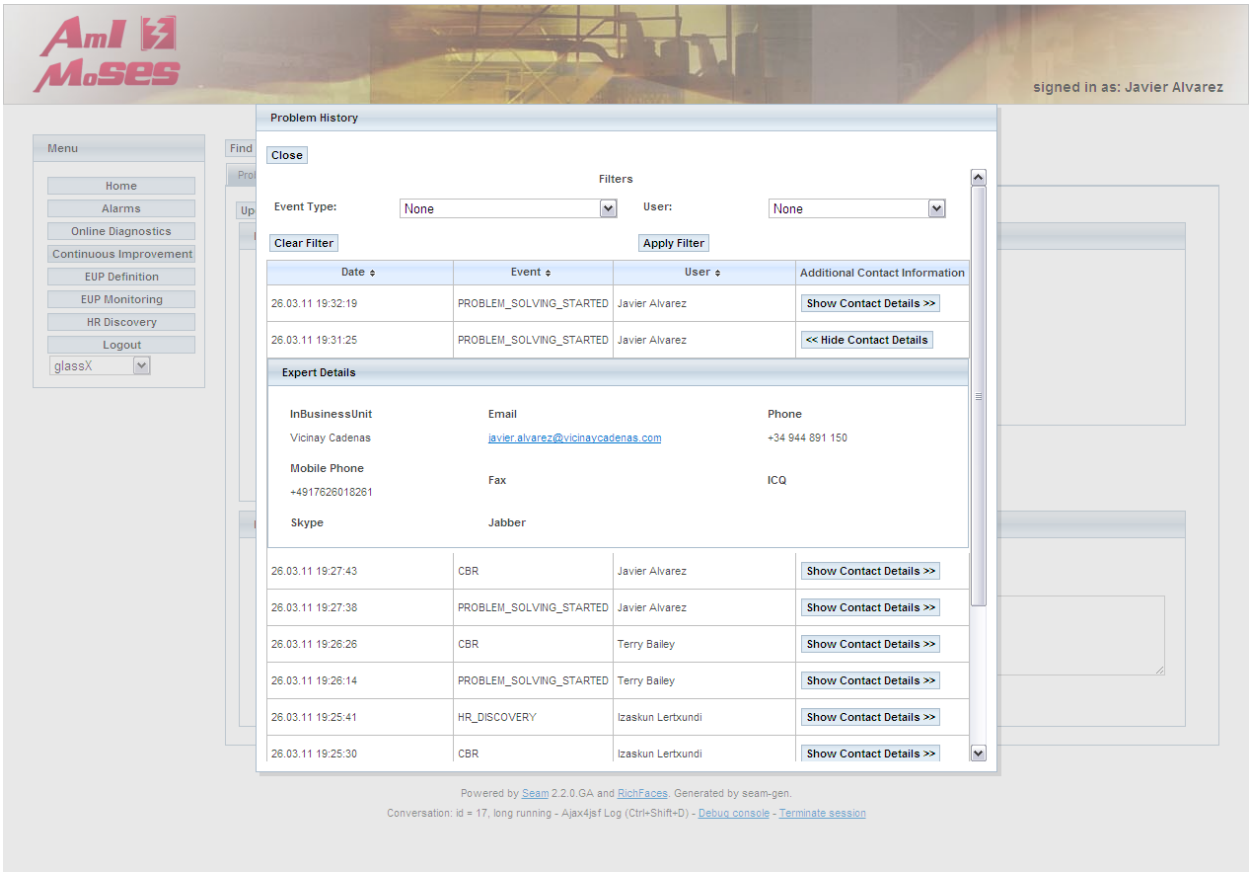


Figure 11: “Tracking & Tracing” search results

The Tracking & Tracing search results can further be filtered by event type and/or user who performed the activity using the dropdown boxes in the “Filters” section. Figure 12 shows the results from Figure 11 filtered by the user “Izaskun Lertxundi”.

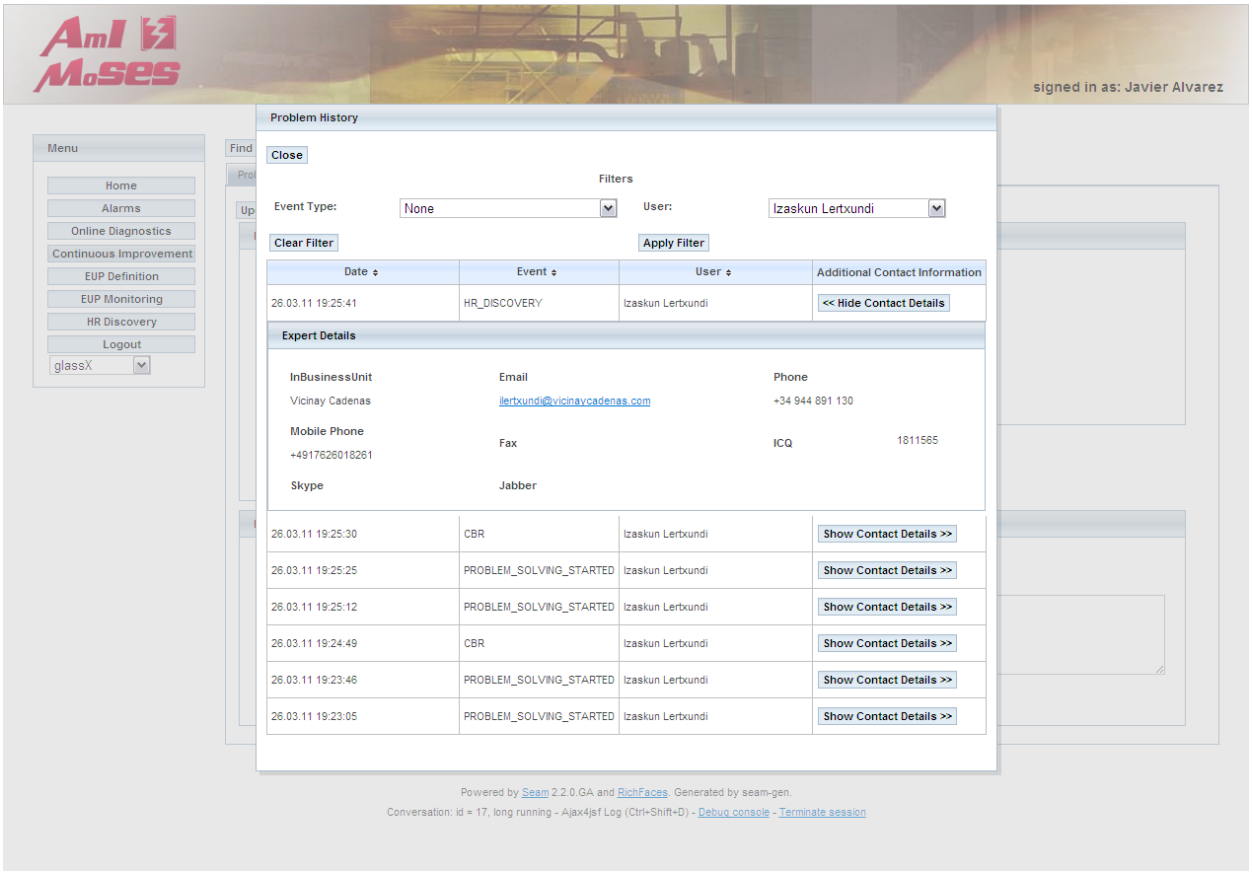


Figure 12: “Tracking & Tracing” search results filtered by user

5.4 Notification Service

The Notification Service provides functionality for informing defined responsible staff member(s) about important events regarding energy efficiency, using existing communication means and taking into account the staff members’ communication preferences. E.g. in the case of an alarm about an energy efficiency problem the notification service will send notifications to the staff members defined in the alarm definition. Currently supported notification methods include e-mail, SMS and a notification to logged in users on the AmI-MoSES platform itself. Figure 13 shows the screen to define notification recipients for an alarm. For each alarm several recipients can be selected, which are shown in the list of recipients. Each recipient can be removed from the list using the “Remove” button. New recipients can be added via the “Add recipient” link above the list of recipients. One or more notification methods for the alarm can be defined using the checkboxes for EMAIL, SMS and PLATFORM.

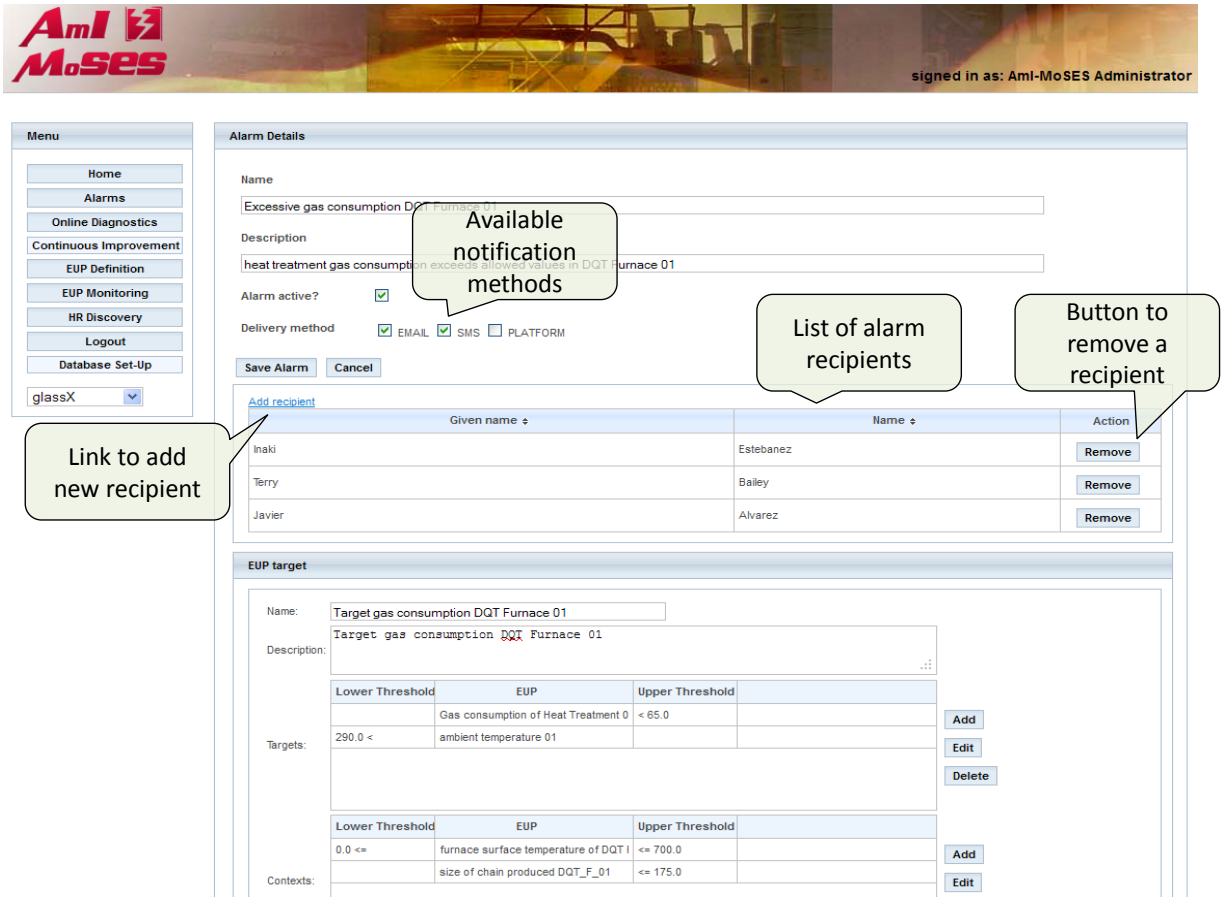


Figure 13: Notification Service – list of alarm recipients

Figure 14 depicts how to add a new recipient to the list of alarm recipients by selecting the user from a combo box.

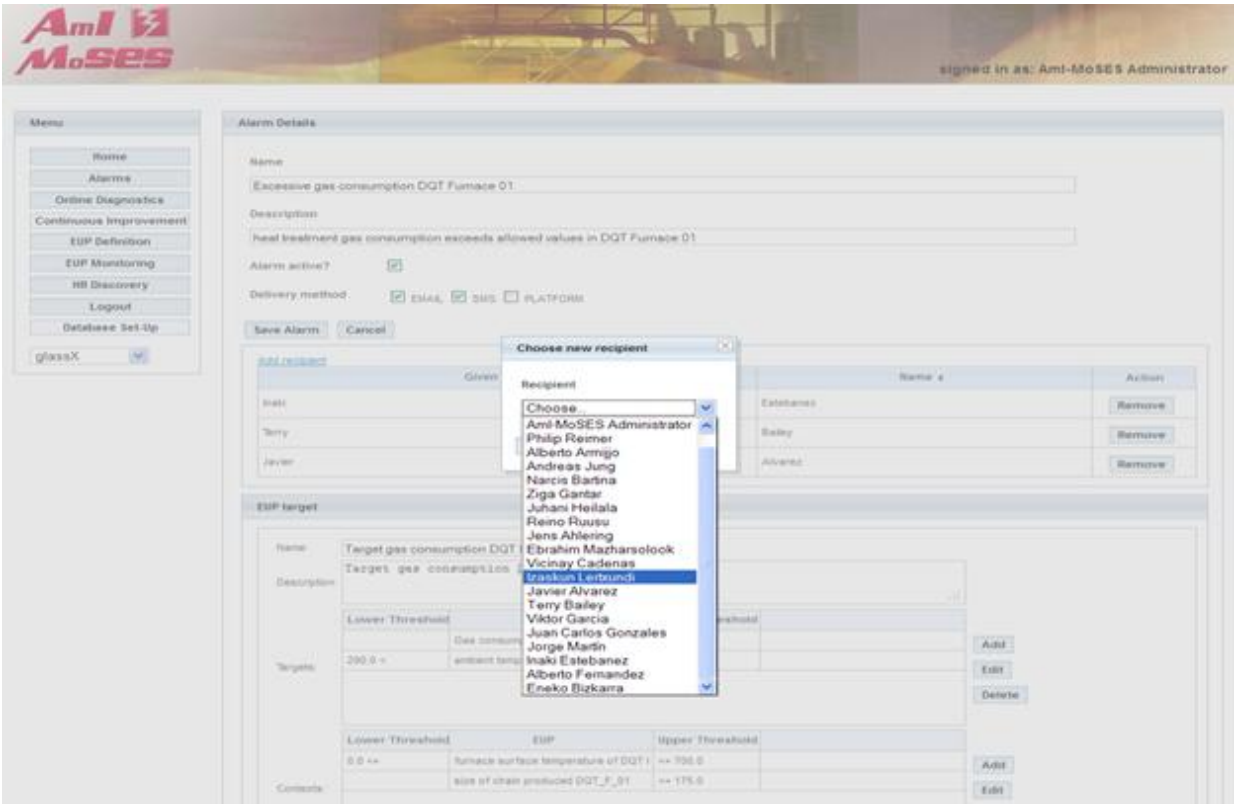


Figure 14: Notification Service – add an alarm recipient

Figure 15 shows how removing a recipient from the list of alarm recipients requires explicit confirmation from the user by clicking the OK button in the confirmation dialog. Only then the recipient is really deleted from the list.

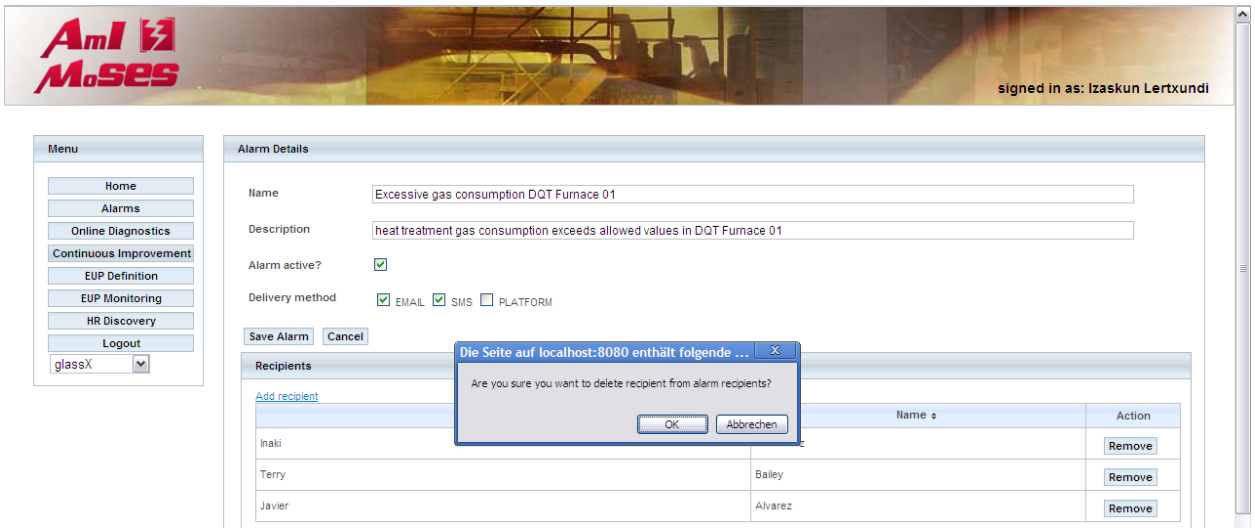


Figure 15: Notification Service – remove an alarm recipient

6 Generic Core Services for Knowledge Management

6.1 KM Service for Case-based Reasoning

This service was realised, as mentioned above, using free software JColibri**.** The CBR core service itself is used in the Service platform directly as a part of the problem solving ASCS and indirectly in the EE services for Online Diagnostics, Continuous Improvements and Ramp-up support. Therefore the implemented CBR functionality in the FP is illustrated through the application in the Online-diagnostics EE service, as presented in the figures below.

Essential functionalities of a Case Based Reasoning system are comparison of "cases" i.e. predefined patterns and calculation of similarities, which are in the AmI-MoSES system applied for comparison of a new problem description with a set of descriptions of previously solved problems – saved in KR – and in discovering of the most similar ones. As a result of the comparison the list of solved problems with corresponding similarity with a new problem is issued. For the problem description several predefined GUIs are applied and one of them related to the EUP description, including context data, is presented in Figure 16.

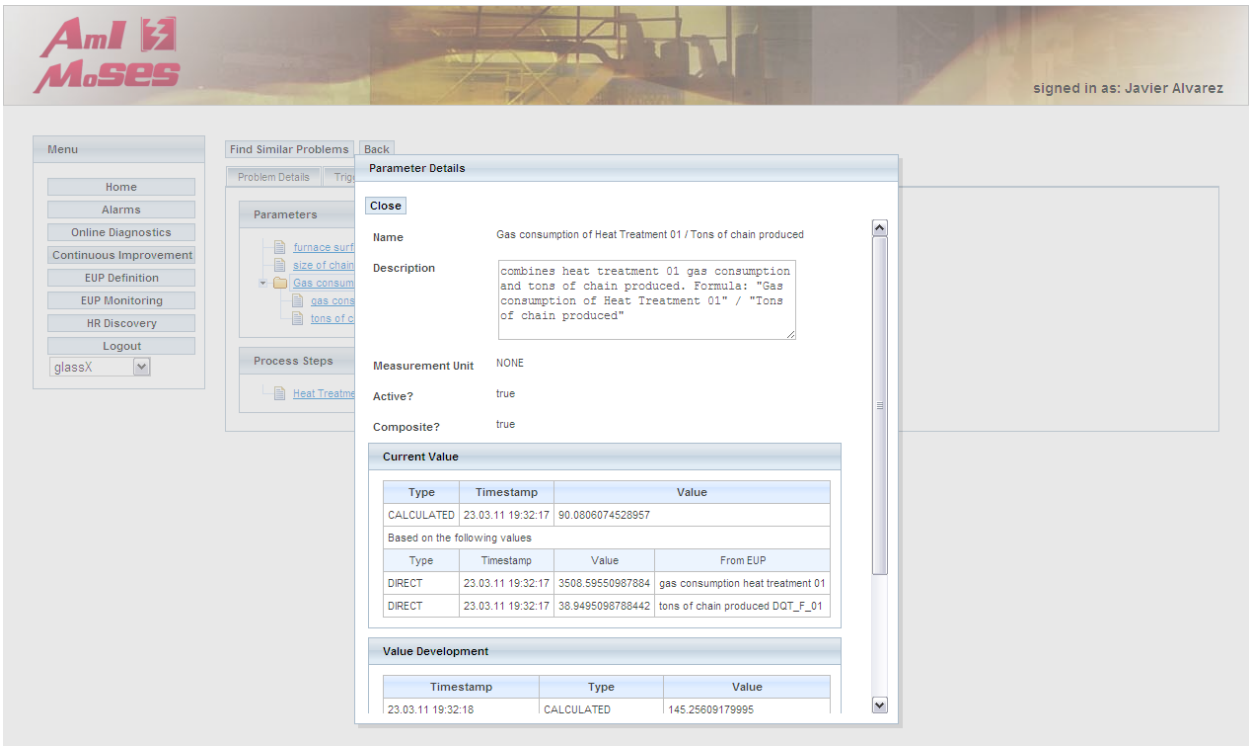


Figure 16: "Case" (Problem) description for the CBR application

Total similarity is calculated as a sum of weighted particular criteria whereby the criteria weights can be allocated for each specific application case with values in the range 0 to 100%, as illustrated in Figure 17.

Figure 18 presents comparison results with corresponding similarity values, in the range 0 to 100%, and Figure 19 presents listed possible problem causes and proposed actions.

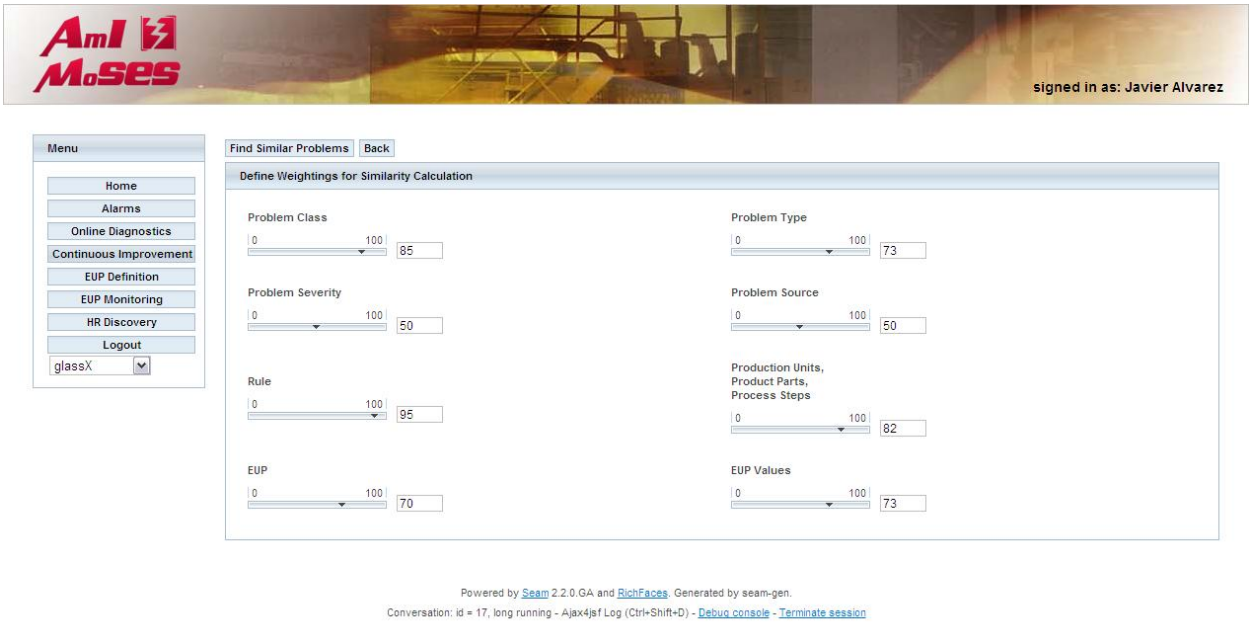


Figure 17: "Criteria weightings" for searching similar problems

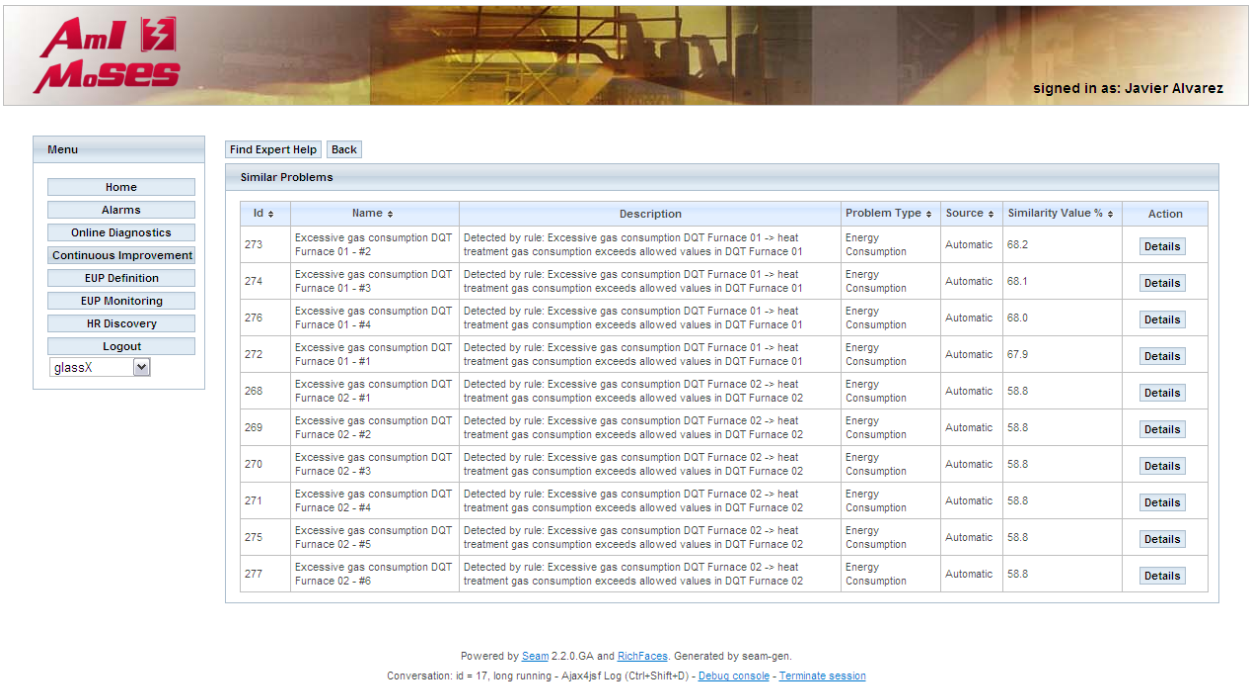


Figure 18: Output of the CBR search

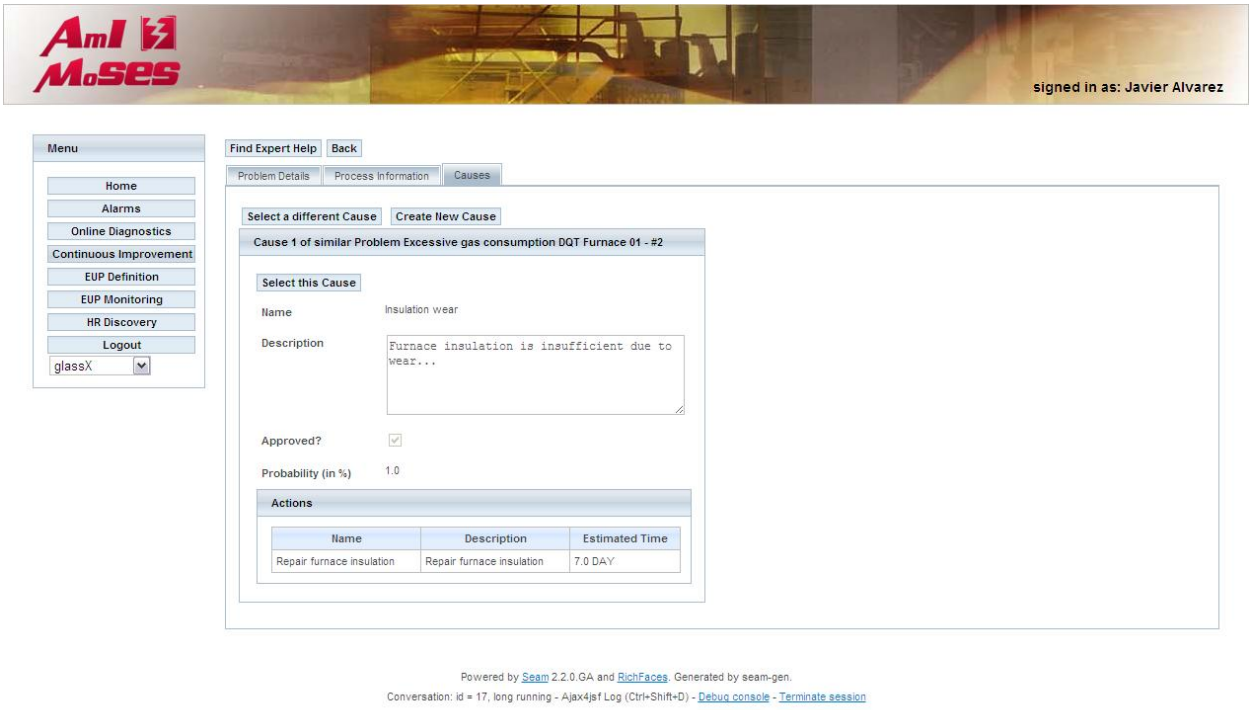


Figure 19: Causes of the similar solved problem and proposed action

Instead of selecting a cause from a found similar problem a user with sufficient rights may also define a new cause and attach new actions to that cause (Figure 20).

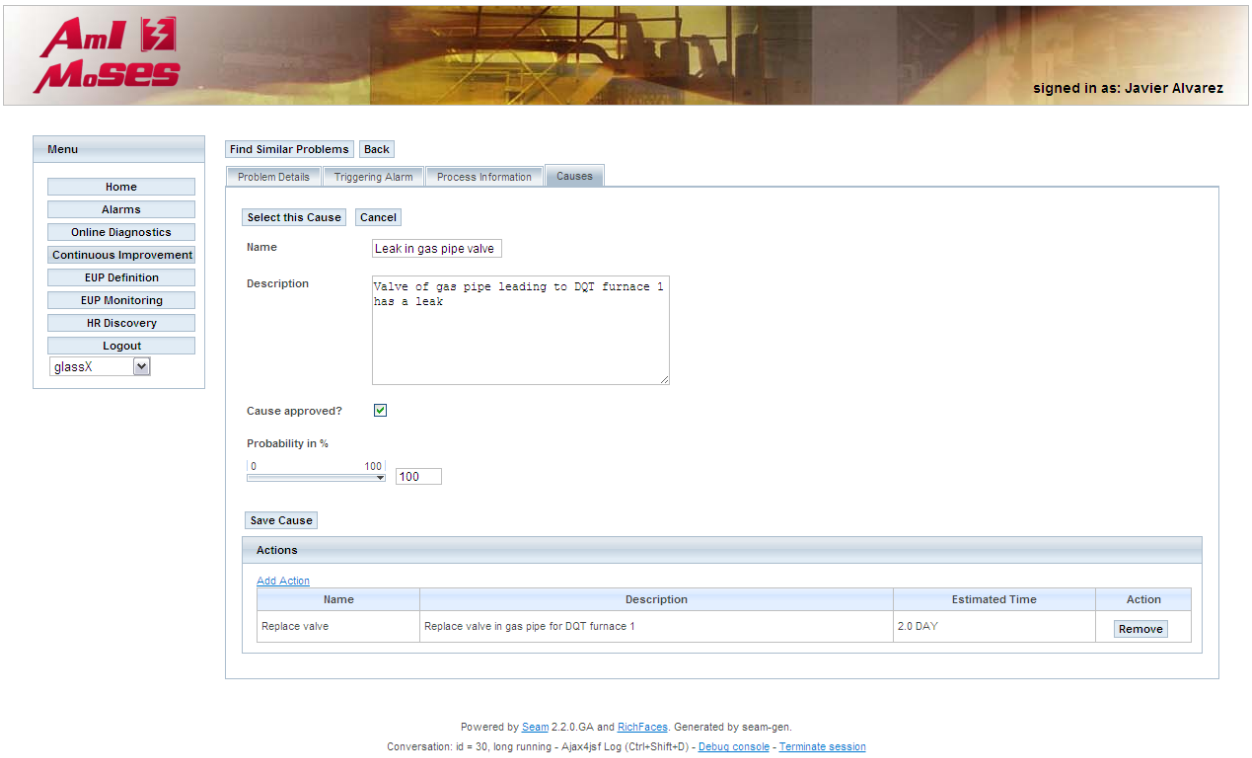


Figure 20: Creating a new cause with actions

6.2 KM Service for Rule-based Reasoning

Basic Rule Based Reasoning (RBR) principle can be described as execution of "if" – "then" inferring on a rule-base, which contains all of the appropriate knowledge encoded into If-Then rules. In the AmI-MoSES system this reasoning functionality is applied in the context reasoning

by the EUP monitoring and in the service for condition-based warning. The evaluation of the rules is done on the fly when a new value is being saved into the system. The process steps are as follows. When a new value comes into the system the RBR component checks if the corresponding EUP for which the value is being saved is a part of an existing rule. If this is true the value is evaluated against the set thresholds in the corresponding rules.

There are two types of RBR checks that are done in this step. First is the normal check that evaluates the current value whereas the second type predicts the future values, it estimates the trend of future values based on several past values. How the second evaluation type is done depends on the prediction method set on the EUP. Both of these checks raise an alarm if the thresholds are breached. The difference is only in the type of the alarm. The alarm for the prediction type check is preventive in way that it is there to prevent abnormal or even erroneous future conditions and is used for condition based maintenance service. The first type of the alarm is raised when these abnormal or erroneous conditions are already in place. In the ramp up phase it is to be expected that more of the error alarms are raised. But with continuous usage more of the prediction alarms are to be expected since more knowledge is stored in the system as well as the user gets more detailed knowledge on hot to fine tune "if-then" rules.

Both of these use the same GUI for adding or editing rules so as not to confuse users. The main view where "if-then" rules are created or changed can be seen in Figure 21. The only difference is that when working with alarms GUI in Figure 21 is only the part of the whole alarm view whereas in the EUP Definition Targeting models this is the main view.

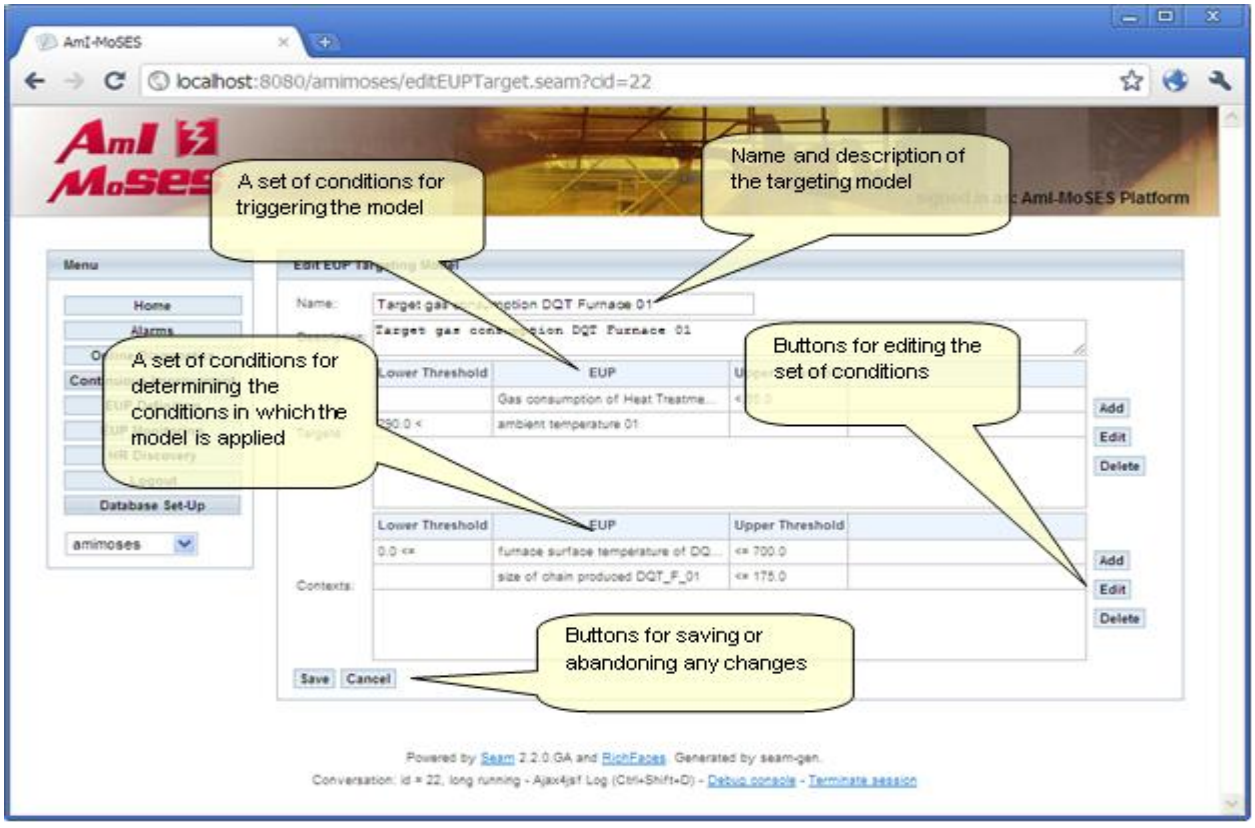


Figure 21: EUP Target editor

The "if-then" rules are applied using mathematical operands <, >, = and their combinations. As can be seen in Figure 21, there can be more than one EUP in one rule and the rules can be combination of target and context rules. That makes possible for rules to take into account the target values in a certain context. In Figure 22 the setting up of thresholds for EUP values is pictured. The result of setting up the threshold values is then seen in Figure 21 as one line in "Targets" or "Contexts".

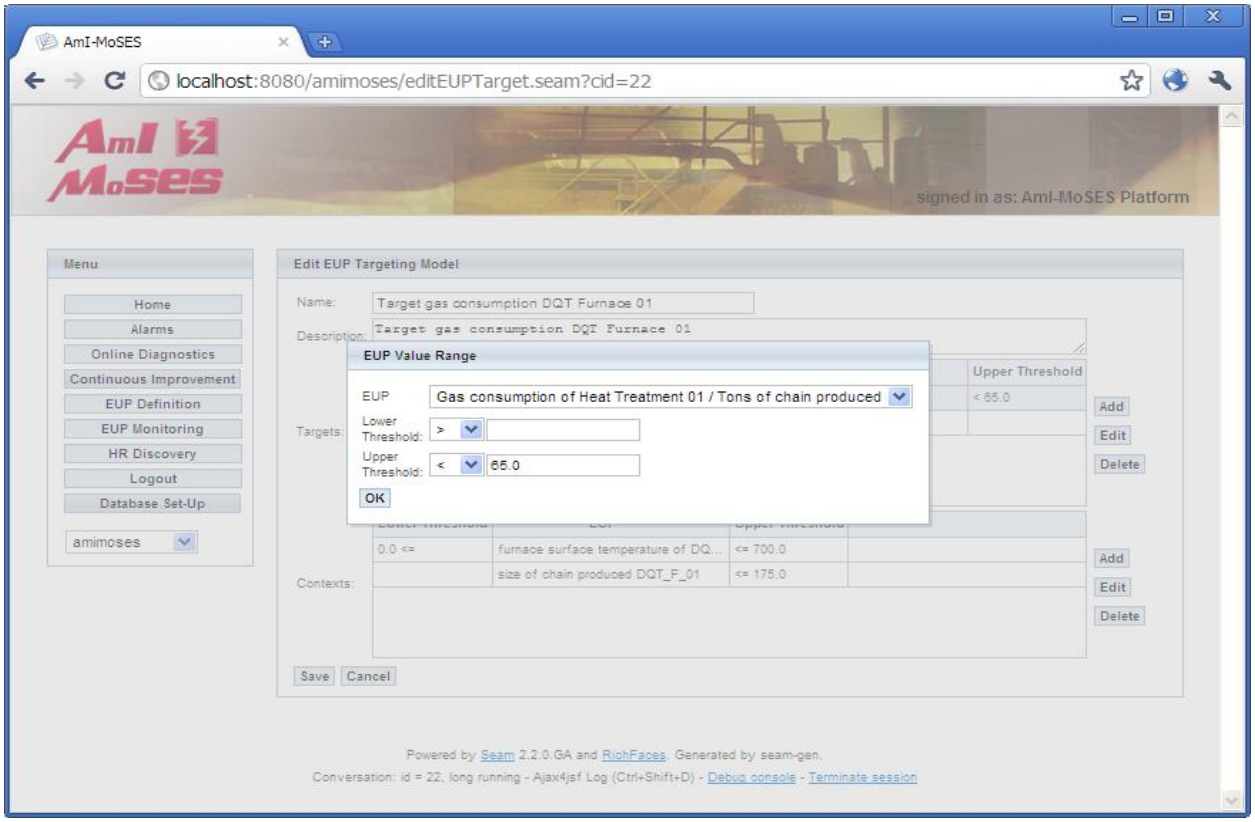
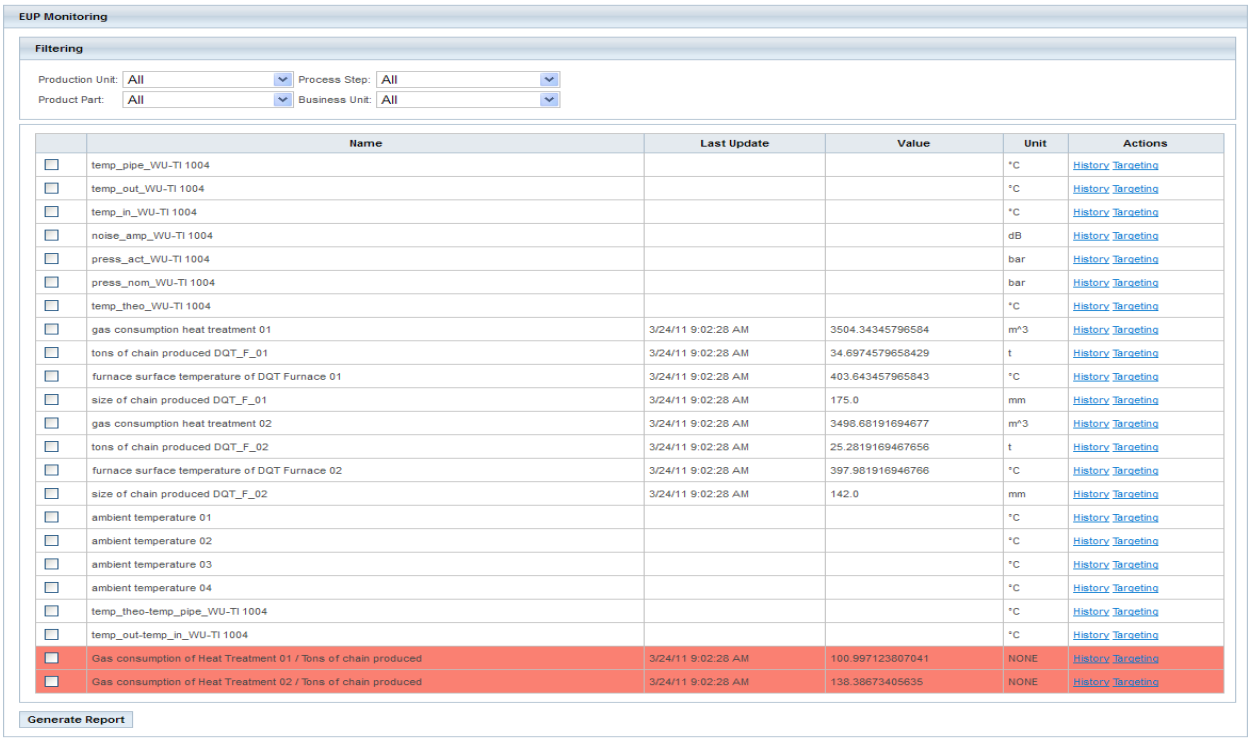


Figure 22: EUP value range

The whole list of RBR or EUP targets as are named in the AmI-MoSES system can be seen in the "EUP Monitoring" as seen in Figure 23. The table is populated with all EUPs and their latest data. In the rightmost column there is a link to "Targeting" which takes the user to the view as seen in Figure 24 where the details of the EUP target can be seen. In both figures the most recent values of the EUPs that are not within the set thresholds of the EUP target are marked with red colour to better alert the user of the breached thresholds.



Name	Last Update	Value	Unit	Actions
temp_pipe_WU-TI 1004			°C	History Targeting
temp_out_WU-TI 1004			°C	History Targeting
temp_in_WU-TI 1004			°C	History Targeting
noise_amp_WU-TI 1004			dB	History Targeting
press_act_WU-TI 1004			bar	History Targeting
press_nom_WU-TI 1004			bar	History Targeting
temp_theo_WU-TI 1004			°C	History Targeting
gas consumption heat treatment 01	3/24/11 9:02:28 AM	3504.34345796584	m^3	History Targeting
tons of chain produced DQT_F_01	3/24/11 9:02:28 AM	34.6974579658429	t	History Targeting
furnace surface temperature of DQT Furnace 01	3/24/11 9:02:28 AM	403.643457965843	°C	History Targeting
size of chain produced DQT_F_01	3/24/11 9:02:28 AM	175.0	mm	History Targeting
gas consumption heat treatment 02	3/24/11 9:02:28 AM	3498.68191694677	m^3	History Targeting
tons of chain produced DQT_F_02	3/24/11 9:02:28 AM	25.2819169467656	t	History Targeting
furnace surface temperature of DQT Furnace 02	3/24/11 9:02:28 AM	397.981916946766	°C	History Targeting
size of chain produced DQT_F_02	3/24/11 9:02:28 AM	142.0	mm	History Targeting
ambient temperature 01			°C	History Targeting
ambient temperature 02			°C	History Targeting
ambient temperature 03			°C	History Targeting
ambient temperature 04			°C	History Targeting
temp_theo-temp_pipe_WU-TI 1004			°C	History Targeting
temp_out-temp_in_WU-TI 1004			°C	History Targeting
Gas consumption of Heat Treatment 01 / Tons of chain produced	3/24/11 9:02:28 AM	100.997123807041	NONE	History Targeting
Gas consumption of Heat Treatment 02 / Tons of chain produced	3/24/11 9:02:28 AM	138.38673405635	NONE	History Targeting

Figure 23: EUP Targeting

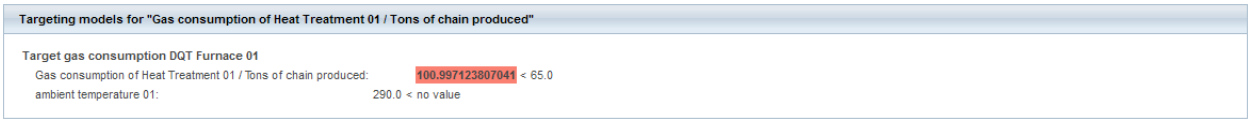


Figure 24: Targeting

6.3 KM Service for Knowledge Provision

This service provides functionalities for uploading, storing and retrieving information resources from the platform Common Repository or if the information is not directly available in the CR the system interfaces existing legacy systems and tries to retrieve information that do not conflict with Extended Enterprise Intellectual Property Rights in order to assist the users in solving energy related problems i.e. in using the Energy Efficiency services.

All users of the AmI-MoSES platform as well as the platform itself access indirectly the Data Management Services through the platform's other services. The Data Management Services' objectives are to allow users and services to manipulate data (knowledge) within the central Knowledge Repository, i.e. to store, search, update and delete data (knowledge) in the Knowledge Repository.

The Data Management Services are decomposed into the following components:

Data Manager: a generic service that offers basic data management functionality to store (create), update and delete an entity, as well as retrieve an entity specified by its ID or all entities of a given class

Specific Data Managers: to perform complex data queries according to defined criteria specific Data Managers are implemented derived from the generic Data Manager.

These user tasks do not require user interaction since the Generic Core services for Knowledge Managements will be interfaced by the Energy Efficiency Services. Thus, the Generic Core Services for Knowledge Management do not have any user interfaces.

7 Knowledge Repository

The complete structure of the Knowledge repository had already been realised for the early prototype and populated with data available and necessary for the EP testing. However, the structure of the KR was deliberately left open for possible adaptations, which were expected to appear during early prototype testing and full prototype implementation.

As the complete class diagram representing the KR would not fit on one page and to increase readability the KR class diagram has been split up into several parts, which are presented below. Each part covers one major area of the overall KR class diagram. Obviously, relationships between entities belonging to different major areas of the KR class diagram are not represented in the diagrams displayed below.

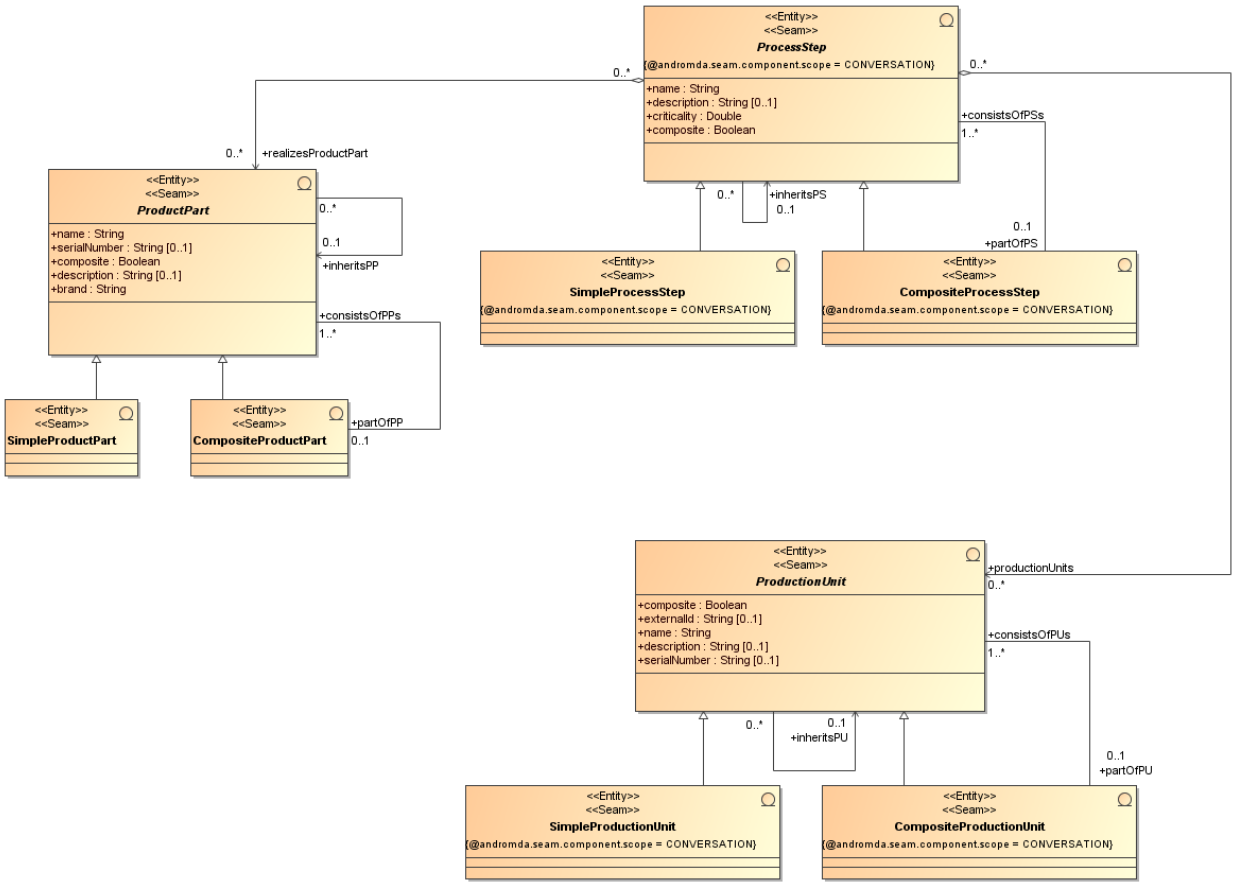


Figure 25: Class diagram of entities related to Production Units, Product Parts and Process Steps

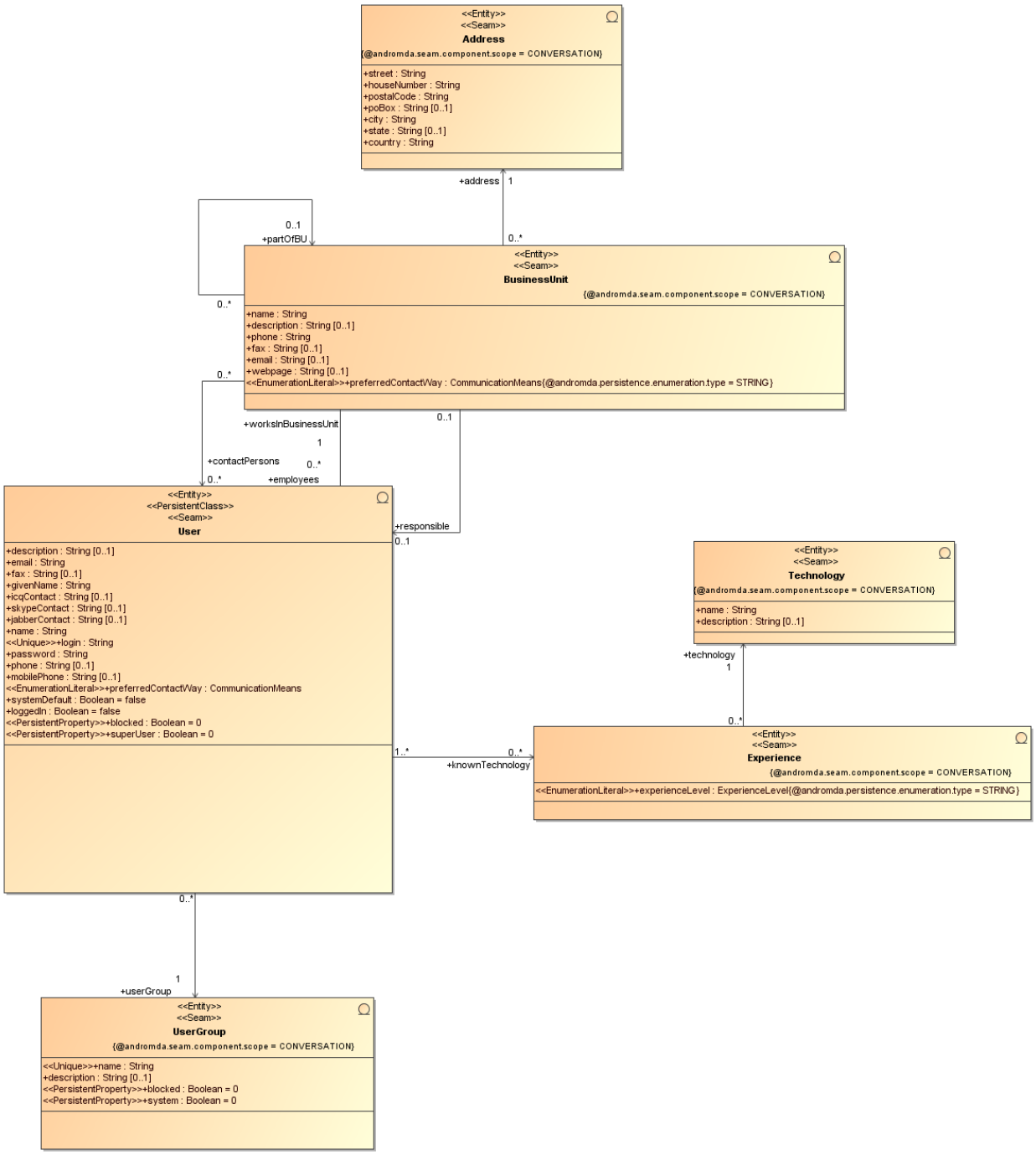


Figure 26: Class diagram of entities related to Users and Business Units

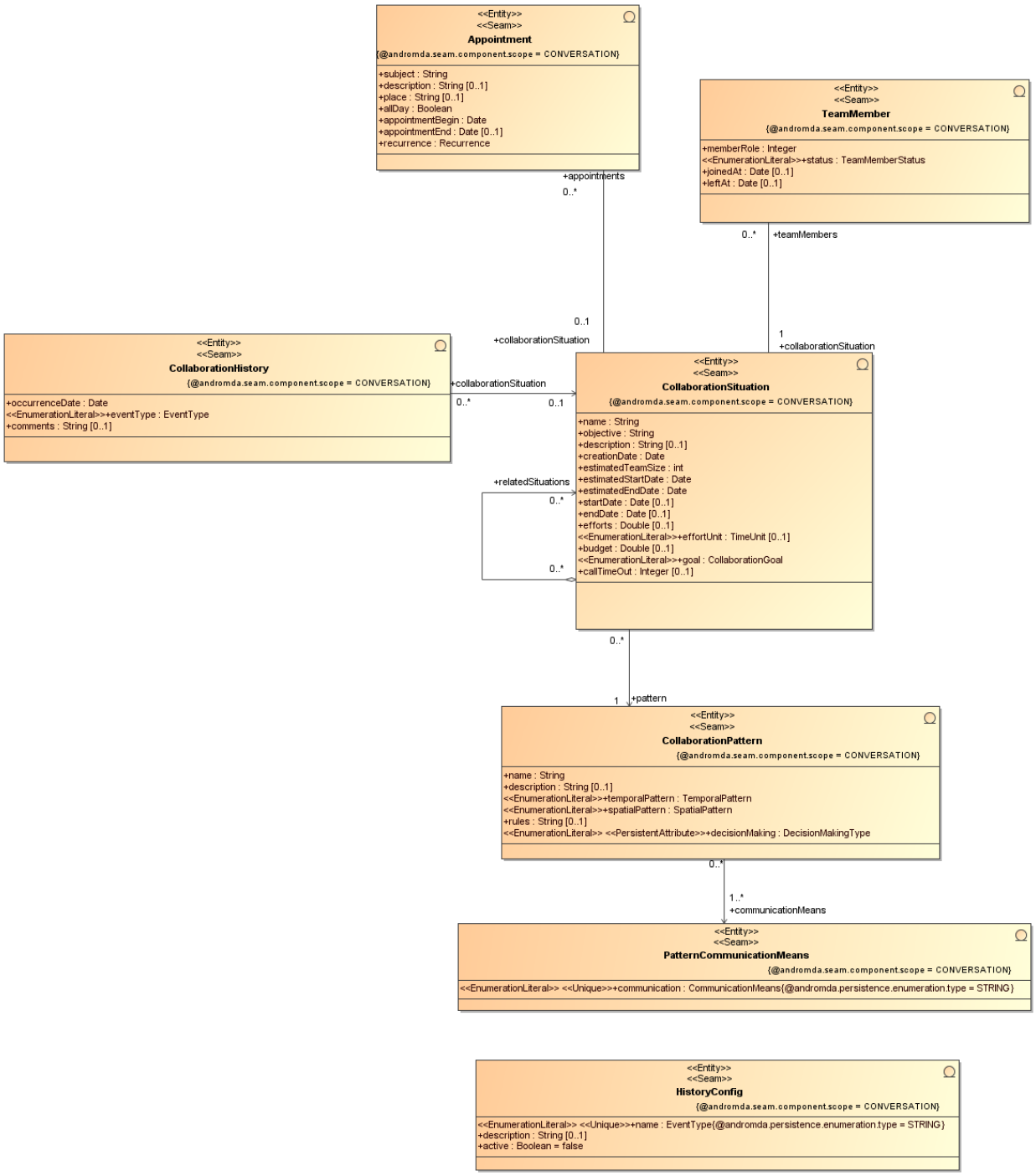


Figure 27: Class diagram of entities related to Collaboration

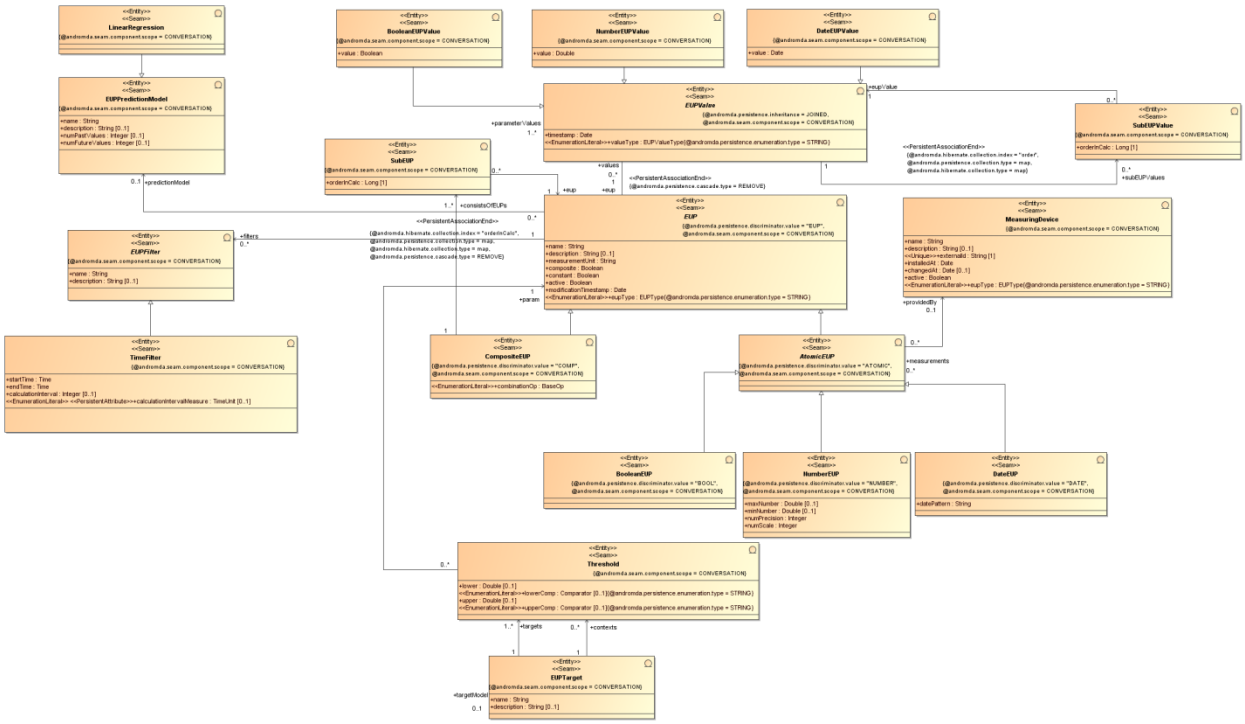


Figure 28: Class diagram of entities related to EUPs

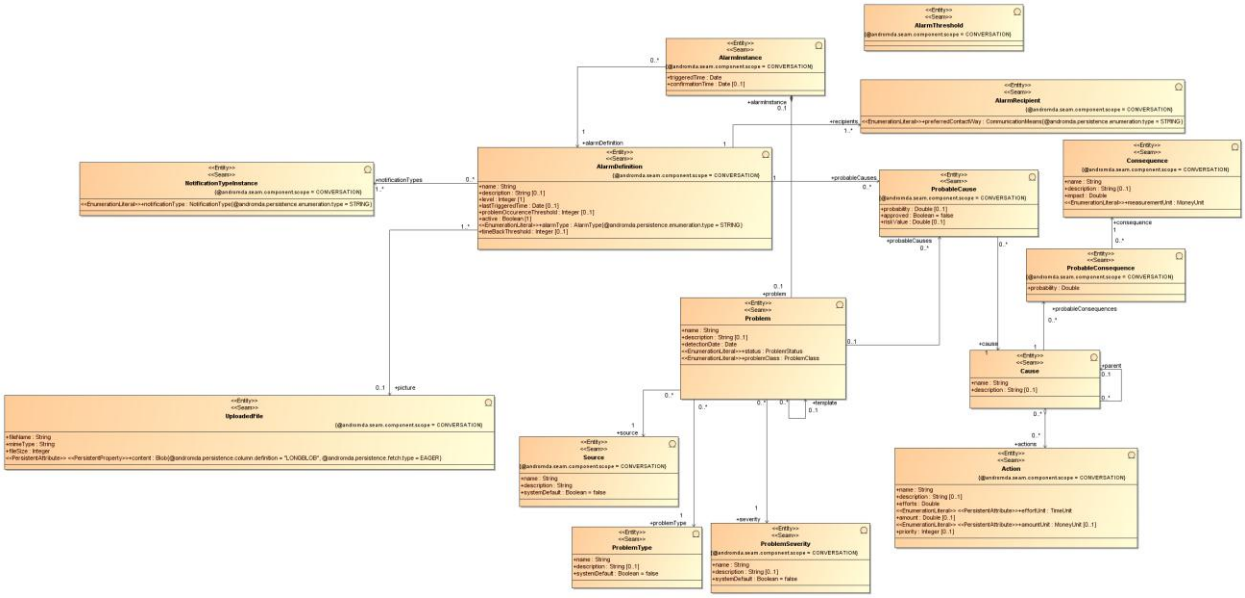


Figure 29: Class diagram of entities related to Problem

8 Conclusions

The platform prototype realised in the project AmI-MoSES and described here clearly demonstrates that an innovative combination of ambience data, coming from manufacturing processes and their physical environment, can be effectively combined with classical energy consumption data using Knowledge Management approach for realisation of an advanced decision support system in Energy Efficiency optimisation systems.

In addition to the application in AmI-MoSES and AmI-MoSES-like systems, this solution allows for combination of different user defined services for different monitoring and optimisation in manufacturing industry, such as e.g. lifecycle parameters monitoring and optimisation, etc. Core services, developed for the Energy Efficiency optimisation can be also widely used in different ICT decision support systems, giving an added value to the system described here and demonstrating its openness and wide usability.

Successful achievement of the objective of realising an advanced solution for Energy Efficiency optimisation provides very good reasons for optimism regarding its successful commercial application in diminishing energy consumption and corresponding costs, which was the basic idea for starting development of such a system.

It can be concluded that for all SMEs and larger companies intending to introduce systems for Energy Efficiency optimisation the achievable benefits from application of the here presented solution are obvious. It is important to point out that the mentioned benefits can be optimally achieved by integrated application of the sub-system described here and the sub-system for Energy Consumption Data processing and Energy Use Parameters Management, described in the corresponding document, published as AmI-MoSES deliverable D3.4.