MOMOCS

Model driven Modernisation of Complex Systems

DELIVERABLE FAR

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1 Executive Summary

This document comprises the final report for the IST FP6- 034466 Project MOMOCS "Model driven MOdernisation of Complex Systems".

MOMOCS aims to develop a methodology and related tools for fast reengineering of complex systems. A complex system is characterized by an interconnection of hardware, software, user interfaces, firmware, business and production processes. MOMOCS studies how a complex system can be modernized. Modernization in MOMOCS focuses on the software portion of the complex system.

MOMOCS will allow the end-user to concentrate on what to do rather than on how to do it. The methodology developed within MOMOCS aims to find a balance between rigorous, bureaucratic methodologies and agile, unstructured ones. The project develops an eXtreme end-User dRiven Process (XIRUP) – a software/system engineering process for modernization. In addition, related tools have been developed to support the methodology.

MOMOCS provide a solution, which comprises the following three main results available for public:

- The XIRUP methodology – what are the logical steps you should follow in order to perform a successful modernization.
- The XIRUP metamodel – the basis or language used to describe the existing system and to model the modernized one (it can be seen as an UML profile).
- The XIRUP tool suite – a set of tools to edit, model, transform, save and retrieve models of your system that are based on the XIRUP metamodel.

During the course of the project we validated and evaluated these results within our two test cases from Siemens (industrial plant modernization – airport logistics) and

Telefonica (modernization of a software system). The evaluation of these test cases where we used the XIRUP results and tried to compared it with the current approach of the companies for modernization (where no explicit modernization tools or methodologies are used). As results of our evaluation we estimated:

About 20% reduction of development time by using XIRUP solutions.

Reduction of error rate and better quality solutions by using XIRUP solutions.

One of the benefits for the usage of XIRUP methodology and tools is the possibility to reuse models and transformations done in previous modernization projects. The vision here would be to build over time a strong knowledge base of your existing system components together with valid transformations. This knowledge base would be a source of documentation and starting point for new modernizations, resulting in an enormous time reduction and quality improvement

The methodology, the metamodel, the tools and their documentation are available through the MOMOCS web site at http://www.momocs.org. The consortium has built a close collaboration with the European IP Project Modelplex and some of his tools (namely the XIRUP XSM Transformation Tool and the XIRUP XSM Metamodel) have been submitted to MoDisco, an Eclipse GMT Project component for model-driven reverse engineering that has been created and launched in the context of the IST European MODELPLEX (MODELing solutions for comPLEX software systems FP6-IP 34081).

The MOMOCS project started in September 2006 and concluded in August 2008.

In the following sections we provide some background and impact information for single results.

2 Table of contents

List of Abbreviations

ADM Architecture Driven Modernization

ATL Atlas Transformation Language

EA Editor Analysis tool

ECMDA European Conference on Model Driven Architecture

EMF Eclipse modelling framework

GMT Generative Modeling Technologies

KBR Knowledge base Repository

KDM Knowledge Discovery Metamodel

MDATC MDA Tool Component – OMG specification for reusability of modules developed for MDA CASE Tools

MDA Model Driven Architecture

MDE Model Driven Engineering

MODELPLEX MODELing solutions for comPLEX software systems FP6-IP 34081

MODISCO Model Discovery

MOMOCS MOdel driven MOdernisation of Complex Systems

MS Modernised system

OCL Object constraint language

OMG Object Management Group

PIM Platform Independent Model

PSM Platform Specific Model

RUP Rational Unified Process

SME Small Medium Enterprise

SPEM Software Process Engineering Metamodel

TBMS To be modernised system

TT	XSM Transformation Tool
XA	XIRUP Analyst
XIRUP	eXtreme end-User dRiven Process
XSM	XIRUP System Model
UML	Unified modelling language

3 The Challenge

Already Charles Darwin pointed out that being able to react on changes turned out to be the most important feature for species in order to survive. In the same manner our artificial systems need to be changed from time to time in order to fulfill new or changed requirements. This in our eyes is modernization. There might be the day that like in science fiction the systems adopting themselves accordingly. Unfortunately, nowadays most things need to be done by humans. Since the systems getting more complex and interwoven, these changes can have unexpected and dramatic side effects (which also can happen when systems are replaced by complete new once). However, due to the complexity and included knowledge over time the effort to re-implement systems from scratch is not affordable any more. Modernization is therefore in many cases the only way one can go and waiting too long for doing needed modernization steps will complicate further efforts.

In order to perform a successful modernization a methodology providing guidelines and steps to follow is extremely helpful. It ensures that all needed steps are done in the right order and therefore reduces the needed time and increases the quality of the modernization.

4 Addressing the Challenge: the MOMOCS's proposition

In MOMOCS we addressed the need of modernization by developing our XIRUP methodology that is specialized for modernization projects and captures the complete lifecycle of modernization.

The complexity of systems should be addressed by according tools. The current research approach is to deal with complexity by transferring systems on higher abstraction levels by fading out implementation details (PSM → PIM). In addition the systems are separated into modules that go a-line with the current trend of using model driven architecture (MDA). One benefit is that modules of different levels can be reused while modeling the same or other systems. This provides the possibility also to reuse successful transformations of those modules elsewhere. In addition these tools should provide an alert in case constrains that are needed and dependencies that exist are violated.

By our XIRUP tool suite based on the XIRUP metamodel, we exactly addressing these challenges. The tools allow users to reproduce their system in a model based way, define transformations and to cope with dependencies, e.g. expressed in OCL.

The goal within the project MOMOCS was to develop a modeling methodology and tools that supports engineers during the re-engineering of technological systems to fulfill an import business need in particular in the analyzed domains of industrial solution business and telco.

With the XIRUP methodology, metamodel and tool suite we can offer a really promising domain independent approach to toggle comprehensively the modernization challenge.

Two pilots in the telecommunication and industrial automation areas have been used as a basis for requirements and validation of results.

5 Who can benefit from MOMOCS

Due to the very generic approach we used and the diversity of our test cases including the industrial airport logistics case of Siemens, we can state that there is a broad community that could potentially benefit from our results. However, it makes sense to differentiate between our results and the various domains to see where the greatest benefits can be achieved.

As results we have the XIRUP methodology, the XIRUP metamodel and the XIRUP tool suite. Hereby the tool suite is built on the XIRUP metamodel in the sense that the models that are created, stored, retrieved or transformed are based on it. Therefore, we analyze the benefit from the XIRUP metamodel and the XIRUP tool suite together. The XIRUP methodology on the other hand can be seen independent from the metamodel and tool suite.

The highest benefits we see for those companies/domains that are close to the test cases we had. In addition consulting companies and tool providers can definitely benefit from our results.

Domain	XIRUP methodology	XIRUP metamodel and tool suite
Industrial (comparable to the airport logistics test case)	**Very high benefit**, since a standardized modernization methodology is currently missing, the XIRUP methodology provides the potential to be used as a standardized guide during modernization projects that would result in less errors	**High benefit** – these domains are characterized by long living systems which makes it necessary to modernize them continuously during their lifetime. Especially a second modernization of the same system can benefit from

	and therefore in a time and cost reduction.	already existing models that have been generated with the tool suite.
Telecom Industry (comparable to the Telefonica test case)	**Benefit** – due to the easiness to understand the methodology.	**High benefit** – as evaluated a reduction of errors and development time could be achieved. Generated models of our test case might be reused or adopted.
Consulting companies	**Benefit** – by a standardized methodology that can be used for different projects.	**Benefit** – by the free availability of our tools that can be used in various modernization projects.
Tool providers	**Benefit** – a standardized methodology provides a better base for tool providers to develop supporting tools.	**Benefit** – by the open source tools we provide they can base their solutions on top of our results.

6 Highlights of Achievements

TO DEVELOP A SPECIFIC EMF BASED METAMODEL

To achieve its objectives the project developed a architectural-oriented and model driven metamodel. Components, interfaces, and connectors are first-class citizen in the MOMOCS' metamodel, so it is possible to describe the system in terms of collaborative elements with well-known boundaries. We completed this static description of the system with models of the data it uses and its runtime behaviour, letting users to describe their system completely. Moreover, the user is able to express additional constraints on his models, and the integrated modernizing environment guarantees that the user is notified whenever one of them is violated.

Leveraging the component-oriented fundaments of the approach, we were able to catalogue them in a knowledge base repository. End-users can easily reuse good components into their system.

We believe that model-driven techniques helps developer in focusing more on the real problem of the system, using automated transformation to carry out the repetitive work. For this reason, we encoded our metamodel with EMF, being able to build all tool on top of it. Moreover, basing on ATL we were able to provide a more advanced transformation system. Being tailored to the modernization of complex systems, it is both more effective and easier to use.

We propose a novel methodology, tailored to the modernization domain, able to combine the strength of RUP with the effectiveness of XP.

TO FORMULATE THE XIRUP METHODOLOGY

The XIRUP methodology provides a generic workflow as well as a set of MDE method fragments for modernization of complex systems. We intended to find a solution for a methodology that had to be applicable to multiple engineering domains and different types of modernization problems. We are convinced the way we solve the problem by providing method fragments is interesting. This was proven by the fact that other EU projects MODELPLEX and SHAPE are moving in this direction, ModelPlex to develop a Simulation Verification and Testing methodology adopting the process fragment mechanism and SHAPE to develop a methodology fragments for SOA

TO DEVELOP TOOLS

XIRUP Tool Suite was created as integration of all MOMOCS assets in order to simplify the installation and maintenance of the tools.

XSM Editor and Analysis Tool provide important visual means for modeling using XIRUP metamodel and analyzing the models with OCL.

Knowledge Base Repository (KBR) Tool as a centralized container of provisional and final artifacts consumed and produced during the different phases of the XIRUP methodology for modernization processes.

XSM Transformation Tool is built for creating, customizing and running MOMOCS transformations

INCORPORATING AND ADVANCING STATE OF THE ART

The tools provided by the MOMOCS Project to support the XIRUP Modernization Methodology supply a dedicated mean to XIRUP system modeling for creation, storage, analysis and transformations of models that is completely novel since built on the basis of the newly created methodology and its approach to modernization of complex system.

The XSM Transformation Tool strongly enhances ATL functionalities such as editing and chain execution as well as provides means to manage transformations within the MOMOCS context. Also, the concept of "Transformation Patterns" speeds up the reusability of transformations and fosters the creation of deployable domain-oriented libraries.

To foster the re-usage of artifacts (models, transformations, etc) created and consumed within the XIRUP modernization methodology, to create a knowledge base with former modernization experiences upon which to underpin new modernization processes, to promote a collaborative, team based modernization methodology: The Knowledge Base Repository (KBR) facilities the acquisition, organization, maintenance and retrieval of XIRUP artifacts created and consumed during the different phases of the XIRUP methodology for the modernization of complex systems, by different XIRUP Analysts (XAs) who concurrent may participate in that modernization process.

CURRENT AND FUTURE SYNERGIES

Main synergies could and can be retrieved by our collaboration between MODELPLEX and MOMOCS. Noteworthy in this respect was our successful workshop in conjunction with the ECMDA 2008 in Berlin. While MOMOCS now officially ended, we submitted some of our tools to MoDisco Project. More precisely we submitted: MOMOCS Transformation Tool (TXT), MOMOCS Metamodel & Simple Editor (POLI). Some of our tools could not be submitted due to incompatible licenses. Currently the MoDisco staff is checking if all packaging and naming conventions they have had been taken into account.

This submission will ensure that the submitted tools will be further explored and maintained by MODELPLEX.

We also had a close contact to the ADM TF of the OMG. Synergies in this respect are explained in the following section.

CONTRIBUTION TO STANDARDIZATION

The MOMOCS project holds a close contact to the OMG since the beginning of the project. In January 2008 the consortium became official OMG member. We started a bilateral discussion between the KDM task force and PoliMi, which developed the XIRUP metamodel. The goal was to understand if and how the two metamodel proposals of KDM and MOMOCS can complement each other. Roughly, our metamodel can be seen as a kind of natural complement to KDM in order to further stress a component-oriented organization of the system we want to modernize.

A presentation of the ideas behind the XIRUP metamodel will be held in the context of the ADM Task Force at the next OMG Technical Meeting in December 2008 in Santa Clara.

7 MOMOCS results

7.1 The XIRUP Methodology

RESULT AT A GLANCE	
Motivation	The methodology development was driven by the user requirements for a comprehensive MDE methodology applicable to multiple engineering domains
Man Characteristics	Basic generic workflow MDE method fragments for composing of dedicated methodologies Dedicated workflow for Telco case studies, validated by Telco case study (Telefonica) Dedicated workflow for Industrial case studies, validated by Industry automation case study (Siemens) Tool agnostic Dedicated tool support is proposed by the MOMCS Tool Suite as well as the supporting external tools are identified.
Main Outcome	The methodology provides the guidelines on the MDE methods and tools for modernisation of the complex systems. These guidelines are illustrated by real-life examples from TID and SIE.

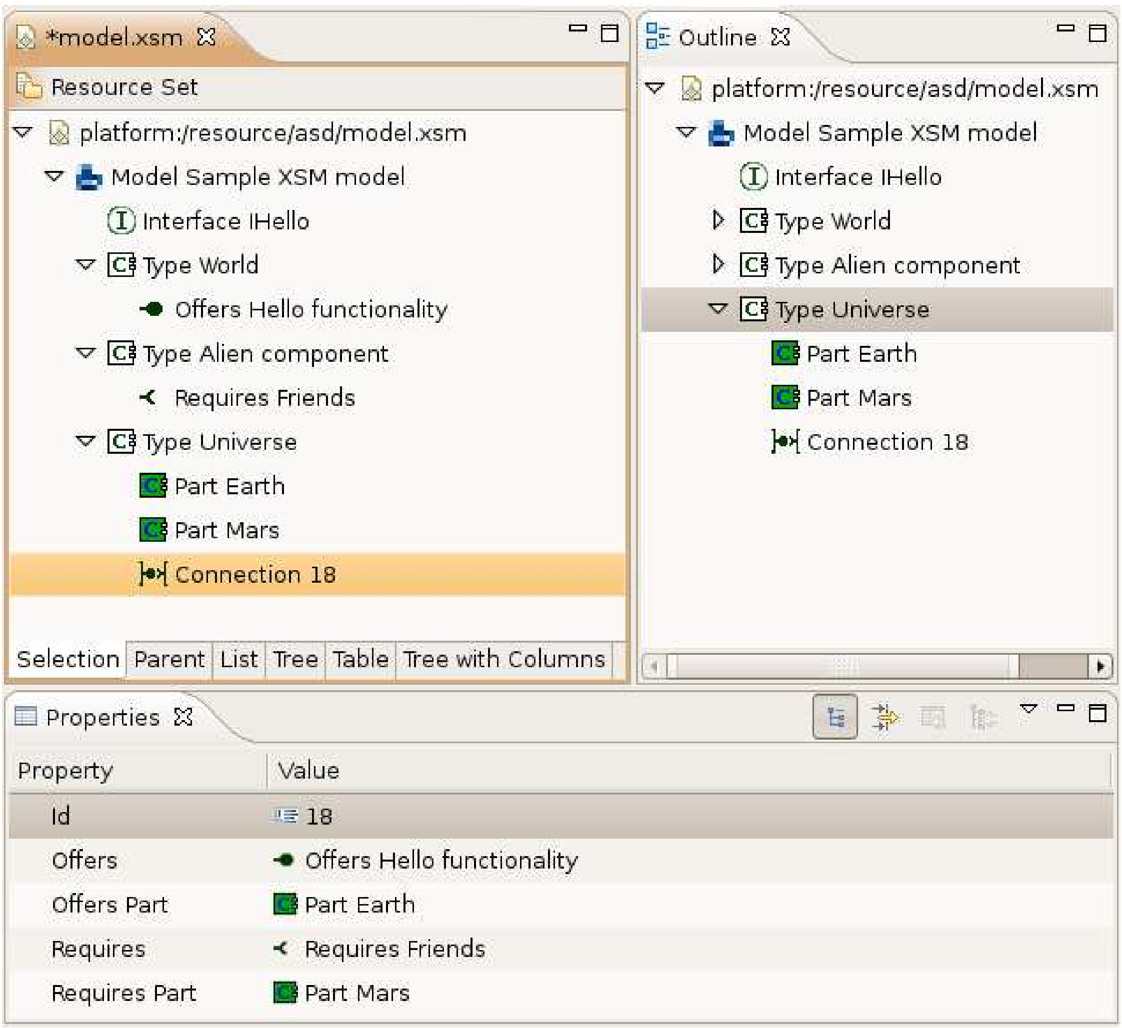
RESULT DESCRIPTION
The methodology is released in providing a generic workflow and a set of dedicated MDE methods for modernisation of complex systems in multiple engineering domains. The methodology in illustrated by examples and validated by TID and SIE. All results are reflected in publicly available D3.1 integrated document.

7.2 XIRUP Tools

7.2.1 XSM METAMODEL

RESULT AT A GLANCE	
Motivation	Aiding the evolution complex system
Main Characteristics	Component-oriented Complexity Handling Focus on the architecture Supports vertical & horizontal system decomposition Integration with OMG's KDM in progress
Main Outcome	The metamodel is encoded using EMF. This allows different vendors to easily create a tightly coupled IDE for modernizing existing applications. Some proof-of-concepts eclipse plugins are also provided, with the purpose to show the possibility to harvest the architectural structure of existing systems, and produce an XSM model of the to-be-modernize system.

RESULT DESCRIPTION
The outcome is composed of: the EMF-based XSM metamodel A simple editor: allows the end-user to interact with metamodel elements both for visualizing it and for manually transforming it

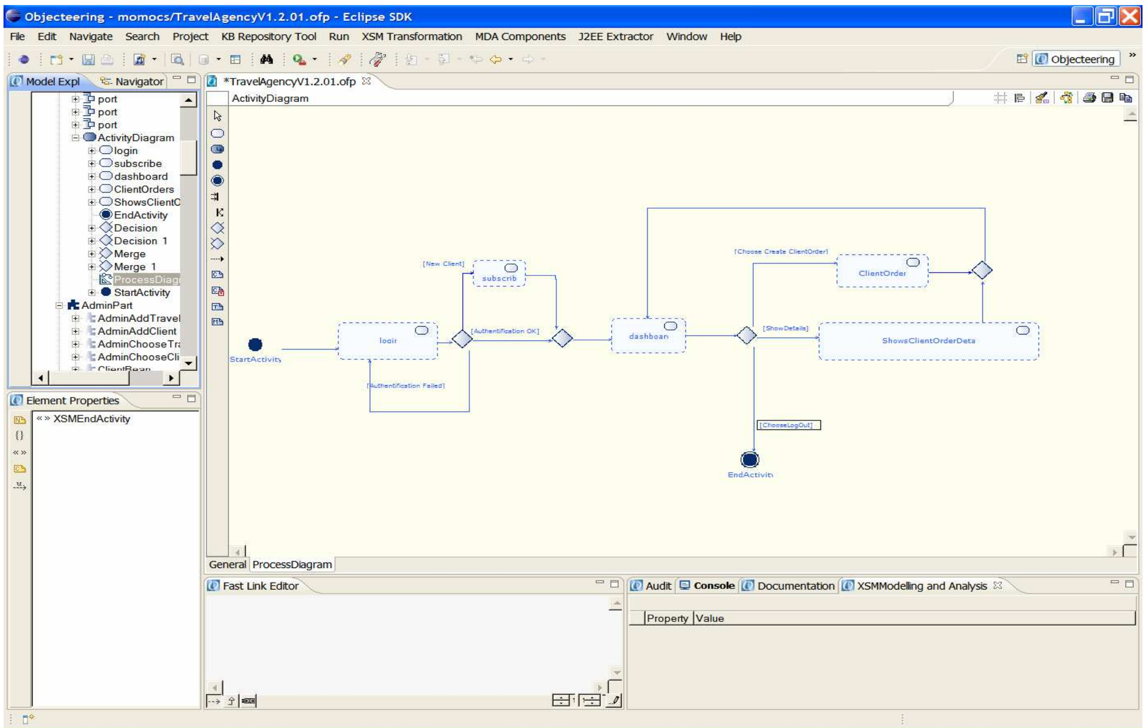


A J2EE model extractor: analyzing the source artifacts of a Java 2 Enterprise Edition system, this tool is able to harvest its architectural structure, and produce the corresponding XSM model of the system.

7.2.2 XSM EDITOR AND ANALYSIS TOOL

RESULT AT A GLANCE	
Motivation	Giving a graphical and intuitive interface for modeling and managing models. Offering analysis features.
Main Characteristics	Graphical interface for model management Automated diagram creation Diagram filtering Import and Export facilities on XSM format OCL constraint checker Component grouping algorithm
Main Outcome	An Eclipse plug-in which gives an environment for XIRUP model managing and analysis.

RESULT DESCRIPTION
The **XSM Editor and Analysis Tool** is an environment where MOMOCS models can be created, modified and analyzed. It consists of six main features:



A graphical interface which allows to create and to specify XSM elements, but also specific model views *i.e.* diagrams.

An automated diagram creation has been implemented in order to expose of some main element.

A diagram filtering feature is provided thanks to the XIRUP tagging possibilities.

XSM Import and Export facilities are present in order to exchange model part with other suite tools.

An OCL checker is available and allows users to follow the status of specified constraint.

A component grouping method extracts groups of strongly linked component and regroups them together in super components.

7.2.3 Knowledge Base Repository (KBR)

Result at a glance	
Motivation	A common shared repository of XIRUP modernization methodology artifacts that fosters their re-usage in the same or in another modernization process.
Main Characteristics	The main features provided by the KBR are the following: Repositories management (structure creation and maintenance) Repository browsing Repository sorting and filtering Storage, modification and removal of artefacts (XSM, Transformations, Attachments, Notes, etc) Artefacts annotation (keyword metadata and semantic metadata) Artefacts search (keyword and semantic matching) and retrieval Artefacts historic Models comparison Repositories backup dump and restoration Repository DB management
Main Outcome	An Eclipse plugin, integrated within the MOMOCS Suite,

Result description
XSM Knowledge Base Repository is a container for XIRUP artefacts produced during the different phases of modernization process that converts the legacy system (TBMS) into

the modernized system (MS), to promote their reuse whenever is possible. KB Repository will provide support for storing and retrieving those artefacts, which may be required later on by some activities of that modernization process, which can be performed following the XIRUP methodology. These main features facilitate the re-use of those artefacts in the same modernization process or in others, as it is suggested by the XIRUP.

The repository stores the following artefacts produced during some phases of the XIRUP methodology:

A XSM created by the Analyst using the XSM Editor.

A metamodel transformation rules set created by the XIRUP Analyst using the XSM Transformation tool.

A XSM model transformation historic including a set of transformation mappings.

The XSMs produced during the modernisation process we can store into the KB Repository follow this classification:

By the system target: we can classify models according into the legacy system (TBMS) models or the modernized system (MS) models.

By the level of abstractness: we can classify the models into CIM, PIM or PSM, that is, different views describing the same system at different levels of detail or concerns.

By the scope or extension of the model: we can consider complete models by they own, describing a whole system, or partial models describing only restricted regions of the system. In the latter case, it is included (among other ones) the "component type models", describing abstract components, which may be instantiated by particular components in the model, and "pattern models", a sort of well-known model solution for a particular problem .

All those kind of models are built by the XSM Editor, which can send and retrieve them to/from the XSM KB Repository.

A transformation rules set is a list of mappings between the elements of a source metamodel and those of a target metamodel[1]. A particular metamodel is XIRUP, which is used to describe XSM models. This transformation rules set is used to convert from one source model (as instance of the source metamodel) into the target model (instance of the target metamodel). XSM transformation rules set is created and edited by the XSM Transformation tool.

Finally, the XSM model transformation mappings are a set of links between objects belonging to the source model and those equivalent ones belonging to the target model after being apply to them the transformation rules set. They allow navigating from the objects of the source model to the objects of the target model and vice versa. A set of transformation mappings linking different models coming from an initial one constitute a XSM model transformation historic, also store into the XSM KB Repository. A XSM model transformation mapping (together with the source model, target model and XSM transformation rules set) constitutes a chain link of that transformation historic.

The main operations supported by the XSM KB Repository are the following:

- Manage the repository
- Store artefacts
- Browse the repository
- Search for artefacts
- Retrieve artefacts

XSM KB Repository is organized according with a hierarchical classification determined by the user. This classification is basically a taxonomical classification consisting of semantically annotated (using metadata and/or ontological concepts) classifiers. In other

[1] In general source and target metamodel are not the same. However, in MOMOCS transformations are defined between XIRUP metamodel and itself.

words, a tree-based structure of semantic annotated folders where are stored the XIRUP artefacts. These folders are semantically annotated by the user, when they are created, assisted by the XSM KB Repository tool, which make use of a set of available domain ontologies. Domain ontologies for MOMOCS case studies are supplied by their domain experts and come with the XSM KB Repository tool bundle. Semantic annotation will be used by the repository to search for artefacts using semantic reasoning.

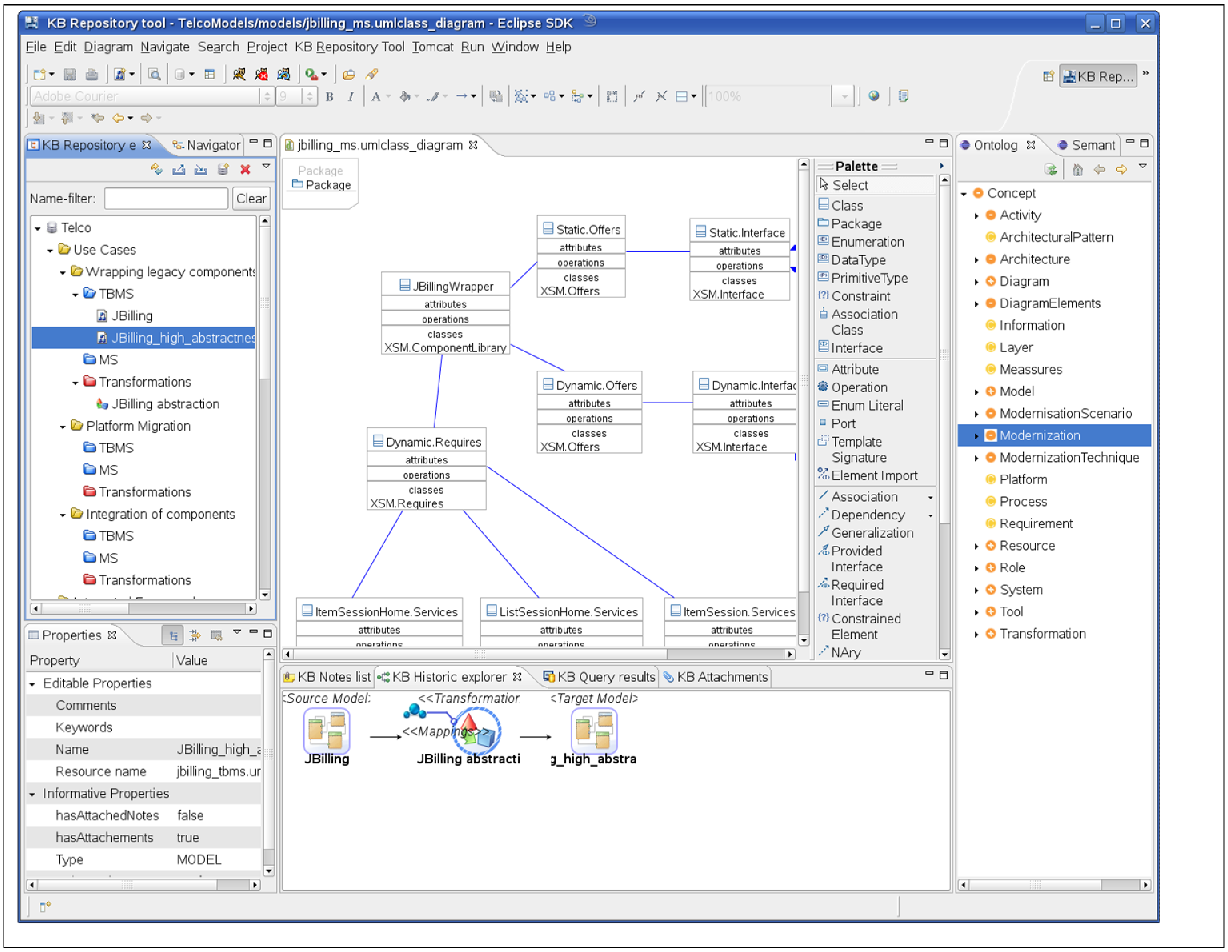
XSM KB Repository management mainly comprises the organization of the repository hierarchical classification above described.

XIRUP artefacts are stored within the repository and annotated in a similar way than for the repository management.

Repository browsing permits to navigate the repository structure to discover the artefacts stored within. Its main purpose is to manually discover and retrieve XIRUP artefacts.

In a same manner, repository Searching is aimed to discover services that match with a searching criteria determined by the user. XSM KB Repository will support semantic searching by creating semantic queries that are used to reason within the available domain ontologies. The discovered candidate artefacts are also ranked, using semantic algorithms that determine the best artefact matching according with the semantic query criteria and the semantic restrictions established by the domain ontologies, so only best scored candidates are shown to the user. XSM KB Repository will assist the user to determine the searching criteria on the basis of the available domain ontologies, and, according with those criteria, it will automatically build the semantic query.

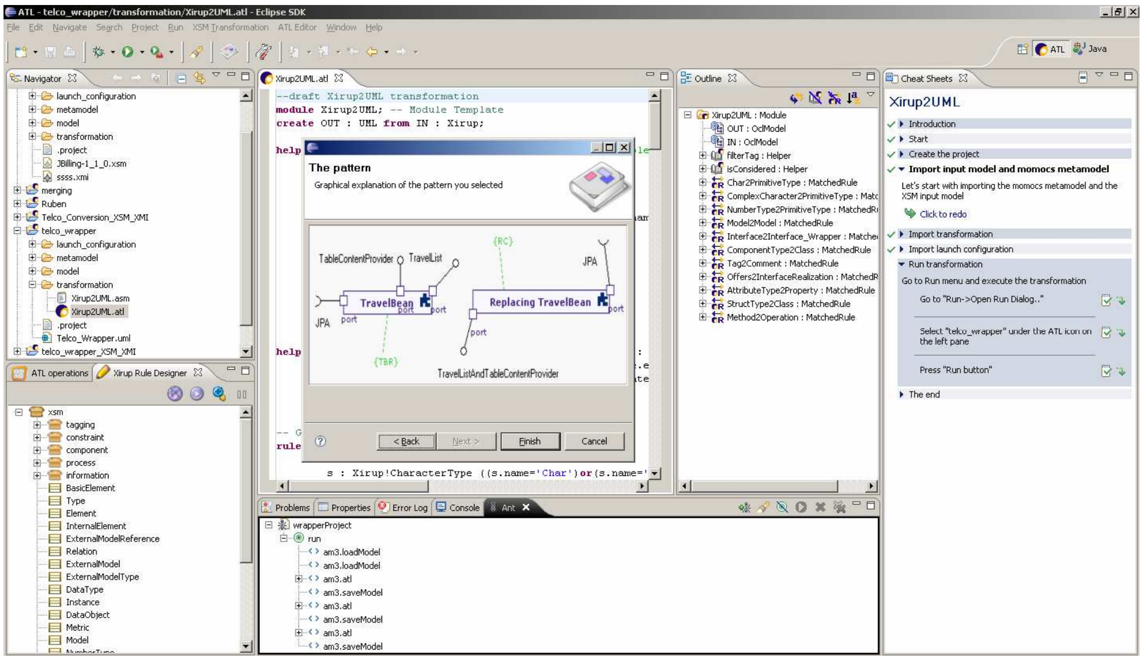
See below an snapshot of the KBR perspective within the Eclipse workbench.


KB Repository tool - TelcoModels/models/jbilling_ms.umlclass_diagram - Eclipse SDK
File Edit Diagram Navigate Search Project KB Repository Tool Tomcat Run Window Help
KB Repository e
Navigator
Name-filter:
Clear
Telco
Use Cases
Wrapping legacy components
TBMS
JBilling
JBilling_high_abstractnes
MS
Transformations
JBilling abstraction
Platform Migration
TBMS
MS
Transformations
Integration of components
TBMS
MS
Transformations
Properties
Property
Value
Editable Properties
Comments
Keywords
Name
JBilling_high_a
Resource name
jbilling_tbms.ur
Informative Properties
hasAttachedNotes
false
hasAttachements
true
Type
MODEL
jbilling_ms.umlclass_diagram
Package
Static.Offers
Static.Interface
JBillingWrapper
XSM.ComponentLibrary
XSM.Offers
XSM.Interface
Dynamic.Offers
Dynamic.Interfac
Dynamic.Requires
XSM.Requires
ItemSessionHome.Services
ListSessionHome.Services
ItemSession.Services
attributes
operations
classes
Palette
Select
Class
Package
Enumeration
DataType
PrimitiveType
Constraint
Association Class
Interface
Attribute
Operation
Enum Literal
Port
Template Signature
Element Import
Association
Dependency
Generalization
Provided Interface
Required Interface
Constrained Element
NAry
KB Notes list
KB Historic explorer
KB Query results
KB Attachments
<Source Model>
<<Transformation
<Target Model>
<<Mapping>>
JBilling
JBilling abstracti
g_high_abstra
Ontolog
Semant
KB Rep...
Concept
Activity
ArchitecturalPattern
Architecture
Diagram
DiagramElements
Information
Layer
Meassures
Model
ModernisationScenario
Modernization
ModernizationTechnique
Platform
Process
Requirement
Resource
Role
System
Tool
Transformation

7.2.4 XSM TRANSFORMATION TOOL

RESULT AT A GLANCE	
Motivation	Aiding the evolution of a TBMS model into a MS model by following the Xirup methodology
Main Characteristics	Advanced editing Embedded transformations and resources to foster the modernization on the Xirup metamodel Transformation patterns for reusable transformations Transformation chains Eclipse-integrated interactive tutorials including advanced transformations Metrics generation
Main Outcome	Set of Eclipse plug-ins that heavily extend and improve functionalities from ATLAS ATL and target them to the Xirup metamodel.

RESULT DESCRIPTION
The **XSM Transformation Tool** is an environment where MOMOCS transformations are created, modified and executed. It consists of six main components:



Editing is for creating or customizing transformations by means of special-targeted views like the Xirup Rule Designer and ATL Operations or key-bind activated syntax templates.

ATL4Xirup is a set of wizards providing fundamental resources for MOMOCS transformations. It also gives the possibility to select among a set of *Transformation Patterns* which are highly reusable transformations defined for common modernization situations.

Transformation Chain is for the automatic creation of "chain scripts" (defined in Ant) that are used to execute a sequence of transformations where the output of a transformation is the input of the immediately following one.

Cheat Sheets is for providing users with a set of interactive tutorial totally integrated in Eclipse. These tutorials also contain a set of advanced example transformations for UML2Xirup, Xirup2UML and model querying.

Context Actions includes a set of useful functionalities defined for some Eclipse

resources such Project, Ecore and Xsm files. Metrics creation from Xsm models is an example. *Online Help* is the XSM Transformation Tool voice inside the Eclipse Online Help

7.2.5 XIRUP Tool Suite

RESULT AT A GLANCE	
Motivation	The main motivation was to improve user experience and the time to get started with the MOMOCS MDE solutions.
Main Characteristics	"one click" installation of the integrated MOMOCS tools including XSM Transformation Tool, XSM Editor and Analysis Tool and XSM Knowledge Base Repository.
Main Outcome	The integrated installer is released and allows installing all MOMOCS tools by "one click".

RESULT DESCRIPTION
The XIRUP Tool Suite provides an integrated solution for modernisation of complex systems enhanced by "one click" installation. The Tool Suite includes XSM Transformation Tool, XSM Editor and Analysis Tool and XSM Knowledge Base Repository. The corresponding information can be found above. The integration of the tools is based on the Eclipse framework and by means of the common work space

concept. The tools share the knowledge of the XIRUP Metamodel which is the background of the integration.

The MOMOC Tool Suite is packaged in one DVD containing the tools, user guides and interactive demonstrations purposed to shorten the learning curve for this innovative modernisation solution.

8 The pilots

To evaluate the developed XIRUP methodology, the metamodel and the XIRUP tool suite two pilots from two very different domains have been defined

- Pilot from industrial solution business
- Pilot from telecommunication business

8.1 The IND Pilot

The IND Pilot is an exemplary project from the solution business. We have chosen a case from a specific Industry sector – the automated Baggage Handling System (BHS) in Airport Logistics. The BHS is the backbone of the major airports. Only a small part of the system is visible to travelers, the check-in and baggage reclaim. Behind the scenes, a complex network of systems is operating. Figure 1 shows the major tasks of a BHS system.

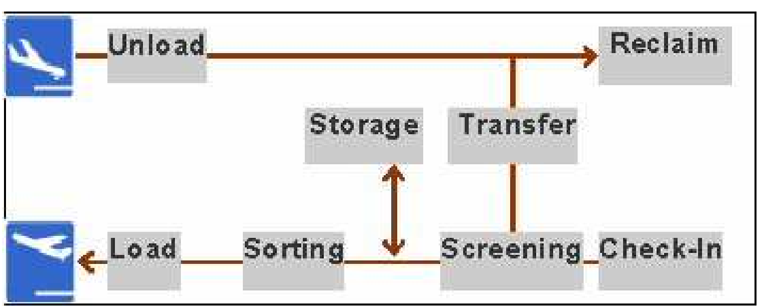


Figure 1. Major Task of a BHS system

The architecture of a BHS is shown in the following picture. The architecture combines elements from different engineering disciplines like software engineering (IT/automation systems), mechanical and electrical engineering.

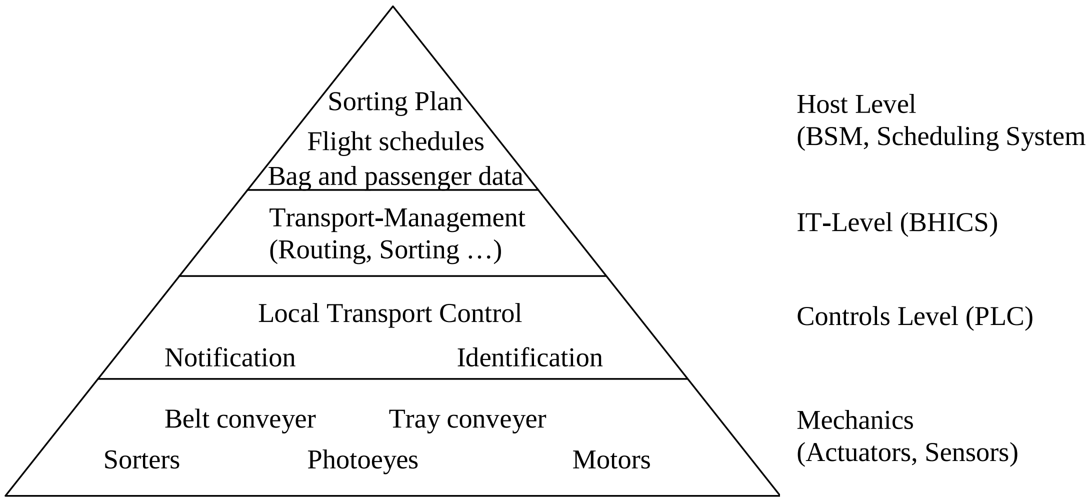


Figure 2. BHS Architecture

8.1.1 Background

A methodical approach to modernization in the Solution Business is often missing until now. Thus the goal within the project MOMOCS was to develop a modeling methodology and tools that supports engineers during the re-engineering of technological systems (especially industrial plants) to fulfill an import business need in the domain of industrial solution business.

From this point of view, model driven modernization of a complex system means the model supports the re-engineering of a technological system in order to overcome its complexity.

Our methodology and modeling concept should provide a method to analyze functionalities and interfaces within a complex system in order to define exchangeable and semantic relevant components through composite structure. For a specific industrial branch, industrial engineering patterns and standard industrial component libraries should be defined by best practice references.

It should also support the concept of “industrial views”. Industrial views means to allow grouping of attributes of a model according to the specific engineering discipline they belong to. In order to illustrate all these aspects, the modernization scenario involves several engineering disciplines.

To lever the benefits on a broad basis within Siemens the defined methodology, metamodel and tools must be applicable for all engineering disciplines and in different industry domains.

8.1.2 Scope of the pilot

There are two basic concepts for the physical material handling of baggage:

- Baggage is transported directly on a belt conveyor
- Each bag is put onto a tray

The tray based concept allows a much more efficient handling of luggage because of the standardized shape and thus a higher transportation velocity. Additionally a tray protects of the baggage.

Empty trays are buffered in an empty tray area. In our “to be modernized system” (TBMS), the empty trays cannot be stockpiled which means that the empty tray buffer is consuming more space (refer to Figure 3. Empty tray buffer (TBMS) .

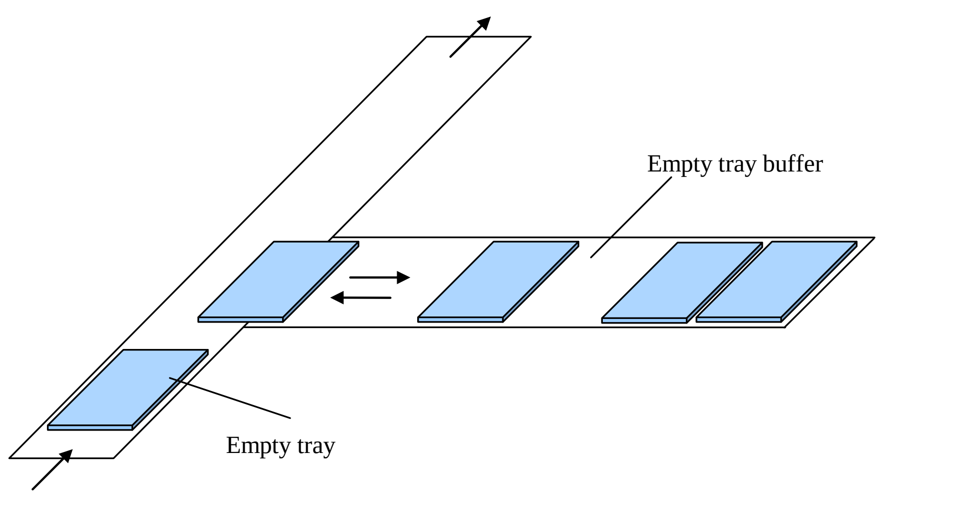


Figure 3. Empty tray buffer (TBMS)

In the pilot we will introduce a new empty tray buffer (modernized system) with stockpiling capabilities (refer to Figure 4). This will be done to save valuable space and transportation time, ergo to reduce costs and to optimize the throughput.

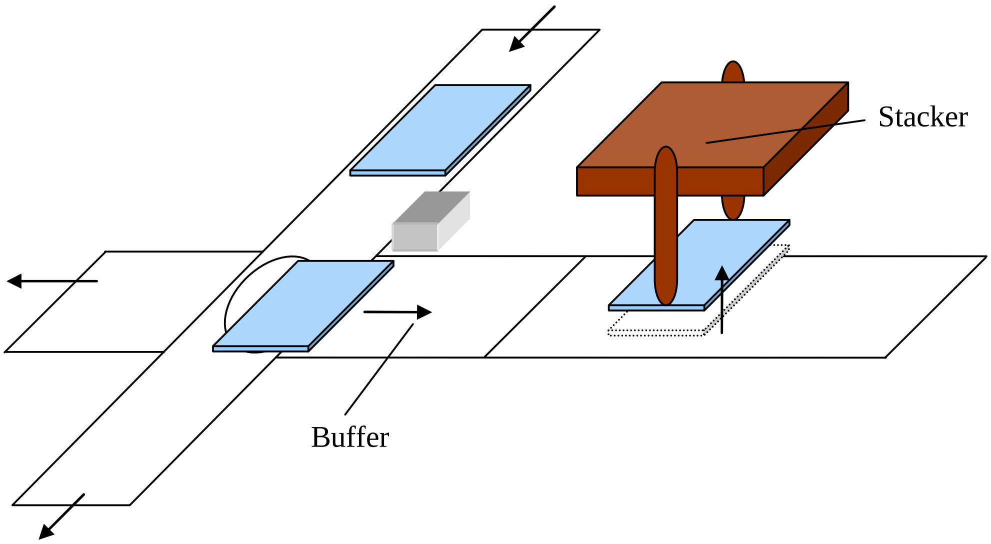


Figure 4 - Modernized ETS

The modernization idea is to install a stacker in the empty tray store in order to put trays in a pile. Additionally, the baggage conveyor is split in two baggage conveyors: one conveyor hosting the stacker and one buffering conveyor before it (in order to let time for the stacker to pile the trays).

8.1.3 Results

We wanted to evaluate how well the developed methodology, the tool and the implemented metamodel can be used in a "real world" working environment for modernising a complex system, with a clear focus on software in three phases:

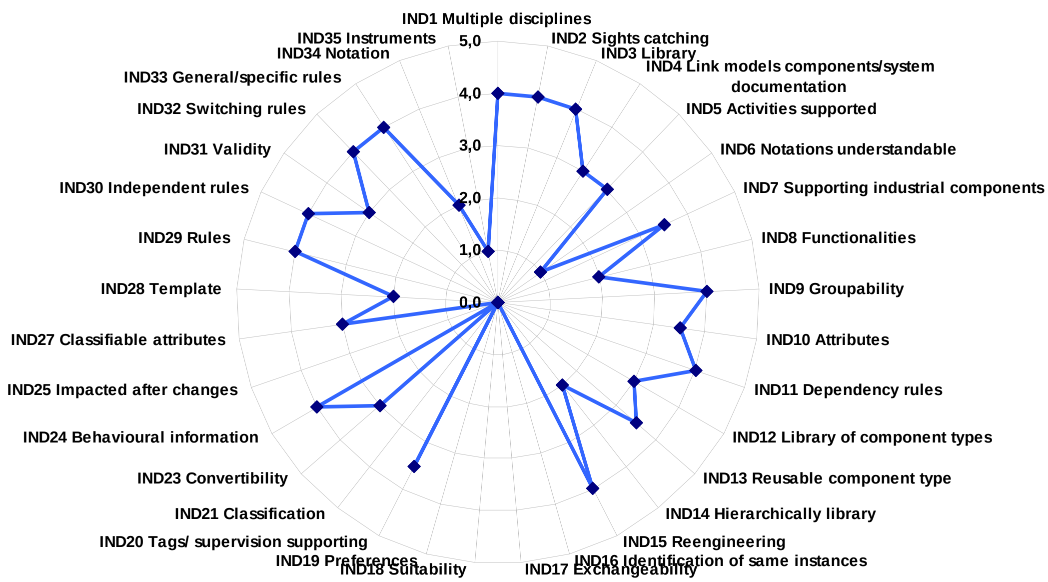
1.) Evaluation of the tool suite with functional test cases and measuring the fulfilment of requirements

2.) Evaluation of the methodology, metamodel and tools with quality test cases

3.) Evaluation of the acceptance of the methodology, metamodel and tool suite

Fulfilment of requirements

We have defined 33 requirements at the beginning of the project (refer to [D12]). The requirement coverage evaluated within the functional test cases is shown in the figure below.



As visible in the figure above the requirement fulfillment covers the range from 0 to 4. No requirement exceeds the requested requirements of D1.2. Six requirements are not covered through MOMOCS like showing the impact of a modernization or identification of the same instances. Twelve requirements varying between first starting point to partly coverage e.g. support of an industrial notation or linking of documentation to model elements. Fifteen requirements meet fully the expectations for example supporting of multi disciplines, granting of a library concept or assisting through rules.

Evaluation of the methodology

With the help of quality test cases, interviews and surveys we could prove that:

- XIRUP covers all phases of the modernization lifecycle

- XIRUP is not another domain specific methodology. It can be used in several industry domains and engineering disciplines.
- XIRUP is adaptable and scalable
- XIRUP is a good alternative in modernization since existing methodologies are missing or have some weaknesses in modernizing complex systems

Overall acceptance

Even if all functional requirements are met trainings of users have taken place etc., we can often witness the failure of a newly developed technology, methodology or tool sets in later use.

The acceptance by the end user of is a crucial factor in every evaluation of such developments. That's why we spend quite some effort to evaluate the acceptance

Summarizing all three measured attributes (Perceived Usefulness, Perceived Ease of Use, and Future Usage) showed positive results.

The MOMOCS results (methodology and tool suite) increased all three measured attributes significantly:

Perceived Usefulness:	3 levels on a scale [1-7]
Perceived Ease of Use:	2 levels on a scale [1-7]
Future Usage:	2 levels on a scale [1-7]

This shows that a very strong improvement in acceptance can be seen.

8.1.4 Benefits

As described in the section before the evaluation of the XIRUP-Methodology, meta model and tools led to positive results.

Based on these results and further work that will be conducted we see crucial benefits

Increased productivity: time can be gained for creative and value-adding activities thanks to reduction of manual tasks; duplication of work can be reduced thanks to clearly defined roles, processes and workflows

Increased ease of work: using modeling to modernize systems is relatively easy and can be done by domain experts rather than modeling experts; (pre-)defined models or components for modeling can be reused

Reduced costs: errors and their effects can be detected in an early phase of a modernization project thanks to the modeling paradigm; modernization is done faster since it takes largely place on model level and not on code level

Enhanced quality: transparency is increased thanks to a clearly-defined methodology and processes

8.2 The Telco Pilot

8.2.1 Background

The Telco case study considers a Small and Medium Enterprise (SME), with a computing infrastructure of isolated PCs for managing client list, employees, clients accounting, and billing. They have also a traditional telecom infrastructure of fixed and mobile phones. As support services they have some applications for accounting, clients, and billing. The purpose of modernization is to adapt this infrastructure and services to an integrated framework that is provided and supported by a Solutions Provider (SP). The SP has an infrastructure that allows adapting generic components to customers needs. There are generic components for secure access, Customers Relationship Management (CRM), Enterprise WorkForce Management (EWFM), location, and communications. The SP framework is facilitated by a service architecture, which is made up of software components and based on architectural patterns, at different levels: organization, control, resource, and basic components.

In order to show the iterative and feature oriented approach of the XIRUP methodology, and to consider modernization in different settings, three concrete scenarios are considered in the Telco case study. These scenarios illustrate three relevant features that can be addressed in iterations of the modernization process.

The first scenario takes into account a concrete application running on SME premises for billing. This application is JBilling (see http://www.jbilling.com/), which is open software, so its source code is available. There are no billing components in the SP platform, and taken into consideration the characteristics of the application, the decision of the modernization engineer is to wrap this application to integrate it in the SP framework as a resource. Therefore, the scenario considers how to extract a model of billing application services and how to build a wrapper according to the SP framework as a resource. The input is the code of the billing software and the SP resource specification. The output is code to wrap the billing software. Data do not need to be modified in this case.

The second scenario takes one of the SP components, whose logic is currently build on a rule engine called ILOG JRules (see http://www.ilog.com/products/jrules/), and modernize it to an Open Source product called Drools (or JBoss Rules, see http://labs.jboss.com/portal/jbossrules). This scenario implies the substitution of the old rule engine for the new one and the adaptation of the reasoning rules to the particular features of the new component. Furthermore, during its implementation, some refactoring has been performed in order to improve code structure.

The third scenario is the more complex as it considers several independent applications of the SME and tries to make an integrated access system for them. For this, it takes SP framework access components and configures these in order to fulfil the requirements from different applications. It provides a role based access system to different services of the modernized system. This scenario can be further decomposed to iterate on simpler features, like the validation of the access credentials or the effective control of the access to components.

By considering these three use cases with concrete scenarios, it has been possible to assess different aspects of MOMOCS methods and tools in a common case study. In particular, these scenarios have been implemented by Telefonica I+D (TID), the Telco partner of MOMOCS, by applying common software engineering practices and with the XIRUP methodology and tools.

8.2.2 Scope of the pilot

The pilot has focused on the first scenario: transforming the Jbilling component into a resource of the SP framework. The pilot implements a code to code case study where the original Jbilling code is "modernised" to became an SP resource which code implements an enhanced version of JBilling offering the interfaces required for interoperate with other SP components. The modernisation process has been achieved using the XIRUP methodology and the XIRUP tool suite in order to evaluate their benefits.

8.2.3 Results

Pilot implementation: Two version of the pilot have been implemented: the first version without supporting tools and the second using the XIRUP suite in order to test the tools and to asses the benefits with respect to the manual version. This version is publicly available for download.

Evaluation results: Qualitative evaluations results shows that the XIRUP approach is perceived as potentially valuable for modernization projects, with an overall satisfaction of 3,16 over 5. This score take into account two important issues which have been successfully overcome: the understanding of innovative technologies such as meta-modelling and model transformations, and their application using prototype tools which usability and stability should be improved. Training in the supporting technology, and the availability of robust, and usable tools are essential to guaranty a wider adoption of the approach in industry. A common drawback is the perceived difficulty to follow a model-driven approach for people that usually consider models as documentation and manually develop the code. Besides, the use of transformations instead of common programming languages constitutes a challenging paradigm shift for developers. Thus, further work is required in the refinement of the methodology (for a more detailed guide) and the development of tools (especially about usability and scalability).

8.2.4 Benefits

The methodology is easy to understand for developers. It provide a common conceptual model and a common view of the modernisation process which facilitates team communication and sharing of knowledge among modernisation engineers

The XIRUP approach provides advice and guidance to modernisation engineers facilitating preliminary analysis and cost analysis, then project set up and project management including knowledge management, dissemination and reusability.

The XIRUP tool suite is a key asset for achieving the modernization process. Evaluation results have shown a reduction of 23 % of development time in the development of use cases in the Telecom pilot. It is important to note that more significant reductions can be achieved in the understanding and in the building phase were a significant amount of effort have been devoted to learn by practising in the use case both, the transformation technology and the supporting tools. Modernization engineers mastering meta-modelling and transformation tools would be able define and reuse transformations, then achieving the building process 50% faster than in the project experience. Code generation from high level models also reduce the number of errors then improving customers satisfaction by increasing the quality of the modernised system and reducing costs.

9 Availability of results

The MOMOCS Open Source Tools are summarized below; both the tools and the supporting documentation are provided under Open Source Eclipse Public License (EPL) v1.0 where not differently stated.

PROJECT RESULT	OWNER/ RESPONSIBLE CONTRACTOR	AVAILABLE AS	RELATED LICENSE	
			Implementation	Documentation
MOMOCS XIRUP Methodology	MOMOCS Consortium		N/A	Open Source
XIRUP Tool Suite	MOMOCS Consortium	MOMOCS Exe Installer	Includes all the Open Source Modules described in the rows below plus Objecteering Free edition (EULA license in Appendix A), the ATL Plug ins (EPL license) and Exist DB (LGPL license)	Open Source
XSM Editor and Analysis Tool + OCL checker	Softeam	MDAC Modules XIRUP and JXIRUP [D52b] and a set of eclipse plug ins *	Open Source	Open Source
XSM Knowledge Base Repository	Atos Origin	A set of Eclipse Plug-in *	Open Source	Open Source
XSM Transformation Tool	TXT e-solutions	A set of Eclipse Plug-in *	Open Source	Open Source
XSM XIRUP Metamodel (including J2EE Extractor)	Politecnico di Milano	A set of Eclipse Plug-in *	Open Source	Open Source

*The set of Eclipse plug-ins are included within an Eclipse feature which allows them to be properly installed into the platform by using the Eclipse Update Manager and its facilities.

Project results are available for downloading under the Download section of project web site: http://www.momocs.org

10 Potential impact of the results

10.1 Technical point of view

XIRUP METHODOLOGY

XIRUP Methodology leverages on the new concept of method fragments. These fragments can be re-used, combined and extended for construction of dedicated modernization methodologies based on MDE. The methodology is validated by case studies and is publicly available. Tools, guides and examples will help to adopt the methodology.

XSM METAMODEL

The XSM metamodel can shift the focus on the system during the modernization process. Traditionally developers cannot leverage on abstraction views higher than the source-code level, but this is problematic when they have to deal with complex systems. The metamodel allows them to handle such system properly, focusing more on the overall structure. This way it is possible to recognize early possible marco-problems of the plotted to-be system, enhancing the possibility of a successfully modernization activity. Even if the current metamodel is pretty promising, we are working to enhance OMG's KDM: in this way the end-user will experience a fully integrated modernizing environment that can assist him through the whole process.

XSM EDITOR AND ANALYSIS TOOL

The XSM Editor and Analysis Tool is dedicated to XIRUP system modeling and helps in their creation and analysis. It is mandatory since the usability is critical for successful adoption of XIRUP methodology and metamodel.

XSM Transformation Tool

The XSM Transformation Tool can foster the creation of domain oriented libraries according to the approach followed for transformation patterns. Reusability is the key-word that accompanies these artifacts.

Patterns can also be executed progressively by using transformation chains: having guidelines on how to combine them is a possible result for the future.

The way in which transformations are created can also be extended to other metamodels (like the UML) allowing a very quick creation of rules if compared with standard ATL editing mode.

UML2Xirup and Xirup2UML transformations defined for MOMOCS test cases prove that porting to the world-wide spread UML metamodel is possible in each direction (reverse and forward engineering).

Knowledge Base Repository

KBR facilitates the adoption some practices in the modernization of complex systems, according to the XIRUP methodology:

A frequent re-usage of the artifacts created during the activities that comprises the XIRUP methodology, since most of them are required for consumption in subsequent activities or in future modernization processes

A collaborative team based methodology in which several XAs are participating according to the different expertise required by the modernization process, and therefore they provided and consume artifacts that are stored and retrieve to/from a centralized repository

To foster the acquisition and exploitation of the specialized knowledge acquired during the modernization processes accomplished in the past. This knowledge could be crucial for the successful accomplishment of future modernization processes.

These practices can also be adopted in other technological projects carried out by IT companies, such as Atos or TXT. These projects range the development, integration, maintenance and evolution of complex systems, engaging large development teams participated by quite different actors with disperse expertise. These projects generates large amount of knowledge that should be acquired, consolidate and catalog for further exploitation in future projects. Therefore, we foreseen an strong potential impact for KBR in the realm of IT software development in particular, and in many other business domains that generate knowledge that constitute the companies wealth.

10.2 Business Point of view

Siemens is integrated technology company that provides plants or complex systems. These complex systems involve all possible engineering domains. One important is industrial automation domain whereas software plays an important role. As the installed base of plants grows continuously and the rate of green field projects decrease, modernization is the spotlight of business attention. A methodical approach to modernization in the Solution Business has often been missing until now.

All our requirements that we described for the methodology and tools had an direct business need as background.

As all essential requirements are covered by the developed XIRUP methodology, Siemens Corporate Technology can now offer a cross industry domain consulting services for a comprehensive model driven modernization methodology. Thus we can lever synergies, promote best practice and know-how sharing.

We can also offer a uniform metamodel (XSM metamodel) for modeling industrial plant.

The provided tools will be very helpful as a proof of concept to demonstrate the utilizability of the developed methodology with some real-life scenarios. Additionally all main aspects of model driven modernization can be demonstrated:

- Concept of type- instances
- Decomposition of complex systems
- Industrial views
- Modeling constrains

The Telecom Pilot developed provide code to code modernization examples where the use the XIRUP methodology and the supporting tools have led to significant reductions in both development time, and effort. Consequently the prototype will be an important asset to show in practice the benefits of applying both the XIRUP methodology and the supporting tools to specific business cases.

In the Telecom, the adoption of the XIRUP methodology and the **MOMOCS** tools will lead to two key benefits:

- Increasing business efficiency and reducing modernisation costs of OSS and BSS.
- Opening new business opportunities by offering integrated services in specific market segments such as consumer/residential markets, and SMES.

11 Lessons learned during the project

During the XIRUP methodology elaboration we faced the following problem. It was required that the methodology was applicable to multiple engineering domains, was flexible and adaptable for short term and long term projects. We analyzed and the general use methodologies like RUP, XP and SCRUM would be fit only to a part of the requirements in any time since they be contradictory. In addition, we found that providing a generic methodology would not satisfy the end users, since they needed concrete instructions for using MDE for modernization. That is how we learned that the concept of the MDE method fragment would be the most appropriate since brings the required flexibility. The methods fragments elaborated may be combined in order to adapt the workflow for particular modernization problem, which was proved during the validation process.

The methodology should be supported by tools in order to be easily adopted by end-users. In addition the simplicity of the getting stated process, integration, visual paradigms are important for user experience and allow shortening the learning curve. That is why we provide the integrated XIRUP Tool Suite and paid special attention to XSM Editor and Analysis Tool. We also learned that using of OCL for model analysis is rather complicated since the language complexity though required as the mandatory feature by end-users. For the a future work on the XSM Editor and Analysis Tool we identify necessity of the OCL usability improvement by providing a template mechanism and smart pre-filling of the OCL constraints.

Transformations should not be “global”, but instead, they should focus on small scenarios or particular cases. This is the reason why the transformation pattern approach is promoted in MOMOCS and, on the same way, different ad hoc transformations, like the UML<->Xirup ones were created.

The gain deriving from the usage of transformations increases proportionally with the number of transformations actually available. This means that starting from scratch and populating the Knowledge Base takes time, but this effort is compensated when the methodology is well established and used.

The same apply for ATL syntax whose knowledge is a mandatory step to create, define and modify transformations. The XSM Transformation Tool aids this task, but minimal ATL knowledge is still required.

Several lessons have been learned during the KBR development process and other problems have been faced by the KBR team, some of which will require to be addressed beyond the project finalization.

Currently, XAs are required to annotate manually with keyword and semantic metadata all the artifacts stored within the KBR, which may be practical for the sake of proof of concept, but it is not in real scenarios. The level of annotation quality achieved by this human approach is by no means refutable. However, it would be more practical a sort of automatic annotation mechanism like that sought after by the Semantic Web. In this sense, introspection techniques could be used to derive metadata by extracting form XSM and ATL transformations (the most important KBR artifacts) key terms to match against the KBR domain ontologies concepts.

KBR usage within the MOMOCS case studies have also revealed that the level of integration among the XIRUP tools could be a bit cumbersome, since it is based on the Eclipse import/export mechanism through the shared workspace. In the case of KBR it could be less agile to browse the repository content without having to export the artifact into the workspace, before it could be opened by the appropriate XIRUP tools. It should be more practical to watch the artifact content (maybe an snapshot) directly from the repository. In that sense, and attending one of the reviewers comments, it has been developed a facility to see directly form the repository diagrams of models stored there. Those diagrams were created by the XSM Editor and attached to the model within the repository.

KBR strength is its feature for quick artifact retrieval through the usage of advance keyword (based on Lucene) and semantic (based on Jena) search. Even if several experiments have been performed in the context of the MOMOCS use cases to test the precision of the semantic search and ranking algorithm with notable results, it is still required more experiments and studies to improve and tune this algorithm, especially in large content repositories. This search and ranking algorithm relies heavily on the metadata annotation process, whereby is quite relevant the automatic annotation process mentioned before.

KBR made usage of the eXist XML database, but this election has proven inadequate, since KBR stores not only XML content but also binary and textual files. Besides, the eXist performance in large content repository is dramatically compromised. Future releases of KBR beyond the MOMOCS project lifetime should address the substitution of its database.

Current KBR offers partial concurrent team-based access since the KBR repository is remotely distributed. However it has been realized that to ensure the data integrity amongst concurrent accesses requires the implementation of some additional mechanisms to cope with those concurrent accesses and the notification of changes in the repository. A similar approach with regards some versioning systems (with update/commit operations) has been foreseen.

The whole consortium recognized the importance of leveraging architectural views to foster the modernization of complex systems. In this way it is possible to deal with the huge amount of information without getting lost in low-level details. We were positively impressed from the flexibility of the achieved result: it was able to adapt itself to both of our case studies, even if they were very different, with different purposes. For this reason our confidence on the overall approach is increased. However, we noticed that only working together with industrial partners we were able to fix a huge amount of low-level details. For this reason we plan to validate continuously our proposal with industrial partners, establishing successful research partnerships.

We found out that one of the most critical issues of the overall approach is to reach a first high-level view on the system. In particular industrial partners appreciate our preliminary tool for reassembling the architecture of the system, and thus we are encouraged in creating more generic strategies to reach the architectural view on the system.

12 Partners

TXT E-SOLUTIONS SPA, the MOMOCS project coordinator is a leading company in the market of computer solutions for e-business and for Supply Chain and Customer Management (SC & CM), offering to its customers complete solutions, based upon kernel products, high-level competence on enabling, innovative IT and specific know-how in a number of application domains. In the frame of the project TXT leaded the development of the MOMOCS Transformation Tool. For additional information, please visit http://www.txt.it.

ATOS ORIGIN S.A.E , ATOS Origin is an international information technology services company. Its business is turning client vision into results through the application of consulting, systems integration and managed operations. Atos Origin's services and solutions add value across many industry sectors including CPG/Retail, Discrete Manufacturing, Financial Services, Process Industries, the Public Sector, Telecom, Utilities and Media. Atos Origin is the Worldwide Information Technology Partner for the Olympic Games. The company's annual revenues are more than EUR 5 billion and it employs over 50,000 people in 40 countries. For additional information, please visit www.atosorigin.com and www.atosresearch.eu.

D'APPOLONIA, D'APPOLONIA is a private firm with over 250 staff, offering consultancy and engineering services to industries, government bodies and research organisations. D'Apppolonia has wide experience as integrator in areas sensitive software applications. and provide IT consultancy in software engineering in the manufacturing automation, defence, security sectors.

Database and Information Systems (DBIS) group at the Institute of Informatics, of the Johann Wolfgang Goethe University, Germany

The Database and Information Systems (DBIS) group at the Institute of Informatics, of the Johann Wolfgang Goethe University, Germany, is one of the leading and internationally recognized research group in the field of databases, information systems and e-commerce. The group is lead by Professor Roberto Zicari, the representative of the Object Management Group (OMG) in Europe.

"Politecnico di Milano" Technical University, Politecnico di Milano (PoliMi) was established in 1863 by a group of scholars and entrepreneurs belonging to prominent Milanese families. In Italy the term "Politecnico" is a synonym for “Technical University”. PoliMi is organized in 17 departments and a network of 9 Schools of Engineering, Architecture and Industrial Design, spread over 7 campuses, with a central administration and management. The 9 schools are devoted to education whereas the 17 departments are devoted to research.

SIEMENS, Siemens AG (Berlin and Munich) is a global powerhouse in electronics and electrical engineering, operating in the industry, energy and healthcare sectors. The company has around 400,000 employees (in continuing operations) working to develop and manufacture products, design and install complex systems and projects, and tailor a wide range of solutions for individual requirements.

SIGS DATACOM, SIG DATACOM is an international and independent company for professionell education in the sector of information technology. It is one of the leading providers of IT-Seminars for professionell education and conferences e.g. the OOP in Munich, the SET in Zurich and the TDWI-Conferences in Munich and Amsterdam. SIGS DATACOM is the official partner of TDWI (The Data

Warehousing Institute) and is of the OMG (Object Management Group USA). It is publisher of the IT-journals OBJEKTspektrum, JavaSPEKTRUM and BI-SPEKTRUM.

SOFTEAM, SOFTEAM is an SME based in France. SOFTEAM is globally renowned as the MDE expert by participation for more then 15 years in OMG, originating the standards (UML2 Profiles, SPEM, MDATC) and publishing the UML2 CASE Tool – Objecteering. In the frame of the project SOFTEAM leaded development and integration of the MOMOCS tools and especially XIRUP Editor and Analysis Tool based on Objecteering CASE Tool, it also coordinated and contributed to the elaboration and delivery of the XIRUP methodology.

Telefónica I+D, Telefónica I+D (TID) is a 100% subsidiary of Telefónica S.A, being Telefónica's R&D arm. TID mission is to help improve Telefonica's competitiveness through technological innovation, acting as a catalyst and broadening the range and quality of services on offer, in order to facilitate operating costs reduction, promoting and dynamizing the Group’s innovative activities. The company is the most important private company in Spain devoted to R&D.
From its position of R&D subsidiary, TID is strongly interested in the research of new services, for their introduction into the different business units of Telefónica Corporation. Its natural clients, therefore, are Telefónica Group companies.

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