

# TanSSe-L System PIM Manual Transformation to Moodle as a TanSSe-L System Specific PIM

Kalinga Ellen A., Bagile Burchard B.

**Abstract**—Tanzania Secondary Schools e-Learning (TanSSe-L) system is a customized learning management system (LMS) developed to enable ICT support in teaching and learning functions. Methodologies involved in the development of TanSSe-L system are Object oriented system analysis and design with UML to create and model TanSSe-L system database structure in the form of a design class diagram, Model Driven Architecture (MDA) to provide a well defined process in TanSSe-L system development, where MDA conceptual layers were integrated with system development life cycle and customization of open source learning management system which was used during implementation stage to create a timely functional TanSSe-L system. Before customization, a base for customization was prepared. This was the manual transformation from TanSSe-L system platform independent models (PIM) to TanSSe-L system specific PIM. This paper presents how Moodle open source LMS was analyzed and prepared to be the TanSSe-L system specific PIM as applied by MDA.

**Keywords**—Customization, e-Learning, MDA Transformation, Moodle, Secondary Schools, Tanzania.

## I. INTRODUCTION

**D**ATA modeling as defined by Marchal [10] is the description of a system. The model is not the system itself but a formalized representation of the system. It serves a very specific purpose to help designers to understand and reason about a system. A model is only a tool for achieving a specific goal more efficiently. The goal is never to build a model, but to address the system. Development of TanSSe-L system was through modeling using object-oriented system analysis and design approach with unified modeling language (UML) from different viewpoints for different TanSSe-L system software development life cycle (SDLC) phases. The final TanSSe-L system database structure obtained was the design class diagram (DCD), hereby referred to TanSSe-L system PIM.

LMS that are in use today are either commercial products (e.g. WebCT, Blackboard), or free open source products (e.g. moodle, claroline), or customized software systems that serve the instructional purposes of particular organizations. LMS that belong to the third category are exponentially increasing, as most education and training institutions are building or planning to build their own LMS. This is due to the fact that a customized LMS from open source LMS will fit better their

specific learning purposes, and proves to give a good return of investment over the years [2]. IEEE, (2001a) [3] and IEEE, (2001b) [4] state that Learning Management Systems (LMS) are specialized Learning Technology Systems (LTS), based on the state-of-the-art Internet and WWW technologies in order to provide education and training following the open and distance learning paradigm. Moore et al. [12] and Carlson [1] argue that the design and implementation of such systems is not an easy task, since they are complex systems that incorporate a variety of organizational, administrative, instructional and technological components. Flexibility on the use of OS LMS has motivated many developed and developing countries like Tanzania to also implement their LMSs as per their context, and be saved from generating complex LMSs from scratch.

Kalinga [6], [7] has shown the modeling of the TanSSe-L database, now needed to shift from modeling view-points to real implementation of the TanSSe-L system through customizing an open source LMS. Using MDA transformation techniques, manual transformation involved the selection of an open source LMS and model merging of the TanSSe-L system PIM (DCD) and the selected open source LMS database structure, in order to prepare the TanSSe-L system PSM for implementation. Moodle open source LMS was selected to be the TanSSe-L system specific PIM for customization.

The rest of this paper is organized as follows: section two gives an overview of MDA transformation. Section three discusses the DCD as a TanSSe-L system PIM, followed by evaluation of Moodle OS LMS for customization in section four. Section five discusses Moodle OS LMS as a specific PIM for TanSSe-L system and lastly the paper gives the concluding remarks.

## II. MDA TRANSFORMATION

The Model-Driven Architecture starts with the well-known and long established idea of separating the specification of the operation of a system from the details of the way that system uses the capabilities of its platform. OMG [13] state that MDA provides an approach for, and enables tools to be provided for:

- Specifying a system independently of the platform that supports it,
- Specifying platforms,
- Choosing a particular platform for the system, and
- Transforming the system specification into one for a particular platform.

The three primary goals of MDA are portability, interoperability and reusability through architectural

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separation of concerns. MDA is an approach to system development, which increases the power of models in that work. It is model-driven because it provides a means for using models to direct the course of understanding, design, construction, deployment, operation, maintenance and modification [13].

MDA is supposed to provide a basic technical framework for information integration and tool interoperability based on the separation of the PSM from the PIM. To support these principles, the OMG has defined a specific set of layers and transformations that provide the conceptual framework and vocabulary of MDA. The set of layers defined includes the computation independent model (CIM), the PIM and the PSM. Along with the conceptual framework, OMG through MDA has also provided a set of standards to express models, model relationships and model-to-model transformations [13]. Model transformation is the process of converting one model to another model of the same system.

Model transformations can be from CIM to PIM, PIM to PIM, PIM to PSM and PSM to code. A CIM can be refined and mapped to another CIM, in the same way PIM can be refined to another PIM. Moodle database structure is the PIM of Moodle.

The PIM and other information can be combined by the transformation to produce a PSM. There are many ways in which such a transformation may be done. However it is done, it produces, from a platform independent model, a model specific to a particular platform. MDA guide provides a note that for PIMs based on virtual machines, transformations are not necessary. Instead, it is the PIM of the virtual machine itself that needs to be transformed to a PSM for a particular platform. When this is done independently of any specific system, the platform specific virtual machine be used with any system targeted to that virtual machine [13].

MDA provides a number of model transformation approaches including: Marking, Metamodel Transformation, Model transformation, Pattern Applications and Model Merge. Model merge is the one adopted while developing TanSse-L system as shown in Fig. 1, whereby manual Transformation was used. In order to make the transformation from PIM to PSM, design decisions must be made. These design decisions can be made during the process of developing a design that conforms to engineering requirements on the implementation [13].

This is a useful approach, because these decisions are considered and taken in the context of a specific implementation design. This manual transformation process is not greatly different from how much good software design work has been done for years. The MDA approach adds value in two ways:

- (i) The explicit distinction between a platform independent model and the transformed platform specific model,
- (ii) The record of the transformation.

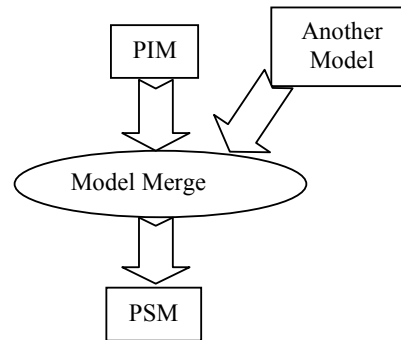


Fig. 1 MDA Model Merge

### III. TANSSE-L SYSTEM DESIGN CLASS DIAGRAM

OOSA&D with UML was employed to get a DCD as a database structure for the TanSse-L system as shown in Fig. 2. The UML has been designed to support Object Orientation. It has a lot of different diagrams (models) to get used to. The reason for this is that it is possible to look at a system from many different viewpoints.

Class Diagram or conceptual diagram being one of these diagrams, is an essential aspect of any OO method. Class Diagram can be used at the analysis as well as the design stage. Class Diagram syntax is used to draw a plan of the major concepts for system stakeholders to understand. After creating collaboration diagrams, we can progress the conceptual model, and build it into a true "Design Class Diagram". DCD is based on the collaboration diagram. Attribute visibility is shown for permanent connections. DCD is a diagram which we can base our final program code upon. We can say that a DCD is a modification of a class diagram.

OMG [13] in its MDA guide explains that a very common technique for achieving platform independence is to target a system model for a technology-neutral virtual machine. A virtual machine is defined as a set of parts and services (communications, scheduling, naming, etc.), which are defined independently of any specific platform and which are realized in platform-specific ways on different platforms. A virtual machine is a platform, and such a model is specific to that platform. But that model is platform independent with respect to the class of different platforms on which that virtual machine has been implemented. This is because such models are unaffected by the underlying platform and, hence, fully conform to the criterion of platform independence. In view of the TanSse-L system, the development of TanSse-L system targeted and focused on a global way of developing LMSs, specifically viewing the presence of open source LMS for customization, as one methodology. Three main functional areas realized, with reference to Fig. 2, included [5]-[7]:

- Management of TanSse-L system users – Area labeled "A"
- Management of learning materials with learning activities – Area labeled "B", and
- How to track users' interaction with learning materials and learning activities, and generation of tracking reports - Area labeled "C"

The concept of designing while targeting to a system model for a technology-neutral virtual machine is excellent since that virtual machine will be a specific PIM to the intended system. For TanSse-L system, the actual virtual machine as a TanSse-L system specific PIM was reached by comparing and merging the two PIMs (TanSse-L system DCD and OS LMS PIM). In this way TanSse-L system DCD was used as a base to modify OS LMS and reach to TanSse-L system specific PIM.

#### IV. EVALUATION OF MOODLE FOR CUSTOMIZATION

There are a number of OS LMS used in different organizations in such a way that it is somehow difficult to identify which one to select to suite your needs. According to many findings, the majority of Open Source LMSs shows the following:

- Similar functionalities: many incorporated with collaborative mechanisms like discussion forums and chat
- Implemented on similar technologies like Linux operating system, PHP, MySQL database server and Apache web server (LAMP) environment

TanSse-L system requirements specification and analysis as indicated by Kalinga, [6], realized that the majority of the open source LMS available world-wide will support the basic functions needed by the TanSse-L system. Selection of which open source LMS to customize out of many lists of them was very difficult. Moodle was selected based on the comprehensive competency (at that time of development by 2010) it has over others, and which was also corresponding to TanSse-L system's specifications, like using LAMP technology as follows [11]:

##### A. Popularity

Moodle [11] Web page accessed in March 2009 showed that by February 2009:

- Moodle Sites: Moodle total known registered sites were 51,228 from 208 numbers of countries. Inclusive, there were a total of 2,728,042 courses, 29,646,254 users, 1,869,432 teachers, 21,539,033 enrollments, 37,261,865 forum posts, 21,766,337 resources and 29,174,247 quiz questions.
- Moodle number of users per site: There were 432 sites with more than 10,000 users. The site with the most users was moodle.org with 53 courses and 644,046 users. The site with the most courses was ATENEA - Campus Virtual de la UPC with 21,948 courses and 70,474 users.
- Community growth (Total Moodle.org users): There were a total of 644,046 registered users.
- Moodle Downloads per month: In July 2004 there were 17,060 Moodle downloads and in February 2009 there were a total of 88,557 Moodle downloads. This was an increase of almost 419%.

##### B. Support

Moodle provides a support through authorized Moodle partners who are serious about providing quality services to users of Moodle software, ranging from basic support to the

development and implementation of complete ICT solutions. Support is also in both the technical and pedagogical sides of e-learning to help in planning and implementing an educational strategy for institutions or business that includes Moodle as part of a complete solution. Partners also provide training if needed. All Moodle Partners contribute directly to the ongoing development of Moodle software via funding or expertise. Moodle Partners are a group of competent professionals.

##### C. Installation

Moodle is easier to install than most other web applications.

##### D. Integration with Other Systems

It is possible to integrate Moodle with other systems. Integrating Moodle with other systems makes Moodle more powerful. Moodle can be integrated with user management systems, school administration systems, LDAP server, other external databases and many others.

##### E. Pedagogically

Moodle was developed with pedagogical consideration. It is a student-centered content management system. Following social constructionist it offers, people can learn best when they engage in social process of constructing knowledge, by doing in groups. The focus is on sharing ideas.

##### F. Platform

Moodle can be installed in Apache, PHP and MySQL/PostgreSQL environment. It can be run on Windows and Mac operating systems and many flavors of Linux (for example Red Hat or Debian GNU).

##### G. Moodle Documentation

A number of relevant documents are being provided to help Moodle users in customizing and using Moodle. Documentation comes through articles and discussion forums. Search from moodle.org in 2009 showed that there were 1,626 articles concerning Moodle of different topic areas.

Comparing Moodle to some other open source LMS like Caroline, which is equally popular, by just using few items, it can be seen clearly why Moodle has been accepted more by many organization as shown in Table I.

TABLE I  
MOODLE OPEN SOURCE LMS VS. CLAROLINE OPEN SOURCE LMS

Item	Moodle	Claroline
Number of countries	There was a total of 209 countries using Moodle open source LMS	There was a total of 101 countries using claroline open source LMS
Moodle number of users per site	There were 432 sites with more than 10,000 users. The site with the most users was moodle.org with 53 courses and 644,046 users.	Claroline has a large worldwide users' and developers' community (exact number was not explicitly shown)
Community growth	There was a total of 839,918 registered users (moodle.org users)	Not explicitly indicated
Moodle downloads per month	In July 2004 there were 17,060 Moodle downloads and in February 2009 there was a total of 88,557 Moodle downloads. This is an increase of 419%.	There was more than 150 downloads per day
Platform Server	<ul style="list-style-type: none"> <li>- A web server - recommend <i>Apache</i></li> <li>- <i>PHP</i> and the <i>MySQL</i> databases server</li> <li>- Linux operating system (can also run on Windows and Mac operating systems)</li> <li>- It can also be used in PostgreSQL database</li> <li>- IMS/SCORM standard compliance</li> </ul>	<ul style="list-style-type: none"> <li>- A web server (recommend <i>Apache</i>, but others should work too)</li> <li>- <i>PHP</i> and <i>MySQL</i> and uses the current standards like SCORM for the exchange of content</li> <li>- Compatible with Linux, Mac and Windows environments</li> <li>- A Mail Transport Agent (optional)</li> <li>- Translated into 35 language packages</li> </ul>
Language Packs	- Translated into 78 language packages	- Translated into 35 language packages

Source: <http://moodle.org/> and <http://www.claroline.net/> accessed on January, 2010

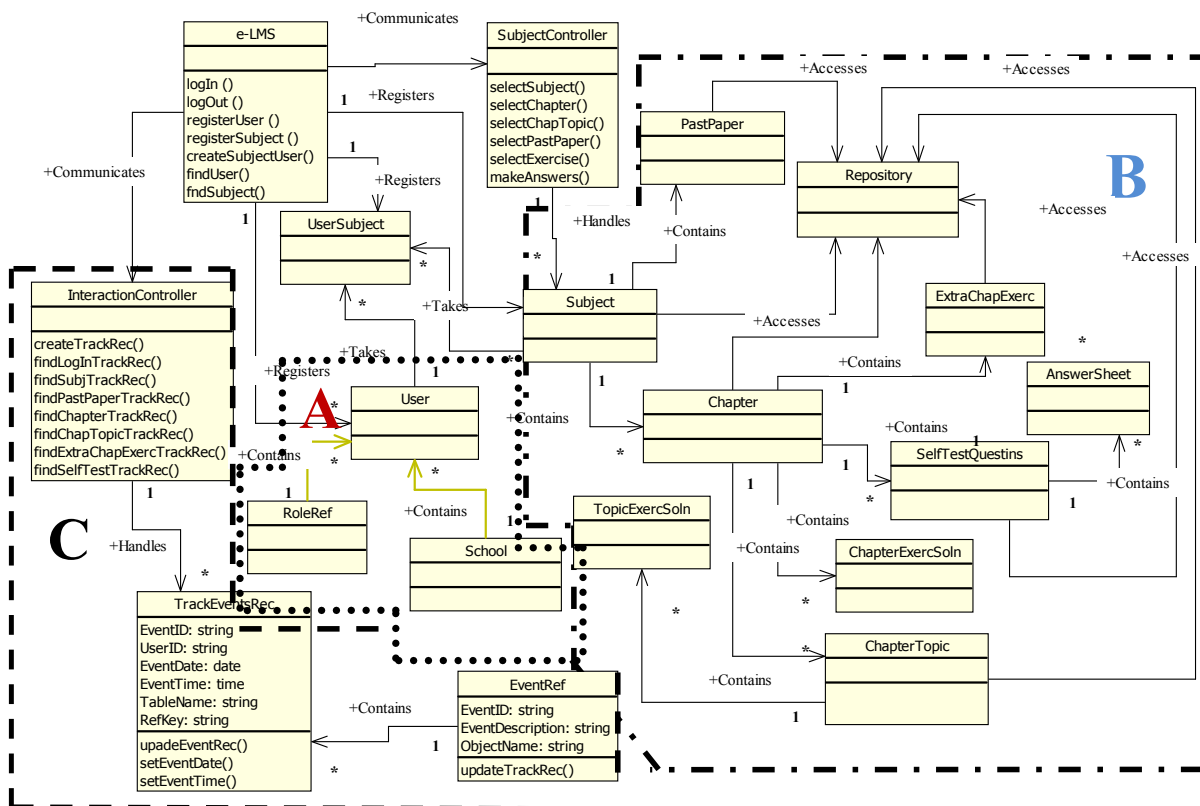


Fig. 2 TanSSe-L System Design Class Diagram (DCD)

### V. MOODLE AS A TANSSE-L SYSTEM SPECIFIC PIM

With reference to TanSse-L DCD in Fig. 2, three major functional areas marked as A, B and C, were needed to be broadly compared to the way Moodle handles these functions. These areas were:

#### A. Management of Users and Users' Information

Recording user information is the most important step since the development of systems needs to track how users utilize the system. Tracking reports will all include appropriate user identification information as per the specific domain in relation to different visits within the system. When looking into the information used to identify a user in Moodle, it can be seen that a lot of information is missing when compared to the TanSse-L system user information. The missing information could easily be accommodated by either adding extra table/s for the missing information in Moodle or by adding extra fields within the table in Moodle (e.g. in mdl\_user for user identification information) during the TanSse-L system implementation stage. This is a kind of model merge approach used.

Apart from the basic information needed to identify a user like userID, username, email, and from the point view of the TanSse-L system, the user also was needed to be identified by *region, district and school name or institution*. Also *form level, subject specialization* (e.g. science, commercial etc) and *subject combination* (e.g. Physics, Chemistry, Mathematics - PCM) were needed information to identify a student. Fig. 3 shows this part within TanSse-L system's DCD (Area 'A' of Fig. 2) in a UML package which provides the user information. On closer evaluation, the following extra information was needed to be added to Moodle during TanSse-L system implementation:

- 'region' to get the name of the 'Region'
- 'district' to get the name of the 'District'
- 'schoolname' to get the 'School Name'
- 'gender' to get the user's 'gender'
- 'fomlevel' to get the 'Form Level'
- 'specialization' to get the subject area of specialization
- 'combination' to get subjects combination

#### B. Management of Learning Materials

The main objective of the TanSse-L system is to support Tanzanian secondary schools with teaching and learning functions. The structure of the learning material is the main part of the TanSse-L system database structure. Findings done by Lujara [8], [9] show clearly the structure of the learning material to be used in tree form as shown in Fig. 4. This learning material structure was incorporated in TanSse-L system DCD portion marked by letter B in Fig. 2. Analyzing the structure of the learning material, Tanzania secondary schools have a number of subjects for each form level. Each subject has recommended books and reference books. When looking inside these books there are a number of chapters and each chapter having a number of topics. At the end of each chapter there is an exercise.

Though it can be seen that there is only one course table in

Moodle (mdl\_course), the final display of the course (hereby named subject in the TanSse-L system) content looked similar to what was needed for TanSse-L system. What was needed by the TanSse-L system was to adopt the way Moodle handles subject learning materials with the slight alteration of having a 'Chapter Format' instead of a 'Topic Format' in Moodle. Fig. 5 shows how TanSse-L system subjects were displayed when adopting the Moodle way of handling a course.

When selecting a subject, a subject home page will be displayed in "chapter format". Chapter format (Topic format in Moodle) comes with a number of divisions/blocks in the middle. The first unnumbered division will be used to display links to subject; syllabus, objectives, outcomes, past paper/s if any and any general information on the subject. Other numbered divisions will represent chapters of the subject, whereby a corresponding single division as a chapter will include links for all chapter topics, all topic exercises, review exercises for the chapter and extra chapter exercises if any.

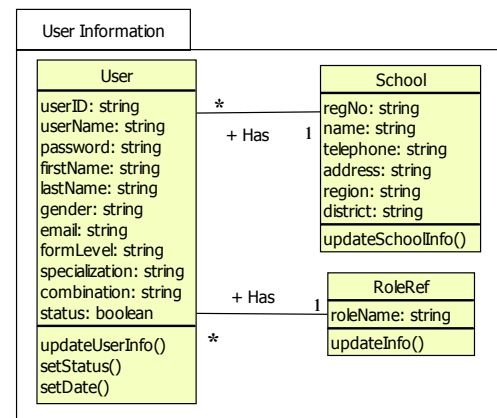


Fig. 3 Part of TanSse-L DCD Showing User Information

#### C. Tracking Users' Interactions with the System

Tracking reports means tracking users' events when interacting with the system, hence reports involve describing the user who did that interaction. All Moodle tracking reports suit the TanSse-L system's needed reports. Moodle reports needed to be modified to produce reports which identify the user as per the TanSse-L system information as explained in sub-section 'A' in Fig. 2, and elaborated in Fig. 3. To have Moodle as the TanSse-L system-specific PIM for this part, the TanSse-L system development included all needed fields in SQL codes so as to add the required user information from mdl\_user in tracking reports.

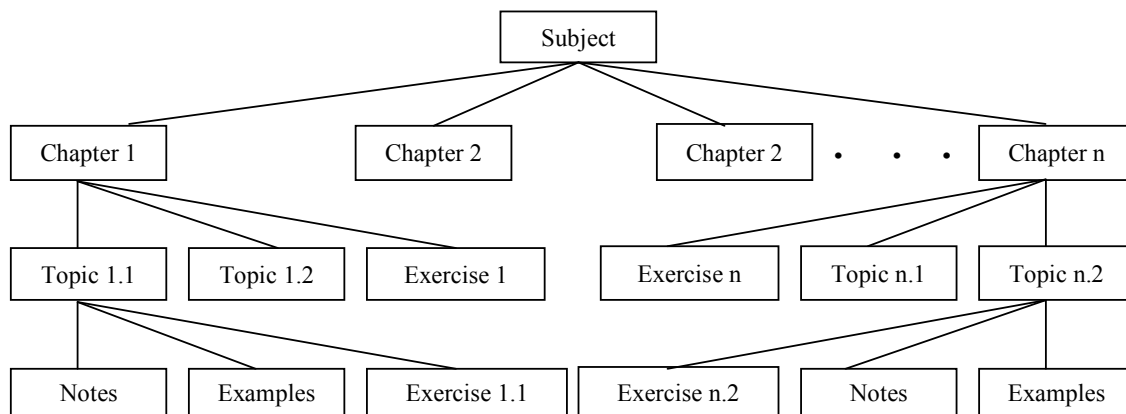


Fig. 4 Learning Material Tree Structure [8]

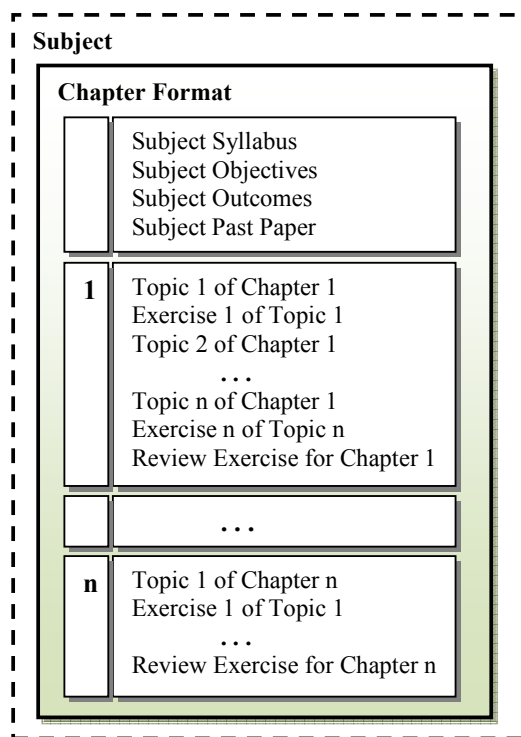


Fig. 5 Chapter Format for TanSSe-L System

With the above evaluation, the TanSse-L system PIM was transformed to Moodle as a TanSse-L system-specific PIM by adding the above-named fields in mdl\_user table, adopting the way Moodle handles subjects, and adding required fields in SQL codes to get the right display of tracking reports. These modifications were realized during the implementation phase when Moodle open source LMS was customized.

## VI. CONCLUSION

The DCD obtained could be implemented using an OO programming language like Java, C++ etc, as per the OO approach, or using PHP when a database is created in a MySQL server. DCD gave all the necessary information to generate the code. It was the database structure for the TanSse-L system. Following the MDA approach, the TanSse-L system PIM was put.

The TanSse-L system was implemented by customizing the selected open source LMS. Instead of generating codes using DCD for implementation, the approach was to analyze the open source LMS with reference to the TanSse-L system DCD as a base. This led to having a TanSse-L system-specific PIM, alongside looking at the technology used in implementing an open source LMS. Therefore, the needed transformation of the TanSse-L system PIM to a TanSse-L system-specific PIM and eventually to the TanSse-L system PSM took place.

Transformations may combine elements of different source models in order to build a target model. According to the number of source models involved in the mapping process, a transformation is simple or a merge. This paper shows the simple transformation technique, whereby what was in the TanSse-L system DCD was simply merged into the selected open source LMS.

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