Organizing Technology Enhanced Learning *

Markus Schmees
University of Oldenburg
Escherweg 2
26121 Oldenburg, Germany
markus.schmees@uni-oldenburg.de

ABSTRACT

Organizational units like courses have different agendas in technology enhanced learning. They must abide by organizational regulations, obtain sustainable learning results, and limit incurring expenses. Various software systems support educational activities, but cannot observe these rules generally. This article presents a way to integrate concepts of electronic commerce for this purpose. Basic idea is to implement organizational rules with help of involved learning applications. For this purpose, concepts of technology enhanced learning are mapped on established concepts of electronic commerce. A database schema is designed that allows specifying rules and a framework is developed to ensure compliance with them. Finally, a methodology is presented to integrate this framework in various learning applications. Thus, compliance with organizational rules is ensured both within one application and cross-system. Above all, organizational units can test auspicious scenarios by specifying own rules. Already known and established applications can be extended easily and act as a testbed for further studies.

Categories and Subject Descriptors

J.1 [**Computer Applications**]: Administrative Data Processing; K.3.1 [**Computers and Education**]: Computer Uses in Education; K.4.4 [**Computers and Society**]: Electronic Commerce; K.6.5 [**Management of Computing and Information Systems**]: Security and Protection

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Technology Enhanced Learning, Electronic Learning, Organizational Rules, Learning Management System, Electronic Commerce, Business Process Integration

1. INTRODUCTION

Information and communication technologies (ICT) more and more influence everyday's life, particularly in business and education. In case of electronic commerce (e-commerce), they support activities in trading and e.g. allow purchasing traditional goods from anywhere at anytime like Amazon shows [1]. Furthermore, they automate business processes and e.g. enable pricing procedures which otherwise would not be practicable, e.g. auctioning low-priced goods as shown by eBay [2]. With their help, anyone is able to implement and realize new business models efficiently like the million dollar homepage proves [3]. In case of technology enhanced learning (TEL), ICT are used to support activities in teaching and education. In addition to electronic learning (e-learning), where learning technologies help achieving desired learning results [29], TEL also comprises activities without influence on this result, e.g. course or content management. Involved resources like scripts, learning units, or administrative services are available digitally and can be addressed or retrieved over networks easily [22]. Because of their digital nature, there is no direct contact necessary between providers and recipients [24]. Learning management systems (LMS) are the most frequently used applications in TEL. They are also known as learning platforms or portals and provide uniform access to provided resources [10]. From a technical point of view, LMS are nothing else but a set of addressable and executable functions. Users invoke these functions in order to access e.g. a digital service.

Although ICT can be conducive to assure quality, TEL is facing many problems. The following section 2 addresses both current challenges and intended objectives. Envisioned solution of these problems is an implementation of organizational rules. Section 3 deals with them and their characteristics. In order to integrate rules in learning applications, section 4 describes a suitable concept that allows modelling and implementing them. For this purpose, concepts of e-commerce are involved. A database schema determines the structure of rules and a framework architecture ensures compliance with them. Moreover, this concept contains a methodology to integrate the framework in underlying applications. Section 5 describes different ideas to apply rules. Related work and approaches are discussed in section 6. Finally, section 7 closes with a conclusion and future prospects.

2. PROBLEMS AND OBJECTIVES

ICT can support both activities in learning as well as organizing education. But besides intended advantages like improving efficiency and flexibility, there are a few drawbacks when involving technology. In particular, these are incurring costs, different objectives, doubtful quality, lacking influence, wasting valuable resources, unmanageable supply, and a heterogenous system landscape. These challenges and associated necessities are outlined briefly in the following.

- **High Expenses**: A lot of different costs are emerging in TEL. Generally, they are difficult to determine and to distinguish [20]. Furthermore, there is a dependency between incurring costs and type, characteristics, and complexity of supported educational methods [26]. In order to meet costs and provide associated services uninterruptedly, business models must ensure a sustainable creation of value [28]. For this purpose, various business models were developed, e.g. in [27] or [16]. Until now, a tool is missing that supports realizing and testing business models in TEL.
- **Different Objectives**: Each player in TEL aims at own targets. Teachers e.g. control the learning process, specify sequences in learning units, and coordinate the interplay between participants. Learners e.g. try to take new knowledge as convenient and efficient as possible. In addition to didactic ones, economical objectives must also be considered. Incurring costs demand sustainable revenues, teachers must sell scripts, universities consider tuition fees and performance-related remuneration. Until now, applications in TEL do not consider an implementation of these objectives.
- **Doubtful Quality**: In 2002, 61% of the participants of a survey were dissatisfied with the quality of e-learning offerings [18]. A distinguishable presentation of prices and benefits as well as mutual ratings help improving quality. With help of market transparency and consumer protection, quality can be assured by market mechanisms like shake-out. But until now, applications of TEL do not provide necessary transparency and therefore cannot implement these mechanisms.
- **Lacking Influence**: Generally, learners have no influence on quality or structure of TEL offerings. But in case individual funds are restricted, participants must use own funds targeted in order to achieve a desired learning success. Thereby, they achieve a say, greater responsibility, and are forced to act economically. This strengthens offerings with impact on the learning success and reduces the use of offerings without contribution. Thus, the trade of resources contributes to quality assurance. But until now, applications of TEL are not designed to sell arbitrary learning resources.
- **Unused Resources**: In TEL different participants are interacting. They do both deliver (e.g. teachers) and consume (e.g. learners) services. In case they are just consuming, own competencies and qualities remain unused. In order to activate these resources, market regulation must be involved. In this case, learners e.g. must provide services like proof-reading term papers in order to earn points that can be used for their own support. Until now, an internal clearing that helps compensating individual efforts is not involved in TEL.
- **Unclear Supply**: Various suppliers provide different learning materials and services, each in miscellaneous quality. This plenty of goods is nearly unmanageable so that learners oftentimes do not know which resources are actually provided or how to access them. Until now, a central point like a marketplace is missing in TEL that brings together providers and consumers by supporting supply, search, and choice of resources.
- **Nonuniform Applications**: Different software systems support activities in teaching and education, e.g. the already mentioned LMS. They are developed with help of various programming languages, are deployed on miscellaneous operating systems, and generally work independently from each other. Generally, each application is specialized in supporting distinct activities like organizing exams or managing courses. Until now, a common integration of regulations is not possible.

One way to meet the mentioned challenges is implementing organizational rules, even cross-system. Therefore, this paper presents a concept that aims at different purposes. These are protecting resources from abuse, involving internal clearing to force an economic behavior, applying market transparency to achieve market mechanisms, integrating business processes to compensate costs, being independent from involved applications, developing a testbed for trying out different scenarios, and evaluating the results. For these purposes, concepts and technologies of e-commerce are integrated in applications of TEL. They allow trading, accounting, and accessing digital learning resources. Moreover, digital services are identified as basic elements for implementing organizational rules. The following section describes both these rules and their characteristics more detailed.

3. ORGANIZATIONAL RULES

In TEL, organizational units like systems, courses, groups, or single users control own resources, e.g. in the form of course material or supporting services. If resources are provided digitally, consumers can access and demand them with help of communication networks. In order to achieve e.g. a desired learning result, an organizational unit determines itself how to use its resources. Organizational rules represent the way an individual user may access and demand a digital resource. They are specified by an organizational unit that controls this resource. On the one hand, they contain preconditions that must be met so that a consumer may access a resource. Thereby, a consumption sequence can be modelled. Learners e.g. may only access an advanced learning unit after finishing basic ones successfully. On the other hand, organizational rules contain postconditions that must be established afterwards. They can depend on a consumer's behavior during consumption. Learners e.g. only then complete a learning unit successfully, if they achieve enough points in a final exam. The type of organizational rule depends on the reason that caused its specification. It is e.g. organizational important to implement existing conditions of study. Didactical considerations demand control over the learning process. Economically, a collection of

fees and tolls is necessary. Different reasons and underlying needs are outlined briefly in the following.

- **Organizational Needs**: Educational institutions like universities enact conditions of study. Therein specified rules must be implemented, realized, and observed. In case ICT are involved, these rules keep valid. Therefore, conformance with them must also be ensured in learning technologies. Students e.g. do not receive diplomas before they successfully finish necessary exams. Teachers e.g. only may allocate an auditorium, if enough students are participating in their lectures.
- **Didactical Needs**: In order to achieve a high-quality learning result, teachers must influence the learning process based on learning theories. In behaviorism for example, learners need direct and efficient feedback on their actions and behavior. If this feedback shall be given automatically, appropriate and machine-readable rules must be specified in advance. May e.g. an exam only be completed after finishing a learning unit, access to this test may not be granted previously.
- **Economical Needs**: Not any teacher or any organizational unit is willing to deliver services free of charge. This must be regarded particularly in on-the-job training and personnel development. For this purpose, various authors describe different business models. Various parts of these models can be implemented with help of ICT. Consumers e.g. only may access a chargeable resource, if they already have paid for it.

Different and even contradict objectives are meeting in TEL. Universities must keep curricula, courses must provide interesting offerings, groups must coordinate activities of their members, and individual learners must achieve aspired learning results. Involved organizational units control own digital resources and define circumstances, under which access is granted. Organizational rules are associated rules that represent both preconditions for accessing resources and postconditions that must be established afterwards. Characteristics of a learning context require an implementation of these rules. Learning theories demand e.g. feedback on a shown behavior, learning forms a control over workflows, learning concepts a monitoring of the learning progress, learning goals must be specified interdisciplinary, and the interplay between courses must be coordinated.

ICT have proven themselves in supporting trading. Therefore, consumers already know how to deal with them, e.g. in case of making bids or purchasing digital goods. In order to implement organizational rules, concepts and technologies of e-commerce are involved. However, any virtual community's communication is different. Therefore, it is more convenient for consumers to remain within a known community for trading. LMS are community applications that support communication, provide access to different functions, and act as uniform portals. As well as other applications they support single activities in the scope of education, but cannot implement organizational rules, generally. Therefore, the following section describes a concept that allows this implementation based on the already involved technologies.

4. CONCEPTUAL DESIGN

In order to meet the introduced needs, to solve mentioned problems, and to try out promising ideas, organizational rules must be implemented. This section describes an approach that allows their specification, integration, and implementation. Furthermore, the presented concept enables learning technologies to ensure compliance with these rules. Basic idea is an involvement of protection mechanisms, internal clearing, and concepts of digital commerce. In order to check preconditions before a digital service is delivered, it must be possible to protect this service and to grant access only to authorized users under specified circumstances. In order to establish desired postconditions, the service's delivery can be combined with an accomplishment of financial transactions. Hence, an internal clearing is required to account these transactions. If economical rules must be implemented, e.g. for selling usage rights, general concepts of digital commerce like dynamic pricing can be involved. The single ideas are pointed out briefly in the following.

- **Service Protection**: The delivery of digital services can be restricted with help of access rights. For this purpose, it is necessary to protect chosen services. Only if a user has an associated right and specified conditions are fulfilled, he may consume the service. Basic idea to realize this kind of protection is an integration of concepts of digital rights management (DRM). Associated systems assign and manage rights in the form of licenses. If a valid license is available, it can be demanded in order to access protected functionality.
- **Internal Accounting**: After delivering a digital service, specified postconditions must be established. For this purpose, financial transactions are used. In order to accomplish them, an internal accounting must be integrated in learning technologies. This combines the execution of protected functionality with an automated accomplishment of financial transactions. Moreover, it ensures an efficient handling and booking. Involved transactions are specified in the scope of the previously mentioned licenses.
- **Digital Commerce**: Because digital services are immaterial economic goods, they can only be sold indirectly, namely as usage rights. An involvement of concepts of e-commerce allows this salary in the form of licenses and thereby the salary of digital services. For this purpose, an application environment is responsible for protecting services from unauthorized access, an internal clearing combines their delivery with an accomplishment of financial transactions, and a rights management coordinates assignment and demand of licenses. Suppliers can specify necessary pre- and postconditions with help of offerings transparently. In order to avoid system discontinuity, the mentioned concepts can be integrated in learning technologies.

Protection mechanisms ensure that protected digital services are only delivered to authorized users or systems. On the other side, a transactional logic determines sender, recipient, and amount of a financial transaction and accomplishes it. Integrating protection mechanisms and transactional logic

in a set of existing services has to meet several requirements. It may not change functionality, but must preserve the original implementation widely. In order to ensure easy addressing and to avoid an adjustment of accessing applications, the call of a service may not be changed. In case of changing rules, a simple way to protect and release services must be given. In order to protect services against unauthorized accesses, protection mechanisms must work independently from a transactional logic. However, to prevent from accidental invoking and to avoid the corresponding accomplishment of transactions, services with a transactional logic must also be equipped with protection mechanisms. To achieve more flexibility in modelling, one service can trigger several transactions. In order to map sender, recipient, and amount of a transaction to conditions that arise during delivery, a conditional accomplishment of transactions must be possible. By accomplishing them after a function is delivered, transactions are avoided in case of a functional failure.

The following section 4.1 characterizes the basic idea to meet previously mentioned requirements, namely to map concepts of e-commerce on concepts of TEL. Thereby, already known concepts can be used for modelling organizational rules. In a further step, these rules can be specified by users with power of control over underlying digital services. Section 4.2 describes a database schema that was developed for this purpose. On this base, a tool can observe and process specified rules. Section 4.3 describes the associated framework architecture. Finally, this architecture must be integrated in applications that shall ensure compliance with these rules. Section 4.4 describes an associated integration methodology.

4.1 Mapping Methodology

Organizational rules represent both prerequisites for accessing digital services and postconditions that must be established afterwards. The delivery of a digital service can influence the fulfillment of involved conditions. Therefore, an individual demand can lay foundations that are required to demand other services. Organizational units define e.g. sequences for using services or determine the number of times a user must demand one service before he may access others. Different organizational rules can be valid, each depending on a determined situation and the behavior of involved participants. In order to implement these rules, they must be integrated in learning technologies, where compliance with them is ensured. Because concepts of e-commerce are well known and established, they are involved for this purpose.

Idea to involve concepts of e-commerce is to map them on appropriate concepts of TEL. Fig. 1 shows the correlation between chosen elements of TEL and e-commerce. In this methodology, functions of a TEL application represent digital services. They are connected to financial transactions which establish certain postconditions. An accomplishment of transactions influences internal accounts that represent requisites for demanding further services. This way, an account represents an organizational unit's individual situation. Preconditions for delivering a service can be modelled with help of accounts, e.g. in the form of points. The demanded service takes care of establishing postconditions, because it triggers transactions. Thus, accounts, services, and transactions are basic parts of this mapping model and therefore explained particularly in the following.

	Technology Enhanced Learning	Electronic Commerce
Status	Type of Organizational Rule	Currency
	Status Storage	Account
	Individual Status	Account Balance
	Change in Status	Financial Transaction
Function	Function of a TEL Application	Digital Service
	Invocation of a Function	Demanding a Digital Service
	Transmitted Parameters	External Factors of Production
	Execution of a Function	Delivering a Digital Service
Right	Right to Execute a Function	License
	Using a Right	Demanding a License
	Consumable Capacity for Using Rights	Consumption Values of a License
	Invocation of a Function	Agreement on License Demand
Selling and Assigning Rights	Right to Assign Rights	Power of Control over Digital Service
	Agreement to Assing/Sell Rights	Assignment of Power of Control
	Agreement to Execute a Function	Assignment of a License
	Rights Salary	License Salary
	Conditions of Sale	Offering
	Revenue Model	Type of License in Offering
	Direct/Indirect Type of Revenue	Relation between Owner and Target User
	Agreement on Offering/Pricing	Making a Bid for Offering
	Agreement on Consequences	Existence of Offering/License
	Revoking a Right and Consequences	Withdrawing a License (by Owner)

Figure 1: Assignment of Concepts

- **Internal Account**: Represents an individual container for keeping information about a current situation. Thus, it represents the proceeding and achieved level of an organizational unit. Every unit obtains an own account, e.g. in the form of a group account within a course. Only those users or units that are associated to this account may control and manage it.
- **Digital Service**: Represents a function of an application in TEL that users can demand by invocation. The software system acts as an operating environment and checks preconditions that are necessary for execution. Only if they are valid, the function may be executed and an associated service is delivered. Because functions can be connected to financial transactions, their accomplishment can be necessary afterwards.
- **Financial Transaction**: Represents individual consequences that can result from a service's execution. They influence the current situation of involved organizational units by influencing their accounts. With help of transactions, specified conditions can be established. The accomplishment of transactions happens during accounting when involved accounts are cleared.

Both the salary of licenses and an accomplishment of financial transactions can be processed without money, e.g. by using individual currencies. These currencies originate from organizational units and represent intended types of rules. Exercise points e.g. help defining examination prerequisites. Students may only apply to an exam, if they have collected enough exercise points in advance. The presented methodology maps rules on licenses and offerings. It comprises concepts of e-commerce, because monetary transactions are involved. A database schema represents the basic structure of these rules and is necessary to ensure compliance with them. The following section describes this schema more detailed.

4.2 Database Schema

There are different participants interacting in TEL, who do both deliver and consume digital services. These participants can be part of various organizational units, like groups, courses, or systems. Those who are in charge of an organizational unit, e.g. teachers in courses, coordinate internal processes and thereby control the behavior of participants. They determine circumstances for requesting a digital service, and combine its delivery to an accomplishment of financial transactions. Although different rules can apply to one user concurrently, organizational units can make different rules for individual participants. Therefore, they need the ability to specify rules individually. Within the scope of TEL, compliance with these rules must be ensured, e.g. to reach a desired learning result. For this purpose, a database schema is needed. It describes the structure of rules and allows their management. Based upon the methodology described previously, it can specify power of control, digital services, and prerequisites for access. Therefore, it connects different preconditions with involved users and associated digital services. Involved financial transactions represent a dynamic that depends on contained preconditions, originates after a service was delivered, and establishes desired postconditions. For this purpose, the database schema facilitates both defining and understanding organizational rules. Thereupon, software components can interpret and realize these rules. Specifying rules is possible independently from involved software systems or frameworks. This is an important factor, because there are different learning technologies involved in TEL and they are upgraded continuously.

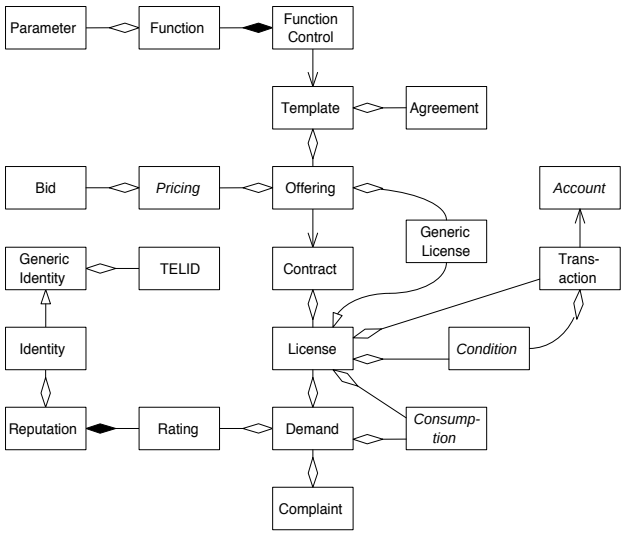

Figure 2: Database Schema

In the form of an UML class diagram, fig. 2 gives an overview over the database schema that allows implementing organizational rules. Quintessence are licenses representing the right to consume a digital service. They contain a consumption value that is reduced per demand. In case of error, a consumer can complain and ask for damages. Depending on the satisfaction with the service, he can rate its provider. All individual ratings as a whole represent the reputation of an organizational unit. This database schema specifies involved digital services as functions. Data about their identification and control as well as external factors of production are represented as parameters. A license can contain financial transactions. Depending on a specified precondition, they transfer a determined amount of a certain currency between two internal accounts. This describes a dynamic that is initiated by a consumer when executing a function. With help of transactions, postconditions can be established. Hierarchically structured identities identify organizational units regarding their association to other units. They relate the schema to TEL and allow specifying both owners and target users of licenses as well as sender and recipient of financial transactions. In case, involved software systems manage own identifiers, a common data type allows their integration. Generic identities are placeholders for identities. They can be integrated in e.g. licenses easily and replaced with a real identity if necessary. Generic licenses represent the type of license that can contain generic identities. Users who control a digital service can assign and sell rights. Offerings are templates for negotiating a contract and for entitling a consumer. They contain information about type and status of an associated pricing method as well as generic licenses that can incorporate potential buyers. In case financial transactions are involved, they must be approved in advance. For this purpose, templates contain an associated agreement. Moreover, they are the prerequisite for creating an offering and assigning a right in the form of a license.

Core of the database schema are offerings, licenses, and financial transactions. Offerings represent a generic data type for specifying organizational rules. In case market mechanisms are involved, they are required to build licenses automatically. Licenses in turn contain transactions that must be accomplished after specified services have been delivered. A strict separation between these data types as well as the possibility to transform or integrate them into each other allows specification by third and independent parties. In the following, the three main data types are described briefly.

- **Conditional Financial Transaction**: Represents a data structure for modelling financial transactions. For this purpose, it specifies sender, recipient, and the amount for transmission. On the one hand, specified currencies can have common types like Euro or Dollar that represent economical rules. On the other hand, they can have individual types, e.g. exercise points from a course, that represent rules of an associated organizational unit. The type of clearing determines whether a sender's account must contain the amount in advance or is cleared during or after accomplishment. An optional precondition specifies necessary requirements for accomplishing a specified transaction. For identifying sender, recipient and individual currency, the already presented hierarchical identities are used. They associate users with organizational units and determine involved accounts for clearing.
- **Transaction-based License**: Represents the right of an organizational unit or function to execute a specified target function. Optionally, a precondition can be specified. The license identifies owners who may revoke the right and optionally contains financial transactions that must be accomplished afterwards. Thus, it also represents approval of those who must pay for the transactions. Moreover, consumption values can

be specified representing the remaining degree of a license's usage. Generic licenses are licenses that can contain generic identities. A right's assignment can use them to create real licenses by integrating owners' identities. A license can be demanded until it expires or an owner withdraws the associated right. Licenses allow controlled access to protected digital services. Only those who are target users of a valid license may demand a specified digital service. Because licenses are machine readable, they are base to automate an accomplishment of financial transactions. In a favorable case, users who execute a function don't even notice this accomplishment. Users with power of control may assign associated rights. This is done by creating a license and associating it to owners and target users. In order to simplify exploration, examination, and demand of licenses, a XML-based schema was developed.

- **License-based Offering**: Is necessary for selling licenses and can contain additional information about provider, consumers, and aspired buyers. Moreover, offerings specify type and status of an associated pricing and thereby determine a validity indirectly. They contain generic licenses that can be transformed to real licenses by integrating a buyers identity after pricing. Licenses can cause two types of costs. They arise from buying a license or from accomplishing financial transactions during its demand. This requires an approval of those, who have to pay for these costs. Offerings support this approval in two ways. On the one hand they specify pricing and are base for bidding. On the other hand, their existence already represents the approval of those, who must pay for financial transactions. In order to combine temporary offerings with approvals, templates are used. As soon as all approvals are collected, a valid offering is created, published, and can be explored by interested parties. Every paying user is specified as a license's owner an can revoke the right in case payment is no longer approved.

The presented database schema allows selling usage rights and combines delivering digital services with accomplishing financial transactions. It represents a structure for specifying organizational rules and is base to ensure compliance with them. Participants can concretize rules and map them to this structure. In a further step, these rules must be implemented. For this purpose, the following section describes a framework architecture that ensures compliance with them and allows an integration in learning technologies.

4.3 Framework Architecture

Central approach to implement organizational rules is the chargeable design of digital services. For this purpose, they have to be protected from unallowed access and combined with an accomplishment of financial transactions. As described in the previous section, organizational rules can be specified with help of offerings, licenses, and transactions. On this base, participants can estimate both their permissions and triggered consequences. In order to obtain compliance with these rules, a framework was developed. Frameworks represent a common solution for a certain class of problems. Therefore, they and their elements are designed reusable, configurable, changeable, and extensible.

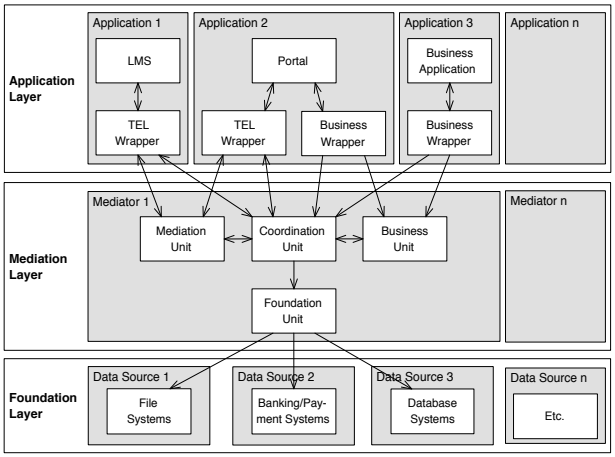

Figure 3: Framework Layers

The architecture of the framework for implementing organizational rules is illustrated in fig. 3. It involves processes of e-commerce, allows specifying, processing and managing specified data types, processes incoming events, maps outgoing data to foreign patterns, involves applications like databases or payment systems, and can be integrated in software systems of TEL. These software systems are written in various programming languages and deployed on different platforms. In order to implement organizational rules cross-platform, this framework realizes a mediation architecture as described in [32]. Essentially, it contains three layers, namely application, mediation, and foundation layer. The individual layers, involved components, and their responsibilities are described in the following subsections.

4.3.1 Application Layer

This layer represents learning applications that must implement organizational rules. Because different platforms and programming languages can be involved, a common interface must be integrated. A wrapper represents this interface and is customized to an application. With help of wrappers, a mediator can address extended applications and access their functions and attributes. Moreover, wrappers transmit relevant events to the mediator. By involving different applications in the same way, one mediator can implement organizational rules cross-application. Furthermore, it manages licenses and coordinates activities related to business. In order to integrate these functions e.g. in portals or shop systems, they must be extended by a business wrapper. Thereby, consumers can access the mediator's functionality when interacting with a familiar application.

Fig. 4 shows components of the application layer. A coordinating unit controls the interplay of involved components. A supervision unit manages both functions of extended applications and associated power of control. The detection unit receives events like a function call or termination. In order to avoid unnecessary communication, a reflex unit realizes event reaction. An analysis unit determines attributes or states of an application and is needed in order to access attributes. In order to verify conditions, the mediator must access wrapper services. A service unit provides these services for external access in a common way. Finally, a busi-

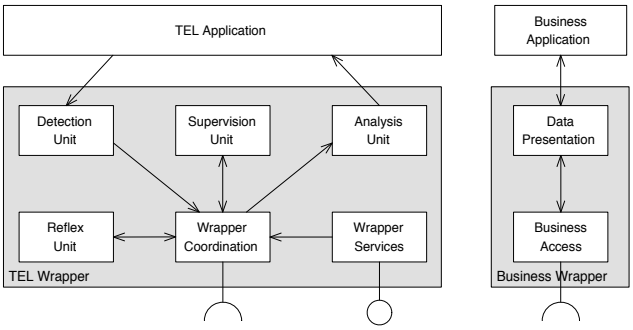

Figure 4: Application Layer Components

ness application needs the ability to present reactions and data of the mediator. For this purpose, a data presentation unit is intended. An associated business access unit transmits the users' interactions back to the mediator. The single components are described briefly in the following.

- **Application**: Users interact directly with different applications. On the one hand, these applications are learning technologies like LMS and designated to implement intended rules. On the other hand, business applications like portals or marketplaces are involved, providing access to a mediator's business functionality.
- **Wrapper Coordination**: A wrapper must be customized to an associated software system in order to act as its interface to the mediation layer. Therefore, an administrator must be able to specify its configuration. This unit manages both configuration and interplay of wrapper components. A mediation connector allows accessing a mediator's functionality.
- **Supervision Unit**: Every software system is separated in different functions. In order to implement organizational rules, they must be managed individually. Only users with power of control can protect associated functions. Consumers can only access a protected function, if they hold a valid license. This requires assignment and withdrawal of rights and management of controlling power, e.g. by a system's administrator.
- **Detection Unit**: Detects a function's invocation as well as additional information about invoking users and transmitted parameters. It decides about involving the mediator and unblocking an invoked function. In order to assure quality or to handle complaints, it registers failures that incur during execution. Afterwards, accomplishing financial transactions can be necessary. For this purpose, it also detects successful terminations and reports them to the mediator.
- **Reflex Unit**: High traffic between mediator and wrappers can effect involved applications adversely, particularly when lots of users are accessing lots of functions concurrently. To achieve an efficient processing, this unit handles events locally. It checks, whether invoked functions are protected and only then involves the mediator for further processing. In case the identification of function and service differs, e.g. as a result of maintenance work, this unit maps them on each other.
- **Analysis Unit**: In order to evaluate preconditions for demanding licenses or accomplishing transactions, an application is analyzed actively. This unit allows the retrieval of states and attributes of involved systems. It facilitates a retrieval of further information about users, organizational units, or transmitted parameters.
- **Wrapper Services**: Usually, wrapper and mediator are deployed on different servers. Therefore, services they provide must be accessible independently from programming languages and platforms. This unit encapsulates the services provided by a wrapper. They analyze an involved application, mail internal messages and retrieve information about function control.
- **Data Presentation**: This unit transforms templates into presentation structures. For this purpose, it can revert to the template engine of an involved application. It presents transactions, functions, offerings, and the state of an integrated pricing. In case a users possesses different licenses, this unit presents them as well as their demands and remaining consumption values.
- **Business Access**: In order to interact with the mediator, e.g. to buy a license, users need access to both its functions and resulting reactions. This unit grants this access, namely to business functionality, license management, and template specification.

The application layer represents involved applications and acts as an interface to users. They directly interact with learning technologies, in order to access provided functionality. For implementing organizational rules, involved applications must be extended with individual wrappers. In order to obtain wrapper functionality, an administrator has to add and integrate these components in his application. Thus, every application is equipped with an own and uniform wrapper. Thereby, one mediator can implement organizational rules cross-systems. The following section describes characteristics of the mediation layer that represents the coordinating and regulating functionality of a mediator.

4.3.2 Mediation Layer

This layer represents the business logic behind organizational rules. It monitors functions, users, and applications and enforces compliance with previously specified rules. Section 4.1 already referred to concepts and methods of e-commerce and DRM. While the application layer represents DRM's operating unit, mediation layer incorporates an associated mediation and business unit. A coordination unit controls the interplay between its components, and a foundation unit establishes connection to the foundation layer.

Fig. 5 gives an overview over components involved in a mediator. A mediator coordination regulates the interplay of involved components. A specification unit allows specifying templates, collecting agreements, and assembling offerings. They are the base for buying licenses. Functionality for digital trading is provided by a commerce unit, a settlement unit handles terms of a negotiated contract. For

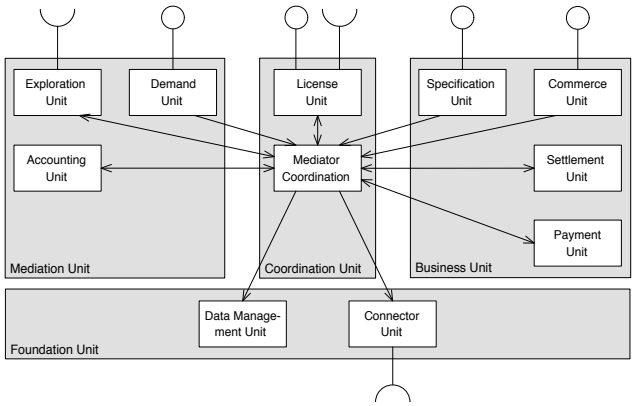

Figure 5: Mediation Layer Components

the purpose of entitling someone directly, a license unit provides appropriate functions. A demand unit checks preconditions when accessing protected functions and establishes postconditions afterwards. The analysis unit is responsible for retrieving attribute values and sending messages. Accomplishing financial transactions is done by an accounting unit. In order to involve external payment systems, a payment unit is provided. Finally, the described data types must be managed. This is the job of a management unit. For management purposes, a connector unit establishes connection to the foundation layer. The particular components are described briefly in the following.

- **Mediator Coordination**: Coordinates the interplay between a mediator's components. It manages both configuration and involved components and provides functions to address required functional units.
- **Specification Unit**: Both incurring costs and the availability of information about prices and goods determine the economic behavior of the market participants [9]. Therefore, market transparency strengthens competition and enables consumer savings. Offerings contain this necessary information. This unit realizes a specification environment of a DRM system. It allows creating and managing templates as well as assembling them to offerings. On this base, participants can agree to financial transactions. After resolving prerequisites, offerings are published. This unit provides functions for interesting parties to access and explore offerings.
- **Commerce Unit**: Provides functionality needed to sell or buy licenses. It starts with publishing offerings for market participants to receive relevant information. Intermediaries can act as a broker and find e.g. economically priced offerings. After finding an appropriate offering, a consumer can take part in pricing by bidding for the required good. As soon as price, purchaser, and further proceeding are determined, external payment systems can be involved to honor debts. Market participants check, if trading partners have fulfilled their obligations. They acknowledge their satisfaction by rating one another. In case of failure or violation, complaints can be made and restitution or a regular fulfillment demanded. If consumers did not pay for the services, this unit takes care of encashing debts. Moreover, it provides services uniformly, so that users can also access commercial services from external systems like portals or marketplaces.
- **Settlement Unit**: While trading partners access functions of the commerce unit directly, settling business activities is done automated. For this purpose, this unit processes incoming bids, each depending on the type of pricing in an underlying offering. After successful pricing, a license is created. Thereby, generic identities within an offering are replaced by an identity of the customer. After agreeing on certain conditions, both trading partners conclude a virtual contract. Therein, vendor and consumer obligate to keep conditions, i.e. creating licenses and paying stipulated prices. After this, trading partners must fulfill these agreements. Therefore, they contact payment systems in order to accomplish electronic payments and monitor the service delivery to avoid complaints.
- **License Unit**: Allows a direct assignment and withdrawal of rights by users with power of control. Therefore, it can create licenses and adds consumers as associated target users. In general, both purchasers and those who must pay for involved financial transactions are owners of a license. In case they are not longer willing to pay or to grant the right, they can raise an objection, withdraw the license, and thereby withdraw the using right. The mediator provides these functions for external access uniformly. In order to determine user rights, the mediator retrieves information about power of control from involved external applications.
- **Demand Unit**: This unit is the interface to protected digital services. It provides functions for checking, if a user may access protected functionality. Because different systems are involved, one organizational unit can own different identifications. In case no common identity management is involved, these must be mapped upon each other. Before releasing a protected function, the validity of a license must be checked. By invoking the function, a consumer demands his license. An accumulated consumption, e.g. CPU time oder memory usage, must be subtracted from the remaining overall consumption value. After a protected function's successful execution, previously specified postconditions must be established. For this purpose, external applications need a way to signalize an execution's successful end. Because different external applications access these functions, they are uniformly provided.
- **Exploration Unit**: For evaluating conditions or informing users, a mediator accesses functionality of external applications. For this purpose, wrappers provide uniform access to these functions. This unit can access an individual wrapper, e.g. to retrieve attribute values or validate conditions. Moreover, it addresses the internal messaging system of an application to inform users about events without irritating them by media discontinuity. Because these functions must be provided cross-system, this unit encapsulates application-based exploration and messaging functionality.

- **Accounting Unit**: Financial transactions are booked to individual accounts of users or organizational units. This unit realizes both internal accounting and external clearing. While financial transactions are processed by reconciliating internal accounts during accounting, an external clearing settles one account by addressing external payment systems. For this purpose, this unit coordinates billing and invoicing.

- **Payment Unit**: If external payment systems are involved, payment data must be adapted to their peculiarities. This unit commutes financial transactions into external payment processes. Furthermore, it tests payment data for validity and checks, if bank remittances have arrived. In case individual currencies are involved, it translates them into real currencies.

- **Data Management Unit**: In order to access necessary data when needed, this unit ensures its durable storing. It includes external data sources and adapts fundamental data types to their characteristics. It manages identities, templates, agreements, offerings, pricing information, bids, contracts, licenses, function's demands, transactions, internal accounts, external account data, mutual ratings, complaints, events, and involved external applications.

- **Connector Unit**: The mediator needs access to a file system, in order to read its configuration or to write log messages. External database systems manage fundamental data. This unit is responsible for involving them as well as external payment systems, which are required for processing electronic payments.

The mediation layer represents business logic for implementing organizational rules. According to a business environment in DRM, a mediation unit checks preconditions after a protected function was invoked, decides about execution, and establishes desired postconditions. A business unit represents a specification environment and allows specifying, composing, assigning, and selling licenses. In order to manage data or to pay electronically, external systems are involved. The following section addresses their characteristics.

4.3.3 Foundation Layer

A mediator uses configuration files to determine its configuration and log files for recording relevant events. For this purpose, it needs access to external file systems. Moreover, it addresses database systems to manage data that specify organizational rules. Finally, there is a connection needed to external payment or banking systems, in order to realize electronic payment. The responsible components and their individual characteristics are outlined in the following.

- **File Systems**: The mediator keeps configuration information within a configuration file. This file determines the components involved in a mediator as specified by the mediator's administrator. In order to reproduce access to digital services, the mediator records any function call. Errors during execution are also recorded with help of log files.

- **Database Systems**: The mediation layer allows specifying organizational rules and ensures compliance with them. This requires a management of data that was already characterized in section 4.2. This component contains the interfaces which allow access to external database systems like Oracle or MySQL.

- **Banking and Payment Systems**: Internal accounts of users or organizational units are cleared by external payment systems. Because there are a lot of different electronic systems providing various functions and supporting miscellaneous payment types, this unit contains interfaces for accessing their functionality.

Aspects of coordination, management, and quality assurance must be considered at any level and layer. The presented framework represents a tool for ensuring compliance with organizational rules. In a following step, it must be integrated in TEL applications. For this purpose, individual wrappers extend involved learning technologies at the application layer. The following section describes the intended methodology to integrate a wrapper in an application.

4.4 Integration Methodology

In this approach, organizational rules are implemented with help of functions provided by applications like LMS. In a further step, these applications must be extended with a wrapper to involve the mediator. For this purpose, section 4.3.1 presented both components of a wrapper and their involvement in the framework. In order to implement organizational rules, these components must be adapted to and integrated in an underlying application.

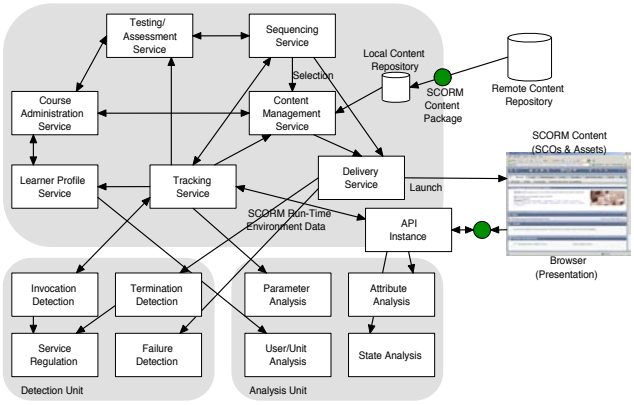

Figure 6: Integrating Wrapper Components

Basically, the methodology for combining an application with framework functionality comprises three steps. First, integration points must be identified that allow both an application's extension and analysis. In a further step, components must be integrated that interpret conditions and states of the underlying application, communicate with a mediator, and process received reactions. Finally, functions that are intended for protection must be equipped with pro- and epilogue. This connects them to already involved wrapper components. After that, a wrapper registers both a function's call and its termination and can intervene if necessary. A short explanation of these steps follows.

1. **Identify Points of Integration**: In order to identify points that are suited for integrating a wrapper, type and structure of an underlying application must be analyzed. Open source software e.g. allows a direct extension of programming code, whereas proprietary software oftentimes provides an API for extensions. Depending on the individual way applications manage their functions, data, attributes, and states, information access and retrieval differ. Fig. 6 shows the common model of a LMS as described in the SCORM standard [13]. Shown services are e.g. responsible for demanding and executing functions, messaging, presentation, and analyzing the system. These services and associated components must be identified or supplemented in case they are not existent.

2. **Integrate Wrapper Components**: After identifying necessary services, a wrapper must be integrated in the application in a further step. For this purpose, fig. 6 gives an overview about the common model of a LMS and its extension with wrapper components. A tracking service tracks user activities like demanding a function. Therefore, it must be connected to invocation detection. A delivery service hands over results of services. Thereby, it notices the end of their delivery and must be connected to termination detection. Both units need the service regulation for further processing. A failure detection notices errors during execution. For this purpose, it works together with the delivery service. In case of failure, it displays an error message and thereby informs invoking users about incurring problems. In order to retrieve information about users and organizational units, the user/unit analysis accesses the learner profile service. Amount, size, and type of parameters that are transmitted when invoking a function are identified by a parameter analysis. For this purpose, it is connected to the tracking service. In order to analyze states and attributes, an analysis unit accesses the API of an involved application.

3. **Add Pro- and Epilogue**: In order to involve single functions when implementing organizational rules, they must be equipped with pro- and epilogue individually. Pro- and epilogue detect both a function's invocation and termination. Therefore, they are connected to a wrapper's detection unit. The proceeding for extending functions is profoundly dependent on the type of software system and involved technologies. If the application's programming code is accessible, pro- and epilogue can be integrated in a function's definition. Because this method is very labor-intensive, an extension of underlying technologies volunteers in order to minimize integration efforts. For enhancement purposes, technologies oftentimes provide an API that supports event handling. In case extending the technology is not possible, e.g. because a proprietary application is involved, a router can be integrated. As a preliminary stage, it can detect a function's call, invoke a prologue, and thereby involve the framework. If it approves execution, the invocation is forwarded to the original system. However, this method does not determine a function's termination reliably and a common epilogue therefore is not implementable, generally.

In order to integrate a mediator's coordination in foreign applications, a developer must create an appropriate wrapper or reuse components that are provided for this purpose. After this, he can adapt these components to characteristics of his application. By avoiding a technology break, an interaction between wrapper and application is more efficient and secure. Equipping an application with central pro- and epilogue, e.g. by extending underlying technologies, is favorable for developers, because basic functionality remains untouched. Both central pro- and epilogue are possible, because they are executed in the same way at all times. The situation dependent customization, i.e. adapting pro- and epilogue to invoking user, invoked function, and current situation, is done by involved licenses.

Mapping methodology, database schema, framework, and integration methodology allow implementing organizational rules in various software systems. After extending them with a wrapper, the framework takes part in executing protected functions. Thereby, it can ensure compliance with specified organizational rules. The following section dwells on methods to apply this concept.

5. APPLICATION

It depends e.g. on a learning theory that learners need more or less positive and negative feedback on a shown behavior. Implementing organizational and economical rules allows specifying and realizing appropriate reactions. Moreover, it is possible to establish an incentive system for improving learners' motivation. Various rules facilitate implementing and testing different scenarios. Examples are salary of learning materials, auctioning entry to courses with restricted membership, performance-related payment of teachers, and a payback of tuition fees in case of learning success. The single ideas are outlined briefly in the following.

- **Selling Learning Material**: A simple idea to balance out incurring costs is the salary of learning materials. Teachers, universities, or libraries can act as providers, whereas learners generally are consumers. If the market is open, prices for own students can e.g. be lower than prices for external consumers. For this purpose, the function that delivers the file for sale must be protected and licenses for accessing this delivery sold.

- **Courses with Costs**: In case there are more learners interested in a course than it can take, e.g. because only a restricted amount of teaching assistants is available, a limitation and selection of participants is necessary. This selection can be accomplished by market mechanisms, e.g. by involving an auction. Those who are interested in participating can make bids during a specified period. At the end of this period, the highest bids are accepted and the associated bidders may participate in the course. On the one hand, involving dynamic pricing allows a maximization of profits and better revenue generation. On the other hand, both the consumers willingness to pay and the current market value of a course can be determined.

- **Performance-related Payment**: Educational institutions consider the payment of teachers based on an achieved learning success. In this case, involved money

does not necessarily come from learners, but from the employing institution as payment of salary. In order to determine the amount of successful students, a university e.g. can make a final exam at the end of each semester. On this base, it can estimate an individual payment or decide about a bonus payment.

- **Refunding Tuition Fees**: Organizational units can use market mechanisms in order to increase a learner's incentive. Until now, these mechanisms are only used for punishment, e.g. with tuition fees in case of long-term students. Contrary to this, universities can award the learning success of their students, e.g. by refunding tuition fees that had to be paid in order to participate in certain courses. The amount of refunding can e.g. depend on an individual learning success or a learner's behavior during the course.

Currently, the University of Oldenburg operates the server based open source LMS Stud.IP version 1.3 [4]. This LMS is implemented in the programming language PHP [5]. As a proof of concept, this LMS was used to realize and test the presented approach. Moreover, it was used to try out different scenarios with a running system involved. Further extensions or changes of the original system are already part of the system's extension and therefore connected to the same rights management and transaction control. The following section describes related approaches to this work.

6. RELATED WORK

Related approaches can be identified in the area of DRM, rights description languages, specification standards, business cases for e-learning, as well as in the scope of LMS extensions. Differences between these approaches and the presented one are outlined briefly in the following.

- **DRM Technologies**: Protect digital products and facilitate the specification of preconditions like users or circumstances to access these products [11]. In case there exists a corresponding license, an operational environment like a player allows accessing concrete contents. DRM systems are based on digital products in particular, but do not regard digital services, generally. Therefore, they can only be integrated partially into TEL, e.g. when users access content.
- **Rights Specifications**: Different languages provide a standardized structure for specifying rights [12]. The eXtensible rights Markup Language (XrML) is an example [6]. These languages concentrate on protecting digital products, but neglect the protection of digital services, generally [25]. Furthermore, XrML is very complex and therefore not very concise. Because no automated accomplishment of financial transactions is considered, an extension would be inevitable.
- **Transaction Specifications**: Different specifications support defining financial transactions. Interactive Financial Exchange (IFX) [7] and Open Financial Exchange (OFX) [8] e.g. support and simplify billing procedures. However, they are not conditional, have another application domain, and support exchanging banking data and services in particular.
- **Business Cases**: An analysis of costs and benefits in e-learning is done e.g. by [30], [31] or [17]. The development of TEL business models can be found in e.g. [16] or [19]. Examples for involving business processes are described by [21] or [15]. Apart from superordinate approaches like subsidization, an instrument is missing that allows realizing and testing these models, e.g. by integrating them into existing LMS.
- **Payment and Pricing in LMS**: In order to sell digital learning contents, [23] integrates payment functionality in LMS. The delivery of chargeable files is connected to external payment systems and access only granted, if a user pays for this file. [14] extends meta data of learning units with pricing information. This facilitates a determination of prices of complex and compound units. In both cases, internal clearing is not necessary. Therefore, they are not common enough to automate financial transactions and can only be used to realize low level business models in TEL.

Until now, the scientific community did not concentrate on specifying and implementing organizational rules in TEL. The following section summarizes essential elements and considerations of this work and mentions further prospects.

7. CONCLUSION

On the one hand, different TEL applications support various activities during education, e.g. exam management, course scheduling, or authentication. On the other hand, more and more rules are accruing, e.g. from conditions of study or educational regulations. Until now, an organizational unit has no chance to model, specify, and integrate own rules in already established applications. An aggravating factor is that involved software systems are developed with various programming languages and deployed on different platforms. However, implementing organizational rules is necessary to abide by organizational regulations, obtain sustainable learning results, and limit incurring expenses.

Topic of this paper was the research question, how to combine concepts of e-commerce and TEL expediently. The answer is to implement organizational rules with help of TEL applications. It identifies digital services as a base for implementation, protects them from unauthorized access, and combines them with an accomplishment of financial transactions. In order to involve well-known concepts, elements of e-commerce are mapped on concepts of TEL. A database schema was designed that allows specifying organizational rules. Thereupon, a framework was developed that ensures compliance with them. Finally, an integration methodology allows involving different applications, independently from their programming language or an underlying platform.

LMS are widely accepted as central technology in TEL, because they serve as platform for integrating other applications. In case the presented concept is applied to a LMS, different scenarios can be specified. The extended LMS can be used as a testing environment for realizing different settings. Thereupon, an examination of the consumers' satisfaction is possible and a base for further empirical investigation.

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