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Flexible Provisioning Adult Learners

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Abstract: In adult education there is a continuous, growing demand for learning opportunities that fit the specific characteristics and preferences of particular learner groups or individual learners. This requires educational institutions to rethink their business and educational models, and develop more flexible online course solutions using ICT. An important downside of this trend is an increasingly complex logistic process that is very difficult to manage, in particular with respect to the provisioning process: which teaching and learning services and facilities should be made available, to whom, when, and how. Rather than implementing provisioning rules directly in the software applications that make up the online delivery environment, we propose a model for an educational provisioning system (EPS) that allows for highly flexible provisioning and reduces the workload drastically. This system is responsible for both expressing and processing provisioning rules that meet the demands of new (online) course models. It supports the use of so-called course access levels that enable to address and provision various learning target groups separately by means of a single course. For reasons of efficiency we suggest an architecture in which the EPS is loosely coupled to the applications in the teaching and learning environment. A first EPS implementation at the Open University of the Netherlands is presented and discussed.

Keywords: Educational Provisioning, Adult Learners, Online Courses, e-Learning, Flexible Delivery, Technology Enhanced Learning
Categories: L.2.0, L.2.2, L.3.0, L.3.5

1 Introduction

Adult learners constitute a rather heterogeneous group with a wide range of learning ambitions, prior knowledge, learning preferences and personal circumstances [Cercone 08]; [Merriam et al. 12]. The societal trend towards increased individualization [Longworth 03] challenges educational institutions more and more to create tailored, personalized learning offerings. However, stepping away from one-

size-fits-all solutions and trying to cater for the demands of particular learner groups (segmented personalization [Martinez 13]) or even individual learners, requires logistic processes that are very difficult to manage and will affect the provisioning process in particular. Provisioning is derived from the verb 'to provide' and refers in general to making something available (http://searchsoa.techtarget.com/definition/provisioning). Within an educational setting, provisioning can be broadly defined as the process of supplying teaching and learning services and facilities to participants (e.g. learners, tutors, and peers) involved in the learning and teaching process. Services and facilities can be physical or digital, and may relate to different educational processes. We distinguish as main educational processes:

1. Primary processes, concerned with designing, developing, running and evaluating courses[1] and programs. These processes include all services and facilities directly related to the activities of learners and teachers in the context of a course or a program, e.g. course management services, content creation services, assessment services, and communication services.
2. Secondary processes, dealing with processes that are *conditional* or *supportive* to the activities in primary processes, which do not directly affect the primary processes of designing, developing, running and evaluating courses and programs. Examples of such services are planning services, intake services or progress monitoring services.
3. Tertiary processes, including all processes that are conditional or necessary, but not directly related to (supporting) teaching and learning, such as authorization and authentication services, subscription and registration services, or payment services, including voucher and credits services.

In distance education, the shift towards online education opens up new opportunities for personalized provisioning to groups or individual learners. This requires that we replace models, systems and buildings for 'stock' management with (new) solutions for provisioning and access management [Vogten and Koper 14]. Rather than selling and sending learning materials, *online provisioning* means granting access to online teaching and learning services, and involves all three processes identified above. For regular educational institutions that are moving towards blended learning and open educational resources, a similar challenge exists: how to manage the logistic complexity related to flexible (online) provisioning.

From an institutional point of view, it is not hard to imagine that an increasing level of flexibility will result in a very complex access control management of the learning and teaching infrastructure. Provisioning and access management are not restricted to granting access, but also deal with revocation of access, as course registrations may have a limited period. It is not always that clear which services should be revoked when a course expires while a user still has other active registrations. Even with a fairly limited amount of users, managing access to all online resources manually would be impossible. Furthermore, we may expect that business models will change over time and with it the rules that determine online access to learning resources, as will be illustrated in [section 2], where we will

[1] 'Course' may have different meanings. In our case, a course is a unit of education with an average load of 120 hours of study, and is completed with a preliminary exam. A course can be part of a program (e.g. a BSc or MSc), but can also be completed separately.

introduce the case of the Open University of the Netherlands. This leads us to the central question this article tries to answer: can we design a system that suits flexible, online provisioning and management of the underlying business rules?

The approach described in this article in brief enables faculties:

- to identify *course access levels*, i.e. to label parts of courses according to their suitability for various target groups; the particular learning design of each of these course access levels depends on teachers' and faculties' pedagogical choices [Hermans et al. in press];
- to easily define combinations of course access levels, along with services transcending a single course, to be provisioned to various target groups (primary & secondary process);
- to apply a sustainable way to handle the multiple combinations of services, facilities and target groups in a context of swift changes (with respect to infrastructure and/or policies).

As such, this research is not so much focused on providing teachers with a means to make their learning designs interoperable [e.g. Prieto et al. 13], but rather on enabling faculties and institutions a way to flexibly provision for different learning target groups by means of a rule-based access management system, called Educational Provisioning System (EPS).

Online provisioning is related to general IT concepts as identity management (IdM) or identy and access management (IAM), which deal with enterprise-wide managing online identities, authentication, authorization in support of access management. Related specifications in this respect are XACML [OASIS 13] and SPML [OASIS 14]. Although these specifications are potentially useful for the technical implementation of educational provisioning, they are too extensive, very technical in their nature and have no specific focus on the educational context, in particular the situation where provisioning information should be managed by non-technical faculty staff. They rather operate at enterprise level, affecting the organisation as a whole.

Rather than implementing provisioning rules directly in an online learning system, we propose a separate educational provisioning system (EPS) that allows for managing provisioning rules independent of the learning application(s) in use. We propose various adapters that will translate the outcomes of these rules into the appropriate access control settings on the various learning systems. This approach has various advantages:

- *Reliability*: there is no need for any manual configuration of the learning system. All configuration is handled by the provisioning system. This applies for both granting and revocation of access rights.
- *Efficiency*: policy changes at institutional or faculty level can be simply implemented by redefining the provisioning rules in the EPS. There is no need for any additional software changes.
- *Traceability*: the existence of explicit rules provides a reasoning mechanism making it possible to explain why users have access to certain resources.
- *Flexibility*: additional provisioning configurations, for instance for different types of users, can be added easily.

To provide a more specific understanding of typical provisioning issues at stake, we present in [section 2] the case of the Open University of the Netherlands (OUNL). From this case we derive the requirements for an EPS that suits online provisioning, and subsequently draw up an EPS model that allows us to express the required provisioning rules. Besides, we provide an architecture that positions the EPS in the broader context of online delivery systems. A first implementation of the proposed model will be presented in the following section. We will conclude with a discussion of our results.

2 A case of flexible provisioning

Below we outline how the OUNL, a distance teaching university, has addressed the issue of flexible provisioning and the logistic complexities it involves. We highlight a new course model that imposes typical demands with respect to provisioning rules.

2.1 Course access levels

The Open University of the Netherlands (OUNL) is a distance teaching university, offering open higher distance education. In the last decade, strategic discussions about the position of the OUNL in the landscape of higher education in the Netherlands led to redefine as OUNL's primary role to provide academic lifelong learning: to offer adult learners facilities to attain a bachelor or master degree in any phase of their lives and to keep up to date with their professions or disciplines of interest [Koper 14). This ambition led to a new business model, in which the population of learners was divided into different learner target groups, each to be served with tailored offerings. In support of the business model, a new course authoring approach was developed [Hermans et al. in press]. Key in this approach was to develop online courses that can be flexibly delivered to different learner groups, by dividing single courses into layers or *course access levels* (CALs). CALs are tailored to particular learning target groups by varying access to learning activities, resources, and services. To facilitate the authoring process, each course access level was represented by a different colour that addresses a different learner target learner group. [Figure 1] depicts the default set of CALs we used for an MSc course, along with the corresponding learner target groups.

Stepping up the hierarchy of course layers, from explorers (lowest level) to regular degree students (highest level), each layer extends the lower layer with learning activities, resources and/or services, tailored to the learning use case of the particular target group. For example self-directed learners who want to keep track with new developments within their domain, receive 'blue' course access, meaning that they can access all course resources relevant to their domain, and are supplied with personal tools for managing their progress and learning results. Regular students, on the other hand, receive 'green' access, meaning that they obtain tutor guidance and that they are allowed to take course exams. For the sake of clarity, the definition of the learning activities, services, and resources to be offered at any level depends on choices at faculty and/or teacher level.

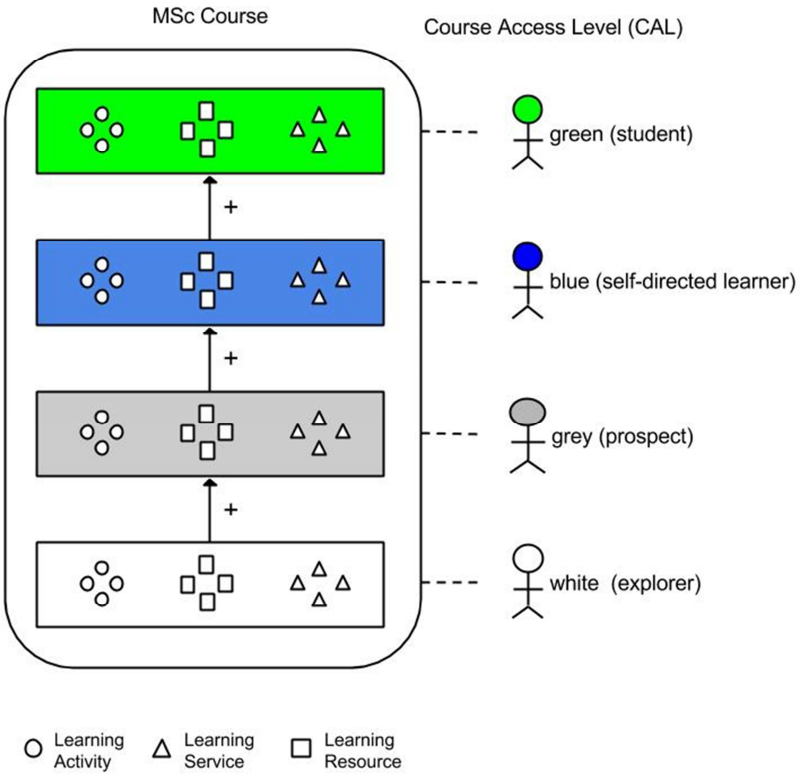

Figure 1: Course access levels MSc course

2.2 New course formats

As part of implementing the new business model, new educational formats for continuous professional development (CPD; see [Rubens and Hoogveld 12]), like *learning tracks* and *online masterclasses*[2], were developed. The learning track provides a good illustration of new demands to online provisioning. A learning track aims at supporting the learning needs of the self-directed ('blue') adult learner. It is a Netflix like subscription system, offering access to all 'blue' MSc courses and all online masterclasses within a domain. The business rules are reflected in the provisioning strategy. Once subscribed to the learning track, learners first of all get access to a course site that provides more information about the learning track. Furthermore, learners must be able to create their own personalized learning paths [Janssen et al. 11]. To this end, they are entitled to freely register for the 'blue' courses of their choice. Along with their subscriptions, learning track users receive access to personal tools for managing their learning processes, such as a course

[2] An online masterclass is a video-based educational format, through which experts and audience discuss trending research topics.

registration tool, a blog and a showcase tool. Together, these kinds of tools make up what can be conceived as a learner's personal learning environment (PLE; see [Attwell 07]; [Hermans et al. 14]). Embedded in an institutional context, Casquero et al. [Casquero et al. 10] characterize this as an institutionalized personal learning environment or iPLE. A final characteristic of the learning track model is that users receive an amount of credit points, which they can exchange in the learning system to gain access to paid services like online masterclasses and conferences.

Both the examples of CALs and the learning track illustrate that in online education target group differentiation and new educational formats require different models for provisioning of learning and teaching services. Next, these requirements will be discussed more in detail.

3 Requirements

This section describes the requirements regarding the kind of provisioning rules the EPS should be able to process. To this end we return to the learning track example (see [section 2]) that allows us to provide the following user scenario that illustrates how a provisioning process may unfold.

"Lily is a primary school teacher who wants to stay up-to-date in the field of learning technologies. To realize her ambition she has signed up for the OUNL's learning system, as she intends to attend (free) online masterclasses. As a registered user she is provided with a dashboard for managing her learning process, a user profile service she can use to create a personal network, and a blog in her personal workspace (T0). She starts with registering for an online masterclass in the area of mobile learning. This registration also gives her access to a website containing state-of-the-art information and resources on the topic of mobile learning (T1).

As a next step, Lily subscribes for the learning track `Learning and teaching in the 21th century'. This involves a one year subscription at a monthly fee, entitling 'blue' access to all MSc courses and including vouchers with credits to sign up for six (paid) online masterclasses. After registration (T2) she now has access to the learning track site. Her registration also gives her membership of a portal providing trends and state-of-the-art research information in the Learning Sciences domain.

In addition, Lily's personal workspace has been extended in two ways. Along with her registration, she has received credits that she can exchange in the learning system to gain access to other courses. Second, she is provided with tools for document management, knowledge sharing, and creating portfolios she will need or may find useful to support her learning track. The portfolio tool, for instance, she will need to draw a report of conducted formal and informal learning activities in the learning track accreditation process.

As a consequence of her learning track registration the personalized course catalogue has been extended with a large amount of 'blue' MSc courses Lily can freely register for. Lily decides to start with the course 'Digital Media and Learning' (T3). By clicking the auto-registration button she gets instant access to this course."

In this user scenario we encounter three kinds of rules that are relevant in the context of educational provisioning:

- *access rules*, specifying which course(s) a learner should have access to, and at which access level, such as 'green' access in the learning track example.
- *entitlement rules*, stating which course(s) a learner is entitled to register for as a result of a particular course registration. In our example the learning track registration entitles a user to (freely) register for a considerable number of 'blue' MSc courses. This type of rule makes it possible to create a fully personalized course catalogue.
- *facility rules*, granting the learner facilities like resources, (personal) tools, or credits.

[Table 1] shows an overview of how the provisioning 'profile' of the user in our example develops over time after various course registrations. Starting with basic tool access upon platform registration the provisioning profile develops into a more and more comprehensive configuration.

Registration	**Access**	**Entitlements[3]**	**Facilities**
T0: platform registration	--	--	• dashboard tool • profile tool • blog tool
T1: online master-class registration	online masterclass ('green' access)	--	• topic community[4] • domain portal
T2: learning track registration	learning track ('green' access)	• all 'blue' MSc courses • all 'topic' communities • all 'archived' online masterclasses	• credits • domain portal • document management tool • knowledge sharing tool • portfolio tool
T3: MSc course registration	MSc course ('blue' access)	--	--

Table 1: Example of provisioning 'profile' development

[3] Entitlements are granted permissions to register for a course or course access level.
[4] Topic communities are research communities, integrated in the learning environment in order to make specific research areas accessible to a wider public.

With this elaborated example in mind we state the following requirements for the EPS:

R1 The EPS must support the creation of one or more CALs for an online course.

R2 The EPS must be able to express provisioning rules for each CAL. The following type of rules must be supported:

R2.1 *Course access rules*: a course access rule specifies the course(s) that must be assigned to a user in the teaching and learning infrastructure, depending on the user's course registration status.

R2.2 *Registration entitlement rules*: this kind of rule expresses that 'registration for course 1 entitles a user to register for course [2..n]'. These kinds of rules allow for conditional, personalized offerings that can be used as part of an educational format such as the Learning Track in our example.

R2.3 *Facility rules*: this kind of rule is to be used for supplying users with facilities. We use the term facilities as an umbrella term for artefacts in the learning system, which may be of a different nature. In our example, facilities relate to tools like the PLE services, resources such as the domain portal, or value tokens such as credit points.

R3 The EPS must be able to process provisioning rules as stated in requirement R2 when either a registration status of a user changes or the provisioning configuration of the CAL has been altered.

For the purpose of efficiency, and considering the design principle of 'separation of concerns' (e.g. [Greer 08]; [Tarr et al. 99]) we stated as an additional, more general requirement:

R4 The EPS must be agnostic with respect to particular applications that are in use for (1) teaching and learning, and (2) user and course administration, in order to make it robust to changes in the application landscape.

4 EPS model

In this section we will first introduce the EPS model for expressing provisioning rules, based on the first three requirements of the prior section. Subsequently we present an architecture that positions the EPS in relation to other systems involved in the provisioning process.

[Figure 2] shows the EPS's conceptual model expressed in a UML class diagram [Object Management Group 14]. A *course* is a complete, self-contained unit of education. It can manifest itself in various configurations, called *course access levels* (CALs; see [section 2]), based on pedagogical choices regarding the learning needs of a particular learner target group.

For each CAL, one or more *provisioning rules* can be defined. These rules involve formalized, conditional business rules, describing the type of grants to be provided to the participants within the online teaching and learning environment, depending on their *registration status*. These business rules are based on policies, usually stated at faculty or institutional level.

A provisioning rule is associated with a user´s course registration status and expresses the provisioning action to be executed based on that particular status. Possible registration statuses are 'waiting', 'registered', 'expired' or 'cancelled'. A user may have multiple registration statuses for a CAL, as CALs can be associated with different educational formats. A user obtains a registration status when, for example, he or she is enrolled in a course. This status changes when a course registration expires. These kinds of state changes are triggers for reapplying the provisioning rules for that user. This may result in additional changes in a user's registration statuses, which will trigger again the processing of provisioning rules.

Following requirement R2 from [section 3], we distinguish three action types: *course access action*, e*ntitlement action*, and s*upply action*. Both course access actions and entitlement actions relate to a CAL a user should be registered for, whereas supply actions address the facilities to be provisioned, such as resources, tools or learning objects.

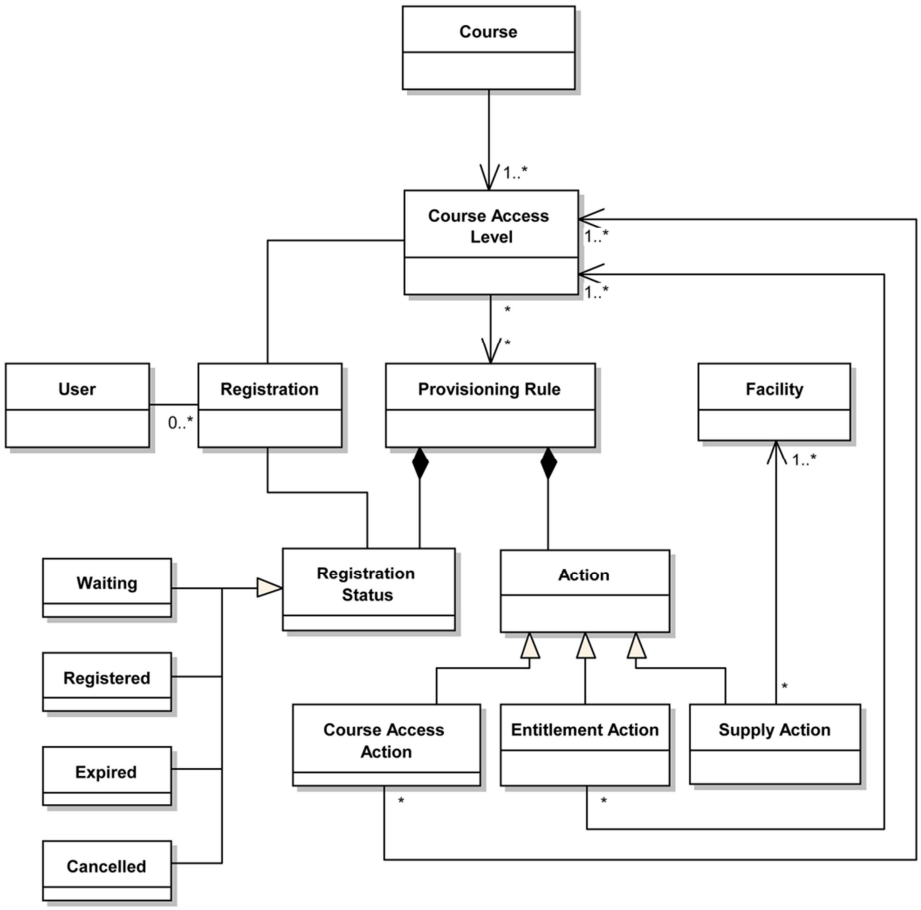

Figure 2: EPS conceptual model

4.1 Architecture

As a final requirement (R4) we stated that the EPS must be able to operate agnostic to the particular application(s) an institution has in use for teaching and learning, as well as for user and course administration. This requirement demands an application architecture in which the EPS is loosely coupled with other systems involved in the provisioning process. This implies for the EPS on the one hand that it must be able to import user registrations and course information, and on the other hand that it must be able to expose resulting user provisioning information (registrations, entitlements and facilities) that can be implemented by teaching and learning applications.

[Figure 3] proposes an architecture, expressed in an UML component diagram ([Fowler 04]; [Object Management Group 14]), that meets the particular requirement. It shows a high-level structure of the EPS, its main components and their dependencies.

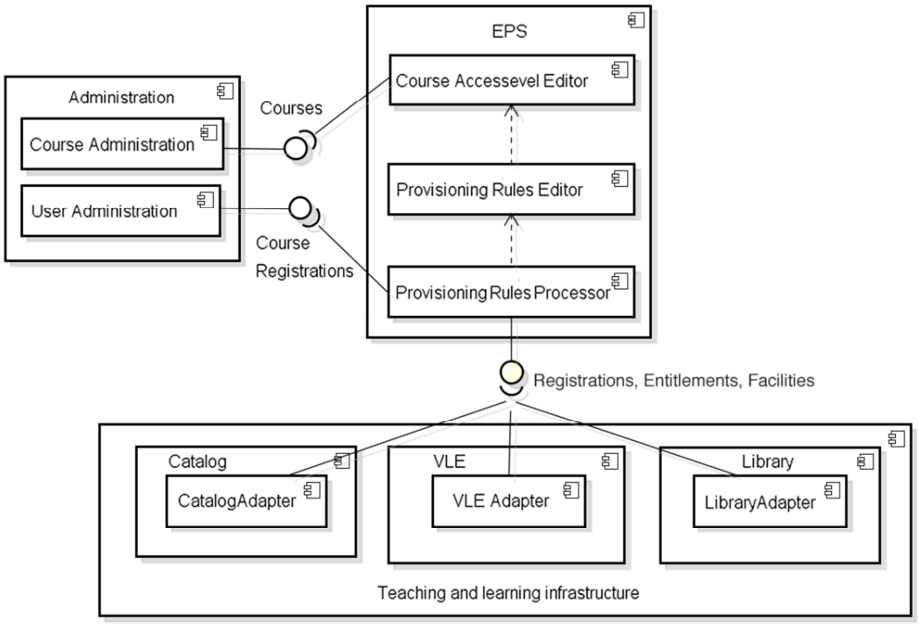

Figure 3: EPS architecture

The architecture takes the EPS as a central component, responsible for expressing as well as processing provisioning rules. The EPS expects course information (*course list*) as well as user registrations (*course registrations*) as input for both these two tasks. This information is expected to be available through interfaces (depicted as lollipops) of the administrative systems that are in use.

The EPS itself is broken down into several other components, each addressing a separate concern. For example the EPS top component in the diagram is the *course accesslevel editor,* an application component that is needed to identify CALs for a

particular course in order to assign provisioning rules and list a CAL for example in a catalog.

The EPS *provisioning rules processor* is a service provider, to be triggered by each change in either a user's registration status or a CAL's provisioning rules. It calculates and exposes user provisioning information (*registrations, entitlements and facilities*) through a high level interface that can be called by applications in the teaching and learning environment. In order to *translate* and *implement* this high level provisioning information, application specific *adapters* are required. These adapters are expected to have sufficient access to the underlying teaching and learning applications, e.g. through available APIs. Applications lacking an API should thus be extended in order to provide the required level of access.

In order to develop adapters, it requires knowledge of how the targeted applications are expected to facilitate provisioning in terms of providing access to their services. This knowledge should be implemented a set of adapter configuration options that can be applied for the various CALs. Hence, an adapter should provide a user interface to enter these configuration options.

5 Implementation

A first version of the EPS was realized as part of OUNL's integrated learning system OpenU [Vogten and Koper 14). The Scrum software development approach [Schwaber 07] was used for an iterative development of the system. As the number of students was growing steadily, we were faced at an early stage with a manual and error-prone application management, as configuring access permissions in the learning system was done manually. We recognized the need to develop an automated provisioning solution instead and out of this need the EPS was developed in several iterations. Because the initial development was focussed on solving our immediate problems, it did not start as a separate layer outside the teaching and learning infrastructure as proposed in the architecture above. However, we were able to develop a solution that conceptually and technically meets the proposed provisioning system and with some effort it is possible to create a stand-alone version of this EPS that will run e.g. in a separate Tomcat application container [The Apache Software Foundation 14].

Below, we will first provide some details about the implementation platform and implementation context. The user story introduced in [section 3] will be used to illustrate the working of the EPS.

5.1 Platform

The EPS was developed by a team of OUNL ICT specialists as an application within Liferay Portal EE [Liferay 14], an open source java-based platform. By default, the platform provides each registered user with a personal workspace that we used to implement a personal learning environment. The platform's fine-grained permissions system allows for detailed personalization and developing flexible courses as highlighted in [section 2]. As each PLE tool could be addressed separately, this allowed for flexible delivery. The platform's community entity was used for the delivery of online courses. A community is technically speaking a container, holding

groups of pages that expose services through portlets: configurable user interface components that can be dropped and arranged on a webpage.

In order to translate and apply EPS provisioning information in the portal's formal learning environment and the course catalog (see [Figure 4]), adapters were built. Along with these adapters we developed tools to monitor proper processing of provisioning information. Manual access configuration of components was still possible, whereas the adapter guarded the proper permissions to be granted through the EPS, so no conflicts occurred when restoring permissions.

5.2 Implementation context

The EPS was deployed within the subject area of Learning Sciences and Technologies. In the e-learning system a total of 26 MSc courses were redesigned to meet the demands of the layered course model . New course models serving lifelong learning involved online masterclasses, MOOCs and Learning Tracks. For each of these course models a default set of CALs was defined and applied for their course instances using the EPS. [Table 2] shows as an example an overview of CAL type's used for MSc courses.

CAL	Target group	Access level	Delivery
OER[5] version	interested users	white	public access
Free version	interested, registered users	grey	self-service
Read only version	learning track subscribers, MSc students	blue	self-service, only for entitled users
Full version	MSc students	green	automatically after payment

Table 2: Overview of CALs for MSc courses

Design documents of all course models, developed by project teams at faculty level, were analysed for the presence of provisioning statements. These statements were transformed into provisioning rules for each possible registration status, which were subsequently presented to and approved by the faculty. Subsequently, for each CAL the appropriate provisioning rules were assigned in the EPS.

[Figure 4] shows the major parts of the e-learning system provisioned by the EPS was deployed: (1) a personal workspace or PLE, (2) a formal learning space for taking courses, learning tracks or online masterclasses and (3) a web shop containing a (personalized) catalogue that lists all CALs a particular user is entitled to register for. Through a web service interface the EPS listens to changes in course registrations

[5] Open Educational Resource

from the administration system (not drawn) and calculates the proper user provisioning information.

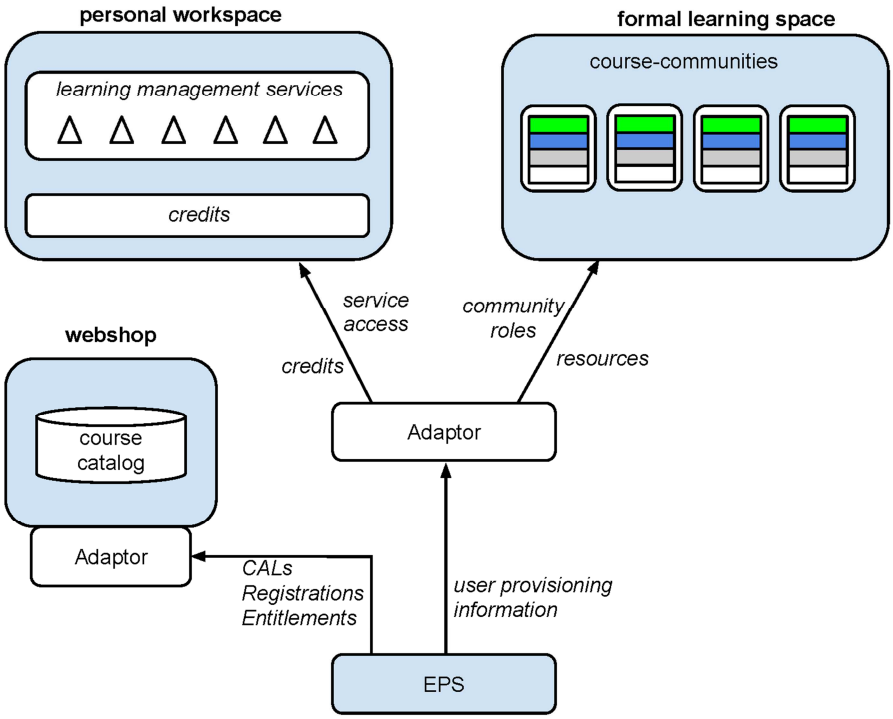

Figure 4: OUNL EPS implementation

5.3 Example

Lily's user scenario in [section 3] showed an elaborated example of how a user provisioning profile may evolve over time. Transition T1 to T2 in [Table 1] marks her registration for the learning track. [Figure 5] shows a screenshot of how Lily's grants at timestamp T1 affect the configuration of the learning system. Top left of the screen her personal workspace is available, providing access to learning management tools (facilities) assigned by the EPS to each person who registers at the platform (T0).

The dashboard tool at the centre of the screen displays three tiles as a result of registering for an online Masterclass. The EPS facility rules for this online Masterclass state that besides full registration for this course, the status 'registered' also gives access to the topic site 'Mobile Learning', as there is a substantive relationship between both, as well as the portal Learning Sciences.

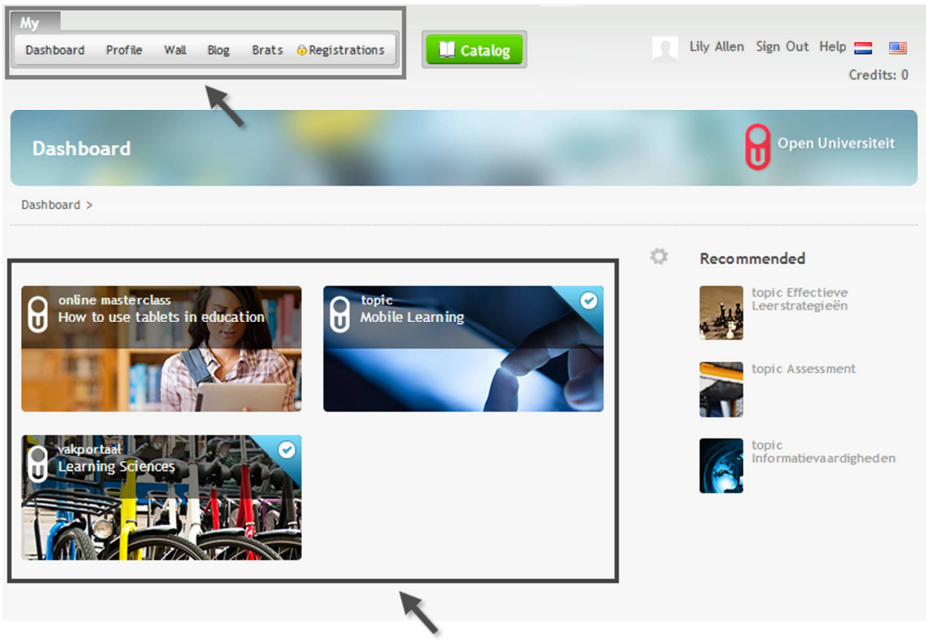

Figure 5: Learning system configuration at T1

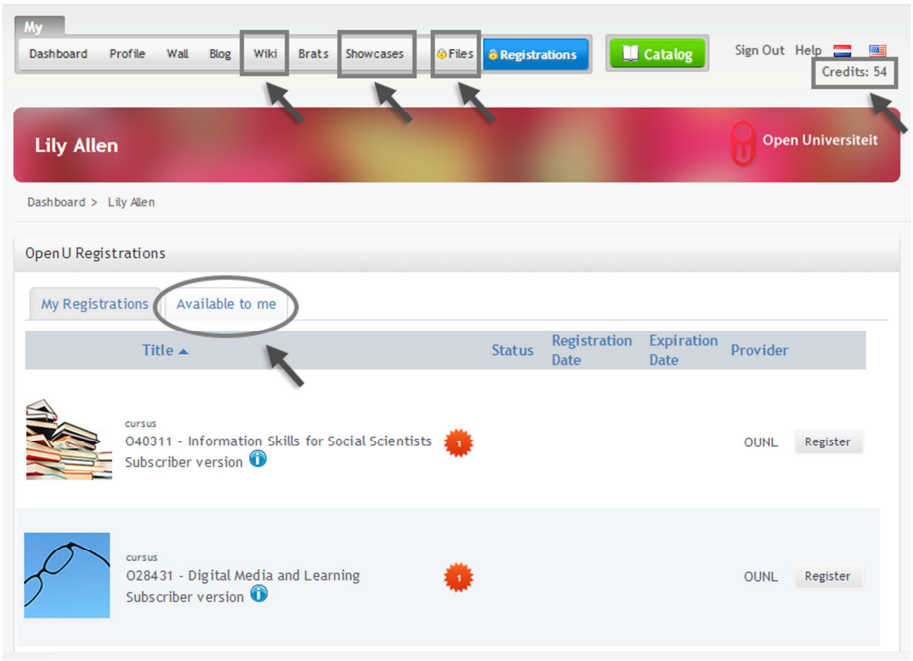

Figure 6: Learning system configuration at T2

From the moment Lily is registered for learning track (T2), the EPS extends her grants with (1) a learning track course registration, (2) an extensive collection of entitlements (which is a key feature of the learning track subscription model), (3) personal tools and credits for buying access to online masterclasses (see [Table 1]). [Figure 6] highlights the impact of these grants on Lily's learning environment. Tools in her personal workspace are extended with a wiki and file management tool. The top right part of the screen shows an amount of 54 credits for buying online Masterclass access. The central part of screen shows the list of entitlements ('blue' courses) she can (un)register for automatically on a self-service base.

6 Conclusions and discussion

In this article we have argued that for flexible and efficient provisioning for different groups of adult learners, we need a new type of system called Educational Provisioning System (EPS). An EPS allows for both managing and processing provisioning rules in order to meet the demands of new online educational formats. It supports the use of so-called course access levels (CALs), through which particular learning target groups can be addressed and provisioned separately. Provisioning rules are formalized business rules, derived from faculty and/or institutional policy, stating which services and facilities are to be provided or revoked to a learner through the software applications that are in use in the teaching and learning infrastructure. To ensure robustness with respect to changes in the application environment as well changes in the provisioning rules, we have proposed an architecture that separates the business provisioning logic from the applications that implement this logic. Besides an EPS, this architecture requires the development of adapters that translate and apply high level EPS provisioning information into the particular access permissions of the underlying applications. Adapters are expected to have access to the underlying applications for teaching and learning, e.g. through available APIs. Applications lacking this access should thus be extended in order to be used within this architecture.

A first EPS implementation was realized against the background of the development of a new e-learning infrastructure at the OUNL. Through this implementation we have been able to provision different learner target groups separately with tailored services and facilities. Moreover, this implementation allowed us to develop and run new educational formats such as the Learning Track, which requires the presence of typical entitlement rules, as supported by the EPS. For a future release of the OUNL EPS, from an architectural perspective, we are planning to migrate the EPS, currently implemented as a Liferay portal application, to a stand-alone application.

The EPS implementation proved to be an efficient solution with respect to managing and processing of provisioning rules. All provisioning rules concerned can be managed in one system, without having to worry about application specific access control, which is taken care of by the application adapter. The EPS helps to tackle the complexity of provisioning, though it can be improved in particular with respect to visualizing provisioning rules in such a way that they are better traceable by humans.

Though the examples and implementation presented in this article are restricted to web based delivery and provisioning, the proposed model and architecture are fully

neutral with respect to delivery channels or devices used. The EPS provides a generic solution for flexible and efficient provisioning and as such may be expected to suit mobile delivery scenarios as well.

Finally, throughout this article we showed how the EPS provides rule-based access to courses or course access levels, using push and pull mechanisms (respectively by course access rules and). Currently these rules reflect the business model of the faculty. However, usage patterns, especially of the services provided through the pull mechanism, might be used to inform future definitions of business rules. In this respect we have only begun to explore the potential use of the EPS, moving from a system that encapsulates business policies towards a system that is capable of suggesting new policies.

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