A widget-based dashboard approach for awareness and reflection in online learning communities based on Artefact-Actor-Networks

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Abstract
The rapid changes to technology and society in the last decade not only reshaped the way people communicate and collaborate; they also fundamentally altered individual learning behaviour and organizational learning offerings. Lifelong and workplace learning are in the focus of many projects and it becomes more and more obvious that learning environments have to focus on the individual learner and be both adaptable and personal. Learners are evermore escaping the boundaries of controlled, heads-on institutional learning and are consuming learning content from uncountable and uncontrollable sources. This perpetual learning in both formal and informal settings, in online and offline discussions, large networked communities as well as small local teams, form the need for a Personal Learning Environment (PLE). PLEs support the learner's individual learning style, providing an open and adaptable framework for the aggregation of learning content from different sources. They encourage networking with learning peers, reflection about learning goals and processes as well as other relevant functions. In this paper we introduce a widget-based Rich Internet Application that focuses on supporting reflection and awareness support for learners in online learning communities. The AANalyzer tool builds upon the theoretical model of Artefact-Actor-Networks, an approach to semantically intertwine social networks with so-called artefact networks made up of objects created during the social interaction of people.

1. Introduction

The rapid changes to technology and society in the last decade not only reshaped the way people are communicating and collaborating using the Internet as an interactive medium; they also fundamentally altered individual learning behaviour. Technologies and methods commonly known as Web 2.0 (cf. O'Reilly, 2005) heavily influence our social interactions; new tools mediate our individual information seeking and learning behaviour influencing the rules of engagement.

The term Personal Learning Environment (PLE) describes the tools, communities, and services that constitute the individual educational platforms learners use to direct their own learning (Educause, 2009). Wilson (2005) expressed the user-centred philosophy of PLEs and van Harmelen (2006) argues that traditional Learning Management Systems fail to address the individual needs of today's learners or simply are not flexible enough to do so. Learners are evermore escaping the boundaries of controlled, institutional learning and are consuming learning content from uncountable and uncontrollable sources in the Social Web. This *perpetual learning* in both formal and informal settings (Cross, 2008), in online and offline discussions, large networked communities (Ellison, Steinfield and Lampe, 2007) as well as small local teams with an unfathomable amount of possible learning objects form the need for ideas like PLEs. The concept of a PLE has fundamentally changed the role of fellow learners, objects used for learning and the role of the learning network. Hence, PLEs

endow the idea of connectivist learning as Siemens and Downes propagate with their "*learning theory for the digital age"* (Siemens, 2005, Downes, 2005).

In this article we will focus on two relevant functions of PLEs, namely awareness and networking and how they can be supported with an awareness dashboard for learning communities. The awareness dashboard AANalyzer build upon the theoretical model of Artefact-Actor-Networks that combines structural information from social networks with relational data of so-called artefact networks and offers a new way of analysing co-operative work with social media.

2. Networking and reflection as two main functions of a PLE

Chatti et al. (2007) are writing about the shift from *e-learning* to *me-learning* with regards to the current changes in the educational and knowledge management ecosystem and name PLEs one of the most appropriate solution approaches to deal with today's requirements on student support. Personal Learning Environments enable learners to facilitate their individual, self-directed learning styles, using resources, tools and peers of their choice that help them during their learning endeavour. Learners use many offline and web-based tools. There is no standardised way of communicating and information is disseminated by a number of different channels.

In 2008 we identified relevant functions that should be supported by a PLE (Nelkner, Reinhardt and Attwell, 2008). Besides sharing, presenting and representing we named **reflecting** and **networking** as key functions of a PLE. Reflection is a central activity in developing learning and networked collaborative learning must be supported by any PLE approach. In order to pursue individual learning goals learners connect with numerous resources and new people. Eking, Glahn (2009) names both, awareness and reflection to be essential for learner's competence development and successful learning processes. This is especially true in unstructured and unguided learning environments such as PLEs. His effectuations go back to the theory of Schön (1983,1987) who distinguishes two types of reflection relevant to learning: *reflection-in-action* and *reflection-on-action*. The connection between action and reflection can be found in feedback from a learners network, outlining the need for continuous interaction with ones peers and more knowledgeable others (MKO)[1] (Vygotsky, 1962,1978). Reflection-on-action refers to those contemplative process starting after an action has ended and cannot be changed anymore. Contrary to these post-action considerations, reflection-in-action refers to the cognitive processes and application of individual knowledge that are needed to actively control an action. Vygotsky (1978) points out that interaction with others is crucial for an individual's mental maturity and individuality. Furthermore he stresses that one's potential mental capacity depends on the self-awareness of one's actions and the reflection of them. Full development of the Zone of Proximal Development would depend on full social interaction.

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[1] It is important to note that in Vygotsky's understanding of the Zone of Proximal Development the relation between the learner (the child) and the MKO is unbalanced: "*The MKO is anyone who has a better understanding or a higher ability level than the learner particularly in regards to a specific task, concept or process. Traditionally the MKO is thought of as a teacher [or] an older adult*" (Clabaugh, 2010) In PLEs however, the relation between learners is much more even, where peers can be more knowledgeable for one topic and the less learned in another parallel situation; the roles can even change with the different actions of solving one problem.

Siemens (2005) stresses the fact that it is more important who you know rather than what you know because individual knowledge lies in the networks. He introduced Connectivism as a new learning theory that presents learning as the social network-forming process with – personal and artificial – artefacts and people. Moreover, Polanyi (1967) emphasizes the importance of dialogues and conversations within (networked) communities – for him knowledge is socially constructed. Also Koper and Sloep (2003) point out the unique characteristic of networking in individual and organizational learning activities in learning networks.

Since Drexler mentioned the term Social Software for the first time in 1987 (Drexler, 1987) much happened in the domain. However, the hype around software that "*allow[s] individuals to communicate with one another, and to track discussions across the Web as they happen"* (Tepper, 2003) started around 2002 with Clay Shirky's Social Software Summit. Since then, both research and engineering have focused on the topic and have come up with fascinating tools, so that Internet users now spent more than half of their time on social networking sites. Computer mediated communication (CMC) with social media has become commonplace today in most sectors of today's economy and science as well as in educational environments. Digital technology and social media have accelerated the use and frequency of output of information. While many people use these developments, not many can effectively and efficiently monitor, filter, and synthesize the amount of data they are confronted with. They may not even be aware of available information that may be helpful for them during learning activities or information seeking processes. However, in many cases it is essential to know who in our personal social network is doing what, to be able to work effectively and efficiently and use the knowledge of our peers for our own purposes. This is often termed *awareness* and simply means knowing which people you are connected with, what they are doing, and how the actions of yourself or others in the group affect them. It is more than difficult to keep up with who is doing what. There is an unfathomable amount of networked information being generated almost constantly in learning communities.

3. Widget-based Rich Internet Applications for PLEs

Rich Internet Applications (RIA) are web applications that are much more interactive than we were used to with the old school "*poor ugly web applications*" (Walther, 2008) and thus allow a richer user experience. As Duhl (2003) points out, RIAs are combining the best of desktop software, the best of communications and the best of the web: "*Specifically, the best of the desktop includes providing an interactive user interface for validation and formatting, fast interface response times with no page refresh, common user interface behaviors such as drag-and-drop and the ability to work online and offline. The best of the Web includes capabilities such as instant deployment, cross-platform availability [… and …] the use of progressive download for retrieving content and data. [T]he magazine-like layout of Web pages and leveraging widely adopted Internet standards [and further advantages]. The best of communication means incorporating two-way interactive audio and video*" (Duhl, 2003, p.7). In doing so they support lightweight service oriented architectures (SOA). Often, RIAs function as mash-ups, using functions from different sources that are integrated into the own system via APIs without the need to implement the according functions once again. This fact also gave rise to the idea of PLEs. Due to the flexibility of SOAs and the great range of RIA technologies, the two concepts go hand in hand with the user-centeredness of the PLE approach. PLEs also allow the user to select and arrange the content and types of representations within the environment.

Widgets are small embeddable applications that can usually be executed within runtime containers like HTML pages or desktop environments. The W3C defines widgets as "*full-fledged client-side applications that are authored using Web standards and packaged for distribution. They are typically downloaded and installed on a client machine or device where they run as stand-alone applications, but they can also be embedded into Web pages and run in a Web browser*"[2]. Widgets can interactively respond to user actions are often used for single-purpose applications or data visualization. They are now available on all major operating systems as well in many web-based systems such as iGoogle, Netvibes or Sourceforge. The W3C is currently developing a specification for the packaging and configuration of widgets, as well as a specification for widget APIs[3], digital signatures[4] and widget URI schemes[5] showing the active developments in the domain of widgets.

Widget-based mash-ups seem to be a proper way to realise Personal Learning Environments and to foster student-centric learning activities (Nelkner, 2009, Nelkner and Reinhardt, 2009). However, they need to provide learners with more awareness about their own learning activities and dynamic changes in their learning network (Koper and Sloep, 2003) in order to enhance reflection-on-action. In the next section we introduce the model of Artefact-Actor-Networks, describe their purpose and possible usages for reflection purposes in the context of Personal Learning Environments.

4. Artefact-Actor-Networks

Artefact-Actor-Networks (AANs) are an approach to semantically intertwine social networks with so-called artefact networks. The theoretical model and a first implementation were first introduced by Reinhardt, Moi and Varlemann (2009). They state that "*Artefact-Actor-Networks allow making claims about the ties between artefacts from multiple sources and the actors involved in their creation, modification and linkage*". They further explain, "*Social networks represent social structures by means of ties between nodes. These nodes correspond to actors, like persons or other individuals. Individuals as actors from different types can be commingled into heterogeneous networks. Edges in a social network can be seen as a special type of association or dependence between nodes respectively actors. Social networks spring up if people communicate, work or share data between each other. […] If the nodes in such a network are no longer individuals or groups, but artefacts such as pictures, blog entries, videos or wiki articles, we call these networks artefact networks. [...] Edges between these artefacts represent the type of connection or common contents of the artefacts. Artefact networks try to make statements about how artefacts are linked and used. If two artefacts are related, it seems that there exists a semantic relation between them. It applies to make them machine readable and evaluable.*"

In the following sections we take a deeper look at the semantically relations in AANs and give a brief overview about the implementation and interfaces of Artefact-Actor-Networks. In particular, we discuss how actors, artefacts and their relations are mod-

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[2] http://www.w3.org/TR/widgets/

[3] http://www.w3.org/TR/widgets-apis/

[4] http://dev.w3.org/2006/waf/widgets-digsig/

[5] http://dev.w3.org/2006/waf/widgets-uri/

modelled, how we obtain data from social media and finally analyse and expose the gained data to an awareness dashboard.

4.1 Types of connections in AANs

In Artefact-Actor-Networks we discern three types of relations: those between artefacts (ART^2 relations), those between actors (ACT^2 relations) and finally relations that exist between actors and artefacts (AA relations). Each kind of relation can be used for certain types of analyses and supports a different type of awareness[6] in co-operative settings. ACT^2 relations describe the nature of relationships between involved people. They characterise simple connections, friendships or kinships. Furthermore, they can show the kind of media people are communicating with. The Friend of a Friend (FOAF) project (FOAF, 2010) developed a RDF vocabulary to express interests, connections and activities of people. ART^2 relations on the other hand provide information on how artefacts are connected. The Dublin Core metadata standard and the SIOC project currently provide an expedient starting point (Dublin Core Metadata Initiative, 2010, SIOC, 2010). Lastly, AA relations describe the semantics of relations between actors and the artefacts they interacted with. Here also Dublin Core and SIOC provide useful relations to build upon, but also the learning objects metadata standard (LOM) could be taken into account.

4.2 Implementation of AANs

The backend system of Artefact-Actor-Networks was designed for future enhancements and to ensure extensibility and flexibility. We have built the whole system on top of the OSGi service platform, which allows the hot deployment of new features. The technical specifics of the backend architecture are described in detail in Reinhardt, Moi and Varlemann (2009).

During the modelling of the application domain however, we found out that we needed to extend the listed ontologies[7] and vocabularies as mentioned in 4.1 in order to cover the specifics of interaction with social media in learning networks. Thus, we created several ontologies for the social media services we are analysing (see Section 4.3) and made our ontologies publically available[8]. The relations build on already existing standards for the modelling and storage of metadata and are further extended by our application. Figure 1 shows a simplified overview of the ontologies used in Artefact-Actor-Networks, where AANBase defines the basic entities Actor, Artefact and Keyword. AANMeta is an ontology that allows the aggregation of multiple actors (online handles) in one real person and the relationship between so-called groups to real people, their actors and artefacts related to a group (for example artefacts that are tagged with one of the group's tags). AANOnline is used to dif-

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[6] For an overview of different types of awareness in software supporting co-operative work see Gutwin, Penner and Schneider (2004) and Berlage and Sohlenkamp (1999).

[7] Lohmann and Riechert (2010) note the very precise and popular definition of the term ontology given by Gruber (1993) who notes that an ontology is "*a specification of conceptualization*". Furthermore Maalej, Panagiotou and Happel (2008) prod to the fact that ontologies normally are valid for a much longer time than conceptual models for example, as they describe a broader application domain and some more general knowledge facts.

[8] http://artefact-actor-networks.net/ontologies/2010/03/

ferentiate between online actions and artefacts that relate to activities taking place offline where offline artefacts are dealt with. The more specific tools and the respective ontologies are located towards the right of Figure 1.

4.3 Integrated Social Media services

At the time of writing, Artefact-Actor-Networks are prepared for storing artefact-, actor- and relation data for the following social media tools:

- *Twitter*, the most prominent representative of so-called microblogging tools. Twitter is often used in learning settings. For example Ullrich et al. (2008) report about the use of Twitter for language learning, Costa et al. (2008) refer to the accidental use of Twitter within a community of Ph.D. students in the domain of TEL and Reinhardt et al. (2009) report about the use of Twitter for learning and sharing within the settings of conferences.
- *SlideShare* is the largest social platform for sharing and annotating presentations. Learners and researchers often use SlideShare for gathering information about latest trends in education and science (Thompson, 2008).
- *Delicious* is a social bookmarking Web-service used by a wide variety of users for storing, sharing and discovering trending bookmarks. Delicious is one of the best-known and probably most used social bookmarking services with more than 5 million users and more than 200 million unique websites bookmarked. Delicious is often used within Web-based communities of interest to share interesting Web pages and to explore the folksonomic power of tagging systems (Vuorikari, 2009).
- *Scribd* is one of the best-known document-sharing, integration and annotation services that are used by researchers, teachers and students likewise to share and discuss about recent writings and publications (Thompson, 2008).

Currently we are examining further tools that are supporting learning, information collection and knowledge exchange that will be integrated in the AAN system soon. Amongst the most probable systems and services are: blogs, instant messenger and other tools that allow the collection of learning-related materials. We are not focusing on tools like YouTube, Flickr or Vimeo as it is hard to extract useful information about the content of the there-stored artefacts.

4.4 Use of Artefact-Actor-Networks for PLEs

Artefact-Actor-Networks can be used to support PLEs with awareness and activity data from the people in a certain learning community. AANs store artefacts that result from individual or communal learning activities and the relations between them. Furthermore AANs store the specific relations of actors – they can be understood as online accounts belonging to a certain person – to the respective artefacts and finally AANs store relations between actors. The content of artefacts is then semantically analysed using a mash-up of web services that offer appropriate solutions. The results are stored within a semantic database and exposed via a standardised API. This way the relational, structural and semantic data about a learning community are open for integration and purposeful reuse within a PLE.

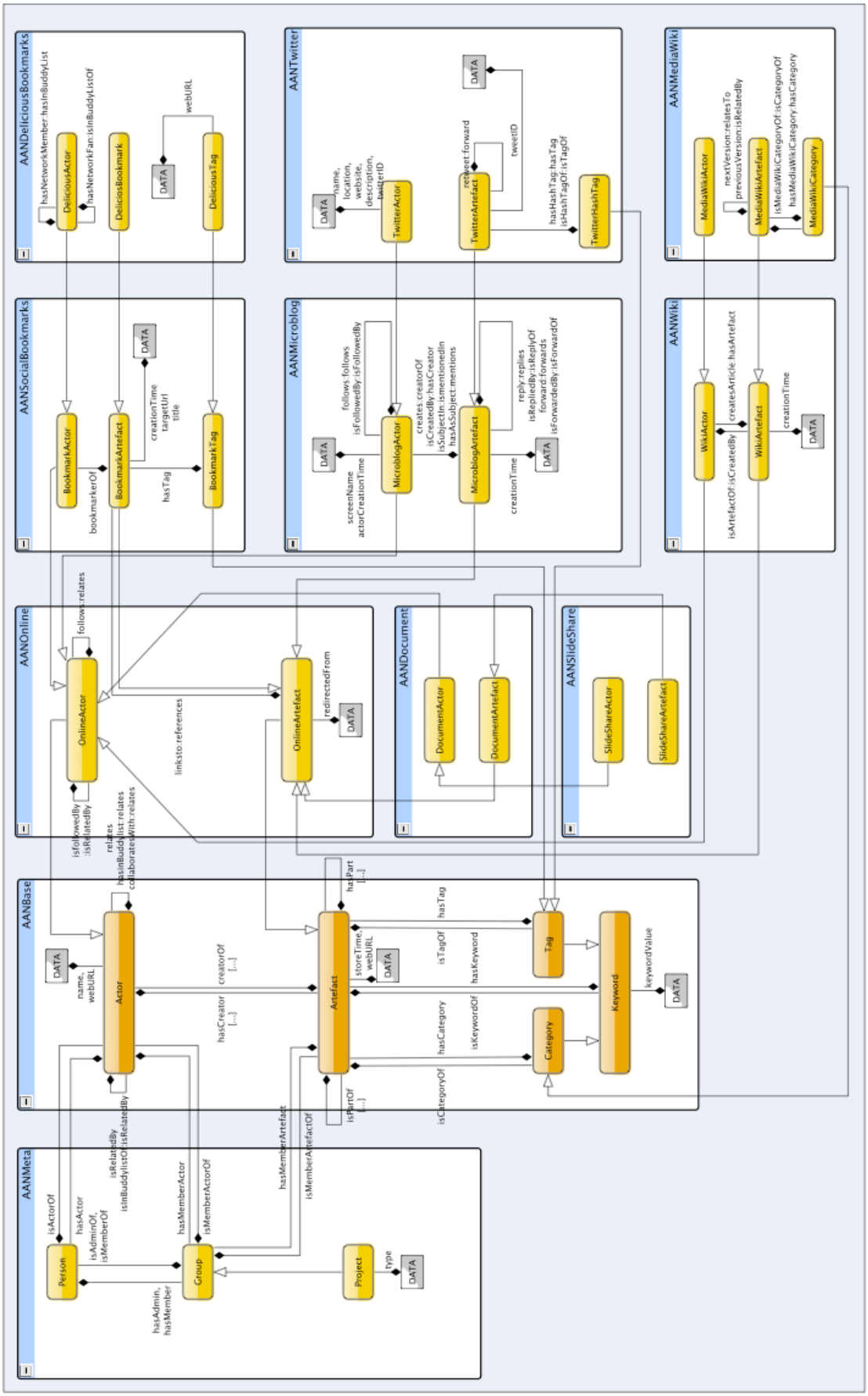

Fig 1: Simplified *Overview of the ontologies used in Artefact-Actor-Networks.*

5. The AANalyzer awareness dashboard

In this section we introduce the requirements and the implementation of the AANalyzer awareness dashboard that uses the previously introduced AAN architecture, its APIs and persistency layer. The AANalyzer awareness dashboard aims at helping people involved in a learning community (e.g. an university seminar or a conference) to re-gain awareness about who in the community is doing what, how their interactions are intertwined and what artefacts result from those interactions. By doing this, the AANalyzer attempts to support reflection-on-action of the individuals in the learning community.

5.1 Requirements

In order to handle the complexity of the stored data and the resulting relations between artefacts and actors in the AAN, we introduced a meta-layer that contains aggregators for actors and groups of actors and artefacts. A person represents a real human actor and is connected to his online actors (aka social software handles). Moreover, we introduced the concept of groups (and more specifically the concept of projects) that can aggregate multiple people and artefacts. Thus, a first requirement on the AANalyzer was to offer means for the management of groups and people. Therefore, the AANalyzer had to employ a user management and project management persistency and rights layer that allowed CRUD functions[9] for both entities as well as the joining and leaving of projects. Furthermore the AANalyzer had to forward the received information about new groups and people to the AAN backend, to store those information and to start the corresponding monitoring actions.

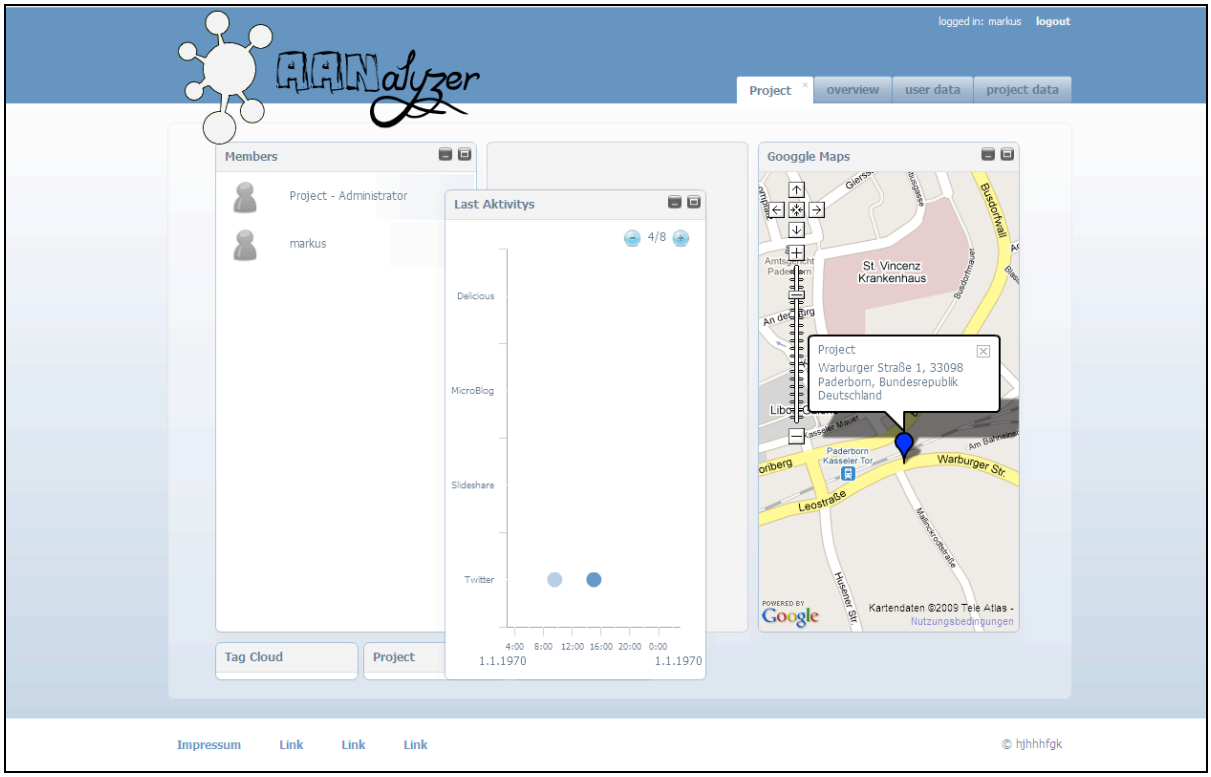

Fig 2: *Interacting with widgets in the AANalyzer awareness dashboard*

[9] Create, Read, Update and Delete (CRUD) are the basic functions of persistent storage in computer programming.

The user interface of the AANalyzer (see Figure 2) should provide the user with a Rich Internet Application that allows the custom selection of visualisation options. We decided to implement a widget-based[10] dashboard application that allows the user to individually arrange and select single-purpose mini-applications on that would best support his individual awareness and reflection needs.

5.2 Awareness widget options

In the following section we introduce available widgets within the AANalyzer that support awareness about interactions within a learning community, the objects used in the learning activities as well as their respective contents. The widgets mainly support reflection-on-action as introduced in Section 2.1. See Figure 3 for an overview of the available awareness widgets and the inter-widget communication allowing widgets to directly interact with each other.

ProjectWidget	*The ProjectWidget marks the starting point for the project-oriented analysis with the help of Artefact-Actor-Networks. It provides an overview about the data that have been specified in the project administration to a project. If a logo is stored, it is displayed next to the project start and end date and the description of the project. Those data are more informative. In case that a place is provided for one project, so it should be clickable and then appears within the GoogleMapsWidget. As important functions, the ProjectWidget contains a collection of the project's tags that ensure the relation between artefacts and the project. A click on any of the tags displays the according artefacts within the ArtefactsWidget.*
KeywordCloudWidget	*In the KeywordCloudWidget a word cloud[11] for the project is presented. It contains all keywords of all artefacts of the project and furthermore all keywords of artefacts that contain at least one project tag. The keyword cloud presents it content in an alphabetical order and highlights more commonly used keywords with increased size. This visualization gives the user an easy-to-follow classification criterion that reflects the content of the project's artefacts. Similar to the project's tags, all keywords of the KeywordCloudWidget can be used to select artefacts to be shown in the ArtefactsWidget.*
MembersWidget	*In the MembersWidget all participants of the project are*

[10] The term widget is often related to a W3C specification for a client-side application that is authored using Web standards, packaged into a zip archive together with a configuration file and executable in web documents (see the W3C specification at http://www.w3.org/TR/widgets/. However, we use the term widget to describe a component of our window system called dashboard. A widget represents a Flash file and allows user interactions such as minimize, maximize and move.

[11] A word cloud is similar to the well-known tag clouds but they do combine tags with extracted word or phrases from analysed text.

	shown with their name and picture. For anonymous participants (e.g. people using the project tags but not yet registered to the system) no information is given. The click on a member refreshes the information shown in the PersonWidget.
ArtefactsWidget	*The ArtefactsWidget is used to represent a collection of artefacts that were previously selected in other widgets. If keywords are selected within the ProjectWidget or KeywordCloudWidget all artefacts from the selected project containing the keyword are selected from the database and depicted within the ArtefactsWidget. In case that a keyword is selected within the PersonWidget, then all artefacts from the selected person (from all his projects) are shown in the ArtefactsWidget. Moreover, the actors interacting with an artefact are displayed and linked to the appropriate PersonWidget if the AANalyzer knows the person. The ArtefactsWidget offers a list-based overview that is ordered from new to old artefacts.*
PersonWidget	*The PersonWidget holds all information related to a participant. In addition to name and picture this information also contains a person's location and project memberships. Moreover the PersonWidget shows person-related keywords (from artefacts the person interacted with) in the before mentioned KeywordCloud style.*
LastActivitiesWidget	*The LastActivitiesWidget is used for the temporal representation of all artefacts that share at least one of the project's tags or have a direct relation to the project. It realises the requirement for a chronological overview about the artefacts related to a project. All artefacts are displayed in a chart that represents the various artefact types as layers on the y-axis while the x-axis represents time. In the course of this, the time axis can make any move in the past and future, displaying the respective artefacts. The timeline visualisation sorts all artefacts according to their creation time and offers a web link to see the artefact's original representation. Similar to the ArtefactsWidget, the LastActivitiesWidget displays an artefact's type, the creator and all associated keywords. See Figure 4 for a detailed view of the LastActivitesWidget.*
GoogleMapsWidget	*The GoogleMapsWidget uses the Flash version of Google Maps to show a projects main location (such as a conference venue), the members places of origin and – if available – the artefacts creation location.*

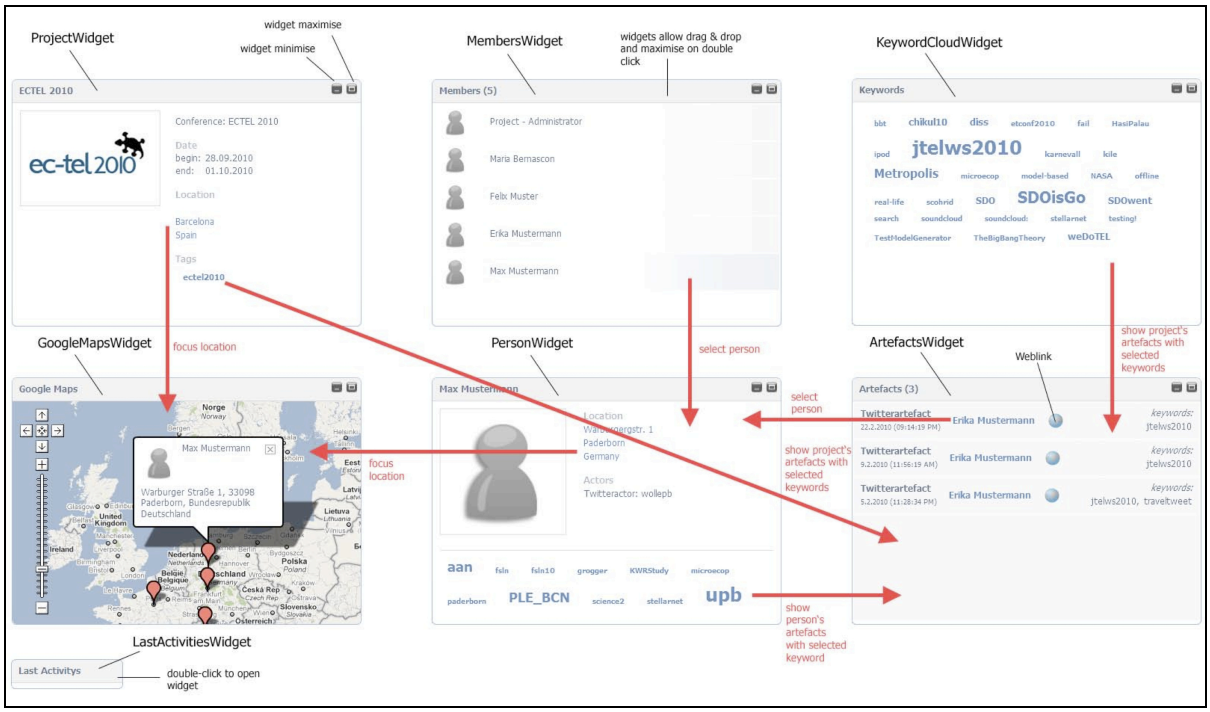

Fig 3: *Overview of available awareness widgets within the AANalyzer and their possible transitions.*

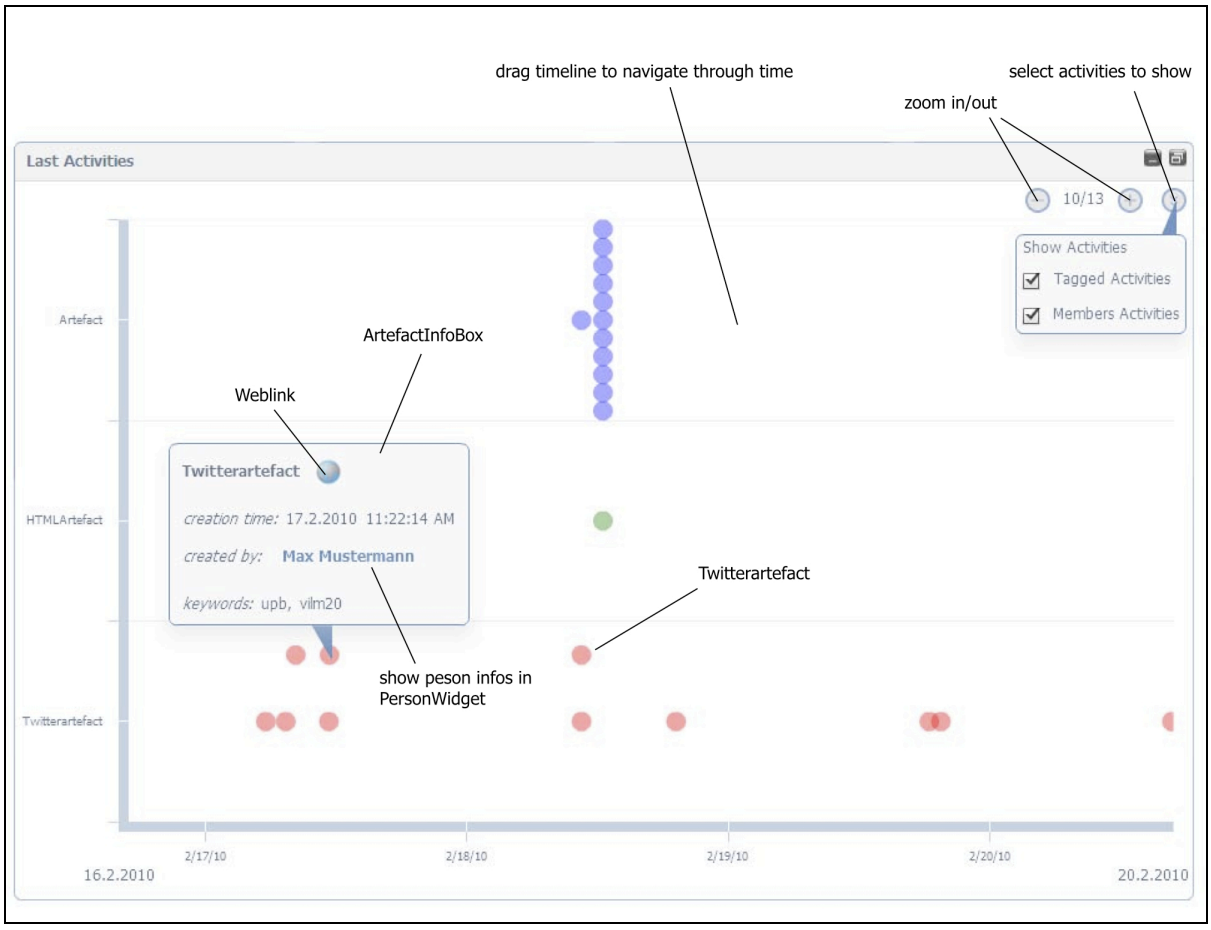

Fig 4: *Annotated elements of the LastActivitiesWidget*

5.3 Implementation

The implementation of the AANalyzer was twofold: the first part, which is concerned with the data layer, is based on PHP and the visualisation part with the widget-based dashboard is based on the Adobe Flex 4 Framework[12]. The Flex Framework assists with the easy development of Flash-based Web applications. Flex combines ActionScript 3 with a declarative XML mark-up language (MXML) to implement Rich Internet Applications. The different modules of the AANalyzer are built upon the open source MVC framework Mate[13]. As Flash applications do not allow a direct connection to a database or the modifications of local files, these functions are implemented in PHP. The AANalyzer accesses the PHP functionality via AMFPHP. For retrieving and updating data from/in the Artefact-Actor-Network, SPARQL queries are posted to the appropriate APIs and the returning XML is then parsed for visualisation purposes.

6. Conclusion and future R&D opportunities

In this article we presented the AANalyzer, a widget-based Rich Internet Application that allows the administration and reflection of data stored in Artefact-Actor-Networks.

We discussed two relevant functions of Personal Learning Environments, namely networking and reflection and how the AANalyzer could help becoming more aware of structures, changes and content distributed in online learning networks. Reflection is a central activity in developing learning and networked collaborative learning must be supported by any PLE approach. In order to pursue individual learning goals learners connect with numerous resources and new people. Artefact-Actor-Networks are analysing interactions of learners with artefacts that are used for individual and organisational learning. The semantically enriched data is then exposes via an open API to be included in various user interfaces. The AANalyzer is the first awareness dashboard that build on the AAN model and will be applied to several learning communities in the course of the year 2010, which will help us to gain user feedback on the awareness support the tool offers. At the same time we are extending the selection of awareness widgets for the users of the AANalyzer with statistics widgets and an advanced word cloud implementation that will allow for the visualisation of timely changes in the importance and use of certain terms.

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