Towards a Service-Oriented Architecture for Giving Feedback in Informal Learning Environments

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Abstract: Feedback has is a part of continuous interaction between learners and their learning environment. It cannot be simplified to self-assessment and rewarding; it also adds tension that motivates the learners on their engagement on learning processes from the very beginning. Feedback relies on the learners' previous actions as well as on the interaction context in which an action occurs. In this paper we propose service components and a service orchestration for a service oriented architecture (SOA) that are aligned to the process of providing feedback by adopting architectural concepts of context-aware applications. Using services instead of fully embedded layers, allows easier integration of components into existing systems at different levels. We describe a method how this is achieved for web-based systems by using state-of-the-art and standardised technology.

Keywords: Service oriented architectures, learner support, feedback, user monitoring, context-awareness, adaptation

INTRODUCTION

Recent developments in social software become increasingly important for informal learning and lifelong competence development. Educational blogging, collaborative writing, or peer exchange platforms have demonstrated how informal learning on the web can be facilitated. Due to the nature of informal learning,

users of these environments are not always aware about their learning processes and the competences they develop. Feedback is known to support self-regulation, and to strengthen self-awareness and engagement in learning processes (Butler & Winne, 1995; Dörnyei & Ottó, 1998; Garries, Ahlers, & Driskel, 2002; Ley & Young, 2001; Mason & Bruning, 1999; Mory, 1996; Orange, 1999; Veermans & Van Joolingen, 1998).

In this article we propose service components for a service-oriented architecture (SOA) for generating and providing personalised feedback in web-based environments and discuss a method of integrating frameworks which are based on services that integrate into existing web-based solutions. The service components and their choreography are the result of analysing the process of providing personalised feedback and state of the art solutions of giving feedback in electronically supported learning.

CONSIDERING FEEDBACK IN LEARNING

Personalised feedback is considered as crucial for all kinds of learning (Mory, 1996) because it is an inherent catalyst for all self-regulated activities such as learning (Butler & Winne, 1995; Orange, 1999). Garries, Ahlers & Driskell (2002) argue that in the interaction process between a learner and a system, the system's feedback on the learner's behaviour is a key driver of learner motivation and engagement to a learning process. Feedback is used by the learner to compare the outcomes with the preceding goals, strategies and performance of the interaction. Such self-evaluation of the learner leads to judgements (or conclusions) relevant for future behaviour (see Figure 1).

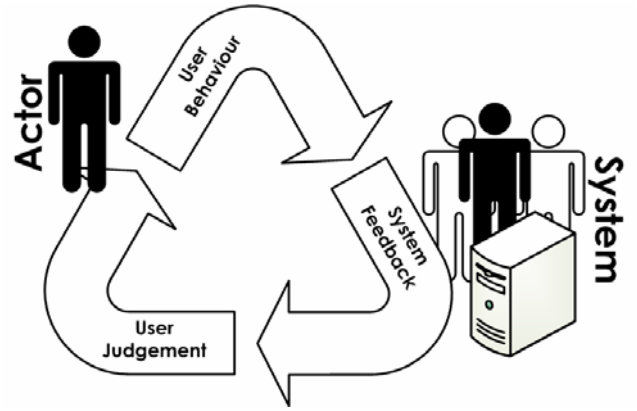

Figure 1 *Basic interaction cycle according to Garries, Ahlers & Driskell (2002)*

From this research we learned that feedback has two important features: first it relies on monitoring of learning actions and second it allows evaluating and assessing of those actions. As learning is a dynamic process, the information that has to be taken into account to meet these features depends on the context of the learners. Therefore, adaptability to the learners' goals, actions, performance, outcomes and contexts are important for giving feedback (Ley & Young, 2001).

A straight forward approach to address this problem from a technical perspective is to monitor the actor's behaviour in the system and generate responses based on action traces an actor has left in the system. This approach has already been used to assess the alignment of students' perception of learning and facts about learning (Janmieson-Noel, Chu, & Winne, 2004) and can be separated into four separate tasks (see Figure 2). Due to the nature of informal learning, the observable information has varying quality in different contexts. Therefore, we need to identify indicators that can be used to generate feedback and their meaning in different contexts. For this reason we consider a context-aware architecture (Dey & Abowd, 2000) that clusters the process of providing feedback into four layers: a sensor layer, a semantic layer, a control layer and an indicator layer (Zimmermann, Specht, & Lorenz, 2005).

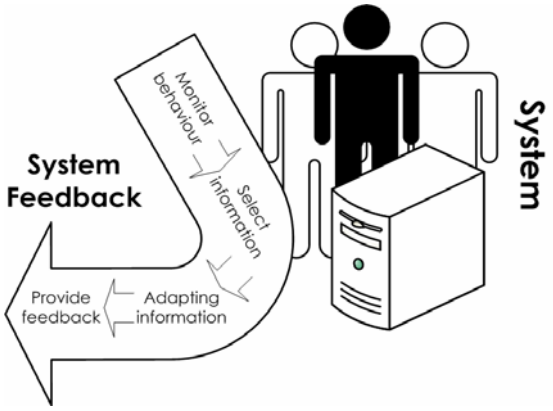

Figure 2: *System activities to provide external feedback*

ANALYSING FEEDBACK IN ELECTRONICALLY SUPPORTED LEARNING

Several approaches of feedback for learner support have been analysed or implemented (Cheng & Vassileva, 2006; Hummel, 2005; Kreijns, 2004; Passier & Jeuring, 2004; Rieber, Tzeng, Tribble, & Chu, 1996; Walonoski, 2005; Weber, 2003). These approaches, however, remain isolated, because the analysed approaches incorporate only a single feedback strategy which is tightly coupled to a distinct presentation style; and they are directly embedded into a learning environment. This limits the opportunities to extend the existing solutions or to transfer the results to other learning environments or interaction contexts. Additionally we found that the different approaches are limited to a learning context, such as higher education (Cheng & Vassileva, 2006; Hummel, 2005; Passier & Jeuring, 2004; Rieber, Tzeng, Tribble, & Chu, 1996), secondary education (Walonoski, 2005) or collaborative work (Kreijns, 2004). As a result the given solutions do not adapt to the goals, actions, performance, outcomes and contexts of a learning process.

A SERVICE ORIENTED ARCHITECTURE TO PROVIDE FEEDBACK

Through an open framework to provide feedback we address this problem. To investigate the effects of different types of feedback, we develop services for *feedback modelling* and *graphical feedback presentation* that can be embedded into web-based environments. In this section we describe the underlying service-oriented architecture (SOA).

A SOA is a logical way of designing software systems to provide services either to end-user applications or to other services distributed in a network through published and discoverable interfaces (Papazoglou, 2003). Feedback can be considered as the service the users receive. This service relies on (1) monitoring the behaviour of the users' actions; (2) the semantic modelling of information that is relevant for giving feedback and is provided by other parts of the learning environment (*information selection*); and (3) on actual and potential ways of selecting specific information which is useful to the learners according to their contexts (*feedback generation*). The selection criteria are derived from the feedback model. Finally, (4) the feedback information is presented graphically to the user (*graphical presentation*). Therefore, the architecture consists of four sub-services that can be aligned to the layer model:

- A sensor service to monitor the learner's interactions with the system.
- An action aggregation service to select context specific data and information.
- A feedback modelling service to generate the feedback.
- An integration service to provide the generated feedback to the learner.

Using service components avoids a tight integration of feedback into the application logic of the learning environment. It is also relatively simple to integrate several sources that capture traces of user interaction

and create an interaction history in a single location, i.e. if users of a learning network use different front-end devices such as mobile phones, PCs or Laptops. The advantage is that service components provide unified interfaces which are required to capture information from different sensors (Dey, Abowd, & Salber, 1999).

The proposed services separate feedback strategies and feedback presentation into different services (see Figure 3). This allows us to develop, test and distribute different feedback strategies and ways of presentation independently. We like to illustrate the information flow within this architecture by an example:

A learner accesses documents with in a document repository. A system can easily observe which documents were requested, how long these documents were accessed and which documents were accessed from another document (e.g. by following a hyperlink). Additional metadata can provide information about complexity and the degree of difficulty of a document (e.g. IEEE, 2002). It also has become popular to allow users to rate a document. This information can be considered as events in the interaction history of a learner that are recognised by the *sensor service*.

However, the learner is usually not interested in the details; they rather want to know about higher level information such as “progress” or “achievements”. Therefore it is not useful to show each event or cue separately. The *action aggregation service* creates a user model as an “objective view” on the learners’ action. This objective view is contextualised by the *feedback modelling service* regarding the learning situation and the learning process.

For the learner using the document repository, it would be useful to provide information about the effort compared to the amount of documents accessed during an early stage of learning, while during later stages it helps to understand how many of the documents have been accessed. If the learner leaves the document repository and enters the discussion forum, information on how the learner is embedded into the community or how actively the learner contributes to the community become more helpful than analysing the effort on reading the postings. This suggests selecting information from the user model and generating feedback differently for the varying interaction contexts (Dey, 2000; Dey, Abowd, & Salber, 1999). Feedback strategies provide the feedback modelling service with the necessary information to complete this task.

Finally, the feedback has to be responded to the learner. Graphical feedback is one possible way to do so, however, the graphical presentation may vary depending on the interaction context, the learning process, and the feedback strategy. The *graphical feedback engine* selects an appropriate widget from a widget repository to display the feedback that has been previously modelled by the feedback modelling service.

INTEGRATING SERVICES INTO WEB-BASED ENVIRONMENTS

The purpose of the feedback architecture is the collection of traces of user actions and to present feedback based upon these traces back to the actors. The architecture does not handle any responses related to the actual interaction of the actors and the learning environment. Therefore, the framework requires integration at the backend that serves as input for monitoring as well as at the front-end to present the feedback in the user interface. Due to the data flow different approaches of service integration are used at both ends of the feedback generation process. **Figure 3** provides an overview on the integrated architecture as we describe it in the following sections.

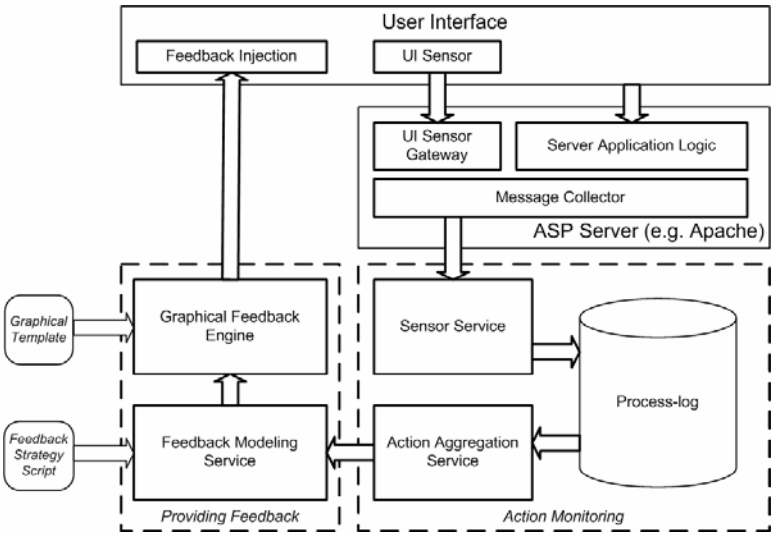

Figure 3 *Overview of the integrated architecture*

Backend integration

Backend integration defines how data and information enter the feedback architecture from the backend of a web-based infrastructure. As already discussed, the sensor service is the part of the system that tracks the actors' behaviour within the interaction process in order to get analysed at a later stage of the process. The way the sensor service is embedded into an existing framework depends on the type of trace that is collected. Some of these traces are generated on the user interface level, others are generated on the web-server and some traces might get collected by third-party web-services. Instead of having the latter traces isolated we want to keep that information in one place (cf. New & Rose, 2001).

Modern web-servers provide an interface to their logging component and support structured log messages. Ideally a solution would embed the action-messaging system into the web-server's normal logging pipeline. Such a solution feeds those messages to the sensor service that refer to user interactions and serves as input for the user modelling service, without affecting the application logic of the users' environment.

For data that is directly related to the user interface and which is usually ignored by or not available to the application logic on the server side a simple "gateway" (Fielding et al., 1999) can be used to generate structured messages and pass the information to the logging component of the web-server.

Front-end integration

Providing graphical feedback to the users implies that some widgets are displayed in the user interface. Instead of integrating the widget description into the user interface at the server, we propose a client-side widget injection technique that uses Ajax components (Garrett, 2005) to minimise interferences with the application logic. This approach just integrates a placeholder into the user interface. The user interface sent from the server contains only a reference to the Ajax components and defines the position of the widget in the user interface, which can be expressed in as little as two XHTML elements (see Figure 4). The actual widget injection takes place during reqest-time in the client's web-browser.

```
<div id="fbwidgetdummy"/>
<script type="text/javascript" src="feedbackhelper.js"/>
```

Figure 4 ***Sample graphical feedback injection code in XHTML.***

The main benefit of this solution is that the feedback presentation remains almost entirely independent from the application logic of the learning environment. As the widget replaces the placeholder element the injection can be provided transparent for the users: if JavaScript or Ajax is not available on the client side the placeholder remains invisible in the user interface. Additionally it is possible to change feedback, widgets and even entire widget concepts during runtime without affecting the placeholder code or the user interface.

CONCLUSIONS AND FURTHER RESEARCH

Feedback has is a part of continuous interaction between learners and their learning environment. It is context dependent because its meaning relies on the learners' previous actions as well as on the interaction context in which an action occurs. The architecture we proposed is aligned to the process of providing feedback (Butler & Winne, 1995; Garries, Ahlers, & Driskel, 2002; Ley & Young, 2001; Mory, 1996; Orange, 1999) by adopting architecture concepts of context-aware applications (Dey & Abowd, 2000; Schmidt, 2002; Zimmermann, Specht, & Lorenz, 2005). Using independent services instead of fully embedded layers, allows integrating the service components into existing systems at different levels which can be achieved by using state-of-the-art and standardised technology, as we have shown for backend and front-end integration.

The challenge with visualising information is still to find a balance between (a) providing useful information for self-monitoring and (b) displaying the information in a pleasant form (cf. Kreijns, 2004; Kreijns & Kirschner, 2002). This requires further research on the role and impact of different feedback strategies and the presentation of feedback information. The proposed architecture supports these needs because it is possible to exchange feedback strategies and ways of presentation independent from each other and from the services.

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