Cloud Services for Learning Scenarios: Widening the Perspective

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***Abstract*—The term "Cloud Computing" does not primarily specify new types of core technologies but rather addresses features to do with integration, inter-operability and accessibility. Although not new, virtualization and automation are core features that characterize Cloud Computing. In this paper, we intend to explore the possibility of integrating cloud services with educational scenarios without re-defining neither the technology nor the usage scenarios from scratch. Our suggestion is based on certain solutions that have already been implemented and tested for specific cases.**

Keywords-Cloud Computing, Cloud Services, Scenarios

I. Introduction

Currently, Cloud Computing scenarios are often used to overcome certain limitations of mobile devices, desktop computers or server systems, especially to improve accessibility and interoperability. Hereby, Cloud Computing is usually subdivided into at least the three following parts [1]:

1. IaaS - Infrastructure as a Service: Virtual provision of computing power and/or memory. A prominent example of an IaaS service is the Amazon WS service.
2. PaaS – Platform as a Service: Provision of a runtime environment, like application servers, databases etc. In this area, Googles App Engine is probably the most prominent example.
3. SaaS – Software as a Service: Provision of usually browser based applications that can directly be used. Here, Google Docs or the Customer Relationship Management software of salesforce.com serves as examples.

One aspect that is common to these three levels is the high degree of automation that is pursued by these kinds of Cloud Services. On the IaaS level, Cloud Computing can be understood as virtualization technology along with a high degree of automation, whereas PaaS provides a flexible way for the deployment of applications and SaaS is able to provide applications directly to the end-user, again, in a flexible and highly automated way.

In this paper, we discuss possible contributions of Cloud Services to new forms of technology-enhanced learning and teaching. The term Cloud Services itself will be explained later on in more detail. Starting with an abstraction of the common understanding of Cloud Computing, transferring the abstracted features to other prominent internet services like, e.g., Twitter and Facebook (which we see as specific instances of Cloud Services in the context of this paper), we argue that in the context of learning scenarios a wider definition of Cloud Services is need to encompass possibly relevant new developments. Furthermore, this paper presents an architecture that allows the flexible usage of services that belong to the extended definition of Cloud Computing. We describe two examples of learning scenarios that build upon the presented architecture to demonstrate how these services facilitate innovative aspects of technology-enhanced learning scenarios. Finally, an outlook for future development of this understanding of Cloud Services is presented.

II. An Alternative Perspective on Cloud Services with Respect to Learning Scenarios

In abstraction, Cloud Computing increases the flexibility of modern applications while at the same time improving security aspects such as availability, data storage or communication. Furthermore, one major aspect in Cloud Computing scenarios is the accessibility of the provided services through a set of standardized services.

With respect to learning scenarios, a different perspective to these abstracted features of Cloud Computing services (referred to in this paper as Cloud Services) offers a new understanding of prominent services like Twitter or Facebook. These Cloud Services can then be used as entry points for value-adding functions both in formal and informal learning settings, remote and co-located situations and in synchronous or asynchronous scenarios. On the one hand using such services allows getting into contact with students on internet platforms where they spend a large amount of their time [2], and on the other hand, to use off-the-shelf software [3], which saves implementation efforts and development time, but allows for using contributions from the students via these different Cloud Services.

III. A Software Engineering Perspective on Cloud Services for Learning Applications

The reuse of software components is one of the building blocks of modern Software Engineering approaches. In [3] the authors state that the term "re-use" can be interpreted somewhat differently with respect to Software Engineering approaches for the field of Technology-Enhanced-Learning (TEL). On the one hand, there is the re-use of content, which seems to be fairly well accepted. On the other hand, there is the re-use of both single software components as well as the re-use of established and approved architectures. In contrast to the re-use of content, these two more technical aspects of re-use are not yet well accepted or used.

Here, the usage of cloud services might help to either increase the re-use of single software components, e.g., provided as Web Services, and the re-use of established and approved architectures.

Web Services, as one of the building blocks for modern Cloud Computing environments, provide in themselves the idea of providing re-usable software components. One view to Web Services is that the major idea of Web Services is to provide re-usable software components that are made available through a set of standardized protocols. These protocols support consumers of these Web Services through the complete development cycle from finding a particular service (e.g., in a UDDI repository), accessing the description of the service interface (e.g., described in WSDL) to consuming the service (e.g., by using protocols like SOAP or REST). Therefore, the provisioning of Web Services in itself already provides a big opportunity for re-using single software components and by using the mentioned standardized protocols, the re-use of these kinds of software components is even possible beyond the borders of a single organization, but the re-use of these services is, from a technology point of view, also possible beyond the borders of a single organization.

This is particularly interesting for learning scenarios, since in this area we do usually not have that many commercially oriented organizations or research groups. Instead, the different players are willing to share their content as well as their developed services among each other in order to foster collaboration among different learning communities. Of course, when it comes to content re-use, aside from the technological problems that are fairly easy to solve by using Web Services, other problems such as the ownership of the resulting learning outcomes and questions about the right to re-use these learning materials arise, as, e.g., discussed in [9].

From an architectural point of view, Web Services allow, due to their possibility of re-use, a completely new approach to the architectural development of the resulting software, and of course also for the resulting learning applications. Here, the development of new software can be performed based on an architecture that is usually referred to as a Service-Oriented-Architecture (SOA). The building blocks of a new software developed based on this architecture are services (in our context usually Web Services). The major idea of a SOA is to build new software based on a number of already existing services. The overall task that a piece of software should fulfill is usually split up into different subtasks that are performed by a number of different, and usually already existing, services. Later on, after completing all the subtasks, the results of these subtasks are aggregated into the solution of the overall task. The combination of the different services that fulfill the subtasks and the combination of the results if often referred to as "orchestration" and the produced code is often referred to as "glue code". Using a SOA based architecture nowadays changes completely the usual software development process from writing yourself every piece of code (even with the help of already developed API's) that is necessary in order to fulfill the task at hand, to finding services that support the developer in solving the special task, the orchestration of these services and providing/implementing the glue code that allows to solve the current task. In this sense, the Cloud Computing paradigm itself provides already a new approach for the architecture of learning scenarios.

Cloud services may also lead to an enrichment on the content level: The matching of user (learner) needs to available materials may draw on existing learner profiles, e.g. in social or professional networks, in addition to content-related of resources, possibly using semantic web technologies. The added value over conventional learning metadata approaches would be the open-ness and free connectivity of the environment.

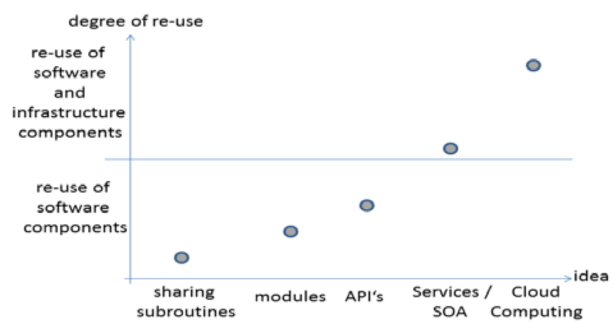

Fig. 1. Different degree of re-use with different software engineering approaches

From a technological point of view, Cloud Computing could be seen as the next consequent development step from a SOA to an architecture that does not only allow the re-use of content and services (in the terms of single steps in a process), but additionally as the re-use of computational resources. E.g. in an SaaS scenario a complete software stack would be re-used, which is pretty close to the idea of a SOA where basically single services are the major goal of re-use. On the next level, in a PaaS scenario, not single services are the target for re-use, but the infrastructure for running these services can be shared by different consumers. Last but not least, IaaS scenarios allow for re-using infrastructure on the lowest technical level, e.g., the re-use/sharing of computational resources (like virtual servers), network resources and/or storage resources. Hence, Cloud Computing allows to overcome the limitations that usually exist within SOA’s, e.g., that the re-use is still limited to the content and/or the services in terms of process steps, and allows to provide re-use for the complete stack from single software services to the technical layer of the network and the storage.

The idea of understanding Cloud Computing as the consequent next step of software engineering in order to extend the re-usability to the level of not only re-using software components but also infrastructure components, is shown in Fig. 1.

IV. EXAMPLE SCENARIOS INCLUDING CLOUD SERVICES

Keeping in mind the previously mentioned benefits of Cloud Computing, services such as, e.g., Twitter and Facebook, provide similar benefits to computer-supported learning environments, e.g., by increasing flexibility, availability and the accessibility of services through standardized methods. Therefore, services as those described above can also be understood as cloud services and can then be used in learning scenarios in order to exploit the described benefits of Cloud Computing based services. Integrating cloud services as input channels.

Our suggestion does not primarily aim at defining new cloud environments for education. The idea is rather to connect specific educational environments, e.g. around virtual or face-to-face classroom scenarios, with existing Cloud Services. A technical infrastructure to support this is outlined in Fig. 1. The major task performed by this infrastructure is to provide a certain abstraction for the messages received through the different input channels, store these messages and later allow a flexible message visualization to be used in learning units.

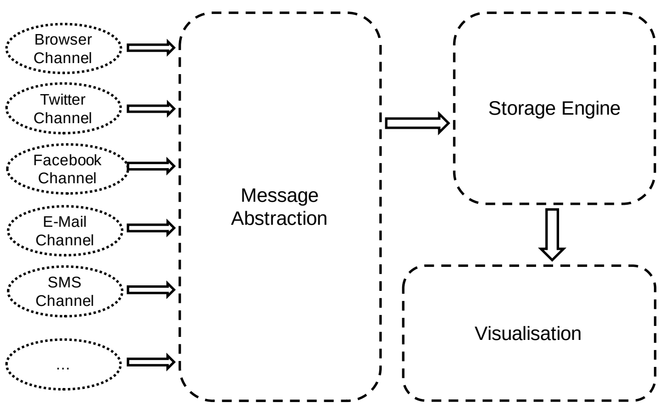

FIG. 2. ARCHITECTURE TO SUPPORT MULTICHANNEL INPUT

This architecture is a generalization of an approach that has been implemented and tested with certain specific cases [4]. In the sequel, we describe some example scenarios illustrating our understanding of the benefits that Cloud Services might bring to learning scenarios. Here, we see advantages in both, formal and informal learning settings. A differentiation can additionally be made with regard to synchronicity – contents can be generated and directly used in class, e.g., to support face-to-face scenarios, to replace moderation cards and flipcharts in individual and group work. Contents can also be generated in class and used in a future session.

One particular strength of integrating this kind of cloud services is that in addition to supporting and enabling the scenarios described here, it also supports seamless transitions between those scenarios. For example, it is intended to motivate the learners in informal learning scenarios, to contribute and make use of this content in a face-to-face classroom situation in a fully integrated way. The following subsections describe two scenarios which can be carried out with the help of the mentioned Cloud Services in more detail. Our basic approach is to use existing services to create, collect and visualize students' contribution in various educational settings and scenarios. These scenarios build upon established learning and teaching scenarios; their realization with the help of the before-mentioned Cloud Services and the proposed architecture add flexibility in time, space, synchronicity and re-usability of technology and data.

A. *One-Minute Papers*

One-minute-papers are a flexible and efficient way of collecting feedback from small and large groups of learners in seminars or lectures (also refer to, e.g., [5-7] for details and empirical findings on the method). Students are handed a piece of paper with questions they have to answer in (typically) one minute.

Example questions may focus on the contents of the seminar lesson, e.g., "What did I like?", "What was new to me?", "What do I consider important?", "What have I learned?" Furthermore, they may also ask for topics and relationships that are still unclear to the learner. In doing this, a personal dialogue is established between student and teacher, which can be especially difficult to establish in larger groups. According to Stead [7], this may improve student motivation.

With the help of our approach and architecture, these scenarios can be brought about by using any kind of computational device (e.g. notebook, smartphone, tablet) and the students' favorite input channels. Providing an environment that enables a computer-supported variant of the One-Minute Paper method brings relief to teaching staff by saving time and material compared to the pen and paper version. Students' comments can be easily organized, compared, visualized and stored. Especially for larger amounts of students, this is expected to ease the handling of learners' feedback. First experiences on the use of a web-based input service (available to smartphones, tablets and notebooks) to realize the One-Minute paper method have been recently described by Bollen et al. [10].

B. *Supporting Self-Learning Phases*

Another application scenario is the support of self-learning phases between classroom sessions. It is important for students to be able to transfer the newly acquired knowledge to situations in their everyday life. The discovery of one’s own examples, together with a sensitivity for similarities and applicability, does also ideally lead to a deepening of knowledge and makes learning contents more easily retrievable when needed.

Tasks like this can appear in almost every domain at every stage of a lecture, seminar or student project. Results can be collected and visualized for an in-class usage. Besides this, as mentioned before, students are regularly prompted to report on situations and examples that illustrate the learning content. Therefore, the learner would be able to contribute and share examples for future sessions.

As an example, which originates from first experiences and trials, the learners' task was to relate a new topic in a seminar with everyday life's experiences. The teacher prepared sentence opener questions to guide the learners, who had one week time to collect and communicate their findings - using tablets, notebooks or smartphones and wherever and whenever appropriate.

Again, the proposed architecture allows for a flexible generation and accumulation of students' contribution over time, together with a visualization support that helps teachers and students likewise organize and share results.

C. *Group discussion support*

As a third application scenario, we present a situation that utilizes the described architecture in a synchronous, co-located manner. In a classroom situation, the proposed system can be used to visualize textual contributions that have been created by the learners and sent from various sources. These contributions are received and processed immediately and can be presented with the help of a large, shared display, e.g. by using a video projection. Similar approaches have been described, e.g., by Liu and Kao [11] and by Bollen et al. [12].

By these means, classroom discussions can be supported in a way that can be beneficial in a number of ways:

- contributions can be formulated and submitted without interference and influence from peers
- contributions can be submitted anonymously, which can raise participation in controversial topics or for more introverted persons
- the course and structure of a discussion can be made explicit in a shared visualization
- discussion results can be stored for later (re-)use, review and comparison

Scenarios like those described above benefit from the integration of Cloud Services by increasing interoperability of peripheral devices. Heterogeneous Cloud Services like Twitter and Facebook allow participation independent of both location and time.

V. Interoperability and Scalability of Scenarios

Important features of computer-supported learning environments are interoperability and scalability towards educational scenarios. Is a learning environment (or a set of a interoperating environments) scalable a) against an advancing number of different scenarios and b) against a varying number of involved students? Is a learning environment (or a set of learning environments) providing interoperability between different education scenarios, i.e. does it support smooth transitions between varying scenarios?

Most notably, computer-supported learning scenarios can be categorized along the dimensions of

- time: Is the user's interaction within the scenario considered synchronous or asynchronous?
- location: Are participating learners are co-located or are they in remote places?
- Group scale: How many learners are interacting in the given scenario?

To give two examples, in this scheme, a classroom discussion would be considered a synchronous, co-located scenario in a large group. A collaborative modeling activity between two learners using a shared workspace environment would be a remote, synchronous scenario in a dyad. Fig. 3 illustrates the dimensions described above:

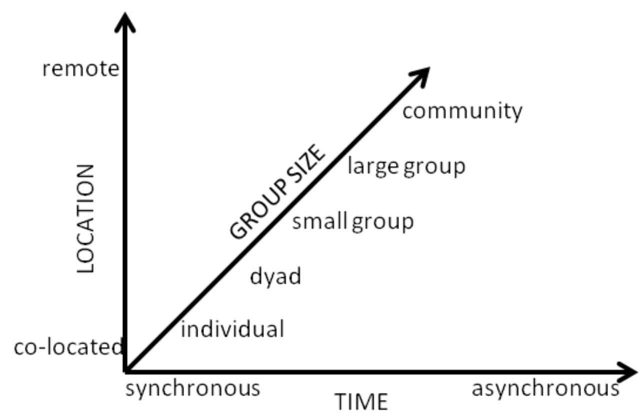

Fig. 3. Dimension of educational scenarios

Along these dimensions, we can further explain the aspects of interoperability and scalability of computer-supported learning environments. We can regard an environment being scalable, if it allows the realization of scenarios along instances of the dimensions mentioned above. We consider an environment being interoperable between scenarios, if it allows smooth transitions between instances of various scenarios.

As an example, if an environment allows the collection of learner's contributions individually over a period of time, and is able to present these contributions using a shared display in a classroom context, this environment is capable to scale over time and group scales, and we may consider it as being interoperable, if the transition between those scenarios requires little or no effort (concerning the use of devices, different software or configurations).

Here, we claim that the use of Cloud services (especially in a way presented in the architecture above), is a means to gain high scalability and interoperability, not only between hardware devices, operating system and software applications, but in particular between educational scenarios. From the point of view of cloud services in educational scenarios, which we are presenting in this article, cloud services are regarded as being advantageous in the context of this section, as they denote a very high accessibility in terms of time, devices, and platforms.

VI. Outlook and Future Work

The presented approach for the integration of Cloud Services into educational scenarios will in the future be used for the implementation of more flexible learning scenarios in which students can participate independent from time and location and by using their favorite communication channel.

Informal learning scenarios can particularly benefit from this kind of participation, as it allows for an easier contextualization of the learner, which is still a hot topic, in mobile learning scenarios for example.

Furthermore, this research allows empirical investigations in areas such as ease of use and usefulness of mobile devices in educational contexts, of relations between user traits and technology usage, or in uncovering usage patterns in this innovative field of computer-supported education. Also, the use of such services increases the possibilities for integrating analysis and context-awareness mechanisms, e.g., by using social network analysis or educational data mining techniques.

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