AGILE-BASED SOFTWARE PRODUCT DEVELOPMENT USING CLOUD COMPUTING SERVICES: FINDINGS FROM A CASE STUDY

Irum Inayat[1]   Siti Salwah Salim[2]   Zarinah M. Kasirun[3]

[1, 2, 3] (Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur, Malaysia

irum@siswa.um.edu.my salwa,zarinahmk@um.edu.my)

ABSTRACT: *Agile methods offer dynamic and iterative development by making use of short development cycles, frequent feedback, customer involvement and adaptive planning. It involves extensive collaboration between development teams and clients. This brings into account the need of a service to support fast iterative development through ubiquitous access to resources for team members. This paper aims to provide a connection between collaboration-oriented agile software development using cloud services. We present findings from a case study of an agile-based software product development using cloud computing services. The findings revealed that cloud services enhance collaboration among agile teams and gear up the agile software development process towards flexibility and agility.*

Key words: Agile methods, cloud computing, collaboration, scrum, product development.

1 . INTRODUCTION

In the last one decade, agile methods have taken the software development industry by storm due to its flexible nature. The dynamic nature of agile methods warrants them to be fit for projects with high requirements uncertainty [1]. Small and self-organising agile teams maintain socio-technical relationships [2,3] with one another and have extensive collaboration in terms of coordination and communication. In agile methods, collaboration is described as two team members working together on a certain task, coordination is when team members depend on one another, and communication is when team members exchange information and share knowledge with one another [4]. In addition, agile methods support customer involvement throughout the product development lifecycle unlike traditional software development methods. The need for constant interaction among team members and access to resources or infrastructure requires ubiquitous service. Thus, to fulfil the collaboration and resource-sharing needs of dynamic agile teams, cloud computing services are used [5]. Moreover, following the present-day trend of global software development (GSD) and outsourcing, the physical presence of clients is impossible. So far, several means have been adopted to replace the off-site customer, i.e. proxy customer, experienced teams, virtual communication etc [6,7]. Cloud computing provides a way out to deal with such situation.

Agile methods deal with highly volatile requirements followed by rapid development cycles and constant customer feedback. This involves a lot of inter-team collaboration and resource sharing. Cloud services make it possible for agile methods to deal with rapidly changing requirements by avoiding communication lapses. Cloud services tend to deal with the rising demands of agile teams on an ad hoc basis in relation to resources, reducing the timely availability[8].

In this paper we discuss a case study of mobile security application development through agile methods, i.e. scrum utilising cloud services. The findings from the case study reveal benefits of using cloud services in conjunction with agile methods. The case study shows that the kind of collaboration and parallel processing required by agile methods can be effectively procured using cloud computing services.

This paper is divided into a number of sections. Section 1 serves as the introduction. In Section 2, we discuss agile software development methods, with specific focus on Scrum. In Section 3, a brief introduction of cloud computing is provided in connection with agile methods. In Section 4, we describe our questions, and in Section 5 we explain our research methodology. In Section 6, the case study is explained. In Section 7, discussions and findings are presented. Section 8 concludes the paper and explains the limitations and future trends.

2. Agile Software Development

Agile software development is based on a set of principles. It comprises a group of several iterative and incremental software development methods with focus on collaboration between cross-functional and self-organising teams. Unlike traditional software development methods, agile methods focus on collaboration and interactions rather than processes [9].This approach enables agile software development to be able to cater to today's fast-growing industry needs by having short development lifecycle, speedy development process and constant interaction with customers [10].

2.1 Scrum

Scrum was introduced in 1995 as a lightweight, project management-oriented method based on several theories of system dynamics and complexity [11]. In Scrum, sprint is the basic unit of work spanning from one week to one month. The self-organising teams work in iterations called sprints with high degree of self-management and decision-making power vested in operational level, unlike traditional control and power- oriented methods [12]. The project is divided into several sprints or iterations depending upon its complexity. During each sprint, the team works on several product features, i.e. user stories or use cases and deliver a shippable product at the end of that iteration. Sprint planning is done at the start in order to specify and prioritise the features to be worked on. The team members discuss their progress and problems in daily stand-up meetings called daily scrums. The work flow of scrum methodology is

illustrated in Fig. 1 below. Scrum offers project management, versioning and requirements traceability through certain artefacts such as product backlogs, burn-down charts and sprint backlogs.
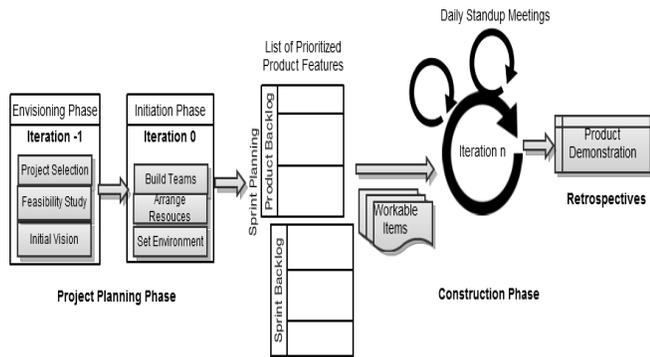

Fig. 1 Illustration of scrum methodology workflow

3. Cloud Computing and Agile Software Development

Cloud computing provides a convenient and on demand network access to resources such as servers, storage, applications. Cloud services are based on the concept of reusability and provide ease of use with easy access to resources. From the perspective of organisations that adopt agile methods, there is ongoing collaboration taking place between software development teams and customers throughout the product lifecycle. This collaboration can take place efficiently by making use of cloud services. Furthermore, cloud computing optimises cost and performance by releasing the unoccupied resources. Cloud services offer additional bandwidth to users as and when required under its "pay only for the services used" feature. The benefits of cloud services such as larger network access, on-demand service availability, resource pooling, increased flexibility and measured service [8] are positive for collaborative and dynamic agile development methods. An illustration of cloud services-based agile development is shown below in Fig. 2.

Cloud computing provides several kinds of services, e.g. Software as a Service (SaaS) like Google docs, Platform as a Service (PaaS) like AppEngine from Google and Infrastructure as a Service (IaaS) like IBM smart cloud. The cloud services are deployed using *Private cloud* exclusively owned by an organisation or enterprise, *Community cloud* shared among several organisations, *public cloud* owned by a third party and is based on "pay as you use" principle, and *Hybrid cloud,* which is a combination of two or more types of clouds based on user needs and usage.

Among geographically distributed teams, the major threat is communication lapse. The cloud-based environments enable group sharing and commenting that lessen the communication gap as well as enhance collaboration [13]. The dynamic nature of agile methods has highly benefited from the scalability, flexibility and ubiquitous availability. This helps to achieve the features agile methods are known to have. The rapid development with constant show-and-tell sessions resulting in change in requirements and

improvements can easily be handled with cloud services' constant updates and connection. The combination of agile methods with IaaS has a scope for rapid development and testing for agile teams [8]. On the other hand, the unavailability of such infrastructure that supports fast and rapid development and collaboration can cause delay in delivery [8].

4. Research Questions

Cloud services are expected to enhance the applicability of agile methods. Therefore, we pose our research questions to find the benefits through a real-world case study, which are:

RQ1: How does cloud computing enhance the affectivity of agile-based software development?

RQ2: How does cloud computing enhance collaboration among agile teams?

5. Research Methodology

Case study method is chosen for this research in order to gain deeper insights of the project [14]. To delve into details, online questionnaires were employed using Google documents service. Moreover, we conducted semi-structured interviews of 10 team members and observed their working style. Sample of several questions is shown in Table 1.
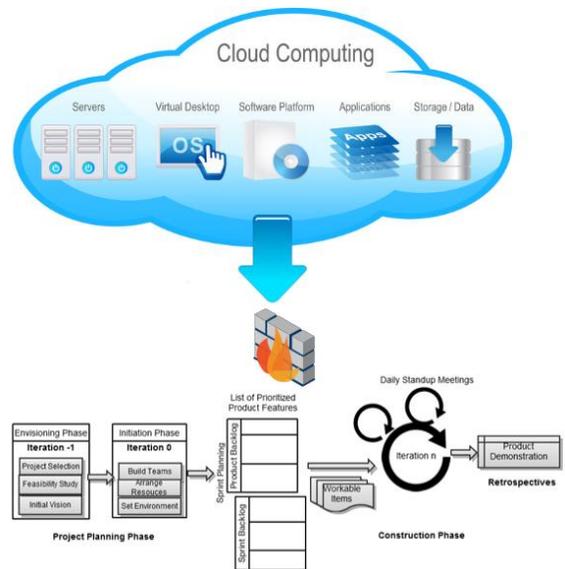

***Fig.* 2 An illustration of cloud services-based agile development**

CASE STUDY

Alpha is an international product-development organisation located in more than 25 countries with its head office in Europe. We conducted this study at one of its offices located in Asia. Alpha follows in-house product development of internet security applications. The organisation develops its own ideas; thus, the conventional role of customer as defined and stressed by agile principles is taken over by product managers (PM), the ideas floaters. The main buyers of products are internet service providers (ISPs). The ideas are gathered from potential customers and users through surveys and workshops. The feedback instigates new and improved product ideas on which the company develops its new products. The product is launched and offered to potential

buyers after completion and is then customised according to the company environmental requirements.

Table 1 Sample of several questions

Questions
Demographics
For How many years have you been using agile methods?
For how many years have you been working at Alpha?
Please define your Role in the team.
Collaboration
How many features of Project Alpha_Security are you working on?
How many features of Project Alpha_Security are you working on in collaboration with other colleagues?
If a change occurs in the User Stories are you informed about the change
How you are alerted about changes made to User stories.
How often do you face changes in requirements?
How often do you communicate with your team members on the distributed site in a day?
How do you communicate with your team members on the distributed site?
How do you grade your awareness or understanding about your workplace (e.g., processes, policies, team structure)
Cloud Services
For how many years have you been working at Alpha?
Please name the cloud services IaaS, PaaS or SaaS which you use.
Did you complete your builds in time after using cloud services?
How cloud computing helped you in in-time delivery?
What are the major differences cloud computing has brought to agile-based product development?

5.1. Company workflow

The company focuses on in-house product development and uses agile methods. The project we have studied adopted the Scrum method. The companywide workflow is executed in accordance with the following phases:

- Envisioning Phase: The product managers propose ideas to the leadership team. Product ideas are gathered through workshop sessions and customer surveys with potential users of the product. The ideas are presented to the leadership team for approval. Once approved, the team prepares the initial vision of the project by allocating resources, decides on completion time and selects teams for the project.
- Initialisation Phase: Teams consisting of 5 to 9 members each are formed. Number of iterations is decided with each one lasting for 2 weeks.
- Construction Phase: In each iteration, Day 1 is dedicated to planning/documentation and Day 10 is for demo. It is not necessary to have deliverables at every demo; for instance, during the first iteration, teams normally come up with plans and documents.

5.2. Project Introduction

The project Alpha_Security is a mobile internet security project which ensures user information security through protection against digital and mobile threats when users go online on a smartphone. To meet the potential challenges of cyber security, the company follows a constant enhancement process that offers customisations and enhancements for every released product version. The project investigated was one of the customised releases of Alpha_Security project. Project Alpha has 6 features; each feature is divided into 2–3 user stories, and each story is further divided into 5–6 tasks depending upon the complexity level. This makes a total of 17 user stories and 85 tasks.

5.3. Team structure

As shown in Fig. 3, the team comprises 9 members: 5 Software Engineers (SE), 2 Quality Engineers (QE), 1 Product Manager (PM) and 1 Product Owner (PO). In addition, the team has 1 User Interface Designer (UX) who is not a dedicated member of the team and is shared by three project teams at most. Four out of nine members present in the Asian office sit close to one another in the same room while the other six members, including UX are at the head office in Europe.
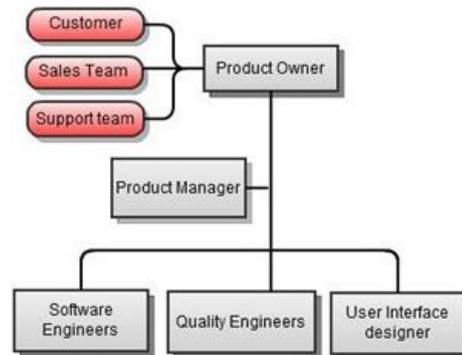

Fig. 3 Team structure at Alpha

6. DISCUSSION AND FINDINGS

The application was developed using PaaS–CloudForge[1], which is a development platform as a service facilitating distributed development teams to manage and scale cloud-based development activities using various tools and applications [16]. Eclipse IDE was used for development. Cloud services enabled the developers to develop and run the prototypes and tests in parallel. The availability and access to multiple servers made parallel working easier. This enabled the clients and distributed members of the team in Europe to access the prototypes and codes as well as provide frequent feedback and participate in the development process without any delay. The prototypes after completion of an iteration

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[1] Cloud Forge is a development Platform as a service (dPaaS) for deploying aplication services using agile methods.
http://www.collab.net/news/press/collabnet-launches-cloudforge-industry%E2%80%99s-first-enterprise-grade-development-platform.

were uploaded to the cloud service and made accessible for feedback. The developers used to get frequent responses and the client felt well informed throughout the project. Cloud services offer immense benefits for application development using agile software development methods. Some of the known benefits that answer our research questions are listed below:

RQ1: How does cloud computing enhance the affectivity of agile-based software development?

Cloud services make parallel processing possible in real life due to the availability of resources to the team members for more than 99% uptime. The other factors that contribute to the efficiency of agile methods via cloud services include the following:

- Large number of testing servers: Cloud computing offers unlimited numbers of testing and staging servers. This offers the testers and developers an opportunity to do their work efficiently without any delay in waiting for the server to be free. Thus cloud services have enabled the testing teams to meet the pace of agile development [15].

- Parallel processing: Agile methods support parallel processing of software development activities, but still there are delays. To avoid these delays, to attain maximum efficiency and to work efficiently, virtual services of cloud are highly important.

- Faster builds: Due to virtualisation, the availability of resources encourages the team to code and test any user story they find interesting or without waiting for the next build. The servers are available and there is no need to wait for the release of resources to continue work, which results in fast and efficient builds.

- Availability of services and platforms: Cloud computing offers the benefit of using services like saleforce.com, platforms like Google applications engine, Oracle database cloud offering databases, and storage and infrastructure like Amazon web services. This provides an automated development platform for continuous integration and testing of code.

- Continuous feedback: Constant response from the client and discussion among teams are made possible through cloud services with data uptime of 99%. The team members can access and communicate as and when required.

- Transparency: In agile methods, transparency is controlled through communication, e.g. face to face and scrum meetings. Data sharing also occurs among team members. Cloud services make it easier for team members to share data through pre-integrated developer services. These services capture and share data continuously so as to avoid any lapse.

- Versioning: In a parallel processing environment where a number of users work on the same code snippet and improve it, maintaining the correct versions is very important. Cloud services provide a mechanism to control versions and replicate them.

- Centralised traceability: Cloud service enables centralised traceability for the changes committed to

codes. The Cloud_Forge provides additional benefits of code, discussion, documents search within and across the project.

RQ2: How does cloud computing enhance collaboration among agile teams?

Collaboration among agile teams is the foremost feature and is achieved when teams communicate and coordinate with one another. In this case study, the teams used services like Skype for communication with one another across the region. Furthermore, the teams used common forums for making changes to documents, codes, and floating comments and suggestions. This approach allows the common artefacts to be accessible to every concerned person all the time. The teams were given one day off in the week and were allowed to work from home using these online collaborative tools. The teams held Skype-based scrum meetings on their off days at an agreed time. The ease of communication among teams made collaboration effective and efficient, resulting in reduced rework and delays. The collaboration patterns of the team members distributed over continents, namely Asia and Europe were studied through online surveys. Findings revealed that teams were well aware of one another's presence and work status [3]. A sample of one of the communication networks generated for requirements negotiations and of work status awareness among team members is shown below in Fig. 4. The size and colour of the nodes represent the degree. The nodes with high degree i.e. large number of in and out edges are bigger and lighter in colour. Whereas, the low degree nodes are darker and smaller. The figure shows that all the team members communicate with one another regardless of their geographical location. Likewise, the work status awareness shows that almost all the team members are aware of one another's work status expect the UX. As mentioned earlier, the UX is not a dedicated member of the team, but is shared by three project teams at most. Therefore, it can be seen that the UX has the least part in both networks. In terms of communication, it was reported that in an iteration having tasks, the teams communicated for more than four times a day through online collaboration tools.

The usage of cloud services to a certain extent enhanced the collaboration among agile teams. Moreover, it provided real-time commenting and messaging facility on project artefacts to enhance the delivery time and avoid delays. In addition, the online accessibility of team members increased awareness among them, which resulted in more communication and knowledge sharing.

The cloud collaboration services and storage servers allow the teams to share their prototypes, files and beta versions with members outside the organisation with due security through firewalls. Furthermore, another important feature of tracking and audit of files also become possible due to proper time stamping and maintenance of communication history feeds over the network. Therefore, the collaborative cloud computing provides low cost, fast and easy collaboration among teams and accessibility to the resources. The above discussion shows that cloud collaboration services make the teams more responsive and agile in reality.
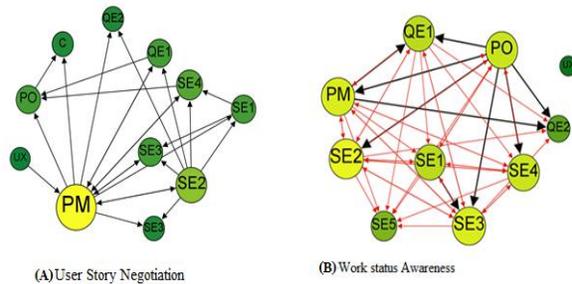
(A) User Story Negotiation   (B) Work status Awareness

Fig. 4 An example of communication and awareness networks

7. CONCLUSION

This paper aimed to investigate the role of cloud computing services in agile-based product development with special focus on collaboration. We have discussed a case study of a mobile security application development availing cloud services and reported the findings. We aimed to identify (RQ1) the role of cloud computing in enhancement of agile software development and (RQ2) how collaboration is supported through cloud services for agile software development. A case study was conducted with the distributed teams located in Asia and Europe. The findings revealed that cloud services enhance the efficiency of agile software development process through the following: availability of resources to the teams all the time; increased transparency of data; provision of version management; provision of continuous feedback; all owing faster builds and provision of various services and platforms at low cost. Moreover, cloud services enhance the collaboration among agile teams, which increases communication and awareness. The increase in communication and awareness among teams reduce delays and rework. Therefore, cloud services are reported to be feasible for agile software development and should be used to reduce cost as well as avoid budget and time overrun.

The main limitation of this work is that only one case has been taken into consideration. We aim to strengthen our findings with more empirical results in the near future. Furthermore, we have only considered the Scrum method. We aim to conduct a study in which we will study multiple projects that use variable agile methods and cloud computing. This will enable us to identify other important factors that help agile methods achieve their due flexibility by using cloud services.

9. ACKNOWLEDGMENT

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