Migrating Software Products to the Cloud: An Adaptive STS Perspective

Marc Werfs
University of St Andrews
UNITED KINGDOM

Gordon Baxter
University of St Andrews
UNITED KINGDOM

Ian K Allison
The Robert Gordon University
UNITED KINGDOM

Ian Sommerville
University of St Andrews
UNITED KINGDOM

ABSTRACT

Cloud computing, as a disruptive innovation, has the potential to adversely affect companies. The effects can be particularly extreme for small and medium sized enterprises (SMEs). Subsequently, considerations of organisational resilience should be made when integrating with disruptive innovations like cloud computing. This paper reports of a longitudinal study investigating how a set of SME high-value software vendors are migrating their software products to the cloud. Adaptive socio-technical systems (ASTSs) concepts are used to provide a framework for understanding the adoption process. This study draws out a set of macro and micro themes relating to key phases of strategy development, the migration process and the impact on customer perceptions. From the findings, more systemic and holistic approaches are identified to address key tensions through the adoption life cycle while considering organisational resilience.

INTRODUCTION

Cloud computing is an example of what Christensen (Christensen & Bower, 1996) describes as a disruptive innovation (or technology). It has opened up major business opportunities for Small and Medium-sized Enterprises (SMEs) that develop software products. In the long term, disruptive innovations have positive effects on costs, performance and quality (Anderson & Tushman, cited in Rosenbloom & Christensen, 1994). Subsequently, cloud computing can be attractive for SMEs to enable them to address geographic spread, customer service and to develop new markets. The most obvious way that cloud computing can be exploited by software developers is through migrating the functionality of their products to the cloud and delivering the product functionality as cloud services.

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In the short term, however, disruptive technologies can adversely affect company performance because the initial potential revenues are often small, and it is difficult to make long term predictions about how markets will develop (Bower & Christensen, 1995). So, software SMEs that use cloud computing to provide their products as a service increase the risk of the company failing because any adverse effects of the disruptive innovation may be felt across the whole company. We argue that these effects can be managed by including considerations of organisational resilience when making decisions about the potential use of disruptive innovations like cloud computing.

Despite the potential opportunities and risks for organisations, to date most of the research into cloud computing has focused on issues such as architectures (e.g. Rochwerger's et al. RESERVOIR model, 2009), potential applications that can be deployed in the cloud (e.g. Liu & Orban, 2008) and costs and benefits (e.g. Assuncao et al., 2009 cited in Alshamaila & Papagiannidis, 2013). Only recently have people started to consider the decision making process that is central to the adoption of cloud computing.

Adopting cloud computing as a way of delivering products and services involves making several choices about:

- the type of cloud that will be used to deliver the product/services (public, private or hybrid),
- how the product's functionality will be delivered,
- the cloud provider that will be used,
- the pricing model that will be used to charge customers for using the product/services.

Each of these decisions is multi-layered. The decision about the type of cloud to use, for example, will depend on the sensitivity of customer data that may be stored in the cloud; the location of the cloud infrastructure that will be used; and the customer's existing IT infrastructure. Understanding such decisions is important in addressing the potential risks.

The cloud adoption toolkit (Khajeh-Hosseini et al., 2012) is a process-oriented framework to support decision making. The process starts with a technological suitability analysis, which is a short checklist for assessing whether cloud computing is appropriate for a particular organisation. The most developed part of the cloud adoption toolkit is the cost modelling tool, which allows organisations to look at how much their particular set up would cost using different cloud providers.

A process based approach to adoption is also proposed by Zardari & Bahsoon (2011). Their approach is based on the use of goal-oriented requirements engineering. They suggest a sequential process which emphasises the technical aspects, and allows for some iteration as requirements are elaborated and negotiations about service level agreements (SLAs), for example, take place. The documented results are used as the basis for establishing more formal contracts with cloud providers. Bidgoli (2011) also suggest a process based approach based on their own 6 step model which highlights a prescriptive set of actions. Their focus, however, is mainly on the technological issues involved, and pays less attention to the wider organisational ones.

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Both Khajeh-Hosseini et al. (2012) and Zardari & Bahsoon (2011) use UK universities to provide a context for illustrating how their work can be used. Alshamaila & Papagiannidis (2013) analysed how a broad range of SMEs approached the issue of cloud adoption from the perspective of the Technology, Organisation, Environment (TOE) framework (DePietro, Wiardo & Fleischer, 1990 cited in Alshamaila & Papagiannidis, 2013). If we are to identify lessons that can be generalised, we need to analyse how several SMEs from the same sector are adopting cloud computing. Whilst building on these previous studies, we consider the issues for software SMEs to be quite distinct as they are both providers and users of cloud services.

In this paper we focus on a group of software organisations that offer high-value products, as they are a distinct set with specific challenges. We begin by considering how socio-technical concepts can inform our understanding of the adoption process for disruptive technologies. We argue that it is more important to understand the business and its processes first. Today's socio-technical systems (STSs) are more open to their external environment than ever before and technologies, like cloud computing, can connect to all levels of the system. New approaches are needed to deal with the constant flux in systems and organisations that is partly due to disruptive innovations. The concept of adaptive socio-technical systems (Werfs & Baxter, 2013) provides an approach to describe this changing world and is used as an analytical framework to study how the companies transformed their products to cloud-based services. We discuss early lessons from a longitudinal study, drawing out key issues from across the companies and suggesting how organisations can address the tensions that emerge when conflicts arise between these issues using adaptive socio-technical systems thinking.

TOWARDS A SYSTEMIC VIEW OF CLOUD ADOPTION

Socio-technical systems involve a complex interaction between people, technology and the environment in which the systems are deployed—both the physical environment, and the regulatory environment of standard operating procedures, rules, laws and so on. STS concepts were developed by what is now called the Tavistock Institute during a study of long wall coal mining (Trist, 1981) as a way of recovering the group cohesion and self-regulation that was lost when automation was introduced. The concepts were intended to inform the design of work carried out by autonomous groups that are involved in making decisions about their work arrangements with a view to increasing the quality of their work as well as technical performance (Walker et al., 2008).

The changing nature of technology has further affected the nature of work. Networking technologies and distributed systems, for example, made it possible for systems in different locations to be connected and share data, and be controlled remotely. The concept of Open STSs, as characterised by Badham, Clegg, and Wall (2000), took account of how STSs had become capable of operating with each other and with the environment. Connections between systems could only be made in limited ways, however, and were often tightly controlled and had to follow strict protocols.

More recently, the advent of technologies like cloud computing, Wi-Fi hot spots and memory sticks have made it easier for systems to connect and exchange data in ways that can be difficult

to detect and manage. As people start to bring their own devices to work, for example, it becomes clear that protocols that existed in open socio-technical systems are more difficult to establish and control because there are now so many more technologies to connect to at all levels of the system (Eason, 2008).

Baxter et al. (2012) describe a case where a developer used cloud computing resources to help produce an application more quickly. It was only much later, when the application needed to be modified and the developer had moved on to another company that problems emerged. The developer had used his own machine and paid for the cloud services using his own credit card. This meant that the company was denied access to the code because they could not provide the appropriate authentication details.

In order to be able to deal with the problems that can arise with the introduction of cloud computing and other disruptive innovations, organisations have to be able to continually adapt to the world around them. In other words, they need to function as something we conceptualised as adaptive socio-technical systems (Werfs & Baxter, 2013). Doing so will allow them to react to events as they occur, which provides a mechanism for responding to failures and degradations in performance (Dalpiaz, Giorgini, & Mulopoulos, 2013). In addition, organisations will be able to adapt in ways that are anticipative too, for positive reasons, such as exploiting expected opportunities in a market, as well as heading off problems that appear on the horizon. Adaptive STSs have the intrinsic ability to change locally, both from a structural and behavioural perspective. Eason (2007), for example, describes how local adaptations helped to exploit technical capabilities while reducing costs and risks within a health care setting. Local adaptations can also adversely affect the wider STS, however, unless care is exercised to make sure that these adaptations are coherent and consistent with the entire organisation.

If adaptation is done in an ad hoc way by the users, this can make processes and tasks become opaque, immeasurable and incomparable as happened in the case described in Baxter et al. (2012). Many companies currently proscribe the general use of disruptive innovations because they have not yet worked out a way to integrate them with their existing structures. An adaptive STS approach would allow these technologies to be deployed in a more careful and controlled way, using ideas from experimental design. In this way it should be possible to locally contain any adverse effects of using disruptive innovations, whilst at the same time providing a way to measure the potential benefits, and consider issues of generalization if the adaptation was rolled out to other parts of the STS.

Adaptive STSs provide a systemic viewpoint that can be used to analyse how organisations adopt cloud computing paying attention to the possible effects on organisational resilience. This means that as well as investigating technological issues we have to consider the effect on the entire company and everyday work and development processes (e.g. HR, Finance, Governance, Risk Management, etc.). Subsequently, we need to investigate the role of end users as they are utilising disruptive innovations every day.

It is necessary to take a long term view to be able to see the effects adaptations have as some may make sense in the short term but may have adverse effects in the long term. One way to

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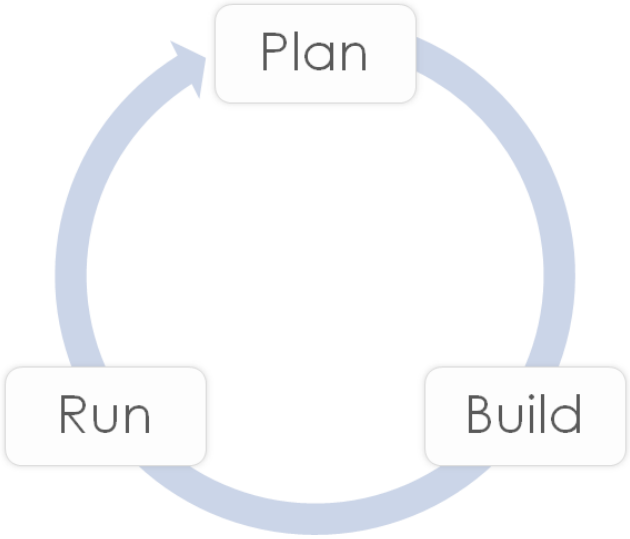
achieve this, for software organisations, is to map the issues to the phases of a development life cycle (like the one shown in
). By mapping the concepts of adaptive STSs to the key phases of a development life cycle we can start to consider how we can more broadly analyse the process of cloud adoption (or any disruptive innovation) and address the possible impact on organisational resilience.

Figure 1: Key lifecycle phases for analytical purposes.



The plan phase concentrates on the development of a strategy for the product which should align with the overall business objectives. In this phase the company needs to decide why and what to use cloud computing for, as well as make decisions about the required resources. The company also needs to review the impact of moving to cloud computing on the entire company. The basic question that arises here is, what are the issues influencing strategic decisions for the use of cloud computing?

The build phase focuses on designing and implementing the product. In this phase the company needs to make decisions about the skills and methods that need to be employed. In addition, they have to consider the needs of their users and decide how to realise the product in the cloud. Two basic questions that arise here are, which areas of a company are affected in what way through cloud computing and how is cloud computing affecting the IT department?

The run phase focuses on providing the product at the right time to the relevant customers. In addition, the company needs to monitor customer experiences of using the product and identify and prepare appropriate modifications to the software product, based on customer requests or incidents for example. The basic question that arises here is how is cloud computing affecting product or service development?

In the following section this framework of adaptive STSs will be applied to investigate the adoption of cloud computing by SMEs.

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RESEARCH METHODOLOGY

The study we describe is part of a three year project in which we are working with SME software developers across Scotland who are considering migrating products to the cloud. The companies are developing their products in a way that allows them to be delivered via the cloud.

We have recently completed the first stage of a 12 month longitudinal study investigating the impact of cloud computing on the project partners. In particular we are investigating how they monitor and measure progress, and how they transform their existing software products into cloud versions (or develop new cloud-specific products). The aim is to identify critical success factors, challenges, and best practices that facilitate successful cloud adoption in a way that maintains organisational resilience. The project partners are currently at different stages of cloud adoption: some are already using the cloud; others are currently moving into the cloud; and the rest are evaluating moving to the cloud.

The full study will allow us to follow the project partners through the process of cloud adoption. For the first stage of the study, we conducted semi-structured interviews with strategic project leaders of five project partners. The interviewees were either Chief Executives, Chief Technology Officers or leaders of product development, and the interviews lasted between 25 and 60 minutes.

Interpretive research can give a better understanding of the underlying processes of cloud adoption. A qualitative study is appropriate as it enables a deeper analysis of factors influencing cloud adoption by SMEs. Semi-structured interviews provide the opportunity to explore all the factors while enhancing flexibility (Leedy & Ormrod, 2005). The interview questions were informed by taking an adaptive STSs perspective (as described above) and were organised using a generic product development life cycle (see Figure 2; the full set of interview questions can be found in Appendix 1). The questions were validated beforehand during an interview with one of the other project partners who had been closely involved in the successful adoption of the cloud in a company outside of our project.

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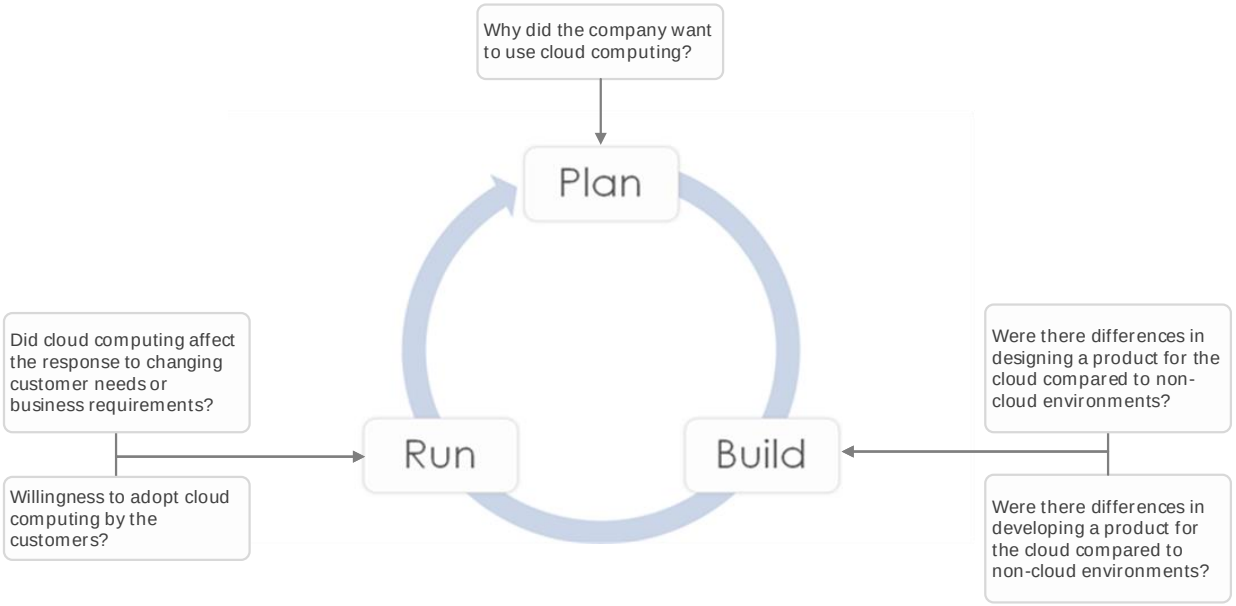
Figure 2: High level questions informed by adaptive STSs.



The recordings and notes taken during the interviews were coded and analysed to identify issues that companies face during the adoption of cloud computing. More specifically we identified issues that occurred during the early phases of cloud adoption (i.e. plan, migration and outcome). From this data analysis we identified macro and micro themes through a (1) thematic conceptual matrix and (2) case dynamics matrix. There are a total of 3 macro themes and 9 micro themes (see
). Each macro theme has three micro themes. The themes can be considered as elements of practice that recurred across the partners and each of the themes will be explained in the next section.

This study is based on a limited number of organisations and is not necessarily generalisable to all organisations. The sample is purposefully selected to be organisations with high value products, and so the outcomes of this study do not apply to consumer, low cost software products. Even within the sample, not every project partner faces the same challenges; hence not all the results are applicable to every partner. The themes identified and described in this paper represent an initial perspective of the adoption process across all of the partners which will need testing through further investigation at a later stage in the process and through a wider survey of similar organisations (see Figure 3).

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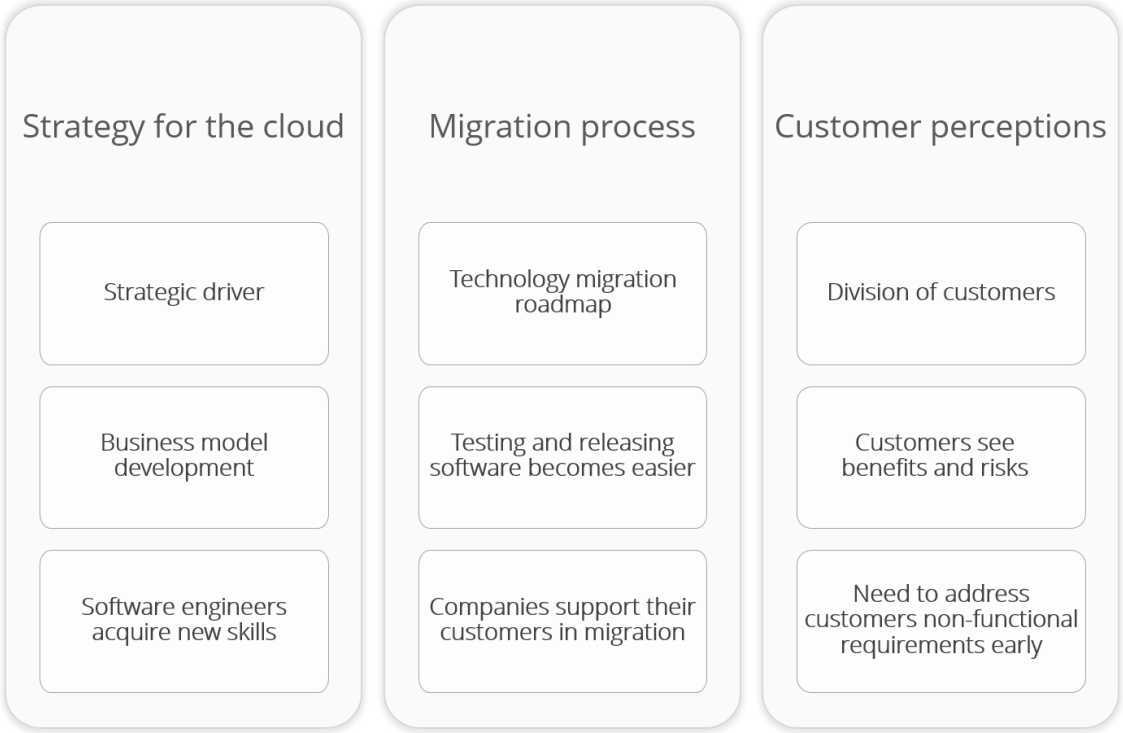
Figure 3: Macro and micro themes that emerged from the coding and analysis of the interviews.



FINDINGS: MANAGING THE ADOPTION OF CLOUD COMPUTING

The first macro theme is *Strategy for the cloud* (see
). The interviews showed that there was no clear trigger for the use of cloud computing (micro theme: *Strategic driver* in
). The change came through a combination of the IT and business functions recognising the market opportunities and also the potential risks if no action was taken. The use of cloud computing in the companies, therefore, can be considered an example of technology push, in that the companies know cloud computing is available and they made the conscious decision to use it, as opposed to market pull, where the pressure to use it would come from the customers. Some project partners have not yet decided exactly how they will utilise cloud computing, e.g. how products will be developed for the cloud, or how existing products will be moved into the cloud.

Some project partners expressed the desire to explore new ways of offering their products to reach a broader customer base and reduce their costs (micro theme: *Business model development*). Many of these companies currently have high-value software products, such as project management tools and applications, serving a strong existing client base. Extending this customer base can be difficult, however, because the high initial price is a barrier to entry for some potential customers. Packaging the functionality into smaller services reduces the initial costs, which means that they can be signed off at a lower level of management within customer organisations. If this approach is combined with a charging model that is attractive to customers

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it may make it possible for those customers to move the costs of using the software from capital expenditure to operational expenditure. The product therefore becomes more affordable and, hence, more attractive to potential customers. In this way it becomes easier for developers to enter a wider global market without any consequent increases in their support and development costs.

While moving the product into the cloud the project partners experienced a change in the skill set of their software engineers (micro theme: *Software engineers acquire new skills*). Although the product features remain largely unchanged, access to the product is now commonly provided through a web browser interface. The net effect was that their software engineers had to acquire new skills to accommodate this change in provision (e.g. HTML, usability, etc.). In addition, some project partners found that they now needed to develop skills and knowledge about the customers' IT infrastructure for accessing the cloud services.

The second macro theme identified was *Migration process*. The companies decided how to move forward with the use of cloud computing on a step by step basis but without defining a clear path upfront (micro theme: *Technology migration roadmap*). This is to some extent consistent with the previous macro theme (*Strategy for the cloud*). Because they are essentially the possibilities afforded by cloud computing the companies want to be able to adjust their plans quickly and dynamically to exploit new opportunities as they arise. The majority of project partners did not consciously use a lifecycle for cloud product development or transition and moved their existing products into the cloud while planning to add cloud specific features in future iterations. They have added features on a demand driven basis, which means that companies add features as required or based on customer feedback. By not developing a rigid plan upfront the companies were able to become more agile.

The later phases of the product development lifecycle become easier through cloud computing, particularly testing and releasing the software product (micro theme: *Testing and releasing software becomes easier*). It is easier for companies to use cloud computing for testing because it facilitates the rapid generation of virtual computing environments in which to do the testing. Having a single instance of the line software residing on the cloud environment avoids installation issues at customer sites. To make the transition from traditional computing environments to cloud computing easier all of the project partners provided assistance to their customers in moving to the cloud, such as data migration and support (micro theme: *Companies support their customers in migration*).

The third macro theme was *Customer perceptions*. Although the majority of customers can see the benefits of cloud computing, not all of them are willing to adopt cloud computing at this time. This means that the project partners have two groups of customers: cloud customers and non-cloud customers (micro theme: *Division of customers*). The project partners reported that some of their customers are still not confident in the security of cloud computing. The concerns of non-cloud customers are often related to issues like commercial confidentiality in the cloud (micro theme: *Customers see benefits and risks*). In order to support a broader adoption of cloud computing these sorts of concerns may need to be addressed early during development. The majority of project partners have already negotiated their SLAs with their cloud provider to fit their specific needs to further support broader cloud adoption by their customers (micro theme:

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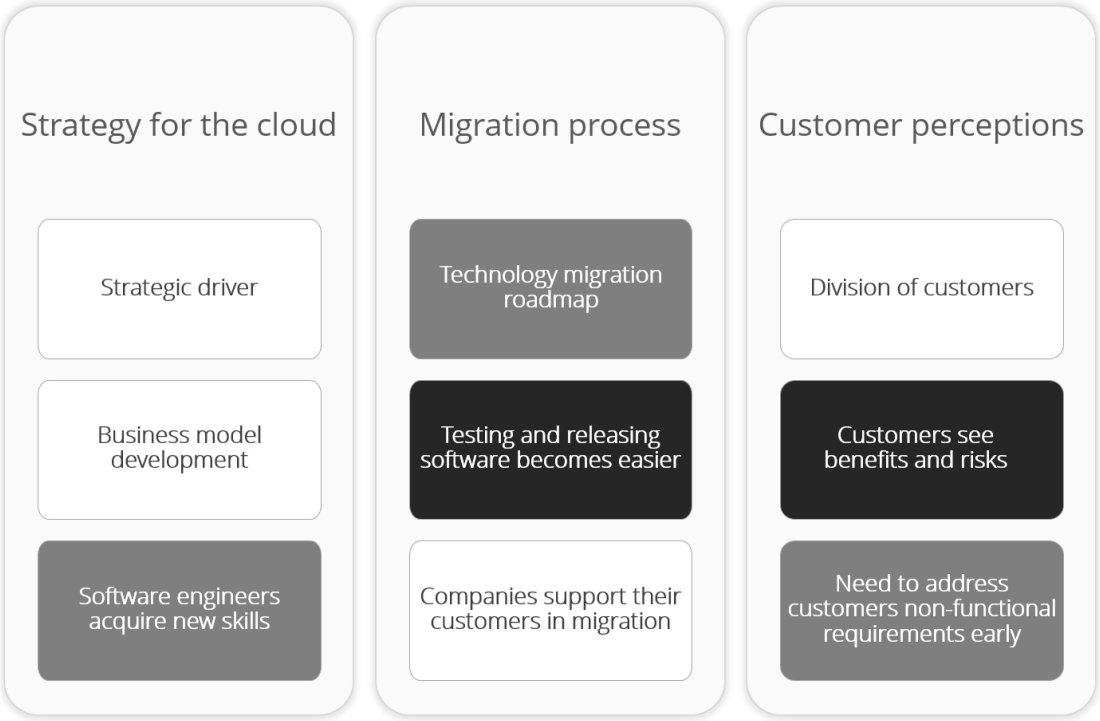
Need to address customers' non-functional requirements early). One issue companies faced was a non-alignment between the SLA of the cloud provider and that demanded by the customer. So the selection of the provider was based on their willingness to respond to this mismatch, thereby avoiding potential customer liabilities.

EMERGENT TENSIONS IN CLOUD ADOPTION

If we now analyse the micro themes in particular, in terms of how they fit in with the notion of adaptive STSs, we can see three tensions emerge during cloud adoption:

- The first relates to the micro themes that deal with cloud computing from a systemic and long term perspective (coloured white in **Error! Reference source not found.**),
- The second relates to the micro themes that deal with the issues caused by cloud computing as a large scale and complex system (coloured grey in **Error! Reference source not found.**),
- The third relates to the micro themes that deal with cloud computing from a customer and user perspective (coloured black in **Error! Reference source not found.**).

Figure 4: Categorisation of themes from an adaptive STSs perspective.



We discuss each of these tensions (which are summarised in

Figure 5) below.

Tension 1: Strategic Drivers Vs. Customer Perception

The first tension can be summarised as the tension between strategic drivers and customer perceptions. Companies are keen to use cloud computing to explore new ways to market their software products and services, which could result in the development of new business models. At the same time, however, they are trying to reduce their software development and support costs and increase their revenue. They simultaneously pay attention to the needs of their existing customers, because not all customers may be willing to move to the cloud straight away. This could be one reason why, for the majority of project partners, their first step was moving their product into the cloud without making any changes to it. In this way they can gather data about customer experiences before investing more time and money to add cloud specific functionalities or fully exploit cloud advantages. For example, some project partners noticed an increase in softer costs (e.g. because they now have more customers spread across different time zones, they need to provide more comprehensive customer support capabilities).

Tension 2: Culture of IT vs. Complexity of IT

The second tension can be summarised as the tension between the culture of IT and the complexity of IT. On the one hand the project partners are giving up control over their IT because they are effectively replacing their IT resources with equivalent resources that are owned by the cloud provider. There are no guarantees, however, that the chosen cloud provider will still exist in twelve month's time. The project partners do not regard this issue as a problem and do not perceive a loss of control but the potential problem still exists. One reason for this could be that the project partners are giving greater weight to their increased level of agility and flexibility that they get through using the cloud. They get what they order from their cloud provider instantly and can cancel the resources when they are no longer required.

On the other hand, the project partners need to retain at least part of their existing IT infrastructure during the migration to the cloud. Not all customers are willing to use products in the cloud, so the partners' IT infrastructure is likely to be more complex because it comprises a mixture of their own equipment as well as resources that are located in the cloud. In addition, the management of the cloud computing infrastructure plays a role, although we obtained conflicting views on this issue: some project partners said that cloud computing is simpler to maintain, others said that cloud computing made their IT infrastructure more complex. One reason for an increased level of complexity could be the fact that it is easy to deploy new resources in the cloud. But because they need to retain some hardware in house the possibility emerges that resources are left unused or unattended (so called Shadow IT). Shadow IT can occur in both the old environment (i.e. the existing in-house infrastructure) and the new environment (i.e. in the cloud) simultaneously.

Tension 3: Short Term Product Development vs. Systemic Product Development

The third can be summarised as the tension between short term product development and systemic product development. On the one hand it becomes easier for the project partners to test and deploy software, and therefore to integrate new customer demands and business requirements more quickly. Through cloud computing the project partners are able to change

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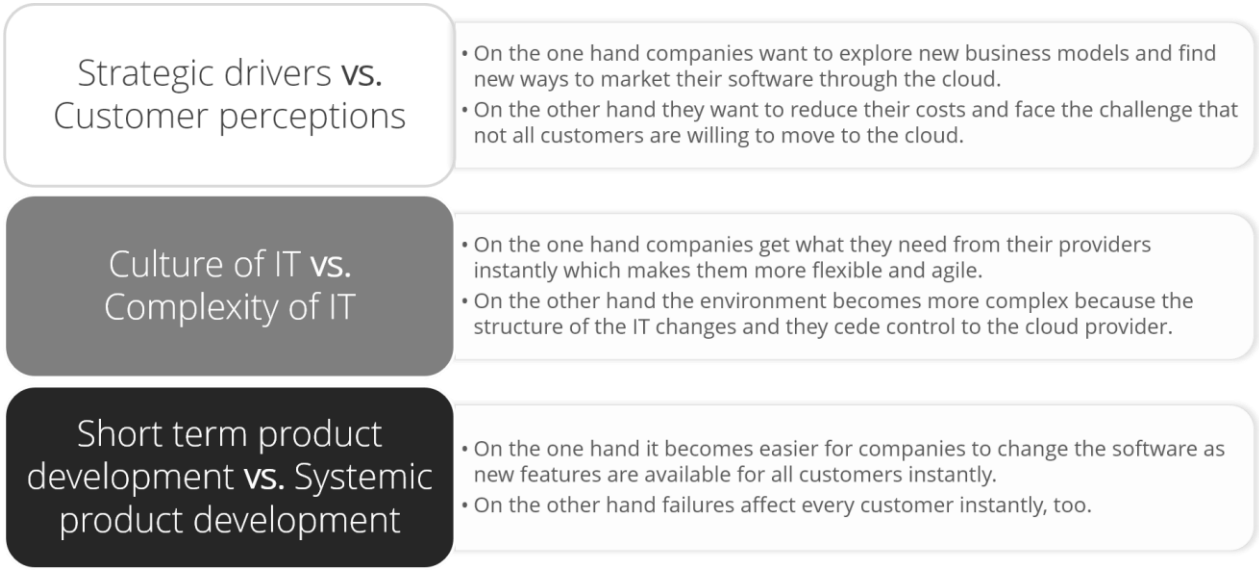
their product in one place and make changes available to all customers instantly. On the other hand the project partners need to pay closer attention to the integrity of their software product because any failures arising out of the changes will affect every customer instantly, too.

Figure 5: Emergent tensions in cloud adoption.



It is not new that it takes time to move from one technology to another, or that companies will have to deal with two groups of customers during this transition. The project partners are not only dealing with technology or IT issues during cloud adoption. Integrating with a new technology, like cloud computing, affects the entire company (e.g. HR, Finance, Risk, Governance should be actively involved during the transition). This means that if things do not go quite as expected—if the tensions are not managed, for example—the impact can be widely felt throughout the company.

ADAPTIVELY MANAGING THE TENSIONS OF CLOUD ADOPTION

Given that we have identified some tensions that can cause problems during cloud adoption, we need to think about how we can manage those tensions. Ideally, we would like to be able to anticipate those tensions before they give rise to any adverse effects on the company. In other words, the company has to be adaptive in the way that it deals with the tensions, anticipating them where possible, and reacting to them in other situations.

A more systemic perspective is necessary to react quickly to unforeseen circumstances. If adaptations happen in an ad hoc, unprincipled way by the employees, processes and tasks may become opaque, immeasurable and incomparable (e.g. if employees order resources without organisational approval). By deploying cloud computing in a more careful and controlled way,

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i.e. execution before innovation, (Rogers, 2003), it should be possible to locally contain any adverse effects of using cloud computing. At the same time it becomes possible to measure the potential benefits, and consider issues of generalisation and innovation if cloud computing is rolled out to the entire company and customers, thus allowing the project partners to maintain their organisational resilience.

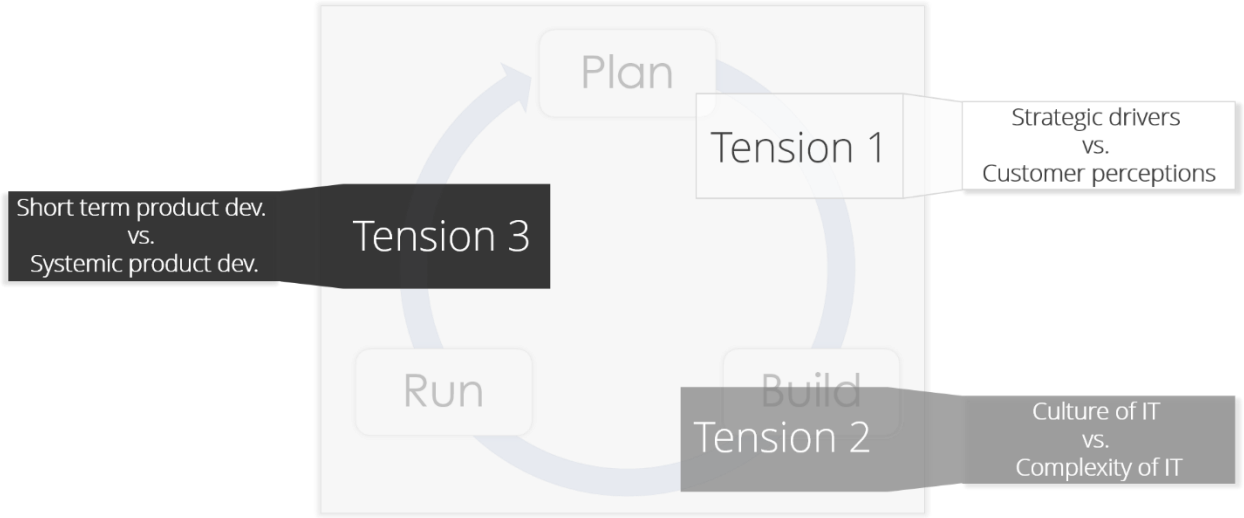
During the interviews we asked the interviewees if they consciously distinguished between phases of development while moving into the cloud (e.g. using a lifecycle) and whether they consciously evaluate each phase. Most of the participants are doing neither at the moment and progress in an exploratory way (see first macro theme *Strategy for the cloud*). In order to explain when the tensions are most likely to emerge we will use the simple generic product development lifecycle we introduced in Figure 1. But instead of using the lifecycle to explain the tensions we developed a template which can be put on top of any lifecycle, or used as a time frame reference for those project partners who are not explicitly using a lifecycle.

The tensions identified in the previous section can be overlaid onto the lifecycle as shown in
. This shows the point in the lifecycle when a company is likely to encounter the different tensions:

- Tension 1: Strategic drivers vs. Customer perceptions
- Tension 2: Culture of IT vs. Complexity of IT
- Tension 3: Short term product development vs. Systemic product development

In the following we will explain in more detail how the tensions can be addressed when moving a product into the cloud.

Figure 6: Tensions in the lifecycle.



Tension 1: Strategic drivers vs. Customer perceptions

Based on the data we gathered during the interviews we believe the project partners are likely to see the first tension emerge during the plan phase. They should decide what their new business

model (using cloud computing) will look like and how costs and revenues, as well as customers, will be affected. Keeping customers involved from an early stage about the move to the cloud could give them time to prepare for it, in terms of both their attitude towards cloud computing and their wider organisational perspective.

Tension 2: Culture of IT vs. Complexity of IT

The second tension is likely to emerge shortly after the start of the build phase. As the company exploits the advantages of cloud computing they are likely to become more agile and flexible. When making decisions about computing resources the companies need to consider the sizes of the traditional and cloud infrastructures. When the company starts to reduce their internal computing resources and increase their cloud resources they should pay attention to interactions and couplings between the two environments. We recommend looking out for the appearance of a Shadow IT at an early stage on so that any associated adverse effects can be contained. Simply being aware of the possibility of a shadow IT may support the partners in containing any adverse effects until they can find a way to prevent the Shadow IT from emerging. For example the project partner could delegate the responsibilities of making sure that no cloud resources are left unused and that every new virtual machine fulfils the company's standards to a specific employee.

We believe employees should be appropriately sensitised to the problems. As well as helping the software engineers, sensitisation could also help the entire company to better understand the impact of cloud computing on the product and company: developing a product in the cloud does not only raise technical issues. Several stakeholders within the company will be affected and we therefore recommend making everyone aware of how cloud computing affects their work will increase the likelihood of the move into the cloud being successful.

Tension 3: Short term product development vs. Systemic product development

The last tension is likely to occur between the run and the plan phases. As the end customers start to use the software product they are likely to provide feedback and start making requests. At the same time the software developers are likely to discover bugs and make improvements to the software product. Although it is easier to change the software in the cloud and make the updated version available to everyone instantly, the project partners can avoid any adverse effects or failures in the software that could affect every customer if they maintain a planned release approach.

Constructive engagement activities can be used to provide a means of integrating cloud product development into software engineering and the organisational change process. There are three types of constructive engagement: (1) defining the problem; (2) constructing the solution; (3) evaluating the solution. By defining the problem everyone involved in the development of the cloud product gets the same understanding of why and how cloud computing is used. This helps to align the development process with the organisational objectives. Constructing the solution involves making the software engineers aware of specific cloud computing issues (e.g. that changes to the software product are available to everyone instantly after release). This includes reaching agreement about which methods are used and integrating them into everyday work

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routines. Evaluating the solution means understanding how the product is meeting customer expectations. In other words, when new requirements arise, or existing requirements change, or when problems arise with satisfying the original requirements, these need to be assessed in their own right, and in terms of the wider development project.

SUMMARY AND FUTURE WORK

Disruptive technologies, like cloud computing, provide benefits and risks. Our findings indicate that the project partners are all going about the cloud adoption process in a controlled way, and pursuing similar goals. All of the partners are still in relatively early stages of cloud adoption within their organisation. The majority are using cloud computing for the products they deliver and only slowly start using cloud computing also internally (e.g. Email in the cloud). As they explore the process of cloud adoption, however, they are learning lessons about cloud computing which extend beyond the technology, such as the need to ensure that they carefully negotiate SLAs with customers *and* cloud providers. These lessons are being applied to help them evolve both their organisation, and the way that they develop and deliver their products to their customers. Our results suggest that there is a need to further investigate the strategic integration of cloud computing and to develop methods that can support companies from both a short and long-term perspective to appropriately deal with any disruptions that may arise.

We have shown that applying an adaptive STS perspective to cloud adoption can help inform organisations about how they can maintain their resilience whilst still being agile. In order to maintain resilience, for example, the organisations need to anticipate potential problems as well as react to them when they occur. The integration of the emergent tensions with the development lifecycle template provides a way for the project partners, and other potential cloud adopters, to understand what kinds of challenges can arise (and when) during cloud adoption.

During the remaining stages of the longitudinal study we plan to investigate how the tensions arise and develop over time within the project partner organisations. Some of the identified tensions potentially carry a greater risk than others to organisational resilience. For example, tension 1 (strategic drivers vs. customer perceptions) is potentially more risky than tension 2 (short term product development vs. systemic product development) because tension 1 has long term implications that are difficult to reverse once in motion, whereas companies can switch more easily between short term and systemic product development depending on what is needed.

Our intention is to try to characterise the tensions so that we can highlight when, where and why they occur, and what the likely effects are. In this way we hope to be able to help companies make informed decisions about implementing appropriate adaptations to manage the effects and thereby maintain organisational resilience. At the same time we will further investigate the effects of cloud adoption on the role of the IT department within the project partners. For example, cloud computing enables companies to offer their applications for smartphones and tablets more easily. This requires, however, a change of skills on the developer side towards human computer interaction because applications designed for a touch screen have different requirements compared to mouse and keyboard ones.

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Our current findings are based on a study involving SMEs who develop software products. In order to test the general applicability of our approach, our long term plan is to apply the ideas to other domains, and to organisations that are not SMEs.

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APPENDIX 1

Questions related to the plan phase of Figure 2:

- Why did the company want to use cloud computing?
- Who proposed the use of cloud computing?
- Can it be considered a Market-Pull or Technology-Push?
- How does the company define cloud computing?
- What will cloud computing be used for?
- What did the decision process look like?
- Was it clear what capabilities are/would needed (to be) developed?
- Did the company go through distinct steps, consciously? (e.g. lifecycle)
- Did the company develop a road map/strategy? (for current and future features)

Questions related to the build phase of Figure 2:

- Were there differences in designing a product for the cloud compared to non-cloud environments?
- Did the company incorporate functionalities of the cloud into requirements engineering to alter your product? E.g. offer functionalities that were not possible before
- Did the work of the software engineers itself change? (processes, methods, skill set)
- Did the IT perceive a loss of control to the cloud provider? If yes, how did the company deal with it?
- Did the company specifically address SLAs, availability, or security in the design process or any other phase?
- Were there differences in developing a product for the cloud compared to non-cloud environments?
- Did this affect the use of cloud computing in other company areas?

Questions related to the run phase of Figure 2:

- Are customers willing to adopt cloud computing?
- Did all the customers accept the use of the cloud? Or did the company have two groups of customers in the end?
- Was there a tension between the two groups of customers (cloud and non-cloud)?
- Did the company support customers with migrating to the cloud?
- Did the adoption of cloud computing adversely affect any part of the company? How did the company identify and deal with it?
- Did cloud computing affect the response to changing customer needs or business requirements?

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