The Impact of Cloud Computing as a Socio-Technical Phenomenon

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring 2023

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

It is often, and correctly stated, that "there is no cloud, it's just someone else's computer," which has profound implications for our relationship to modern technology, as this thesis will address. In this project I will focus on cloud computing, the capability for people to request services like storage and computation from powerful, physically remote computers, which is a major part of modern personal life and business practices. I will use the actor-network theory (ANT) analysis framework to address the social dimension of cloud computing proliferation. Although cloud computing is a socio-technically rich area of study, I aim only to describe how it changes existing relations between organizations, technologists, and everyday people. Thus, the use of knowledge from specific niches within cloud computing does not provide a comprehensive exploration of those niches. The questions addressed by this thesis are important because they focus on a specific development in the computing world which has wide-ranging applications, and thus, implications. Cloud computing has been wholeheartedly embraced by individuals and institutions, yet not much attention is paid to the scope of the potential social ramifications of its widespread adoption. By exploring the overall change in relations caused by cloud computing, my project will be able to pick apart both the positives and negatives.

In the next section, I will discuss the history and use of ANT to orient the reader to the flow of the paper. The following sections will take each of the groups whose relationship to cloud computing is under study and explore how its relationships changed with the adoption of this technology. Finally, I will conclude by discussing how this project fits with other work on the subject of cloud computing.

Background

1. Actor-Network Theory

Although ANT is an approach to social analysis with various constitutive concepts, I will only discuss it in sufficient depth to make the proceeding analysis of cloud computing clear. ANT posits that human and non-humans both participate in the social constitution of technology and that the influence of social forces on the relations of the various actors should not be taken *a priori* to the nature of the relations. Rather, if there are such things as social forces, they are completely constituted by the various relations of between the actors (Latour, 2007). Along a similar vein, analyses by ANT avoid essentialist explanations of the inherent nature of any actor by the reliance on the relations between actors to explain any particular state of an actor-network (Muniesa, 2015).

Important ANT concepts that I will use in this paper are actor/actant, actor-network, sociology of translation, and hybridity. Actors are heterogeneous elements whose associations are traced in actor-networks (Latour, 2007). Because of the broad aim of ANT, nonhuman actors can range from plants to texts and natural phenomena. However, supernatural beings and symbolic natural objects are not covered under the category of nonhuman actors (Sayes, 2013). This paper will take the groups of organizations, technologists, and everyday people as the primary actors around which to situate the actor-networks. Each of these groups is defined more fully in the next section. The sociology of translation, or simply translation is a four-part process through which innovators try to create a collaborative central network in which all the actors agree it is worth building and defending (Callon, 1984). It is important to note that the innovators are also actors, which follows from ANT's rejection of elements not explained by associations. The four parts of translation are problematization, in which the innovators attempt to make themselves and the network important to other actors, interessement, in which the innovators

bind the other actors to the parts that are assigned to them in the network, enrollment, in which the roles assigned to all the actors are connected and mobilization, the determination of whether the actors in a study are adequate representatives of their class (Callon, 1984). This paper will explore how the development of cloud computing can be understood through this process of translation, although emphasis on each part will not be equal. Hybridity is the idea that neither a human nor a nonhuman actor is pure. This means that human and nonhuman entities are to some extent produced through interactions (Jackson, 2015).

ANT can be criticized for its lack of explanatory social forces because they could explain why a network formed the way it did rather than in some other configuration. However, as this paper only aims to discuss the change in relationships caused by cloud computing, which will be represented as an actor, the presence or absence of forces outside of the network does not detract from changes observed after the introduction of cloud computing.

2. Cloud Computing

Cloud computing is a term that encompasses a variety of practices, but they all center around the existence of large scale, remote computing hubs, server farms, or the term which I will use throughout this work, data centers. As businesses and technologists seek to reduce their overhead for information technology (IT), these groups have increased their reliance on computation by people with specialized resources (Ranger, 2022). Additionally, with people creating and storing more digital files than ever, cloud storage is gaining more individual use for personal and business purposes because of the space and flexibility it offers (Sebastien, 2021).

It is important, for the sake of a consistent analysis, to properly define the “organizations, technologists, and everyday people” the change in whose relationships my project will explore. My definition of an organization is inspired by Perrow (1991) in that it is any highly structured

association of people with specific aims, and a target customer base. My use of "customer base" encompasses all people to whom services are rendered by an organization, regardless of whether they are commercial. Unlike Perrow, I will consider any organization with the above characteristics regardless of size. The distinction of organization size is not of great importance when talking about cloud computing because of its availability at multiple tiers (Sebastien, 2021) and its scalability, which translates to non-proportional impact (Ranger, 2022). The social group of technologists is defined as people who are knowledgeable and participate in technological innovation through some sort of tinkering, regardless of the success or results of that tinkering. This group consists of institutional researchers and people who independently explore and modify technology for personal fulfillment or amusement. They either directly explore cloud computing, or they use services that depend on it and are familiar with the nature of that dependence. Everyday people are those who simply rely on cloud-supported products without familiarity with the nature of the dependence.

Because all of the above groups are defined in direct relation to the pure function of cloud computing, that is, the ability to use large scale, remote data centers to operate on data, I am leaving out social groups that don't use the functionality of cloud computing but may be related to it in some way. These groups include the people involved in the resource extraction necessary to create data center equipment and people isolated from the cloud computing phenomenon for a multitude of other reasons. They are left out of my analysis because a discussion of their relationship to cloud computing would require deep exploration of the process of the development and proliferation of cloud computing. Questions raised by this would range from why they are not related to cloud computing to how the technology could have been developed in

such a way as to have them participate in its functionality, which are all beyond the scope of my research.

Analysis

Because I aim to explore how the existence of cloud computing changes the relations between the above-mentioned groups, I will explore the structure of actor-networks centered around each of the groups before and after the proliferation of cloud computing. I will work backwards by starting with the current uses and effects of cloud computing, then determining the previous nature of those relationships if they existed at all. Because the central actors in the networks I am analyzing are groups of a general kind of entity, rather than specific entities, other actors will also be groups. This allows me to abstract away unique attributes of relationships that may exist between more specific entities to arrive at a general description of the relationships between the groups. On the other hand, this does not bar the inclusion of specific entities in relation to groups. It is possible that a relationship exists between a group and only, or in proportions so overwhelming that it may as well be, one entity.

To facilitate the development of the actor-networks, I will examine the stories that are told about cloud computing. For these stories, I will primarily look at scientific literature and popular technology magazines. Identifying protagonists and antagonists in stories will help expand the network because each constituent of a story, when explored, can be part of another story. Necessarily, there will be some redundancies across these artificially separated actor-networks, but that does not lessen the strength of the analysis.

1. Organizations

Cloud computing offers organizations possibilities for outsourcing software developmental operations across distinct geography (Khan et al., 2022). This helps place the

general category of software developers as a human actor in the network. However, it is not reasonable to assume that organizations in general are directly related to software developers. Instead, I will introduce software as a nonhuman actor that is directly related to organizations and software developers as an intermediary because virtually all modern organizations rely on some form of software for various productivity-improving functions (Byrne et al., 2018; Khan et al., 2022). Outsourcing is the business practice of contracting work to (usually) foreign suppliers to improve efficiency and cost. Being neither supernatural nor a symbolic natural phenomenon, outsourcing can also be a nonhuman actor in the network. The final actor that is important to organizations in the cloud computing regime is the internet, as it facilitates organizations relationships to the other actors (Khan et al., 2022). High speed internet has been integral to the proliferation of cloud computing (Byrne et al., 2018).

Before the advent of cloud computing, organizations still needed to perform many of the same tasks that are now facilitated by it. Because high speed internet was so instrumental to the movement towards cloud computing, I will use 2003, at which point fiber optic bandwidth limits were being stretched, as the demarcation of the time before and after cloud computing (Yao, 2003). Many technologies were employed for the seamless and efficient use of software (Foley & O'Reilly, 2003; Byrne et al., 2018). An important technological development that enabled organizations to start moving to take advantage of high intensity computation as a precursor to cloud computing, was virtualization. Virtualization is the capability to host multiple distinct computing environments on the same hardware. It has been commercially available in IBM mainframes since the 1970s (Byrne et al., 2018). From this fact, mainframe computers in general emerge as an important actor in the organization network before cloud computing. This allows a convenient description of all organizations that took advantage of virtualization capabilities in

common hardware. Time-sharing services are another actor due to their use and advantages for the 30 years following 1955 (Byrne et al., 2018). Before cloud computing, outsourcing was also an actor in the network for organizations, their relationship had a different character (Currie & Seltsikas, 2001).

2. Technologists

Because it is necessary for technologists to connect to the cloud, the internet is the most obvious actor in the network for technologists. Technologists, like any user, access cloud services from some cloud provider, which places cloud providers in the network as well (Sebastien, 2021; Khan et al., 2022). Cloud providers offer cloud access with varying capabilities and costs which can be chosen by technologists for their desired purposes (Byrne et al., 2018; Sebastien, 2021). A common motivation for software developers' use of cloud computing in their work is to improve efficiency, according to metrics like cost and development speed (Khan et al., 2022). As Khan et al. further document, resource use is an important feature of cloud-based software. Because my definition of technologists is focused on those who are cognizant of the workings of cloud computing, I believe the consideration of resource use can be generalized to all technologists and not just software developers. This makes resources an actor in the network, which are conserved for technologists by cloud computing. Although "resources" is a general category, it is helpful to remember that it includes, but is not limited to money, energy, and compute time.

Before cloud computing, although academic and non-academic technologists depended on somewhat different computing paradigms, they had commonalities which can be generalized to all technologists for the purpose of this paper. Timesharing was dominant in academic settings until the 1980s but remained more so in other organizations until the rise of cloud computing

(Arms, 2014; Byrnes et al., 2018). Its uses included teaching programming and fast computation for engineering and the sciences (Arms, 2014). Thus, timesharing services are an actor in the technologists network before cloud computing.

3. Everyday people

Given the belief of 92.13% of people that cloud storage has influenced them, storage is clearly an important use of cloud computing for everyday people (Sebastien, 2021). Cloud storage is an actor in the network for everyday people because people use it as both primary and back-up storage for office and personal data (Sebastien, 2021). Unlike organizations and technologists, the cloud is not widely used by everyday people for computing, with only 33.8% of people reporting such use (Sebastien, 2021). Because the survey reported by Sebastien considers usage by all people without differentiating between technologists and everyday people as I do, the actual number of everyday people that use the cloud as a medium for computation is likely lower than the reported 33.8%. Given the low number, I will not consider computing, that is, using remote data centers for calculations and processing, as something generalizable to the entire category of everyday people. Cloud providers are an important actor in the network for everyday people. Like technologists, they also require cloud access through cloud providers although their usage may require a different selection of providers (Byrne et al., 2018; Sebastien, 2021). Software, which is increasingly cloud-based, is another important actor in the network for everyday people (Khan et al., 2022).

Before cloud computing, cassette tapes, floppy disks, CDs, flash drives and other physical media were used to facilitate everyday people's demand for file storage and file sharing (Sebastien, 2021). Such media was also the dominant means for software distribution, as exemplified by Microsoft's reliance on other distributors for its Office software suite even in

2010 (*Office 2010 Frequently Asked Questions - Products - Microsoft Office*, 2010). Thus, it is reasonable to add technology retailers as an actor that everyday people depended on for software distribution before the proliferation of cloud computing.

Discussion

I will explain how each of the relationships identified as existing before cloud computing was changed or eliminated through the sociology of translation. Since the 1960s, universities and commercial organizations' have been using and developing systems of multiple computers to do work (Arms, 2014; Byrnes et al., 2018). This common problem for organizations provides an obligatory passage point for problematization which allows organizations to be enlisted into the actor-network of cloud computing. The fact that many organizations at the time were beginning to heavily rely on software, whose development and execution was costly, increases the effectiveness of the multi-user problem in convincing organizations of the importance of cloud computing.

The initial divergence of university computing from other computing by focusing more on interactivity for faculty and students rather than on large batch jobs can be seen as a resistance to joining the network which must be overcome by interessment. This could be achieved due to universities' common goal with other organizations of maximizing the use of the processor compute cycles (Arms, 2014). Thus, I can say that the interessment of organizations had two stages. First, universities had to submit to the development of their identities as intertwined with other organizations, and then the group of organizations as a whole had to submit to the development of their identities by cloud computing. Arms' account of universities collaboration with other organizations in the development and proliferation of networks and personal computing demonstrates the first step in this process. Joaquin Lippincott, CEO of Metal Toad,

offers the mechanism for the interessment of organizations as a whole. Namely, through the evolution of software and customer demand. When AWS began posting its prices online, it made it clear how businesses could benefit from the use of cloud by just looking at the monetary advantages. CEO's belief that "The Cloud is changing how all software should - and will - be built. Software is no longer a cost center or a need-to-have for most corporations, but rather a critical part of their customer experience and value chain" (Lippincott, n.d) is a clear demonstration that at least corporations' identities have been tied into the cloud because of the dependence on software. Universities, having enjoyed educational partnerships in computing for a long time, benefit from cloud computing in their use of software, responsibility to educate students about the latest technology, and their use of Google and Microsoft cloud services for storage and file sharing. This dependence does not merely demonstrate interessment, but also enrollment, because the relationship at this stage does not merely consist of questions to be answered (Callon, 1984). Finally, I need to address the question of whether the organizations mentioned are sufficient representatives of the class of organizations. That is, I must address whether the fact of universities' and corporations' use of cloud computing is enough to say that organizations in general have been enrolled in the network with cloud computing. Given that the enrollment of both of these kinds of large organizations is partially characterized by the dependence on cloud-based software, it is fair to say that most organizations, who have such a dependence for payroll, distribution, and many other functionalities, are enrolled. Furthermore, Lippincott's statements offer evidence that an increasing number of organizations will follow the example of the organizations that are already heavily using cloud computing in their operations.

Because computing required so much capital in its formative years, it would make sense that the sociology of translation for technologists was heavily tied to that of organizations.

However, I believe that does not give sufficient consideration to the technologists that did not belong to large organizations, the hobbyists. Based on how cloud computing became generally available to individuals at a different time than it did to organizations, it seems reasonable to say that the hobbyists who use cloud computing have a different focus than those before cloud computing. In fact, it seems that unlike for organizations and organization-dependent technologists, problematization, interessment and enrollment happened nearly simultaneously. As cloud computing became more available to individuals, they were more apt to explore the problems to which they could apply it. In this way, cloud computing became integral to hobbyists because of their own efforts to join the network. After this process, though of course it is always ongoing, hobbyists and organizational technologists can be discussed as one group in the network of cloud computing. As with organizations, the question of adequate representation is complicated by the natural fact of the variation within the group of technologists. Rather than relying on technologists use of cloud-based software, which is a central feature of modern life, I will use their dependence on cloud computing capabilities for their own work as the feature which makes them representative. Those do not use cloud computing are limited in the scope of projects that they can undertake. This inability is existential, but not in the same way as with organizations. Those technologists who do not use the latest capabilities to explore the latest questions will cease to be technologists. This may seem extreme, but I think it is somewhat analogous to the development of other technologies related to cloud computing. Multiprogramming was once a unique method for allowing multiple programs to be run on a single computer in specialized facilities, but it is not available for everyone on a smartphone or personal computer.

Cloud computing initially made itself indispensable to everyday people with its primary offering of remote storage space with the release of Dropbox, Google drive, and other such services. Peoples desire for convenient (non-physical), low-cost storage space led to the high use rate documented by Sebastien (2021). The interessment and enrollment of everyday people also seems to have taken place simultaneously, as people depend on cloud data storage for their primary storage. This is a clear acceptance of a role within the cloud computing network. Although the simultaneous worry about data privacy may create the appearance of a continued struggle to fully enlist everyday people in the network, I think the increasing use rate provides contrary evidence. It is more likely that the worry about data privacy will only lead to data-protective measures being increasingly enlisted into the cloud storage network rather than everyday people leaving it. Unlike the previous groups, the question of representation for everyday people seems to have straightforward answers by seeing whether the people using cloud computing are being followed and how much the exceptions matter. Each generation uses cloud storage at a higher rate than older generations, which is a clear demonstration that not only is there mimicry, but also increased intensity in the relationship between everyday people and cloud computing. On the other hand, drawing from Callon's (1984) election analogy, it is safe to take the overwhelming majority of people who believe they have been influenced by cloud storage as those who have been elected as spokespeople, therefore silencing others. After all, the United States' representative system often accepts much lower turnout as sufficient representation of the citizens.

Conclusion

Networked computing, let alone the modern cloud, was once an aspiration of computing researchers, but it has grown to be an influential actor in modern life, business, education and

technology development. My exploration of the development of cloud computing started from the early era of large scale computing and described how some relationships that existed then have persisted and changed, as well as how new relationships sprung up from the availability of cloud computing. The various relationships surrounding cloud computing and organizations have remained closely intertwined, while those surrounding cloud computing, organization-independent technologists and everyday people, respectively have more recently developed. I used the ANT framework to explore how cloud computing affects those who use it, but the same framework can be taken in future work to explore the effect of cloud computing on those who do not use it with similar descriptive power.

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