E-THELLO

SERVERLESS COMPUTING AND ITS INFLUENCE ON LABOR DYNAMICS WITHIN THE TECHNOLOGY INDUSTRY

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Engineering

By
Brian Lai

December 1, 2023

Technical Team Members:
Ziang Jiao, Brian Lai, Dennis Tian, Lawrence Truong

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.

ADVISORS

Joshua Earle, Department of Engineering and Society

Adam Barnes, Department of Electrical and Computer Engineering

Introduction

Cloud computing, which was first popularized in 2006 with the introduction of services such as Elastic Compute Cloud from AWS (Bigelow, 2022), is a computing paradigm allowing for simple on-demand access to computing resources through the Internet. Instead of having to buy and maintain the software and hardware they wanted to use, businesses and users can now leverage a wealth of on-demand computing resources including cloud-based applications, storage, services, and machines (Bigelow, 2022). This allows businesses to save on capital, labor, and expertise that would otherwise be needed for buying and maintaining these computing resources themselves.

Serverless computing follows the same concept, allowing developers to use servers hosted on the cloud without worrying about managing or configuring them, instead paying for CPU and memory used (Amazon Web Services, Inc., 2023). However, these benefits incentivize companies having a 3rd party replace IT professionals who would otherwise fill in the role of maintaining and configuring on-premises servers. The aim of my STS project is to determine how the adoption of serverless computing has impacted the labor dynamics within the technology industry, and the social and economic implications for IT professionals, including potential shifts in job roles, skill requirements, and job security.

For my technical project of my prospectus, I am currently developing an electronic Othello board that allows users to play against a built-in artificial intelligence program. Othello itself is a two-player strategy game played on an 8x8 grid where the objective is to capture your opponent's discs by strategically sandwiching and flipping them to your color (World Othello Federation, 2023). As an extension to classic Othello, my project aims to bring many of the features of online Othello games to a physical electronic board, like move highlighting,

automatic board updating, and multiple difficulty levels. This project is important as it aims to introduce the game to beginners wanting to learn the mechanics of the game while also providing the benefits of online Othello to more experienced players, making the game more accessible to a wider audience. Despite not being directly connected to my STS project, this also serves to reinforce concepts learned in my ECE courses. In addition, my STS research question is important as it takes an objective look at a widely used cloud service model that most people only focus on the benefits of. It also suggests potential solutions to how companies can repurpose their workflows to fit IT specialists into different roles, adding new jobs and careers to the market. Throughout this prospectus, there will be a section covering Othello and the related technical project, followed by a discussion on serverless computing's impact, my learning objectives, and research roadmap. This will be concluded with an exploration of the key texts included in my bibliography and their relevance to serverless computing.

Technical Topic

Othello is a classic two-player board game played on an 8x8 grid using discs that each have a black and a white side (World Othello Federation, 2023). Players take turns placing one disc on the board, and they must make a move that results in flipping at least one of their opponent's discs (World Othello Federation, 2023). To do this, the player must place a disc such that a row of the opponent's pieces is "sandwiched" between one of the player's previous discs and the newly placed one (World Othello Federation, 2023). Then, the opponent's sandwiched discs will be flipped to the player's color (World Othello Federation, 2023). The game ends

when the board is filled or no legal moves remain for either player, with the winner being decided by disc count (World Othello Federation, 2023).

Like many other popular board games, Othello can also be played online, which has advantages, such as legal move highlighting and automatic updating of the board state, making it much more friendly for beginners. In addition, many online versions of Othello also offer the option to play against a computer if there is not a second person to play against. However, people who prefer playing on a physical board or those without internet access miss out on these convenient features and cannot play at all if there is not a second player. Our project's goal is to solve these problems by incorporating features normally exclusive to online Othello into a self-contained physical board. From a technical standpoint, this project incorporates move highlighting and showing the board state through 8 LED Strips arranged to form an 8x8 grid of LEDs, along with buttons accompanying each LED. By wiring these strips to the Raspberry Pi, pre-existing Neopixel libraries can be used abstract any low-level embedded code and simplify controlling each individually addressable LED through a Python script running on the Raspberry Pi. In addition, the buttons will be soldered to an array of resistors to determine which tile the user chose; these will also be wired to the Raspberry Pi, which can update the board state based on the button press. Lastly, all these components will be assembled and housed in a 3D-printed enclosure with 64 buttons, both of which be designed using Autodesk Inventor.

This project introduces a unique variant of Othello that carries many benefits normally exclusive to online versions of Othello, making it perfect for people of all backgrounds and ages to play. By being entirely self-contained, incorporating an AI opponent, and only requiring a power bank to run, it also makes it a great portable option in areas with no cellular service or power outlets. Additionally, the board does not require physical pieces, as the board state is

represented entirely by the state (on/off) and color of the LEDs. This makes setting up an Othello game quick and hassle-free and removes the possibility of pieces being lost. Lastly, since the difficulty of the AI opponent is adjustable, this idea is great for players in any skill range.

STS Topic

Research Question:

For the STS project, my research question is: How will the adoption of serverless computing impact the labor dynamics within the technology industry, and what are the social and economic implications for IT professionals, including potential shifts in job roles, skill requirements, and job security? Specifically, this project focuses on serverless offerings from AWS, including but not limited to Lambda, Fargate, SQS, S3, and more. Due to my familiarity learning about these tools for my AWS Cloud Practitioner Certification, as well as Amazon's market dominance in the cloud infrastructure services market (Ofcom, 2023), it makes the most sense to focus specifically on AWS offerings. The topic is important as it discusses the effects of serverless computing in a social context and emphasizes how emerging technologies can reshape employment opportunities and workforce skills. It also analyzes how the skillset of IT specialists has changed due to more companies adopting cloud and serverless computing technologies. Lastly, it suggests potential solutions to how companies can repurpose their workflows to fit IT specialists into different roles, adding new jobs and careers to the market.

Relevant Social Groups:

The social groups of interest for this project include the U.S. Department of Labor, hiring teams at tech companies, Amazon's consumers, Amazon's upper management team, researchers

in academia, and IT specialists. Except for academic researchers, these groups are all related to Amazon either through employment or by making the major decisions and strategies for the company, which includes hiring decisions, company principles, and research efforts. Hiring teams at major companies, who define the availability and desired skills for job postings, directly impact the job market for IT specialists and are thus directly related to answering the research question. Likewise, Amazon's upper management also plays a role in the company's operations, overall direction, and objectives, which in turn affects how much hiring needs to be done for varying departments within the company. In addition, they define the company's culture and expectations, all of which are also connected back to the job market for IT specialists.

As for the other two groups, I decided to include them for different reasons. Amazon's consumers, which include all individuals and organizations that use AWS services, also influence the market demand for IT specialists (Galup et al., 2004), more of whom will be needed as the size of the underlying AWS infrastructure increases to meet the growing number of customers. In addition, I decided to include Academia because of preexisting research on AWS and the job market for IT specialists. This research could also be useful for identifying Amazon's current demand for IT specialists, what goals they fulfill in the company, and what services and infrastructure they are expected to work with. This is important to understand as it would likely reflect the role of IT specialists in smaller tech companies that use AWS serverless offerings, which could provide insight into their overall role in the current cloud computing market. Lastly, the U.S. Department of Labor would likely have the largest impact out of all these social groups, as their aim is "to foster, promote, and develop the welfare of job seekers; improve working conditions; advance opportunities for profitable employment; and ensure work-related benefits and rights" (U.S. Department of Labor, 2023). Since my research question is

based around the job market for IT specialists, this department would likely play a role in regulating employer practices and compensation at Amazon.

However, I decided to leave out several other potentially important social groups, the first of which is the general group of all Amazon employees. This is because they have less influence than upper management or hiring managers on the company's need for IT specialists, even if they have some say in the process. Another interesting social group that I left out was the upper management at all major tech companies other than Amazon. Although looking into them can shed light on their hiring decisions and company principles, researching this group would be redundant and unnecessary since most other major tech companies including Google, Apple, and Microsoft don't primarily use AWS services in their infrastructure for security and strategic purposes (Michalowski, 2023).

Researching these social groups is important as it sheds light on the current role of IT specialists in the cloud computing industry and helps to build a better understanding of how the current role of IT specialists can be adjusted in a market where serverless technologies are becoming increasingly common. By learning what tools, infrastructure, and software IT specialists work with, researching how these can be applied to serverless technologies will enable companies to add new jobs and careers to the market to provide economic support that would otherwise never be achievable through government intervention alone.

Actor/Network Theory Framework:

The Actor-Network Theory (ANT), which is my framework of choice, focuses on the connections between both human and non-human entities, or actants, and aims at examining how they influence a larger techno-social system, or network (Crawford, 2020). In other words, an

actor-network isn't a network of actors, but rather is an assemblage of different forces, including physical and social factors, into something greater than the individual forces (Edler-Vass, 2015). Anything could be an actor-network; for instance, an iPhone 15 is an assemblage of physical factors like technological and scientific innovations, as well as social factors including consumer demand and having a distinction by belonging to the Apple brand. Changing any one of these factors in the actor network, such as adding a home button, changes the entire actor-network into something different, even if only by a little.

In the context of my STS topic, my actor-network is the assemblage of interconnected entities, both human and non-human, that play a crucial role in shaping and influencing the dynamics surrounding serverless computing. This framework is well-suited for analyzing complex interactions between various actors (Britannica, 2023), such as IT professionals, Amazon's upper management, and Amazon's consumers. It also weighs non-human actors (Britannica, 2023) such as AWS serverless offerings as equal participants in networks and aligns with my research on power relationships between technology companies, IT professionals, and the labor market. Lastly, my research also explores the social and economic implications of serverless computing on IT professionals, which fits well with ANT's emphasis on societal implications. For my methodologies, ethnography and referencing previous historical literature best fit my topic. For my project timeline, I will first conduct interviews with IT professionals and AWS users to gather insights on labor dynamics and economic implications. Next, I will look at academic papers on the IT profession, and use sources such as hiring principles, hiring pages, and the AWS website to see how Amazon's hiring culture and services can become actors in this network. Finally, I will research the goals of each member of Amazon's upper management to see how they influence Amazon's hiring process and company values.

Key Texts

The Ofcom Cloud Services Market Study (Ofcom, 2023) is the primary report that will be the focus of my STS topic. This outlines all the findings on the study done in the UK to better understand the market for cloud services in the United Kingdom and determine whether it works well for customers. This 222-page report is important to my project because it provides an in depth look into the cloud services market, how competition works in the sector, the main players in the market, and context to major cloud service providers and the different types of cloud service models. It allows me to not only understand the context behind AWS serverless offerings and the role they play in the market, but also give me some insight into how Amazon as a whole interacts with its customers and the market from an unbiased perspective.

The second source is Amazon's AWS homepage for serverless services (Amazon Web Services, Inc., 2023), which provides an overview of the major AWS serverless offerings for computing, application integration, and data store. This also outlines the advantages of their technologies, including lower costs, automatic scaling, built-in service integrations, and no operational overhead (Amazon Web Services, Inc., 2023). This is important to my project as it serves as my primary reference for researching any AWS serverless technologies, which will give me insight into what skills or technologies are needed for IT specialists to adjust to the changing needs of companies.

The Demand for Information Technology Knowledge and Skills: An Exploratory Investigation (Galup et al., 2004) is an academic paper which documented the desired information technology knowledge and skills that employers were searching for between 2001-

2002. In this paper, they examined the content of job advertisements for information technology professionals placed in an online job placement website over a 2-year period (Galup et al., 2004). This is important to my STS topic as it provides a baseline as to what the job market was like for IT professionals before the introduction and widespread use of cloud computing technologies from major technology companies. This can then be compared to current cloud computing trends as well as more modern job postings to get an idea of how the labor dynamics in the tech industry have changed.

Lastly, *The Impact of Cloud Hosting Solutions on IT Jobs: Winners and Losers in the Cloud Era* (George et al., 2023) is another more recent academic paper outlining the how the transition organizations are making to cloud hosting solutions impacts IT jobs. Although it doesn't focus specifically on AWS and their serverless offerings, it highlights the emerging roles in high demand and key skills that are critical to future employability for IT specialists (George et al., 2023). As such, this is directly connected to the research question posed by my STS topic and can serve as a good reference before I narrow down the non-human actors to AWS serverless services specifically.

References

Amazon Web Services, Inc. (2023). *Serverless Computing – Amazon Web Services*. Retrieved October 10, 2023, from https://aws.amazon.com/serverless/

Bigelow, S. J. (2022). *The history of cloud computing explained*. WhatIs.Com. Retrieved October 26, 2023, from https://www.techtarget.com/whatis/feature/The-history-of-cloud-computing-explained

Britannica (2023, October 5). *Actor-network theory | sociology*. Retrieved October 26, 2023, from https://www.britannica.com/topic/actor-network-theory

CompTIA (2022). *IT Industry Outlook 2023*. Retrieved October 10, 2023, from http://connect.comptia.org/content/research/it-industry-trends-analysis

Crawford, T. (2020, September 28). Actor-Network Theory. *Oxford Research Encyclopedia of Literature*. Retrieved 30 Nov. 2023, from https://doi.org/10.1093/acrefore/9780190201098.013.965

Elder-Vass, D. (2014). Disassembling actor-network theory (Version 1). Loughborough University. https://hdl.handle.net/2134/17424

Galup, S. D., Dattero, R., & Quan, J. J. (2004). The Demand for Information Technology Knowledge and Skills: An Exploratory Investigation. *Journal of International Technology and Information Management*, *13*(4). https://doi.org/10.58729/1941-6679.1200

George, A. S., Fernando, S., Almatroudi, Y., & George, A. s. (2023). *The Impact of Cloud Hosting Solutions on IT Jobs: Winners and Losers in the Cloud Era*. *02*, 1–19. https://doi.org/10.5281/zenodo.8329790

Michalowski, M. (2023, July 24). *Who's Using Amazon Web Services? [2023]*. Spacelift. https://spacelift.io/blog/[slug]

Ofcom (2023, October 5). *Statement: Cloud services market study (final report)*. https://www.ofcom.org.uk/consultations-and-statements/category-2/cloud-services-market-study

U.S. Department of Labor (2023). *About Us*. Retrieved October 10, 2023, from http://www.dol.gov/general/aboutdol

World Othello Federation (2023). *Official Rules For The Game Othello*. Retrieved Oct. 26, 2023, from https://www.worldothello.org/about/about-othello/othello-rules/official-rules/english