

**Speculative SuperOptimization: Boosting Performance via Speculation-Driven Dynamic Binary Optimization**

**Vetting Social Media: Has social media contributed to anti-liberalism and anti-democracy in the US and India?**

A Thesis Prospectus  
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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**

In today's world, we see a large amount of growth in research in different computing methods such as the conventional processor or the more revolutionary quantum computer (*Report highlights growth in Quantum Research 2021*). Through this growth, we have seen the introduction of more efficient and modern services that have bettered our standard of living. In effect, large technological giants have been created that hold unprecedented amounts of data on their users, giving birth to new concerns as some people argue these huge companies are damaging our foundational values (*"Freedom, Equality and Justice" – the essential Values for Peace 2019*). I hope to address both the research into speeding up a conventional processor and what role these technology companies play in our society in my technical and STS papers.

I will be considering two research topics for my Capstone, with one being more focused on a technical research project while the other being focused on STS principles. The technical project includes super-optimizing micro-ops at runtime to get a speedup. The STS paper focuses more on the extent to which large companies like Facebook, Whatsapp, and Twitter have been used for the erosion of democratic and liberal principles by governments, corporations, and other actors around the world. I chose to primarily focus on Facebook, Whatsapp, and Twitter due to their large audiences and strong political presence in terms of people who use them and the content posted there. When performing my analysis, I will employ Winner's "Do Artifacts Have Politics?" in order to analyze how these three tools have a political aspect inherent to them due to which they reach a certain outcome.

### **Technical Project Introduction:**

Due to many factors such as the rapid growth and expansion of software, changing market risks, rising security threats, and fundamental technological limitations, the

microprocessor industry has reached a turning point. The turning point is having a significant impact because the execution efficiency of modern general-purpose CPUs, which drive a substantial chunk of the world's computational demands, is seeing consistently diminishing rates of improvement. The technical project hopes to address this problem by taking advantage of existing hardware in the processor to aggressively speculatively super optimize the code at the hardware level to get a significant speedup by vectorizing as many loops as possible. It will primarily take advantage of the micro-op cache in the front of the processor to (WikiChip, 2020) detect loops, and then attempt to vectorize them as much as possible. This should provide speedup beyond what compilers already do because more information is available at runtime that can be used when vectorizing.

### **STS Paper Introduction:**

The STS research paper will focus on the broad impact of Facebook, Whatsapp, and Twitter on our society, especially our political system, democracy, and other liberal values. A lot of discussions have been taking place in congress, and at the presidential level regarding the role of big technology firms and their immense power in our society (Feiner, 2021). There have been some proposals by senators warning that the current technological companies are so big and powerful that they have the potential to derail our political system, and therefore we need to break up big-tech like was done in the past to big oil (Britannica, T. Editors of Encyclopaedia, 2020). This paper attempts to determine the extent to which these concerns are well-founded and in what ways, if any, have Facebook, Whatsapp, and Twitter shook the fundamental tenets of democracy and other liberal values of our society. Some cases that would be considered for this analysis include the US election of 2016 (Detrow, 2018), and the Indian government's use of IT

farms on the three platforms to aid in domestic politics (Christophe Jaffrelot & Gilles Verniers, 2020).

### **Technical Project Detailed:**

Recently, the software computing industry has seen rapid growth (Software - Worldwide, 2021), and new challenges have emerged regarding market needs and security. In response to that, modern compilers and JIT engines have made significant progress in generating carefully tuned and optimized machine code (Hall, 2009). This, however, has seen limited impact as a considerable chunk of wasteful computation persists due to compilers' inability to adapt execution to changing workload patterns and hardware resource availability. In addition to that, the progress in the ISA domain has been further limited by the market risks associated with legacy software. Legacy software forces the ISA to not majorly change, causing software and hardware engineers to consider inefficient workarounds. All of this has made apparent the absolute need to more aggressively and seamlessly super-optimize machine code that can adapt to dynamic execution environments even post-compilation and post-deployment.

The goal of this project is to take advantage of an already existing feature - the micro-op translation interface (Fig. 1) - to enable more aggressive and speculative super-optimization of machine code. The project will also take advantage of the existing suite of speculation techniques such as branch prediction, loop stream detection, and load value prediction, etc. (Techopedia, 2017) to track deterministic memory access/branch patterns including potential program variants that are not known at compile-time, and will then leverage this rich knowledge of dynamic execution behavior to transform a given micro-op sequence into a compact stream of super-optimized micro-ops. These new super-optimized micro-op translations will then be placed in the existing micro-op cache (Fig. 2), alongside the regular micro-ops so they can be used

when needed. More specifically, this project will focus on super-optimizing loops by detecting them and potentially vectorizing them based on the statistics collected in regards to different kinds of instructions run in the loop. This research will be conducted under the mentorship of Computer Architecture Professor Ashish Venkat and a Ph.D. student Logan Moody. The work will be broken into chunks based on the following different objectives: 1) Be able to detect a loop 2) Be able to collect statistics about the loop 3) Determine if the loop is vectorizable 4) Vectorize the loop.

When it comes to advancements in modern processors, a lot of focus has been on increasing core counts, but the fact is that most software applications today are still sequential, and thus adding cores does not necessarily lead to faster processing in practical use (Research Computing Services, 2020). As for optimization at the compiler level, even though compilers feature sophisticated optimizations, significant wasteful computation persists due to computational patterns that are unpredictable at compile-time. The proposed research direction tackles this problem by deploying aggressive speculative binary code optimizations at the processor level, enabling continuous optimization of sequential code. Alongside that, since the research will significantly expand the capabilities of classical superoptimization by exposing them to a wide array of speculative processor features, this would prove helpful in other computer science research involving programming languages, compilers, and architecture research. Therefore, the success of this work will have important implications on more than one track of computer science research.

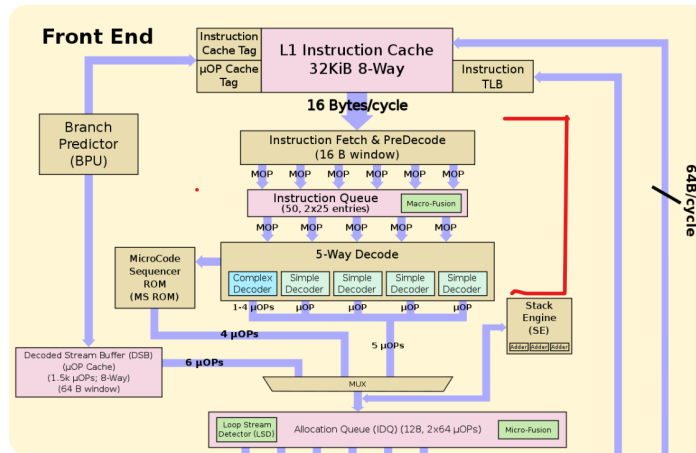


Figure 1: The microprocessor translation interface marked by red lines

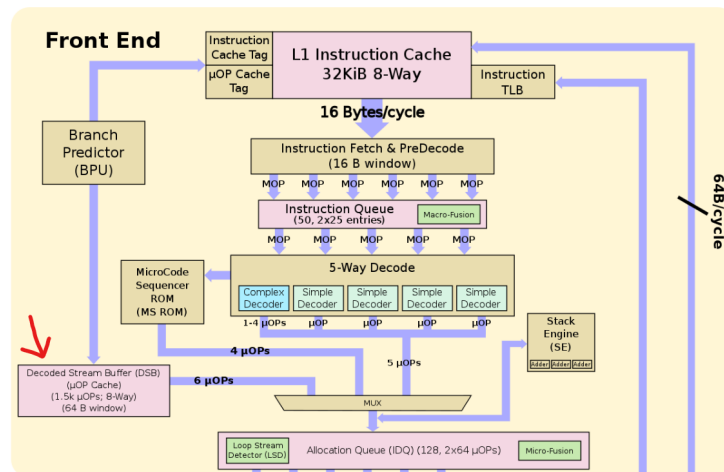


Figure 2: The micro-op cache marked by the red arrow

### STS Project Detailed:

The discussion regarding the role of social media companies in today's society reached a climax after the 2016 presidential election victory of US President Donald Trump as there were many accusations of the use of bots by the Russian government to influence the voting patterns of Americans. A special counsel was set up to investigate these claims headed by Robert Mueller. Mueller's report confirmed initial accusations of information warfare unleashed by the Russian state against the US, and this has started a movement within the US to control big tech

companies like Facebook, Google, and Twitter, etc. (Mueller, 2019). However, before any decisions are made regarding imposing more regulations or breaking up big tech, a careful study is needed of whether the social media tools are responsible for any serious negative events around the globe. For this matter, this research will prove extremely useful as it hopes to determine the extent to which social media, especially Facebook, Whatsapp, and Twitter, contributed to anti-liberalism and anti-democracy around the world.

The STS paper will explore major events around the world that Facebook, Whatsapp, or Twitter caused or advanced, and study how those events impacted the ideals of liberalism and democracy in our society. Some main ones that this paper will consider include the American 2016 presidential elections (Detrow, 2018) and India's ruling party BJP's use of Twitter, Facebook, and Whatsapp to muzzle voices of dissent and promote communal divisions between the Hindu majority and Muslim minority to get an edge in the electoral process against opposition parties (Christophe Jaffrelot & Gilles Verniers, 2020).

The American elections example will serve as a good case study for whether the three chosen social media platforms can play a manipulative role in the most fundamental tenet of democracy: Free and fair elections. Next, the example involving the Indian government serves as a good case study of whether social media can be used by governments to further fascist ideals, or if there are checks to stop that. This example is a lot different from others as it goes beyond just data gathering and involves the government having an active, funded presence on Facebook, Whatsapp, and Twitter.

The paper will analyze for each case which social media tools from Facebook, Whatsapp, or Twitter were used, how they were used, and ultimately determine the role these platforms played. Another aspect that will be considered is what, if anything, did these companies do to try

and stop these grave events from occurring. Data regarding this will be collected by looking at investigative reports such as the Mueller report (Mueller) and Cambridge Analytica papers (Guardian News and Media). Also, information released by whistleblowers, press releases, and testimonies by heads of Twitter and Facebook/Whatsapp to congress will be used. This information will then be analyzed using the STS framework of “Do Artifacts Have Politics?” (Winner, 1980) as a model to determine if unregulated social media poses a threat in the future and whether there is serious potential to these platforms leading to anti-democracy and anti-liberalism around the world.

As mentioned before, a potential Science, Technology and Society (STS) theory that could be used to support this thesis’s analysis of whether social media is playing a role in eroding the democratic and liberal values of western societies is Langdon Winner’s “Do Artifacts have Politics?”. Based on Winner (1980), there are two ways that objects can have politics: by decision, and by necessity. He describes the first one as follows: “instances in which the invention, design, or arrangement of a specific technical device or system becomes a way of settling an issue in a particular community” (p.3) and the second as “cases of what can be called inherently political technologies, man-made systems that appear to require, or to be strongly compatible with, particular kinds of political relationships”(p. 3). This theory pushes back against claims like “what matters is not the technology itself, but the social or economic system in which it is embedded” (p. 2) and argues that the technical objects themselves are worth studying as they are political themselves. This framework would apply well to the research topic because social media platforms are accused of directing increased traffic towards more controversial and questionable posts to keep the viewer engaged and increase the click count (Edelman, 2021). This behavior results in many conspiracy theories prospering in society and is



one way that social media platforms themselves are a political tool that further extremist views. Taking this further, the social media platforms themselves have politics beyond just influencing the politics of the users, and that is what I will focus more on. These platforms hope to get users to spend as much time on them as possible so more ad revenue can be generated, and in effect, they once again encourage addicting and extremist content. This is an intentional design choice that results in the platforms getting those certain politics.

**Conclusion:**

In conclusion, the technical project will focus on using tools like the Intel Pin to detect loops, and then collect statistics regarding those loops. That information will then be used to decide if the loop is vectorizable or not. If it is vectorizable, the loop will be vectorized, but if it isn't it will just be ignored and treated regularly. This, when implemented in hardware using gem5, should result in a speedup in the processors, however, the hardware implementation is not part of this project.

The STS paper will determine to what extent are concerns regarding the negative influence of social media on liberal and democratic values well-founded by studying some real-world cases of extremists/manipulative events that allegedly were caused by Facebook, Whatsapp, or Twitter.

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