Expanding on Multiple Cryptocurrency and Wallet Software

(Technical Paper)

Reducing the Environmental Impact of Data Centers

(STS Paper)

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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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General Research Problem

How can computationally intensive technologies better integrate into society?

Moore's Law is a prediction made in 1965 stating that the number of transistors per silicon chip, and thus computing power, will double every year. Moore's Law has held in the 65 years since enabling powerful new consumer technologies in the "Digital Age" (Moore, 1965). Greater access to complex technologies have led to a society built on digital technology and the movement of information (IGI Global, n.d.). It is critical to assess the impact of the computation heavy technology that shapes society, innovation, and the environment (UNEP, n.d.). Increased software complexity and greater dependance on communication technologies brings challenges in large scale software architecture, storing data, developing accessible software designs, promoting digital literacy, and in powering this new array of technologies.

Expanding on Multiple Cryptocurrency and Wallet Software

How can abstraction simplify interaction with multiple cryptocurrencies within the same software for developers and users?

Cryptocurrencies and software wallets lack uniformity in implementation and features creating scaling issues for software intending to interact with multiple types. This project aimed to generalize the interaction process into stages, streamlining the developer experience and minimizing domain knowledge required by a user. A framework was designed by a technical lead to simplify interaction with multiple currencies via abstraction and encapsulation. I contributed to this team project in a previous internship by understanding the established codebase, fixing bugs, and researching tools to implement the cryptocurrency Monero within the framework. Professor Daniel Graham of the Computer Science department will sign off as the technical advisor for this independent project.

Multi-wallet software is directly related to this project. Software such as “FreeWallet”, “Exodus”, and “Coinomi” provide custom individual wallets for each cryptocurrency they are able to work with (Coinomi Ltd., n.d; Exodus n.d.; Wallet Services Ltd., n.d.). In contrast, this multi-wallet framework works with external wallets allowing for flexibility for the user. An alternate design for working with multiple currencies is multi-asset wallets like “ViaWallet” which provides a single wallet that stores multiple cryptocurrencies. ViaWallet also exposes some of its blockchain functionality in an API for public use, demonstrating similar developer-oriented design goals (ViaWallet, n.d.). Previous research has explored new methodology for multi-asset system design. Tian et al. (2021) investigated an alternative transaction scheme for cross-cryptocurrency transaction using smart contracts, while Xu et al. (2020) designed a system to maintain privacy and security when managing multi-asset cryptocurrency transactions.

A prototype software was built to implement and test project features before deployment. I was directed to use test driven development since functionality for each currency was predefined by the framework. Test Networks were used along with replica currency to test functionality without the risk of using real currency. Project features were split across developers by currencies and/or wallet as each implementation is independent. Planning and general development was handled with a loose agile development style with weekly sprints.

The framework abstracts away the minutiae of a cryptocurrency transaction by splitting the process into two portions - connecting to a daemon and interacting with the software wallet. The developer implements a standardized set of functionalities for each new wallet and cryptocurrency while the user must only know their own currency and wallet. I was initially tasked with exploring and understanding this system such that I could fix bugs and assist in implementing new cryptocurrencies. I then researched whether the publicly available resources for the coin Monero would allow implementation within the multi-wallet framework as is. Monero is a privacy focused coin as opposed to a transaction-oriented coin like the other implemented currencies (Bitcoin, Ethereum, and Litecoin) causing it to have unique quirks in its management of its public and private keys.

Bug fixes and research into additional currencies expanded the array of currencies the framework, and thus the end user, could interact with. The potential implementation of Monero also demonstrates strength in framework design and implies potential in handling similar currencies.

Reducing the Environmental Impact of Data Centers

How do interest groups, including environmentalists, policymakers, and technology companies, strive to reduce the environmental impact of data centers?

Data centers are large scale computing infrastructures that are critical to the backend of the internet, cloud, and data-intensive applications. Global electricity consumption of data centers is about 2 percent and these demands have an annual growth rate of about 5 percent. (Dayarathna et al., 2016). Data centers also account for 0.3 percent of global carbon emissions due to energy use in IT equipment. Cooling infrastructures are particularly energy intensive, with high potential for waste. (Jones, 2018). A benchmarking study by Andrae et al. (2015) predicted the information and communications technology (ICT) ecosystem could use up to 20 percent of global electricity use by 2030, with data centers accounting for a third. Despite data center traffic having an annual growth rate of 23 percent, as of 2018 the electricity use was steady in data centers due to increased efficiency in computing. “The trend is good right now, but it’s questionable what it’s going to look like in 5–10 years,” says Dale Sartor, who oversees the Federal Energy Management Program’s Center of Expertise for Data Centers. (Jones, 2018;

LBNL, n.d.a). As demand for data only increases, what techniques have been used to reduce the environmental impact of data centers?

Participants include “tech giants” such as Google, Microsoft, and Facebook who outline self-imposed sustainability plans (Joppa & Walsh, 2021) and establish groups such as the Open Compute Project (Facebook, n.d.) to promote redesigned hardware to make computing more energy efficient. These efforts manifest in “sustainable data centers” with innovative cooling technologies that are stated to reduce impact on water supplies by working with locals (Walsh, 2021). Participants also include regional policymakers such as the Office of Energy Efficiency that establish data center design guidelines and fund research for energy efficient technologies. (Office, n.d.). Data center efficiency organizations such as the Center of Expertise for Energy Efficiency in Data Centers established by the Federal Energy Management Program also provide technical support, advising, and training programs to private stakeholders (LBNL, n.d.b).

Local participants include “Not in My Backyard” regional grassroot organizations that oppose pollution from generators and high resource use of local data centers. (Glanz, 2012) Environmentalist groups often organize against gas-powered data centers threatening large carbon emissions. (Jordan, 2021; Miller 2014) This has spurred local lawmakers to enact policy mitigating heat, noise, and energy drain from local data farms. (D'Ambrosio, 2019) Participants also include lobby groups created by tech giants such as Google, Apple, and Amazon opposing country-wide data center construction limits established to avoid impacting carbon neutrality goals (Beesley, 2021). Finally, participants include unorganized and organized groups of environmentalists seeking to raise awareness on the energy consumption and carbon emissions of data centers (Kolbert, 2021).

Researchers have investigated policy effectiveness and incentives for reducing energy consumption. Avgerinou et al. (2017) concluded voluntary agreements were favored over mandatory regulations when dealing with the private companies who own data centers such as Europe's Data Centre Code of Conduct. Koronen et al. (2019) highlighted "Ecodesign" requirements in Europe setting minimum efficiency and reporting standards for data center technologies. Kaestner (2014) contrasted incentives for data centers and energy policies within the same U.S. states and discussed how they could better align. General reviews of the technological challenges, environmental impact, and ethical concerns of large-scale data usage have also drawn comparisons between environmental and economic policy (Song et al., 2019; Lucivero, 2019).

Researchers have also investigated company and local participant perspectives. Gilmore & Troutman (2021) performed a review of the local conflicts about water use surrounding Google's South Carolina data center through local news, concluding that despite the potential economic incentives, the core issue is the use of natural resources which embroils Google in local politics. Mills et. Al. (2007) found that improved energy efficiency in high tech facilities such as data centers would lead to increased profits, but companies often prioritize capital use for short over long-term gain.

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