Defending Against Centralization via Asynchronicity.  
by  
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## **Chapter 1**

**Research Problem**

**Researching the Problem of Centralization**

The research problem that the study will address is how to defend against centralization in blockchain technology with a focus in Asynchronous Byzantine Fault Tolerance (aBFT) protocols. To properly address how to defend against centralization in blockchain, a few key theories need to be discussed that fuel the decentralization discussions. Beginning with a fault tolerance problem proposed by the works of **(Lamport et al.1982)** called the Byzantine General Problem (BGP). The BGP is argued to be the underlying philosophy behind blockchain theory and is supported by the proposed statement from (**P. Kuo, 2019)** that “The Byzantine general problem is the core problem that consensus algorithms are trying to solve, which is at the heart of the design of blockchains.” The research articles on the BGP mentioned above are important to defending against centralization in blockchain technology because the contents question underlying issues related to consensus algorithms used in decentralized distributed systems.

The next theory that needs to be addressed is the Blockchain Trilemma. A reference to the Blockchain Trilemma is proposed in the works of **(Aiyar, Halgamuge and Mohammad,2021)**  and states that “three important properties of a blockchain system, involving decentralization, security, and scalability, cannot perfectly co-exist.” The establishment of the Blockchain Trilemma asserted in the research above is important to defending against centralization, because the research quoted claims that there is no one size fits all answer to blockchain solutions and that gaining a better position on one side of the Blockchain Trilemma means losing positions on the other side. **(Aiyar, Halgamuge and Mohammad,2021)**

The next theory to be discussed is the Fischer Linch Patterson (FLP) Theorem that states “an asynchronous network where messages may be delayed but not lost, there is no consensus algorithm that is guaranteed to terminate in every execution for all starting conditions, if at least one node may experience failure.” **(Fischer, Lynch, and Paterson, 1985)** The FLP theorem is an important theorem in asynchronous consensus and can be seen referenced in other research articles such as the works of **(Kaushal, Bagga, and R. Sobti. 2017)** that propose **“**The consensus in a decentralized environment raises serious issues. In literature, there are some impossibility results in distributed consensus like Byzantine’s Generals’ Problem, and Fischer Lynch Paterson impossibility of distributed consensus with one faulty process.” The FLP theorem is specifically important to asynchronous consensus protocols because FLP was the base problem to be solved for The Honey Badger (HoneyBadgerBFT) protocols innovating its atomic broadcasting.**(Andrew Miller, Yu Xia, Kyle Croman, Elaine Shi, and Dawn Song. 2016. )** The HoneyBadgerBFT protocol is accepted in academic research as major breakthrough in practical asynchronous BFT algorithms **(Knudsen et al., 2021)** The FLP theorem from 1985 influencing the conception of the HoneyBadgerBFT in 2016 is important to defending against centralization in blockchain because it shows that aBFT consensus is just now starting to be developed.**(Duan,Reiter, and Zhang, 2018)**

The problem of centralization is blockchain is that it can create vulnerabilities in the distributed system whit the impact potentially being Denial of Service (DoS) attacks and falsified records.**(Q. Lin, C. Li, X. Zhao and X. Chen, 2021)** Because of the potential impact to security mentioned above it is important to defend against centralization in blockchain systems. The current gap in knowledge being that blockchain systems have high costs and low throughput or they gain advantages in those categories by giving up decentralization.**( Y. Jia, C. Xu, Z. Wu, Z. Feng, Y. Chen and S. Yang, )** This is particularly true with aBFT protocols such as the HoneyBadgerBFT that are considered to have a high run time overhead and low scalability **(H. Knudsen, J. Li, J. S. Notland, P. H. Haro and T. B. Raeder)**

## **Chapter 2**

**Research Goals**

**Goals of Defending Against Centralization Research**

The main goal of this research paper is to better understand how to defend against the manifestation of centralization in blockchain technology with a focus in asynchronous implementations. The need for the dissertation work is expressed in the following research studies. The first need is the ability to create solutions to the BGP and Blockchain Trilemma. These problems are the underlying architecture arguments to blockchain **(BGP ref, and Blockchain Trilemma ref)** By addressing these issues blockchain can better defend against centralization.  **(BTC centralized ref.)** The dissertation builds upon the BGP and Blockchain Trilemma problems by getting a better understanding of how to solve the two problems with a focus in asynchronicity. The second need for the dissertation work is to build upon and create implementations that argue the FLP theorem. The FLP theorem argues the issues of consensus with asynchronicity (**FLP ref) .** By understanding and addressing the FLP theorem issue aBFT consensus becomes stronger and an example of this is supported by the implementation of the HoneyBadgerBFT protocol arguing the FLP and Blockchain Trilemma in 2016.**( HoneyBadgerREF)** The next need for this dissertation work is to challenge previous findings. HoneyBadgerBFT is used as a baseline to compare to in aBFT consensus research such as in the works of BEAT (Beat ref) and ABFT (ABFT reference.) By validating the findings of previous aBFT research the field of aBFT gets more peer review on the subject matters.

There are a few specific goals outlined in the research dissertation being proposed. The first specific goal is how to address centralization in blockchain with a focus in asynchronous protocols. The second specific goal is to validate previous research articles on aBFT to verify contents when comparing to other aBFT protocols. The next specific goal is to expose the short comings of aBFT. The last specific goal is to propose future trends in aBFT as it relates to decentralization.

The main research question that this study will address is how can asynchronicity defend against centralization? Are the current researched empirical data validated by other peer reviewed sources and are the contents the same? And what are the future trends of aBFT in regard to blockchain decentralization in the future? There are a few hypotheses that this study will address. The first being the hypothesis that aBFT is just now being practicalized and that there is nothing implemented well enough to compete with the security of traditional blockchain technologies. This can be measured using three degrees of decentralization metrics :Gini coefcient **(Yujin Kwon, Jian Liu, Minjeong Kim, Dawn Song, and Yongdae Kim,2019)**, Shannon entropy **(Keke Wu, Bo Peng, Hua Xie, and Zhen Huang.,2019)**, and Nakamoto coefficient (Balaji S Srinivasan et al. 2019) These metrics are popular in the measurement of decentralization as seen in the research of (**Q. Lin, C. Li, X. Zhao and X. Chen,2019) .** The next hypotheses that this study will address is that the peer reviewed research on aBFT has conflicting data. The research will validate that other research dealing with aBFT has similar outcomes when comparing baselines of consensus protocols such as BTC PoW, ETH PoS, HoneyBadgerBFT aBFT, along with others. The consensus protocols will be judged on the empirical data metrics mentioned above and other metrics such as throughput and latency. Lastly the study will address the hypotheses that future trends in aBFT will become more prevalent in blockchain technology. This will be quantifiable by researching and validating studies that are continuing to research the problems in aBFT and qualitatively asserting these studies potential future use.

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