ABSTRACT

1. This thesis titled '**A Study on Robust Clock Synchronization in a Distributed Network using Mathematical Techniques and Tools**' comprises of 08 chapters. Abstracts of each chapter is given in the succeeding paragraphs.

2. **Chapter 1** is an introductory chapter where we have given a basic background of distributed network, idea and requirement of clock in a network, clock synchronization, fault tolerant clock synchronization and basic definitions. Motivation of under taking the research including intent to utilize **Mathematical Techniques and Tools** to obtained optimized clock synchronization, research contribution and thesis organization is discussed in the later part of the thesis.

3. In **Chapter 2**, we carry out literatures review starting from clock synchronization algorithms available from early 1970s and present day. Some of the Convergence Averaging methods, Convergence Non-Averaging methods and latest synchronization methods are discussed here. Various literatures available on Mathematical Tools and Simulation are also discussed here.

4. **Chapter 3** explore various areas of applied mathematics in some details. Some fields of applied mathematics are used in some form or the other during our research. **Operations Research, Mathematical Optimization, Stochastic modelling and Markov chain** are some of the fields encountered during the research. Concept of **Random Walks model** is also discussed in some dept in this chapter.

5. **Chapter 4** presents a synchronization algorithm, which achieves clock synchronization by using a **weighted averaging as a convergence function**. This algorithm is called **Weighted Average Synchronization Algorithm (WASA)** and it utilizes the concept of sliding window to find the **minimum variance data set** upon which the **convergence function** is used. **We here utilized mathematical concepts of Normal distribution, Variance,**

Weighted Averaging etc to develop the algorithm. We also carried out Theoretical analysis including Analysis for optimal weight assignment for weighted average, Message Complexity Analysis and Time Complexity Analysis. The work presented in this chapter has been published in "**A precise clock synchronization algorithm in network**". Journal of communication engineering & systems. ISSN: 2321-5151.Volume 10, issue 1, 2020. **UGC Care List up to 2019.**

6. In **Chapter 5** we study an **important field of Operation Research i.e., Simulation** for further analyses of our algorithm. A Study on WASA algorithm using simulation is carried out in this chapter. In order to validate the functioning of an algorithm apart from theoretical analysis, simulation of the algorithm also assist in better understanding and subsequent validation of the algorithm. Here we theoretically analysed and run simulation of Weighted Average Synchronization algorithm in various setting for different size of networks. The result of the simulation is analysed and also compared with simulation of well-established clock synchronization algorithm. An **improvement of 33% in precision** is achieved in the worst-case scenario is brought out here. The work presented in this chapter has been published in "**Analysis and Simulation of Weighted Average Synchronization Algorithm: A Novel Precise Clock Synchronization Algorithm**". High Technology Letters. ISSN: 1006-6748. Volume 27, Issue 3, 2021. Scopus (UGC CARE LIST JOURNAL).

7. In **Chapter 6** we further carry out study on clock synchronization. Clock drifting is an intrinsic property of a clock, which necessitates the synchronization and resynchronization. A network consists of nodes, which may behave appropriately or behave badly. The mischievous node may pose difficulty in clock synchronization. We require a method to overcome the effect of mischievous nodes. Synchronization can be achieved in two ways namely accuracy and precision. In this chapter, we present an **Accurate Weighted Average Clock Synchronization Algorithm (AWASA)** to execute a coordinated activity in a fault-tolerant manner. We use trusted clock value from GPS/GLONASS/IRNSS as a reference clock to achieve better accuracy. We also use behaviour of the node to compute normalized weight in a localized

manner, which lies between unit intervals. This weight assignment enables us to contain the effect of misbehaviour up to some extent. This algorithm offers better accuracy and precision while tolerating mischievous nodes. The upper bound of tolerance boundary is one-third of the network size. The work presented in this chapter has been published in "**A Novel Precise and Accurate Clock Synchronization Algorithm**". J. Math. Comput. Sci. 11 (2021), No. 1, 109-124. ISSN: 1927-5307. Scopus (UGC CARE LIST JOURNAL).

8. **Chapter 7** explains the complexity of maintaining synchronization across communication network increases with increase in size of the network and is also dependant on the type of network and its operating environment. In high fault environment, the challenge is high and resource extensive, especially if presence of malicious faults is suspected. Accurate Weighted Average Synchronization Algorithm (AWASA) is one such algorithm designed to provide accurate and precise network synchronization including in high fault network environment. Here we analysed and simulate AWASA in various setting for various sizes of networks. We further analyse the result of the simulation and compared with simulation of Weighted Average Synchronization Algorithm (WASA). The work presented in this chapter has been published in "**Accurate Weighted Average Synchronization Algorithm: Analysis and Simulation**". High Technology Letters. ISSN: 1006-6748. Volume 27, Issue 7, 2021. Scopus (UGC CARE LIST JOURNAL).

9. **Chapter 8** is a concluding chapter. This chapter aims to provide a thorough summary of the major findings and the arguments of the research. The chapter summarizes the works presented in the thesis and conveys the relevance of the research. The chapter also explains Why to go for fault tolerant Clock Synchronization System, Limitation of the algorithms presented and Future Research Direction.