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Review methods for clock skew measurement

Azra Ariel Azmir [1]*, Ni Made Ary Esta Dewi Wirastuti [2], Komang Oka Saputra [3]

[1,2,3] *Department of Electrical Engineering, Faculty of Engineering, Universitas Udayana*

*****Corresponding Author: *azraaariel@gmail.com*

Abstract: Clock skew is the deviation of the clock from the true time, which makes it an important role in time information. Clock skew is unavoidable and causes each clock to run at a different speed, so there is a very slight difference between them, but it can still be observed properly. The known properties of clock skew make it potential research for many experts, such as Paxson, Aoki, and Huang. To produce a more accurate clock skew measurement, this study uses the ant colony optimization method by adopting the behavior of an ant colony in searching for food by choosing the path with the shortest route, which will become the cluster offset as a material for measuring clock skew. Ant colony optimization method has the most potential to be adapted in clock skew measurement because the cluster offset is not affected by the upper and the bottom outliers to produce an accurate clock skew measurement.

Keywords: ant colony optimization, clock skew, cluster offset

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Introduction

Clock skew is the deviation of the clock against the actual time, which is the ratio between the clocking speed between two digital clocks that have the stability between one time with the other and the ability to distinguish between the two devices [1]. The known properties of clock skew make it potential research for many scientists. Such as research related to cloud computing, local area network (LAN), metropolitan area network (MAN), wide area network (WAN), and even research using a smartphone. Research related to clock skew is important because of its measurement accuracy.

Many experts research the measurement of clock skews, such as Paxson, who solves the outlier filter using the median line procedure [2]; Aoki, who uses linear regression to calculate the minimum skew offset [3]; and Huang, who uses the quick piecewise minimum algorithm (QPM) to calculate the skew from the minimum offsets based on the collected offsets at the start and the end of the segment [4] also, the linear programming algorithm (LPA) which determines the clock skew of the line gradient that lies below the entire offset. All the existing methods focused on achieving the accuracy of clock skew in the presence of outliers by utilizing offset characteristics that converged on the cluster bounded at the bottom [5].

Then, the research with hough transform, which combines the concept of clock skew for improves clock skew measurement when the lower bound is unstable due to the presence of low outliers in short time measurements and is particularly suitable for security applications such as device fingerprinting, which require high jitter wireless network connections [6].

Based on the existing research on measuring clock skew, this study will review potential methods to be used in measuring clock skews, such as genetic algorithm methods, ant colony optimization methods, particle swarm optimization methods, and bee colony optimization methods, and analyze these methods to associate with the clock skew measurement.

This study will review several methods that have the potential to be used in measuring clock skew, such as the genetic algorithm method, which determines the cluster offset by taking the results of determining the optimal solution of a problem. The ant colony optimization method determines the cluster offset based on the shortest route obtained by the ants during the food

search process. The particle swarm optimization method determines the cluster offset by narrowing the search area for the food location, and the bee colony optimization method determines the cluster offset by finding the best food location. It is hoped that this method can be used in measuring clock skew.

Methodology

This research was conducted at the Telecommunication and Multimedia Network Engineering Laboratory, Electrical Engineering, Faculty of Engineering, Udayana University, Bukit Jimbaran. This research was initiated on July 2022. The stages of the research can be seen in Figure 1.

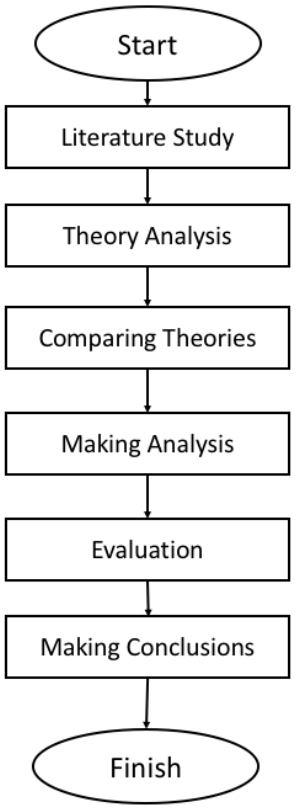

Figure 1. Research stages

Explanation of Figure 1:

Step 1. Literature study and data collecting

The first stage is carried out in the form of literature studies sourced from relevant literature, such as journals and books related to the research topic, and collecting data from previous research.

Step 2. Theory Analysis

The second stage is an analysis of the theory that has been collected. Several existing theories will be analyzed one by one.

Step 3. Comparing Theories

The third step is to compare the theories with each other. It is done to see the strengths and weaknesses of each existing theory.

Step 4. Making Analysis

The fourth stage is making an analysis. After comparing the existing theories, the advantages and disadvantages are obtained, then an analysis is carried out to get the best theoretical results.

Step 5. Evaluation

The fifth stage is evaluation, where all the methods and the best ones will be re-checked to get the best results.

Step 6. Making Conclusions

The sixth stage is making conclusions, where conclusions are drawn after going through several methods, and it is concluded that one of the best methods is obtained.

Results and Discussions

Bee Colony Optimization

Bee colony optimization is a method that adopts bee colonies when looking for natural food. The bee colony optimization method aims to optimize the habits of the bee colony by exploring to get a more optimal solution. The bee colony optimization method describes several running processes, such as the source of food, the quality of the food source, and the amount of food in the food source [7].

The process of bee colony optimization starts with determining the initial route, with the nearest neighbor followed by the foraging stage, where the bees will choose the food source to be visited next based on the value and distance between food sources. The last one performs a waggle dance where the worker bees will dance, influencing the seeker bee to follow and join in picking up food from the food source [8].

Suppose the bee colony optimization method, which aims to find food, is adapted to the clock skew measurement method. In that case, searching for food will be similar to a cluster offset where the bee colony will look for a cluster offset at random when the bees get the cluster offset location. The bees will signal the other bee groups to approach and form a cluster offset path. With the optimization support, the bees will choose the cluster to offset the path with the shortest route, which is expected to get accurate clock skew measurement results using the bee colony optimization method.

Ant Colony Optimization

Ant colony optimization is a method that adopts the behavior of ant colonies when looking for food in nature [9]. Ants will move from the anthill to the food source by passing several existing paths until the ant colony finally gets the path with the shortest route from the anthill to the food source. Figure 2 will explain the working process of the ant colony optimization method [10].

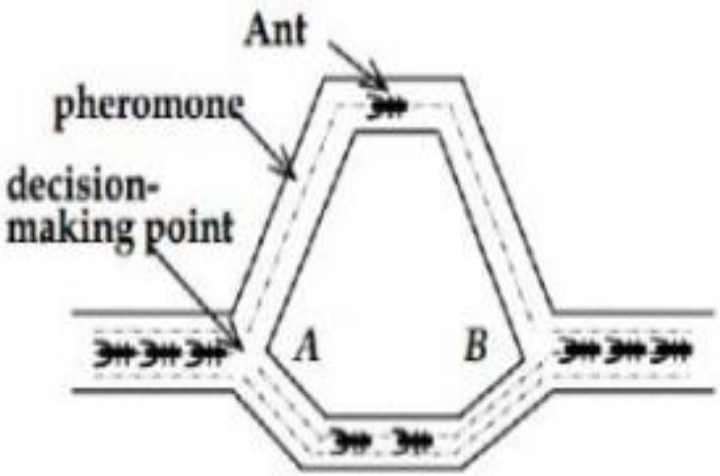

Figure 2. Ant colony optimization process

The process stage of the ant colony optimization method starts when the ant moves from the anthill to the food source, the ant will pass through several existing paths to get to the food source [11]. When passing through, the ant's path will leave a pheromone substance as a sign that the ant is passing through the path. After repeating several times from the anthill to food sources, ants will choose the path with the most accumulation of pheromone substances to pass, which means that the path is the shortest path when looking for food [12].

In the ant colony optimization method, the aim is to find the path with the shortest route. When it is adapted to the clock skew measurement method, the food search path passed by the ants will be shaped like a collection of cluster offsets used when measuring clock skew, the path for ants, which becomes the cluster offset, will be optimal with the help of optimization which is expected to be a method of measuring clock skew with ant colony optimization to get accurate results.

Particle Swarm Optimization

Particle swarm optimization is a method that adopts the behavior of a group of birds when looking for food sources randomly, with other particles that will influence each other in the flock when finding the best food position. Figure 3 describes the process of particle swarm optimization [13].

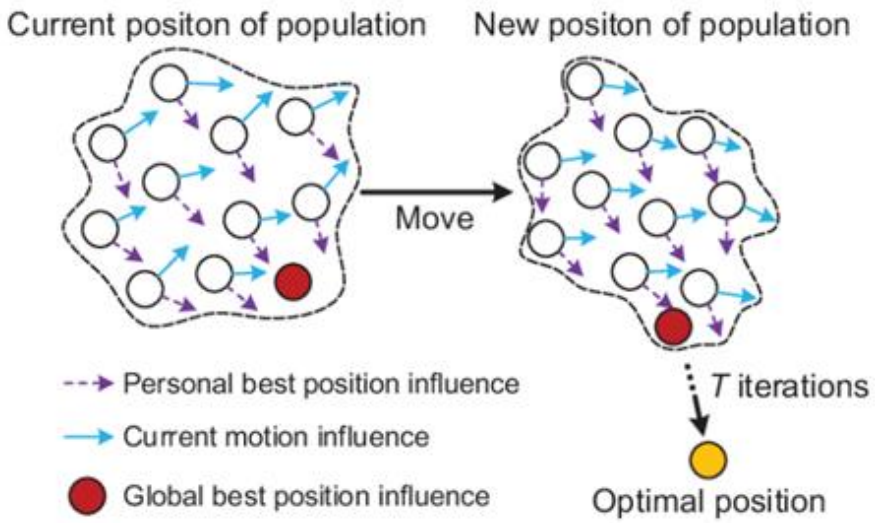

Figure 3. Particle swarm optimization process

Figure 3 shows searching for food by narrowing the foraging area. In the particle swarm optimization process, initially, a group of particles or swarms will move randomly, which aims to find a position in the repetition of the food search, followed by several variables to take the best position and as repetition to search for food as well as in the optimization process that determines the direction of a particle to move. The search for food locations in the particle swarm optimization method will be carried out repeatedly to get food locations that are getting smaller and narrower to get an optimal result.

In the particle swarm optimization method, the aim is to narrow the food search area [14]. When it is adapted to the clock skew measurement method, namely, the position of the food will resemble a cluster offset where the food search is carried out repeatedly, which aims to narrow the position of the food location with the help of optimization methods that will get the accurate results in determining the cluster to offset so it is expected to get accurate clock skew measurement results using the particle swarm optimization method.

Genetic Algorithm

A genetic algorithm is a computational algorithm that originates from an evolutionary theory and is adopted into a computational algorithm that aims to find a solution to a problem naturally, such as by getting the value of an optimal solution to a problem with several possible solutions [15].

The process stage of the genetic algorithm method starts when taking the initial population and applying operations on genetics that aims to create the next generation, where each part of a population will be considered as a chromosome that can represent one feasible solution to a problem. Individuals who have high similarity will have the opportunity to reproduce by exchanging genetic information through the crossover with other individuals. After the crossover process, the gene mutation process is carried out to change some properties of certain non-

producing genes. The resulting offspring may replace several individuals with relatively low fit functions. This reproductive cycle, crossover, mutation, and evaluation will repeatedly occur until the best solution is acquired.

The genetic algorithm method aims to obtain an optimal solution to a problem. When adapted to the clock skew measurement method, the optimal solution will be considered a cluster offset in clock skew measurement. The genetic algorithm will work by finding several solutions to the existing problem until the best result is obtained. Therefore, the genetic algorithm method is hoped to be optimal for measuring clock skew.

Potential Clock Skew Measurement Method

Based on the four methods of measuring clock skew that has been observed, by looking at the advantages and disadvantages of each method, the most potent method to be used in measuring clock skew is the ant colony optimization method. Ant colony optimization method that adopts the behavior of ants looking for food [16], where ants will move from the nest to the food source through multiple paths available. The ants will choose the path with the shortest route to search for food in nature [17]. Figure 4 explains the process of ants in search of food.

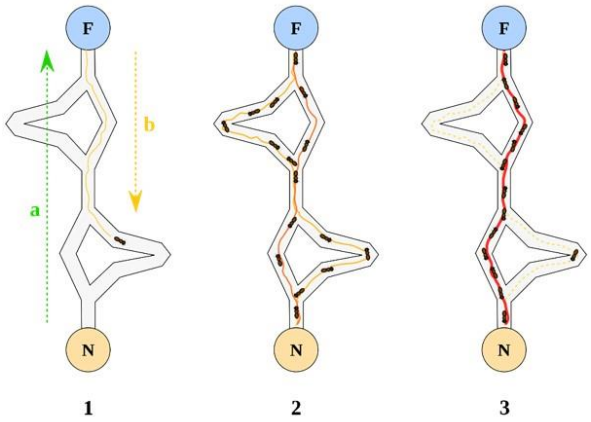

Figure 4. The process of ants in search for food

The route of ants foraging can be linked to a cluster offset in clock skew measurements. In Figure 4, path number 3 is the shortest route the ants choose, marked with the red mark, representing the cluster offset, where the ants will choose a few paths. Then with the ant colony optimization method, the ants will choose the path with the shortest route because it is more efficient where the path with the shortest route can be associated with a cluster offset. The cluster offset will not be affected by outliers at the top and the bottom because the path of the ants resembles a cluster offset, so it is expected to get accurate clock skew measurement results.

Conclusion

There are a few methods in clock skew measurements, such as genetic algorithm, ant colony optimization, particle swarm optimization, and bee colony optimization that are the potential to be a method in clock skew measurement. The ant colony optimization method has the highest potential to be adapted as the method in clock skew measurement. First, the ants will try a few paths to the food source, and eventually, the ants will choose the path with the shortest route to the food source. This shortest path for ants when looking for food sources can be linked to a cluster offset in clock skew measurements, where the path of the ants represents a cluster offset that will not be affected by the upper and the bottom outliers to produce an accurate clock skew measurement.

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