World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Review Article)

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Nature inspired algorithms in dynamic task scheduling: A review

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World Journal of Advanced Research and Reviews, 2023, 20(03), 829–833

Publication history: Received on 31 October 2023; revised on 13 December 2023; accepted on 15 December 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.20.3.2531

Abstract

The process of scheduling involves allocating shared resources gradually so that tasks can be completed effectively within the allotted time. In task scheduling and resource allocation, the terms are used independently for tasks and resources, respectively. In computer science and operational management, scheduling is a hot topic. Efficient schedules guarantee system effectiveness, facilitate sound decision-making, reduce resource waste and expenses, and augment total productivity. Selecting the most accurate resources to complete work items and schedules for computing and business process execution is typically a laborious task. Particularly in dynamic real-world systems, where scheduling different dynamic tasks involves multiple tasks, is a difficult problem. Emerging technology known as "nature inspired algorithms" has the ability to dynamically solve the problem of optimal task and resource scheduling. This review paper discusses a study that looked at algorithms inspired by nature and used them to schedule tasks dynamically. The Nature Inspired Algorithms used in dynamic task scheduling and a comparative analysis of those methods are used in this paper to address the study's findings.

Keywords: Task Scheduling; Nature Inspired Algorithms; Genetic Algorithm; Bacteria Foraging Optimization Algorithm; Genetic Based Bacteria Foraging Algorithm; Krill Herd Algorithm; Water Cycle Algorithm; Symbiotic Organism Search Algorithm.

1. Introduction

The process of task allocation guarantees that the appropriate resources have been distributed efficiently to complete work tasks with a specific outcome at the appropriate time. It ensures that the availability of resources and the demand for process execution facilities are balanced. Scheduling, which is the process of allocating tasks or resources, has several applications, including Network Routing, Public Transport, Grid Computing, and Industrial Workforce Management. Since dynamic task scheduling is essential to efficient resource sharing, it has attracted a lot of attention in these domains [1].

The Scheduler component in a computer system handles scheduling, which primarily addresses response time, latency, and throughput. Throughput is the rate at which a given number of tasks can be completed from start to finish in a given amount of time. On the other hand, latency refers to the turnaround time, or the amount of time needed to finish a task from the moment it is requested or submitted to the end, including any waiting periods required to fulfill the request. Response time, or waiting time, is the amount of time it has taken to complete a task or fulfill a request [2-4].

Static and dynamic scheduling are the two main categories into which scheduling solutions can be separated [2-4]. Decisions are made during compilation in static scheduling, while computational state information is used in decision-making during execution in dynamic scheduling/adaptive work sharing. Complete prior knowledge of the task set characteristics is required for static scheduling, which is difficult to come by in an unpredictable setting. Because dynamic scheduling can handle situations where dependencies are unknown at compile time, it is more promising than

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static scheduling. It requires dynamic load balancing and is more computationally demanding, allowing for different parallelization strategies. Because dynamic schedulers are adaptable and can adjust to changing task scenarios, they are a great choice for deployment in unpredictable environments. Mainly, this article focuses on dynamic scheduling.

This article describes the early attempts at dynamic task scheduling using algorithms inspired by nature. In order to provide a better solution, Section 3 ends by outlining the research challenges for dynamic task scheduling and highlighting the viability of nature-inspired algorithms.

2. Evolution and State-of-the-Art of Nature inspired Algorithms in Dynamic Task Scheduling

The insights from earlier studies on dynamic task scheduling with nature-inspired algorithms are presented in this section. The section begins by explaining the underlying theory of nature inspired algorithms [5-9]. The majority of Nature Inspired Algorithms used for dynamic task scheduling are then explored. Deep learning and machine learning research are also conducted by the dynamic task scheduling. The readers can get the idea of machine learning [10-15] and deep learning in details from the papers [16-19].

2.1. Nature Inspired Algorithms

New metaheuristic approaches are primarily motivated by nature, which is why nature-inspired algorithms are frequently employed in system creation and problem solving [5-7, 20]. The biologically-inspired algorithms are the main categories of nature-inspired metaheuristic algorithms. The remarkable ability of the bio-inspired algorithms to mimic the most useful traits found in nature accounts for their efficacy. In particular, these algorithms rely on the survival of the fittest in biological systems that have evolved over many years via natural selection.

Metaheuristic techniques inspired by nature stem from biological, physical, and chemical systems as well as swarm intelligence. As a result, depending on the sources of inspiration, these techniques can be referred to as swarm-intelligence-based, bio-inspired, physics-based, or chemistry-based [5-7, 21]. Although not all algorithms are very good, only a small number have proven to be extremely good and as a result have become well-known resources for solving problems in the real world. Since nature has inspired many analysts from a variety of backgrounds, it may serve as a rich source of inspiration. Given that they were developed by drawing inspiration from nature, the majority of novel tactics nowadays are nature-inspired.

Nature is the primary source of motivation in its broadest sense. The practical majority of novel strategies can therefore be noted as being inspired by nature. Most methods inspired by nature rely on certain useful aspects of biological systems. As a result, the majority of techniques inspired by nature are biology-inspired, or bio-inspired. Every method was founded on biological systems. All of the previous methods can be divided into four main groups: Physics/Chemistry-based, Bio-inspired (non SI-based), Swarm Intelligence (SI) based, and others. These divisions are not mutually exclusive at this time; they can be further divided into several categories [7-9].

2.2. Genetic Algorithm (GA)

The goal of the Genetic Algorithm (GA) [1, 8, 22] is to solve NP-hard problems using a meta-heuristic approach. The basic idea behind GA is to randomly create an initial population made up of each chromosome, or unique solution to the problem, and then grow this population over a number of iterations known as Generations. Every chromosome is estimated for every generation using fitness metric. The next generation serves as the source of new chromosomes, which are produced by either combining two chromosomes from the previous generation using a crossover operator or mutating a chromosome—also known as offspring—using a mutation operator. Selection creates a new generation based on fitness values, keeping the population size constant by keeping a small number of parents and offspring and rejecting others. Chromosomes with greater fitness are more likely to be selected. Following several generations, the techniques come together to identify the most productive chromosome that best represents the ideal or less than ideal solution to the problem.

Darwin's theory of natural selection and the survival of the fittest inspired Holland [23] to develop GA-based strategies, which Goldberg [24] first suggested for scheduling problems. Following the initialization of all parameters, the algorithm tests a number of results simultaneously while repeatedly executing various stages of the GA methodology, including evaluation, selection, crossover, and mutation. This process continues until a termination criterion is found.

2.3. Bacterial Foraging Optimization Algorithm (BFOA)

Given the social foraging behavior of Escherichia coli (E. Coli) bacteria found in the human intestine, Prof. K.M. Passino introduced the Bacterial Foraging Optimization Algorithm (BFOA) in a seminal paper in 2002 [1, 25]. From its inception, BFOA has been regarded by analysts as a high performance optimizer. Several successful applications of BFOA in image processing, network scheduling, electric load forecasting, optimal control engineering, and other fields have been demonstrated [1, 8, 9].

2.4. Genetic based Bacteria Foraging algorithms (GBF)

Task assignment that makes use of the suggested Genetic based Bacteria Foraging algorithms (GBF) [1, 8] benefits from both GA and BFO. While the BFO can make a small adjustment to the search space and look for better results, GA can find potential results while avoiding premature convergence. To improve the search capability in the interim, heuristics are added to the GA as a local search. The simulation results in this paper [1] demonstrated that GBFO is unquestionably superior to GA and BFO.

2.5. Krill Herd Algorithm (KHA)

Gandomi and Alavi introduced KHA [26–27], which may be a brand-new algorithm with biological inspiration. These subsets of stochastic search techniques are population-based and use the best-survive criterion [28]. The fact that KHA uses a stochastic random search rather than a gradient search means that the derived data is not necessary, which is one of its obvious advantages. Furthermore, KHA's simplicity is another important advantage. It is very easy to implement in this way [29].

2.6. Water Cycle Algorithm (WCA)

The Water Cycle Algorithm (WCA), a nature-inspired algorithm, is based on how streams and rivers flow downward toward the ocean and then reverse course. It was presented in [3–4, 30]. Streams and rivers are the forms of water flowing downhill; rivers originate high above the mountains and empty into the ocean. Rivers and streams both collect precipitation runoff and slow down streams as they descend. Once plants release water through transpiration, the water in rivers and lakes evaporates. When the evaporating water reaches the atmosphere, clouds are formed at that point. By condensing clouds in the cool atmosphere, water is released as rain, creating new and fresh streams and rivers.

2.7. Symbiotic Organisms Search algorithm (SOSA)

Doddy Prayogo and Min-Yuan Cheng created this algorithm in 2014 [31–33]. Numerous optimization problems in engineering design have been resolved by this algorithm. The Symbiotic Organisms Search algorithm (SOSA) is a multi-objective meta-heuristic algorithm that draws inspiration from nature. It is used to schedule all tasks on various processors in a multiprocessor environment with global optimization to reduce the execution time. In an ecosystem, SOSA replicates the beneficial association strategies that living things receive in order to survive. The obtained outcomes validate the simulation of SOSA on multiprocessor scheduling issues using additional algorithms inspired by nature.

3. Conclusion

It was possible to compile a substantial amount of information about the approaches, theories, strategies, benefits, and drawbacks of scheduling systems and frameworks created for dynamic task scheduling in the fields of computer science and operational management through the literature review. Nature Inspired Algorithms, the primary method of dynamic task scheduling, have yielded a great deal of success. An approach that can be applied to real-world scheduling problems in complex and uncertain environments is much needed, though, as this has been a major issue in many fields of work. In dynamic real-world scenarios, an adaptable and scalable model-independent dynamic task scheduling framework with optimized Nature Inspired Algorithms would result in efficient resource utilization. It will take time for Nature Inspired Algorithms to advance and develop through problem-solving, but in the end, this will provide significant research benefits for the field. being a field of emerging research; In the near future, a viable technology that would empower numerous research directions and offer great prospects in dynamic scheduling would be Nature Inspired Algorithms.

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