CHAPTER 1
INTRODUCTION

This chapter contains overview of the research work, need and importance of the research problem, objectives and scope of work, and finally organization of the thesis.

1.1. Overview of Research Work

From the research papers it is observed that in automotive and aerospace systems, there has been exponential increase in use of electronics and computer based control replacing predominantly mechanical systems [1]. These paradigm shifts from mechanical control to x-by-wire systems encompass safety critical requirements. The critical system is one where its malfunction may lead to economic or loss of life. Hence, there is a necessity of highest level of safety integrity and reliability in the system [2]. The Reliability is nothing but in an interval there should be probability of no failures and also this is the measure of performance for fault tolerant systems. Thus, fault tolerant design is must for applications involving high level of reliability and safety [3]. The objective of the development of time triggered computer architecture is its application in distributed real time fault tolerant systems [4]. M.Sparchmann, in his thesis verified that time triggered architectures provide clear advantage over the present design approaches for safety critical systems particularly concentrating on fault tolerant real time design, especially in the case of transport sector [5].

The Electronic Control Units (ECUs) typically get there inputs from sensors and switches, compute them and then enforce the output to actuators. If all these devices and sensors were to be connected point-to-point, then the cable length may grow to several kilometers. This would add to overall cost and induce reliability related problems. To overcome the above problem several communication network protocols like LIN, CAN, TTP, Byteflight, and most recently Flexray were developed. In present day high end vehicles, more than 70 ECUs are interconnected to various subsystems for exchange of nearly 2500 signals in between them and these may grow if the applications require short latencies, demand for determinism and possessing high accuracy of operation [6,7]. To manage the complexity and number of ECUs in a

vehicle, it has become a key challenge of Original Equipment Manufacturers (OEMs) at automotive industry.

Depending upon the type of communication and the processing activities between the two nodes (ECUs), Event or Time Triggered approaches are selected for the design. The Event Triggered process is based on well known interrupt mechanism, where activities are initiated with significant change in the state is recognized, whereas in Time Triggered Structure the communication process and the sequence of activities are put into action at a pre-determined time [8]. The Event Triggered Architecture works on anticipatory scheduling and at a precise synchronization of the tasks, whereas Time Triggered Architectures have set activation period and can be scheduled offline. The limitation is a prior knowledge of worst case situation should be known for consideration in the development process [9]. The major setback of Event Triggered System is non-determinism i.e, there is no guarantee of message transfer and conflict of access is seen. Whereas in Time Triggered Systems only one node or ECU is authorized for communication, collision is eliminated and the tasks are executed in allotted time period which is referred as Time Division Multiple Access (TDMA) [10].

The Task scheduling in multiprocessing systems were studied in the past decades for high complexity of the targeted problem. Tasks have important estimations to make like cost, duration and resource usage for performance measures. Whatever the task may be, it requires use of single or a set of resources for execution and the resource utilization may change during the task in operation. The estimations of cost and duration may be dependent upon the resources employed to the task or used by the task. The performance measures found to be probabilistic or deterministic. Depending upon the resources employed to complete the task, which can be executed in more than one mode i.e, the task may be executed in multiple modes. For instance, if two people are allotted to complete a job, it may be finished in half of the time compared to a single person. Various scheduling problems having resource constraints are proposed, implemented, and evaluated for over fifty years. The solution processes are organized in two noticeable classes: Heuristic methods and Exact methods. Further, these classes are classified into Deterministic approach and Stochastic approach. Exact method finds a solution for an existing problem otherwise

provides some indication. A heuristic Optimization solution doesn't have such assurance. However some assurance can be furnished analytically that some strength of optimality in the solutions is achieved. Stochastic process consists of probabilistic operations where the operations may not be executed in the same way but the results obtained may be same for two or more similar operations. While the deterministic methods work in the similar way each time, whenever the problem is applied.

Many methods concentrated completely on message scheduling and were static in design. In static scheduling process the data has to be pre-fetched and can be pipelined for assignment in different stages during the task execution. While the dynamic scheduling process uses the dynamic components/job tasks by nature. Here, the execution time of the task cannot be estimated in advance so the task allocation is done on the fly. Thus the dynamic scheduling process consumes more runtime overhead compared to static scheduling process.

Static cyclic scheduling is considered for most of the hard real time systems and often the solution is list scheduling where order of selection of tasks is important as given in [11, 12, 13, 14, and 15]. However, the alternatives proposed are evolutionary approaches as used in [16]. A feasible solution to multiprocessor, distributed hard real time system proposed in [17] was Simulated Annealing approach, but it requires large computation time. In this work we have investigated with Greedy Nearest Neighbour, Simulated Annealing, Ant Colony and Genetic Algorithm approaches for better optimal solution to overcome the problems stated earlier i.e. to achieve best solution.

1.2. Motivation – need and importance of research problem

Nowadays, high reliability requirement is increased tremendously in real time systems for safety critical applications like operation of Sensors in Aircraft Engine. It is required to allocate tasks on Sensors (*referred as nodes or ECUs in this dissertation*) within minimal time i.e. in seconds (referred as units). By this, they become more complex as the requirement is fault tolerant, that is highly dependable and often involves strict timings. The traditional Event Triggered Systems cannot be suited for the above requirement; hence Time Triggered Architecture is taking

control. Similarly, the scheduling process has to be redefined for optimality in resource allocation.

In the early 90's Genetic Algorithm became a powerful optimization technique in flow shop scheduling and much of research is carried out, lots of papers were presented using these techniques. The list of papers documented with proposed Genetic Algorithm are plenty, which leads to the solution in task scheduling problems for the past two decades as given in [18]. Different scheduling problems like travelling salesman problem, job shop assignment and etc, have been studied. Genetic Algorithm applied to the Travelling Salesman Problem (TSP) involves implementation of crossover function, calculation of fitness function, and then application of mutation function for generating the best possible solution. A good calculation of fitness obtained depends on actual length of the solution. Various methods of applying the crossover function and the mutation function were discussed in [19]. Since, much research work has been performed with simple Genetic Algorithm in multi-objective scheduling domain, hence a lot of research work is observed in implementing Genetic Algorithm with modifications, which is able to perform better than the simple Genetic Algorithm in many instances and the work presented here reflects a clear move towards making modifications based on works carried out in [20] and [21].

In [20] Probir et al. the Standard Task Graph (STG) is used as benchmark function for the evaluation of multiprocessor scheduling algorithms. In STG, all the task graphs are generated randomly without consideration of communication cost. As it is hard to evaluate on all the task graphs, they have randomly chosen several task graphs from the standard STG and performed the evaluation. The tests have been carried out with small number of nodes. For large number of nodes this method becomes complex, hence suggested for better benchmark, like Travelling Salesman Problem combined with Genetic Algorithm use may result in optimum solution.

Besan et al. [21] carried out a comparative study between Nearest Neighbour and Genetic Algorithm using Travelling Salesman Problem for scheduling in multiprocessor system and suggested that Genetic Algorithm with TSP yields best solution. But they have not visited for Multiple TSP which is often required in multiprocessor applications. Simulation results show the algorithms suitability if the

number of tasks are more and available ECUs (*simply referred as 'nodes' whenever or wherever necessary*) are also large in number compared to the present algorithms (Greedy Nearest Neighbour, Simulated Annealing, Ant Colony, and Simple Genetic algorithm). Thus, schedulability of tasks in such system is analyzed with Proposed Genetic algorithm (*named as Adaptive Dynamic Genetic Algorithm (ADGA*)), optimizing the system processor usage in the present research work.

1.3. Objectives and Scopes

The Objectives of this research work are given below in a simple and obvious way that on attaining these goals will lead to the better optimized results:

- To study Real Time Systems like Time Triggered Architecture and procedures to overcome fault tolerance related problems.
- To investigate state-of-art Optimization algorithms like Greedy Nearest Neighbour, Simulated Annealing, Ant Colony, and Simple Genetic Algorithm to solve the scheduling problem and attempt to modify the basic algorithm as per the requirement.
- To establish the proposed Adaptive Dynamic Genetic Algorithm (ADGA) by combining Multiple Warehouse Multiple Travelling salesman Problem (MWMTSP) with the Simple Genetic Algorithm as per the requirements and also to tabulate statistical comparison of best Solution.
- To develop a frame work of proposed algorithm; which allocates tasks to the available ECUs for execution.
- Further, the proposed methodology can be extended to all existing optimization algorithms to verify their credibility to achieve the best solution.

1.4. Organization of the Thesis

The work reported in this thesis is organized in six chapters, as follows-

Chapter-1: INTRODUCTION

This chapter presents an introduction and the key areas of the work carried out in the thesis.

Chapter-2: LITERATURE SURVEY

This chapter presents an in-depth literature review about Time Triggered Architecture and Optimization Techniques applied for task allocation.

Chapter-3: OPTIMIZATION METHODS USED

This chapter contains all the Optimization methods used mainly consisting of technology descriptions, existing work and Proposed method

Chapter-4: EXISTING METHODS -EXPERIMENTAL INVESTIGATIONS

The simulation results of existing methods are presented in this chapter.

Chapter-5: PROPOSED METHOD -EXPERIMENTAL INVESTIGATIONS

This chapter contains the simulation results of proposed method and a statistical comparison is carried out with existing methods.

Chapter-6: SUMMARY, CONCLUSIONS AND FUTURE SCOPE

This chapter is an amalgamation of a brief summary of results obtained on application of proposed method to get the expected outcomes and scope for further work.