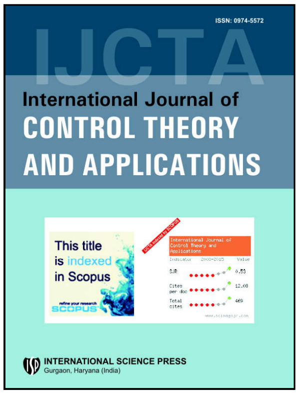

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Dynamic Clustered Hierarchical Real Time Scheduling for IoT Based Human Organ Transplantation

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Abstract: Human organ transplantation is one of the extraordinary researches in 20th century. Organ Transplantation process is directly related with life and death that's why there is emerging need to use internet of things and real time scheduling which can transport donated organs quickly and safely .Now days there is increase in incidences where vital human organs such as heart, kidney, lungs, pancreas etc failures occurs and due to inadequate supply of human organs specially from dead bodies most of the human lost their lives. Human organ transplantation is very complex and costly process consists of various phases and stakeholders .Effective and efficient management of these is today's need. The aim of this paper is to describe the development of Dynamic Cluster based Hierarchical Real Time scheduling framework for human organ transplantation system based on Internet of Things(IOT) to enhance efficiency, rapidity, safety, quality and management of human organ transplantation process.

Keywords: Human Organ Transplantation, Internet of Things, Clustered Hierarchical Real Time Scheduler

1. INTRODUCTION

Human organ transplantation opened the new horizon in medical research. Organ transplantation is very complex and costly process consist of various phases, activities, processes and stakeholders [1].The existing process of human organ transplantation has many inherent drawbacks such as delay in organ supply, inefficient management of resources involved in organ transplantation process, coordination and communication between different stakeholders .Effective and efficient management and organization of human organ transplant process is today's need. Internet of things is a communication platform where the object of everyday life can communicate with user and other similar objects [2].IOT provides the platform where different devices like home, monitoring and sensing and actuating devices can have easy access. IOT paradigm can be used in wide varieties of real time applications such as healthcare, home automations, smart grid, smart and intelligent traffic system, industrial automation, medical automation, public administration, farming and many more [3]. Most of these application based on IOT platform. are embedded systems and require real time operations. Demand of real time communication increases day by day ,to satisfy that demand there is major paradigm shift in processing platform from single processing to multiprocessing platform because of the following drawbacks of single processing platform like high power consumption, low computation capability, high heat dissipation. Multi-core platform offers several advantages over single processing platform like higher throughput, linear power consumption, efficient utilization of processor cores and high performance per unit cost over the many single core processors unit. The applications based on IOT platform can be of type real as well as non real type. Real time scheduler is require to efficiently use multi-core IOT based platform. This paper presents the analysis of cluster based hierarchical scheduling for multi-core system use for IOT based application platform.

The organization of this paper is as follows section II represent key challenges in implementation of IOT and the different features and characteristic of real time scheduling require for the implementation of IOT applications. Section III represent hierarchical real time scheduling for IOT implementation. Section IV represent clustered hierarchical real time scheduling based on IOT platform for human organ transplant system . Section V mention conclusion of this study.

2. ORGAN TRANSPLANTATION AND IMPACT OF IOT

Healthcare is the area where automation of services can benefits a lot to human being. Organ transplantation is very complex process and require automation of different services using Internet of Things .The use of IOT related technologies like RFID(Radio Frequency Identification) RTLS (Real Time Location System),Real time communication technologies provides many services to that enhance safety of patients, improve clinical operation and optimize resources of hospitals, The Internet of things era require configurable, modular, energy efficient, secure, expandable real time system for implementation. In Organ transplantation the demand of donated organs increases a lot than organ supply. Persons who are eligible for organ donation must screen carefully and then the database of organ donor is added to the waiting list. Organ tracker is a web platform use to track the location and status of donated organ while it is transported. It is used to reduce the time required to transport the organ safely.

Human organ transplanation process comprises of many services that can be implemented using Internet of Things.These sevices are:

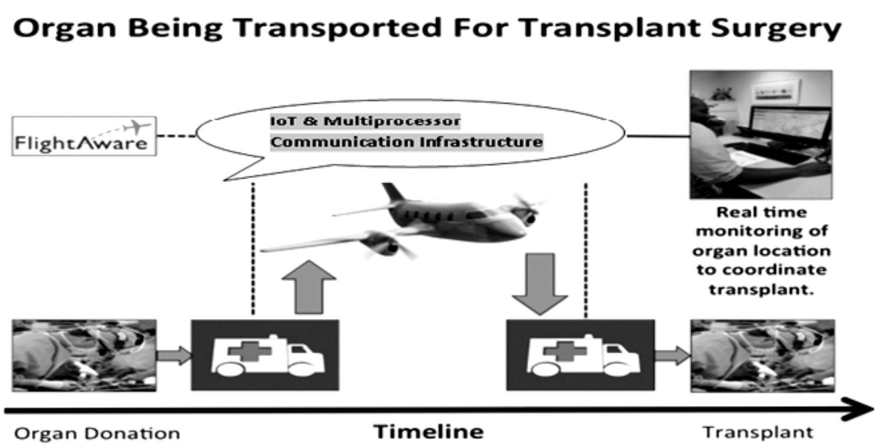


Figure 1: Organ Transplantation Process using IOT

a) Blood, Organ, Tissue and Cell Banking

There must be blood,organ ,tissue and cell bank and the database of all must be maintain online and accessible throughout the world. This online database system in human organ transplantation responsible to performs following processes like

- Manage the national transplant waiting list.
- Matching of donors to recipients

- Database that holds all kind of data related with every transplant event.
- Provide common platform to policy makers so that best use of limited supply of organ can be possible.
- Monitoring of organ match process to ensure the organ policies must get followed.
- Sensor technology to maintain monitor different parameter.

b) Real Time Information to Physician

- Real time monitoring of ambulatory patients.
- Real time information about patients to monitor vital sign of patients such as sugar level, blood pressure etc.
- To alert physician when above parameter goes out of control.
- Interface between physician and patients

c) Drug and Medical devices monitoring

- Monitoring of medical devices, biological and prescription drugs
- Monitoring of patients food
- Identification of patients at risk because of drugs and medical devices
- Error reductions in medicals instruments
- Enhance patients surveillance
- Recalling of medical devices and drugs
- Efficient product managements
- Product validation and tracking
- Managements of medical sponges during organ transplants surgical process
- Give alert if no of sponges issued not match with the no of sponges submitted
- Detection of misplaces devices

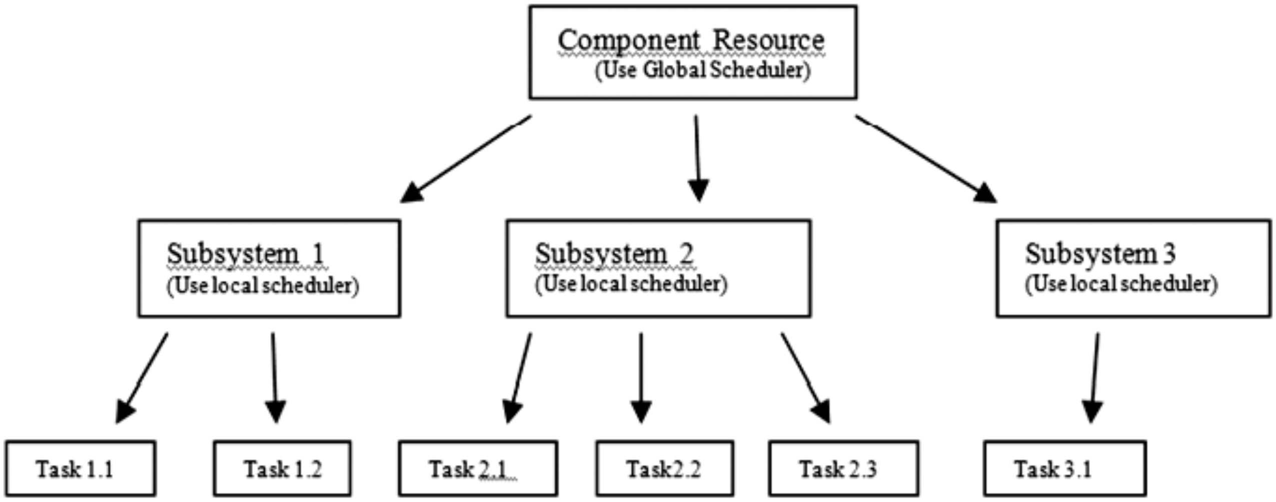
2.1. Challenges in IOT implementation

The objects in IOT applications ranging from small embedded devices like washing machine ,street light to large embedded devices such as automobiles to nuclear reactor .To fully utilize the advantages of IOT some, embedded system designer must meet following challenges of IOT[4].

- Devices must have real time communication facility
- Security among different IOT objects.
- Fault tolerance and energy efficiency in IOT applications reduce system development cost

3. HIERARCHICAL REAL TIME SCHEDULER FOR IOT

Scheduler acts as one of the important part of any real time operating system. The operation of scheduler can affect other important properties of real time operating system such as energy efficiency ,real time operations etc.The scheduler are of two types preemptive scheduler and non preemptive scheduler. Preemptive scheduler can abort currently running low priority task and allow high priority task to executes its operations. Various Application of IOT



such as audio, video processing, health care, industrial and home automation, defense system are using compositional system to run several real time and non real time tasks. Dynamic cluster based hierarchical real time scheduling offer facility to schedule real time tasks with diverse applications of IoT. Hierarchical real time scheduling play an very important role in safety critical real time system such as healthcare, avionics and home and industrial automation[7][8]. Most of the IOT based application is composed of no of subsystems and these subsystems must have temporal and fault isolation among themselves.Hierarchical real time scheduling framework is scheduling framework which provide composition of multiple levels of subsystem in hierarchical manner to provide temporal and fault isolation among the subsystems as shown in Fig2.It consist of two type of scheduler global and local scheduler. Global scheduler is used to select which subsystem is executed and local scheduler is used decide task among subsystem.

Hierarchical approach in cluster scheduling also used to develop clustering algorithms that result in good utilization and load bounds. For improved integration and analyzability of shared resource accesses using hierarchical approach for dynamic cluster scheduling on multi-core platform is the need of deploying more complex applications on today's platforms.Dynamic clustering inherently requires hierarchical scheduling; inter-cluster and intra cluster scheduling[7]. Under inter-cluster scheduling, physical processors are dynamically assigned to dynamic clusters[8]. Under intra-cluster scheduling, processor allocations given to dynamic cluster are assigned to tasks as shown in Fig. 3. Inter cluster scheduler invoke when whenever either a server budget is expired or get replenished via activation. If m processors are available in a scheduling point, it picks m most

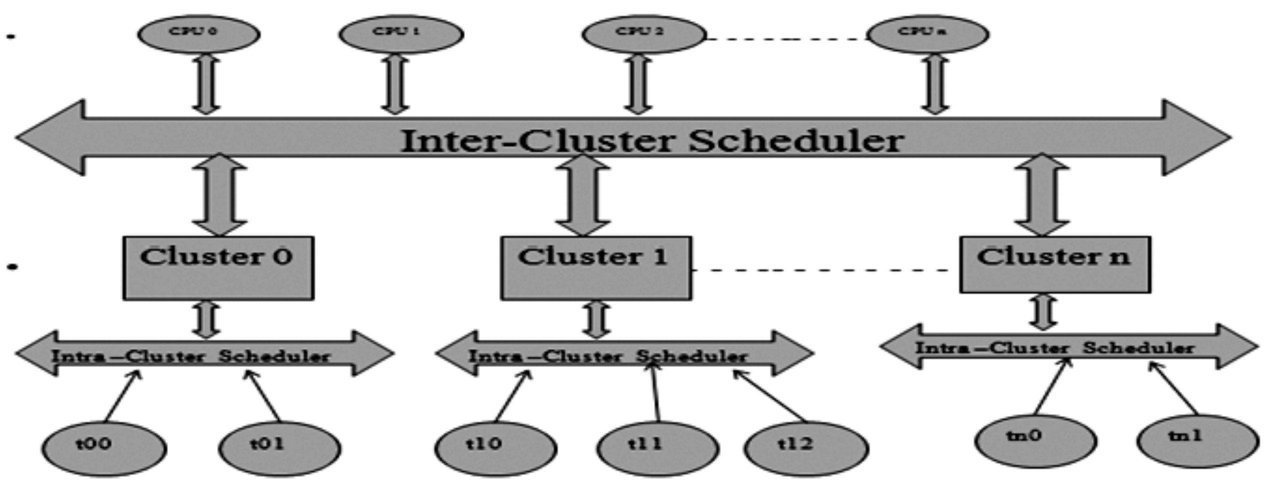


Figure 3: Dynamic Cluster based Hierarchical Scheduling Framework

suitable servers to execute on processes. It invokes the intra-cluster scheduler whenever a server of that cluster either gets a new budget or gets preempted or expired its budget [9].

It should manage status of the idle processors. The intra-cluster scheduler is responsible for scheduling tasks within the cluster into available processors for the cluster. It manages the real-time tasks similar to the local scheduler but uses the task queues of the cluster[10]. However, the intra-cluster scheduler employs any global scheduling algorithm to schedule tasks into processors as there can be more than one processor available for the cluster. Processing time received by the cluster is represented by the periodic servers. It is invoked by the inter-cluster scheduler or when a new task job of the cluster becomes ready or completes its execution[11]. Depending upon the availability of server it selects task to execute on them.

4. CASE STUDY ON CHRTSF FOR IOT BASED HUMAN ORGAN TRANSPLANTATION

Human organ transplantation processes is done manually by telephonic or fax communication. This manual human organ transplantation processes having several drawbacks like difficulty in keeping track of patient who require vital organs, gap between supply of organ and demand of organ, increase in time to allocate organ, communication gap between different stockholders of organ transplantation process. These problems can be solved by strong communication infrastructure through internet.IOT applications are extensively used in health care system to secure life of humans.IOT devices can be used to monitor various stakeholders status of human organ transplant process.IOT based application can provide efficient platform for human organ distribution process. The main objective of dynamic cluster based hierarchical real time scheduling is to enhance efficiency, rapidity, safety and quality of organ distribution in human organ transplantation process. Human organ transplantation system consist of no of subsystem system like pre-transplant,inpatient,clinicians, organ provider organization donar care, recipient care etc. Information exchange and coordination of different stakeholders are main parts of human organ transplantation system are if these things are not managed properly then quality and efficiency of organ transplantation system get hampered. Information technology based on IOT has great potential to provide different services that can solve that hurdle[12][13]. In pre transplant subsystem is related with task which is to be executed before organ transplantation. The IOT based application is used to manage growing waiting list of patients and coordination among different organ transplant programs and allow to access, integrating and analysis and interpretation of large amount of patient clinical information quickly[14][15]. It also felicitates local and national procurement organization to manage organ shortage efficiently. Ones the organ available, then selection and matching of organ for best suitable recipients is very crucial task and to implement that task efficiently IOT based information system, telemedicine ,PDAs can be used to improve quality of life. In pre-transplant phase, IOT platform can also be support clinicians to manage and evaluate different type of information coming from different consultant physician in real time which results into para-clinical and investigation of laboratory[16][17][18].Inpatient transplant subsystem includes some tasks which are are responsible for several settings of inpatients for caring of organs and prevention of failure or rejection of organ transplantation this include the tasks that are used to manage dosages of medicine require in organ transplantation. This subsystem also includes some tasks that are utilize to manage different resources of labs to improve lab utilization and safety of inpatients in several medication process. To improve process of organ transplantation, IOT based application can be develop to promote evidence based inpatients. The post transplant subsystem include care and monitoring of patients after post transplantation which is used to protect recipients organ rejection or failure. It also manage long term medications. Monitoring of labs systems can be used by clinicians to monitor lab values. The post transplant subsystem includes some tasks which provide real time patient data and inform doctors whenever changes in lab settings are required and help to remotely monitored status of other medications. Monitoring of other medication such as antiviral drug also part of that system. Fig 4 shows the architecture of human organ. transplantation system which consist of different web services involved in organ transplantation system, mobile apps and applications which are used in implementation of organ transplantation and various medical sensor devices that are used in organ transplantation connected to IOT platform.

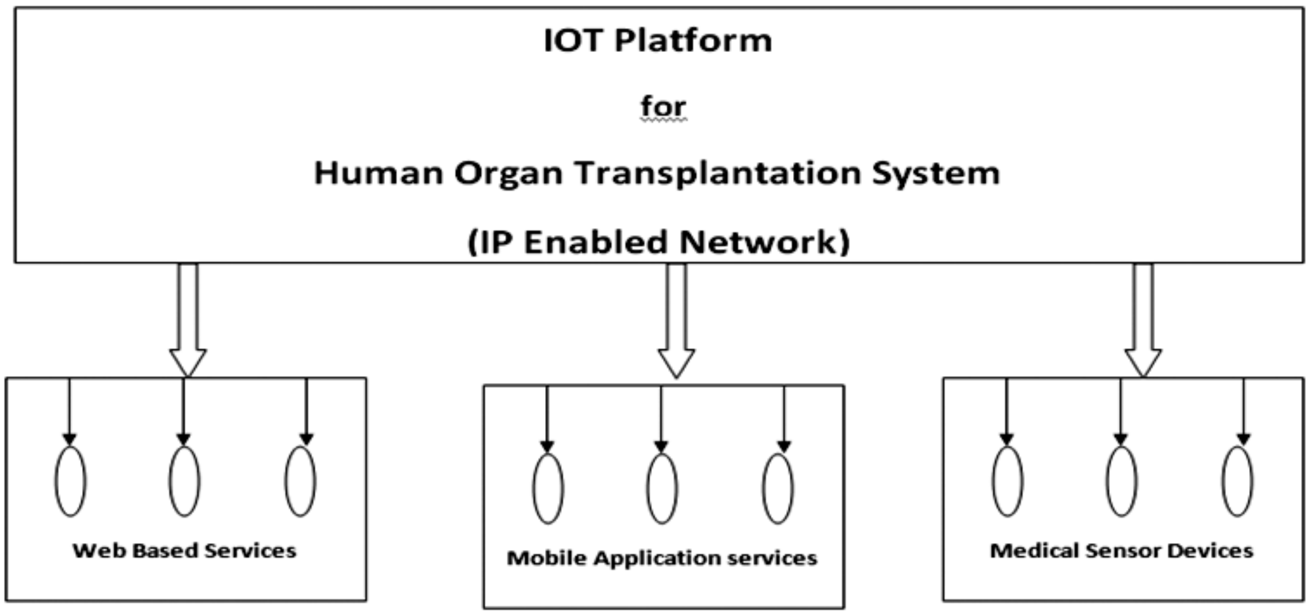


Figure 4: IOT Platform for Human Organ Transplantation System

Most of the services involved in IOT based human organ transplantation system are real time and require high real time computations. To satisfy these increase computation demands,multi-core platform are now days preferred. Currently available most popular real time schedulers for multi-core domain are partitioned and global scheduling and these schedulers not suitable to efficiently use this multi-core platform efficiently. Hierarchical real time scheduling framework is require to execute all the subsystem which are involved in human organ transplantation such as pre transplant ,intransplant and post transplant in single platform for cost efficiency and it also reduce the communication overheads among the different subsystem. Hierarchical real time scheduling framework also maintain temporal and fault isolation between these subsystems[19[20].

The cluster based scheduling is a hybrid approach that combining benefits of both partitioned and global scheduling. The cluster based scheduling further classified into static and dynamic cluster scheduling. In static cluster based scheduling each cluster is assigned to a fix set of processor. In dynamic cluster based scheduling cluster dynamically assigned to processor .Comparative analysis of these scheduling algorithms shows that dynamic cluster scheduling offer several advantages over existing scheduling approaches in terms of resource utilization, load balancing, reliability etc. Dynamic clustered scheduler also reduce average response time .It is possible to form cluster of different resources and and best suitable for larger and less uniform multi-cores.

Dynamic cluster based hierarchical real time scheduler can be develop for multi-core platform for IOT based human organ transplantation system to execute various real time tasks of different subsystem involved in human organ transplantation system in one platform that provide temporal as well as fault isolation among these subsystems with efficient resource utilization ,load balancing and reliability. Different subsystem and task involved in dynamic cluster based hierarchical real time scheduler for IOT based human organ transplantation system is represented in table1.Pre-Transplantation subsystem includes tasks to manage waiting list, organs procurement process,tasks to match and select best candidates, clinical resource management tasks, tasks to alert different stakeholders of organ transplantation system[21] and tasks to coordinate communication among different consultant. In transplant subsystem includes tasks like dosage management task[22], safety related tasks, medication administration related task[23],patient education related tasks. Post transplant subsystem consists of tasks which is used to protect and monitor patient against organ transplant rejection, tasks which manage and monitor long term drugs,tasks which gives clinician information about patient heath status.

Table 1
Subsystem & Task involved in Human Organ Transplantation

Subsystem of Human Organ Transplantation System	*Sample Tasks involved Each Subsystem*
Pre Transplant Subsystem	Waiting List Management
	Organ procurement
	Matching of best candidates
	Selection of best recipient
	Clinical resource management
	Information to all stakeholders
	Information from different consultant
In Transplant Subsystem	Inpatient settings
	Automated dosage management
	Lab resource management
	Safety of inpatient
	Medication administration
	Patient education
Post Transplant Subsystem	Protection of patient against transplant rejection
	Detection and management of long term drug
	Help clinician to monitor patient health status
	Alert to clinician regarding changes heath status
	Assurance regarding patient receive necessary dosages

Clustered Hierarchical Real Time Scheduling Framework(CHRTSF) for IOT based Human Organ Transplantation System is as shown in fig.5.Clusterd hierarchical scheduling framework consist of two scheduler intercluster scheduler and intracluster scheduler. Intercluster scheduler decide which subsystem of IOT based

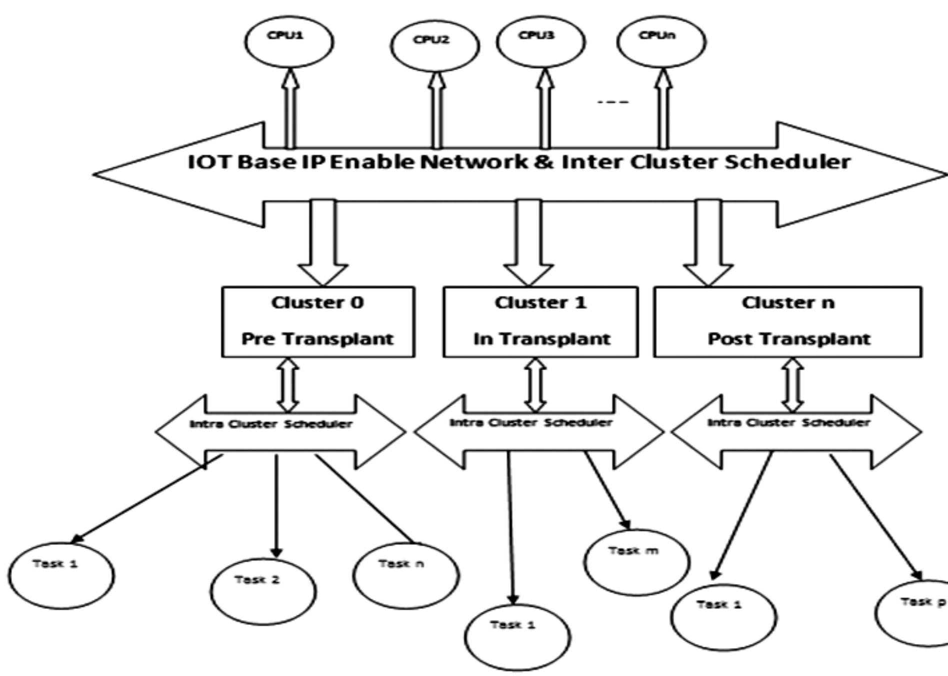


Figure 5: Clusterd Hierarchical Real Time Scheduling Framework for IOT based Human Organ Transplantation System

human organ transplantation system should be executed and every subsystem consists of local intra cluster scheduler that decides which particular task will executed if at a time different task are ready to execute so that all task of all subsystem must get executed within its deadlines.

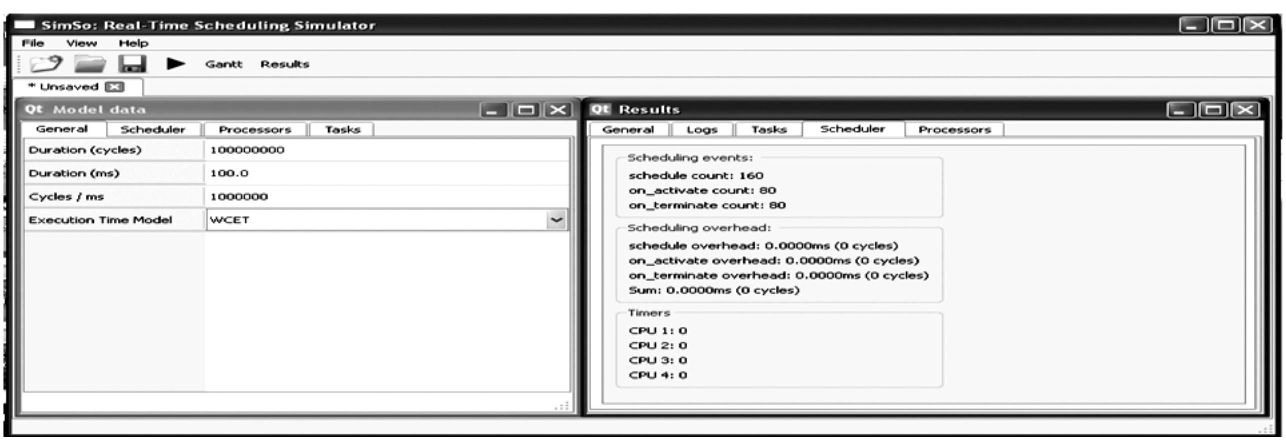
Inter cluster scheduler invoke when whenever either a server budget is expired or get replenished via activation. If m processors are available in a scheduling point, it picks m most suitable servers to execute on processes[24]. It invokes the intra-cluster scheduler whenever a server of that cluster either gets a new budget or gets preempted or expired its budget. It should manage status of the idle processors. The intra-cluster scheduler is responsible for scheduling tasks within the cluster into available processors for the cluster. It manages the real-time tasks similar to the local scheduler but uses the task queues of the cluster. However, the intra-cluster scheduler employs any global scheduling algorithm to schedule tasks into processors as there can be more than one processor available for the cluster. Processing time received by the cluster is represented by the periodic servers. It is invoked by the inter-cluster scheduler or when a new task job of the cluster becomes ready or completes its execution. Depending upon the availability of server it selects task to execute on them.

5. EXPRIMENTAL SETUP & RESULTS

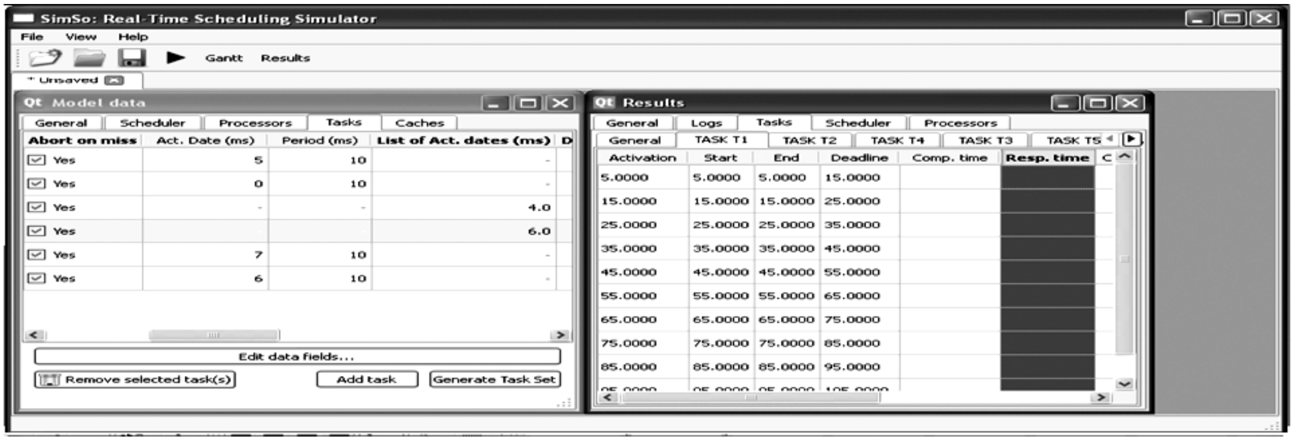
Experimental setup consists of six processors group into three clusters. Each cluster consists of two processors. First cluster is used to handle all periodic and sporadic task associate with pre transplant subsystem. Second cluster can handle all tasks related with in transplant subsystem of human organ transplantation process and third cluster handle the execution of all tasks associated with post transplant subsystem. Tasks sets consist of five periodic tasks which are used to handle periodic events and three sporadic task. The tasks sets can be tested on different combinations of cluster like cluster with 2,4,5, and 6 processors.Simso simulation tool [36]is used for the performance analysis of dynamic cluster based real time scheduler for human organ transplantation

Table 2
Scheduling Methods

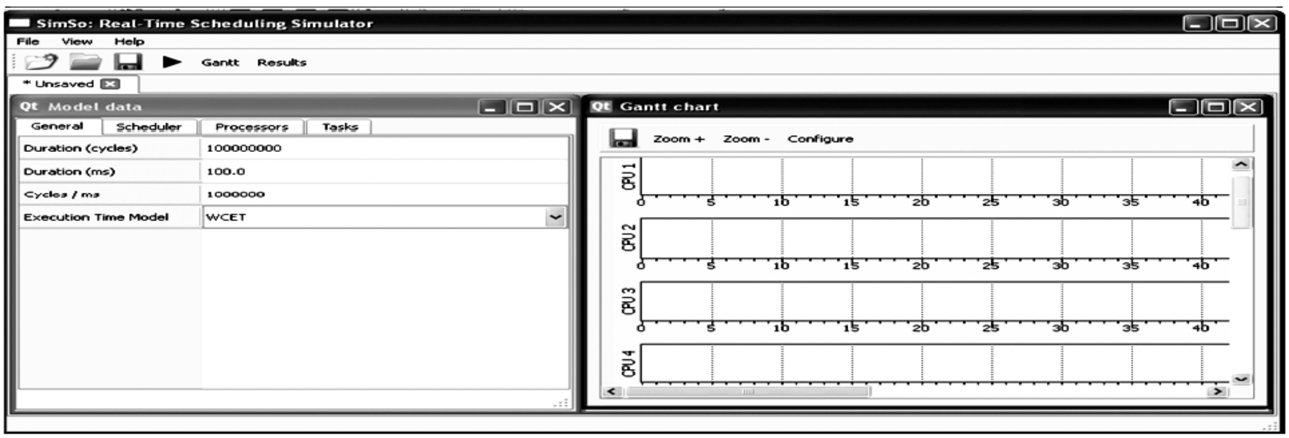
Method	*Description*
init( )	It is used to initialize different parameters of scheduler.
on activate( )	Executed when job is created
on terminated( )	Call when execution of job is done
schedule( )	called to take scheduling decision
Simulation result and Gantt chart is as shown in fig.6	



(a)



(b)



(c)

Figure 6: Scheduling Results & Gantt Chart

system with multi-core platform. The tool is used for the analysis of real time scheduling algorithms on multi-core platform in realistic way and available freely under open source license. The real time scheduling simulator provides the facility to generate tasks sets.Tasks sets can be a combination of task ,their utilization,period and deadlines.To evaluate the performance of real time scheduling algorithms, data related with success rate, preemption and migration of tasks, scheduler calls and laxity should be collected from the simulator.Python high level programming language is used for the implementation of simso scheduler. Dynamic cluster scheduler is a python class inherits from scheduler class with following methods as shown in table.2

6. CONCLUSIONS

Clustered Hierarchical Real Time Scheduling framework based on IOT for Human Organ Transplantation system can reduce many technical difficulties occurs in human organ transplantation process such as reduce organ distribution time, efficient resource utilization of labs and other devices which are use in organ transplantation process, management and coordination of information shared between different organizations associated with organ transplant process.IOT platform is used to enhance the collaboration of all devices and services involved in human organ transplantation process. Clustered hierarchical real time scheduling approach can be used to manage time criticality involved in different tasks and services of human organ transplantation system and enhance resource utilization, efficiency, safety, rapidity, reliability in human organ transplantation system. Dynamic clustered hierarchical real time scheduling improves processor utilization, load balancing, integration and analyzability of shared resource accesses and reliability temporal and fault isolation among different subsystem independent software development and enhance software reusability.

Moreover, when comparing to the other real time scheduling methods for multi-core, the proposed dynamic clustered hierarchical real time scheduling can further reduce the scheduling overheads of dynamic clustered scheduling.

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