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REVIEW OF FAULT TOLERANCE COMPUTING FOR NEXT RESEARCH DIRECTIONS: A SYSTEMETIC STUDY

Mr. Nitesh Kumar, Assistant Professor, Department of Computer Science & Engineering, Roorkee Institute of Technology (RIT), Roorkee, Uttarakhand
Mr. Vikash Arora, Assistant Professor, Department of Computer Science & Engineering, Roorkee Institute of Technology (RIT), Roorkee, Uttarakhand

ABSTRACT
Fault tolerance is an important feature of modern computing system. This feature provide the continue operating capability to different computing system for example clustering based cloud computing without any interruption like failure of components. In previous research, program interruption and service barrier is a biggest problem in different computing system, so next proposed work on a system which provide continue service and backup to running system. Highly availability and continue service provider is an important feature of fault tolerance computing. This paper, propose the review of fault tolerance computing for next research work. In this paper, discuss the awareness and fundamental knowledge of fault tolerance computing with introduction, types of fault tolerance system, performance matrices of fault tolerance computing system, approaches of fault tolerance with reactive and proactive nature, review of literature which indicate the survey or implementation work on behalf of fault tolerance, research gaps or weakness of research on behalf of literature survey and proposed work for fault tolerance computing system behalf of research gaps which produced by literature survey.

Keywords: Fault tolerance computing, hardware fault tolerance, software fault tolerance, fault tolerance matrices, approaches of fault tolerance, reactive fault tolerance, and proactive fault tolerance

Introduction
Fault tolerance computing is a system used for backup to system like hardware based backup and software based backup due to failure on execution of program. When hardware based fault like power is fail is occur in system due to program execution than used to hardware fault tolerance and if software based fault like database corrupt is occur in system due to program execution than use to software fault tolerance. In this paper, discuss the understanding knowledge of fault tolerance computing with including types of fault tolerance, matrices of fault tolerance and approach of fault tolerance with review using previous research. Following figure 1 show the basic structure of fault tolerance. In figure 1, first phase is fault, this is fault in system like eliminate of data, engage of data, and second phase is error means power breaks, complicated process, third phase is failure of system due to break the program execution and finally fourth phase is fault tolerance means services for remove the failure to system.

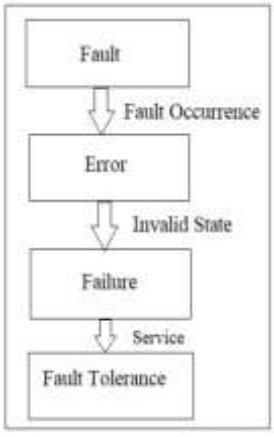

Figure 1.Structure of fault tolerance computing

Fault Tolerance Computing

Fault tolerance is a facility to computing system for handle the component failure like hardware and software error occurs in system. Fault tolerance computing is a system build for preventing to situate failure of components [10]. In this computing, fault tolerance provides the ability of continuous operating and recovery without failing to components. The computing of Fault tolerance includes different types of levels for tolerance such as lowest level (capable to power failure responding), A step up (backup system use immediately when system fail), enhanced fault tolerance (mirror disk provide due to disk failure) and high level fault tolerant (immediately correct errors). There are two types of fault tolerance techniques used in system, show in table 1 as:

S.No.	**Fault Tolerance Computing Types**	**Description**
1	Hardware Fault Tolerance	This type of fault tolerance computing is based on hardware backup like power sources and server. Power generator and backup server is a part of hardware fault tolerance due to electricity fail and network fail.
2	Software Fault Tolerance	This type of fault tolerance computing is based on software backup like secondary database in the case of primary database corrupt.

Table1. Types of Fault Tolerance

Matrices of Fault Tolerance Computing

Matrices are parameters of designing to fault tolerance computing system. In this section, discuss the different matrices of fault tolerance computing, show in table 2 as:

S.No.	**Fault Tolerance Matrices**	**Description**
1	Availability	Services of resource access in particular time with proper functionality.
2	Reliability	In certain time continuously services with correct results.
3	Maintainability	Repairing and maintenance of a system is easily.
4	Scalability	When new nodes increase than manage using algorithm without service degradation.
5	Safety	Operate correctly to system when temporary failed.
6	Confidentiality	Safe to unauthorized access.
7	Performance	Includes efficiency and throughput.

Table2: Fault tolerance matrices

Approaches of Fault Tolerance Computing

The fault tolerance computing is based on two main approaches due to error or failure reducing of system, first approach is reactive fault tolerance and second approach is proactive fault tolerance. Reactive fault tolerance approach is used for reduce the system failure immediately or on demand basis due to error occur in system process. Proactive fault tolerance approach is used for decrease the error or failure of system on the basis of prediction.

Reactive Fault Tolerance Approaches

The approach of fault tolerance computing is based on detect the fault and remove the error immediately means on-demand purpose use in system. Reactive fault tolerance approach is classified in different categories show in table 3 as:

S.No.	Reactive Fault Tolerance Approach	Description
1	Restart /Checkpoint	This approach is used for failure in large application due to uncompleted task.
2	Replication	The approach is guarantees for fault tolerance due to event of crash.
3	Job Migration	The approach is based on migrate the task to new machine due to impossible execution of current machine.
4	Retry	In this approach, task is repeated due to execution is failed.
5	S-guard	This approach is based on rollback recovery process due to restarted fail nodes.
6	Timing Check	This approach is used for time critical task due to failure in case of alteration.
7	User defined exception Handling	In this approach treatment of failed task by user specifies.

Table 3.Reactive approaches of fault tolerance

Proactive Fault Tolerance Approaches

The approach is based on prediction of failure before the fault or error occurs in system. Proactive fault tolerance approach is classified into four important techniques which is show in table 4 as:

S.No	Proactive Fault Tolerance Approach	Description
1	Self Healing	This approach is easily handled to fault with automatically and isolate the task on different machine.
2	Preemptive Migration	The technique is used for handle to dormant and latent fault by using feedback control.
3	Software Rejuvenation	This technique is used for update and check to system record due to system failures.
4	Load Balancing	When auto scaling policy is required due to threshold in computing resources like CPU or loads of memory then used this technique with auto scale.

Table 4.Proactive approaches of fault tolerance

Literature Survey

In this section, discuss the previous research which indicates working with fault tolerance computing, show in table 5 as:

References	Research Category	Research Contribution
Calderón-Arce C. et al., (2022)	Analysis of swarm robotics	Proposed the survey of swarm robotics which is combination of swarm intelligence and multi-robot system with its hardware, software, platforms and simulators through comparison to other accessible resources [1].
Rehman A. U. et al., (2022)	Fault tolerance in cloud computing	Proposed the review of cloud computing under fault tolerance with system level matrices of fault tolerance, fault tolerance framework and component level matrices of fault tolerance [2].
Webster P. et al., (2022)	Quantum computing with	Proposed the implementation of fault tolerance with universal logic gates in quantum computing using

	universal fault tolerance	stabilizer codes and handle the continue errors as of out of control [3].
Hilder J. et al., (2022)	Fault tolerant parity read out in trapped ion quantum computing	Proposed the experimental review on shutting based trapped ion quantum computing with fault tolerant parity read out measurement and handle the error using stabilizer codes [4].
Tawfeeg T. M. et al., (2022)	Reactive fault tolerance technique in cloud dynamic load balancing	Proposed the survey on cloud based dynamic load balancing using reactive approach of fault tolerance computing with explain the framework for availability of high service [5].
Wang G. et al., (2022)	Fault tolerance quantum computing with state preparation boosters	Proposed the implementation of fault tolerance quantum computing using quantum algorithms under state preparation boosters for analysis the optimization of high dimension quantum circuit [6].
Siddiqui S. et al., (2022)	SDN based IOT networks under fault tolerance	Proposed the survey on fault tolerance for SDN based IoT networks with including the study of SDN based architecture and IOT based architecture for handle the traffic with security [7].
Cohen L. Z. et al., (2022)	Long range connectivity under low overhead fault tolerant quantum computing	In this paper, propose the method for long range connectivity on low overhead fault tolerant quantum computing known as low density parity check (LDPC) used for interaction between logical qubits and physical qubits [8].
Fawzi O. et al., (2022)	Space overhead for fault tolerance computing under lower bound	Propose the experimental survey of fault tolerance computing with space overhead under lower bound using threshold theorem for achieve the fault tolerance [9].

Table5. Literature Review

2.1 Weakness of Research on Behalf of Review

When review is complete in this paper than find the weakness or limitation of research paper according to review in form of research gaps show in table 6 as:

S.No.	Research Gaps
1	The open control environment is biggest problem in robotics [1].
2	In this review, discuss fault tolerance in only single perspective of cloud computing [2].
3	No mention any theorem or architecture for handle errors by fault tolerance with the universal logic gates in future perspective [3].
4	The work is only experimental not any operational [4].
5	The mostly problem is failing the task when beginning to execution and difficult to handle in check points [5].
6	The field transition of state is a big problem in this research when ground state is overlapped under the manner of controller [6].
7	The biggest research gaps in this research paper for further research like high traffic load, weak security, require to scalability and energy efficiency [7].
8	High thresholds confirmed by LDPC codes and difficult the managing of overheads [8].

9	Quantum error occurs due to the maximum length with upper bound of fault tolerance in this research [9].

Table 6: Research gaps of paper

2.2 Future Work for Next Research on Behalf of Research Gaps

If find the research gaps according to literature survey then focus on next work according to weakness of work on behalf of research gap of literature review, show in table 7 as:

S.No.	Proposed Work
1	Next work on real life robotics using swarm intelligence.
2	Further work on multiple perspectives of cloud computing with proactive and reactive approaches.
3	Next work on design the efficient architecture with implement the suitable theorem for handles the errors by fault tolerance.
4	Upcoming work on demonstrated approach for flag based fault tolerance quantum computing for handle and correct the error.
5	Future works on a method which purpose on job move from one failure node to other.
6	Further work on an algorithm for ground state boosting under fault tolerance quantum computing.
7	Further work on the emerging challenges like network function virtualization, middleware with block chain based solution and open flow adaptation using fault tolerance.
8	Next work on current approach of fault tolerance for achieves the scale of overhead.
9	Further work on quantum error correction using resolving of amplitude damping noise on fault tolerance computing.

Table 7. Future Work on behalf of research gaps

I. Conclusion and Future Scope

Fault tolerance is best facilities in recent computing system. This facility is used for recovery and backup to computing system due to system failure in process. In this research paper, explain the introduction to fault tolerance system with the type as hardware and software fault tolerance. When analysis of fault tolerance, in any computing system than used to matrices or parameters of fault tolerance. When we design of fault tolerance in computing system then used to approaches of fault tolerance like reactive and proactive approaches. In this study research paper, discuss the introduction of paper under fault tolerance, type of fault tolerance, approaches of fault tolerance, matrices of fault tolerance, review of literature on behalf of previous research regarding to fault tolerance, weakness of research in behalf of literature survey and proposed work on behalf of weakness. Future scope of this paper is focus on weakness and proposed work of this review with study and implementation work.

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