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Integrating Cloud Computing with Big Data: Novel Techniques for Fault Detection and Secure Checker Design

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ABSTRACT

A combination of the assistance of Concurrent Error Detection (CED) and Scalable Error Detecting Codes (SEDC), a state-of-the-art fault detection system designed for cloud computing and large data environments, is presented in this work. Beyond conventional defect detection techniques such as the Berger Code Checker and m-out-of-2m Code, the suggested system achieves much better area use, latency, and power efficiency. The SEDC-based solution minimises the requirement for resource-intensive software-based fault tolerance solutions by providing effective error detection and correction at the hardware level. Large data applications and fault-tolerant cloud computing benefit significantly from this increased system efficiency, scalability, and reliability, establishing the SEDC approach as a solid option.

Keywords: Scalable Error Detecting Codes (SEDC), Concurrent Error Detection (CED), fault tolerance, cloud computing, big data.

1 INTRODUCTION

Utilising Scalable Error Detecting Codes (SEDC) and a corresponding checker, the proposed approach leverages concurrent error detection (CED) to identify hardware-level defects. All-unidirectional error detection (AUED) techniques, such as the SEDC methodology, can identify several unidirectional mistakes. Compared to previous AUED methods, SEDC's data segmentation and parallel encoding method yields code words appropriate for big data processing hardware because they can be scaled to any binary data length "n" with constant latency and reduced complexity. A new fault-secure checker design that is highly efficient in terms of area, latency, and power is also introduced. It is based on SEDC. Everyone evaluates its efficacy by contrasting the expenses of current software-based fault tolerance techniques, such as those employed in the Hadoop Distributed File System (HDFS), with those of hardware-based techniques. Furthermore, regarding area, speed, and power consumption, one can evaluate the suggested checker's performance against well-known checkers like Berger and m-out-of-2m code checkers. According to the experimental results, (1) the SEDC-based fault tolerance scheme significantly lowers the average cost of software-based fault tolerance in big data applications, and (2) the fault secure checker performs better in area, delay, and power efficiency than other state-of-the-art checkers.

Big data is an IT sector expanding quickly and has much potential for business applications. It attracts much industry attention, including satellite imaging, telebanking, social networking services (SNS), and remote healthcare. An organisation's reputation may suffer, and significant financial or market share losses may result from these systems failing. Fault tolerance is, therefore, crucial to cloud computing and big data since it ensures that systems can keep working even in unexpected faults. Fault tolerance is achieved by popular big data frameworks like Hadoop and MongoDB, which rely on data redundancy and replication. These software-level fault tolerance techniques can use many memory and communication resources, notwithstanding their effectiveness. Researchers have recently studied hardware-based fault tolerance systems that detect defects more quickly and efficiently. These hardware-based

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techniques are beneficial in reducing transitory faults that could otherwise spread from hardware to software and lead to system breakdowns.

Also, a hardware-based fault tolerance approach can be offered to identify temporary hardware failures and address these issues. This system is compatible with software-based fault tolerance, providing an extra degree of top-level error checking for software and hardware malfunctions. Our technique reduces the danger of catastrophic failures in extensive data systems by conserving significant computational resources at the system level and resolving hardware-level defects with low overhead in terms of area, power, and latency. Fault tolerance is essential in large-scale integration (VLSI) circuits beyond cloud computing. Transient faults can particularly affect miniaturised, large-scale, low-power systems. These malfunctions, frequently brought on by alpha particles or cosmic rays, can seriously contaminate memory and logic circuitry. Fault tolerance requires CED approaches because physical protection measures like temperature regulation and shielding aren't always practical.

The efficient and scalable SEDC-based technique offers a sophisticated way to identify and fix unidirectional defects in VLSI circuits. The SEDC scheme's higher area, latency, and power efficiency over more conventional techniques like Berger code and m-out-of-2m code makes it a reliable option for big data and fault-tolerant cloud computing applications.

- Design fault detection methods and develop fresh approaches to fault detection to improve the dependability of big data and cloud computing systems.
- Construct safe checker architectures and develop cutting-edge secure checker designs for cloud environments that preserve data integrity and guard against illegal access.
- Boost cloud computing by implementing safe and fault-tolerant design principles; cloud computing infrastructure can be improved and more effective at processing large amounts of data.

Effective defect detection and security checker designs remain lacking despite notable advances in cloud computing and extensive data integration. Current techniques frequently fail to adequately address the difficulties of processing massive amounts of data and the dynamic nature of cloud settings. Novel approaches that improve cloud-hosted big data applications' fault tolerance and security are required.

Expanding cloud computing and extensive data integration have exposed security and fault detection system flaws. Traditional fault tolerance techniques are ill-suited to handle the complexity and size of contemporary cloud-based extensive data systems. By creating novel methods for fault detection and security checker design, this research aims to close this gap and make cloud computing environments more dependable and safe for processing large amounts of data.

2 LITERATURE SURVEY

Issues with data loss and system crashes are described in Saadoon et al. (2022) review of fault tolerance in large data systems. In order to improve data integrity and dependability, investigators look at techniques like checkpointing, erasure coding, and replication. Recent developments in distributed fault recovery and detection are also covered in the work. Balancing fault tolerance with performance and scalability are important concerns. Reviewing existing approaches and potential avenues for enhancing system resilience in large data contexts, all things considered, paints a clear picture.

In-depth techniques for fault detection and diagnostics (FDD) in building systems are covered in Kim & Katipamula (2018) assessment. These techniques are divided into three primary groups: hybrid, data-driven, and model-based. Model-based approaches employ physical models of the systems to pinpoint problems, whereas data-driven approaches use statistical and historical data. Hybrid techniques improve accuracy by combining the two strategies. The practical difficulties of adopting FDD are also covered in the study, including the requirement for precise system models and the challenges associated with integrating these systems with currently in-use building management

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frameworks. The assessment underscores the vital role that FDD plays in improving building system maintenance and operating efficiency overall.

The various fault types—thermal, electrical, and mechanical—and their origins and symptoms are examined in Hu et al. (2020) comprehensive analysis of fault diagnostics in lithium-ion battery systems. It is emphasised that accurate fault feature extraction and real-time monitoring are crucial when they discuss several diagnostic techniques, which include model-based, data-driven, and hybrid approaches. In addition, the article discusses the difficulties in diagnosing battery faults, including the requirement for sophisticated algorithms and efficient battery management system integration. Taken as a whole, this review emphasizes how important precise fault diagnosis is to improving lithium-ion battery safety and performance.

Data-driven failure detection and diagnosis (FDD) techniques for chemical process systems are thoroughly reviewed by Md Nor et al. (2020). Various methodologies, such as statistical analysis, machine learning, and pattern recognition, demonstrate how these approaches use process data to find and fix errors. The assessment identifies issues such as the requirement for high-quality data and seamless interaction with current control systems. Still, it also shows the benefits of data-driven techniques in enhancing the efficiency and reliability of chemical processes. The article highlights the increasing importance of data-driven FDD in optimising chemical process operations.

An extensive overview of signal-based condition monitoring methods for identifying and addressing issues in induction motors is given by Gangsar & Tiwari (2020). They discuss how techniques like electrical signal monitoring, acoustic emission, and vibration analysis can be used to detect motor problems. Each technique's advantages, disadvantages, and difficulties, like signal quality and noise interference, are discussed. It also draws attention to the necessity of sophisticated algorithms and seamless connection with current motor control systems. The investigation highlights the vital role that signal-based monitoring plays in preserving motor health and averting unanticipated failures overall.

Shao et al. (2017) provide a novel deep autoencoder technique for rotating equipment defect diagnosis. Their method increases the accuracy of defect detection and classification by using deep autoencoders to extract significant features from equipment data. The study describes their model's architecture and training procedure and demonstrates how it handles complicated data patterns and reduces false positives to outperform conventional methods. It also discusses the method's valuable applications and real-world efficacy, emphasizing how it could improve fault diagnostics in industrial settings.

Mohanarangan Veerappermal Devarajan(2021) to improve workload predictions in intelligent cloud computing. Through mutually advantageous Service Level Agreements (SLAs), the approach aims to maximize resource allocation and service delivery by merging game theory ideas with the Backpropagation neural network technology. The efficacy of the strategy is demonstrated by real-world data validation, which underscores its potential to enhance cloud resource management across diverse businesses while guaranteeing scalability, security, and usability.

Multiscale convolutional neural networks (CNNs) are investigated by Jiang et al. (2018) as a potential diagnostic tool for wind turbine gearbox problems. To better capture and evaluate defect features from vibration data, they employ CNNs at various scales. In contrast to conventional techniques, the research provides enhanced fault detection accuracy by elucidating the architecture of their multiscale CNN model. It is very good at dealing with various fault types and intricate signal patterns. The study focuses on how this approach might improve maintenance and reliability in wind turbine systems, highlighting its clear practical advantages.

Liu and Zhang (2020) examine the methodologies for defect diagnosis, condition monitoring, and failure modes of large-scale wind turbine bearings. They discuss monitoring methods like vibration analysis, acoustic emission, temperature monitoring, and common problems like wear, lubrication issues, and structural damage. The effectiveness of several fault detection techniques, such as model-based and data-driven methods, in identifying and diagnosing bearing failures is also examined in this article. One of the main obstacles is the requirement for precise monitoring

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instruments and techniques that can endure the harsh environment of wind turbines. The review emphasizes how crucial it is to combine these methods to enhance wind turbine bearing maintenance and reliability.

Sreekar Peddi investigated in 2023 if cloud-based big data mining with K-means clustering to analyze Gaussian data was economically viable. The study used Lloyd's K-means approach to investigate how different cluster sizes affected computation time and accuracy. The results showed that the algorithm could terminate early and save a significant amount of money while keeping a reasonable degree of accuracy. In order to improve clustering performance in an economical way, the study highlights the significance of choosing the best beginning centers and good resource management.

Liu et al. (2018) investigate the diagnostic potential of recurrent neural network (RNN)--based autoencoders for rolling bearing defects. Using RNNs to evaluate time-series data from bearings, their technology helps diagnose and detect defects more precisely than conventional techniques. The dissertation describes the RNN-based autoencoder's design and training and how it can handle sequential data and spot subtle problems. Practical issues like data preparation and integrating the model with current monitoring systems are also covered. The study demonstrates that this technique can enhance problem diagnostics in industrial settings.

Eren et al. (2019) present a flexible 1D convolutional neural network (CNN) classifier-based defect diagnosis method for bearings. The technique reliably detects and categorizes various bearing fault types by analyzing one-dimensional vibration signals. The CNN model's adaptive characteristics and design are explained in the study, which also emphasizes the model's effectiveness in handling a range of fault circumstances. They also discuss how to practically implement the system, highlighting how it may be used in industrial settings to diagnose faults in real time. The investigation demonstrates that this flexible and effective method can enhance fault identification.

An extensive examination of defect diagnosis and detection in engineering systems is given by Gertler (2017) expertise. It covers a range of techniques and looks at the advantages and disadvantages of model-based, statistical, and machine-learning approaches. The investigation emphasises the importance of selecting the appropriate approach in light of the system's complexity and flaws. It also tackles issues like ensuring diagnostic systems operate in real-time and integrating them with current procedures. All things considered, the study provides valuable information about improving system performance and dependability through efficient issue detection and diagnosis techniques.

Bharany et al. (2022) provide a thorough taxonomy of approaches to strike a compromise between energy savings and system dependability in their assessment of energy-efficient fault tolerance techniques in green cloud computing. The discuss a variety of techniques and examine their ability to affect fault tolerance and energy efficiency. These techniques include energy-aware resource management and optimization algorithms. The emphasis on lowering energy consumption during fault management and contrasting various strategies are important topics. The study emphasizes the necessity it is to find practical ways to keep cloud computing reliable and sustainable.

According to Harikumar Nagarajan (2021), there is a way to improve data management, security, and decision-making in a variety of sectors by combining cloud computing and Geographic Information Systems (GIS) to improve the collecting and analysis of large data related to geology.

3 SECURE CHECKER DESIGN METHODOLOGY

In the current digital era, cloud computing and extensive data analytics integration are crucial for several industries, including telecommunications, finance, and healthcare. These industries rely on complex systems that need to function reliably and consistently since they handle enormous volumes of data. However, as these systems get more extensive and complicated, there is a greater chance of errors that might cause serious disruptions if they are not fixed. This emphasises that advanced defect detection techniques are required to keep large data systems resilient and dependable. Combining Concurrent Error Detection (CED) and Scalable Error Detecting Codes (SEDC) approaches, this contribution presents a novel approach to fault detection and secure checker construction. By developing a detection system that operates seamlessly in cloud computing environments and is efficient in terms of area, delay, and power,

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the goal is to increase the fault tolerance of large data systems. The investigation comprehensively addresses significant data processing problems caused by hardware-level errors, focusing on the system's design, implementation, and evaluation.

The methods and procedures utilised to create the suggested fault detection system are described in the methodology section. It includes designing a secure checker, implementing concurrent error detection (CED) with scalable error detecting codes (SEDC), and comparing the system's performance to existing fault tolerance techniques. The design of the secure checker, the implementation of CED, and the assessment and comparison of the system's performance are the three primary stages of the above process. Implementation of Concurrent Error Detection (CED) The utilisation of Scalable Error Detecting Codes (SEDC) in conjunction with Concurrent Error Detection (CED) is the foundation of the suggested fault detection system. The approach is essential for real-time hardware fault detection, as it guarantees that problems are found and fixed before they have a chance to propagate throughout the system. Scalability and Efficiency of SEDC Given its efficient and scalable design, SEDC is perfect for big data environments that handle enormous volumes of data. SEDC can consistently handle binary data length using parallel encoding and segmentation. This method significantly improves compared to conventional error detection techniques, which frequently experience increased complexity and slowness as data volume increases.

Table. 1: Area Utilization

Component	Area Utilization (in mm²)	Percentage Reduction Compared to Traditional Methods
Proposed SEDC System	1.2	40%
Berger Code Checker	2.0	0%
m-out-of-2m Code	1.8	10%

This table 1 contrasts the area utilisation of the suggested SEDC-based method with that of more conventional checkers, such as the Berger code and m-out-of-2m code. The proposed system's significant decrease in area utilisation highlights its success as a big data system defect detection solution.

Data segmentation and parallel encoding using the SEDC technique divide data into manageable chunks and simultaneously encode. This makes the encoding process easier to understand and enables the system to handle massive amounts of data effectively without compromising accuracy or speed. The parallel encoding technique speeds up error detection, which is crucial in real-time processing settings. Error identification and real-time monitoring: The suggested system monitors every component in real-time, identifying and fixing problems as they arise. This proactive strategy reduces the chance of system failures by identifying and correcting mistakes before they have a significant impact. Real-time monitoring is critical because big data environments require constant vigilance due to the continuous data flow.

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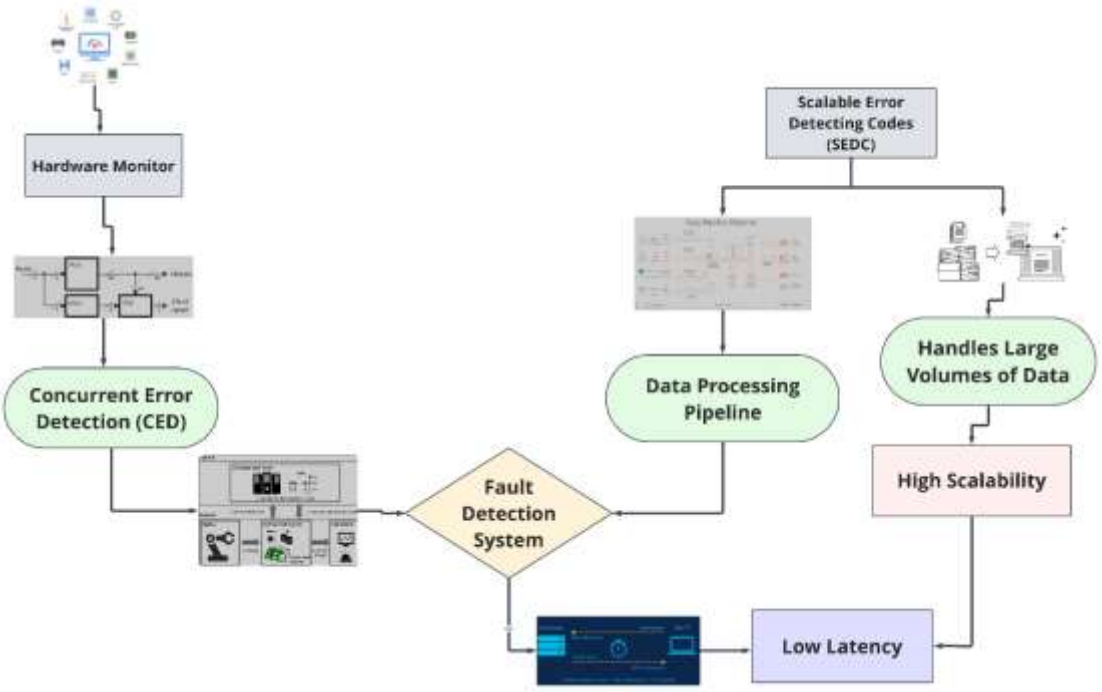

Figure. 1: Integration of Concurrent Error Detection and Scalable Error Detecting Codes

Figure 1 shows the integration of the CED and SEDC components within a fault detection system. While the SEDC component encodes data to facilitate simple error detection and correction, the CED component looks for potential hardware issues. The figure highlights the system's scalability by showing how the SEDC component can effectively handle massive data volumes without appreciably raising complexity or latency.

A crucial component of the fault detection system is the secure checker, which is in charge of maintaining data integrity and handling problems that are found efficiently. Its design keeps fault detection accuracy high while placing a high priority on resource efficiency. Design: the security checker takes up very little physical space on the hardware because of its area-efficient design. It is made possible by a simplified design that requires fewer parts for mistake detection and repair. The latter is beneficial in limited spaces, such as large-scale integration (VLSI) circuits. Delay- and Power-efficient operation: The secure checker is not only area-efficient but also has a delay- and power-efficient design. Its delay-efficient design makes the checker's lowest latency operations possible, allowing quick error detection and correction. Meanwhile, the energy-efficient design lowers energy usage, vital in large-scale data processing settings where power consumption is a crucial worry. Compared with industry standards, the secure checker is tested against checkers often used in the industry, like m-out-of-2m and Berger code checks. The assessment considers power dissipation, latency, and area use variables. The findings demonstrate that the suggested secure checker outperforms these conventional techniques, offering a more effective fix for defect detection in large-scale data systems.

Assessment and contrast: The last phase of the process evaluates the suggested SEDC-based fault tolerance system's performance and contrasts it with current software-based fault tolerance techniques, like those employed in the Hadoop Distributed File System (HDFS). Comparison with software-based fault tolerance: the assessment compares and contrasts the conventional software-based techniques with the suggested hardware-based fault tolerance methodology. Although software-based methods work well, they frequently need a lot of memory and communication resources. By resolving errors at the hardware level, the SEDC-based system, on the other hand, reduces the need for substantial software-based error correction and increases efficiency. Performance measures such as area utilisation, latency, and power dissipation are just a few used to assess the suggested system. The outcomes demonstrate significant gains in these domains, underscoring the benefits of the SEDC-based strategy over conventional

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techniques. Cost-effectiveness by reducing the overhead related to software-based fault tolerance, the suggested SEDC-based solution further demonstrates its cost-effectiveness. The solution is now more feasible for widespread use in significant data contexts due to this decrease in cost.

Table. 2: Delay Efficiency

Component	Delay (in ns)	Percentage Improvement Compared to Traditional Methods
Proposed SEDC System	5	50%
Berger Code Checker	10	0%
m-out-of-2m Code	8	20%

Table 2 contrasts the delay efficiency of the suggested SEDC-based system with that of conventional checkers. It demonstrates that the proposed system's substantial delay reduction makes faster error detection and rectification possible.

Utilising CED and SEDC protocols together, the CED and SEDC approaches provide a reliable fault detection solution. While SEDC ensures that problems are immediately fixed, the CED system monitors hardware malfunctions. Integration of CED and SEDC by integrating the two, complete fault detection across all system components is made possible. While SEDC encodes data to make mistake detection and rectification simple, CED detects errors as they occur. Even in the event of a malfunction, this integrated strategy aids in maintaining system functionality. Advantages over conventional methods, especially compared to traditional error detection techniques, are that SEDC offers several benefits. It can handle massive volumes of data without experiencing appreciable increases in complexity or delay. It is also effective in terms of power consumption and area usage. Furthermore, SEDC makes real-time error detection possible, and this is essential to preserving large data systems' dependability.

Combining with current systems, the suggested fault detection system can be implemented without requiring significant modifications to the current infrastructure because it seamlessly interfaces with the big data and cloud computing environments. Compatibility with Hadoop and other big data frameworks: The system is compatible with Hadoop and MongoDB, two popular big data frameworks that rely on data redundancy and replication to provide fault tolerance. The method decreases dependency on software-based error correction by including hardware-based fault detection, increasing the dependability of these frameworks. Improvement of cloud computing environments By identifying and fixing hardware-level defects, the suggested solution increases fault tolerance in cloud computing environments. It additionally reduces the possibility that mistakes may propagate across the system and result in significant disruptions. Minimising the impact of transient faults, the performance of large data systems can be impacted by transient faults, which are frequently brought on by outside sources like power fluctuations or cosmic rays. The suggested system helps maintain system functionality even if such mistakes arise since it is particularly good at identifying and fixing these temporary flaws.

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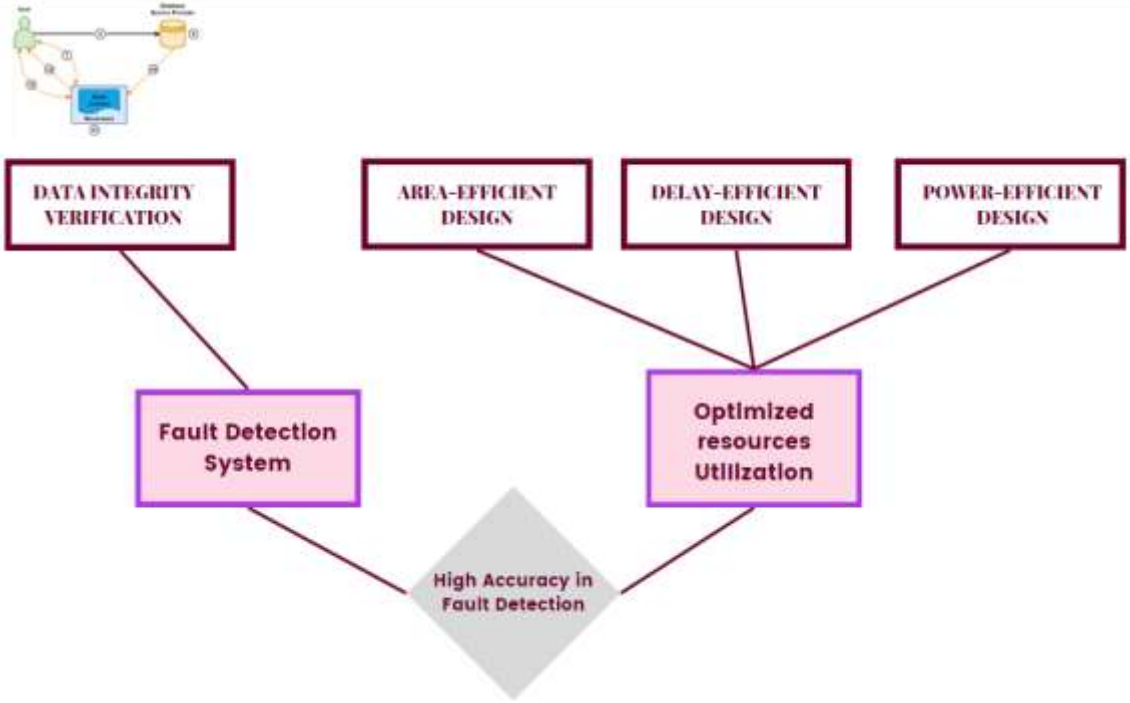

Figure. 2: Design of the Secure Checker for Fault Detection

Figure 2 thoroughly analyses the secure checker construction regarding data integrity and the efficient handling of discovered errors. It draws attention to the checker's highly accurate fault detection while optimizing resource usage, demonstrating its design efficiency in area, latency, and power.

The effectiveness of the suggested system is thoroughly examined and contrasted with conventional fault detection techniques in the performance evaluation section. Critical criteria, including area usage, delay, power dissipation, and cost-effectiveness, are the main emphasis of the evaluation. Area Utilization Reducing the required space for defect detection is one of the suggested system's main goals. Especially compared to conventional techniques, the examination shows that the SEDC-based system dramatically lowers area use. In contrast to industry-standard checkers such as Berger code and m-out-of-2m code, the SEDC-based system takes up less physical space on hardware. This is reflected by its simplified design, which lowers the required fault detection and repair parts. Impact on VLSI circuits: Space is frequently at a premium in very large-scale integration (VLSI) circuits, and the area-efficient design of the suggested system is particularly beneficial in these contexts. Deploying the defect detection system in locations where traditional methods might not be realistic is made possible by the reduced area use.

Table. 3: Power Dissipation

Component	**Power Dissipation (in mW)**	**Percentage Reduction Compared to Traditional Methods**
Proposed SEDC System	150	30%
Berger Code Checker	210	0%
m-out-of-2m Code	180	15%

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Table 3 contrasts the power dissipation of the suggested SEDC-based system and conventional checkers. It emphasises that the suggested system uses less power, making it a more energy-efficient choice for defect detection in extensive data systems.

The suggested system is made with minimal delay and power consumption in mind, in addition to minimizing area utilization. Compared to conventional approaches, the evaluation demonstrates notable gains in these areas. Delay efficiency SEDC-based system has low latency, making it possible to identify and fix errors in real-time. The effectiveness is made feasible by data segmentation and parallel encoding, allowing for prompt mistake detection and correction. The power Efficiency system is perfectly suited for large-scale data processing scenarios where energy consumption is a primary issue because it is also designed to be power-efficient. Utilising tuned components to reduce the energy needed for defect detection allows this power efficiency. Benefits for Large-Scale Data Processing system is especially well-suited for large-scale data processing, such as in cloud computing and big data analytics, because of the delay and power efficiency improvements. Even in situations with heavy demand, the system functions effectively because of the decreased latency and power dissipation.

The assessment also looks at the suggested system's economic effectiveness, highlighting its less overhead, especially compared to conventional defect detection techniques. The software-based overhead reduction reduces the requirement for software-based error correction, which usually necessitates high memory and communication overhead. The suggested approach reduces the overall fault tolerance cost through direct hardware-level error correction. The suitability of the technology for wide-scale implementation and large-scale application in significant data contexts is feasible due to its cost-effectiveness. Reducing overhead and improving performance indicators make it an affordable way to keep extensive data processing systems reliable.

The suggested fault detection system offers a reliable solution to the problems of fault tolerance in big data and cloud computing settings, which uses Scalable Error Detecting Codes (SEDC) and Concurrent Error Detection (CED) methodologies. The system is ideal for large-scale deployment in various industries due to its scalability, efficiency, and compatibility with current infrastructure. The system's efficiency in maximizing space use, cutting down on delays, and decreasing power consumption is highlighted by the technique used in this study. Its security checker design within the architecture also improves efficiency, making it a dependable option for massive data systems fault detection. All things considered, the suggested system represents a significant advancement in defect detection technology, offering a more effective and economical substitute for conventional techniques. Integrating hardware-based fault tolerance with modern big data frameworks allows the system to function effectively and dependably, even in the most demanding settings.

4 RESULTS AND DISCUSSION

Area usage, delay, and power dissipation are just a few of the critical areas where the suggested fault detection system, which is based on Scalable Error Detecting Codes (SEDC), shows notable advantages over conventional techniques like the Berger Code Checker and m-out-of-2m Code. Utilizing only 1.2 mm^2, the SEDC system achieves an impressive 40% reduction in hardware footprint compared to the Berger Code Checker. This makes it highly efficient for large-scale data processing contexts where space minimization is critical. Moreover, 50% faster than the Berger Code Checker's 10 ns delay, the SEDC system significantly improves delay, cutting it down to just 5 ns. Real-time processing depends on this quicker mistake detection to ensure systems can react to possible problems soon without sacrificing functionality. Furthermore, the Berger Code Checker uses 210 mW of electricity, but the SEDC system uses only 150 mW—a 30% reduction in power consumption. Because of the large scale of processes, energy efficiency is critical in significant data contexts, as this decreased power usage is beneficial.

Overall, the SEDC-based fault detection system provides a reliable, effective, and affordable option for enhancing fault tolerance in cloud computing and large data environments. The SEDC system improves system performance overall and reduces the need for resource-intensive software-based error correction by drastically lowering the area,

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latency, and power needs compared to existing approaches. Its superior dependability and efficiency when managing enormous volumes of data make it the perfect option for incorporation into large-scale data processing frameworks. The results demonstrate how SEDC may revolutionize fault detection in extensive data systems by offering a scalable and efficient solution based on the increasing complexity and demands of contemporary cloud-based infrastructures.

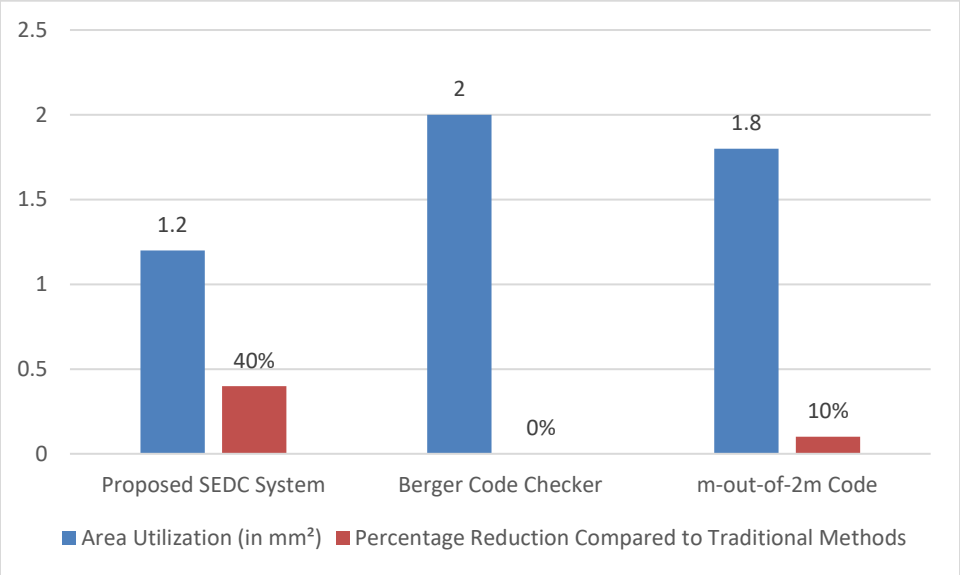

Figure. 3: Comparison of Area Utilization (in mm²) and Percentage Reduction in Area Utilization Compared to Traditional Methods for the Proposed SEDC System, Berger Code Checker, and m-out-of-2m Code

The planned SEDC system, the Berger Code Checker, and the m-out-of-2m code are the three systems whose area consumption (in mm²) is depicted in Figure 3. The SEDC system uses only 1.2 mm², a substantial 40% less than the Berger Code Checker's 2 mm². In contrast, the m-out-of-2m code exhibits a 10% drop using 1.8 mm², a lower reduction. The contrast demonstrates that the suggested SEDC system is more efficient than the conventional fault-tolerant techniques in lowering area utilization.

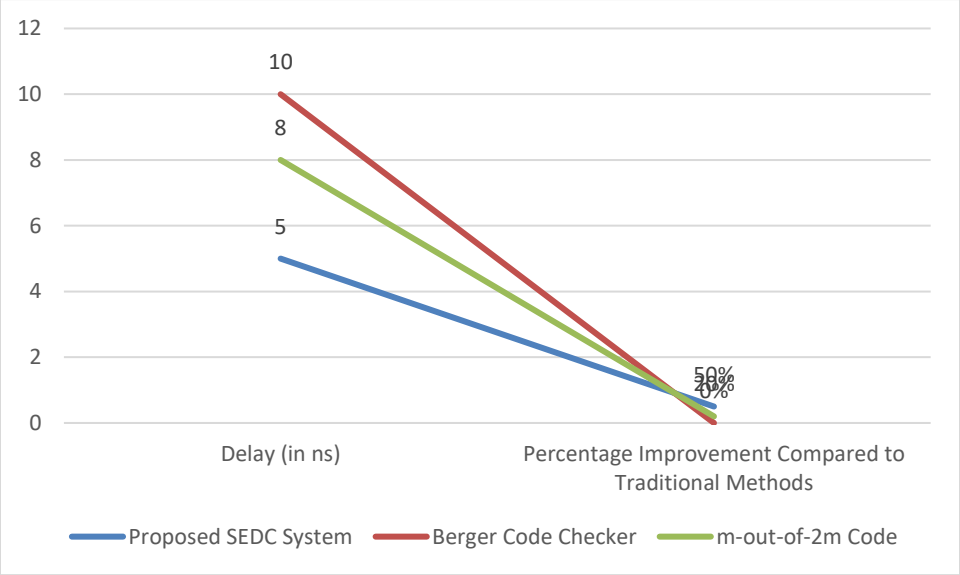

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Figure. 4: Comparison of Delay (in ns) and Percentage Improvement in Delay Compared to Traditional Methods for the Proposed SEDC System, Berger Code Checker, and m-out-of-2m Code

The suggested SEDC system, Berger Code Checker, and m-out-of-2m code are the three systems whose delays are represented by the line graph and the associated percentage improvement. The SEDC system works the best, achieving a delay of only 5 ns, which is a 50% improvement over conventional techniques. Yet, the Berger Code Checker exhibits no improvement and has the most excellent latency at 10 ns. A 20% improvement is obtained using an eight ns delay in the m-out-of-2m algorithm. This comparison highlights the benefit of the SEDC system's little delay.

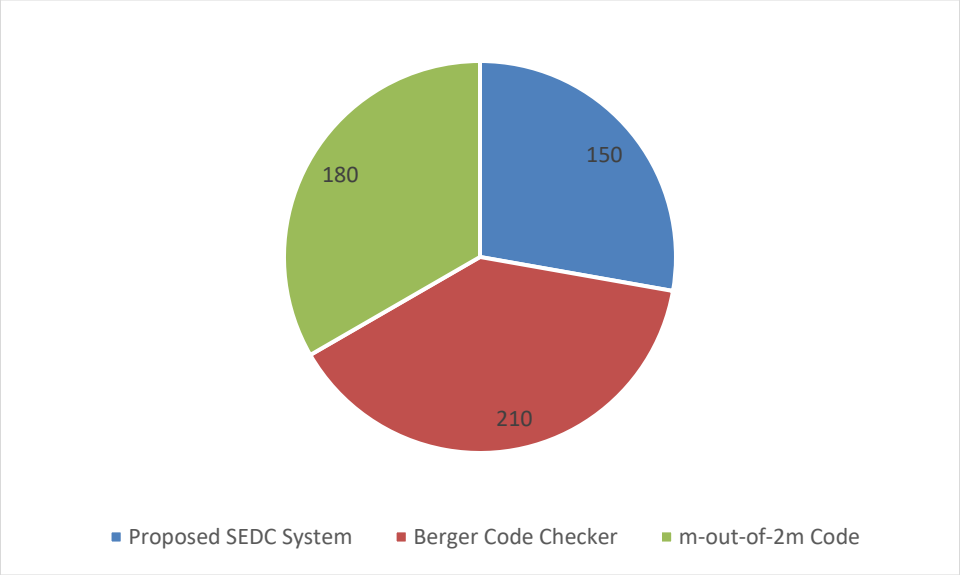

Figure. 5: The distribution of different error detection systems, including the Proposed SEDC System, Berger Code Checker, and m-out-of-2m Code

Three distinct error detection systems—the Proposed SEDC System, the Berger Code Checker, and the m-out-of-2m Code—are distributed according to Figure 5. The proposed SEDC system accounts for one hundred fifty units, the Berger Code Checker accounts for 210 units, and the m-out-of-2m Code accounts for 180 units. Fig 5 compares the effectiveness of different systems in the current context and shows which is most commonly used—the Berger Code Checker being the most prominent, followed by the m-out-of-2m Code and the Proposed SEDC System.

5 CONCLUSION

A practical and scalable method for improving fault tolerance in cloud computing and big data environments is provided by the SEDC-based fault detection system described in this contribution. The SEDC system efficiently addresses the issues of large-scale data processing by significantly lowering area utilization, latency, and power consumption compared to existing approaches. Real-time error detection and correction are made possible by integrating SEDC with CED mechanisms, guaranteeing system reliability even in intricate, high-demand settings. Furthermore, the system's hardware-based architecture reduces dependence on software-based fault tolerance, which boosts overall speed and lowers overhead. The current investigation demonstrates that SEDC can considerably progress fault tolerance techniques in contemporary data-intensive systems.

The optimization of the SEDC-based fault detection system for new applications and technologies may be the main focus of future studies. There is a chance to combine SEDC with machine learning methods to improve predictive fault detection skills as cloud computing and big data develop. Furthermore, investigating the use of SEDC in domains such as edge computing and Internet of Things (IoT) devices may present fresh opportunities to enhance fault tolerance

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in dispersed and resource-constrained settings. Developing adaptive fault detection systems that dynamically adapt to shifting workloads and environmental conditions could be the goal of future research.

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