International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Generalized Statistical Indicators For Cloud Computing Fault Tolerance

Subramanyam m vadlamaani [1], P K Bharti [2], M. Rudra Kumar [3]

Submitted: 06/06/2022 **Accepted:** 10/09/2022

Abstract: Contemporary information and transaction processing systems mainly rely on cloud computing for their infrastructure. A shared pool of reconfigurable computing resources (such as networks, servers, storage, applications, and services) may be quickly deployed and released with no administration labour or service disruption thanks to cloud computing, which offers universal, practical, on-demand network connectivity. Due to the increasing need for more fault-tolerant and high-availability cloud computing servers, server managers must increasingly concentrate on key performance indicators for these systems. Server administrators are very concerned about the performance of high-availability and fault-tolerance systems since it is usual for unanticipated and unplanned outages to occur often. Based on the sustainability and pattern indicators discussed in earlier research, this study suggests a directional analytic pattern indicator for cloud computing servers. The Heikin Ashi charting pattern, which is akin to a Japanese candlestick pattern, is used by the Generalized Statistical Indicators for Fault Tolerance (GSI-FT) to identify the patterns in service consumption across various time periods. The preceding research's ISO/IEC 30134-1 and 30134-2-Datacenters-Main performance indicators, which examined the internet bandwidth frequency for high availability and fault tolerance movements, were used as the basis for the experiments. Results of testing have demonstrated that GSI-FT may function as a directional indicator to identify the pattern frequencies of the performance indicators and offer details on fault tolerance by giving observation frequency, performance trend, and awareness level for this pattern. The red candlesticks show the model's progress toward fault tolerance, while the green symbolises the model's high availability. A charting model that has evolved over time over the pattern shows the model's capacity to depict server-level signals that are plausible using our methodology.

Keywords: *Cloud Computing Indicator Patterns; Computer Programming; Fault Tolerance; Heikin Ashi Cloud Indicators; KPI indicators for Cloud Computing.*

1. Introduction

Information and communication systems have progressed, and today's powerful IT infrastructure solutions enable more effective administration of information systems. Cloud computing has made IT infrastructure management and long-term development easier.

Most applications and information systems are now cloud-based, and older storage solutions are becoming obsolete. Cloud solutions must be efficient as cloud-based applications become increasingly significant. Fault-tolerance solutions are critical given the demand on information systems and cloud servers [1].

Fault tolerance refers to a system's capacity to manage services without interruption in the case of a component failure (network, cloud resources, systems accessing cloud apps). By preventing single-point failures, developing a fault-tolerant system helps manage system availability and business continuity.

Backup components that are automatically triggered depending on failing components and service loss control the fault-tolerance system. Components of the back system include

- Resources
- Computer programming
- Power sources are required for system administration.
- Process Management for P&D

For non-disruptive system processing and catastrophe recovery, fault tolerance is critical. Several organizational catastrophes have resulted from a lack of fault tolerance mechanisms. Users of stock-broking applications can't view real-time charts or experience slowness, or folks from specific locations can't use it, and so on. Low-bandwidth banking applications do not allow users to transact [2].

While the examples above are simple, the lack of a reliable fault-tolerance solution might have an impact on stakeholders. Fault tolerance must be seen from several

[1]*Research Scholar, Department of CSE, Shri Venkateshwara University, Gajraula, UP*
Email: subrahmanyamvadlamaani@gmail.com
[2] *Vice-chancellor, Shri Venkateshwara University, Gajraula, UP.*
Email: vc@svu.edu.in
[3] *Professor, Department of CSE, GPCET, Kurnool.*
Email: mrudrakumar@gmail.com

* *Corresponding Author Email: subrahmanyamvadlamaani@gmail.com*

angles. First, create a fault tolerance system that is reliable. Second, maintain effective performance indicators and reporting systems.

Previous research had offered fault-tolerance management strategies and frameworks. Only a few studies have created a complete set of indicators for evaluating application fault tolerance and controlling action triggers. Monitoring system performance and fault tolerance conditions puts network and server managers under a lot of pressure [1].

This paper examines existing cloud-based fault-tolerance indicators and suggests a "Heikin Ashi"-inspired indicator for fault tolerance and high availability performance movement.

Heikin ashi indicators for cloud computing fault tolerance are introduced in Section 1. Cloud failure tolerance was covered in Section 2. Related work and fault-tolerant cloud computing concepts were discussed in Section 3. Model-related procedures and materials were explored in Section 4. Data metrics and HAI-FT implementation are explained in Section 5. Data interpretation and data analysis are described in Section 6. Experimental studies and model comparisons were done in Sections 7, and 8. The article's conclusion and reference are included in Section 9.

2. Fault-Tolerance Application in Cloud Computing

2.1. Categorization

In the case of cloud computing, fault tolerance might be ascribed to creating a strategic system for managing the current work in the event that the service paradigm is unavailable or interrupted. Fault tolerance is described as the capability of a service that continues to work despite failure in part of the system, or some external effects. The creation of such a system makes it possible to manage the needs for the infrastructure and the services with no problems. Maintaining a pool of computers with standby service is considered to be one of the basic steps that should be taken for providing fault tolerance in the cloud environment Despite this, fault tolerance systems are not a perfect substitute; they can give network administrators enough time to respond to a problem strategically and tactically, as well as, in the case of robust information systems, to operate in continuous mode and to manage the system efficiency levels [3], [4].Critical Aspects of Fault Tolerance in Cloud Computing

- **Redundancy**

In the instances of a system performance failure to the desired state, it is essential for a robust backup alternative. In an illustrative scenario, when a web application with a database system is down due to hardware implications, a backup database should be active to counter the offline condition. In simple terms, the server manages a contingency database constituting numerous redundant services within [1].

- **Replication**

The fault tolerance solution is about managing replicas of every service in the system operation. In the instance of a specific system going wrong, other instances can trigger performance and continuity. When a database cluster has three different servers with the same real-time information available, one server stands active. The other two stand inactive and on standby for any fault tolerance kind of backup as required [5].

- **High Availability**

High availability in a cloud-system context refers to a system's ability to mitigate the loss of service by reducing any interruptions or downtime. Profoundly, the concept is explained in terms of system-up time or running time. The context is opposite to the fault tolerance and reflects on the capability of the system to handle high load instances [6].

For a robust business continuity strategy, high availability and fault tolerance is prerogative to ensure that the organization manages essential functions in the instances of minor failures and towards disaster management. Also, the individual importance of fault tolerance and high availability are different and cannot be ignored [3], [5].

2.2. Techniques

All the critical service composition in the system needs to consider in the designing of a fault tolerance system, including the database solutions and power sources.

Prioritization of the services, load balancing capabilities, and high availability capability of the main servers and back-up servers are essential. In an illustrative scenario, for a high traffic transaction processing web application, when the main server is down, the back-up systems should be equally efficient and last until the main servers are resumed. If such prioritization is not in place, the purpose of managing fault tolerance solutions is not addressed [6], [5].

Transaction or information processing in the fault tolerance instances are imperative for some impact. However, the impact should not transpire into a single point failure for the application systems. Such an outcome can be managed only when the administrators can have both objective and subjective views of the ongoing performance of the multiple systems, servers, and alternate solutions [1], [2].

In the other dimension, the fault occurrence is to be managed exclusively in comparison to other systems, and it helps the system admin teams to work on the system failures and resumptions more effectively.

The mainline system's performance could be affected by any or many of the following, but not limited to.

- Application Issue
- Hardware issue
- Network Issue
- Security breach
- Stack overflow conditions

- Maintenance requirements
- Upgrade Requirements

Fault-tolerance, in the case of system management, is to be focused on both the aspects of deploying the fault-tolerance system combined with high-availability management for the cloud-servers [3].

2.3. Need for the Indicators

The monitoring teams must be aware of the load balance, requirement for server space, bandwidth, power resources, and other infrastructure consumables for the primary and backup servers in the event of a well-fit cloud server with an acceptable fault tolerance system and high availability system. Such analysis will aid in greater efficiency, contingency planning, and constraint conditions readiness. A real-time indicator pattern illustrating the system approach might be more useful for the system stakeholders even though there are several types of cluster or silos reports generated for high availability and fault-tolerance [2].The monitoring teams must be aware of the load balance, requirement for server space, bandwidth, power resources, and other infrastructure consumables for the primary and backup servers in the event of a well-fit cloud server with an acceptable fault tolerance system and high.Therefore, the focus of this publication is on creating a comprehensive solution that serves as indicators for the performance trend of cloud data servers, assisting admin teams in concentrating on key conditions for system functioning toward high availability or fault-tolerance conditions.

3. Related Work

Several research have concentrated on establishing fault-tolerance solutions for cloud computing in order to increase efficiency and performance. Few studies have looked at fault-tolerance measuring indications or trends in real time.
A distinct set of sustainable metrics for regulating cloud server fault-tolerance was examined in previous study. The goal of the business scenario is to provide cloud server managers with clearer, more intuitive visual indicators that illustrate trends and deadlines.
This overview of related work presents complete methods and relevant indicators for analysing fault tolerance and high availability in cloud computing platforms.
The contemporary model [6] builds on prior research and conducts a literature review on cloud computing fault-tolerance frameworks. FT-Cloud, PCFT, Self-Adaption, FT Place Framework, Hybrid Fault Tolerance Architecture, Dynamic Adaptive Fault Tolerance (DAFT), FTM, MULTS Architecture, and Preference-Based Fault Management were chosen as finalists in the review. The authors of the study make no mention of any visual or metric-based methods for presenting real-time reality.
The contemporary approach [7], [8] which focuses on cloud computing sustainability criteria, is also useful. The report identifies difficulties, trends, and sustainability issues regardless of high availability or fault-tolerance. As a metric of sustainability, the study looks at ISO service management standards and ITIL standards.
The study's indicators are tabular data computations based on Magalhaes and Pinheiro's ITIL and IT service management techniques from 2007. Data flow, data kinds, and data consumption are used to assess process conditions in ISO/IEC 19944 – Cloud services and devices. The measure determines whether or not sustainability fulfils SLA. There are few signs that a cloud application is moving toward high availability or fault tolerance.
The application of ISO 9000: Quality Management criteria for Plan-Do-Check-Act Cycle compliance is also highlighted in the review research. A sustainability indicator exists, but there is no effective pattern that reflects the structure.
Cloud computing fault tolerance and resilience are measured by the researchers [9]. The essay looks at scenarios when fault tolerance is required. The process structure of each condition is listed. The indicators are correct for all metrics, and the scenario is frequently classified as semi-active, active, or semi-passive. The structure tabulates the indication evaluation settings. A consolidated report may be feasible, but it may lack the sensitivity of real-time analytics.
Fault Tolerance (FT) techniques and models were investigated by the authors of [10]. The research looked on FT approaches and models. The research makes no recommendations for a specific visual signal to assist the monitoring system.
Real-Time Online Interactive Applications is a monitoring system presented in the research [11]. (ROIA). They can aid users in visualising important service parameters. The authors of the study spoke about a possible process flow that shows real-time system performance in a graphical chart (ECG movement). The administration staff must concentrate more on the model when it comes to server performance adjustments. Fault tolerance practises are also included in the ROIA for solution development.
Other papers relevant to fault tolerance application models for cloud computing [12-19] highlight the need of addressing fault tolerance circumstances. There are few studies on indicator system practises. The study model is inspired by the above-mentioned related work, which focuses on enhancing fault tolerance models in cloud computing applications. Enhanced models in indication systems can provide cloud server monitoring teams with easy and effective levels of indicators, allowing them to manage long-term solutions.

4. Proposed Method and Materials

HAI-FT (Heikin Ashi Indicators for Fault Tolerance) uses trendsetting to examine crucial server metrics. The model is dynamic, so the solution can be applied to multiple timeframes, and the administrator can get a practical perspective of the system's average performance in an up-trend, down-trend, or sideways trend, where high availability and fault tolerance zones may be evaluated.

4.1. Heikin Ashi

Heikin Ashi is popular among traders because to its potent trend indication. Millions of stock market traders utilise Heikin Ashi candlestick indicators to forecast programmed movement trends. The recommended approach uses Heikin Ashi indicators to show load factor trends in relation to session volume and performance conditions. Network managers should be able to make decisions regarding the current situation with the help of the general trend.

Figure 1: Conventional and heikin ashi candlestick patterns

Its capacity to reduce the noise of real-time movements in the load-factors (or, in stock market jargon, to reduce the noise related to stock movements in real-time) and provide clear directions even in the volatile conditions served as the inspiration for the choice of the Heikin Ashi type of chart indicators. Accordingly, the model may assist in reducing real-time indication noise and reflecting in a clear direction [18], attributing the same to the cloud server environment.

A phrase that refers to the average bar in Japanese is suggested statistics. It refers to the updated price values over a chart in stock market lingo. The Japanese candlesticks are profoundly composed of the four sections open, high, close, and low. The Heikin Ashi model alludes to a movement in a certain direction, whereas the standard candlestick gives the open, close, high, and low values for respective candlestick of a time period [19], [20].

As depicted in Figure 1, the normal candlestick pattern refers to the real-time movement over a specific timeframe. Assessing the trends (uptrend or sideways or downtrend) in the model is overly complex unless the patterns are used in conjunction with other indicators. Whereas the Heikin Ashi model refers to the averaging approach, identifying a specific trend over a period is much easier [21], [22], [23].

Heikin-Ashi model depends on formulae of two-period averages, offering a smoother appearance and providing spot trends for upwards or reversals, alongside depicting any obscure gaps.

4.2. Heikin Ashi Interpretation

The model refers in specific to a direction in which the chosen metric is conducting itself in a more simple and specific method. The green or red candles with shadows only to the specific direction (red constituting lower wick and Green constituting only upper wick). The gaps in the candlesticks are not evident in the model, as the chart is calculated according to information from earlier candles.

The critical advantage of the model is the ease with which the information over two periods can be seen more simply to spot the trend. The model is seen as effective due to reducing the false trading signals sideways and even in choppy conditions.

4.3. Heikin Ashi Formulae

The Heiken Ashi formula used to derive these average values is as follows:

Open = (open of previous bar + close of previous bar)/2

Close = (open + high + low + close)/4

High = the maximum value from the high, open, or close of the current period

Low = the minimum value from the low, open, or close of the current period.

Table 1 represents the conditions wherein the normal candle estimations are shown to the left. The calculations over the Heikin Ashi models for a scribe are depicted in the right columns. Despite that the model is vividly used in the stock price charting models, the same theory can be applied to the cloud server load capacity management visualization wherein the movement can be observed for high availability or running towards fault tolerance conditions [22], [23].

Figure 2: Heikin ashi trend indicators

The green offshoots in Figure 2 refer to the positive direction (seen as source as high availability). The red offshoots refer to the negative movements (seen as low availability aka fault-tolerance scenario). In terminology to this manuscript model, the upside trend shall refer to the performance management towards high availability, which indicates the strength of the cloud infrastructure to handle the load, and the strong red candles indicate the heavy reliance on the fault-tolerance solutions [24], [25], [26], [27].

The small candles, as depicted in Figure 3, refer to the trend reversals, which can be an indicator for cloud server administrators to focus on the action required at the instance.

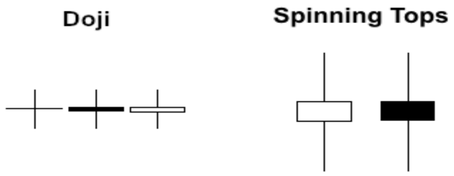

Figure 3: DOJI -reversal trends

4.5. The objective of Implying the Model

To understand the load balancing capacity for the cloud servers based on information like whether the attributes are available for high availability or being handled towards fault tolerance conditions.

To provide a visual representation of the system's usage as high-availability or fault-tolerance based on simple charting analysis, efficiently indicating the stakeholders the current capacity of the cloud-server infrastructure.

To develop the model in a simple format that can be resourceful for any attribute estimation wherein the time frame analysis is possible. The attribute can be assessed for open, high, low, and close numbers.

5. HAI-FT Implementation

The proposed assessment is a presumed cloud-server scenario wherein the administrator must monitor for the server load trends, response trends for the sessions active for the server. Thus, considering such a hypothetical scenario, the following are the key metrics considered integral for analysis.

- Hardware Systems – Processors, Network, bandwidth
- Software Systems – System response, functioning as per the information
- Power Sources Integral to System Management – Main Source Power, Back-up System activation.
- Physical and Digital Process Management

Table 1: Calculation Tabulation for Heikin Ashi Candles

Heikin ashi candlesticks								
QQQ	**Open**	**High**	**Low**	**Close**	**HA-Open**	**HA-High**	**HA-Low**	**HA-Close**
01-Aug-11	58.67	58.82	57.03	57.73	58.67	58.82	57.03	58.06
02-Aug-11	57.46	57.72	56.21	56.27	58.37	58.37	56.21	56.92
03-Aug-11	56.37	56.88	5535	56.81	57.64	57.64	55.35	56.35
04-Aug-11	55.98	56.09	40.17	54.17	57.00	57.00	54.17	55.10
05-Aug-11	54.79	55.03	52.32	53.83	56.05	56.05	52.32	53.99
08-Aug-11	52.21	53.12	50.59	50.59	55.02	55.02	50.59	51.63
09-Aug-11	51.31	53.08	49.93	53.03	53.32	53.32	49.93	51.84
10-Aug-11	51.82	53.04	50.8	50.86	52.58	53.04	50.80	51.63
11-Aug-11	51.58	53.69	51.34	53.10	52.11	53.69	51.34	52.43
12-Aug-11	53.42	53.9	52.88	53.57	52.27	53.90	52.27	53.44
15-Aug-11	53.77	54.36	53.53	54.36	52.85	54.36	52.85	54.01
16-Aug-11	53.82	54.35	53.18	53.90	53.43	54.35	53.18	53.81
17-Aug-11	53.98	54.42	53.02	53.58	53.62	54.42	53.02	53.75
18-Aug-11	52.13	52.14	50.48	50.95	53.69	53.69	50.48	51.43
19-Aug-11	50.43	51.67	49.99	50.03	52.56	52.56	49.99	50.53
22-Aug-11	51.21	51.24	50.06	50.21	51.54	51.54	50.06	50.68
23-Aug-11	50.56	52.28	50.34	52.28	51.11	52.28	50.34	51.37
24-Aug-11	52.18	53.42	51.71	52.69	51.24	53.42	51.24	52.50
25-Aug-11	52.64	52.91	51.65	51.83	51.87	52.91	51.65	52.26
26-Aug-11	51.68	53.31	51.15	53.13	52.06	53.31	51.15	52.32
29-Aug-11	53.64	54.67	53.64	54.61	52.19	54.67	52.19	54.14
30-Aug-11	54.39	55.3	54.11	54.97	53.17	55.30	53.17	54.69
31-Aug-11	55.29	55.74	54.60	55.06	53.63	55.74	53.93	55.17

5.1. Data Metrics

The metrics chosen for the project are developing a comprehensive solution that can work as an active indicator for the cloud server's performance in terms of high availability and fault tolerance conditions in Table 2. The performance of the cloud server in terms of high availability and fault tolerance conditions

The candle chart formation for the solution is captured in terms of data managed exclusively referring to open, close, high, and low values for the respective conditions. For instance, in the case of the power consumption metric, the power consumption is measured in units for the time frame.

6. Data Interpretation and Analysis

The data for the proposed model analysis is carried out in a simulated scenario wherein a random unit consumption value for each of the metrics is generated as open, close, high, and low. For the testing purpose, the data is simulated on two metrics as the RAM Capacity and the Internet Bandwidth Availability for the server.

The data generated is for 15 min time frame for ten days. To ensure that the simulated data is more in line with the real-time conditions. The test data is aligned to the free datasets available as the usual consumption indicators in busy cloud data servers.

The total amount of data tested for the simulation is for 960 rows of data wherein exclusive information as the bandwidth speed at open of the time frame, high, low, and close for a respective time frame. The key advantage of choosing the metric for assessment is to have a real-time understanding of the conditions that help in more effective assessment levels of the indicator.

Data generated for the simulation has been classified into three categories randomly where in the values reflect the high availability, normal sequence, and fault tolerance conditions.

Table 2: The performance of the cloud server in terms of high availability and fault tolerance conditions

Metric	**High Availability (indicated as a green candle)**	**Fault Tolerance (Indicated as a red candle)**	**.Remarks**
Power Consumption	Running on Main Power Line	Running on Alternate power line	If there is adequate and lines are good, strong green candles can be seen
Bandwidth Availability	Running on more than the SLA speed	Running on Alternate internet lines or lower than the agreed SLA speed	If there is adequate and lines are good, strong green candles can be seen
RAM Load	Managed as per the SLA speeds	Managed lower than the SLA speeds	Impact or good condition is reflected in a positive or negative candle.
Resource Scheduling	Adequate resource schedule for all servers and availability for more loads	Constraints of resource allocation and is high on interim implications	The positive or negative impact is reflected

6.1. Process Flow

Step-1

Setting the Contextual Time Frame

{choosing the time frame as required … (for the test analysis, the charting is carried out like 15 min)

Step-2

Choosing the metric for analysis

{for the test analysis, the bandwidth available for the period are tested… whereas any metric can be applied for the period)}

Step-3

Script code implementation connection for capturing the data

{script code implementation for data connectivity to the tracking solution}

Step-4

Application garners the information and accordingly executes the formulae for charting.

{

Open = (open of previous bar + close of previous bar)/2

Close = (open + high + low + close)/4

High = the maximum value from the high, open, or close of the current period

Low = the minimum value from the low, open, or close of the current period}

Step-5

The application plots the chart in any of the following three patterns

{

Green Candle with a long wick on the upper side

Or

Red Candle with a long wick to the lower side

Or

Small green or red candles based on the averages, and might have wicks to both sides}

Step-6

Interpretation of the Candle.

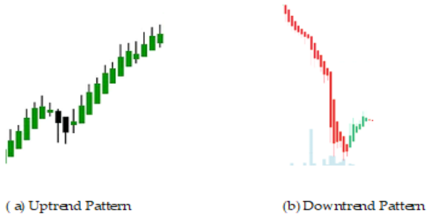

Figure 4: Uptrend and down trend depiction for heikin ashi

The trend constituting continuous green candles with the uptrend indicates the system is running successfully and is having the scope of high availability.

The two dark black patches in Figure 4(a) refer to the conditions wherein the system performance is affected and could be heading towards fault tolerance conditions. Whereas in the next sequence, it seems to have course correction, and the system resumes normalcy and high availability.

The red candle charting pattern, as depicted in Figure 4b), refers to the conditions wherein the system is working on the fault-tolerance model for a specific period and followed by resumption to normal operating conditions.

- **Key Inputs of Interpretation**

For the success of a robust cloud server, the model needs to be dynamic for both high-availability or Fault-tolerance conditions. The indicators referring to a long pattern of high availability or fault-tolerance only refer to the efficacy of the cloud server in handling the contingent conditions on both the fronts of a sudden influx of load or issues in the server maintenance.

Step-7

Server Admin is facilitated with a real-time charting indicator for the fault-tolerance model.

7. Experimental Analysis

7.1 The Data

For the experimental purpose, the simulated data is generated to a spreadsheet for the internet bandwidth conditions, with open, high, low, and close prices mentioned in Mbps available for the period. Based on the data available, the information for all the 15-minute time frames have been plotted. Using the charting style of the Excel sheet, the random values were generated for the model to depict the analysis.

7.2 The process

The mapping representation depicted below refers to the number of green, red, and reversal candle formations that were observed post the deployment of the Heikin Ashi candle formulae.

The pattern followed is about the random generation of OHLC for 960 rows (15-minute timeframe for ten days) and used the data to calculate the generalized statistical indicators charting calculations using the formulae mentioned in the process flow Step-4. Post the calculations' development, using the excel sheet stock charting pattern; the data is formulated into a candle chart pattern.

7.3 The analysis

Table 3 refers to the number of candles formed for different classifications based on the actual charting and generalized statistical indicators inspired charting model.

In line with the accuracy and the purpose of developing the indicator, the following pattern refers to the conditions wherein the charting has provided more accurate insights into the trend in terms of high availability or the fault-tolerance conditions integral to the process. Figure 5 refers to the conditional image of the flow of patterns picked randomly for the reporting purpose. The generalized statistical indicators chart pattern below indicates the sequential pattern wherein at specific timeframes, the fault tolerance was at work, and the high availability for a chart is at work.

Table 3: Refers to the number of candles formed for different classifications

Formation Type	Cumulative Candles
Long Green Candles	327
Short Green Candles	247
Long Red Candles	123
Short Red Candles	156
Reversal Trends	107

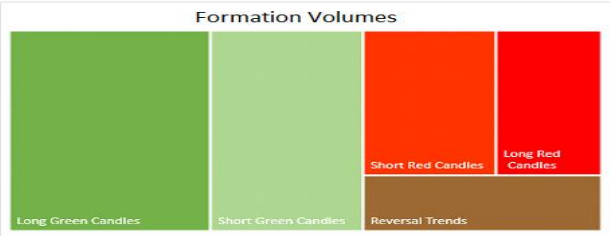

Figure 5: Formation values from charting

Figure 6: Internet bandwidth movement from experimental analysis.

Figure 6 represents the conditions wherein the normal candlestick pattern representation of the internet bandwidth availability and the generalized statistical indicators model representation is depicted. The conditional inputs available in the generalized statistical indicators model provide a specific mode of high availability or the fault tolerance scenario in force.

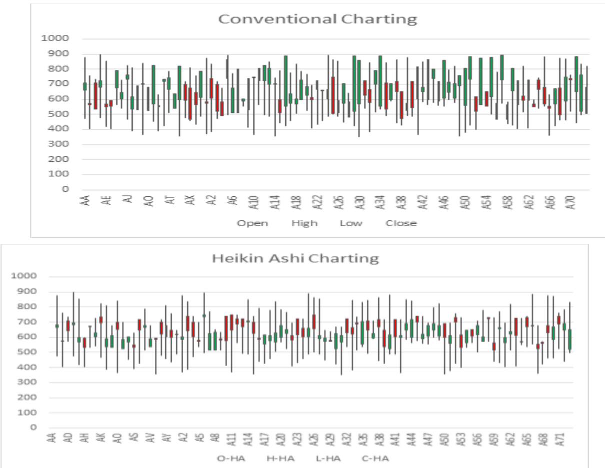

Figure 7: Experimental Data Charting

Figure 7 shows experimental analysis is in inspiration to the patterns and indicators of sustainability discussed in [9]; the following are critical and integral factors that can define the sustainable services from the cloud computing solutions. While the framework discussed in the research paper provides a detailed framework, there is a lack of structured indicator pattern suggested in the model, which can help in understanding the compliance with the

- ISO/IEC DIS 19086-2 – Service Level Agreement (SLA).
- ISO/IEC FDIS 19941 – Interoperability and portability.
- ISO/IEC 19944 – Cloud services and devices: data flow, data categories, and data usage.
- ISO/IEC AWI 22123 – Concepts and terminology.
- ISO/AWI 22624 – Taxonomy-based data manipulation for cloud services.
- ISO/IEC NP TR 22678 – Guidance for policy development.
- ISO/IEC 30134-1 and ISO/IEC 30134-2 – Datacenters – Main performance indicators.

One of the critical elements of the framework in [7] is about ISO/IEC 30134-1 and ISO/IEC 30134-2 – Data centres – Main performance indicators, wherein the cloud server having robust internet bandwidth connectivity is integral to undisrupted service conditions. Thus, taking such factors into account, the indicators developed in this manuscript can be highly resourceful in analyzing the patterns and trends for key performance indicators.

Also, the advocated generalized statistical indicators model discussed in this manuscript can be applied to all the key performance indicators for a cloud computing model. However, one of the key criteria that are to be followed in the model is about ensuring there is OHLC (open, high, low, and close) for the metrics chosen and the time frame application. If such data can be plotted to the generalized statistical indicators model, it can support ineffective plotting of the trend on a real-time basis.

8. Performance Analysis

The performance of GSI-FT is evaluated using the metrics "make-span rate," average turnaround time interval of a constant set of virtual machines with variable load, average turnaround time interval of a variable set of virtual machines with constant load. The GSI-FT Values for Fault-tolerant software systems cloud computing FTSS-CC [3] comparison and analysis. The metric values for GSI-FT, FTSS-CC, and their competence are described below.

Table 4: Rate of the GSI-FT and FTSS-CC-make-span

Metrics	10	15	20	25	30	35	40	45	50
GSI-FT	33	37	42	44	46	47	49	51	53
FTSS-CC	22	23	26	35	37	38	37	39	39

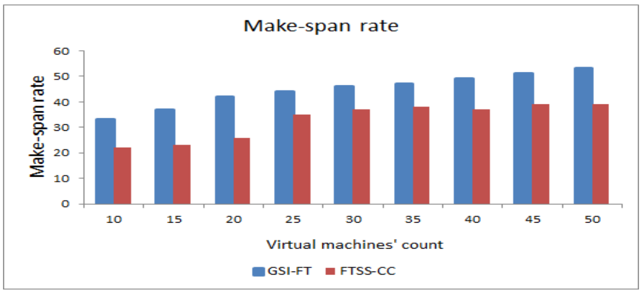

Figure 8: The GSI-FT and FTSS-CC make-span rates

Table 5: A consistent load's average turnaround time compared to a fluctuating number of virtual machines.

Metrics	10	15	20	25	30	35	40	45	50
GSI-FT	28	25	24	23	21	18	15	13	7
FTSS-CC	47	43	44	41	37	33	31	30	25

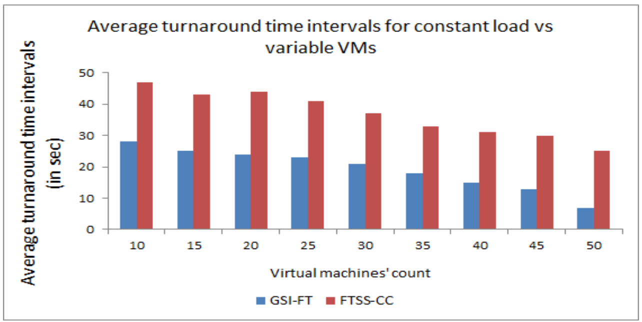

Figure 9: the variable number of virtual machines and the average turnaround times of GSI-FT and FTSS-CC

The availability or load scope of a virtual machine is measured by the "make-span rate" metric. A good metric make-span rate is represented by higher values. The make-span rate represents the availability of virtual machines. The proposed GSI-FT has a make-span rate of 44±6, which is much higher than the rate for the current model, the FTSS-CC, which is 32.5± 6.6, as shown in Figure 8 of Table 4.

Table 5 and Figure 9, the average turnaround times for models GSI-FT and FTSS-CC against a varying number of virtual machines under a constant load were tabulated. A balanced load is indicated by minimal average turnaround times. In comparison to FTSS-CC 36.7±7, the average turnaround time interval for GSI-FT is 19±6.3.

Table 6: Average turnaround times for virtual machines with a fixed number of users versus those with variable loads.

Metrics	10	15	20	25	30	35	40	45	50
GSI-FT	7	10	14	20	18	20	23	31	34
FTSS-CC	24	27	31	33	35	37	44	44	50

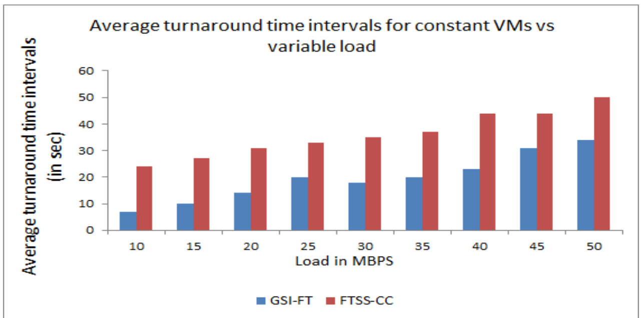

Figure 10: Statistics on turnaround time for the GSI-FT and FTSS-CC models under variable load

In table 6, which is depicted in Figure 10, the average turnaround times for the models GSI-FT and FTSS-CC versus a fixed number of virtual machines with different load sizes are tabulated. A balanced load is indicated by minimal average turnaround times. GSI-FT average turnaround time is 19.66 ±8.39, substantially less than the FTSS-CC average turn around time of 36.11± 8.06.

Table 7: Energy consumption for each make-span with a variable load.

Metrics	10	15	20	25	30	35	40	45	50
GSI-FT	3	3	7	10	16	19	22	23	27
FTSS-CC	5	12	18	20	23	28	35	40	45

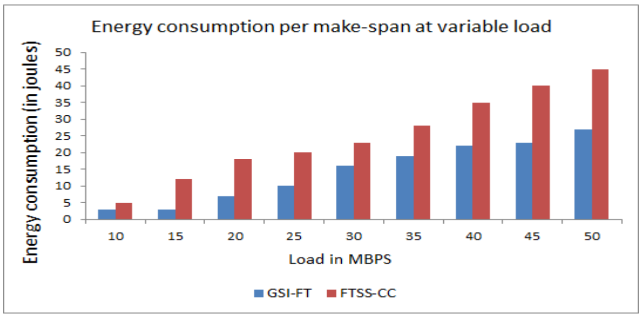

Figure 11: The metric for average energy use in relation to variable load.

Another crucial objective for load balancing is energy consumption. GSI-FT and FTSS-CC models' average energy consumption per make-span versus changing load was tabulated in Table 7 and is seen in Figure 11. The ideal and competent metric values are lower values. In comparison to the 25.11 ±12.38 of FTSS-CC, the typical energy consumption of GSI-FT is 14.44±8.48.

A model for cloud load balancing is compared to the one mentioned in this paper. The framework is based on FTSS-CC, which distributes load using fault-tolerant software systems in the cloud. The load assessment process in the model selected for comparison study is intricate and tabulated for simple comprehension. The model put forward in this book, however, can only describe the load factor for a single type of virtual machine (VM) in cloud computing.

9. Conclusion

Optimizing the effectiveness for the cloud server systems in terms of high availability and fault-tolerance is a more practical necessity with the rising trends of cloud-based servers being utilised for managing information systems. Numerous studies have proposed models to support the ideal circumstances for fault tolerance techniques and high availability patterns. The emphasis of this book is on the indicators that may be used to track trends in cloud server load. In order to analyse the cloud server load factor, the model suggests a collection of statistical candlestick patterns. The proposed indicator's goals are to give the server monitoring teams with the appropriate trend pattern and eliminate visual noise. The suggestion, herein, is to use a collection of statistical candlestick patterns for analysing the trends in cloud server load. The conditions under which patterns are shown for the team are referred to in the experimental investigation of the model created over the simulated data and the recommended statistical patterns. The proposed publication is an expansion of the preceding work [7], which analyses the sustainability indicators framework and patterns crucial to managing the performance of cloud computing platforms. This proposed work is a thorough investigation of the proposed model and pattern collection to help improve the cloud server teams' decisions by providing a detailed and self-explanatory analysis This study supports experimental insights on how the metrics may be tracked using useful indicators, even though the framework restricts the discussion to the relevant measurements. The data gathered in the pattern relates to successfully putting the model into practise to have a more useful and long-lasting indicator pattern for determining the future course of high availability or fault tolerance scenario.

Acknowledgement

The author Subramanyam m vadlamaani has made substantial conceptual and design contributions, gathered and analyzed important data, manuscript drafting and critically revised the paper in keeping with important intellectual content.

The author P K Bharti has provided final approval of the article and agreed to be acknowledge the accuracy of the work.

The author M. Rudra Kumar has provided final approval of the article and agreed to be acknowledge the accuracy of the work.

References

[1] Xu, Dong. "Cloud computing: An emerging technology." *In 2010 International Conference On Computer Design andApplications*, vol. 1, pp. V1-100. IEEE, 25th June 2010, DOI: 10.1109/ICCDA.2010.5541105.

[2] Shahidinejad, Ali, Mostafa Ghobaei-Arani, and Mohammad Masdari. "Resource provisioning using workload clustering in cloud computing environment: a hybrid approach." *Cluster Computing,* 24.1, March (2021): 319-342, DOI: https://doi.org/10.1007/s10586-020-03107-0

[3] Chinnaiah, Mylara Reddy, and Nalini Niranjan. "Fault tolerant software systems using software configurations for cloud computing." *Journal of Cloud Computing,* 7.1, 7th December (2018): 1-17, DOI: https://doi.org/10.1186/s13677-018-0104-9.

[4] Sai, M. P. ., V. A. . Rao, K. . Vani, and P. . Poul. "Prediction of Housing Price and Forest Cover Using Mosaics With Uncertain Satellite Imagery". International Journal on Recent and Innovation Trends in Computing and Communication, vol. 10, no. 8, Aug. 2022, pp. 36-46, doi:10.17762/ijritcc.v10i8.5666.

[5] Kumar, Madapuri Rudra, *et al.* "Change Request Impacts in Software Maintenance." *CRC Press*, 6th August 2020.

[6] Hasan, Moin, and Major Singh Goraya. "Fault tolerance in cloud computing environment: A systematic survey." Computers in Industry 99, 1st August (2018): 156-172, https://doi.org/10.1016/j.compind.2018.03.027.

[7] Kero, A., Khanna, A., Kumar, D., & Agarwal, A. An Adaptive Approach Towards Computation Offloading for Mobile Cloud Computing. *International Journal of Information Technology and Web Engineering (IJITWE)*, 14(2), 1st April 2019, 52-73, http://doi.org/10.4018/IJITWE.2019040104.

[8] Vale, Kádna Maria Alves Camboim, and Fernanda Maria Ribeiro de Alencar. "Challenges, patterns and sustainability indicators for cloud computing." *Brazilian Journal of Development*, 6, no. 8, 14th August (2020): 57031-57053, DOI: https://doi.org/10.34117/bjdv6n8-203.

[9] Madapudi, Rudra Kumar, A. Ananda Rao, and Gopichand Merugu. "Change requests artifacts to assess impact on structural design of SDLC phases." Int'l J. Computer Applications, 54, no. 18 (2012): 21-26, https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.415.6382&rep=rep1&type=pdf.

[10] Jhawar, Ravi, and Vincenzo Piuri. "Fault tolerance and resilience in cloud computing environments." *In Computer and information security handbook*, pp. 165-181. Morgan Kaufmann, 2017, https://doi.org/10.1016/B978-0-12-803843-7.00009-0.

[11] Padmakumari, P., and A. Umamakeswari. "Methodical review on various fault tolerant and monitoring mechanisms to improve reliability on cloud environment." *Indian Journal of Science and Technology*, 8, no. 35, 20th December (2015): 1-6, https://sciresol.s3.us-east-2.amazonaws.com/IJST/Articles/2015/Issue-35/Article17.pdf.

[12] Gill, D. R. . (2022). A Study of Framework of Behavioural Driven Development: Methodologies, Advantages, and Challenges. International Journal on Future Revolution in Computer Science &Amp;

Communication Engineering, 8(2), 09–12. https://doi.org/10.17762/ijfrcsce.v8i2.2068

[13] Hasan, Moin, and Major Singh Goraya. "Fault tolerance in cloud computing environment: A systematic survey." *Computers in Industry,* 99, 1st August (2018): 156-172, https://doi.org/10.1016/j.compind.2018.03.027.

[14] Kaur, Satjot, and Gurbhej Singh. "Review on Fault Tolerance Techniques in Cloud Computing." *International Journal of Engineering and Management Research (IJEMR),* 7, no. 3 (2017): 69-71, https://indianjournals.com/ijor.aspx?target=ijor:ijemr&volume=7&issue=3&article=014.

[15] Kumari, Priti, and Parmeet Kaur. "A survey of fault tolerance in cloud computing." *Journal of King Saud University-Computer and Information Sciences,* 33, no. 10, 1st December (2021): 1159-1176, https://doi.org/10.1016/j.jksuci.2018.09.021.

[16] Tebaa, Maha, and Said EL Hajji. "From single to multi-clouds computing privacy and fault tolerance." IERI procedia, 10, 1st January (2014): 112-118, https://doi.org/10.1016/j.ieri.2014.09.099.

[17] Linda R. Musser. (2020). Older Engineering Books are Open Educational Resources. Journal of Online Engineering Education, 11(2), 08–10. Retrieved from http://onlineengineeringeducation.com/index.php/joee/article/view/41

[18] Jhawar, Ravi, Vincenzo Piuri, and Marco Santambrogio. "Fault tolerance management in cloud computing: A system-level perspective." *IEEE Systems Journal*, 7, no. 2, (2012): 288-297, DOI: 10.1109/JSYST.2012.2221934 .

[19] Das, Pranesh, and Pabitra Mohan Khilar. "VFT: A virtualization and fault tolerance approach for cloud computing." *In 2013 IEEE Conference on Information & Communication Technologies*, pp. 473-478. IEEE, 11th April 2013, DOI: 10.1109/CICT.2013.6558142.

[20] Shaikh, Anwar Ahamed, and Sheesh Ahmad. "Fault tolerance management for cloud environment: a critical review." *International Journal of Advanced Research in Computer Science,* 9, Issue 2, (2018): 34, https://www.academia.edu/download/58398647/6133-12948-1-SM.pdf.

[21] Modiya, P., & Vahora, S. (2022). Brain Tumor Detection Using Transfer Learning with Dimensionality Reduction Method. International Journal of Intelligent Systems and Applications in Engineering, 10(2), 201–206. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/1310

[22] Yang, Chao-Tung, Jung-Chun Liu, Ching-Hsien Hsu, and Wei-Li Chou. "On improvement of cloud virtual machine availability with virtualization fault tolerance mechanism." *The Journal of Supercomputing,* 69, no. 3, September (2014): 1103-1122, DOI: https://doi.org/10.1007/s11227-013-1045-1.

[23] Agarwal, Himanshu, and Anju Sharma. "A comprehensive survey of fault tolerance techniques in cloud computing." *In 2015 International Conference on Computing and Network Communications (CoCoNet),* pp. 408-413. IEEE, 16th December 2015, DOI: 10.1109/CoCoNet.2015.7411218 .

[24] Madapuri, Rudra Kumar, and P. C. Mahesh. "HBS-CRA: scaling impact of change request towards fault proneness: defining a heuristic and biases scale (HBS) of change request artifacts (CRA)." Cluster Computing 22.5 (2019): 11591-11599

[25] Katuk, N., & Chiadighikaobi, I. R. (2022). An Enhanced Block Pre-processing of PRESENT Algorithm for Fingerprint Template Encryption in the Internet of Things Environment. International Journal of Communication Networks and Information Security (IJCNIS), 13(3). https://doi.org/10.17762/ijcnis.v13i3.5101

[26] Trivedi, Smita Roy. "Technical Analysis Strategies: Development of Heiken Ashi Stochastic.", MPRA, (2018), pp. 1-5, https://mpra.ub.uni-muenchen.de/id/eprint/90439.

[27] Rudra Kumar, M., Rashmi Pathak, and Vinit Kumar Gunjan. "Machine Learning-Based Project Resource Allocation Fitment Analysis System (ML-PRAFS)." *Computational Intelligence in Machine Learning*. Springer, Singapore, 2022. 1-14

[28] Rosemaro, E. . (2022). Understanding the Concept of Entrepreneurship Management and Its Contribution in Organization. International Journal of New Practices in Management and Engineering, 11(01), 24–30. https://doi.org/10.17762/ijnpme.v11i01.159

[29] Kumar, M. Rudra, Rashmi Pathak, and Vinit Kumar Gunjan. "Diagnosis and Medicine Prediction for COVID-19 Using Machine Learning Approach." *Computational Intelligence in Machine Learning: Select Proceedings of ICCIML 2021* 834 (2022): 123

[30] Nishchal Sharma, Dr, and Chaman S. Chauhan. "Heikin-Ashi Transformation and Its Effect on Neural Network Learning for Stock Market Data." (2016).

[31] https://financestrategysystem.com/heikin-ashi-excel/#:~:text=Max_HA%20%3D%20Max%20(current%20bar%20Maximum%2C%20Open_HA%2C%20Close_HA).&text=Min_HA%20%3D%20Min%20(Current%20Bar%20Minimum,and%20green%20during%20an%20UpTrend.

[32] Suneel, Chenna Venkata, K. Prasanna, and M. Rudra Kumar. "Frequent data partitioning using parallel mining item sets and MapReduce." International Journal of Scientific Research in Computer Science, Engineering and Information Technology 2.4 (2017)

[33] Roy Trivedi, Smita. "Technical analysis using Heiken Ashi Stochastic: To catch a trend, use a HASTOC." *International Journal of Finance & Economics*, 27, no. 2 (2022): 1836-1847, https://doi.org/10.1002/ijfe.2245.