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Comprehensive cost analysis of voice call recording storage with and without NAS and GSM gateway integration via unified communication server

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Abstract: This study is an extension of existing research, which previously demonstrated the effective integration of Network Attached Storage (NAS) with a GSM Gateway into Unified Communication (UC) Platform, thereby realizing remarkable enhancements in system scalability, data security, privacy, network and overall server performance. Although the technical and operational benefits of this integration were well understood and documented, however there was an important gap that is cost analysis. This paper addresses the gap by providing a comprehensive cost analysis of voice call archiving with and without NAS and GSM Gateway integration using UC. The analysis considers essential financial factors, including initial investment, ongoing operational costs, and long-term savings due to lower maintenance and scalability. While the findings reveal that the upfront costs of NAS and GSM Gateway integration are higher, these are offset by long-term operational efficiencies and system resilience, leading to substantial financial gains. The evaluation results offer organizations a strategic model to assess the cost-effectiveness of using this NAS-GSM Gateway integrated approach for voice data archiving in UC environments. This custom-costing solution provides a much-needed holistic perspective on the combined technical and financial benefits.

Keywords: *Cost analysis, Energy Efficient archiving, voice call recordings, NAS-GSM integration, Scalable storage, UC platform.*

1. Introduction

The swift pace of change in digital communication technology has profoundly altered the way organizations approach communication systems. Open-Source Unified Communication (UC) [1-3] platforms are emerging as the core of communication for most organizations, providing a single interface that integrates voice, video, messaging and conferencing. Enhanced with reconciliation, UC offers the tools needed to enable high levels of collaboration, process efficiency and compliance which can be a significant cost in industries where data retention and monitoring are required. Voice call recording is essential for compliance, quality assurance, legal requirements, performance analysis and other activities, making it one of the most important functions of UC platforms.[4]

In Open-Source Unified Communication Platforms [4], voice call recordings have been stored locally on UC servers using typical hard disk storage to save communication data particularly voice call recordings. While this is a straightforward method, it presents significant challenges as the volume of recorded data increases. This puts high demand of storage and resources, which must scale as the organization grows, leading to scalability issues, privacy, network and system performance [5][6]. As a result there is a need for periodic hardware upgradation, driving up both capital expenditure and operational costs. Additionally, the server performance degrades as communication services and data storage are centralized, creating server bottlenecks. These factors tend to overload resources particularly as businesses expand and communication data grows exponentially.

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Another major issue is the security of the voice recording data [6]. Storing sensitive communication data on local UC server exposes the enterprise to risks like unauthorized access, breaches and data tampering. Local storage vulnerabilities including hardware failures, cast doubt on the integrity and accessibility of critical voice data especially in regulated industries like finance, healthcare or education. Organizations often struggle to find the right balance between cost, security and performance.

One of the solutions, that has been making road to solve these problems, is the integration of Network Attached Storage (NAS) [7-9] with a GSM Gateway [10] in UC Platform [4]. NAS provides centralized and scalable storage that is ideal for storing voice call recordings outside of the UC server. By incorporating these, not only can scalability be improved but also data management with NAS features like RAID (Redundant Array of Independent Disks) [11-14] configurations for redundancy, encryption for security and automated backups for data protection. To make this process even more efficient while maintaining the NAS system for centralized record and playback functionality, GSM Gateways also integrate with it directly to capture voice calls from mobile networks outgoing via the UC server in real-time without affecting the local storage of UC server.

Prior research [5-6,15] has already demonstrated the technical feasibility of GSM and NAS integration via UC Platform, proving the superior sever performance, guaranteed data security, more privacy and improvements in network performance leading to high reliability. By replacing local storage of UC Server with NAS can decrease server performance issues, network congestion and enhance the overall performance of the UC server. In particular, these enhancements have provided significant benefits to high-volume communication environments where efficient storage and retrieval of voice call recording data are crucial for maintaining system operations.

While the technical and operational aspects of NAS and GSM Gateway integration via UC Platform [5] have been extensively studied and published, one important area that has not received attention in the existing literature [6] is the cost impacts associated with this implementation. A research gap exists at the interface of economics related to the initial costs associated with setting up a NAS and GSM system, ongoing operating expenses and long-term financial benefits. Because NAS hardware involve higher upfront costs. It is essential to determine whether operational savings offset these initial higher price points in the long run.

This study fills this critical gap by performing a comparative cost analysis of conventional UC server-based storage versus NAS-GSM Gateway integration. The analysis will address major financial indicators: startup investment, operational costs and anticipated savings over next 5-year period. If the model is implemented in businesses, this research will provide essential information to optimize decision-making processes for integrating NAS and GSM in archiving voice data, reconciling technical benefits with economic affordability.

The goal of this paper is to provide a comprehensive view about the adoption of NAS and GSM Gateway integration via UC sever both in terms of performance and security as well as from an economic & operational efficiency perspective. The outcome will help companies establish whether the integration of NAS and GSM via UC Platform can deliver immediate as well as strategic value to their complex communication environments.

2. Previous Work and Integration Confirmation

Interfacing of Network Attached Storage (NAS) with GSM gateway for UC Platform is researched and experimented area. Earlier work had largely been concentrated on how to scale systems, secure data and what operations would optimally be performed specifically in voice call recording environments. Initial attempts proved that the use of NAS and GSM Gateways could relieve UC servers of the storage duty, improve data redundancy whilst also increasing overall system resilience. All these attempts have lead to several developments which made way for future studies.

2.1. Integration

One major accomplishment to come out of early test experiments was the test build that demonstrated the technical feasibility of integrating into an NAS-GSM Gateway which is showing in

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Figure 1. A related paper, "Enabling Streamlined Call Recordings by Integrating NAS with a GSM Gateway through a UC Platform" was later published in IEEE Xplore (2024) [5] building on this work. This publication was a key milestone that emphasized the applicability and utility of this convergence and led to better results from call recording systems when it comes to UC environment performance and data security.

The conference presentation of the paper at "IEEE TEMSCON-ASPAC 2023" further confirmed the importance of our research. It demonstrates a solution to the issues of data privacy, hardware failover and finally new voice call recording method to NAS and GSM Gateway integration through UC platform. Thus, the superlative of the study was revealed with high credential and practical significant which his recognition and publication in prestigious "IEEE TEMSCON-ASPAC" conference; that have demonstrated believe-built how much would be guaranteed reliability momentum in capacitance of NAS-GSM integration on communication technology.

The technical process and details of integration were also well documented thus providing real-world UC systems with a guideline for implementation. The process of integration is thoroughly explained and illustrated in section C of the published paper and allowing readers to understand precisely how this type of integration improves performance and security for voice call recordings.

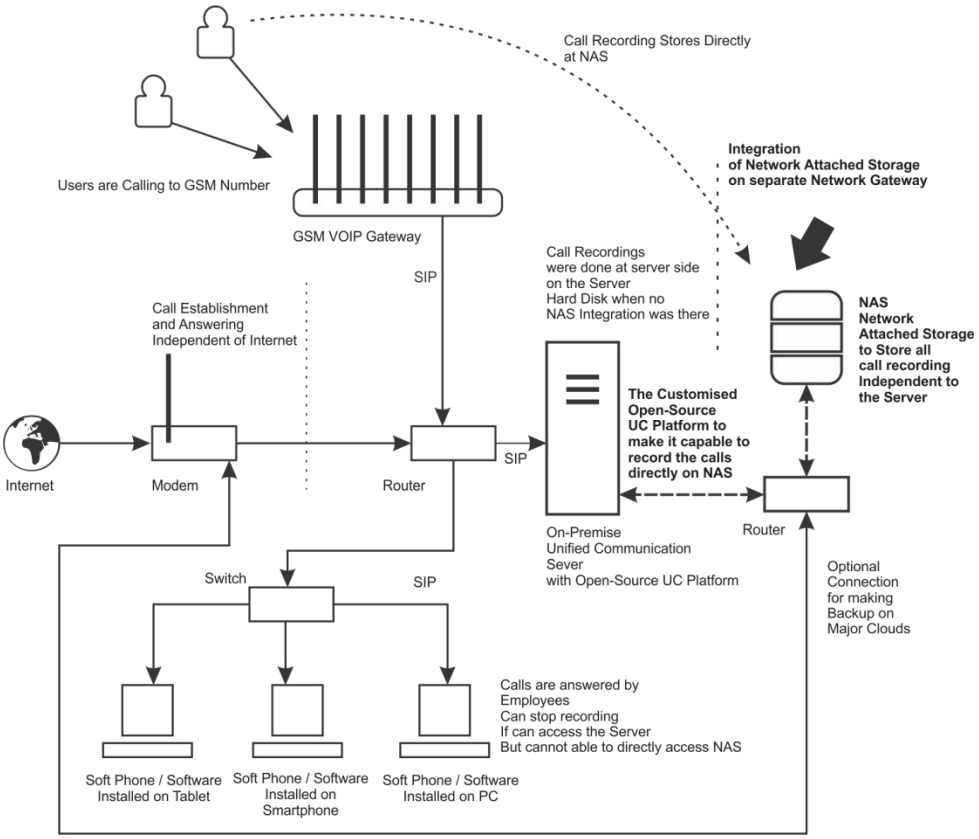

Figure 1.
Integration of NAS with GSM Gateway via UC Server. Call Recordings on Local UC Server vs NAS.

2.2. Performance Analysis

The next part of the research built on the technical findings by conducting a performance analysis of NAS-GSM Gateway integration via UC Platform. This work was published as "Assessment and Analysis of NAS-GSM Gateway Fusion for Voice Data Archiving via UC Infrastructure" [6] covering key performance areas like server performance, data privacy and network performance. While the study showed how the integration improved performance, it didn't include a full cost analysis. The purpose of

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this paper is to address that gap by examining the financial impact of using NAS-GSM Gateway integration via UC Platform.

The technical and performance upsides of integration are well documented, yet the financial feasibility which pivots primarily on cost-effectiveness and long-term ROI has not been explored in equal depth. With the goal of better informing organizations on the financial impact of a NAS-GSM Gateway integration into their UC environment, this paper extends the prior technical findings to provide an in-depth cost analysis.

3. Research Gap

Although definitive research has advanced and benefits have been documented, current literature gaps largely lie in comprehensive cost analyses comparing traditional local storage of voice call recording on UC Server with NAS-GSM Gateway integration via UC server by bypassing local storage [5]. Previous studies have examined the potential of this integrated method from a technical perspective and performance gains but have not assessed their economic implications in any systematic way. Furthermore, although scalability and security improvements have been covered to some extent by the studies, a thorough analysis of cost factors in terms of costs and operational expenditure related to long-term savings is critical to guide organizational decisions.

3.1. Limitations of Previous Research

The previous work [5-6] mainly centered around the technical integration between NAS and a GSM Gateway via UC Server, thus providing performance benefits and security improvements. However, the piece did not take an extensive look at the economics of such an integration, in terms of cost breakdowns, nor did it provide a thorough comparison to traditional storage methods. This research deficit prompts further investigation for an exhaustive view of the financial advantages of NAS-GSM Gateway integration in UC environments.

3.2. Current Research Focus

This research is designed to expand the previous research by filling the gap through a detailed cost analysis. It compares the cost of the initial investment required to get started with NAS and GSM Gateway setups via UC platform to the ongoing operational costs and the gains achievable in terms of scalability, data security, and performance. The study attempts to quantify these factors to help decision-makers better understand the economic benefits and tactical advantages of adopting NAS-GSM Gateway integration in UC deployments.

3.3. Contrast with a Similar Integration

Few related studies have been conducted to compare different storage solutions and communication technologies, such as cloud storage vs. NAS. However, our study stands out because it focuses on integrating NAS into GSM Gateways within UC premises. By comparing this complete solution with other common strategies involving multiple software systems, it clearly distinguishes the benefits of such an integrated model, including cost savings, improved data management, and enhanced operational efficiency.

4. Objectives

The present investigation attempts to address the following research objectives:

4.1. Comparative Cost Analysis

Compare the total cost of ownership for voice data archiving using conventional local storage methods versus a solution featuring Network Attached Storage (NAS) integrated with a GSM Gateway in Unified Communication (UC) environments.

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4.2. Examine Initial Investment

Compare the capital expenses of implementing NAS and GSM Gateway integration against traditional UC server-based storage solutions.

4.3. Examine Operational Costs

Compare the ongoing operational costs of maintaining and managing NAS-GSM Gateway integration via UC server with UC local storage solutions.

4.4. Investigate Long-Term Cost Benefits

Analyze the potential long-term cost benefits attainable through NAS-GSM Gateway integration via Unified Communication server, including scalability features, advanced levels of data security and system performance improvements.

4.5. Strategic Suggestions

This objective reviews increasingly significant recommendations stemming from practice settings and trend analysis to be adopted in case studies. The focus will be on best practices and knowledge to generate cost efficiencies, improve data management, and enhance overall UC system performance.

The research attempts to lend insights on the economic feasibility and operational benefits of NAS-GSM Gateway integration in UC environments be serving these objectives. The results can enable decision-makers to get a detailed picture as to how easy it is to realize the value and cost of this stitched technique used for archiving voice call recording.

5. Drives Used in UC Server and NAS

Selecting the correct hard drives is a key component for performance and longevity in Unified Communication (UC) storage solutions. NAS-driven systems differ from local UC server setups in terms of the hard drives used. This section examines the prices, performance features and suitability of these drives for long-term data archiving.

5.1. Hard Disks Used in Local UC Servers

5.1.1. High-speed RPM drives

These drives are typically of 7200 RPM or higher [16] which should be used on a Unified Communication server to maintain system performance and ensure voice, fax, video and communication capabilities are properly managed. These drives are optimized to achieve high data transfer rates which is essential for keeping the UC server responsive at all times especially when there is a large amount of communication occurring.

5.1.2. Cost Considerations

High-speed drives are cheaper, but they lack built-in redundancies to support 24/7 operation and are not as durable under constant reading and writing (which is typical in voice call recording storage). This presents a challenge for organizations as these hard drives must not only handle all UC server's operations but also store voice call recordings. They tend to fail more frequently and leading to higher costs due to the need of repairs and replacements.

5.1.3. Performance vs Durability

The speed of these drives is ideal for fast data access but this comes at the cost of durability, making them not really intended as a long-term storage solution with lots of read and write operations going on constantly. Heavy usage of these drives would accelerate their wear which could result in performance degradation of the UC server. Over time, a worn-out drive under excessive load could become unusable for storing voice call recordings.

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5.2. Hard Disks Used In NAS

5.2.1. Specialized NAS drives

These drives [17-19] are designed for data storage instead of speed and they come with slower RPM (generally 5400 to 5900 RPM) than the usual drives used inside a computer where performance counts more. These drives are highly durable, reliable and capable of working continuously for long hours making them ideal for data archiving. These are particularly built for 24/7 workloads with a suite of optimization capabilities and special error recovery controls having vibration resistance to maintain data integrity over prolonged use.

5.2.2. Durability

NAS drives are specifically designed to have relatively longer lifespans compared to a standard hard drives and can survive the heavy wear and tear of regular data storage and access. These are built up on fault tolerant and data preservation design instead of high-speed performance which fits voice call recording storage requirement very well. Even if it is necessary to replace one of the disk over time due to failure, the NAS drives continue to spin reliably and are still operational (without downtime) all along with uninterrupted access to stored call recordings data.

5.2.3. Cost comparison

These drives are costlier than standard high speed hard disks because these are manufactured and designed for more durability and improved features to suit more lifetime. The initial and setup cost might be higher but this upfront cost pays itself back in the maintenance savings.

5.3. SSDs and NVMe for UC Servers

5.3.1. Performance

Many UC servers operate faster because of the speed and performance boost in Solid-State Drives (SSD) [20][21] / NVMe drives [22]. These drives are fantastic at delivering fast access to data and as a result, have the potential to speed up UC processes.

5.3.2. Storage Limitations and Expense

SSDs provide improved performance but this also comes at a higher cost as well as offering low storage which might make them infeasible for storing large sets of call recordings. More expensive per gigabyte and the fact that they add up to requiring more replacements over time due to their limited read/write lifespan, makes them not feasible for long-term voice data archiving.

5.3.3. Short lifespan

SSDs have a limited number of read/write cycles, which means they will fail after a certain time if data is constantly being written to them. That disqualifies them from being used as a primary storage medium on UC servers dealing with bulky voice call data, which would require frequent replacements, thereby escalating costs.

5.3.4. Implications

The findings illustrate that high speed hard drives and SSDs improve UC server performance but they are not fit for long-term storage of voice call records due to a lack of endurance and prohibitive OPEX. While not as fast NAS drives are built for long-term reliable operation and provide satisfaction that it is the optimal option when archiving voice recordings at NAS. This ensures operational benefits in terms of data fidelity and low downtime at the same time without sacrifice.

Although the upfront investment in NAS drives is more they are cost-effective when considering that drive replacements will not be as frequent, reducing maintenance and expensive re-configurations. It appears to be a wise choice particularly given that UC archives will be needed for long-term data needs requiring solutions with reliable and scalable storage media.

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6. Methodology

6.1. Cost Components

The study presents a cost analysis that examines the financial consequences of two different methods for storing voice call recordings—UC server-based storage and NAS integration—without factoring in GSM Gateway costs. Key cost components include:

6.1.1. UC server local Hard Disk

The costs of hard disks for UC server data and voice call recording storage machine. This takes into account the purchase price as well as the cost to replace it if there is any hardware failure, and the effect on server performance this entails.

6.1.2. Setup NAS

This includes the purchase of NAS hardware (e.g., Zyxel NAS540) [23][24] and disks (each 2 TB). This section covers the NAS as a fully scalable shared storage solution, excluding GSM Gateway costs.

6.1.3. UC server installation and maintenance

Initial costs for the UC server including labor, configuration and setup fees. This component also accounts for the costs associated with managing the server in an active state and how operations are impacted when a hard disk fails.

6.1.4. Network infrastructure and installation

This includes cover the purchase and configuration of routers, network switches, cabling, etc. required for efficient data transfer among the UC server, NAS and all other devices on the network. It is important to have this efficient network installation to provide data traffic optimization without network congestion.

6.1.5. Auto backup solutions

The charges associated with installing auto-backup systems for the NAS such as licenses for different types of software and configuration cost along with a cloud backup service (if any). Auto Backup takes a regular backup of the server data to make sure it has data redundancy in case the data loss happens due to hardware failure or any other interruption.

6.2. Data Collection

6.2.1. Hardware Prices

Current prices of NAS device, local hard disks, routers, networking accessories and backup solutions will be obtained through well-known online shops such as Amazon. This real-time data from online stores will help to find the realistic estimates for initial investment.

6.2.2. Ongoing Operational Expenses

Similarly, survey the market for an estimate on ongoing operational costs including electricity usage, routine maintenance and server hardware failure costs. This data provides a quantitative way to measure the additional costs that occur with UC local storage as well as after integrating NAS.

6.3. Comparative Analysis

6.3.1. Initial investment

Work out the upfront cost needed for setting up a UC server with local disks in comparison to a NAS setup and all its related network gear and auto-backup solutions.

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6.3.2. Operating Costs

Evaluate the operating costs per year for each option including power consumption by the UC server and NAS, expenses on server upkeep, hard disk replacements through scheduled maintenance and running auto-backup facilities.

6.3.3. Long-Term Benefits

Consider the long-term benefits of using a NAS service such as scalability when data grows, better security and privacy for call recordings and less maintenance on the server because storage-focused work is moved to a more efficient system. This analysis will examine the financial benefits of reduced hardware replacement needs in future and improved operational efficiency over next five-year of period.

6.3.4. Strategic Recommendations

Deliver strategic recommendations around the most optimal way for organizations to consider voice data archiving solutions based on cost-based Comparative Analysis. The recommendations will be customized to the investment level and long-term savings that balance with system performance optimization as well as data security.

6.3.5. Limitations

The main restrictions in this study were hardware price changes, regional fluctuations for operating costs and network setups criteria depending on the individual organizational perspective. A sensitivity analysis will be performed on these variables to see how they overall influence the cost-effectiveness of integrating NAS for archiving voice call recording.

7. Results

The specific hardware components deployed for comparing different settings of the UC server (e.g., call recording storage in a typical UC server environment versus NAS integration). The review focuses on a UC server such as Elastix [4], an open-source platform which is installed on a CentOS with minimal system requirements.

7.1. UC Server Setup

Comparison of UC server in two different configurations:

7.1.1. UC Server on HDD (Seagate 1 TB)

The Elastix UC server is installed on a Seagate 1 TB HDD (Compute) [25] that shares storage between the operational data of the UC server and voice call recordings. This is a bare setup that lacks the performance of good storage but it does meet cost.

7.1.2. UC server on SSD (120 GB SSD with Seagate 1 TB HDD)

In this environment, Elastix UC server was mounted on a 120 GB SSD (General) [26] which has improved the responsiveness and performance of the server while Seagate 1 TB HDD [25] is used for voice call recordings. This provides functionally better UC performance however it still maintains call recordings on the disk-based hard drive.

7.2. NAS Setup

The call recording storage for both UC server configurations is offloaded to an external NAS.

7.2.1. Network Attached Storage

Zyxel NAS540 (4-bay)[23-24]

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7.2.2. 2 TB WD Red NAS Drive

A slow speed (5400 RPM) but robust, long-lasting and reliable drive [27] built for a NAS environment.

7.2.3. 2 TB Seagate Iron Wolf NAS drive

Seagate's low-speed, higher-durability drive [28] is designed specifically for constant operation in a NAS environment and offers great vibration resistance as well. This drive has been used for backup and cloning of first drive.

7.3. Router

TP-LINK [29], the UC server and NAS can communicate directly over it, allowing for quick data transfers among them.

7.4. Initial Cost Analysis

The Initial Cost of hardware used for both configurations, with and without NAS integration with GSM gateway using UC server is shown in Table 1.

Table 1.
Initial cost analysis.

Component	Description	Price USD	Reference
UC server (1 TB HDD Setup)	Seagate 1 TB HDD (Compute) (7200 RPM)	45	[25,30]
UC server (SSD Setup)	General 120 GB SSD	19	[26,31]
	Seagate 1 TB HDD (Compute) (Call recording)	45	[25,30]
NAS device	Zyxel NAS540 (4-Bay)	240	[23-24,32]
NAS hard disk 1	WD red 2 TB HDD (NAS-specific HDD)	80	[27,33]
NAS hard disk 2	Seagate Iron Wolf 2 TB HDD (For backup)	95	[28,34]
Network router	TP-link router	40	[29,35]

7.4.1. UC Server 1 TB Seagate HDD (For Server Installation and Call Recordings)

The Elastix UC server is installed on a single 1 TB Seagate HDD, which performs both the server operations and call recordings. This configuration is often the low-cost alternative, but one downside with this setup could be degraded performance since there will need to share workload on a single drive. When disks fail, multiple re-configurations of the entire UC server with storage-based infrastructure in place can be costly and resulting in system downtime.

-Price: $45 for the Seagate 1 TB HDD.[25,30]

7.4.2. UC Server on SSD (120 GB SSD For Server, 1 TB HDD for Call Recordings)

In this setup, a 120 GB SSD has been used for the UC-server installation, leading to much faster server response and operational behavior. There is a 1 TB Seagate HDD exclusively for call recording. Despite the careful selection of an enterprise-class HDD with longer life and durability for call recording storage, the SSD helps increase server speed as well.

- Total cost: $19 for the 120 GB SSD [26,31] and $45 for the 1 TB HDD [25,30] bringing it to a total of $64.

7.4.3. NAS Integration (Zyxel NAS540 with WD Red & Seagate IronWolf Drives)

This NAS configuration uses a Zyxel NAS540 (4-Bay) unit with two reliable, low-RPM drives designed specifically for NAS environments: a Seagate IronWolf 2TB and a WD Red 2TB. These drives are built for continuous 24/7 operation without downtime, with lifespans significantly longer than

typical hard disks used in UC servers. Call recordings are managed within the NAS system which helps offload the UC server and making it more reliable and scalable.

- NAS Cost: $240 for the NAS [23-24,32]
- NAS Hard Disk Pricing: $80 for the 2TB WD Red [27,33] and $95 for the 2TB Seagate Iron Wolf.[28,34]

7.4.4. Network Router

To accommodate a secure data flow between the UC server and the NAS system specifically for accessing and managing call recordings. The router cost is included as part of the initial network setup expense.

- Cost: $40 for the router.[35]

7.5. Running Cost Comparison over 5 Years

This section compares the ongoing costs over five years for a UC server setup (using local hard disks) versus a NAS setup. The analysis includes expenses for hardware replacements, reconfiguration fees and maintenance associated with the UC server setup and compared to the NAS system which does not require any disk replacements during this period.

7.5.1. UC Server (Local HDD Setup)

When using mechanical hard drives, it was common to replace them every year as the constant read/write activity wore out the extremely fragile spinning disk.

7.5.2. Reconfiguration Costs

An approximated cost of reconfiguration and downtime charges each occasion the HDD crashes in the UC server, requiring formatting, reinstalling, and configuring the system. (Cost: $300).

- Cost of HDD: $45 for each new 1TB Seagate HDD.
- Annual Maintenance Expense: Approximately $120 for server maintenance and growth.

7.5.3. UC server (SSD + HDD setup)

- SSD Replacement: No SSD replacement required over 5 years.
- HDD Replacement for Call Recordings: As in the first setup, assumed once every year.
- Reconfiguration Costs: Applicable for HDD failure and reconfiguration ($220).
- HDD Cost: $45 per replacement (1 TB Seagate HDD).
- Yearly Maintenance: Estimated at $120.

7.5.4. NAS Setup (Zyxel NAS540)

NAS drives (WD Red and Seagate Iron Wolf) are unlikely to fail within the 5-year period so hard disk replacement costs are not included.

- Annual Maintenance: Approximately $120 for network and backup system maintenance (no recurring charges from downtime or reconfiguration).
- Power Consumption: Lower than traditional UC server maintenance as the NAS operates at lower wattages and keeping operational costs minimal compared to continuous power demand.

7.6. Technical and Statistical Analysis

The running cost analysis uses the Total Cost of Ownership (TCO) approach comparing each setup's cumulative expenses over five years. The formula is used to calculate the cumulative cost as follows:

$$TCO = II + \sum (YM + RC + RCC)$$

Where:

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II stands for Initial Investment and includes the cost of hard disks, NAS, and other equipment.
YM stands for Yearly maintenance and includes regular operational and upkeep costs.
RC stands for Replacement Cost and apply only to **UC** setups with traditional HDDs.
RCC stands for Re-Configuration Cost and apply to UC server setups in the event of hard disk failure.
Cost Calculation for UC Server (Local HDD Setup)
Year 1:

$$TCO_{UCHDD,1} = 45_{HDD} + 0_{RC} + 120_{YM}$$

$$TCO_{UCHDD,1} = 165_{USD}$$

Year 2 to 5: In each subsequent year, a recurring cost of hard disk replacement, reconfiguration and maintenance:

$$TCO_{UCHDD,y} = 45_{HDD} + 300_{RC} + 120_{YM}$$

$$TCO_{UCHDD,y} = 465_{USD/year}$$

Total Cost for 5 Years

$$TCO_{UCHDD} = 165 + (465 \times 4) = 2025_{USD}$$

7.6.1. Cost calculation for UC server (SSD + HDD setup)
Year 1:

$$TCO_{UCSSD,1} = 19_{SSD} + 45_{HDD} + 0_{RC} + 120_{YM}\ TCO_{UCSSD,1} = 184_{USD}$$

Year 2 to 5: In each subsequent year, a recurring cost of hard disk replacement, reconfiguration and maintenance:

$$TCO_{UCSSD,y} = 0_{SSD} + 45_{HDD} + 220_{RC} + 120_{YM}$$

$$TCO_{UCSSD,y} = 385_{USD/year}$$

Total Cost for 5 Years

$$TCO_{UCSSD} = 184 + (385 \times 4) = 1724_{USD}$$

7.6.2. Cost Calculation for NAS Setup (Zyxel NAS540)
Year 1:

$$TCO_{NAS,1} = 240_{NAS} + 80_{WDHDD} + 95_{SEAGATEHDD} + 120_{YM}\ TCO_{NAS,1} = 535_{USD}$$

Year 2 to 5: In each subsequent year, a recurring cost of hard disk replacement, reconfiguration and maintenance:

$$TCO_{NAS,y} = 0_{HDD} + 0_{RC} + 120_{YM}$$

$$TCO_{NAS,y} = 120_{USD/year}$$

Total Cost for 5 Years

$$TCO_{NAS} = 535 + (120 \times 4) = 1015_{USD}$$

7.6.3. Cost Comparison Over 5 Years

The summary of cost comparison for 5 years is shown in Table 2. and graphical representation is showing in Figure 2.

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Table 2.
Cost comparison.

Component	UC server (HDD Setup)	UC server (SSD + HDD)	NAS setup
Year 1	$165	$184	$535
Year 2	$465	$385	$120
Year 3	$465	$385	$120
Year 4	$465	$385	$120
Year 5	$465	$385	$120
Total	$2025	$1724	$1015

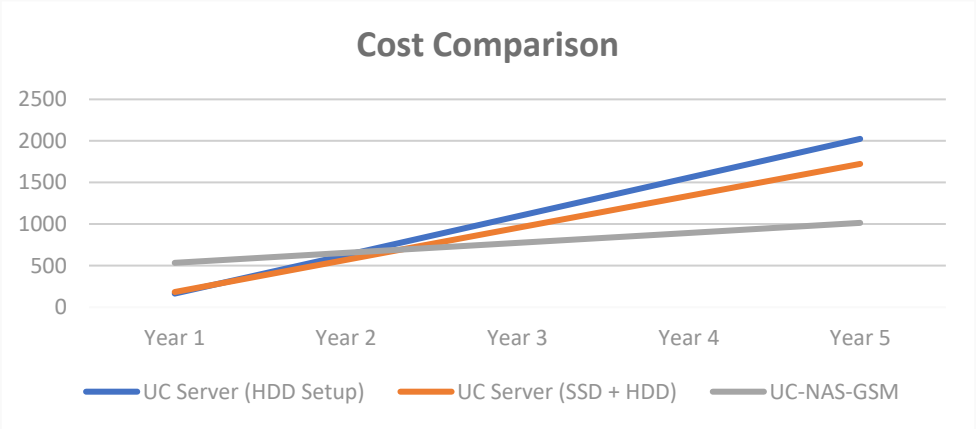

Figure 2.
Cost comparison graph.

7.7. Statistical Analysis

Statistical analysis conducted over a 5-year period demonstrates that NAS integration incurs significantly lower running costs as compared to traditional UC server storage and deployments. On average, the Total Cost of Ownership (TCO) for NAS stands at less than half of that for UC setups with either local hard disks or SSD (to install UC server) + HDD (for call recordings) configurations ($1015 vs $2025 or $1724 respectively). Although the initial investment for NAS is higher than the local storage on UC server but ongoing operational expenses remain minimal with no hardware replacements and no re-installation of UC server. Additionally, downtime and reconfiguration charges are largely mitigated.

The capital expenditure (capex) variance per year also reveals that NAS costs remain steady whereas UC server's local storage setups experience recurring annual peaks due to hard disk failures, broken heads or necessary internal hardware maintenance and re-installation of UC server.

8. Discussion

8.1. Cost Analysis

The analysis concludes that NAS does require a larger upfront cost but then saves substantial costs over a next five-year period. Due to the durability and easy maintenance of NAS the TCO (Total Cost of Ownership) comparison shows that NAS minimizes operational interruptions and lowers maintenance costs. On the other hand, UC server configurations incur high recurring costs for hardware failures, server reconfigurations and maintenance. This comparison emphasizes that NAS can present a financially sustainable option for organizations that need affordable yet efficient voice data archiving solutions.

8.2. Strategic Implications

Exceptionally upon the introduction of NAS integration for UC environments, the strategic ramifications are:

8.2.1. Less Downtime

NAS systems guarantee continuous operation providing hot-swappable drives and RAID configurations and ensuring data is always accessible with no disruption to recording activities. This will not only reduces service downtime but also saves on configuration and replacement costs.

8.2.2. Scalability and Long-Term Storage

NAS drives are designed for 24/7 operation which can serve as a reliable, scalable alternative to traditional and high-maintenance HDD replacements. So, while the upfront costs for NAS might seem high at first but it becomes an economical solution for proactive storage for voice call recordings that allows organizations to expand as needed without incurring high additional costs on the back end.

8.2.3. Predictable Costing

The NAS setup allows for a steady, predictable cost structure, as opposed to the cyclical spikes in costs of the UC server setup. With NAS, organizations can plan their budgets for annual maintenance more accurately since they will not face sudden reconfiguration charges or hardware replacement costs.

8.3. Supporting Analysis

Other studies align with these findings (see, for example, "Performance Analysis of NAS and SAN Storage for Scientific Workflow" [18], "A NAS Integrated File System for On-site IoT Data Storage" [36], "Cloud-Based NAS (Network Attached Storage) Analysis as an Infrastructure as A Service (IAAS) Using Open Source NAS4FREE and Owncloud" [37], which found that NAS systems rated for continuous operation exhibit lower failure rates, making them a more sustainable storage solution). This validates NAS as an economical solution for UC ecosystems requiring enterprise-grade, low-cost, high-availability, long-term, resilient, and cost-effective storage.

8.4. Limitations and Future Consideration

This study is a good effort but has its share of limitations in UC systems such as the variability of hardware prices and organizational call recording storage needs which varies from one organization to another and one region to the other. Further evaluation of NAS performance through case studies implemented in various industry settings is a potential direction for future research and consideration. Moreover, examining improvements in NAS technology especially with regard to incorporation of cloud backup and energy efficient designs could add a long-run economic perspective on the use of NAS with GSM gateway for UC systems.

9. Conclusion

This work presents a detailed cost analysis of different storage configurations for UC platforms, in a direct comparison between traditional UC server storage configurations and NAS backends for archiving voice data. Although initial hardware costs for UC server configurations based on HDD and SSD (for server installation) + HDD (for call recordings) are lower than the costs associated with NAS integration solutions, the five-year total cost of ownership study shows these systems incur high costs over time due to their frequent maintenance and reconfiguration requirements of the UC server and the need for ongoing HDD replacements. Indeed, in comparison, NAS integration leads to massive savings over a period of time at a higher initial cost due to high facility reusability and operational stability.

9.1. Key Findings

Cost over time makes a strong case for NAS integration with GSM via UC server to store voice call recordings. Integrating into the rest of the business makes it cheaper and more resilient over the long haul. Durable, expandable and worry-free solutions tend to be built on top of those. NAS oriented hard

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drives will stand the test of time to continuously read/write data unlike regular HDDs which may fail more frequently. NAS provides a steady and predictable cost structure over a five-year period with a cumulative cost of $1015 per NAS versus $2025 for a UC server with HDD-only storage and $1724 for a UC server with an SSD + HDD solution.

This conclusion is further backed up graphically with a cost-decreasing trend immediately after the first year for NAS while UC server setups show periodic peaks in expenses due to hardware faults, reinstalling and reconfiguration fees. This sheds light on the necessity of looking not just at upfront costs but also at the Total Cost of Ownership (TCO) when choosing a storage solution.

9.2. Strategic Recommendations

For organizations looking for a very cost-effective and permanent solution to archiving voice data in UC environments, NAS integration is advisable as it is:

9.2.1. Lower Downtime and Maintenance Costs

Hot-swappable NAS drives and RAID configurations greatly reduce the chances of downtime by keeping you online so that you can access and archive data even if your hardware needs to be reconfigured.

9.2.2. Predictability of Costs

The annual costs associated with a NAS setup do not fluctuate as much with time that organizations remain able to budget accordingly and are not required to deal with unexpected expenses from the need to frequently repair and/or rebuild their setup as is common with traditional setups.

9.2.3. Scalability And Reliability of Support

The NAS allows for simple storage expansion as organizational needs which is important for UC environments with high volumes of voice data.

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References

[1] R. Singhal and S. Agarwal, "Unified Communication – Importance towards Growing Modern Business," *International Journal of Management and Social Sciences Research (IJMSSR)*, Vol. 5, No. 6, June 2016.

[2] A. D. Tesfamicael, V. Liu, W. Caelli, and J. Zureo, "Implementation and evaluation of open source unified communications for SMBs," in Proceedings of the *2014 International Conference on Computational Intelligence and Communication Networks*, Bhopal, India, 14-16 Nov. 2014. DOI: https://doi.org/10.1109/CICN.2014.260

[3] D. Gaisbauer et al., "Unified communication framework," in Proceedings of the *2016 IEEE-NPSS Real Time Conference (RT)*, Padua, Italy, 2016, pp. 1-2. DOI: https://doi.org/10.1109/RTC.2016.7543158

[4] C. Li, H. Li, K. Wang, and K. Nan, "Research and Implementation of Unified Communications System Based on Elastix," in Proceedings of the *2011 7th International Conference on Wireless Communications, Networking and Mobile Computing*, Wuhan, China, 2011, pp. 1-4. DOI: https://doi.org/10.1109/wicom.2011.6040550

[5] A. S. Veer and S. Bhardwaj, "Enabling streamlined call recordings by integrating NAS with a GSM Gateway through a UC Platform," in Proceedings of the *2023 IEEE Technology & Engineering Management Conference - Asia Pacific (TEMSCON-ASPAC)*, Bengaluru, India, 2023, pp. 1-7. DOI: https://doi.org/10.1109/TEMSCON-ASPAC59527.2023.10531455

[6] A. S. Veer and S. Bhardwaj, "Assessment and Analysis of NAS-GSM Gateway Fusion for Voice Data Archiving via UC Infrastructure," *Multidisciplinary Science Journal*, Vol. 7, No. 1, July 2024, p. 2025061. DOI: http://dx.doi.org/10.31893/multiscience.2025061

[7] R. H. Katz, "Network-attached storage systems," in Proceedings of the *Scalable High Performance Computing Conference (SHPCC)*, Williamsburg, VA, USA, 6 Aug. 2002. DOI: https://doi.org/10.1109/SHPCC.1992.232686

[8] S. Mohanty, P. Nayak, and S. Biswas, "Network storage and its future," *International Journal of Computer Science and Information Technology*, Vol. 1, No. 4, pp. 235-239, 2010.

[9] L. M. N and M. Y. Yong Chen, "A Storage Cluster Architecture using Network Attached Storage Devices," in Proceedings of the *Ninth International Conference, IEEE*, pp. 301-306, 2002. DOI: https://doi.org/10.1109/ICPADS.2002.1183415

[10] M. Rahnema, "Overview of the GSM system and protocol architecture," *IEEE Communications Magazine*, Vol. 31, No. 4, pp. 92-100, April 1993. DOI: https://doi.org/10.1109/35.210402

[11] P. Zabback, J. Menon, and J. Riegel, "The RAID configuration tool," in Proceedings of the *3rd International Conference on High Performance Computing (HiPC)*, Trivandrum, India, 1996, pp. 55-61. DOI: https://doi.org/10.1109/HIPC.1996.565797

[12] D. A. Patterson, P. Chen, G. Gibson, and R. H. Katz, "Introduction to redundant arrays of inexpensive disks (RAID)," in *Digest of Papers. COMPCON Spring 89. Thirty-Fourth IEEE Computer Society International Conference: Intellectual Leverage*, San Francisco, CA, USA, 1989, pp. 112-117. DOI: https://doi.org/10.1109/CMPCON.1989.301912

[13] J. Guo-song, X. Chang-sheng, and W. Bo, "Research and Implementation of RAID Algorithm based on RAID Controller," in Proceedings of the *2007 International Conference on Networking, Architecture, and Storage (NAS 2007)*, Guilin, China, 2007, pp. 251-252. DOI: https://doi.org/10.1109/NAS.2007.44

[14] B. Bhargava and J. Riedl, "Implementation of RAID," in Proceedings of the *Seventh Symposium on Reliable Distributed Systems*, Columbus, OH, USA, 1988, pp. 157-166. DOI: https://doi.org/10.1109/RELDIS.1988.25791

[15] A. S. Veer and S. Bhardwaj, "An Adaptive Storage Switching Algorithm for Fault-Tolerant Network Attached Storage Systems," in Proceedings of the *2024 2nd International Conference on Computer, Communication and Control (IC4)*, Indore, India, 2024, pp. 1-7. DOI: https://doi.org/10.31893/multiscience.2025061

[16] T. Atsumi, "Analysis of unobservable oscillation in repeatable run-out for head-positioning system of hard disk drive," in Proceedings of the *2016 American Control Conference (ACC)*, Boston, MA, USA, 2016, pp. 5328-5333. DOI: https://doi.org/10.1109/ACC.2016.7526504

[17] R. K. M. G. et al., "Network-Attached Storage: Data Storage Applications," *TURCOMAT*, Vol. 12, No. 12, pp. 2385–2396, May 2021.

[18] A. Jaikar, S. Shah, S. Noh, and S. Bae, "Performance Analysis of NAS and SAN Storage for Scientific Workflow," in Proceedings of the *2016 International Conference on Platform Technology and Service (PlatCon)*. DOI: https://doi.org/10.1109/PlatCon.2016.7456814

[19] "SSD vs. HDD," *PC Viewed*, [Online]. Available: https://pcviewed.com/ssd-vs-hdd/. [Accessed: 03-Nov-2024].

[20] Li et al., "Review on HDD-Based, SSD-Based and Hybrid Key-Value Stores," in Proceedings of the *2017 IEEE 15th International Conference on Dependable, Autonomic and Secure Computing, 15th International Conference on Pervasive Intelligence and Computing, 3rd International Conference on Big Data Intelligence and Computing and Cyber Science and Technology Congress (DASC/PiCom/DataCom/CyberSciTech)*, Orlando, FL, USA, 2017, pp. 1236-1241. DOI: https://doi.org/10.1109/DASC-PICom-DataCom-CyberSciTec.2017.198

[21] R. Micheloni and P. Olivo, "Solid-State Drives (SSDs) [Scanning the Issue]," in Proceedings of the *IEEE*, Vol. 105, No. 9, pp. 1586-1588, Sept. 2017. DOI: https://doi.org/10.1109/JPROC.2017.2727228

[22] M. Bayati, J. Bhimani, R. Lee, and N. Mi, "Exploring Benefits of NVMe SSDs for Big Data Processing in Enterprise Data Centers," in Proceedings of the *2019 5th International Conference on Big Data Computing and Communications (BIGCOM)*, Qingdao, China, 2019, pp. 98-106. DOI: https://doi.org/10.1109/BIGCOM.2019.00024

[23] "NAS540," *Zyxel Guard*, [Online]. Available: https://www.zyxelguard.com/NAS540.asp. [Accessed: 03-Nov-2024].

[24] "NAS540 Data Sheet," *Zyxel Guard*, [Online]. Available: https://www.zyxelguard.com/datasheets/Storage/NAS540_7.pdf. [Accessed: 03-Nov-2024].

[25] "Barracuda Hard Drive," *Seagate*, [Online]. Available: https://www.seagate.com/in/en/products/hard-drives/barracuda-hard-drive/. [Accessed: 03-Nov-2024].

[26] Lexar, "Lexar SSD NS100," *Lexar*, [Online]. Available: https://americas.lexar.com/product/ssd-ns100/. [Accessed: 03-Nov-2024]

[27] "WD Red Pro SATA HDD," *Western Digital*, [Online]. Available: https://www.westerndigital.com/en-in/products/internal-drives/wd-red-pro-sata-hdd?sku=WD2002FFSX. [Accessed: 03-Nov-2024].

[28] "IronWolf Hard Drive," *Seagate*, [Online]. Available: https://www.seagate.com/in/en/products/nas-drives/ironwolf-hard-drive/. [Accessed: 03-Nov-2024].

[29] "Archer C1200," *TP-Link*, [Online]. Available: https://www.tp-link.com/us/home-networking/wifi-router/archer-c1200/. [Accessed: 03-Nov-2024].

[30] "Product on Amazon," *Amazon*, [Online]. Available: https://www.amazon.com/dp/B01LNJBA2I. [Accessed: 03-Nov-2024].

[31] "Product on Amazon," *Amazon*, [Online]. Available: https://www.amazon.com/dp/B07TKGGJ1T. [Accessed: 03-Nov-2024].

[32] "Product on Amazon," *Amazon*, [Online]. Available: https://www.amazon.com/dp/B010W36M7Y. [Accessed: 03-Nov-2024].

[33] "Product on Amazon," *Amazon*, [Online]. Available: https://www.amazon.com/dp/B0C4X31Q9F. [Accessed: 03-Nov-2024].

[34] "Product on Amazon," *Amazon*, [Online]. Available: https://www.amazon.com/dp/B09NHV3CK9. [Accessed: 03-Nov-2024].

[35] "Dual-band Gigabit WiFi Internet Router," *Amazon*, [Online]. Available: https://www.amazon.com/Dual-band-Gigabit-WiFi-Internet-Router/dp/B08KJF5BS7/. [Accessed: 03-Nov-2024].

[36] Y. Okamoto, K. Arai, T. Kobayashi, T. Fujihashi, T. Watanabe, and S. Saruwatari, "A NAS Integrated File System for On-site IoT Data Storage," in Proceedings of the *2020 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops)*, Austin, TX, USA, 2020, pp. 1-7. DOI: https://doi.org/10.1109/PerComWorkshops48775.2020.9156143

[37] Hariyo Sasongko and T. Yudi Hadiwandra, "Cloud-Based NAS (Network Attached Storage) Analysis as an Infrastructure as A Service (IAAS) Using Open Source NAS4FREE and Owncloud," *IT Journal Research and Development*, pp. 83-97, 2021. DOI: http://dx.doi.org/10.25299/itjrd.2022.5712

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