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A Comparative Study of Cloud Printing Architectures and Services for Cloud Computing Environments

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Abstract— The traditional methods of printing have become inefficient and inconvenient for big organizations such as colleges, universities, and MNCs. Managing printing needs across various locations and devices leads to crowds at printers, long queues, and reduced productivity. Cloud printing software provides a centralized and convenient way to manage printing needs, but organizations struggle to find a solution that meets their needs and integrates well with their infrastructure. The goal of this research paper is to develop an innovative cloud printing software solution that enables users to manage printing needs seamlessly across distinct locations and devices. The solution will be easy to use, cost-effective, and scalable to meet the growing demands of businesses of all sizes. The system will ensure data privacy by implementing robust security protocols and encryption standards to protect sensitive information. Users will be able to upload their documents to a secure cloud server and remotely send print commands to nearby stationary shops,

eliminating the need for physical presence and reducing waiting time for printing jobs. The system will facilitate easy and secure payment for the prints and automatically delete documents from the server after a specified time to prevent overloading.

Index Terms—cloud printing, cloud computing, remote printing, data privacy, cloud server

I. INTRODUCTION

Cloud computing is a revolutionary model of computing that offers on-demand access to IT resources through the Internet. It enables users to access computing power, data storage, and databases without investing in expensive infrastructure or hardware. Cloud printing is a specialized aspect of cloud computing that enables individuals to conveniently print documents and images from any location using a device connected to the internet [1].

1. The user sends a print request from their device to a cloud printing service. This can be done through a web application or mobile app provided by the cloud printing service [2].
2. The cloud printing service receives the print request and processes it. The service then sends the print job to the printer associated with the user's account [3].
3. The printer receives the print job and prints the document. This can either be done directly if the printer is cloud-enabled, or through a print server if the printer is not cloud-enabled [4].
4. The printed document is then delivered to the user, either by printing it directly from the printer or by emailing it to the user [5].

The growing demand for printing services among organizations such as colleges, universities, and MNCs has led to an increase in crowds at printers, long queues, and reduced productivity. Traditional methods of printing have become inefficient and inconvenient, making it challenging for organizations to manage their printing needs across various locations and devices [6]. Cloud printing software provides a centralized and convenient way to manage printing needs, but many organizations struggle to find a solution that meets their needs and integrates well with their existing infrastructure [7].

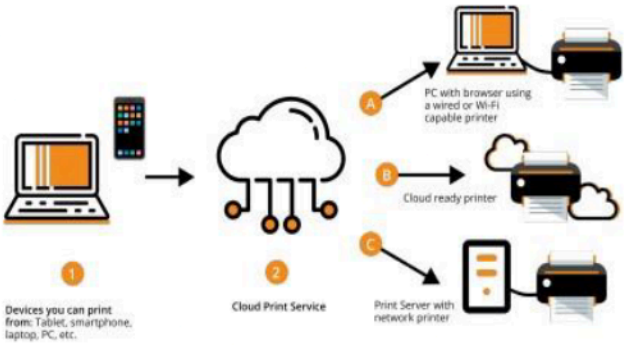

Fig. 1. Working of cloud printing.

The goal of this research paper is to develop an innovative cloud printing software solution that enables users to manage their printing needs seamlessly across distinct locations and devices. The solution will be cost-effective, easy to use, and scalable to meet the growing demands of businesses of all sizes. It will ensure data privacy by implementing robust security protocols and encryption standards to protect sensitive information. Users will be able to upload their documents to a secure cloud server and remotely send print commands to the printers, eliminating the need for physical presence and reducing waiting time for printing jobs. The system will also facilitate easy and secure payment for prints and automatically delete documents from the server after a specified time to prevent overloading. The evolution of cloud printing technology has played a significant role in addressing the challenges faced by organizations in managing their printing needs. This paper will explore cloud printing technology and how it has evolved over the years. The problem statement of this paper is to provide a comprehensive solution that enables users to manage their printing needs seamlessly across distinct locations and devices while reducing crowds at printers, saving time, and increasing productivity, all while ensuring security and compliance.

II. COMPONENTS OF CLOUD PRINTING:

Cloud printing architecture comprises various components as shown in Fig 1. that collaborate to facilitate its functionality. These components include:

Printer: This physical device carries out the printing process by receiving the print job from the print server and producing a physical document.

Cloud Print Connector: It is a software element installed on printers or client devices to establish a connection with the cloud print server and transmit print jobs. **Print Server:** This is a computer or device responsible for managing the printing process. It receives print jobs from client devices and forwards them to the appropriate printer. Print Queue: It is a data structure that stores pending print jobs in the order they are received. The print server oversees the print queue, ensuring that jobs are printed sequentially.

Print Driver: This software component converts print jobs into a format compatible with the printer. It communicates with the printer to transmit the print job and obtain status updates. User Interface: This can be a web-based interface or mobile app that allows users to submit print jobs, manage print settings, and access their print history.

Cloud Print Service: A web-based service that permits users to submit print jobs to the print server from any internet connected device. It authenticates users and forwards print jobs to the print server.

Cloud Print Proxy: This software component operates on client devices and acts as an intermediary between the client device and the cloud print service. It authenticates users and forwards print jobs to the cloud print service.

Monitoring and Reporting: A system for monitoring print activities, generating usage reports, and identifying potential issues or inefficiencies in the printing process.

Security and Authentication: A set of protocols and measures that ensure the confidentiality, integrity, and availability of print data. It also authenticates users and devices accessing print services.

III. ADVANTAGES OF CLOUD PRINTING: ACCESSIBILITY:

Cloud printing enables users to print from anywhere in the
world, if they have an internet connection. This pro- vides great flexibility and convenience, especially for people who frequently travel or work remotely.

Cost savings: Cloud printing eliminates the need for busi- nesses and individuals to invest in expensive printing hardware and infrastructure, as they can simply access cloud printing services on a pay-per-use basis.

Faster printing: Cloud printing services can often print documents faster than traditional printing methods, thanks to the use of high-speed data connections and modern printing technologies.

Scalability: Cloud printing enables users to scale their printing needs up or down as required, without having to make significant investments in new hardware or software.

Security: Cloud printing services often incorporate advanced security features to protect sensitive data during trans- mission and storage. This provides a higher level of security than traditional printing methods.

Reliability: Cloud printing services are typically highly reliable, with minimal downtime and disruptions. This is because cloud printing providers often have redundant systems and backups in place to ensure continuity of service. Ease of use: Cloud printing is typically very easy to use, with user- friendly interfaces and streamlined workflows that can save time and reduce errors.

Compatibility: Cloud printing services can be used with a wide range of devices and platforms, including desktop computers, laptops, tablets, and smartphones.

Collaboration: Cloud printing services enable users to share documents and collaborate on projects in real time, which can improve productivity and efficiency.

Integration: Cloud printing services can be integrated with other cloud-based applications, such as document management systems and

workflow automation tools, to streamline business processes.

Reduced maintenance: With cloud printing, the responsibility of maintaining the printing.

IV. DISADVANTAGES OF CLOUD PRINTING:

Dependency on internet connectivity: Cloud printing is dependent on an internet connection, which can be unreliable or unavailable in certain areas. This can limit access to cloud printing services and cause delays or disruptions. Potential security risks: While cloud printing services typically incorporate advanced security features, there is always a risk of data breaches or cyber-attacks that could compromise sensitive information. Limited customization: Cloud printing services may offer limited customization options, which could be a disadvantage for users who require specific printing features or workflows. Limited control: Cloud printing services may limit the control that users have over their printing workflows and processes, which could be a disadvantage for businesses with specific requirements. Cost: While cloud printing can be cost- effective for small and medium-sized businesses, larger organizations may find that the cost of using cloud printing services outweighs the benefits. Quality: Cloud printing quality may be lower than that of traditional printing methods, particularly for high-resolution images or documents with complex formatting. Privacy concerns: Cloud printing services may store user data and documents on remote servers, which can raise privacy concerns for some users. Dependence on third-party providers: Cloud printing services are typically provided by third-party vendors, which can create dependencies and potential risks in terms of service quality, reliability, and security. Integration challenges: Integrating cloud printing services with existing workflows and processes can be challenging, particularly for businesses with complex IT environments. Learning curve: Users may require time and training to become familiar with the features and functionality of cloud printing services, which can be a disadvantage for businesses with limited resources or tight deadlines. Despite these limitations and challenges, cloud printing software offers numerous benefits in terms of centralized management, flexibility, compatibility, and security. It has become an increasingly popular solution for organizations seeking efficient and scalable printing solutions across multiple locations and devices.

V. LITERATURE SURVEY

Cloud printing and cloud computing have been trending research topics in recent years due to their potential in improving the lifestyle and usability of technology. In this section, we present a survey of existing work based on cloud printing, cloud computing, and internet security. Bhosale et al. [7] designed a system that allows for remote printing so that a user does not need to search for a printer shop. The primary use of the system is online printing, which also includes document editing, print preview, and real-time observation. Through the cloud platform, the user can also upload their documents and download those of others. This system provides users with pertinent information and technical support for online printing. However, several areas require improvements, such as the security aspects and the absence of corresponding data encryption. Raghavendran et al. [8] highlight its benefits, such as cost savings, scalability, and accessibility, as well as challenges such as security and privacy concerns. The paper discusses the different cloud computing service models and their advantages and disadvantages. The paper concludes by emphasizing the importance of businesses carefully consider- ing their options when adopting cloud computing services. The paper by Qian et al. [9] acknowledges cloud printing as the utilization of cloud computing technology to enable printing over network connections. Specifically, it refers to the printing capabilities in the era of mobile internet. The study explores various contemporary technologies such as cloud computing, mobile internet, and cloud services, while also focusing on the design of a platform for cloud printing services. The aim is to enhance the traditional printing industry and establish a novel

printing environment. In their work, Zhang et al. [10] explore the design of a cloud-based print manufacturing management system that enables users to access the application from anywhere and at any time, as long as they have an internet connection. The paper highlights the importance of enhancing output and efficiency in the printing industry due to intense competition and rising labor costs. However, the study is limited by the small number of printers investigated. To address this, future research should consider increasing the sample size. Additionally, while the paper presents a prototype of a Software-as-a-Service (SaaS) application model, a practical system should be developed in the future. Furthermore, the authors suggest that future research should incorporate additional aspects, such as security, into the system design. The paper concludes by emphasizing the need for further research to assess the effectiveness and scalability of the proposed system. [11] explore the use of Google Cloud Print (GCP) for library printing services. The paper discusses the benefits of using GCP, such as cost savings, improved accessibility, and reduced maintenance. It also describes the implementation of GCP in libraries, including the required hardware and software components. The paper concludes by highlighting the potential of GCP for library printing services and the need for further research and development in this area. Disha Saraswat [12] highlights the benefits, such as accessibility and cost savings, of modern printing and discusses the limitations of tradi- tional printing systems. The paper describes various cloud printing architectures and technologies, their advantages and disadvantages, and practical applications. The paper concludes by emphasizing the potential of cloud printing technologies and the need for further research to address the challenges associated with them. Eissa Abdulaziz Alatwan's [13] paper explores recent advancements and developments in the field of cloud computing. The study highlights the utilization of remote printing, which enables secure connections to printers without the need for locating procedures. Mobile printers are discussed, offering various opportunities such as supporting multiple services and accounts, as well as providing convenient printing options through Android mobile applications. The concept of pull printing is introduced, which allows for the secure release and management of print jobs from any location. The suggested cloud printing solution emphasizes customization based on organizational needs and provides tailored options to meet those requirements. Factors considered include the number of devices in use, the organization's size, privacy concerns, and Printer On as a solution to ad- dress organizational challenges. Sheth et al. [14] provided an overview of cloud computing, highlighting its benefits such as cost savings, scalability, and accessibility, and discussing the associated challenges such as security and privacy concerns. The paper describes the various cloud computing deployment and service models, their advantages and disadvantages, and provides examples of popular cloud computing platforms. The paper concludes by emphasizing the growing importance of cloud computing and its potential to transform the IT industry. Pang et al. [15] propose a cloud printing system that uses location-based services and knowledge printing. The system utilizes artificial intelligence to optimize printing based on factors like document type, paper size, and ink usage. The paper highlights the benefits of cloud printing and the limitations of traditional printing systems. The proposed system is shown to be more efficient, cost-effective, and environmentally friendly in experiments. The paper concludes by emphasizing the potential of cloud printing systems based on LBS and knowledge printing and the need for further research. Miao et al. [16] propose a cloud-based printing platform with enhanced security using an improved AES-RSA encryption algorithm. The paper discusses existing challenges in cloud printing, presents the system architecture, and describes the implementation of the encryption algorithm. Benefits include enhanced security, flexibility, and convenience. The paper concludes by emphasizing the importance of data security in cloud printing and the potential for the proposed solution to address the existing challenges in the field. Neelima et al. [17] present the essential technologies and virtual storage architecture in the cloud in their study. Because of its

availability, scalability, performance, mobility, and functional needs, cloud storage is preferable to traditional storage. The scalability and availability of cloud storage are improved by implementing virtualization; however, it is challenging to provide security in a virtual environment. Therefore, security in virtual storage should be emphasized in addition to virtualization. Mehra et. al [18] propose a cloud-based printing system that utilizes mobile phones for printing. The paper discusses the benefits of cloud-based printing and the limitations of traditional printing systems. The proposed system involves a mobile application that integrates with cloud storage services and printers, allowing users to access and print documents and images from anywhere. The paper emphasizes the potential of cloud printing systems using mobile phones and the need for further research. The research paper" Design of smart printing System Based on cloud computing" proposes a smart cloud-based printing system that uses a combination of cloud computing, IoT, and wireless communication technologies. The paper highlights the benefits of cloud-based printing and describes the system's architecture, implementation, and evaluation through experiments. The proposed system performs better than traditional printing systems in terms of efficiency and cost-effectiveness. The paper emphasizes the potential of smart printing based on cloud computing and IoT technologies and the need for further research in this area. Goutham S. et al. [19] conduct a comprehensive review of the key elements concerning the validation of three-level passwords. The paper discusses the limitations of one-factor authentication, which solely relies on passwords, as well as the insufficiency of two factor authentication in ensuring enhanced security in today's technologically advanced digital era. The authors emphasize the need for stronger security measures considering the significant advancements in information technology. The paper by Lohit H et al. [20] presents a systematic implementation of file encryption and decryption using software that utilizes the AES-128-bit encryption mechanism. The paper discusses the user-friendly interface and outlines the process of loading files onto the system. It introduces two distinct modules for encryption and decryption, allowing users to enter the desired encryption key. Additionally, the paper highlights the software's capability to encrypt and decrypt files of different types and sizes. Agrawal et al. [21] in their paper proposed a method used for message communication through which short messages can be sent securely using encryption techniques. The approach is based on the number of letters in the message, and calculations and operations are performed to minimize the time to execute. Later, this work for special characters will be implemented. In their paper, Gill et al. [22-25] address security concerns related to data privacy and access control in cloud computing. The study emphasizes the challenges and nature of cloud security issues, specifically focusing on data privacy and access control. The paper provides suggested solutions to these challenges, offering valuable insights for other researchers in the field [26-30].

VI. PROPOSED METHODOLOGY

Cloud printing can enhance printing efficiency for organi- zations, and we propose an innovative cloud printing soft- ware solution to address the limitations of traditional print- ing methods for large organizations. The proposed solution offers a centralized and convenient way to manage printing needs across various locations and devices while ensuring data privacy with robust security protocols and encryption standards. Users can upload documents to a secure cloud server and send print commands remotely to the printers which are connected to the cloud server, reducing waiting time and eliminating the need for physical presence. Secure payment processing and the automatic deletion of documents after a specified time are additional features included. The proposed solution will improve productivity by reducing crowds and queues, resulting in a seamless and efficient printing experience. The proposed cloud printing software solution involves a centralized, scalable system that can manage printing needs across various locations and devices. It incorporates a cloud- based server

to manage printing requests, a user interface for document upload and print job management, and integration with printers connected to the cloud for print job processing. Security is a top priority, and the system implements robust security protocols and encryption standards to protect sensitive information. It is cost-effective, easy to use, and scalable, making it suitable for businesses of all sizes. The design flow for the cloud printing solution involves user authentication, printer selection, document selection, print job preview, print job confirmation, payment gateway integration, payment confirmation, print job processing, print job completion, billing and reporting, and user feedback. If the printing fails, the user will receive a refund if they have already paid. This design flow can be adapted to meet the specific requirements of the cloud printing solution and can integrate with other features such as document scanning, storage, and access control.

Overall, the proposed cloud printing software solution as shown in Fig. 2 offers an efficient and convenient way for organizations to manage their printing needs across various locations and devices. It is secure, cost-effective, user-friendly, and scalable. The design flow ensures a seamless and efficient printing experience for users and can revolutionize the printing process for organizations.

A. User Interface and User Experience: When designing a cloud printing solution, the user interface design should be easy to use and accessible to all users, regardless of their level of technical expertise. The design should be intuitive, providing step-by-step guidance through the printing process to avoid confusion and ensure a seamless user experience. Additionally, the design should be responsive and compatible with various devices and operating systems to accommodate different users' needs.

B. Security: Security features are crucial in designing a cloud printing solution to protect users' confidential and sensitive information. The solution should be designed with robust encryption protocols, multi-factor authentication, and secure cloud storage to prevent unauthorized access and pro- tect against hacking attempts. The solution should also offer auditing and logging features, allowing users to monitor the printing activity and identify any security breaches quickly. Robust encryption protocols are a set of security measures used to protect data from unauthorized access or interception. Encryption is the process of converting plain text data into an unreadable format, making it difficult for anyone without the correct decryption key to access the original data. Robust encryption protocols are designed to ensure that the encrypted data is secure, even in the event of an attack or a breach of the encryption key. These protocols typically include advanced algorithms and key management systems that are difficult to crack or compromise. There are several robust encryption protocols that can be used to secure cloud printing solutions:

a) TRANSPORT LAYER SECURITY (TLS)
b) SECURE SOCKETS LAYER (SSL)
c) ADVANCED ENCRYPTION STANDARD (AES)
d) SECURE SHELL (SSH)
e) PRETTY GOOD PRIVACY (PGP)
f) ELLIPTIC CURVE CRYPTOGRAPHY (ECC)

Out of the encryption protocols mentioned above, Transport Layer Security (TLS) is the most used and suitable for cloud printing. TLS provides end-to-end encryption between the client and the server, ensuring that data is protected during transmission. It also provides a secure and reliable means of authentication, ensuring that the communication is only between the authorized parties. TLS is widely supported by most web browsers and devices, making it an ideal choice for cloud printing solutions that require compatibility across var- ious platforms. Additionally, TLS is constantly being updated to address any known vulnerabilities, making it a robust and secure encryption protocol for cloud printing.

Fig. 3. represents the integration of TLS encryption in Python using the SSL library. Multi-factor authentication (MFA) has become an essential security measure for protecting sensitive data and preventing unauthorized access to

systems and applications. It is a security mechanism that requires users to provide two or more forms of authentication to verify their identity before accessing a system or application. MFA adds an extra layer of security by requiring something a user knows (such as a password), something a user has (such as a security token or a fingerprint), or something a user is (such as biometric data like facial recognition) to gain access. For example, when logging into a website with MFA enabled, a user may be required to enter their password (something they know) and then enter a code sent to their mobile device (something they have) to verify their identity. This makes it more difficult for unauthorized users to gain access to an account or system, even if they have obtained the user's password. Fig. 4. Shows multifactor authentication with password and OTP using Python and the 'pyotp' library.

C. Scalability and Flexibility in Cloud Printing: Scalability and flexibility are equally crucial factors in designing a

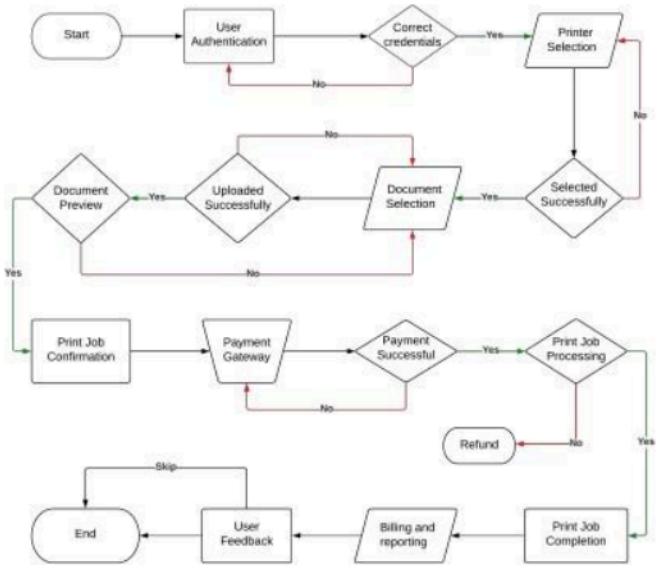

Fig. 2. Design Flow.

```
#TLS ENCRYPTION INTEGRATION
import socket
import ssl
# Create a socket object
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
# Wrap the socket with TLS encryption
ssl_sock = ssl.wrap_socket(s, cert_reqs=ssl.CERT_REQUIRED, ssl_version=ssl.PROTOCOL_TLS)
# Connect to the server using TLS
ssl_sock.connect(('example.com', 443))
# Send data over the encrypted connection
ssl_sock.sendall(b'Hello, world!')
# Receive data over the encrypted connection
data = ssl_sock.recv(1024)
# Close the connection
ssl_sock.close()
```

Fig. 3. TLS encryption.

```python
#MULTI FACTOR AUTHENTICATION
import pyotp
# This is the user's password
password = "my_password"
# Generate a secret key for the user's OTP token
totp_secret = pyotp.random_base32()
# Create an instance of the TOTP class with the secret key
totp = pyotp.TOTP(totp_secret)
# This is the user's OTP code
otp_code = input("Enter your OTP code: ")
# Check if the OTP code is valid
if totp.verify(otp_code):
    # OTP code is valid, now check the password
    user_password = input("Enter your password: ")
    if user_password == password:
        print("Authentication successful!")
    else:
        print("Incorrect password.")
else:
    print("Invalid OTP code.")
```

Fig. 4. Multi-factor authentication.

cloud printing solution. The solution should be flexible enough to accommodate different organizations' needs and integrate with various software applications and hardware devices, providing a seamless experience for users. The solution should also be scalable to accommodate the changing needs of an organization, such as increasing or decreasing the number of users or printers.

```python
import requests
import json
def print_file(file_path):
    with open(file_path, 'rb') as f:
        file_data = f.read()
    headers = {
        "Authorization": "Bearer <YOUR_ACCESS_TOKEN>",
        "Content-Type": "application/json"
    }
    payload = {
        "printerid": "<PRINTER_ID>",
        "title": "My PDF document",
        "capabilities": {
            "page_orientation": {
                "default": "portrait"
            }
        },
        "content": file_data.hex()
    }
    response = requests.post("https://www.google.com/cloudprint/submit",
                             headers=headers,
                             data=json.dumps(payload))
    if response.status_code == 200:
        print("Document has been printed successfully.")
    else:
        print("Error printing document: ", response.content)
if __name__ == "__main__":
    file_path = "<PATH_TO_PDF_FILE>"
    print_file(file_path)
```

Fig. 5. Cloud printing using google cloud print API.

D. Economy: When designing a cloud printing solution, cost-effectiveness is a key consideration. It is important to strike a balance between cost-effectiveness and efficiency, ensuring that the solution offers affordable pricing models while providing reliable and secure printing services. This can be achieved by implementing a subscription-based model or a pay-per print model, depending on the organization's needs and budget. The subscription-based model allows users to pay a fixed fee for a specific period and access a certain number of prints. On the other hand, a pay-per-print model charges users for each print, making it

ideal for organizations with infrequent printing needs. Additionally, the cloud printing solution should offer transparent pricing, with no hidden fees or charges, to avoid any surprises for the user. By implementing a cost- effective pricing model, the cloud printing solution can provide a compelling value proposition to the organization, enabling them to save costs while improving their printing efficiency.

E. Cloud printing using Google Cloud Print API: Cloud printing enables users to print documents from any device connected to the internet, without the need for a physical connection to a printer. Google Cloud Print is a web-based service provided by Google that allows users to print from anywhere using any device. Python is a powerful programming language that can be used to interact with Google Cloud Print API and automate cloud printing. Fig. 5. illustrates the integration of Google Cloud Print using the Google Cloud Print API.

The API enables developers to interact with Google Cloud Print and integrate printing capabilities into their applications. This integration allows users to print from any device, anywhere in the world, as long as they are connected to the internet. With the Google Cloud Print API, developers can create custom printing solutions that meet their unique business needs. By leveraging the power of the cloud, printing becomes more flexible, cost-effective, and accessible, providing a seamless and convenient experience for end-us.

VII. CONCLUSION

In conclusion, the research paper proposes an innovative cloud printing software solution that addresses the challenges faced by organizations in managing their printing needs. The traditional methods of printing have become inefficient and inconvenient, leading to reduced productivity and increased waiting times. The proposed solution is cost-effective, easy to use, and scalable to meet the growing demands of businesses of all sizes. It ensures data privacy by implementing robust security protocols and encryption standards to protect sensitive information. Users can upload their documents to a secure cloud server and remotely send print commands to the printers, eliminating the need for physical presence and reducing waiting time for printing jobs. The system facilitates easy and secure payment for prints and automatically deletes documents from the server after a specified time to prevent overloading. Overall, the proposed cloud printing solution provides a comprehensive solution that ensures security and compliance while providing a centralized platform for managing printing needs.

REFERENCES

[1] T. Puri, R. K. Challa, and N. K. Sehgal, "Energy-efficient delay-aware preemptive variable-length time slot allocation scheme for WBASN (ed- pvt)," *Proceedings of 2nd International Conference on Communication, Computing and Networking*, pp. 183–194, 2018.

[2] N. Kaur, "Thermal aware routing protocols in WBAN," *2021 4th International Conference on Signal Processing and Information Security (ICSPIS)*, 2021.

[3] T. Kaur, N. Kaur, and G. Sidhu, "Optimized energy efficient and QoS aware routing protocol for WBAN," *Recent Patents on Engineering*, vol. 14, no. 3, pp. 286–293, 2021.

[4] N. Chauhan and P. Tekta, "Fraud detection and verification system for online transactions: A brief overview," *International Journal of Electronic Banking*, vol. 2, no. 4, pp. 267–267, 2020.

[5] N. Chauhan, N. Kaur, and K. S. Saini, "Energy Efficient Resource Allo- cation in cloud data center: A comparative analysis," *2022 International Conference on Computational Modelling, Simulation and Optimization (ICCMSO)*, 2022.

[6] P. Rani, S. Verma, N. Kaur, M. Wozniak, J. Shafi, and M. F. Ijaz, "Year). Robust and secure data transmission using artificial intelligence techniques in ad-hoc networks," *Sensors*, no. 1,

pp. 22–22.

[7] Sood, M., Verma, S., Panchal, V.K.: Optimal path planning using hybrid bat algorithm and cuckoo search. Int. J. Eng. Technol. 7(4.12), 30–33 (2018).

[8] Kumar, P.; Verma, S. Detection of wormhole attack in VANET. Natl. J. Syst. Inf. Technol. 2017, 10, 71.

[9] Batra, Isha, Sahil Verma, Arun Malik, Kavita, Uttam Ghosh, Joel J. P. C. Rodrigues, Gia Nhu Nguyen, A. S. M. Sanwar Hosen, and Vinayagam Mariappan. 2020. "Hybrid Logical Security Framework for Privacy Preservation in the Green Internet of Things" Sustainability 12, no. 14: 5542.

[10] Gaba S, Verma S. Analysis on Fog Computing Enabled Vehicular Ad hoc Networks. Journal of Computational and Theoretical Nanoscience, 2019, 16(10), pp. 4356–4361.

[11] N. Kaur and S. Verma, "Detection of plant leaf diseases by applying image processing schemes," Journal of computational and theoretical nanoscience (JCTN), vol. 16, no. 9, pp. 3728–3734, 2019.

[12] M. Shafiq, H. Ashraf, A. Ullah, M. Masud, M. Azeem, N. Jhanjhi, and
M. Humayun, "Robust cluster-based routing protocol for IoT-assisted smart devices in WSN," *Computers, Materials & Continua*, vol. 67, no. 3, pp. 3505–3521, 2021.

[13] M. Lim, A. Abdullah, and N. Z. Jhanjhi, "Performance optimization of criminal network hidden link prediction model with deep reinforcement learning," *Journal of King Saud University-Computer and Information Sciences*, vol. 33, no. 10, pp. 1202–1210, 2021.

[14] V. E. Adeyemo, A. Abdullah, N. Z. Jhanjhi, M. Supramaniam, and A. O. Balogun, "Ensemble and deep-learning methods for two-class and multi-attack anomaly intrusion detection: an empirical study," International Journal of Advanced Computer Science and Applications, vol. 10, no. 9, 2019.

[15] Babbar, H.; Rani, S.; Masud, M.; Verma, S.; Anand, D.; Jhanjhi, N. Load balancing algorithm for migrating switches in software-defined vehicular networks. Comput. Mater. Contin. 2021.

[16] Dogra, V.; Verma, S.; Kavita; Chatterjee, P.; Shafi, J.; Choi, J.; Ijaz, M.F. A Complete Process of Text Classification System Using State-of-the-Art NLP Models. Comput. Intell. Neurosci. 2022, 2022, 1883698.

[17] Ghosh, Gopal, Kavita, Divya Anand, Sahil Verma, Danda B. Rawat, Jana Shafi, Zbigniew Marszałek, and Marcin Woźniak. 2021. "Secure Surveillance Systems Using Partial-Regeneration-Based Non-Dominated Optimization and 5D-Chaotic Map" Symmetry 13, no. 8: 1447. https://doi.org/10.3390/sym13081447Y.

[18] Miao, H. Jia, X. Liu, Y. Zhang, and W. Tan, "The Research and Application of Cloud Printing Platform Based on Improved AES-RSA Encryption Algorithm," 2019 Scientific Conference on Network, Power Systems and Computing, 2019.

[19] M. L. Neelima, "Cloud Printing: An Innovative Technology Using Mobile Phone," International Journal of Computer Science and Mobile Computing, vol. 3, no. 5, pp. 966–971, 2014.

[20] Kumar, M., Raju, K.S., Kumar, D. et al. An efficient framework using visual recognition for IoT based smart city surveillance. Multimed Tools Appl 80, 31277–31295 (2021). https://doi.org/10.1007/s11042-020-10471-x

[21] S, K, S. R, F, J. F, & M, and A, "A Study on Three Step Multifactor Authentication System for Modern Security," *International Journal for Research in Applied Science and Engineering Technology*, vol. 10, no. 3, pp. 45–49, 2022.

[22] S. H. Kok, A. Abdullah, and N. Z. Jhanjhi, "Early detection of crypto- ransomware using pre-

encryption detection algorithm," *Journal of King Saud University-Computer and Information Sciences*, vol. 34, no. 5, pp. 1984–1999, 2022.

[23] Hamid, B., Jhanjhi, N. Z., Humayun, M., Khan, A., & Alsayat, A. (2019, December). Cyber security issues and challenges for smart cities: A survey. In *2019 13th International Conference on Mathematics, Actuarial Science, Computer Science and Statistics (MACS)* (pp. 1-7). IEEE.

[24] Humayun, M., Jhanjhi, N. Z., Alruwaili, M., Amalathas, S. S., Balasubramanian, V., & Selvaraj, B. (2020). Privacy protection and energy optimization for 5G-aided industrial Internet of Things. *IEEE Access*, *8*, 183665-183677.

[25] Khalil, M. I., Jhanjhi, N. Z., Humayun, M., Sivanesan, S., Masud, M., & Hossain, M. S. (2021). Hybrid smart grid with sustainable energy efficient resources for smart cities. *sustainable energy technologies and assessments*, *46*, 101211..

[26] Amal F.Abd El-Gawad , Shereen Zaki , Esraa Kamal, A Survey on Machine Learning Techniques for Supply Chain Management, American Journal of Business and Operations Research, Vol. 2 , No. 1 , (2021) : 24-38

[27] Noura Metawa , Mohamed Elhoseny, Feature Selection Optimization Model for Business Risk Assessment Model, American Journal of Business and Operations Research, Vol. 2 , No. 1 , (2021) : 51-64

[28] Kopal Sharma , Vidhi Kapoor , Kartikay Laddha, Ethics in the Financial Industry, American Journal of Business and Operations Research, Vol. 3 , No. 1 , (2021) : 39-47

[29] Ali Alfartoosi , Mohd Abdullah Jusoh , Hussein Jaleel Mohsin , Harith Yas, The effect of e-accounting and mediated by internal control system on the performance of SME in Iraq, American Journal of Business and Operations Research, Vol. 3 , No. 1 , (2021) : 05-38

[30] Noura Metawa , Saad Metawa, Internet Financial Risk Early Warning Based on Big Data Analysis, American Journal of Business and Operations Research, Vol. 3 , No. 1 , (2021) : 48-