Intuitive cloud computing framework for Tamil Nadu egovernance infrastructure system

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***Abstract*—Information and communication technologies (ICTs) have significantly improved modern computing environments through enhanced processing capability, communication efficiency, storage management, and software accessibility. Cloud computing has emerged as an effective platform for delivering scalable and on-demand digital services through internet-based infrastructures. The Tamil Nadu eGovernance system utilizes cloud enabled services to provide citizen-centric applications accessible from any location at any time. However, the existing centralized infrastructure faces several challenges, including limited scalability, communication delays, network congestion, security vulnerabilities, and single point failure issues.To address these limitations, this paper proposes a blockchain enabled decentralized cloud computing framework for the Tamil Nadu e-Governance infrastructure system. The proposed framework integrates decentralized cloud architecture with Ethereum based blockchain mechanisms to support secure data sharing, distributed storage, transparent transaction management, and efficient resource utilization. The architecture reduces bandwidth consumption and communication latency while improving service availability, scalability, fault tolerance, accountability, and data security. In addition, blockchain-assisted smart contracts provide tamper-resistant authentication and integrity verification across eSevai operations. The proposed framework offers a reliable and scalable solution for secure next generation smart governance and large scale digital public service delivery.**

***Index Terms*— e-Governance, Decentralized computing, Cloud Computing, Blockchain.**

I.INTRODUCTION

In the twenty first century, adopting information and communications technologies (ICTs) is increasingly crucial to people's daily life[1]. Governments all across the world have implemented e-government services, and their real use has increased quickly due to the Internet's broad use. According to SpeG[2], EGovernance is the use of information and communication technologies to improve the efficiency, effectiveness, transparency, and accountability of informational and transactional exchanges within government, between government and government agencies at the national, state, municipal, and local levels, citizens, and businesses, and to empower citizens through information access and use.In India, eGovernance is unfolded from the automation of government institutions to uncoordinated efforts directed at accelerating eGovernance adoption at the national, state, and municipal levels[3]. In 2006, the National eGovernment Plan (NeGP) unified these various initiatives into a single vision and objective (NeGP, 2006).

The Tamilnadu eGovernance Plan, which was approved in May 2006 as part of the Tamilnadu governments commitment to large-scale e-Governance implementation, is a deliberate pillar of the state's e-Governance Plan. E-Government provides a vast array of government-to-citizen and government to business solutions. Information management systems are intended to provide simplified access to administrative resources that are accessible anywhere, at any time, and in any format for interactions between governments (G2G), individuals (G2C), and businesses (G2B). The initiative enables the private sector and non-governmental organizations (NGOs) to participate actively in the execution of eGovernance and become government partners in the development of Tamilnadu's rural areas.

1.1 SERVICES BY TAMILNADU E-GOVERNANCE

The MeiTY/GoTN has designated the Tamil Nadu e-Governance Agency (TNeGA) as the ``State Designated Agency (SDA)" for implementing the statewide rollout of the e-District project via the Common Service Centers (CSCs).The program's objective is to use ICT to deliver the most comprehensive array of government services while also offering all high-quality and economically priced e-Government services under one roof. The distinguishing feature of the Tamilnadu e-Governance System is its ability to provide web-enabled e-Government services in urban and rural areas to provide 207 services for more than 28 corresponding departments, including Revenue, Social Welfare, Civil Supplies, TN Police, TN Transport, TN Registration, Animal Husbandry, Dairying and Fisheries, and Health. Given the following, the revenue department played a significant role in the existing e-Government system and related services:

In Revenue Department

- Community Certificate

- Income Certificate
- Nativity Certificate
- Certificate for First Graduate
- Deserted Woman Certificate
- Agricultural Income Certificate
- Family Migration Certificate
- Unemployment Certificate
- Widow Certificate
- Loss of Education Certificates because of disasters
- Certificate for marriage among Inter Caste
- Certificate for Legal Legatee
- Other Backward Classes (OBC) Certificate
- Certificate of Residency
- Certificate for Small / Marginal Farmers
- Certificate for Solvency
- Certificate for No Male Child
- Unmarried Certificate
- Economically Weaker Sections Certificate (Income \& Assets)
- Certificate for Destitute Widow
- Licence under Pawn Broker Act
- Old Age Pension Services
- Licence for Money Lendering

A good e-Governance system should be cost-effective, user-friendly, and simple to administer. Cloud-based e-Governance is a new model for distributed computing of e-Government applications that uses services as functional building blocks to create flexible networks of cooperative applications that are spread inside and outside the confines of government [4].

The remaining portion of the essay is structured as follows. The Proposed methodology is described in Section II. The Tamilnadu e-Governance Blockchain Decentralised is described in Section III. In Section IV, the paper is finished.

1.2 EARLY WORK STUDY ON CLOUD BASED E-GOVERNANCE SYSTEM

Sharma et al. claim that [5] explores cloud computing and looks at how it is used in e-Government. With a model for e-Government that relies less on infrastructure, cloud computing has the potential to significantly reduce costs by addressing issues with cost, the unavailability of infrastructure like hardware, software, and networks, as well as with undertrained workers and software applications on the user end. The installation phase of e-government services will go more swiftly thanks to cloud computing. Significant cost savings, increased adaptability, accessibility from anywhere, elastic scalability and ease of implementation, service quality delegation of non-essential applications, always the most recent software, document sharing and group collaboration, data recovery, and distributed data centres are just a few of the advantages of cloud computing for e-government.Cloud computing could be a good strategy for adopting e-Government in order to increase efficiency and customer satisfaction. Cloud computing has the potential to improve government performance by reducing costs and increasing efficiency and dependability. The cloud also offers affordable technology and environmentally friendly computing [6].When it comes to e-Government, decentralised computing architectures that are built on public cloud standards are best, and this is where cloud federation comes in. As a result, it is possible for several government departments and organizations to dynamically collaborate and share workloads for achieving higher quality of service (QoS) based on better resource utilization, increased dependability, and cost effectiveness. Many cloud federations can also give consumers legal assistance with regard to where to store their data for applications that are subject to regulatory constraints [7][8].

1.3 METHODOLOGY OF TAMILNADU E-GOVERNANCE

The DIT Government of India's National e-Governance Plan includes the state mission mode project (MMP) e-District. The Government of Tamilnadu (GoTN) created the e-District project with the goal of automating district administration workflow and internal processes with the hope of integrating various departments seamlessly to provide services to citizens whenever and wherever they need them.

1.4 THE E-GOVERNANCE WORKING METHODOLOGY

The CSC management oversees every aspect of functioning for e-sevai centres. All centre administration tasks, such as centre formation, centre enabling or disabling, and service availability configuration, will be handled by CSC management as well. In addition, the data owner (DO), data handler (DH), Data Authorizer (DA), central authority (CA), cloud server (CS), are the five entities in the Tamilnadu E-Society centralized access concept, as indicated in Fig.1.

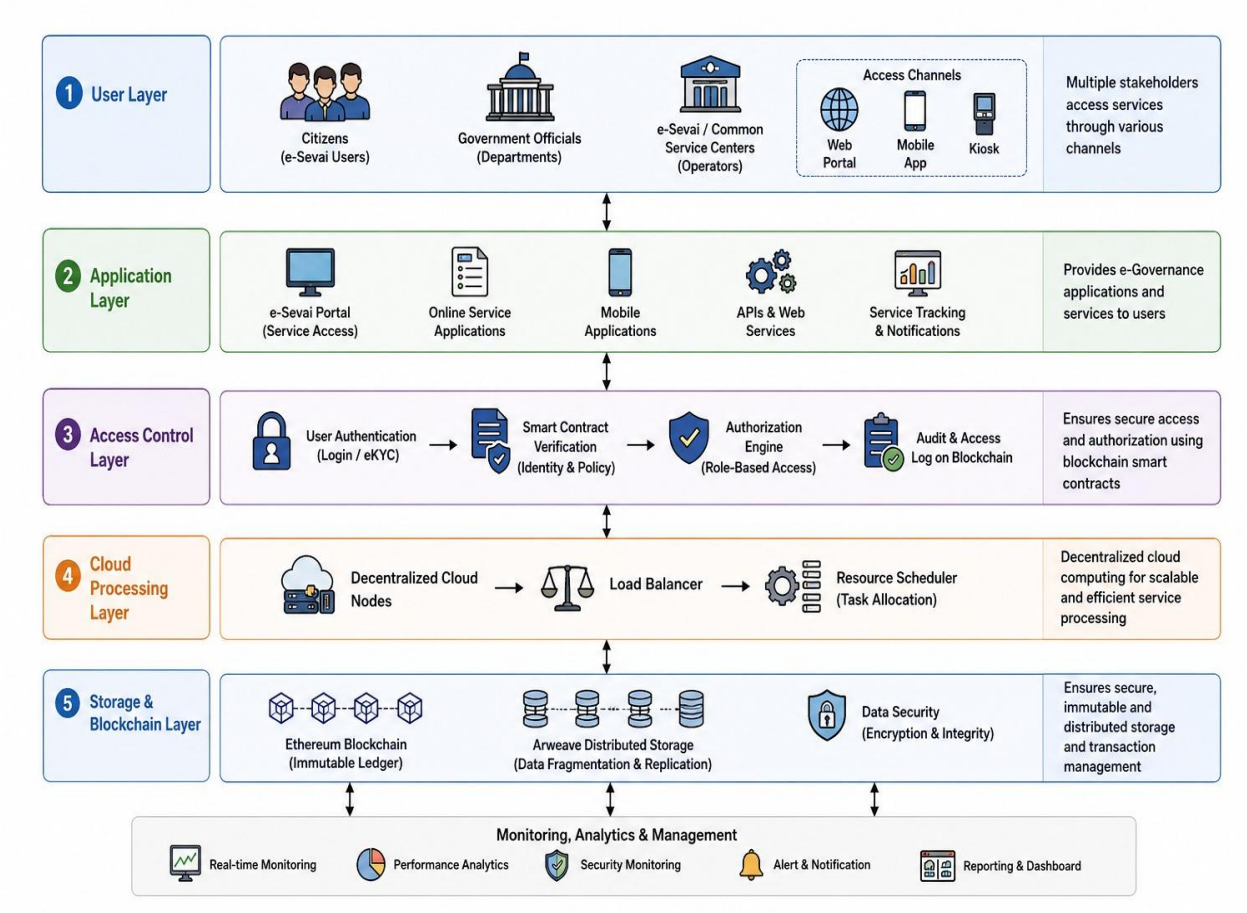

Figure 1: Layered Operational Architecture of the Proposed BeTG Framework

The CA is a Centre Access Control that controls access policies and generates keys for the DH and DA. The DH uploads DO resources and data to the centralized CS, while the CS archives the data and offers a transmission service to the DA. The DA must check and authorize the required information. Finally, the DH gets and downloads the necessary DO data in accordance with the access rules.

1.5 THE CLIENT-SERVER MODEL IN TAMILNADU E-GOVERNANCE

The Tamil Nadu e-Governance now uses the client-server strategy Fig 2 for centralized computing. This model considers the possibility of a server with powerful computing capabilities. Each citizen, operator, and data authority must submit a request to this server, which is also responsible for serving the control authority. In other words, a centralised server makes the same, abundant computational resources available to all users.

When users visit the Tamilnadue-Governance service for a given service, the cloud controller maintains resource scheduling [9] for the user and storage system.

A single server in the cloud controller oversees all activities and allocates users nearby resources when the instances are to be deployed. In contrast, the arrangement for central storage is simpler. In this arrangement, all user images, files, and data are kept on a single storage system, and the required papers to apply for some services are uploaded. It does away with pricey, performance-eroding middleware by merging storage with cloud-level management.The preponderance of user requests is processed by the virtual machine.

Additionally, it aids in VM discovery and administration. It monitors the virtual machines storages and discs with different backends. It may support multiple storage topologies, including and network-connected storage arrays, storage area networks, and internal file systems.

The virtual machine registry provides foundation templates for the creation of new service layers. The cloud VM registration component [10] is considered centralized if all virtual machine servers utilize a single database to maintain information on e-Sevai service users and the state of virtual machines.

A master server that must index all data nodes as part of the present Tamilnadue-Governance's architecture could end up being the system's bottleneck. Typically, an e-Governance single server handles a lot of user requests over years.

However, May, June, Julyis always the months with the highest load during the month of April. Due to the server having to deal with both requests from the user at once, processing will take longer. Data loss, delays, and packet corruption could result from this. As a result, the server is unable to properly respond to each user's inquiry. As a result, processing takes longer. Along with the rising demand for cloud storage and related worries about security and privacy in centralized cloud storage, traffic and congestion can arise.

The suggested system makes use of a peer-to-peer (ad hoc) network, which is a decentralized method for providing and sharing hardware resources. By granting users access to free storage, decentralized P2P storage aims to create an ad hoc network of users. The Ethereum-blockchain network also facilitates the use of smart contracts, which makes it possible to store user data in a cloud network. Using the Arweave Protocol, the system effectively distributes files among several network partners.

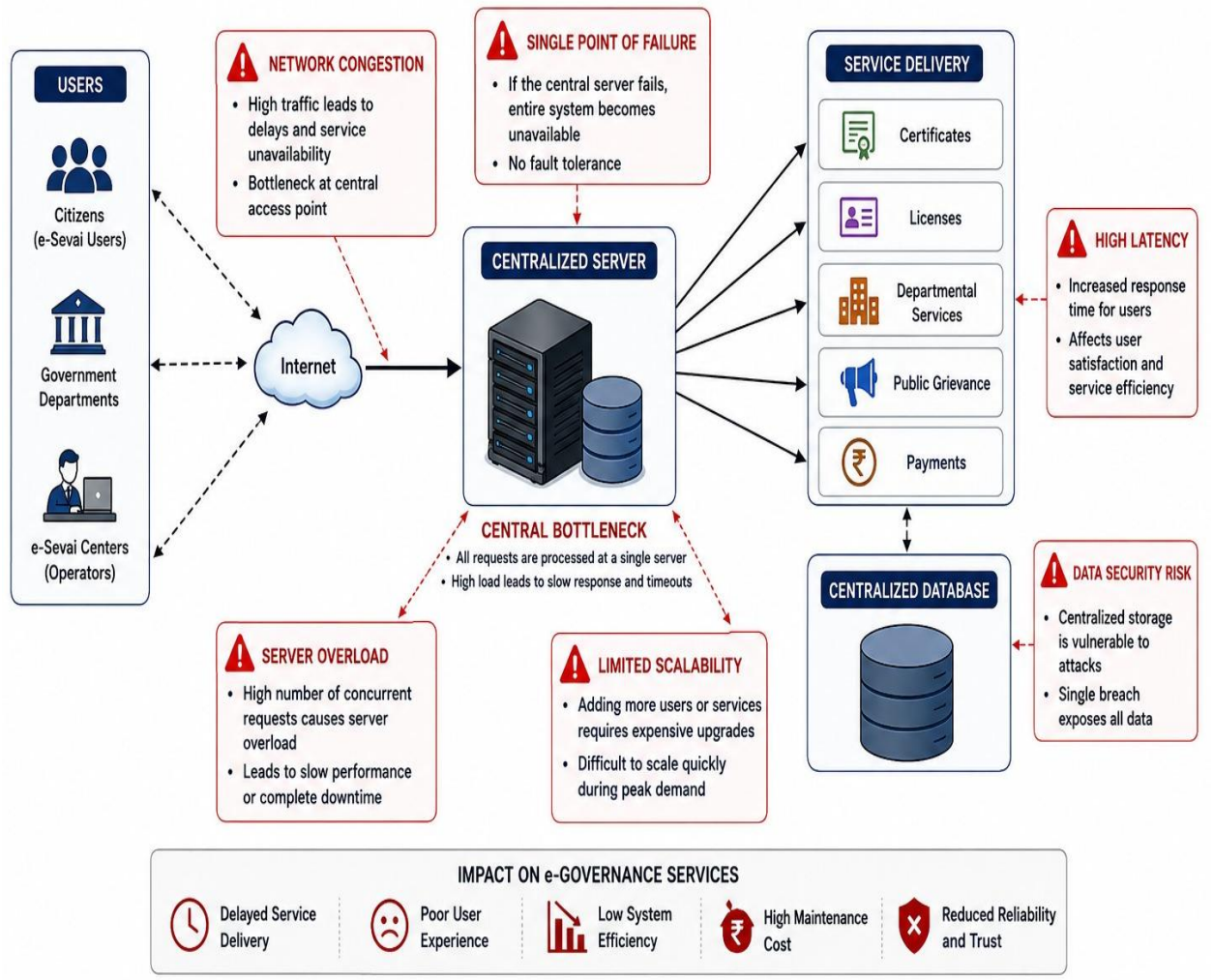

Figure 2: Limitations of Centralized Tamil Nadu e-Governance Infrastructure

1.6 CHALLENGES OF TAMILNADU E-GOVERNANCE

Highly uncertain on network connectivity: Since Tamilnadue-Governance network only has one hub; a node losing connectivity could bring down the central server.

Difficult server maintenance: Because there is just one single server hub for Tamilnadu e-Government, shutting it down for maintenance is both inefficient and unprofessional. Due to this, things are more difficult, and the e-Governance service will not succeed.

Single point of failure: Because centralized systems only have one point of failure, if the e-Government's central node fails, the entire system will also fail.

Lack of transparency: The e-Governance systems that are centralized lack transparency since the central authority has total control over them.

Security hazards: Centralized systems are more vulnerable to security problems since the central authority has complete access to every piece of information on the e-Government server.

Limited scalability: Tamilnadu's centralized e-Government system is not very scalable because the central node can only handle so many users at once.

2.PROPOSED METHODOLOGY

2.1 CONCEPT OF DECENTRALIZED CLOUD

The notion of a dematerialized cloud is novel. A decentralized cloud can be conceptualized initially as a cloud architecture in which a cloud service provider (CSP) maintains a number of geographically dispersed data centres from which consumers can access all [11]. Though, the utmost sophisticated application of decentralization is the deployment of communal cloud services to a number of actual places external of the CSP's data centres, while still being managed by the entire CSP [12]. In contrast, decentralized cloud dispositions permit clients to execute their requests or specific application mechanisms in various locations, that includes on-premises data centres, public clouds, and other network edge locations, in order to encounter precise necessities for response time and legal adherence. Although cloud users can access the CS from any location and administer them as one blob from one command centre, the originating CSP retains primary administration and maintenance responsibilities for the distributed cloud infrastructure (DCI).

2.2 BLOCKCHAIN INNOVATION

Blockchain is a decentralized environment system in which each node manages an accurate ledger via competition and collaboration. Each node operates independently but is intricately interconnected. Numerous current security implementations have been supplanted by the decentralized solutions offered by blockchain technology, a rapidly expanding security cryptography system. The level of security offered by blockchain technology has led to a recent increase in its adoption. Despite utilizing a distributed database, blockchain makes data corruption more unlikely. Using machines equipped with blockchain software, the data are processed and encrypted in accordance with the principles [13].

Using the Ethereum framework, we can construct an economic software platform, administer data, and ensure that each token used for exchange is equivalent to other token in every system. This proposals primary objective is to deliver a blockchain medium based on the creation of a distributed system. Account transactions are feasible with Ethereum. The global state of the Ethereum blockchain is the sum total of the accounts that already exists. The creation of Ethereum accounts is a crucial aspect of platform development. As opposed to enabling users to conduct secure data transactions, Ethereum is a system that may change the status of a transaction since it is a state machine [14].

Ethereum transactions control every communication amid users and the Ethereum blockchain platform by allocating locally and establishing processing of private keys the network of blockchain. There are transaction costs associated with these exchanges between users and the Ethereum blockchain network, also known as transaction fees. The unit of measure for this transaction fee is gas. Each instruction and transaction in the virtual machine of incurs a fixed cost. This gasoline price is determined at the conclusion of the operation procedure in order to calculate the total transaction cost. In order to authenticate and contribute to a corpus of new blocks that will be added to the ledger in blockchain in the future[15], the Ethereum blockchain network gathers these transactions. Anyone can utilize the Ethereum Virtual Machine (EVM), a universal device, for a nominal fee in ether. Technically, it is a mechanism composed of several distinct devices.

2.3 EVM (ETHEREUM VIRTUAL MACHINE)

Distributed ledger is commonly employed when discussing blockchains such as hyper ledger fabric, which employ fundamental cryptographic techniques to facilitate decentralized data [16]. Smart contracts are one of the most potent components of the blockchain. Ethereum is a pivotal database since it stores not just financial data like balances from accounts but also a computing configuration that can carry out computations on any opcode and can alter from block to block according to predefined rules. The EVM defines the principles for state modification from block to block.

Accounts, transactions, and the Ethereum Virtual Machine (EVM) for smart contracts are discussed in depth in [17]. In lieu of a register-based architecture, the EVM's stack-based design provides a unique execution environment that shields external contract execution threats and prevents defective contracts from negatively affecting the structure as a whole. The EVM will look for and retrieve the contract code from the current database in response to calls to the contracts (via message calls or operations). Smart contracts, in contrast to traditional software, allow all public services to be used as entry points

3.BLOCKCHAIN BASED DECENTRALIZED CLOUD FRAMEWORK IN TAMILNADU E-GOVERNANCE

In order to lessen the strain on server farms and other centralized computing resources, we introduce a blockchain technology based novel architectural method for Tamilnadu e-Governance cloud decentralization called Blockchain enabled Framework of Tamilnadu e-Governance in Fig 3 BeTG_Framework. BeTG minimizes network bandwidth usage, lowers communication latencies, and makes use of the resources on users' smart devices.

BeTG integrates the advantages of cutting-edge blockchain ethereum security technology. On the ethereum smart contract portal, which is part of the Tamilnadu E-Governance platform, the E-Sevai users first creates an account. The Programme uses web3.js to retrieve the E-Sevai user's account information and data from the smart contract. Through the file picker, users choose the file to upload. The user's file is stored via the Arweave protocol across all accessible peers after the payment is confirmed. The hash value that Arweave provides then contains the path to the file. This route is then connected to the address of the user's and securely stored on the blockchain through smart contract.

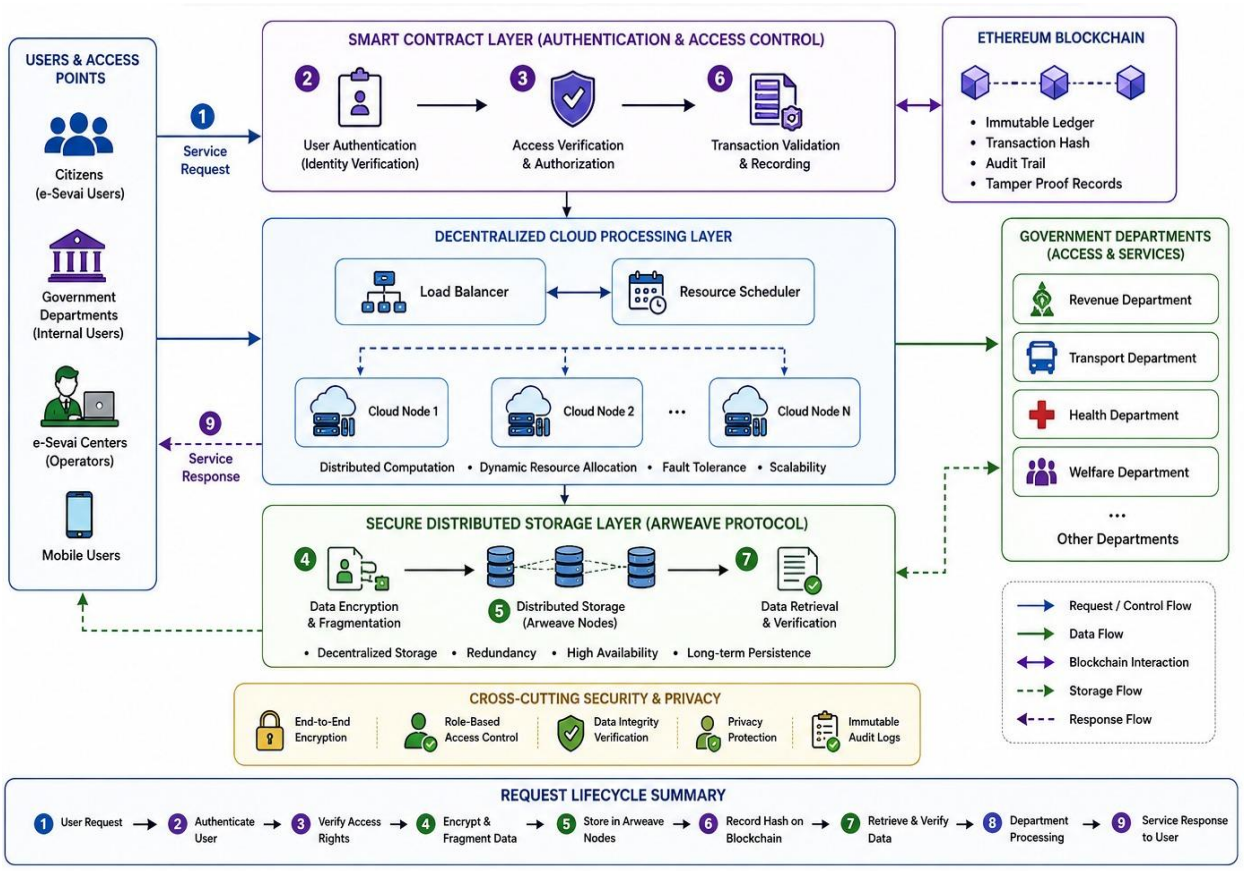

Figure 3: Proposed Blockchain-Enabled Decentralized Cloud Framework for Tamil Nadu eGovernance

3.1 Operational Workflow of Proposed BeTG Framework

The proposed Blockchain-enabled Framework for Tamil Nadu e-Governance (BeTG) operates through an integrated decentralized cloud and blockchain-based infrastructure for secure, scalable, and fault-tolerant e-Governance service delivery. The framework combines decentralized computation, distributed storage, blockchain-assisted authentication, and smart contract based transaction management to overcome the limitations of conventional centralized Tamil Nadu e-Governance systems. Figure~\reffig:betg_framework illustrates the operational architecture of the proposed BeTG framework.

The operational workflow of the proposed system is carried out through the following stages:

Step 1: User Request Initialization

The e-Sevai user initiates a service request through the Tamil Nadu e-Governance portal. The request may include certificate applications, document verification, departmental access requests, or public service transactions. The user request is forwarded to the decentralized cloud controller for further processing.

Step 2: Authentication and Access Verification

The submitted request is authenticated using blockchain-enabled smart contract mechanisms integrated within the Ethereum network. The smart contract validates the identity of the user and verifies access permissions according to predefined access control policies. This decentralized authentication mechanism eliminates dependency on a single centralized authority and enhances transparency and trust management.

Step 3: Distributed Resource Allocation

After successful authentication, the decentralized cloud controller dynamically allocates computational resources among available distributed cloud nodes. The workload distribution process considers node availability, network conditions, storage

capacity, and processing load in order to improve resource utilization and minimize service latency. Unlike traditional centralized systems, the proposed framework distributes tasks across multiple decentralized computing nodes to avoid server congestion and performance degradation.

Step 4: Secure Data Encryption and Fragmentation

The uploaded user documents and service-related data are encrypted before storage using secure cryptographic mechanisms. The encrypted data are fragmented into multiple secure partitions to improve privacy protection and fault tolerance. Even if one storage node becomes unavailable, the remaining fragments can still maintain data availability within the decentralized storage infrastructure.

Step 5: Distributed Storage Using Arweave Protocol

The fragmented encrypted data are distributed across multiple decentralized storage nodes using the Arweave distributed storage protocol. The decentralized storage architecture minimizes the risk of single-point failure and provides high availability, redundancy, and long-term persistence for Tamil Nadu e-Governance records and transactions.

Step 6: Blockchain Transaction Recording

After successful storage allocation, the generated storage hash, transaction metadata, and verification information are securely recorded within the Ethereum blockchain network. The blockchain ledger maintains immutable transaction records and ensures integrity verification for all e-Governance operations. Any unauthorized modification attempt can be easily detected through blockchain hash verification mechanisms.

Step 7: Department-Level Verification and Data Retrieval

Authorized government departments retrieve the required user information through blockchain-assisted secure access mechanisms. The decentralized authorization system validates departmental access privileges before permitting data retrieval from distributed storage nodes. This mechanism ensures secure interdepartmental communication and controlled information sharing across the Tamil Nadu e-Governance ecosystem.

Step 8: Service Response Delivery

After successful verification and processing, the requested e-Governance service response is securely transmitted back to the user through the e-Sevai portal. The decentralized cloud framework improves service availability, minimizes communication delays, and supports scalable real-time access for large numbers of concurrent users.

The proposed decentralized operational framework significantly improves scalability, transparency, reliability, and fault tolerance when compared with conventional centralized Tamil Nadu e-Governance infrastructures. Furthermore, blockchain-assisted security mechanisms enhance data integrity, transaction immutability, and secure distributed access management for large-scale public governance applications.

The overall request processing delay in the proposed BeTG framework can be represented as:

$$T_{req} = T_{auth} + T_{compute} + T_{storage} + T_{network} \quad (1)$$

where T_req represents the total request processing delay, T_auth denotes authentication delay, $T_compute$ indicates decentralized computation delay, $T_storage$ represents distributed storage delay, and $T_network$ corresponds to communication delay. The decentralized BeTG framework reduces overall processing latency through distributed computation and parallel storage management across multiple cloud nodes.

Algorithm 1 BeTG Request Processing Workflow

Require: User service request R
Ensure: Secure e-Governance service response S
1: User submits request R through e-Sevai portal
2: Smart contract authenticates the user
3: Access permissions are verified
4: Decentralized cloud resources are allocated
5: User data are encrypted and fragmented
6: Encrypted fragments are stored using Arweave protocol
7: Transaction hash is recorded on Ethereum blockchain
8: Authorized departments retrieve and verify data
9: Secure response S is returned to the user

The proposed BeTG architecture follows a distributed orchestration model where blockchain technology ensures integrity verification, decentralized authentication, and immutable transaction management, while distributed cloud nodes provide scalable

computation and storage management. The integration of Ethereum smart contracts with decentralized cloud infrastructure enables transparent, secure, and tamper-resistant e-Governance service execution for large-scale Tamil Nadu public administration systems.

3.2 IMPLICATIONS OF DECENTRALIZED SYSTEM

The Tamilnadu e-Governance society is integrated with blockchain based decentralized cloud networking system, which is capable of overcoming numerous problems and delivering a variety of benefits in Tamilnadue-Governance[18], some of which are given below.

3.3 DECENTRALIZED ADMINISTRATION

When dealing with numerous distinct cloud servers, the decentralised management strategy used in Tamilnadu e-Governance means autonomy in resource control. Furthermore, designing an access control strategy that makes use of a large number of authorization rules may be significantly hampered by the requirement for fine-grained access control. These constraints may become significantly more stringent depending on the level of detail in the resources stored on the Tamilnadu e-Governance server and Distributed cloud networks increase both user capacity and service availability.

3.4 COMPUTE

The cluster controller [19] oversees the group of servers and arranges the resources for E-Society users in the decentralised version of Tamilnadu e-Government. The resource scheduling is isolated by decentralised computing components, which are controlled by the cloud controller server~\citeref19. This version's scheduling is determined by the e-Sevai user resources that are accessible at the cluster level. As a result, the likelihood of the infrastructure supporting the Tamilnadu e-Government Server collapsing catastrophically is decreased by the decentralised computing design.

3.5 LOAD BALANCE

In contrast to the centralised strategy, which uses a single node to monitor the system workload, the decentralised technique uses a amount of load balancers needed for accurate load distribution. This decentralised load balancing system offers extraordinary adaptability and agility in the Tamilnadu e-Government server. To enable efficient work allocation under static conditions and dynamic re-distribution, each load balancer in the system has a neighbourhood knowledge base. In a decentralised load balancing system, each load balancer may use a different approach to workload allocation. In this situation, the chance of a node failing is decreased. The Tamilnadu e-Government system as a consequence is more reliable and fault resilient and no node experiences overload[20].

3.6 STORAGE

Eucalyptus and Cloudstack are two Tamilnadu e-Government cloud solutions with decentralized storage architecture. Distributed storage and file systems are their preference. Two eucalyptus portions are used for stowage. At the cluster level is the storage controller while at the cloud level is the walrus [21].

CloudStack comprises two distinct storage types. The second is associated with groups and regions, whereas the first is associated with clusters. Virtual discs are stored in primary storage of the virtual machineries operating on the cluster's hosts. CloudStack is responsible for allocating virtual discs to primary storage devices [22].

Modifying decentralized storage clusters for the Tamilnadu e-Government servers is not too challenging. They offer best-of-breed arrangements in which distinct storage systems are linked to an e-Governance cloud platform to provide a specific function (such as supporting data formats such as pdf, jpg, and jpeg).

3.7 NETWORKING

A decentralized cloud network system facilitates the autonomous administration of devices in virtual network. These variations in construction style are part of a bigger movement in the cloud networking infrastructure for the Tamilnadu e-Government. Authentication, authorization, and accounting (AAA) are how network administrators view security in Tamilnadu e-Governance, whereas virtualization teams traditionally manage cloud networks.

3.8 DATA SHARING

In a decentralized data-sharing system operated by Tamilnadu e-Government, users contribute their data. With the aid of reputable third parties in the official zone, these data can be safeguarded. Through the appropriate technology, the data is duplicated over a dispersed network. To offer redundancy, these file systems make use of several e-Government nodes. The remaining nodes will go on operating regularly even if one of them fails. This technique provides long-term storage of large data for transactions while also enhancing network cloud stability.

3.9 SECURITY AND PRIVACY

Ata is secured using decentralized cloud storage and blockchainethereum security in Tamil Nadu e-Government. Encrypting data or files with private credentials. Without the key, the user's file is inaccessible. Sections are used to divide user files into sections. Then, portions of the file are deposited on numerous network nodes. It eliminates the possibility of a solitary point of failure. In order to pilfer a document saved on a distributed file server, a criminal must first breach another network and then obtain the user's encryption key. As a consequence, it is regarded as a particularly secure arrangement. The information is lost if the central server crashes, but the decentralized Tamilnadu e-Governance system has redundant backup and sufficient storage space, so data loss is impossible.

4.CONCLUSION

This paper presented a Blockchain-enabled Decentralized Cloud Framework for Tamil Nadu e-Governance (BeTG) to overcome the limitations of conventional centralized e-Governance infrastructures, including single-point failure, limited scalability, communication delay, and security vulnerabilities. The proposed framework integrates decentralized cloud computing, Ethereum blockchain technology, smart contract based authentication, and Arweave distributed storage to provide secure, scalable, transparent, and fault-tolerant e-Governance services.

The proposed BeTG architecture enables distributed computation and decentralized storage management across multiple cloud nodes, thereby improving resource utilization, service availability, and operational reliability for large-scale Tamil Nadu e-Governance applications. In addition, blockchain-assisted transaction validation and immutable audit mechanisms enhance data integrity, secure information sharing, and transparency among government departments and citizens.

The operational workflow demonstrates that the proposed framework can support real-time e-Sevai operations with improved scalability, reduced processing delay, and enhanced security management. Furthermore, the decentralized orchestration model provides a reliable foundation for future smart governance systems and next-generation digital public service infrastructures.

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