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Block Chain Based Internet of Medical Things for Uninterrupted, Ubiquitous, User-Friendly, Unflappable, Unblemished, Unlimited Health Care Services (BC IoMT U^6 HCS)

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ABSTRACT The most burning topic of today, calls for a holistic solution that is reliable, secure, privacy preserved, cost effective Cloud storage that can tide over the turbulent conditions of the rapidly budding digital storage technologies. This send an outcry for a devoted solution, in the form of an individualized, patient-centric care - IoMT that augments precise disease identifications, decrease in errors, reduction in costs of care through the support of technology, allows patients to direct health information data to doctors ,manage drugs, keep Personal Health Records, caters to remote medical supports Care, provides proactive approach to preserving Good Health, improves and Accelerates Clinician Workflows, empowers extreme connectivity due to better automation and perceptions in the DNA of IoMT functions. But IoMT adoption is like a rose with thorns like constraints of increased administrative costs, deficiency of universal data access, present-day electronic medical records. The BCT is used in the framework to overcome the security issues of IoMT through the use of latest encryptions. Furthermore, this framework harnesses the benefits of Block Chain like reduced cost, speed, automation, immutability, near-impossible loss of data, permanence, removal of intermediaries, decentralization of consensus, legitimate access to health data, data safekeeping, accrual-based imbursement mechanisms, and medical supply chain efficacy. The outcomes in this paper are (i)A systematic investigation of the current IoMT, Block Chain and Cloud Storage in Health Care;(ii) Explore the challenges and necessities for the confluence of Block Chain (BC), Internet of Medical Things (IoMT), Cloud Computing (CC) ;(iii)Formulate the requirements necessary for the real-time remote Health Care of one-to-one care structure, which, supports the vital functions that are critical to the Patient Centric Health Care;(iv) Design and develop a novel BC IoMT U6 HCS (Block Chain based Internet of Medical Things for Uninterrupted, Ubiquitous, User-friendly, Unflappable, Unblemished, Unlimited Health Care Services) Layered Architecture, to support the vital functions critical for Patient Centric Health Care and (v) Implement and test with the previous established and proven techniques. The integrity of the Layered Architecture is validated with the already existing ones in terms of audit performances. The results from the Layered Architecture are validated and are proven to be competent in achieving safe auditing and surpass the former ones. The technology is in the sprouting phases, it is perilous that affiliates of the Health Care community realize the rudimentary ideas behind Block Chain, and detect its feasible impact on the future of patient centric medical care. Finally, and most importantly, this paper also gives a panoramic view on the current research status, and imminent directions of Secure Internet of Medical Things Using Block Chain.

INDEX TERMS authentication, authorization, availability, Block Chain, Cloud computing, confidential, consensus, data privacy, data security, electronic medical records, Health Care, integrity, Internet of Medical Things, Internet of Things, interoperability, Patient Centric Health Care, privacy preserving, provable data possession, remote monitoring devices, security.

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I. HEALTH CARE ENABLING TECHNOLOGIES – AN INTRODUCTION

Technology is unavoidable, irresistible as gravity and inexorable as moving water. The same holds true for all the enabling (disruptive) technologies in the Health Care. Health Care is the conservation or enrichment of welfare through the deterrence, detecting, treatment, regaining, or recovering from ailment, disorder, damage, and other physical and mental damages in individuals. The regulatory, standards and guidelines are still in the initial stages and this do not fully guarantee against the data security and privacy of the Health Care steeplechases to the implementation of the enabling technologies.

A. RATIONALE

Recent 2020 report given by the World Bank and WHO, states that *approximately half of the world population can't* afford or even *access* to *elementary Health Care services*. The report further expresses the prevalent incongruity in the availability and affordability of Health Care services even in the industrialized world. The utilization of computers in Health Care has led to the computerization of Health Care record system; dispersal of reliable information; inspection in Big Data; and alliance in clinical practice and diagnosis [3],[76]. But even then, it is not a perfect one-point solution.

To combat with the prevalent challenges, we have to erect the real-time remote Health Care one-to-one care structure, on the four pillars of enabling technologies, namely, Block Chain (BC), Internet of Medical Things (IoMT), Cloud Computing (CC)and Big Data Analytics (BDA). The confluence of the above enabling technologies *minimizes not only the cost, disbursed on surgery and medicines, but also reduces the number of visits to the hospitals by the patients*. This aids even the *uninsured patients* to receive good cost-effective Health Care services. The scope of this paper is about the integration of the two technologies and the related research on Block Chain based IoMT Cloud smart Health Care solutions.

B. CONTRIBUTIONS

Many research studies have accredited the utilization, efficacy of Block Chain and IoMT in the Health Care Ecosystem in delivering a one-to-one care solution. Nevertheless, none of the works in the literature have focused on the Fusion of Block Chain technology, Internet of Medical Things, Cloud Storage to arrive at an impeccable Patient Centric Health Care. Obviously, the proposed Layered Architecture is anticipated to slender down the clefts in the research slits and the key take-away given in this paper are condensed as the following five facades:

a. A systematic scrutiny of the current IoMT, Block Chain and Cloud Storage in Health Care.
b. Explore the challenges and necessities for the confluence of Block Chain (BC), Internet of Medical Things (IoMT), Cloud Computing (CC).
c. Formulate the requirements necessary for the real-time remote Health Care of one-to-one care structure, which, supports the vital functions that are critical to the Patient Centric Health Care.
d. Design and develop a novel BC IoMT U^6 HCS (Block Chain based Internet of Medical Things for Uninterrupted, Ubiquitous, User-friendly, Unflappable, Unblemished, Unlimited Health Care Services) Layered Architecture, to support the vital functions critical for Patient Centric Health Care.
e. Implement and test with the previous established and proven techniques. The integrity of the Layered Architecture is validated with the already existing ones in terms of audit performances. The results from the Layered Architecture are validated and are proven to be competent in achieving safe auditing and surpass the former ones.

The flow of this paper is ordered as follows. *Section 2* gives the characterization, an overview IoMT, its role, all its related works like the existing system, reasons for its adoption, prospects, challenges and the motivation to create the BC IoMT U^6 HCS Layered Architecture. *Section 3* discusses the overview of Block Chain, reasons for preferring the Block Chain in health care, all its related works like the existing system and the motivation to create the BC IoMT U^6 HCS Layered Architecture. *Section 4* gives an outline of the Cloud computing issues and requirements. *Section 5* deals with the Confluence, benefits of Block Chain in Health Care IoMT. *Section 6* deals with the literature review on Block Chain in Health Care - IoMT and highlights the requirements. *Section 7* highpoints the main research gaps in Block Chain on embracing the IoMT. *Section 8* expresses the problem statement. *Section 9* gives a description of the proposed problem, its solution, the proposed system architecture and its exhaustive design. *Section 10* deals with the operation of the proposed layered architecture. *Section 11* discusses the pragmatic outcome and examination. *Section 12* pinnacles the main inferences. *Section 13* briefly articulates the imminent work.

II. IoMT (INTERNET OF MEDICAL THINGS) OR H-IoT(HEALTH CARE IoT)

Based on the survey conducted by Allied Market Research, the **IoT Health Care market** is expected to spread up to $136.8 billion worldwide. Moreover, the vision of medical services at 'anytime, anywhere and anything' is also altering the patient expectations and this inspires the next generation of innovations.

A.IoMT (INTERNET OF MEDICAL THINGS) OR H-IoT(HEALTH CARE IoT)

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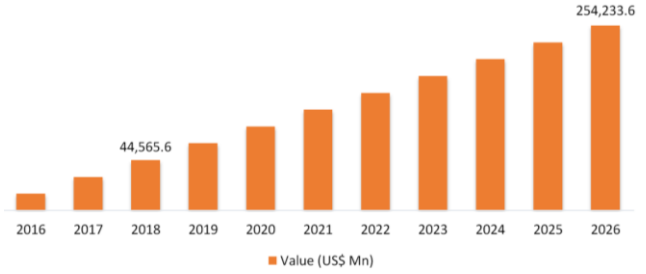

FIGURE 1. Worldwide Internet Of Medical Things(IoMT) Market, 2016-2026,US$ Mn
Source:https://www.alltheresearch.com/report/166/internet-of-medical-things-market

Based on an analysis given by Frost & Sullivan, the world IoMT market in 2016 is worth $22.5 billion; and it is predicted to reach $72.02 billion by 2021, at a compound yearly growth rate of 26.2%. Additionally, AllTheResearch , projects(see figure .1) that the **IoMT market** is expected to reach 254.2 billion USD by 2026. AllTheResearch further states that, "This is a massive increase from 44.5 billion USD predicted in 2018. The increased adoption of sensor technology and smart devices comes from the change in consumer lifestyle as trends like health and fitness are on the rise".

A.IoMT/ H-IoT - A QUICK REVIEW

The IoMT (Internet of Medical Things) is the unification of data from various medical gadgets (equipped with sensors) and software applications in the Health Care systems wirelessly. The IoMT collects remote patient health data from the wearable sensors; pre-processes the collected data, streams it to the Health Care Professionals via machine-to-machine (M to M) fortified with Wi-Fi. The Health Care data is stockpiled in the Cloud server for additional analysis. This data unification results in *improved patient outcomes* by combining the people, data and processes through connected medical devices and mobile applications. The IoMT thus *increases the efficacy of Health Care devices, and the speed and accessibility of Health Care services*.

DEFINITION- IoMT - TechTarget which gives the technology professionals and executives the information they need defines Internet of Medical Things (IoMT) as, "*The Internet of Medical Things (IoMT) is the collection of medical devices and applications that connect to Health Care IT systems through online computer networks. Medical devices equipped with Wi-Fi allow the machine-to-machine communication that is the basis of IoMT. IoMT devices link to Cloud platforms such as Amazon Web Services, on which captured data can be stored and analysed. IoMT is also known as Health Care IoT.*"

B.MOTIVES FOR IoMT ACCEPTANCE

Gus Vlahos [33] lists the rationale for IoMT adoption:

- **IoMT improves and accelerates the clinician workflows.** *For example*, Memorial Hermann Health System in Texas Tools uses IoMT to send SMS, scan barcodes, and to transmit images.
- **IoMT empowers good connectivity** due to Better automation and perceptions in the genetical makeup of the functions of IoMT. *For example*, the "smart pills, are used to send alerts and deliver messages to the concerned doctor's smartphone.
- **IoMT aids in remote medical support and care** – IoMT assists in remote patient monitoring, by collecting data and sending it to analysts (providers); who will estimate the long-term metrics to rapidly envisage the onset of critical illness very much ahead distress. *For example*, Remote Patient Monitoring (RPM) in various hospital's across Europe like UCLA Health and Children's Health in Dallas have succeeded in minimising the readmissions.
- **IoMT helps to proactively conserve Good Health** – The increase in the usage of consumer wearables to accumulate and send the health data to care takers and medical personnel. Treatment is useful to proactively handle Health Care. *For example*, Apple Watch 6 (keep well, save lives by forewarning the onset of heart problems) has a new sensor to alert blood oxygen levels; Google's Verily (clinical trial), Amazon (PillPack and online symptom-checker Health Navigator), Microsoft's Healthcare NExT (AI in health care).

C.ROLE OF IoMT IN HEALTH CARE

The IoMT supports in *reduction in costs of Health Care through the support of technology, precise identification of diseases, minimisation of errors, and allowing patients to directly communicate health information data to doctors*. This is particularly important in current COVID-19 crisis; because, the IoMT does not need in-person medical visits. AllTheResearch gives an implication that the global pandemic of COVID-19 has only further accelerated the need for IoMT and is playing a huge role in the growth of the technology. IoMT comes as a handy technology to the medical industry researchers, who, are in search of the most efficient screening process and quick monitoring of patient symptoms. AllTheResearch likewise, states, that technologies, such as, IoT in 5G, Cloud Computing and Block Chain powered alongside Artificial Intelligence will definitely make for a massive competent Health-Tech Ecosystem.

D. IoMT/ H-IoT - HEALTH CARE APPLICATIONS

To list a few of the *IoMT devices that monitor* patients are the fitness trackers (wristbands or smart watches), remote

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patient one-to-one care for chronic disease, smart pills and cybernetic consultations.

TechTarget lists a few examples of IoMT technology as follows:

- Infusion pumps are connected to the analytical consoles and sanatorium beds (armed with sensors) help to quantity the patient's dynamic signs;
- patient's habiliment mobile gadgets, send information to caregivers;
- distant patient intensive care of people with unending or lasting conditions; and
- trailing patient medication orders along with the geo-position of patients.

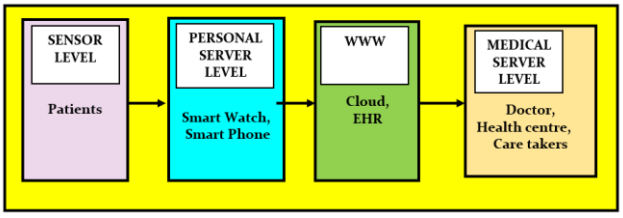

FIGURE 2. High Level Diagram of Internet of Medical Things

Figure 2. depicts the High-Level Diagram of Internet of Medical Things. The Internet of Medical Things (IoMT), has four levels, namely, sensor level, personal server level, operational computer networks (WWW) level and Therapeutic server level. The data is collected from the patients via sensors, tags, from medical gadgets from applications, harbored at the personal server level. This is linked to the Health Care IT systems (Therapeutic server level) through operational computer networks (WWW). The Medical devices armed with wireless connectivity permit the machine-to-machine communication; the devices in turn are connected to Cloud platforms, on which the captured data is stored and analyzed.

E. PROSPECTS WITH INTERNET OF MEDICAL THINGS

Farahani, et al., [23], states, that, IoMT provides a holistic solution by amalgamating different *technologies* in perfect symphony and it renders user-based personalization of the content or service; which, leads to reduction the *costs of Health Care, offering the availability* and *accessibility, as it can be used at* any time and any location.

Gulraiz, et al., [31], states, that IoMT *improves the pricing reasonably*, *facility and uncomplicatedness in use of devices, and enhancing the efficiency.* Besides, the doctors can concentrate on the real-time health status of patient and can monitor a greater number of patients.

Irfan & Ahmad,et al., [52], mention that with IoMT, patients can be *pragmatic during their aera* , and get a *whole long-term picturing of their Health Care data.* Deloitte [15], highlights the prospects for *lessening the costs* with usage of IoMT, *improve drug administration, diagnosis, treatment, augment patient involvement and permit distant 24-hour care of chronic diseases, paving way to upgraded patient consequences.* Lindman and Saarikko [58], narrate the augmentation of *allied Health Care solutions and how to offer security by alerting Health Care specialists when a patient desires assistance.* In short, IoMT shows a promising prospect of offering a better quality Health Care at a *lower cost* [52], which finally ends up in *lengthier lives* [31].

F. ORDEALS OF IoMT

- IoMT, *deals with enormous amount(*volume*), of heterogenous Health Care data(*variety*)*, generated continuously(velocity); which, mandate's the necessity to *devise special techniques to tackle the big Health Care data*.
- *High cost is incurred* on patients *(*for linking to fitness smart devices, remote patient monitoring systems), and Medical care takers (integrating of medical equipment into the current Health Care ecosystem).
- Health Care data includes *extremely sensitive data* like patient's ailment information, treatment details and their geolocations. This *necessitates for devising strong privacy protection mechanisms.*
- IoMT implementation brings to the forefront issues like *security perils* (linked to the movement and network necessities), vague passwords and less frequent (if any) mending upgrades. This calls for an outcry of a comprehensive endpoint protection strategies like *Strong Security, and data Integrity Measures.* There are also issues that are linked with sustaining the growth of the IoT environment like, *transparency, trust and longevity to be handled.*

Taking into account the above challenges, we have to double our intensive effort in devising comprehensive protection strategies and robust network monitoring; which necessitates the inclusion of Block Chain technology. Let us see how we can rope Block Chain for use in IoMT.

III. BLOCK CHAIN

Block Chain picks up where IoMT & Cloud technology bites the dust. BC is used to store information securely in safe locations for future information sharing. A Block Chain is a ledger which is dispersed and it operates based on *consensus alias validation mechanisms* programmed on dissimilar nodes of its networks. The Block Chain is used to generate a tamper-proof digital ledger of transactions; which is shared among the parties. The transactions among the parties are signed using public-key cryptography and these dealings are stockpiled on a circulated ledger. The ledger is encompassed of cryptographically linked blocks of transactions, to form a block chain. Once recorded it is very

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difficult to remove a block from the Block Chain ledger. Block Chain thus gives a digital version of etching information into solid stone. Block Chain technology further permits dispersed preservation of encrypted data.

A. TYPES OF BLOCK CHAIN

There are many, types of Block Chain (see Table 1), that have emerged such as public, private, semi-private, side-chains etc.

TABLE I .
TYPES OF BLOCK CHAIN

Type of block chain	Functioning
Public Block Chain	anyone can participate
Private Block Chain	can participate after requesting membership
Semi-Private Block Chain	combination of public and private Block Chains
Sidechains	Concept of running a separate distributed ledger off of the main chain but with transactions able to take place in the same currency

Consensus mechanisms (see Table 2) are used for verification of the transactional data between the nodes in a network.

TABLE II .
SUMMARY OF CONSENSUS ALGORITHMS IN BLOCK CHAIN

Algorithm	Characteristics
Proof-of-Work (PoW)	solve a mathematical puzzle to get incentives.
Proof-of-Stake (PoS)	Can own a section of Block Chain and this acts as a carter to maintain a version of ledger which is of true state. Should have casing in the game.
Delegated Proof-of-Stake (DPoS)	Owner votes for an agent, who, executes the function of validating transactions and maintaining the Block Chain.
Proof of Elapsed Time(PoET)	Based on a lottery game, a leader is selected; and this Leader picks the next version of the ledger
Practical Byzantine Fault	A consensus algorithm for the enterprise consortiums in which the members are partially Tolerance (PBFT) trusted.
Proof-of-Weight (Po Weight)	PoS algorithm solves the biased nature using "weighted factors".
Proof-of-Bum (PoB)	Miners dispatch coins to an "eater address". The one who burns the coins gets a prize and can pit a new block.
Proof-of-Activity (PoA)	Two consensus algorithms PoW and PoS are mixed to obtain security.

Block Chain platforms are selected based on the subjective assessment of their ease of prototyping, Popularity, Activity, Type of network, Pricing, and supported languages. The various Block Chain platforms like IBM Block Chain, IOTA, Multichain, Open-chain, Quorum, R3 Corda, Ripple, Stellar, Symbiont Assembly.

B. BLOCK CHAIN IN HEALTH CARE

A vast body of literature is available that converses the use of Block Chain in Health Care. The year 2015, witnessed the popularization of Block Chain as a novel economic model [85] and the use of Block Chain for decentralizing privacy [97].

The year 2016, saw the evolution of Block Chain [5], Electronic Patient Record systems (EPRs) [6], and its utilization in empowering the patient-physician relationship [6]. Azaria, A, et al., [3] in their paper described about the utilization of Block Chain for handling authorization in medical domain, with a developed application named as Medrec. Some authors cited the use of Block Chain as solutions for Interoperability [9].

In the year 2017, Block Chain evolved rapidly [14]; and it was used in various Health Care applications [2],[7],[16]. The Block Chain is substantiated to be very energetic for Health Care [34], consequently vesting e-health [18]. Many preceding works mentions about the challenges and opportunities of Block Chain in e-Health Care [77], [56].

Esposito, C, et al., [22] showed how in 2018, Block Chain gained its celebrity status as an assurance for offering security and privacy of eHealth Care. Example To name a few systems - Blochie [55], FHIRchain [92] and Mistore [96].

Other works that is of interest are : AuthPrivacyChain (blockchain-based access control framework with privacy protection) proposed by Caixia Yang, et al., [10]; blockchain-empowered AAA scheme for accessing data of LS-HetNet proposed by Na Shi, et al., [70] and zkCrowd (an innovative hybrid blockchain crowdsourcing platform) named and proposed by, Saide Zhu et al.,[80].

C.REASONS FOR PREFERRING BLOCK CHAIN IN HEALTH CARE

M. Mettler[60], enumerated several advantages obtained by applying Block Chain in smart Health Care. For example, health data can be stockpiled on the Block Chain in a *safe, way*. *The Characteristics of Block Chain viz., no particular point of failure (as it is distributed), complete pellucidity, strong cryptographic techniques, near 100% immutability* and its ability to use insightful contracts, makes it the most preferred mechanism of data integrity in the Cloud. These Characteristics has ignited the Block Chain revolution, which has not only swept the feet of the financial industry by storm, but is also making inroads in every sector like Health Care, energy, retail, governance, supply chain and agriculture, including Data integrity; thereby disrupting the walks of life of people.

The ground-breaking Block Chain technology is useful to solve many challenges like: *Immutability* (transaction cannot be changed once it is agreed and shared across the distributed network), *Innovation* (ample space for new creation of Block Chains), *Reduced Transaction Expenses*(with elimination of the third parties), *Security* (due to decentralization),*Transparency* (since all alterations are made public).Block Chain Data Integrity in Cloud, ensures that the data assets stored on the Cloud are intact and nothing has been tampered with. A Keyless Signature

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Infrastructure (KSI™) via a RESTful API is *enough to provide the desired integrity*.

The utilization of Block Chain technology, offers *reliability* (decentralized architecture) and *safety* in the Health Care system. The Block Chain can alleviate problems arising from the privacy and integrity of patient information, due to the features of Block Chain, such as immutability, transparency and reliability. Block Chain supports in the management of logs and the auditing of the data.

D. BLOCK CHAIN APPLICATIONS IN HEALTH CARE

The benefits that arise from the integration of Block Chain techniques with Health Care have been documented by several authors [3],[34],[69],[75], are *the computerized execution of services, disparity access control* for various user types, *the enactment of health-care regulations, logistics, distant data collection, indexing, the unification or calibration of information, redundancy* and *fault lenience*.

The general key aids for implementing Block Chain technology in IoMT, biomedical and Health Care applications are *24/7 monitoring and data access, Business Model changes, Consistent rules via smart contract, data provenance, data storage and security, decentralized management, immutable audit trail, Integrity of medical records , interoperable health data access, medical supply chain efficiency, robustness, availability, security, privacy, Budget friendly, Single data source, Single patient identification, Storage capacity and value-based payment mechanisms.* Uniting the Block Chain technology with IoT, it can augment the reliability (due to immutability of the data) of the evidence carried in real time.

1).BLOCK CHAIN-BASED HEALTH ASSET TRACKING AND MANAGEMENT IN THE SUPPLY CHAIN

The Block Chain assists in the *management of drug supply chains*, primarily because of its immutability characteristics, which makes the forgery of drug, more challenging (for example the tragic consequences for the Nigeria population). The Block Chain can thus be applied to many areas like control and management of drugs. Block Chain assists in monitoring the dispersal of drugs, and check that the resources trail the supply chain pattern fittingly. Say for example, in *drug distribution*, cycling through all the stages in the *supply chain*, assist in *combating drug counterfeiters*, such as the deviation of pharmaceutical products and theft.

2).HEALTH CARE INFORMATION MANAGEMENT

The Block Chain protocols are used in Health Care information management to control transactions, process of distributing electronic health records, with increased security, immutability of data, and privacy. The Block Chain satisfies the necessities to improve the quality and security of data transfer, as well as the reduction of energy costs. As the consensus protocols are becoming more advanced, they can be used in the resource-constrained devices (e.g., IoMT), as from light consensus protocols such as PBFT and SCP [37]. The Block *Chain endorses the sharing and storage of medical big data.*

3). SECURE SHARING & STORAGE OF HEALTH CARE DATA

All the stakeholders who are into Health Care are to securely share patients' medical Data. The shared untampered data relevant to the patients are necessary to make good Health Care decisions. The speedy development of Block Chain ensures the sharing and stowing of health data on the Block Chain in an *absolute, safe and consistent way*. The primary protocol that is involved in the network trust building processes are the consensus protocol, which *helps to share patient records, images sharing, Log Management in Health Care Systems, managing Health Care information, Patient Monitoring with the aid of personal sensors, reliability and monitoring patients through sensors with limited hardware*.

The medical data is to be stored securely, especially with good data honesty, which is a daunting task. The medical data like patients' complete medical histories, are stored and maintained using a Block Chain communally in a decentralized way.

The Block *Chain endorses the importance of Block Chain technology in the Health Care industry by utilizing it in a number of other ways – namely, for increased reliability, increased efficiency, privacy, security, developing integration, and lots more.*

4). PRIVACY AND SECURITY IN BLOCK CHAIN FOR HEALTH CARE

Feng, et al., [24] has listed about the prevailing challenges of privacy in the Block Chain as (i) *Identity privacy* - preserve the user's private identity, without linking to the transaction and (ii) *Transaction privacy* - guaranteeing the inaccessibility to the contents of transaction by unauthorized users.

The striking literatures, citing the utilization of Block Chain to achieve, privacy in health care are : Cynthia Dwork, et al.,[13] work on differential privacy, Abbas Acar, et al.,[1] work on homomorphic cryptography , M. Sabt, et al.,[61] work on trusted execution environments (TEE) , and Eli Ben-Sasson, et al.,[20] work on zk-snarks (derived from the zero-knowledge proof).

IV. CLOUD COMPUTING

Cloud computing is defined by National Institute of Standards and Technology (NIST), *as "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications,*

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and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This Cloud model is composed of five essential characteristics, three service models, and four deployment models".

A. CLOUD SECURITY ISSUES

In spite of the countless highly prioritized Cloud security issues, like, Elasticity, Network Diffidence, still *data integrity* gets its prime focus from all the stakeholders owing to the significance of the concept of data currency. The data integrity might be compromised due to reasons like human errors, software bugs, hardware faults or malicious attacks.

V. CONFLUENCE OF BLOCK CHAIN IN HEALTH CARE-IoMT

The IoMT and Block Chain technologies are perfect when they are working in silos, but have their own limitations. Both technologies are integrated together and this confluence of IoMT and Block Chain assures the following:

- Affordability
- continuously monitor the activities of the children and the aged people is made seamless; sends an automatic alert to the concerned persons if any health condition goes awry.
- Easy management of patients records by Doctors
- Energy efficiency
- Eventual benefit is healthier and longer lives,
- Improved Life quality, Outcome of patient, user end experience
- Improvisation in care for patient
- Make life more convenient
- Management of diseases is real-time
- Maximum diseases management and inhibition
- Reduction in operational costs
- Simplicity, Ease to use

A. BENEFITS OF BLOCK CHAIN IN HEALTH CARE-IoMT

The merging of the Block Chain and IoMT technologies enables not only Remote Patient Monitoring but also the Collection and integration of Clinical Data (say for instance-administrative data, clinical trial data, disease archives, health insurance entitlements, health surveys, etc.) in a unified cost-effective manner, that helps in self-governing, thereby reducing time and effort. Block Chain finds its use in identifying and treating diseases like aberrations in internal organs, cancer, apt utilization of sensory devices such as ingestible pills, heartbeat monitors, and more.

Listing a few of the paybacks of Block Chain in Health Care IoMT:

- **Collaboration** – assists to manage and sync in a proper way through distributed ledger technology, and sustains the innovation in the field;
- **Data Provenance & Integrity** – supports to handle the surge in the rise in the number of users and devices of Health Care facilities to process and store information;
- **Data Protection** – ensures to safeguard important documents and information, prohibits unauthorized users to access information and data;
- **Monitoring** – helps to authorize to access the medical information, document transactions in correct format, transparent, saves time, effort, and cost;
- **Simplifying the Process** – relieves the effort to safeguard heavily and this results in an overall improvement to the system.
- **Enables the realisation of Smart Hospitals** – Even locating an individual or a machine/thing, which, saves a lot of clerical tasks and catalogue managing activities that are done more efficiently, cutting down the cost for Health Care service providers.
- **Provides one-to-one health care** for emergencies, Intensive Care Units (ICU).

VI.LITERATURE REVIEW ON BLOCK CHAIN IN H-IOT

Every day lots of researchers are contributing to the development of a fool proof block chain-based Health Care services.

J. Zhang, et al., [54], proposed a protocol to collect data and disseminate the collected data amid the Pervasive Social Network (PSN) nodes. Q.Xia, et al., [74], gave, a foursome-layer edifice named as MedShare, which, uses smart contracts to manage the contact to the data in the Block Chain.

M. A. Uddin , et al., [88] proposed a Block Chain based privacy preserved architecture to ceaselessly monitor the patient's health. The tailored Block Chain has a Patient-Centric Agent (PCA), to remotely monitor. PCA takes control of the sorting of stored data based on their criticalness, favouring the drillers.

J. Xie , et al., [53] mentions that the primary application of Block Chain is to store and provide access control to the collected medical data, which results in security, integrity, and privacy. M. Simic, G, et al., [62], proposed a big data application with Block Chain for medical data management; as the Block Chain imparts bounciness and security to the data collected by the sensor nodes.

A. BLOCK CHAIN-BASED APPROACHES IN IOMT

Ellouze, F[21], grouped the techniques that are used to integrate Block Chain into IoMT. The groups are based on *Ethereum, Hyperledger-Based Contributions, General*

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Block Chain Concept Without Technical Specifications, Modified Cryptographic Technique and Modified Consensus Protocol.

1). Ethereum-Based Contributions - An **Ethereum-based architecture** was proposed by Mohan, S.,et al., [65], to remotely monitor diabetes patients, with *smart contracts managing the data access* .The **private Ethereum-based architecture** proposed by Malamas, V[63], implements the *consensus mechanism using smart contracts*. The proposed framework directs the players' pleas to the medical or the technical possessions; uses three Smart Contract (SC) functionalities to enable *the registration* [Registration Smart Contract (RSC)], *authorization* [Actor Handling Smart Contract (AHSC)] and *logging requests* [Log Management Smart Contract (LMSC)]. An InterPlanetary File (IPFS) stores all the health-related data. A Proof of Medical Stack (PoMS) is proposed to protect the smart contracts from malicious actions.

A **private Ethereum-based Block Chain** was proposed by Khatoon, A. [57], for *managing* the medical data. It works on Ethereum smart contracts to allow *data access amid all involved entities*. The smart contract is made of nifty depictions of *medical records along with approvals, record proprietorship metadata and data integrity*. The medical data is stockpiled off-chain (external server) and the cryptographic hash is kept on the Block Chain ensuring data integrity.

Nguyen, D.C, et al., [72], developed a **Cloud-based IoMT framework data with an Ethereum-based Block Chain network** to safely transfer and share data amid Health Care users. Smart contracts *control users access to data in the Cloud, and to monitor the development, to store and process.*

Griggs, K.N, et al., [30], proposed a **permissioned Block Chain-based architecture to safely monitors patient using Ethereum**. The smart contracts *analyse data and send alerts to alert caregivers.* Practical Byzantine Fault Tolerance (PBFT) is used as an alternative to PoW consensus model. The proposed architecture is deficient to meet the issues related to IoMT-Block Chain integration.

2). Hyperledger-Based Contributions - Attia, O, et al., [4], proposed an IoT-Block Chain based architecture to permit monitoring of health remotely. There are two types of Block Chain, named as *Medical Devices Block Chain*, and *Consultation Block Chain*. A user interface is developed to envision the patient health data. The transactions are substantiated and authenticated using Chain codes in Fabric.

3). Modified Consensus Protocol - Uddin, M.A., [59], proposed a **consortium block chain-based architecture**. The authors developed a *patient agent software (PA)* to define the Block Chain functionalities and is deployed on the Edge computing network. The Smart contracts are used to *manage health data including filtering clinically useless health data, generating alarm for some events, drift data to the Cloud if necessary, classify data and others*. Compared to PoS, authors maintain that the adapted PoS is more effectual in term of energy consumption and block generation time.

4). Modified Cryptographic Technique - Natarajan, B, et al., [89] used hashing technique and a *novel encryption algorithm for encryption*. The algorithm covers all the medical objects with very low time complexity supporting the real time obligation of IoMT.

Dwivedi, A, et al., [19], *tailored the Block Chain-based framework* and made it private to evade the POW consensus protocol. The high-volume data produced by IoMT devices, are congregated as encoded data in blocks and stockpiled the combined blocks in the Cloud. The hashes of blocks are set aside on the Block Chain.

Uddin, M.A, et al., [89], proposed *ring signature* which is used as standard public key based digital signature to guarantee the privacy.

5). General Block Chain Concept Without Technical Specifications - Gupta, S, et al., [32], used the *tamper proof feature of Block Chain to safely share and store the IoMT data*. The patient data are stockpiled as blocks(strings) in the Block Chain and the IoMT data are stored in blocks in off-chain database. Smart contracts ensure the privacy and security of the Block Chain.

Shen, B, et al., [83], proposed a **MedChain consortium Block Chain-based framework** to efficiently share data streams generated from medical sensors. The MedChain network has *two separate decentralized sub-networks - Block Chain network*, and *P2P network.* MedChain uses the *BFT-SMaRt as a consensus protocol*. Seliem, M, et al., [82] proposed the BIoMT, which is **an optimized, lightweight Block Chain-based framework**. The proposed architecture is made up of *four stratum*-namely, *Device layer, Facility layer, Cloud layer, and the Cluster layer.* This work does not provide any technical details. It is neither implemented nor evaluated. Dilawar, N, et al., [17] and Uddin, M.A, et al., [88], proposed a Block Chain-based architecture to *allow secure transmission and storage of large amount of sensitive data generated* by IoMT.

VII. RESEARCH GAPS IN BLOCK CHAIN ADOPTED IoMT

Though the integration of IoMT and Block Chain technologies assures, continuous monitoring, relaxed management, improved Quality of Life, comfortable, maximum diseases management and inhibition in real-time, reduction in operational costs, effortlessness and calm to use; there are still many challenges to be attended to.

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Moreover, problems like, the *requirement of constrained devices in Health Care applications* have to be taken care.

A. UNSOLVED OPEN ISSUES

The literature review showcases many research gaps. Integrating Block Chain technology with Internet of Medical Things (IoMT)gives rise to numerous challenges due to the differing necessities in these two technologies:

TABLE III .
COMPARISON OF BLOCK CHAIN IOMT DEVICES

	Block Chain	IoMT devices
Mobility	has fixed network topology	topology varies, due to the mobility
Processing	needs more computation and high energy consumption due to the mining process and composite cryptography	resource-constrained
Real Time	generation of blocks consumes time	it demands real time and instant response, as it is life-threatening.
Storage	produce enormous data with large flow which is	limited storage capabilities
Traffic Overhead	connect unceasingly to orchestrate which generates noteworthy overhead traffic	are bandwidth-limited.

A quick review of the literature on the research challenges faced by the confluence of Block Chain adopted IoMT are as follows:

Chao-Hsi Huang , et al., [11], points out the research gaps in the *Intelligence area* of Medical Care. Boyi Xu , et al., [8], mentions in their paper the *issues pertaining to the integration of data.* Hyun Jung La Han Ter Jung , et al., [36],discussed the challenges in the *Software implementation of medical analytic schemes*. They further explained the *Technical challenges involved in Modeling the relationship between acquired measurement and diseases.*

Boyi Xu , et al., [8], Foteini Andriopoulou , et al., [25], pointed out the *Interoperability issues arising from the things.* Shu-yuan Ge et al., [84], discussed the *issues related to constraints over network performance like bandwidth, CPU capacity and Memory of the system*. Matar, G, et al., [64], indicates the *Hardware implementation and design optimization issues.* Pallavi Chavan , et al., [73] specifies the *issues arising due to the amorphous, rising and varied data at exponential rate.*

Tsoutsouras, V, et al., [87] discussed the challenges related to *data privacy, flexibility and evolution of applications, low power consumption, managing device diversity, need for medical expertise, real time processing, scale, data volume and performance, system predictability.* Foteini Andriopoulou , et al., [25] specifies the issues arising due to the *availability of resources, data exchange and privacy*. Several authors [25],[78],[87] have documented the *security research challenges*.

For storing the big IoMT data, most of works [72] proposed an off-chain storage. Some researches [32,63] proposed to use IPFS because of its distributed data structure. Authors like Nguyen, D.C, et al., [72] , Dwivedi, A, et al., [19], Khatoon, A.: ., et al., [57], Seliem, M., ., et al., [82],Uddin, M.A., et al., [89] , proposed the *encryption of data prior to storage in the Cloud, and placing the hash references of the data* in the Block Chain. But it doesn't stand guarantee for immutability. In fact, any alteration of data will be spotted by the hash stored in the Block Chain. Authors like, Khatoon, A, et al., [57] , have exterminated the consensus protocol to meet IoMT necessities.

Malamas, V , et al., [63] used smart contract to *self-verify and self-execute transactions* ; but it is subjected to threats using a lightweight consensus mechanism. Griggs, K.N, et al., [30] proposed a *lightweight consensus protocol*. PoS protocol have been modified to fit in the IoMT environments [Malamas, V, et al., [63], Uddin, M.A, et al., [89]. A few authors [Dwivedi, A , et al., [19] have *aggregated nodes into clusters, selected a header for every group to effect transactions, and to authenticate and create blocks*. Some other authors have given solutions novel framework for trading range counting results like [Zhipeng Cai, et al., [94];privacy-preserved data sharing framework for IIoTs, where multiple competing data consumers exist in different stages of the system [Xu Zheng, et al., [91] ;a work targeting coin hopping attack[Saide Zhu et al., [79] (2019)]; ABE model with parallel outsourced decryption for edge intelligent IoV, called ABEM-POD[Chaosheng Feng, et al., [12] and a novel mechanism for data uploading in smart cyber-physical systems, which considers both energy conservation and privacy preservation[Zhipeng Cai, et al., [93].

Most of the earlier works have given solutions to bring about and regulate access rights. Most of the solutions [Nguyen, D.C, et al., [72],Khatoon, A, et al., [57], Malamas, , et al., [63], Mohan, S, et al., [65], deploy smart contracts to permit access to only permitted users based on some attributes of the IoMT ecosystem and their collaboration with the users. The authors [19], [71], [89] proposed a lightweight privacy-preserving algorithms to preserve patient privacy .

Other works that is of interest are : Zhiwei Guo, et al., [95] proposed Collaborative neural network-based Spammer detection mechanism (Co-Spam) in social media applications; Zhipeng Cai, et al.,[94] proposed a novel framework for trading range counting results.

Several issues have been studied and relevant solutions have been proposed for data (like security) in the IoMT, Block Chain, Cloud. But still a lacuna is there which can be looked as an opportunity for finding the apt technical resolutions, and this paper is intended at such a trivial step. Lacuna like **Lack of standards** are yet to be attended. A

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few worth mentioning and the pertinent concepts of preserving privacy are prevailing in literatures, [26-29], [38-51],[66-68],[81],[90].Most of the research on Block Chain in the Internet of Medical Things (IoMT), is focused only on privacy, data integrity, concealment and authentication. But it doesn't tackle the problems arising out of big data stream produced by resource-constrained IoMT devices.

VIII. PROBLEM STATEMENT

Propose, design a generic Layered Architecture christened as, "Block Chain based Internet of Medical Things for **Uninterrupted, Ubiquitous, User-friendly, Unflappable, Unblemished, Unlimited Health Care Services** (BC IoMT U^6 HCS) framework". The architecture is designed to effect a patient centric health care, seamless user responsive, Block Chain based Internet of Medical Things that can manage, safeguard patient data in transit, storage, authenticate, audit, validate data in the Health Care - IoMT Cloud environment.

A. PROBLEM DESCRIPTION

The proposed Layered Architecture is designed to minimize the research gaps arising out of the challenges and necessities for the confluence of Block Chain (BC), Internet of Medical Things (IoMT), Cloud Computing (CC). The requirements that are needed for the real-time remote Health Care of one-to-one care Block Chain based Internet of Medical Things are taken into consideration in the design. Hence, the genesis of the novel BC IoMT U^6 HCS (Block Chain based Internet of Medical Things for Uninterrupted, Ubiquitous, User-friendly, Unflappable, Unblemished, Unlimited Health Care Services) Layered Architecture, to support the vital functions critical for Patient Centric Health Care.

IX. PROPOSED BLOCK CHAIN BASED INTERNET OF MEDICAL THINGS

The usage of Block Chain in the proposed system imparts decentralization, security, integrity, anonymity, good performance, elasticity and security to the data collected by the IoMT. The general Secure Privacy Conserving Provable Data Possession (SPC-PDP) framework [48], is used optionally to provide an additional layer for safeguarding the data integrity along with privacy preserving, batch auditing, and dynamic data auditing. When the SPC-PDP framework is concomitated it supports data validation, verification, secrecy for Cloud storage; along with the decentralization, security, integrity, anonymity, good performance, resilience and security of IoMT with Block Chain.

The proposed Block Chain Based Internet of Medical Things offers the users a six-pronged strategy by an uninterrupted, ubiquitous, user-friendly, unflappable, unblemished, unlimited Health Care services.

a. **Uninterrupted Health Care Services** – The services offered are *24*7 and support to stream the body parameters of patients* from remote locations through their personal devices using mobile and desktop apps via Wi-Fi connections, to doctors. This *protect the patients from any new infections* (Say for example, by contact tracing, alerting the proximity of infected patients near their locations) and to *provide quality and uninterrupted care to all who need these, including patients with acute diseases, children and elderly population. The supervision and feedback system from doctors are offered* through various modes like the video/web conferencing.

b. **Ubiquitous Health Care Services -** The ubiquitous availability of *personalized* medical services is made obtainable due to the intelligent computing systems that acclimatize to the user, and whose interfaces to the wearable devices or Internet of Medical/Health Things, *allow the user to make inborn use of the system, fitting in mobile devices, newly enhanced, more prevailing, and less controlled versions of medical sensors and equipment.*

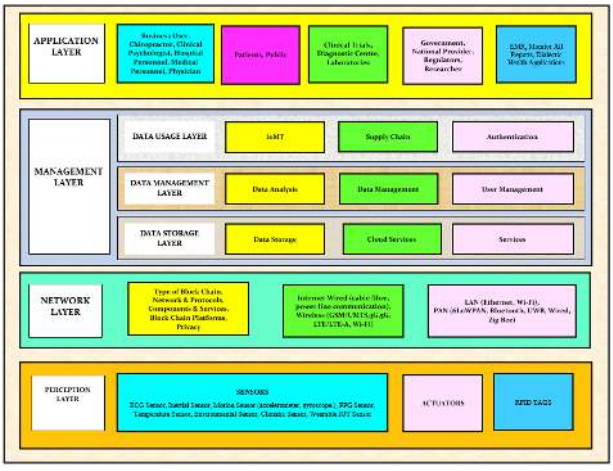

FIGURE 3. Layered Architecture of Block Chain based Internet of Medical Things for Health Care Services (BC IoMT U^6 HCS)

The Layered architecture of **BC IoMT U^6 HCS** is composed of four layers as shown in figure 3.

c. **User-Friendly Health Care Services -**User-Friendly Health Care Services and applications (synonymously apps) are made *for Early Disease Detection System, baby siting and caring System, Lifestyle Monitoring System, Position Tracking and Fall Exposure System, Restoration/Quality of Life (QoL) Enhancement System (for recovering patients, geriatric and debilitated population),Smart Device Based Assisting Health Care Systems and Vital Signs (Blood Pressure, Body Temperature, Oxygen Saturation) Monitoring System.*

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d. **Unflappable Mental Health Care Services -** This is offered by psychiatrist, psychologist or other mental health profession or stress management profession to : (i) Elderly persons *mental health communal teams which offer valuation and treatment, convalescence and case management services*;(ii) Provide aid to other aged care service providers and *tutoring for consumers, families and carers*;(iii)Elderly Persons Mental Health *initiatives for people whose mental illness cannot go into the mainstream aged care residential services*;(iv)*Severe in-patient services, (short-term management and mental health treatment) during a severe phase of mental illness* and ;(v) *Stress management services and activities for all age groups.*

e. **Unblemished Health Care Services -** Takes care of *privacy, security, confidentiality, integrity* concerns and worries of unwanted attacks to health data records as all the Health Care records are on a distributed ledger, which safeguards them from many attacks like ransomware attacks. Block Chain technology for IoMT systems offers an *unblemished safety via data access management, support for smart contracts, trust less consensus, tamper-proof video recording, and transparency.* All the transaction/information, real-time, between relevant parties are affected in a secure and immutable fashion.

f. Unlimited Health Care services – Many Unlimited IoMT Health Care Services are offered like *Ambient Assisted Living Service* (prolong life that is simple, comfortable, independent and easy);*Community Health Care Service* (offer a platform involving local community, caregivers, physicians and hospital);*Embedded Gateway Configuration Service* (integrates the nodes of patient to the internet and to the therapeutic equipment's);*Indirect Health Care Service* (provides indirect Health Care data like road traffic, climatic condition and prediction, approachability and means of transport, exigency and accident warnings);*Medication Management Service* (to combat Dissenting medication problems like antagonistic drug reaction or adverse reaction);*Semantic Medical Access Service* (platform to collect and used data from using declarative programming techniques like ontology);*Wearable Device Access Service* (non-invasive wireless sensors).

A. PERCEPTION LAYER

Perception layer has sensors, actuators and tags. Perception layer is in complete authority for data procurement through the equipment's that are used for detection and measuring. The layer is not used to procure information, it is also used to convey proper reaction by actors.

Sensor (s) - Sensors can be self-tracking devices and solutions. Sensor(s)uses a process for detecting and signaling the activities, by the appropriate sensors(shown in Table 4), each made up of an electronic circuit having an indicator and an optical signal activator, in which the one or more sensors are joined to the frame; a power source electrically connected to the one or more sensors; and an pressure signal electrically linked to the photosensitive signal trigger, and its use in providing an intelligent alert module. The collected data is streamed. Connection is achieved either by wire or wirelessly sensor. The quantified devices/sensors can be habiliment electronics and/or multi-sensor platforms home appliances as part of IoMT.

TABLE IV.
SENSORS

Sensor(s) type	Sensor(s)
Standard sensors	• ECG/EKG Sensor – Electro Cardio Graphy – records the movement of the heart • EEG Sensor - Electro Encephalo Graphy is used to record the electrical activity from the scalp • EMG Sensor - Electro Myo Graphy is used to quantity the electrical activity of muscles • GSR sensor - Galvanic Skin Response is used to measure the skin conductivity • PPG Sensor -Photo Plethysmo Graphy is used to measure blood flow volume • Motion Sensor (accelerometer, gyroscope) • Climatic Sensor • Environmental Sensor • heart rate sensor is used to calculate the heart rate variability • heart rate variability sensor • Inertial Sensor • Temperature Sensor • Wearable IOT Sensor.
Enumerated tracking devices and applications	• BodyMedia • Emotiv brain-computer interfaces (BCI). • Fitbit • Luminosity's Brain Trainer • MapMyRun • MoodPanda • myZeo • NeuroSky • Nike Fuelband • RunKeeper • The Eatery
Wearable products and low-cost disposable coverings	• smartwatches • wearable sensor patches • wristband sensors
products with sensors	• artificial reality-augmented glasses • brain computer interfaces • environmental monitoring and • home automation sensors • smartphone applications • smartwatches • wearable body metric textiles • wearable sensor patches • wristband sensors
sensor OS	• Tiny.os • Contiki

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The future drift is from single- sensor platforms to multi-sensor platforms (multiple sensing elements).

Actuators - A *prompter/Actuator* (a hardware component) works on the physical environment and the electrical signal from the connected device is transformed to activate a physical action, like turn on or off the alarm. The Actuator is configured using software. Actuators, act on the direct environment to permit right operation of the machines or devices. The actuators can be four main classes based on their structural pattern and the role they play in a exact IoT environment-(i) *Linear actuators* (permit motion of objects or elements in a straight line),(ii) *Motors* (permit precise gyratory movements of device components or whole objects),(iii) *Relays* (electromagnet-based actuators to activate power switches in lamps, heaters),(iv) *Solenoids* – (for locking or triggering mechanisms in home appliances).

Radio Frequency Identification (RFID) is a radio object detection technology utilizing the radio frequency technology indications for very short-range communique. Radio-frequency identification (RFID) sensors/Tags - have unique identifiers and are be armed with a variety of sensing capabilities. RFID tags are also used to send signals. RFID communications is affected between two entities- RFID reader (reading device) and RFID tag . The RFID tags can be of two types - active reading tags (driven by power, costly, utilize high-frequency bands) and passive reading tags (work on lower frequencies, lack core power source).

TABLE 5.
USE OF RFID TAGS

TYPE OF RFID	USE
IoMT-based RFID tags	manage drug availability problems and supply cost
tags on medication packet	aid the manufacturers to ensure supply chain quality(edible IoT "smart" pills, developed by WuXi PharmaTech and TruTag Technologies)
passive RFID tag	ambient monitoring of patients' environment
RFID tag	delicate temperature monitoring for storing drugs
Autonomous RFID tags	body area healthcare systems

B. NETWORK LAYER

The network layer is made up of

- any type of Block Chain,
- Block Chain Platforms,
- Components & Services,
- Internet Wired (cable fibre, power line communication),
- LAN (Ethernet, Wi-Fi),
- Network & Protocols,
- PAN (6LoWPAN, Bluetooth, UWB, Wired, Zig Bee).
- Wireless (GSM/UMTS,3G,5G, LTE/LTE-A, Wi-Fi),

All the communications and the related data go through Block Chain (see Figure 4), to form an immutable and traceable record of connections. This method is valuable in trade and rent set-ups to get reliability and security. It records all the exchanges.

The Block Chain (see Figure 5), also controls all the dealings between service and Cloud providers. This will grant access to the patient data collected through sensors, actuators and tags. *Gateways* are publishers and they create all the data linked to a patient. The Publishers state the access control levels and permissions (read/write/modify) in the Cloud (using smart contracts). *Authorities* are subscribers who are able to access the data generated by the publishers in the Cloud.

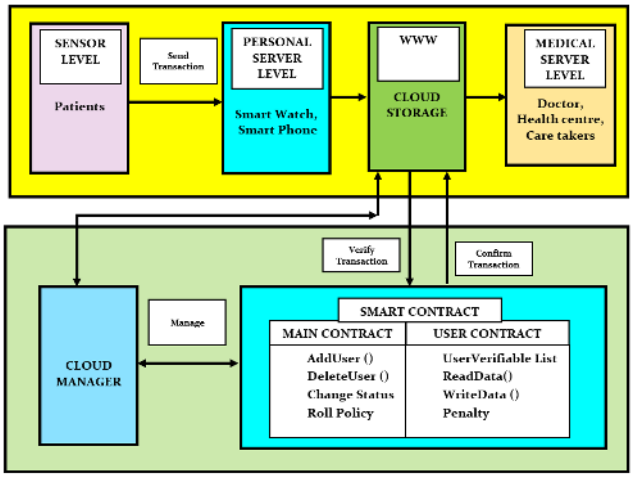

FIGURE 4. Block Chain based Internet of Medical Things for Health Care Services (BC IoMT U⁶ HCS)

Ethereum is open sourced, distributed, blockchain-based framework for evolving applications. Applications run on each node, and each state transition produced by them is validated and recorded by the blockchain. Ethereum Virtual Machine (EVM), is used to create applications. Ethereum platform (Permissioned/permission-less) works on has Customizable Consensus, is used to generate the medical formats, rules and state transition functions for medical transaction. Ethereum 's smart contract platform is preferred due to the degree of standardization and easier and less risky provision it offers. Solidity, is the smart contract programming language, to achieve the standardization and it eases the setting up contracts. In Smart contracts two or more separate parties enter into an agreement through digital contracts.

Block Chain Based Internet of Medical Things offers the users a six-pronged strategy by an uninterrupted, ubiquitous, user-friendly, unflappable, unblemished, unlimited Health Care services.

Steps involved in the functioning of Block Chain

Step 1. Demand Contract
Step 2. Create a block (represents transaction)
Step 3. Create a Block Chain

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Step 4. Send Chunk to every node in the network
Step 5. Authenticate the contract by the node
Step 6. Collect (Nodes) an incentive for the proof of work
Step 7. Add block to the existing chain
Step 8. Complete Transaction

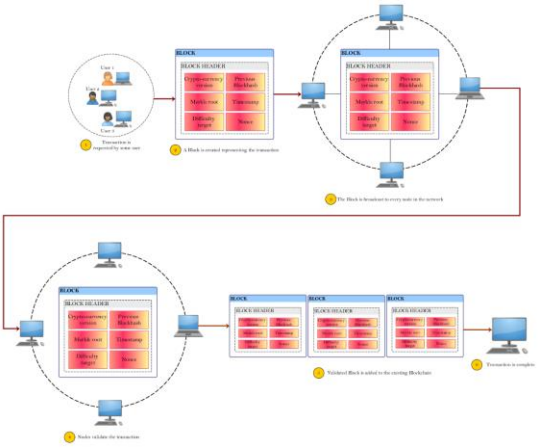

FIGURE 5. Working of IoMT Block Chain

C. MANAGEMENT LAYER

The management layer is subdivided into

- **data usage layer** (IoMT, supply chain and authentication),
- **data management layer** (data analysis, data management, user management) and
- **data storage layer** (data storage, Cloud services).

Security and privacy are like two sides of coin and they are critical. Data created is stored on blocks or on the Cloud storage. The *Cloud provider layer* will take care of all the processing and storage capacities in the Cloud.

Health Care data management in Block Chain

Step 1. Generate primary data upon interaction with Patient by the doctors, and specialists
Step 2. Produce a record with the primary data collected in the initial step.
Step 3. Include prescription and treatment information from doctors, and pharmacy
Step 4. Make the Individual patient owner of the sensitive record.
Step 5. Customize access control to the owner
Step 6. Request permission to view record
Step 7. Forward request to owner
Step 8. Request received by the owner
Step 9. Decide if permission can be given or not
Step 10. Authorize Health Care providers
Step 11. Permission granted to Health Care providers
Step 12. Get access (End user like Health Care providers-informal clinic, public Health Care center, hospitals)

In the management layer, we endorse the working of the secure and integrity preserved storage. The generic Secure Privacy Conserving Provable Data Possession (SPC-PDP) framework [48], is used as an additional layer for ensuring the data integrity. The generic PDP mechanism has four main phases – setup, challenge, proof, and verification.

D. APPLICATION LAYER

The application layer consists of Business User, Chiropractor, Clinical Psychologist, Hospital Personnel, Medical Personnel, Physician, Patients, Public. It also includes Clinical Trials, Diagnostic Centre, Laboratories. The Government, National Provider, Regulators, Researcher are all placed in this layer. The EMR, Monitor All Reports, Dialectic Health Applications all are laid in this layer.There are *several Private Block Chain* at the patient level. The main node in the Block Chain is an influential computer (*Public Block chain*) that will be the gateway to other higher layer Block Chains. The end user are the Health Care providers who will be permitted to access the patient records only upon the grant of consent from the data owner; this is for legitimate rights.

Algorithm to Fetch Health Care data from a data base

Step 1.	Search for file
Step 2.	Fetch File
Step 3.	Load File
Step 4.	Read File
Step 5.	Completed reading file
Step 6.	Close file

Algorithm to add block into Block Chain by the medical doctor

Input : Name of the patient
Output : Block added to Block Chain

Assign block (patient p)
Chain the Blocks
Subscribe for Identity (identity)
Read loaded file (p.Patient)
Generate Block (read, timestamp, identity)
Check the formed Block
Transmit the Block
Check for approval
Condition for approval is satisfactory

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Approve Sanction
Check if block is in similar chain
If yes,
Add Block in chain
Show Status of Block
Successful
else
Add Block in Fork
Block added successfully as a fork into the chain
Condition for approval is not satisfactory
Discard Block
Update Block chain
Display status of Block chain

Every block includes data of the patient, originating time of the block, and the block creator information. Based on the amount of mining data, the block is endorsed. Reward is given to the initial miner who solves the mathematical riddle, and broadcasts the created block to all peers in the network, gets the reward. Upon acceptance of the new block by a greater number of peers, it gets inserted into the chain. The block gets forked and is orphaned in the chain if it is not matching with the previous block. After the block gets added to the chain, it cannot be detached or changed without disturbing adjacent blocks. This aids in viewing the Patients past in a very authentic innocent manner, deprived of any anxiety of getting tampered.

X. IMPLEMENTATION

Connected medical devices that are less intrusive and more comfortable to use like wearables, collects data on environment, nutrition, and other body vitals and streams it.

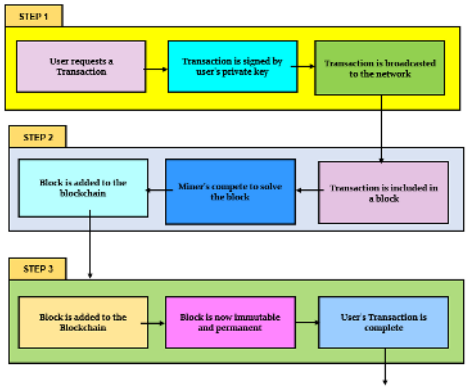

FIGURE 6. Steps for Block Chaining

This if need be, is combined with clinical data (medical procedures or laboratory tests), and the physicians are able to get a holistic picture of the patient's health to make more informed diagnostic or treatment decisions. Post treatment the patients are continually monitored.

XI. RESULT AND ANALYSIS

Section 11 discusses the observed result and analysis. In this section, the proposed BC IoMT U^6 HCS Framework are practically validated to achieve the results.

Results related to Layered Architecture demonstrate the advantages of, "BC IoMT U^6 HCS," over the existing framework. Finally, in this paper the main results observed and the conclusions drawn from the experiments are reported.

Figure 7, shows the efficiency obtained by the BC IoMT U^6 HCS framework, in contrast with the conservative frameworks. With increase in the quantity of files, the reliability is more or less obstinate in both the earlier and proposed frameworks.

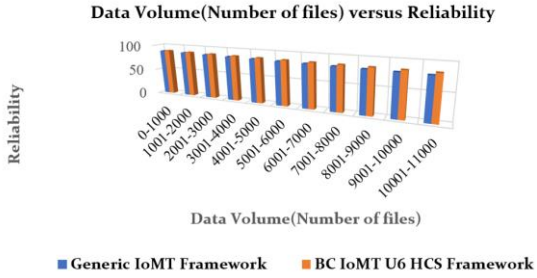

FIGURE 7. Data Volume versus Reliability

Figure 8, shows the efficiency obtained by the BC IoMT U^6 HCS framework, in contrast with the conservative frameworks. With increase in the quantity of records, the efficiency appears to be more or less persistent in both the earlier and proposed ones.

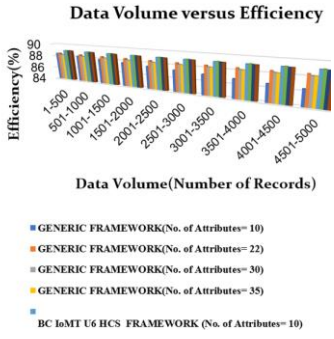

FIGURE 8. Data Volume (Number of Records) versus Efficiency

The size of attributes in a record is kept a persistent and the number of records is progressively enlarged to meter the competence of the framework. It is observed that rise in the amount of records the BC IoMT U^6 HCS framework are competent and adeptly attains secure auditing, privacy, integrity and surpasses the erstwhile Generic IoMT framework.

Figure 9, shows the efficiency obtained by the BC IoMT U^6 HCS framework in contrast with the conservative frameworks. Even with rise in the quantity of attributes;

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efficiency is more or less same in both the existing and proposed frameworks. Keeping the amount of records a constant; increasing the number of attributes the efficiency of the framework is measured. It is observed that as we increase the number of attributes the BC IoMT U^6 HCS framework more competently and capably achieves secure auditing, privacy, integrity and excels the former Generic IoMT framework.

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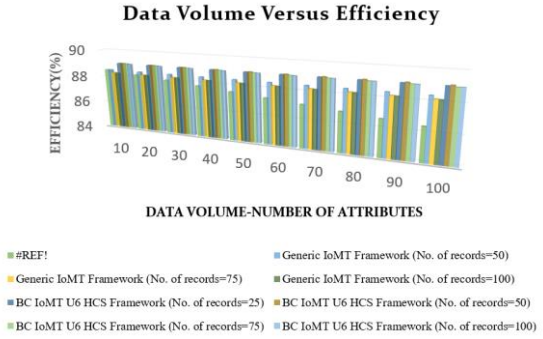

FIGURE 9. Attributes vs Efficiency

The time taken to run rises with an increase in data volume and is more or less same for both the frameworks - BC IoMT U^6 HCS framework, Generic IoMT framework. The amount of time taken to recover the user data-running time, is just very few seconds. After the execution of the project, the time consumed by the challenge and response is calculated. It is noted that with increase in file size, time spent also upsurges. Time duration of diverse file sizes fluctuates only in few milli seconds and this is very negligible for the user /verifier to cannot observe the alteration in challenge and reply.

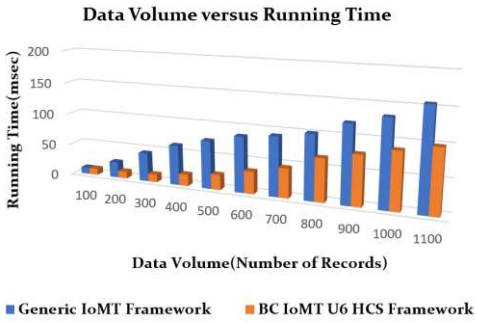

FIGURE 10. Data Volume versus Running Time

Figure 10, shows the efficiency obtained by the BC IoMT U^6 HCS framework, in comparison with the conventional layered architecture. With an increase in the size of files, the reliability appears to be more or less obstinate in both the previous and proposed layered architecture.

XII. CONCLUSIONS

Section 12 highlights the main conclusions. The fusion of the IoMT, Cloud Storage with Block Chain technologies not only offers benefits like reduced cost, speed, automation, immutability, near-impossible loss of data, permanence, removal of intermediaries, decentralization of consensus, but also overcomes most of the issues especially the security issues of through the use of latest encryptions. The fusion has no doubt made possible, the effective deployment Internet of Medical Things (IoMT), demands for more *individualized, patient-centric care IoMT* that augments affordability (cost effective care, reduced operational costs) ,simplicity and easy to use, improved life quality, life more comfortable, convenient, healthier and longer lives, provide proactive approach to preserving good health, cater to remote medical support care, continuous monitoring, allow patients to direct health information data to doctors ,augments precise disease identifications, management of diseases is real-time, maximum diseases management and inhibition, decrease in errors, improve and accelerate clinician workflows, improvisation in care for patient , easy management of patients records by doctors, keep personal health records, energy efficiency, manage drugs, outcome of patient, user end experience, empowers extreme connectivity due to better automation and perceptions in the DNA of IoMT functions. The main contributions of this paper are full analysis including the challenges of the present-day IoMT, Block Chain, Cloud storage data schemes in the domain of health care; design and develop a novel BC IoMT U^6 HCS (Block Chain based Internet of Medical Things for Uninterrupted, Ubiquitous, User-friendly, Unflappable, Unblemished, Unlimited Health Care Services) layered architecture, which, will also support the vital functions essential for public auditing.
The results from the Layered Architecture has validated and has proved to be competent in achieving safe auditing and surpass the former ones in privacy, reliability and integrity.
To sum up this paper provides a panoramic view on the present position of current research, and imminent directions of Block Chain Based Internet of Medical Things.

XIII. FUTURE WORK

The consensus algorithm has the following constraints that does not allow its adaptation and utilization in many of the existing IoMT- frameworks. Future research work can be undertaken in along the following lines like (i) The time taken endorse the blocks is non-compliant with IoMT-QoS; (ii)The high computational resources, are needed for the consensus algorithms which cannot be afforded by the IoMT; (iii) Sharing of cryptographic key in a dispersed WBAN is yet to be resolved;(iv) threats arising due to identity-based network layer is yet to be resolved.

The research gaps that are to be resolved are identified briefly as (i) escalating initial expenditure in adopting the new technology; (ii)*Research Gaps in Philosophy* – the global community, has to adopt to the purchase of the technology; (iii) *Research Gaps in Energy*- Block Chain for sustaining its operations uses a network of nodes, and ensuing extensive computing power; (iv) *Research Gaps in*

Integration – at inception be co-existent with present technologies, and later get integrated overtime; and (v) *Research Gaps in Regulation* – authorities to regularise and settle down the issues of regulatory over Block Chain technology.

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