



Medical laboratories and IoT (internet of things)

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Abstract: Medical laboratories with IoT (internet of things) connections through machines and sensors make the way with restoring of balanced work-life. IoT devices collect the data through the physical world and formed the data availability in the laboratory cloud. The connectivity is properly exploited through different tasks and performed continual monitoring over it. The laboratory environment and data collection processes are performed through the smart environment, robotics, online doctors, remote results, and cloud storage. The laboratory devices are connected properly for the workflows performed in a streamlined manner. The assurance is provided to the equipment and all processes that run smoothly with adherence to the regulatory guidelines. In the proposed research work, the IoT involvement is highlighted properly that are linked through the medical laboratories throughout the world with cloud-stored health information. The customer's samples are collected in the laboratory system through advanced IoT technology means and results are uploaded also over the websites through which customers get the results by the personal log-in process. The brief clarification is explained out that are related to the medical laboratories function over IoT world with different proposed plans.

Keywords— *IoT, Sensors, Smart Healthcare, Physical Health, Laboratories, Medical Things*

I. INTRODUCTION

IoT technology is used in hospital medical laboratories to track the supplies, equipment, and people properly to improve the work function through an advanced term [9]. The congestion and delays are reduced that monitor the equipment conditions with the reduction in the replacement of devices [4]. The applications related to IoT increase the productivity of medical laboratories that reduce the wastage of resources and other time.

IoT can monitor continuously and reliably especially in the COVID-19 hard situations when a patient required quick results. The customer's samples are collected in the laboratory system through advanced IoT technology means and results are uploaded also over the websites through which customers get the results by the personal log-in process. Better personalization is provided over the medical laboratories that have IoT-enabled devices for the process of digital storage. Medical laboratories with IoT (internet of things) connections through machines and sensors that make the way with restoring of balanced work-life [7]. IoT devices collect the data through the physical world and formed the data availability in the laboratory Cloud. The personal information of the patients is connected properly to the databases of the medical laboratories in an appropriate way.

Through logging over the website the management is performed that assess the detailed work to solve the problems properly. The tracking things are measures that affordably analyzed the essential parameters [8]. The quality processes allowed the clinical laboratories with error-free goals to manage the medical work. The detailed focus is provided by tracking the location of the medical laboratories with essential steps for higher levels in quality terms.

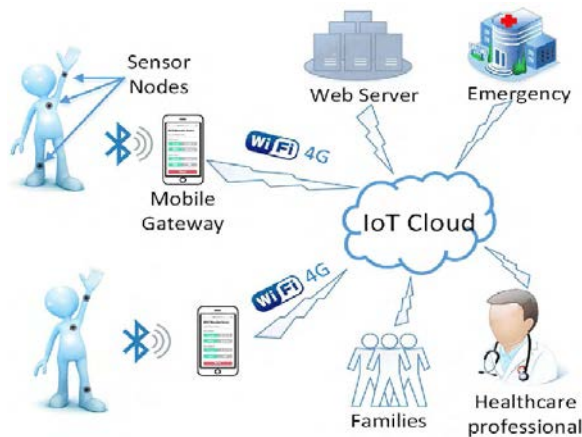


Figure 1: IoT Cloud in Medical Laboratories

II. LITERATURE REVIEW

According to [3], the healthcare solutions are analyzed that are used in medical laboratories by using IoT technology. The sensors, smartphones, cloud storage proved that the control is managed properly with the advanced embedded system. The patients provided detailed samples of their test and after that, through the advanced technology of IoT, the training is managed over it. Different types of software and hardware developed useful services in healthcare gadgets. The policy support is necessary to be applied over the medical laboratories enablers related to the IoT technologies [9]. The web-based and software-related programs are required to be delivered with different types of health services. Different processes are used over the developing concerns for the IoT infrastructure and implementation is given out in the medical laboratories.

In the research work of [4], the technology of IoT over the medical laboratories are mainly accessible that are easy for usage. Consumers and other health-related professionals provide greater access to all of the digital resources that are ever being used over it properly. IoT in the medical laboratories makes the individual support that is accessible for the technology and individuals can support the access properly with reliable hardware and internet services. The customers' samples are collected in the laboratory system through advanced IoT technology means and results are uploaded also over the websites over which customers get the results by personal log-in process [2]. Similarly, the individual's used the laboratory functions in a user-friendly manner and experience the connections that did not feel initiative over the consultation among

health professionals and patients about the laboratory reports. In this way, the results produced by the medical laboratory reduce the frustration and reluctance to all services related to the customers provided appropriately[8].

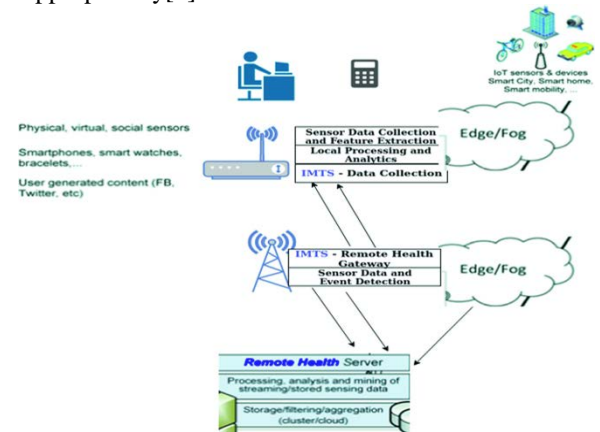


Figure 2: Medical laboratories workflow system

Research work explained the IoT cybersecurity that is mainly focused on the resilient and robust market for the adoption of different matters. Privacy must be maintained that ensured to prevent the unauthorized tracking and identification of medical laboratories reports. From the perspective of IoT involvement, a higher level of intelligence and autonomy is provided with all devices that are connected over the system. The protection and privacy must be ensured that identifies with different terms and means for challenges avoided processes [3]. The gap is absorbed in the paper related to the acceptability and the confidence for the data safety process in cloud-stored data related to medical laboratories.

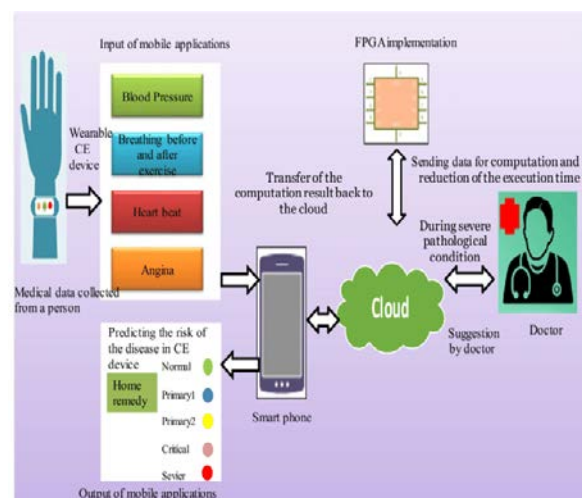


Figure 3: Cloud Implementation with Doctor Link

Over the advanced research work of [9], the adoption of IoT makes the societal perspective over the medical laboratories and manages the processes properly. The health care professionals deliver the perceived value through which the infrastructure of the hospital is engaged with advanced IoT terms. The acceptability and confidence related to IoT technology provide a diverse range of factors over medical laboratories that have the technology-supported program include compatibility, accuracy, ease of use, and usual systems.

Due to IoT involvement in medical laboratories the professional security impact on the external factors, reimbursement, and professional interaction [7]. The opportunities are allowed to be followed and the personal information of customers in medical laboratories is collected to save from attacks. The IoT technology faced two main issues related to cyber-attacks for reasons such as wireless communication, eavesdropping, and components used over the fewer energy concerns [10]. It is hard to implement the security means that ensure the complex scheme for guide and management of data security. The cloud data is stored in a centralized manner and considered to be managed with all user's requests. The confidentiality of the data sharing over medical laboratories is evaluated properly.

III. STUDY OF EXISTING SYSTEM

IoT has consisted of different physical objects that are connected through sensors, electronics, and software through the connectivity terms. It enabled properly to achieve the service and greater value through data exchanging processes by connected devices [3]. The things are identifiable and embedded through the computing system and interoperate through existing infrastructure.

The clinical lab provides the automation over the processes and manual work is removed completely. It is difficult to track the processes and determine the SOPs that are followed properly. The deployed and well-designed processes are managed with an IoT system and errors are discovered quickly with fixed terms. High-quality levels are lead dramatically with driving processes and reduced the risk of the error that threatens the safety of the patient [9]. IoT allowed clinical laboratories quality test results by pre-analytical processes.

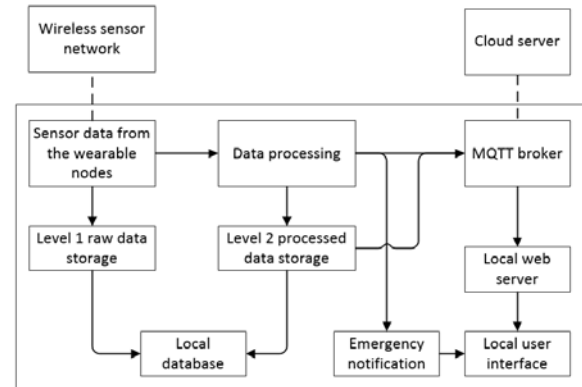


Figure 4: Data Flow for Storage Process

The sample testing is performed through the collection, identification, and labeling of the issues. Transportation is avoided during the IoT addressing that has a significant area with different terms and conditions [10]. The real-time data make the location and quality over the management processes and transit it properly. The test samples in the medical laboratories are managed with the correct defects over real-time and compromised of capability management.

A. Tests tracking:

The hospital management, patients, and nurses track the test available in the medical laboratories properly for the management processes [10]. The lab kits and techniques are linked with advancement for the management and stored, stashed, misplaced through different locations. The tests are tagged, located, and tracked easily for all hidden and misplaced items. In the overall results, the usage makes the wastage of reduction over the under-utilization tests. The full availability is given out to the hard access and the expenditures are managed with the money and on latter properly.

B. Queue reduction and data recording automation:

The equipment is tracked properly which is difficult to be managed for mobile work and too hard for tracking processes. IoT can help out to make the centrifuge for the limited intra-lab bickering. The data recording is managed through automation and manual recording is avoided completely with the medical set-up. The information is lost in the old system over with the nurses and patients faced difficulties over the hospital management [5]. The information is lost with the outgoing concern and transfers the sorted data for which the person leaves the lab. The experiment is performed to check the characteristics and quality of all medical laboratory equipment and can be excruciating for all data [3].

Through automation, the data is recorded over the clear things and managed with all processes appropriately.

C. Restocking supplies automation:

The workflow related to medical laboratories is managed properly with the supplies and hampered over the investigation that is forced for an experiment. The lab managers and the hospital staff is required to managed all tracking related to an inventory in an appropriate way. By checking out an inventory through an inefficient, tedious, and inaccurate process is the main process that is removed for improved results. Through an IoT, inventory tracking is applied over the things that are altered and the running process becomes fast to manage the supplies properly. The stock management becomes automated and extra supply from the neighbored labs can be borrowed properly. The digital records help out to managed the tracks and borrowed with the required terms and conditions applied over it.

D. Predictive maintenance of Lab machines:

Same as in the hospitals, the labs depend on the equipment that is required for regular maintenance. The costly and inefficient ways are servicing through the autoclaves and over the same way management is performed through it [6]. Most of the machines are used heavily and required frequent way of maintenance with less required attention. Through the analysis process over the usage through IoT, the frequently used equipment's are scheduled properly with all services in proactively linked manner work in an unexpected way [2]. IoT helps out to identify the way used with equipment and provide the conventional monitoring for the noticed way until the variant breakdown occurred. Through IoT, the temperature sensors are connected with cell incubators for a continuous data analysis process. The overall data trend illustrates that has machine learning schedules in the repair manner preemptively.

E. Moving forward (Robotics):

The application of IoT over the medical labs includes the traffic flow that analyzes the robots to increase the usage with congestion processes in a reduced manner. Due to mobility the congestion is reduced and increases the space of the robots over an appropriate way. In overall terms, there are many successful applications related to IoT in the setting of medical laboratories and can be repurposed for increased efficiency and productivity [7].

IV. PROPOSED RESEARCH

A. Need of the study:

The reliable information system of the digital world makes the main contest over the medical field through the COVID-19 situation that is understood through IoT. The benefits of medical laboratories through an IoT involvement make the critical applications for higher requirements work efficiently. The issues are extended with the capability that provides innovative information during the days of COVID-19.

B. IoT implementation in medical laboratories during Covid-19:

In the implementation of IoT, the medical field makes fine outcomes with the comfort of inventive technologies. The new reality is analyzed in the COVID-19 days with the best services based on reality and performed the precise way with surgery [5]. The complicated cases are handled easily that are controlled digitally with ongoing conditions of the pandemic. IoT provides support for patients, surgeons, and doctors with different identified steps over an excellent support implementation.

The sensors are used properly to capture and sense the information or data related to the patient's diseases and health issues with received processes. Hereby, all of the linked physical objects are linked with an internet network and devices are displayed continuously for proper monitoring purposes. The medical information is provided with specified requirements and all doctors and patients are covered in it.

C. Technologies of IoT for the medical laboratories in COVID-19:

IoT devices are connected through the medical devices, machines, and tools that create the intelligent information system with individual COVID-19 requirements of the patient. The upcoming diseases are analyzed properly with knowledge analysis in different interdisciplinary ways. The vital patient data are determined with relevant information and deliberates the technologies through IoT obliging medical laboratories through COVID-19. The expertise are captured and stored with personalized solutions in the digital data analysis process [3]. All clinical work is maintained properly in a digital manner through the help of patient data, internet facilities that are shared through emergencies and doctors performed the jobs efficiently.

Through smart sensors, the capability is monitored that control the essential requirements through medical sugar level check, temperature, blood pressure, and data related to COVID-19 health patients. Software is interlinked with the greatest method of communication processes through strong monitoring processes. All types of archives are kept privately through greatest management ways in future related terms [8].

Artificial intelligence is involved that enhances the performance of surgeons and doctors for the achievement of efficiency, accuracy, and different terms of reliability over the treatment. After applying different technologies concerns that reduce the pain of the patients through quick identification by proper medication [6]. Different types of actuators have been introduced that control the physical objects and motion with virtual reality over the best technology of IoT. The planning is introduced that improves the real-time information in the medical laboratories. This creates a positive impact on healthcare through millions of people that improved their lives.

The diseases that occurred in the patient related to COVID-19 are detected and monitored properly through the medical laboratories. The customized attention is given out to the people that are linked with the beneficial work appropriately. All of the technologies are reminded with the blood pressure, disease conditions, and COVID-19 information [10].

Table 1: Different IoT technologies evaluation over international medical laboratories

Over the field of medical, innovations have occurred for the best techniques that track the staff and patient's work to reduce the waiting time. Several devices are introduced that make the patients completely comfortable and analyzers provide an development with inpatient care.

IoT is pertinent to become the structure for different applications and make the medical equipment's over the connected imaging, patient monitoring, clinical processes, and laboratory tests with suppository management for COVID-19. IoT

helps out all doctors and health-related specialists for the superlative patient treatments and formed the centralized information system over a medical laboratory [6]. The actions are kept digitally through the records analytics for problem-solving processes in COVID-19. The technology is monitored easily through the health of the patient and makes an accurate decision over the complete processes.

V. CRITICAL EVALUATION

Over the medical laboratories, the IoT brings essential changes through an improved facility during the COVID-19 days such as

- The digital system is improved through the management and medical processes in the hospitals and new applications through which the devices of laboratories are associated to an internet.
- The inter-connected devices are presented for tracking the medicines and all tests performed related to COVID-19 patients.
- It can monitor continuously and reliably especially in the COVID-19 hard situations when a patient required quick results.
- The customer's samples are collected in the laboratory system through advanced IoT technology means and results are uploaded also over the websites over which customers get the results by personal log-in processes performed in a significant manner.
- Through right patient information, the data storage through paperwork is reduced and over Cloud, all information is stored properly.
- The problems are controlled properly and chances of issues are reduced completely related to the medical devices.
- In the critical emergency tests of COVID-19 patients, the losses are minimized and fast adoption is performed over a medical field.

Serial no	Functions	Medical laboratories names	Description
1.	Remote results formation of reports.	MedAsk Lab Collection Center	24 hours services
		The Biogene Lab	24 hours services
		Kazimi International Laboratory	24 hours services
		Khaleej Diagnostic Center	12 hours services
2.	Doctors linked on reports result.	Vivify	24 hours services
		Kazimi International Laboratory	24 hours services
		Propeller Health	12 hours services
3.	Cloud storage IoT system	Omada	24 hours services
		DexComn	24 hours services
		Vivify	24 hours services
		MedAsk Lab Collection Center	24 hours services
		AliveCor	24 hours services
4.	Robotics	Excel Labs	24 hours services
		Propeller Health	12 hours services

VI. CONCLUSION

IoT technology become the best option in healthcare field such as medical laboratories for better managing of chronic disease, better patient care reports, medical emergencies reports, fitness, blood pressure monitoring results and health check system with advance control processes. It can monitor continuously and reliably especially in the COVID-19 hard situations when patient required quick results.

The customer's samples are collected in the laboratory system through advanced IoT technology means and results are uploaded also over the websites over which customers get the results by the personal log-in process. Better personalization is provided over the medical laboratories that have IoT-enabled

devices for the process of digital storage. The personal information of the patients is connected properly to the databases of the medical laboratories in an appropriate way. IoT technology completely helps out to minimize manual working and errors are reduced with online results generation through an informed decision.

Due to the involvement of this technology, the medical laboratories become smarter and more efficient during the hard days through smarter networks communications. Medical laboratories with IoT (internet of things) connections through machines and sensors that make the way with restoring of balanced work-life. IoT devices collect the data through the physical world and formed the data availability in the laboratory Cloud. Thus, the technologies extend the communication and immediate information process for improve test reports of the patients with better treatment creations.

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