Project Summary :

There is a huge gap between Medical Colleges and Technological Universities in India for which we cannot take advantage of technological advancement. Moreover, it has several drawbacks in Hospitals, Medical Colleges and Technological Universities. Therefore, there are several questions regarding the Medical Colleges, Hospitals, and Technological Universities, which are outlined below- Q1: Can we bridge the Medical Colleges, Hospitals, and Technological Universities gaps? Q2: Can we build a framework where the data are available for free for researchers, students, and practitioners? Q3: What are the barriers in interdisciplinary research? Q4: Can we enhance the existing Medical systems? To address the above raised four questions, we propose Edge Computing structured framework, called MedEdge. Our proposed framework aims to bridge the gap between Doctors, Patients, Pathologists, Nurse, Pharmacists, and Engineers. Moreover, this framework significantly boosts the research work of the Medical Colleges and Technological Universities. The project's vision is to bridge the medical Colleges, Hospitals, and Technical Universities gap to enable collaborative research and enhance the current state-of-the-art hospital system using the Edge Computing paradigm. The missions of the project are- • To bridge the gap among Doctors, Engineers, Radiologists, Nurses, Pharmacies, and Patients. • To enable collaborative research work between Doctors and Engineers. • To build a platform for interdisciplinary research work. • To investigate diverse issues and challenges in building Edge Computing for Medical Colleges and Technological Universities.

Objectives :

• To investigate diverse issues in collaborative and interdisciplinary research works.
• To model a framework to bridge the gap among Medical Colleges, Hospitals, Pathological Labs, and Technological Universities.
• To develop a framework to model the workflow for the Doctors, Engineers, Radiologists, Nurses, Pharmacies, and Patients.
• To investigate diverse cryptography and security issues and challenges in designing the proposed project.
• To develop a framework to minimize the time consumption of the Doctors, Radiologists, Nurses, Pharmacies, and Patients.
• To automate entire medical systems.
• To develop a product, called MedEdge.
• To publish papers in reputed journal, conferences and books.
• To file Indian/Australian patent.

Keywords :

Healthcare, Edge Computing, Cloud Computing, Internet of Things, Collaboration, Biomedical Engineering

Expected Output and Outcome of the proposal :

Outcomes of the project are outlined below- • A model for collaborative and interdisciplinary research works. • A framework to bridge the gap among Medical Colleges, Hospitals, Pathological Labs, and Technological Universities. • A platform for the workflow of the Doctors, Engineers, Radiologists, Nurses, Pharmacies, and Patients. • Solutions of diverse cryptography and security issues and challenges in designing the proposed project. • Enhancement of the time consumption of the Doctors, Radiologists, Nurses, Pharmacies, and Patients. • Enhanced Healthcare systems. • MedEdge API for web and Android applications. • Research papers in reputed journal, conferences and books. • Indian/Australian patent.

Suitability of the proposed work in major national initiatives of the Government:

Startup India, Digital India, Smart Cities

Theme of Proposed Work:

Health, Cyber Physical Systems including AI, IOT and Cyber Security

Other Technical Details

1. Origin of the proposal

(Scientific rationale for doing this work should be elaborated)

Edge Computing [1] is emerging in recent days, and it has to be applied in diverse areas, for instance, Biomedical Imaging. Moreover, it becomes more significant due to the emergence of IoT, for example, smartphones and the Internet of Medical Things. Edge Computing architecture can be realized in bridging the gap between Doctors, Patients, and Engineers. Technological advancement can change our lifestyle and leads to healthy and reliable life.

There is a huge gap between Medical Colleges and Technological Universities in India for which we cannot take advantage of technological advancement. Moreover, it has several drawbacks in Hospitals, Medical Colleges and Technological Universities. Therefore, there are several questions regarding the Medical Colleges, Hospitals, and Technological Universities, which are outlined below-

Q1: Can we bridge the Medical Colleges, Hospitals, and Technological Universities gaps?

Q2: Can we build a framework where the data are available for free for researchers, students, and practitioners?

Q3: What are the barriers in interdisciplinary research?

Q4: Can we enhance the existing Medical systems?

Question **Q1** indicates that there are huge gaps among the Medical colleges, Hospitals, and Technological universities. It demands a framework to bridge the gap among them. Moreover, there is no framework available to bridge these gaps. Question **Q2** highlights that it requires a framework where the medical data can be stored and download for educational purposes. Furthermore, Medical data are not available in India for research work, study, and practice purposes. Question **Q3** shows the limitation of interdisciplinary research in India. There is a lacking of collaborative research works between the Doctors and Engineers. Finally, Question **Q4** poses the time taken to diagnose and generating reports in India. It demands a framework to reduce the time consumption among the Doctor, Radiologist, Patients, Pharmacy, and Nurse.

To address the above raised four questions, we propose Edge Computing [1] structured framework, called MedEdge. Our proposed framework aims to bridge the gap between Doctors, Patients, Pathologists, Nurse, Pharmacists, and Engineers. Moreover, this framework significantly boosts the research work of the Medical Colleges and Technological Universities.

2. Review of status of Research and Development in the subject

2.1. International Status

(Researchers working in the area worldwide and their contributions must be properly highlighted with recent references and reviews. A correct and faithful description of the international research status must be given)

After the introduction of Edge Computing in 2009 [1], it becomes one of the most popular technologies that is derived from Cloud Computing. Edge Computing is composed of Cloud Servers, Edge Nodes, and Edge Devices. Cloud Computing suffers from network latency due to the distance of the server locations from the users. Many technologies are emerging; however, the Internet of Things (IoT) is the most prominent

technology dominating the entire world. Connected devices are continuously growing, and it is predicted to reach 25.44 billion in 2030 [2]. Moreover, there are 8.7 billion active IoT devices worldwide [3]. Most of the IoT devices are low-powered computing devices. For instance, wearable technology. On the contrary, the Internet of Medical Things can have high-powered computing devices along with low-powered devices. Therefore, Cloud Servers need to provide services to all the devices, including from high to low powered computing devices. Hence, latency becomes a significant barrier to the Cloud Computing paradigm. To this end, Satyanarayanan *et al.* [1] devices a method to reduce the latency for the IoT devices. Since then, Edge Computing has become one of the most popular Cloud Computing and IoT research community technologies.

Cloud servers can offload the data to the cloudlets (Edge Nodes). The Edge Nodes can be mobile or stationary cloudlet where it brings the data to the near to the clients. Thus, Edge Devices can easily download data from local Edge Nodes. Edge Nodes boost up the connectivity significantly by bringing data near to the clients. The latency is lowered dramatically due to the distance between the users and the Edge Nodes. Moreover, Edge Nodes can reduce loads of Cloud Servers dramatically.

Numerous researches have been carried out on Edge Computing for various purposes. For instance, Healthcare. Ma *et al.* [4] proposes a lightweight medical diagnosis systems using Edge Computing. The framework provides privacy-preserving medical diagnosis and enables machine learning on the diagnosis data. It also considers Homomorphic encryption, which is not feasible for IoT. Similarly, Abdellatif *et al.* [5] proposes a solution for Healthcare using Edge Computing and Blockchain, called MEdge-Chain. However, MEdge-chain depends on Blockchain; therefore, it inherits the disadvantages of Blockchain, for instance, energy consumption. MEdge-Chain features data exchange and automated patient monitoring based on peer-to-peer architecture. As we know, the Merkle tree of Blockchain is very complex to construct and create unnecessary network traffic [6]. Also, Li *et al.* [7] proposes a framework similar to our proposed project, called EdgeCare. It features mobile Healthcare and decentralized electronic medical record management. Researchers are putting efforts into decentralized and peer-to-peer healthcare systems using Edge Computing. It requires Blockchain technology. Blockchain technology unnecessarily wastes energy and computing resources. Moreover, it is few more disadvantage: a) Blockchain is not scalable, b) it cannot be backtracked, and c) it is not completely secure. Therefore, Blockchain in Healthcare has yet to mature. However, several similar works with our proposed system do not consider bridging the gaps among the Hospitals, Medical Colleges, and Universities. Moreover, a state-of-the-art healthcare system uses Blockchain, not a distributed computing, and thus, it cannot be deployed in real life.

2.2. National Status

(Same as above to cover the contribution of Indian Scientists in the project area)

Several researchers are working on Healthcare domains; namely, Healthcare [8], Edge Computing [9, 10], Securing Healthcare Data [11], and Machine Learning [12]. Singh and Chatterjee [11] demonstrates the security challenges in healthcare using Edge Computing. Similarly, Mukherjee *et al.* [10] demonstrates the task offloading for Edge Computing in Healthcare. Pustokhina *et al.* uses Deep Learning in Edge Computing for Healthcare. However, Kakkar and Farshori [8] presents similar work on Edge Computing and Healthcare; however, it concentrates on inventory management systems. Still, we have not found similar research work to our proposed project in the literature search.

2.3. Importance of the proposed project in the context of current status

(Highlight what is the new area or gap which will be solved in the project in relating to what is already known. This is a very important section to project the novelty content of the proposal)

MedEdge provides remarkable features which are outlined below-

- Bridge the gap among the Doctors, Engineers, Patients, Radiologists, Nurse, and Pharmacists.
- Provides data for research and education purposes to the researchers, scientists, students, and practitioners.
- It reduces the time taken among the Doctors, Patients, Radiologists, Nurses, and Pharmacists.

- It ameliorates the quality of Education in Medical Colleges and Technological Universities.
- It enables interdisciplinary research works.

2.4. If the project is location specific, basis for selection of location be highlighted

NA.

3. Work Plan

3.1. Methodology

(It should contain all the details of how each of the objectives will be addressed. This section must be detailed and have clear plans, not vague and generalized statements. It should have several schemes, tables, figures, equations etc. in addition to text, explanation and justification of why the project research plan will work)

Architecture

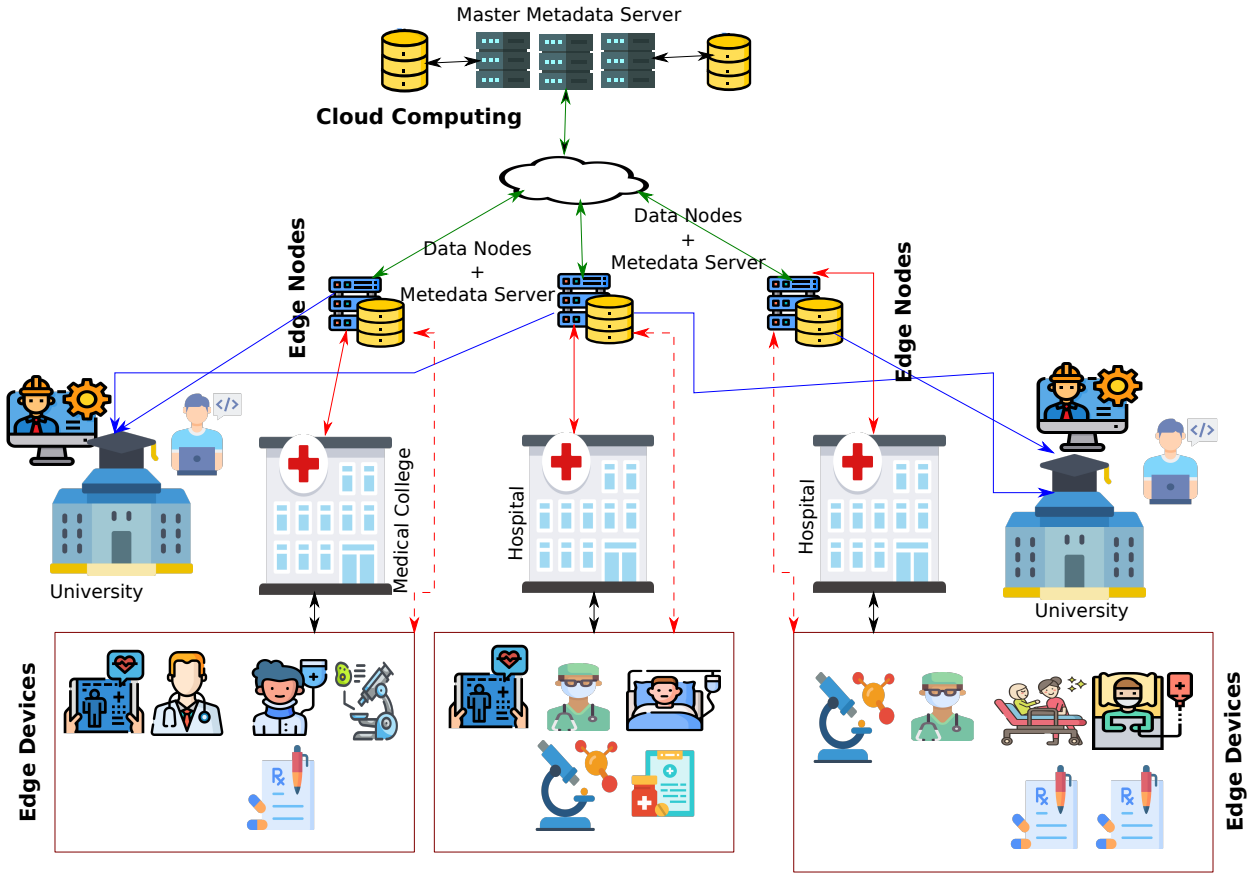

Figure 1: Edge Computing structured architecture of MedEdge.

Figure 1 demonstrates the Edge Computing structured framework for Doctors, Patients, and Engineers. Alternatively, it focuses on bridging the gap between Medical Colleges, Hospitals, and Technological Universities.

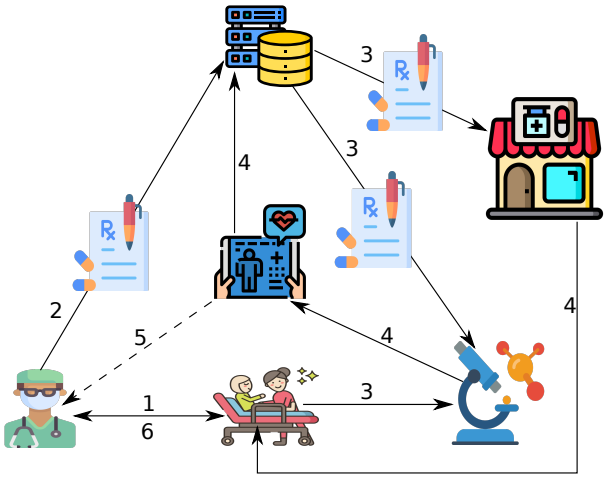

Figure 2: The workflow among the Doctors, Patients, Pathology and Pharmacy.

Cloud Server

Figure 1 demonstrates the Cloud Server as Metadata Server (MDS), and it does not store data itself. The metadata defines how to retrieve a stored data, where to store the data, available replications, etc., [13, 14, 15, 16]. However, Cloud Server is responsible for distributing metadata to all the Edge Nodes. When an Edge Node creates a data, the corresponding metadata has to sent to the Cloud Server. The Cloud Server distributes the metadata to the all Edge Nodes. Thus, all Edge Nodes know stores the universal of metadata.

Edge Nodes

The Edge Nodes store the data and metadata. The MDS at Edge Nodes are separate from the data nodes. The metadata stores the information of local as well as global metadata information. Data node store local data and replicated data. The Edge Nodes are installed at Technological Universities, Medical Colleges, and Hospitals. It is similar to the Apache Hadoop framework.

Patients, Doctors, Pathology, and Pharmacy

Figure 2 demonstrates the workflow among the Doctors, patients, pathology, and pharmacy. Figure 2 also labels the steps in the edge of the diagram. At the very beginning, a Doctor and a patient interact with each other to understand the illness. Then, the Doctor writes a prescription depending on the disease. The Doctor may prescribe pathological tests, for instance, Blood Tests, MRI, XRAY, etc., to investigate the diseases in-depth. Moreover, the prescription may contain medicine to administer. The pharmacy retrieves prescriptions and keeps ready the medicine for dispatch. The patients find the pathological labs and diagnose the illness as prescribed by the Doctor. The pathological diagnostic report and images are stored in Edge Nodes. The Doctor can retrieve the pathological report and write another prescription. This process may repeat several times, which saves the time of patients and Doctors. The pathological report is sent to the email of the patients. If the patient does not have any email ID, then the patient can collect the prescription. This process reduces patient's time significantly as compared to the traditional system. Also, it can save many lives because time-saving is the crucial factor of emergency cases.

Pathological Data

The pathological data is uploaded into the Edge Nodes. From the Edge Node, the particular Doctor can review the reports and images of the prescribed patients. It is not permitted to view the pathological data to any other Doctors. However, at the patient's willingness, the data can be made visible to all other users of MedEdge. The pathological data and reports are categorized into several categories: breast cancer, lung cancer, etc. It can be used for future research purposes for MedEdge researchers. However, data privacy is strictly maintained, and at any cost, the identity of users are not revealed.

Data Collection

The pathological data are collected at pathological laboratories. These data are stored in Edge Nodes in several specified categories. Therefore, there will be a data silo to be managed in a distributed framework. Researchers can download the desired data from MedEdge.

Data Replication

The data are collected in pathological laboratories and uploaded into the nearest Edge Node. Now, these data are replicated and duplicated into the different Edge Nodes. Data replication and duplication are performed based on the geographical location. The Edge Node is responsible for replicating and duplicating the data. Replicating split the data blocks and stores into several Edge Nodes according to the geographical condition. Duplication sores entire data into nearest Edge Nodes.

Data for Education

The Biomedical data are available for medical students as well as engineering students. They can study the data without paying any fee. The students can also conduct research work on the available data. Therefore, MedEdge will not only boost up health but also the students.

Data for Research

The MedEdge provides several kinds of data which is stored in different locations. A researcher downloads the data; however, complete data location information is abstracted from the researcher, i.e., the researcher will not know where are the data located and how the data are streamed. Therefore, there will be no data scarcity for the researcher.

Collaboration

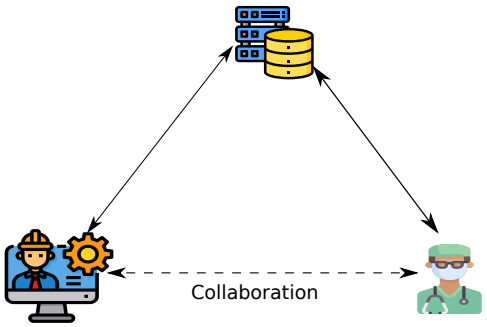

Figure 3: Collaboration Establishment between the Engineers and Doctors.

Figure 3 demonstrates the collaboration establishment through Edge Node. A researcher can be conducted by collaborating between Doctors and Engineers. In this case, a researcher can select the collaborators from the list of the associated Doctors for the dataset and specializations; for instance, MedEdge provides the entire list of Expert Doctors on MRI images for Brain Tumor. A researcher selects the collaborators and starts conducting research work. For instance, a data scientist wants to research MRI images using CNN. In this case, there will be many data in the dataset and start working the deep learning. Moreover, the selected Doctors (collaborators) can continuously guide the works. Furthermore, a researcher can also research without collaboration.

Remote Doctors

Pathological report can be fetched from Edge Nodes by the remote doctors for critical and rare diseases. These collaboration will boost up the local doctors and remote doctors. Since, the remote doctor can see the pathological report and images, and patients details. A remote doctor can continuously administer the local doctor and discuss with the local doctor the treatment. This process significantly saves money, times and lives.

Disaster management

The data are stored in Edge Nodes. There is much uncertainty of the Edge Nodes. The Edge Node can be affected by Flood, Fire, War, Earthquake, Machine Failure, etc., which results in data loss. Therefore, MedEdge provides data replication and duplication to resist any natural calamities and unnatural disasters.

Communication

The Doctor prescribes the patients to the pathological lab via networks. The pathological lab can keep ready before reaching the patients if the patients condition is very bad. The pathologist scans the patient's body, generates a report of the prescribed patients, and uploads the generated images and reports into the MedEdge. The Doctor can now generate a prescription online and offline. The generated prescription is sent to the pharmacy to keep ready the desired medicines and other instruments. A nurse or attender of the patients can collect the materials. Therefore, this automated system will save many lives because times matter in emergency cases.

Security

Security of the data is the grand challenge of all time. There are diverse challenges in securing the data; for instance, DDoS attack [17]. At any time, an intruder can intrude the systems. Therefore, it requires systematic security measures. A TLS/SSL license need to purchase to establish the connection among the users securely.

Cryptography

Medical image transmission is the most sensitive issue; for instance, the image is mutated to malignant cancer after transmission. Therefore, it requires an efficient provable mechanism to prove the immutability in transmission. For the transmission, we will use HEX-BLOOM for efficient proofs of the immutability [6]. Moreover, our proposed system requires symmetric encryption, for which we will use privateDH [18], and Stealth [19]. For image hashing, we will use [20]. For asymmetric communication, we will rely on RSA algorithm [21].