Ru-Urb IoT-AI powered Healthcare Kit

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***Abstract*—The Healthcare of a country plays a major role in defining a country's development. It is the expenditure, quality, and accessibility of health services that govern the quality of healthcare. With this in mind, this research work intends to develop an IoT based healthcare kit that is portable, low cost, lightweight, and low power electronic health care system. It will record and monitor health parameters like temperature, ECG, heart rate, blood pressure, etc. providing primary patient monitoring and care assistance to strengthen our country's healthcare system from rural to urban sectors. The kit is accessible 24/7 as real time data can be stored and fetched from the cloud anytime and anywhere. A significant issue in rural India is the 1:10,000 ratio of doctor to patient, which is now resolved by this kit because doctors all over India can now access the data on their timeline. Also, our Rasa based NLP-powered AI bot helps in assisting patients in identifying their illness via credible symptom checking, providing remedies for their illness, scheduling doctor appointments, and notifying caregivers. A web app is also provided for our system to broaden usability.**

Keywords— IoT in Healthcare, Sensors Technology, Embedded System, Cloud Computation, Natural language processing, Chatbot.

I. INTRODUCTION

The healthcare industry plays a vital role not only in the physical health of people but also in the economy as a whole. While the healthcare sector is constantly improving, a country like India with its growing population always falls short on adequate facilities. India has a universal healthcare model that is mostly administered at the state level rather than the federal level, with each state having its own publicly funded healthcare[1]. The National Health Policy focuses on the emergence of the robust healthcare industry. In practice, however, the private healthcare sector is responsible for the majority of healthcare in India. Major medical professionals are in urban areas which just cover some parts of India. Lack of exposure to rural areas increases the risks and reduces the quality of life. In addition to this, the cost of medical treatment is pretty high. Normal body checkups, to and fro hospitals, pre-and-post hospitalization medical expenses all add up to a hefty amount that people cannot afford.

To change all these demerits, the full benefit of the revolutionizing IoT in healthcare are considered[15]. The Internet of Things has made objects smart without any manual intervention. It establishes a platform that creates opportunities for people to connect devices and control them with big data technology. It is a perfect amalgamation of real-time analytics, wireless network sensors, and embedded systems. There are countless advantages of IoT in healthcare fields like time management, less expenditure, better and accurate results[4]. Because of this, all the inefficiencies in the health sector will reduce. With emerging technologies, data management also becomes an important part of the healthcare system. Millions of data have to be stored and this causes space complexity in databases. Here's where cloud computing comes into the picture. Amazon Web Services (AWS)[3] is a cloud platform that has widened its roots into IoT services. It is reliable, scalable and most importantly it adheres to data management and provides rich analytics.

The idea of this project originated to give good medical care and reduce the need for patients to visit the doctor for a regular health checkup. This kit facilitates cost and time savings for both patients and doctors and it also allows doctors to give more time for emergency cases. The kit will help the disabled and old people [8] who cannot come to hospitals independently for their regular checkups (fig.1). The system provides a distinguishing characteristic of continuous real time analysis of various health parameters such as ECG, heart rate[9], blood pressure, oximeter[4], and temperature by using various sensors whose data is sent to the cloud[1,10]. The data will be accessible to doctors on their website where the sensor's data are plotted and visualized in a real time chart [3]. The doctors can retrieve the past records of patients for reference from the Electronic Health Records stored in the cloud. They will notify the patients about their diagnosis and if it is required, they can stay connected with the patients.

Our proposed system also includes a mobile app that will have a notification section where the patients will get their reports updated. For this, the patients need to register themselves on the app, and doing so, will give them access to various features. Nowadays people tend to seek knowledge or information from the internet related to health. To reduce this, the introduction of a chatbot in the kit is a completely new concept and a highlighting feature [5,7]. A Healthcare bot is a technology that makes the interaction between man and machine possible by using natural language processing with the support of Rasa. The information for the healthcare services given by the bot can be trusted and it can be chosen over traditional community-generated systems because they are more reliable, compatible, and provide instant remedial options[12]. It intends to provide personalized health and therapy information to patients[11]. Moreover, because of the feasibility of chatbot, the visit to doctors for minor issues will also decrease thus, saving time and expenditure.

II. Related Work

Title	Author	Year of Publication	Findings
IoT Based Health Monitoring System	Tamilselvi V, Sribalaji S, Vigneshwaran P, Vinu P, J.GeethaRamani	2020	The system mainly focuses on coma patients. It can assess basic symptoms like pulse rate, temperature, etc of the patient through IoT sensors [15]. All the information is collected via the internet and their devices are all connected to cloud services. It offers an accelerometer sensor that displays the body movements of the coma patients.
IoT based Health Care Monitoring Kit	Anand D. Acharya, Shital N. Patil	2020	The developed system consists of basic health parameters like Heartbeat, ECG, body temperature, and respiration [14]. The data is collected from the following sensors and sent to raspberry pi for the processing which is again transmitted to the IoT network. Although the project is effective, there is no data visualization interface for the kit.
IoT based smart healthcare kit	Punit Gupta, Jasmeet Chhabra, Pulkit Kumar Dhir, Deepika Agrawal	2016	The proposed model collects data from the sensors like pulse rate, blood pressure, and ECG [13]. If any anomaly is detected an emergency alert to the patient's doctor with his current status and full medical history is sent. The server uploads the database with current medical information which can be accessed any time by the doctor. But after a certain amount of registration, the database will be a constraint.
Intelligent Healthbot for Transforming Healthcare	Vivek Katariya, Vitthal S Gutte	2019	The healthcare bot can understand and analyze patient's health related queries and lead the conversation to the final diagnosis [11]. It uses the text based diagnostic technique. The integration of Machine Learning in healthcare with a Chabot as your doctor is set to witness a significant paradigm shift.
IoT Based Medical Assistant Robot (Docto-Bot)	Anowar Hossain, Jasmin Uddin Qureshi	2020	This project proposes a conversational Healthcare bot that is developed to prescribe, suggest and give information on generic medicines for diseases to the patients [7]. Doctors can access the data and via video call, they can communicate with the patients. In addition to this, the robot consists of medical reminders, automated hand sanitizer, and an E-Health monitoring system.

III. Need of Healthcare

Rural healthcare is one of the biggest challenges and as per the 2011 provisional population totals of Maharashtra, more than 50% of the population resides in rural areas. The number of government hospitals in this area was reported at 273 Units in 2015. This records a decrease from the previous number of 450 Units for 2013. The data reached an all-time high of 735 Units in 2010 and a record low of 273 Units in 2015. In 2015, there was an increase in the total number of hospitals with 711 Units, but a steep decline in the number of hospitals in rural areas. So more hospitals were being constructed in the urban areas, making it inconvenient for people residing in rural areas to walk miles for visiting hospitals. This data was referenced from CEIC and is reported by the Central Bureau of Health Intelligence. As the lack of health facilities is clearly visible from the data shown in Fig. 1, there is a need for low cost medical care in rural areas.

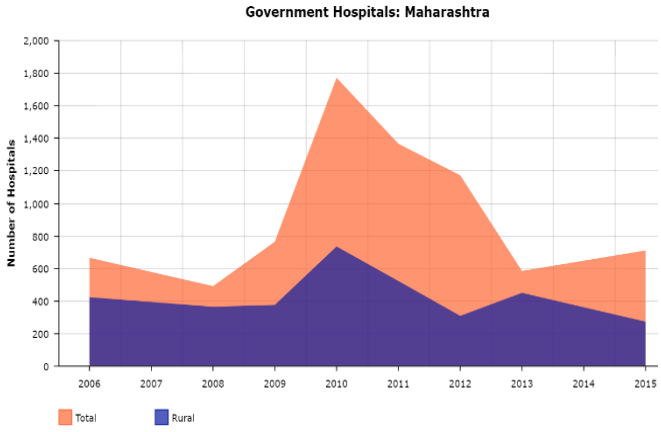

Fig. 1. Government hospitals in rural areas of Maharashtra

Even though there are several government hospitals in Maharashtra, only a few of them are in rural areas, creating a necessity. Fewer people have access to healthcare than their urban counterparts. To overcome this, a system has been proposed to reduce this gap and provide people of every age quality care.

IV. Proposed System

The healthcare sector in India lacks three major factors that are supply, utilization, and equipment. The IoT healthcare kit is one of the vital elements of the IoT in healthcare. It facilitates the transmission and reception of records and enables the use of tailored health communication. Fig. 2 demonstrates the flow of our healthcare system.

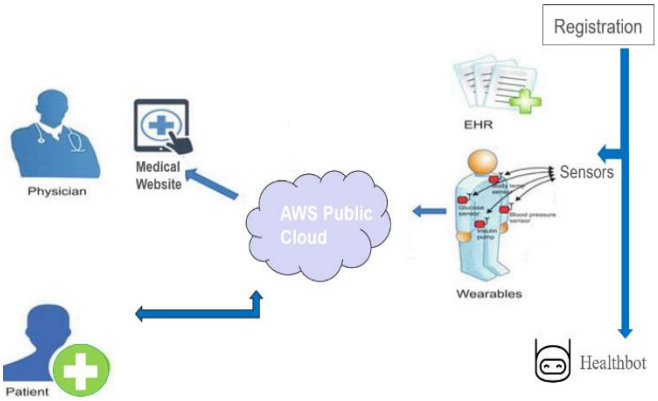

Fig. 2. Flow of healthcare system

To use the kit, the patient first needs to register themselves to the system. After registration, the patient can then wear the connected sensors to get their health parameters monitored. This data is then sent to the cloud where it will be stored and an Electronic History Record

(EHR) of each patient will be maintained for future usage. A web and mobile application is used where the available doctors from any location can then analyze the patient's records and notify them of their results. The application enables us to monitor the user's health while providing access to all the earlier data and video conferencing to lessen the hassle and improve the lifestyle of individuals. Furthermore, the website will include health blogs, the history of the patient, and a chatbot that will provide a Self-assessment of mild symptoms. For better understanding, the proposed system has been divided into two sub-topics:

A. IoT based Healthcare Kit

The kit has an inbuilt display that will be used to interact with the users. The screen displays different languages as shown in Fig. 3

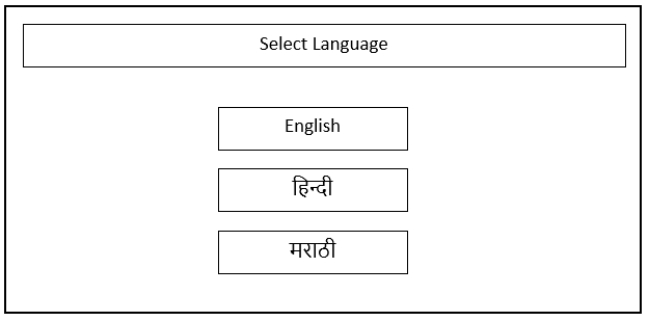

Fig. 3. Selection of language

After the selection of language, the user needs to register itself which will create a profile for the user as shown in Fig. 4

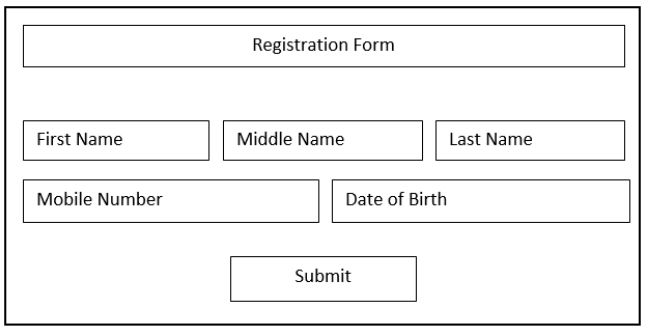

Fig. 4. Registration form

Before the provision of health kits in rural areas, every area will first be surveyed to analyze the need and requirements of that particular region. Through this, we will come to know which region is facing what illness overall. Moreover, for all such surveyed regions a custom-made kit will be fabricated by adding those particular problems as options while selecting for consultation. If the user is unaware of the illness, he can always select the general option. For example, if in a region people are likely to have more stomach issues, then that kit will have a gastroenterologist as a different option. (Fig. 5) In other regions where the cases are not similar, the option will be customized according to what the data is showing for that particular region.

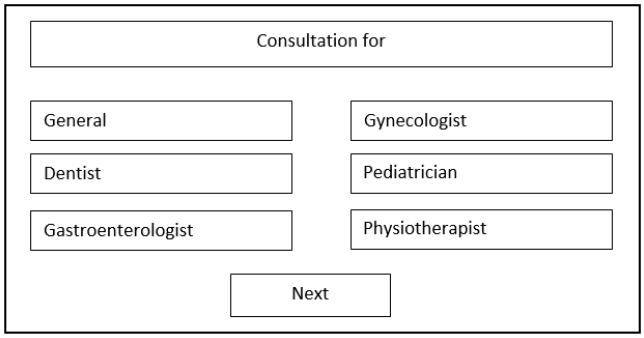

Fig. 5. Consultation

After the consultation is selected, the instruction manual for usage of the kit will appear as shown in Fig. 6, so that the user comes to know how to use the kit without any difficulty.

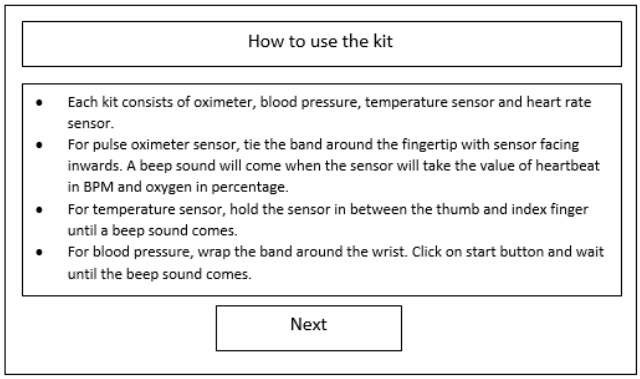

Fig. 6. Instruction manual

Finally, the last step would be to use the sensors. The kit includes a Blood pressure sensor module that uses 5V, a Temperature sensor that requires 3V – 5V and can go up to 50 degrees Celsius, and Pulse Oximeter MAX30102 in which oxygen is in percentage and the heart rate is measured in BPM. The wearable sensors will collect the health parameters and their value will be displayed on the screen. (Fig. 7)

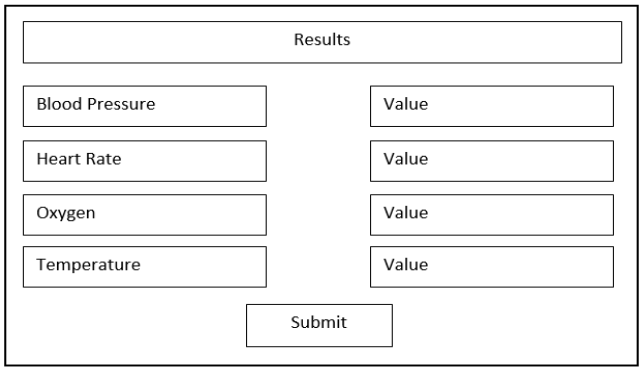

Fig. 7. Results

We will connect our devices to AWS IoT via MQTT/HTTP securely. In Fig. 8, the device gateway allows the connected devices to talk over the MQTT message protocol. MQTT is a highly fault-tolerant protocol with a small footprint in terms of the code you need to put on the device and is very efficient in terms of its network bandwidth

requirement. The connected devices talk over TLS, a successor of SSL. AWS makes it easy to create, manage and deploy x.509 certificates for authentication. By mapping the roles and policies of these certificates, authorized devices have access to AWS IoT[3]. Since the device gateway is built on top of MQTT, it uses the Publish-Subscribe programming model that allows one-to-many connectivity between different devices. This enables a much more scalable environment for low latency, low overhead communications and is easy to add devices since all they have to do is subscribe to the data and they can start receiving it. The registry feature establishes an identity for the device and keeps track of the metadata of the connected devices[6]. Shadow allows interacting with the devices when they are offline and retrieves the last reported state or sets a desired future state of the devices through RESTful API.

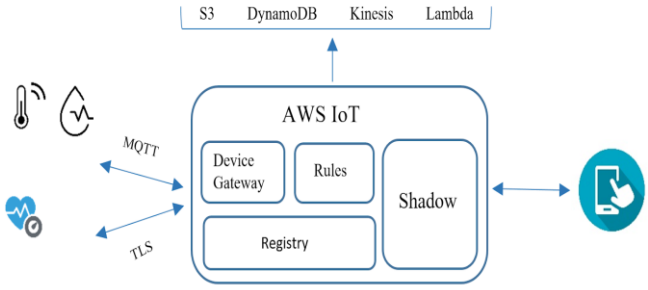

Fig. 8. Connecting devices to AWS IoT

IoT devices tend to create a large amount of data and it is very challenging to understand which data is important and which is not. For this purpose, we use Rules engines that will filter the published message from the connected devices and start processing them. This information then can be used to trigger lambda function, put into Amazon kinesis, stored into Amazon s3 or the data can be moved to Amazon DynamoDB. Using this data we can send push notifications at the time of emergency. Then using our created Web and Mobile Applications we can read the data reliably at any time[10].

In Fig. 9, the portal consists of two main interfaces: the user side and the doctor side. In addition to this, it has features like publishing articles and workshops to ensure that the users get to grow knowledge in the healthcare domain. The homepage has basic amenities like book an appointment, blogs, about us, login/register. Once the user/patient signs up he will have to fill up a detailed profile made for a better understanding of the patient.

Fig. 9. Website Homepage

The profile has been divided into three broad categories: Personal, Medical, and Lifestyle. Each domain will have certain questions such as their blood group, age, allergies, etc. that have to be answered by the user. Fig. 10 explains the basic flow of registration, whereas Fig. 11 shows its implementation. The main agenda of this is to know more about the patient beforehand. In addition to having access to edit their profile, they can upload their healthcare-related documents and book appointments.

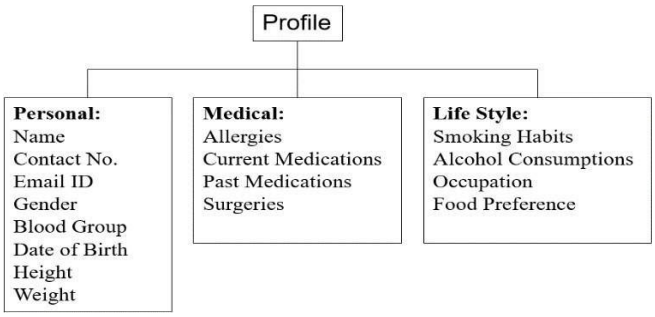

Fig. 10. Patient Registration Profile

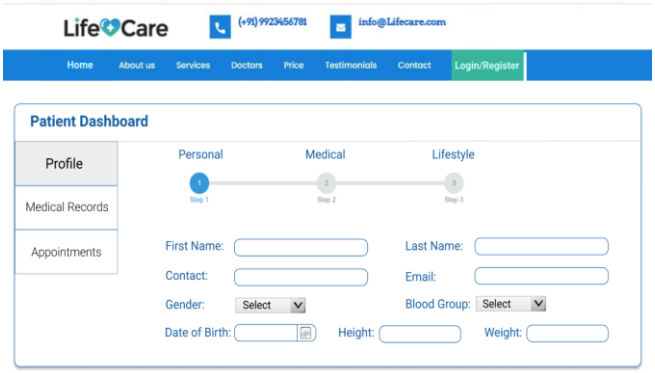

Fig. 11. Patient Dashboard

The doctor's side portal will get access to each of their patients' documents as shown in Fig. 12. They can accept/reject an appointment. They can see the profiles of their patients. They can schedule a video call to meet up with the patients. In addition to this, they can publish articles related to health care and even start workshops wherein they can provide tips to improve their lifestyle. As all the data is stored in the cloud doctor from any location can analyze the patient's records and notify them of their result. The same website is also converted to a mobile app to broaden the spectrum of the users.

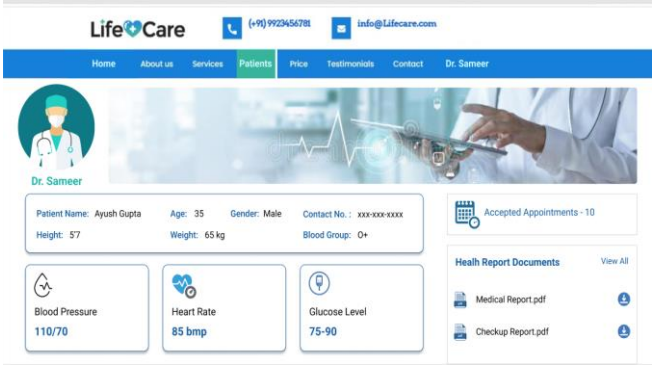

Fig. 12. Doctor's Page

B. *Health bot*

Fig. 5 provides the basic prototype for the Health chatbot. A Healthcare bot is a technology that makes the interaction between man and machine possible by using natural language processing with the support of Rasa. The basic aim of this system is to bridge the vocabulary gap between the doctors and patients by providing replies to the questions asked by the patients[11]. The most captivating point is that it facilitates 24/7 consultation and it has been developed for people speaking different languages.

Fig. 13. Health Chatbot

The chatbot uses intents and entities for implementing a smooth conversation and then leading to a final diagnosis by an effective text-based diagnostic technique. Every question asked by the chatbot has multiple options for the user to select. The objective of this is for the chatbot to collect the keywords from the initial messages. It will ask questions related to the options that are being selected and by doing so it concludes and suggests remedies and medications to the user[7], as shown in Fig. 14.

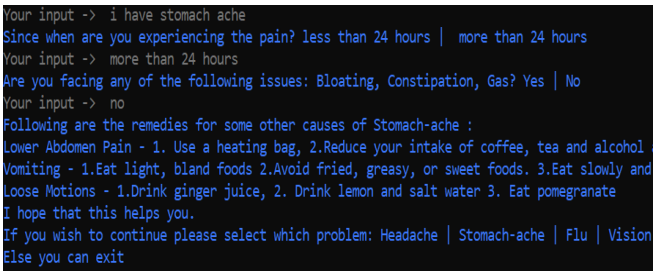

Fig. 14. Rasa Chatbot

Provided here are the factors that affect the healthcare sector and how our project complies with each of them.

1) Usability:

- Useful in the healthcare sector, mainly in rural areas, where there are limited facilities of resources and hospitals.
- Extremely efficient for disabled and old-age people who cannot independently come for regular checkups.

2) Scalability:

- We are planning to start this initiative in a district in Thane and gradually increase the horizon from there.
- This place is chosen particularly as it is a very small district consisting of 3820 people where transportation and other facilities are not at their best.
- As the main cities and towns are approximately 10 km away it is not a feasible option to travel all the time and with this ideology, more people will get health care facilities within the district itself.

3) Economic sustainability:

- One health care kit will require a minimum amount of 6000 rupees.
- As it is a one-time purchase, we believe it is a viable option.

4) Environment Sustainability:

- Casing used for the development of a healthcare kit will be made from a biodegradable material.
- As this kit doesn't require any paperwork, we will be saving a lot of wood and electricity consumption.
- No waste will be generated. Therefore, it is not going to contribute to any sort of land pollution.

V. Conclusion

The proposed system provides healthcare solutions anytime and anywhere. It will majorly benefit people living in the rural areas as well as the elderly and disabled people. Our system obtains real-time medical information about a patient and stores it in the cloud as Electronic Health Record. It also helps in the self-diagnosis of the patient by combining medical databases with Natural Language Processing. This results in a better understanding of the medical terminologies and provides a customized service to the patients via our Healthbot. Our web application can contribute to ease of accessibility to the masses as it can be used by rural people through mobile phones. We aim to make virtual assistance to doctors, patients, and workers to build better and well-connected healthcare for society.

VI. Future Scope

The project is not connected to any pharmaceutical company as of now. The survey made can be used to analyze what type of illness is majorly caused in every region and according to that the supply of medicines to the respective regions can be added. This will not lead to a shortage of medicines and people won't have to struggle to find their medications. The doctors can directly send the prescription of patients to the pharmacy and the delivery can be made from there directly rather than patients coming all the way to buy medicines. An enhanced version of a health bot can be developed to solve complicated issues and provide more options for consultation. We will add advanced machine learning to increase the efficiency of the health bot.

Acknowledgment

We thank A. P. Shah Institute of Technology for providing us with space and resources to complete this project. We are grateful to our college faculties for helping and encouraging us by making us available with the necessary components and supervising us in the entire process. We got an opportunity to learn the needs of quality healthcare in rural areas, how IoT can help in overcoming this gap and how it will be beneficial to society. We would like to thank our Head of Department Mr. Kiran Deshpande for his guidance and continuous support on how to implement a user-friendly low-cost portable system. Lastly, we would like to express our sincere gratitude to our parents for their immense support and motivation.

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