# IMPLEMENTATIONOFIOT TOSTOREPATIENT DATA GLOBALLY FOR CHRONIC KIDNEY DISEASE(CKD) PREDICTION

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## Abstract:

Chronic Kidney Disease (CKD) is a growing global health concern, and early detection is crucial for effective management. The integration of Internet of Things (IoT) technologies offers a transformative approach for continuous monitoring of CKD patients by collecting real-time data on vital health parameters such as blood pressure, glucose levels, and kidney function biomarkers. This paper presents the development and implementation of an IoT-based system for storing patient data globally and predicting CKD progression. The proposed system utilizes wearable sensors and remote devices to monitor patients continuously and uploads the data to a secure cloud-based platform for global access. The cloud infrastructure ensures the storage and retrieval of patient data, allowing healthcare professionals to track and analyze health trends remotely. Additionally, machine learning algorithms are applied to the stored data to predict the onset and progression of CKD, facilitating early intervention and personalized treatment plans. The system aims to improve CKD management, reduce healthcare costs, and provide a scalable solution for global health monitoring. By leveraging IoT, cloud computing, and machine learning, the system enhances decision-making and patient care while enabling collaborative research in CKD management worldwide.

# **Keywords:**

Chronic Kidney Disease (CKD), Internet of Things (IoT), Patient data storage, Cloud computing, Machine learning.

## **1.INTRODUCTION**

"Internet of Things (IoT)" is the term coined for amalgamating different technologies together for achieving an advanced communication system. Different technologies like sensors, actuators, tracking devices, artificial intelligence, and many more are included in IoT. It not only connects the users through the internet but also helps in handling data sent by the user.Itisachievedwiththedevicenamed"ESP-8266" which is nothing but a Wi-Fi module interfaced with a microcontroller to achieved van cement in data handling. IoT proved its worth in different

fields of telecommunication, embedded systems, informatics, etc. The base ideology behind the IoT and its connectivity is that any devices with on and off-control actions can be a part of it. The devices that can be connected are mobile phones, laptops, home appliances, and many more with the internet.

#### 1.1 IOT-AGatewaytoEvolvedCommunicationSystem

Ideally, IoT is applicable in all the fields of science and technology. But the research requirement is for developing an emotional recognition system with a data handling setup. The for the application of IoT to this part of research is main theme that thecreatininemeasuringemotional recognition systems enses the creatinine value of the patients and these data must be transferred and stored in some secure place so that the dataassessmentcanbedoneatanytimeandanywhereacrosstheworld.So,forthisissue, IoT acts as a tool to store data in a server and enables data access to the user anytime.

ThedevelopmentofIoTtookplaceintheyear1982whentheCokemachinewas loaded with bottles. This was the first machine to be connected to the internet and was doneatCarnegieMellonUniversity.Itcouldreportwhetherthebottlesloadedwerecold or not [1]. In the 1991. Mark Weiser was the scientist who concept of year proposed the "ubiquitouscomputing". This computer technique helps in connecting any device a part from computers to the internet and anywhere and anytime [2]. Later in the year 1999, a device-todevicecommunicationwasdevelopedbyBillJoy.Alongwiththisidea,Kevin

AshtondescribedIoTasinterconnecteddeviceswiththeinternet.RFID(radio-frequency Identification) was the base idea behind IoT. In 2005, home automation, industrial automationwasimplementedviaIoT[1].ItwasproposedthatIoTcouldbeimplemented

even in health care. It was observed that these ns ors, actuators, communication devices all

werecontrolledthroughtheinternet. Thiscouldhelptoworkinavirtualenvironmentand control the real environment with much ease. No longer computing would be limited to computers [3]. E-healthcare and remote healthcare run with the help of IoT. To advance the level of communication 4G (fourth generation) high-speed internet was introduced whichwasevenappliedtohealthcarecommunicationsystems. Laterslowly telemedicine came to the picture where the physicians guide their interns through video calling and assist them throughout surgery, medications, and tests [4].

Through IoT different devices get connected and their data are collected and furtherprocessed. An ideawas proposed tohelpthepeopleinthefieldofhealthcareand

aidthemincaseofemergencyasitisveryimportanttoassesstheIoTdataglobally.Here the IoT data is stored and then interpreted which can be helpful during an emergency. Finally, resource-based data accessing was devised with the help of IoT and computing. It was concluded that this method effective in database management was very systems [5].Asystemwasdevelopedinordertodeterminethesuccessrateofthecompanieswith the help of customer lifetime value. This IoT-based system personally approaches the customer and knows the credits of the products and then determines the worth of the productanditscompany.Italsohelpsinimprovingtheserviceoftheproductconcerning the customers' reviews about the product.

SmarterCommerceCustomerEngagementArchitecture(SCCEA)wasdeveloped with the help of e-commerce, IoT, and customerengagement. Similar methodologies are applied for healthcare with the SCCEA system [6]. RFID is a prerequisite to IoT. The features of RFID technology are that the cost of implementation is low when compared toIoT.Buttherangeofstorageiscomparativelyless.Asystemwasdesignedthatsenses

theuser'shealthconditionaswellas theuser'senvironment liketemperature, creatinine low, and other gases with the sensors. This experimentation was done with the help of disposable sensors, low power devices, and many more [7]. An IoT-based system was developed in order to sense the movement in Parkinson's disease (PD) patients. A lightweights ensorwasd eveloped and was fixed in the patient's cloth. This sensor would

sense the movement of the patient and it is connected to a table to move the patient which it is finally connected with a medical database. IoT database not only provides storage of patient's data while visit but also for regular diagnosis at home. Through this system development, patients' comfort can be determined and their health can be consistentlymonitored. Thissystemalsohelpsthepatientstohelpthemselvesbysharing their experiences with the physicians as well as peer groups. It gives great comfort to a patient that they always care and their health status is always monitored and during any emergency, they can be [8]. With IoT easily treated the development of in medical science, new technologies like cloud computing and bigdata areals oemerging. A system wasdevelopedinsuchawaythatitincludedalltheadvancedfeaturespresenttoday. This is a sensor and a measurement system.

The sensor is made from a fabric material attached to the washable clothes. It senses the subject's physiological signals and helps to determine the health status of the subject along with a determination of the emotional state of the subject [9]. For treating chronically ill patients an instrument was developed in the name of Interactive Telecare System (ITCS) which connects the

caregiver's smartphone with the chronically ill patient's medical devices which assist them. This is done with the help of IoT and then all the devices are interconnected globally. Even in the absence of the caregivers the medical devices assisting the patients can be activated with the help of the caregiver's smartphone through IoT. Experimentation was done with the help of glucose monitor in sugar patients and then with the help of ITCS, it was observed that most of the medical institutions find it advantageous to work with ITCS system and gave positive feedback on such IoT based Telecare systems [10].

Mostly in all the sectors, IoT plays a crucial part. Sectors like agriculture, manufacturing, utilities, transportation, healthcare, and much more use IoT for connecting different equipment. IoT is completely based on data sharing and the risk of data vulnerability is also considerably increased. In order to safeguard the data, а new study with the help of Generic Programming (GP) was implemented. To prevent the attacks, an artificial Immune intrusion detection system (IDS) was developed. It was observed that GPattackersfocussedonthepublish-subscriptiontypeofmessages. Theperformance of theIDSwasimprovedwiththeGPattacks[11].Asmarthealthcaresystemwasdeveloped with the help of ambient assisted living (AAL). The performance of AAL is solely dependent on the of of accuracy predicting the nature the environment and human behavior.Datacanbecollectedfromdifferentsensorspresentaroundusanditisneeded thatthesedatacollectedarefurthersentforprocessinganddrawingoutconclusionsbased the on observed data. In AAL elderly people are monitored continuously and then their changes are observed very carefully.

Not only were the changes measured from the elderly subjects but also Alzheimer's disease (AD). With the development of AAL, doctors can interact with the patient remotely and access the health status more accurately, and also can assist them without their actual presence. Moreover, it provides great relief to the patients that they are always taken care of which helps them in recovering soon [12]. Because of the massive usage of IoT in different fields in order to of IoT enhance the availability and makeitaccessibletoalmostallpartsoftheworld.ItwasdecidedtocombineideasofIoT with that of social networking due which the Social Internet of (SIOT) to Things was developed.Atrustworthyautomaticschemewasdevelopedinordertojudgetheproduct. This scheme enabled different users to judge the products and then score them accordingly. It also helped in determining the other users to choose the products wisely and then enable the product service also. Social networking along with the IoT enabled the trust factor of the products or the objects [13].

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IoT handles datavery well and an almost largenumberofdata can be stored and accessedthroughIoT.Buttheissueofinterpretingthedataremainsachallengingtaskto IoT. So human interference in this subject is also liable and makes the system more accurate. Two IoT-enabled devices taken for the experimentation of understanding are thedatameasuredthroughthesensorsapartfromstoringitinthecloud.Itwasconcluded that human-aided IoT higher of systems have а rate accuracy when compared to that simpleIoTstructuresforthedevelopmentofmedicalhealthcare[14].Withtheevolution

ofIoT, patients can be monitored remotely. The health of an individual can be determined with the study of sleep postures. But exact tool to assess the sleep posture to study the sleep pattern is still a challenging task.

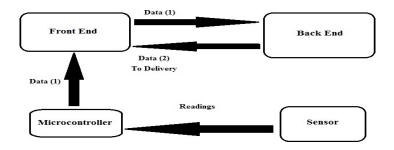
Anagent-Basedsimulationsystemisdevelopedalongwith the smartbedtostudy the movements of the sleeper. An algorithm was developed to understand the sleeping postureofthesubjectonthesmartbed. This measurement is done with the help of placing the load sensors determining changes in on the bed for the the sleeping posture. The developedsystemwasgiventhenameABS-BedIoT, which determines the sleeping posture of the subject and then determines the graphical analysis of the results obtained from the measurement. States of the bed sensors are represented not only in graphical method but also using star plots, evolution and visual The charts. representation. techniqueisnotonlyfeasibleonlinebutalsooffline. The code used for the algorithm can be easily retrieved from the public research repository. The accuracy rate of the determination of sleep posture is increased with the help of the alternative technique for measurement. Final data processing is done with the help of Big Data and created logs for the sleeper's posture recognition. The average accuracy of the system is determined to be 98% with the help of a developed algorithm [15]. In the UK an experiment was conducted to combine health care management with that of IoT. The design was such thatit included continuous monitoring of the patient and necessary decisions are also implemented when needed It at most. was concluded that the developed system alone cannot be that effectives otomake it more reliable and accurate it is important to interfacehuman experience into the system [16].

#### 2.STEP-WISEIMPLEMENTATIONOFIOTARCHITECTURE

Afteradetailedstudythepatientdatabaseiscreatedandthedataarestoredin the cloud with help of IoT. Hence the implementation requires the following steps,

#### 2.1 BasicTerminologiesInvolvedinWebDevelopment

The development of IoT technology involves many steps and each stage of development requires a separate set of procedures to be followed and all these methodologies are discussed.



### Fig2.1BlockDiagramRepresentationofIoT

CertainterminologiesareusedinIoT, whichisnecessarytobeknown. Herethe *cloud* meansthepla ceallthecreatininevalue is about to be stored. It is assisted by the *frontend* and *backend*. The frontend means the monitors creen of the PC, tablet, phone, Laptop which acts as a receiver. Coding is done to develop the front end of the server. Now, the back end refers to the storage area, which is accessed when the data is moved to the front end either automatically or manually by the user. "*PHP*" is the programming language for Webdevelop mentwhich includes Cand

C++asaprimaryelements. With the help of PHP backend is connected to the front end and data transfer is possible. The detailed explanation of the block diagram is shown in Fig 2.1, firstly the data received from the sensor is sent to the front end through microcontroller coding. And then the data is sent to the back end of the server. Data (1) means the creatinine value estimated by the controller which cannot be seen by the user until it is moved to the front end again from the back end of the server. Data (2) means the creatinine value which is seen by the user area. It is is important to note

thatprogramminglanguageslikeHTML,Java,JavaScript,andPHPcanbeusedtocode

fordatatransferfrom the backendto thefrontendwhereas thePHPtoolisusedtocode for data transfer from the front end to the back end. *Bootstrap, CSS* is the other programming languages that are used to improve the presentation of the front end and make it more attractive to the user.

#### 2.2TransmissionofcreatininevaluetoServer Manually

Forsendingthedatatotheservermanuallyitisessentialtoinstalltwoapplication software named *Notepade*++ and *Xampp*. These two applications are necessary to develop a local server. Firstly, PCs in which these applications are installed are made to work as a local server and the data is sent manually. From this trial version, gradually code can be extended and then allow the microcontroller to be interfaced with IoT and

accessaprivateserverthrough the internet. It is one of the most important criteriatos ave any code with .php and .html formats. One of the most advantageous features of these applications is that it helps in detecting the error in the code before running it. There are many other applications available for web development by Xampp and Notepade++ is considered to be a handy tool.

Xampp is an application specially designed for testing the code in a local server. Moreover, an internet connection is not required after this application is being installed. ForatrialversionofIoT, theserverisnothingbut the PC. Here, the data entered manually is sent to the laptop the above-mentioned applications. Fig 2.2 shows the Xamp++ via applicationafterbeinginstalledonthePC.Thenthefurtherprocessisdonewiththehelp of the setup wizard.

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Fig 2.2SetupWizardWindowofXamppFig2.3Windowfor choosingLocalServer

Fig2.3showshowthelocalserverischosenoncewhentheXamppapplicationisinstalled.Afterpressingthe"Next"optionfromthesetupwindowitasksforlocalserverselection.ThecodeswrittenforthedatatransferinthelocalserverarewritteninPHPorHTMLandthenfurtherthiscodeissavedinthehtdocsofXamppfromthelocaldiskC.Nowwiththehelpofgooglechromewithoutactuallyconnectingtotheinternet,typethelinkhttp://127.0.0.1/dashboard/.AssoonasthelinkissearcheddashboardoftheXamppispopped in the window of the PC as shown in Fig 2.4.

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you understand the implications and you checked the FAQs to learn how				
LAMP which are similar packages which are more suitable for production				phpMyAdmin
Start the XAMPP Control Panel to check the server status				Version information: 4.7.4     Documentation
	Activate Windows			Official Homepage     Compliate
Community			Conside	Get support     List of changes

Fig2.4DashboardofXamppinthePCFig 2.5"phpMyAdmin"WindowinXampp

After which phpMyAdmin page is opened. Another alternative is provided to reachthephpMyAdminpagewiththehelpofthe linkhttp://127.0.0.1/phpmysdmin/and a new database is created as shown in Fig 4.5. The appearance of the database can be changed on this page with the help of the appearance setting.

MySQLisknownastheStructuredQueryProgrammingforimplementationofthetable . "Query"basicallymeansfunctionorelsecanbetermedasacommand.MySQLlanguage uses operation commands such as create, insert, extract, order by, join, etc. As shown in Fig2.6newdatabasecanbecreatedwiththehelpofanewoptionfromthephpMyAdmin window. "Sensor" is the name given to the new database such as "Creatinine Data" can be created as the name for the new database which is clearly shown in Fig 2.7. After finalizing the name of the database further "Create" option is clicked.

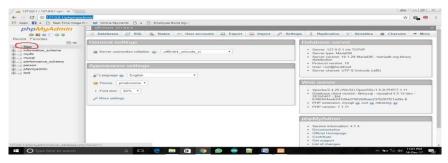


Fig2.6Selecting"New" for database

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Fig2.7Namingthecreateddatabase

From Fig 2.8 it can be seen that the new database "Sensors" is created under the new option. This indicates that the new database was created successfully. Understructure, the table "<name>" is selected. It is important to note that the name of the table and the column of the table is needed, not the rows.

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Fig2.8Creating thelayout of atable for data storage

Thetitleof thetable is chosen as "readings" as thecreatininevalueofthe datais about to be stored under the table. After which numbers of columns are selected this is particularly4aspertheneedoftheuser.Afterfinishingthetablelayout"GO"optioncan be clicked to create the table which is shown in Fig 2.9. All together four columns are introduced in the table which are Serial Number, Patient ID, Time and date, creatinine value, and State of the Subject under the name content of the table.

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Fig 2.9Creatingthecontentsinsidethetable

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Fig2.10 InsertionofDataManually

FromthephpMyAdmin window, theSQLoption next to thestructure selected to enter the table manually as shown in Fig 2.10. "INSERT INTO" is the code used for inserting the data. After filling in the data INSERT option is selected to upload the data into the table. From Fig 2.11 it can be noted that the values which are uploaded getupdated.Herethecreatininehighandcreatininelowvalues are uploaded as 99 and 66. So is the proced ureforcereatinine data entry.

C @ 127.0.0.1/phpmya	tmin/sql.php?server=1&db=sensor&table=reading&pos=0	12 Sa 10
Apps 🖬 a 🗅 Real-Time Image	Pro 💶 Chiline Payments 🗅 a 🕒 Employee Bond Agro	
		S Triggers
	Label Lat every user access this bookmark	

Fig2.11FinalViewoftheTablewithDataEntered Manually

## 2.1.1 UploadingDataAutomaticallyViaControllerandWi-FiModule.

The above-mentioned procedure is done in the Back End. To make it viable for microcontroller update it is essential to work under the front end and separately code it withthehelpofanotherapplicationcallednotepad++.From Fig2.12itcanbenotedthat the developed code is stored in htdcos of Xampp folder from the C drive.

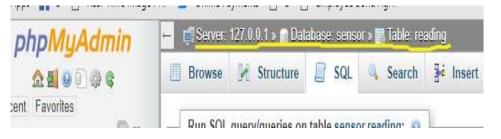


Fig2.12DatabasecreatedusingFrontEnd Coding

## 2.1.2CreatingandTransferringDataTotheWeb Page

Nowaseparateweb pageiscreated in the server and anew domain name is given. The user has to register in the link www.awardspace.com which is one of the important websites to create a new domain. The webpage opens a new window in which the name of the domain is chosen which is clearly shown in Fig 2.13.

- C B Secure https://cp1.awardspac	se.net/beta/		n - + m
Apps 🖬 a 🕒 Real-Time Image Pro 💶 Onli	ne Payments 🕒 a 🕒 Employee Bond Agro		
Dear siva prakash,	control panel / Click here		
We are constantly trying to improve the web hosting services we offer you			
If you spot any kind of bugs related to the system functionality or have any other suggestions, please on the your the diblack here or use the contact form on	Alternatives Treeds		
If you like our hosting services you can make our hosting community become even more popular by	Website Manager #	Advanced Tirols	Email Menager + +
hosting community become even more popular by writing a review and value for us.		- I I I I I I I I I I I I I I I I I I I	
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Fig2.13NewWebsiteforDomainCreation

From Fig 2.14 it can be seen that the name of the domain is chosen. It is important to choose a unique domain name that can be used permanently. So, a random name under the "name" is given and then the domain is checked.

omain Names	Section Information	Video Tutorials	FAQ		
Register	a Domain				
Transfer	a Domain	Register a new	Domain		
Host a D	omain	xsdsasdd		com	\$ Check Domain
Create a	Free Subdomain				
Register	a Free Domain				

## Fig2.14CheckingDomainName

Fig 2.15 shows the image of the screen when the domain "name" is chosen uniquely. After the authentication of the domain "name" the registration process is successfully completed.

All Domains	Registered I	Domains	Hosted Domain	s Subdomains			
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		Subdomaii	n	*	Statu	S	Settings

Fig2.15Authentication of DomainName

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Confirm Database Password	(8-32 alphanumeric char	5)	
Database Version	5.7	\$	

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Activate Window:

# Fig2.16MySQLDatabaseCreation

All Databases	MySQL	Datab	ases PostgreSQL Dat	tabases					
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	Name		User	Host	Port	Quota 🔻	Management	Туре	Options

Fig2.17Authentication of the created database

Successfully the database is created which is clearly shown in Fig 2.17. Here to increase the privacy of the data transferred into the web page, a special password is also given.

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Fig2.17NewlyCreatedServerand Database

FromFig2.18itcanbeseenthattheserver'sname,databasename,thepassword is shown which represents the state of the web page that is newly created.

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Fig2.18uploadingtheFront-EndCodeIntoAwardspace

FromFig2.14filemanagerischosenforuploadingthecode.Finally,thecodeof the controller sending the data of creatinine automatically which is in the PHP format is uploaded here which can be seen from Fig 2.20.

# 2.2 RESULTANDDISCUSSION

← → C () localhost/te	st1/home.php		
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Patient ID	Semen Creatinine Level (µmol/L )	Salivary Creatinine Level (µmol/L)	Time_Date
			Time_Date 10:55_12-08-19
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1299570091 1299570092	(µmol/L ) 92	(µmol/L) 108	10:55_12-08-19
1299570091 1299570092 1299570093	(µmol/L) 92 118	(µmol/L) 108 92	10:55_12-08-19 11:22_12-08-19
Patient ID 1299570091 1299570092 1299570093 1299570094 1299570095	(µmol/L) 92 118 290	(µmol/L) 108 92 123	10:55_12-08-19 11:22_12-08-19 12:34_12-08-19
1299570091 1299570092 1299570093 1299570094	(µmol/L) 92 118 290 122	(µmol/L) 108 92 123 120	10:55_12-08-19 11:22_12-08-19 12:34_12-08-19 13:09_12-08-19

Fig2.19FinalViewoftheTableonthe Webpage

Fig2.19showsthefinalviewofthetablecreatedwiththecreatininelowandcreatinineHighvaluesareshowni nthisimage.ThisishowthetableiscreatedforS.No, creatinine value, time, date, patient ID, and state of the subject are determined and then filled inside the table.

# **2.3 CONCLUSION**

Theanalysisofthecreatininevalueinallemotional states helps in validating the risk factors of the subject and helps in predicting any abnormalities much before the onset of any dangerous disease. Physicians or caretakers be with the patient all the time. may not present So. itbecomesnecessarytomonitorthehealthstatusofthepatientregularlywithoutany interruptions with help of IoT.Moreover, it is inevitable to automaticallysend the data to the serverwithout the helpofthemicrocontroller. Itisalsonecessarytounderstandthesupporting applications

fordevelopingtheIoT.Apartfromthatthedatafromthecreatinineisprocessedandthen these values are changed in the URL itself which is aided by the front end Xampp code. Changing the contents of the URL makes the entered thetable.Withthehelpoftheautochanges in values that are in incrementfeature, the tablecreation is automatically done. Oncethedataisuploadedthenthebackendcodeisexecutedandthedataor updatedtableissenttothefrontend.Nowfromtheuserside,thetabularformatof creatinine value with the state representation is depicted and then further analysis of the datacanbedoneontheMATLAB.Herewithhelpofthedomainnameandthepassword user can access the data and of the world In order maintain from any part at any time. to the privacy of the databeing up loaded to the server, the password is generated along with

thecreation of the domain. In this way, the privacy of the data is restored and cyber threats can be minimized to great extent by making it viable to an authenticated user.

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