Sharing of Patient Health Record (PHR) in Jelastic Cloud in a Secured Manner

UmmeAfifa Jinan,Sultana Jahan Soheli

Department of Information and Communication Engineering
Noakhali Science and Technology University
Noakhali, Bangladesh

Authors'contributions

Thisworkwascarriedoutincollaborationbetweenbothauthors.AuthorUmmeAfifadesignedthestudy, developedthemodel, and did necessary research and system development.AuthorSultana Jahan managedtheliteraturesearches, and wrote thefirstdraftofthemanuscript.Bothauthorsreadandapprovedthefinalmanuscript.

ABSTRACT

Now-a-days cloud computing is a prominent way of providing resources and services in very secure manner. Gradually more and more organizations, companies and industries are picking up cloud technology for the safe keeping of their data. The objective of this work is to apply cloud service in healthcare system by building a practical patient health record (PHR) application and deploying it in the cloud. The system is 'doctor-centric' health record portal where only the doctor or hospital authority is responsible for securing their patients' health data and this labor-free, paperless system is giving relief to the doctors and hospital authorities from various error-prone traditional health record keeping systems. Jelastic cloud is used to provide cloud service to the developed application which provides security, scalability, quality of service and ease of maintenance of the application. Jelastic cloud also provides load balancing whenever the user load is high. We are developing an interactive PHR application which is dynamically storing, creating, modifying and maintaining data and deploying it in the JelasticCloudJiffy server by the use of InMotion Hosting server. CloudJiffy is India based fully redundant, high performance and scalable cloud "Platform-as-a-Service (PaaS)" under Jelastic Cloud Union. The whole system will be an efficient way for safe keeping Patients' health records, their medical history and sensitive health information in a pervasive, confidential manner. The system is highly compatible for preserving medical records of eminent persons of our society and for those whose health information must be kept confidential in a highly secure way.

Keywords— *Patient Health Record; Jelastic Cloud; CloudJiffy Server; InMotion Server; PaaS;*

.

1. INTRODUCTION

Cloud computing is a new way of delivering computing resources and services which provides functionality for managing information in a distributed and pervasive manner supporting several platforms, systems and applications. Cloud computing is a subscription-based service where one can obtain networked storage space and computer resources. It provides flexible and cost effective way to access the data to end users in multiplatform at any time[1]. There are different cloud deployment models namely Public Cloud, Private Cloud, Community Cloud and Hybrid Cloud. Existing processes for patients' vital data collection require a great deal of labor work to collect, input and analyze the information which are usually slow and error prone[2]. The digitally managed **EHR** (Electronic Health Records)/**PHR** (Patient Health Records) systems in cloud based services offer advantages like cost reduction, data security, redundancy, privacy and availability. The integration of healthcare with the Internet and smart technologies has led to increased accessibility to healthcare providers, more efficient processes and higher quality of healthcare services. With the advancement of Information Technology, current healthcare systems are being transformed from traditional scenario that requires manual care and monitoring to more advanced scenario where patients can be automatically monitored [3]. The 21st century Healthcare Information Technology (HIT) has created the ability to electronically store, maintains, and move data across the world in a matter of seconds and has the potential to provide healthcare with tremendous increasing productivity and quality of services. It permits each provider to have his own database of Electronic Medical Records. The cloud computing market in the health care sector is expected to grow by 2017 to $5.4 billion. Hence from this survey [34]it can be interpreted that the applications of cloud in healthcare is going to be a huge industry in the near future [4]. Cloud computing based healthcare system makes it quite easy to get healthcare services over the internet using a web browser on a range of devices. Cloud data storage and maintenance frameworks offer a cost effective solution to the problem with increased security and ease of management. Patient records can be stored in Jelastic cloud in order to maintain a secure environment for digitally maintained PHR application. Jelastic cloud is a cloud service provider for hosting providers, telecommunication companies, enterprise and developers. It is a new type of cloud hosting provider which combines PaaS(platform as a service) and CaaS(Container as a service) which supports languages such as Java, PHP, Ruby, Node.js, Python, .NET. We can buy servers, configure our OS, configure application server, and configure database and then start deploying our code all at a time simply by hosting Jelastic cloud. It is easy to start, deploy, scale, manage and load balancing is high which supports up to 12 cloudlets. It supports 'Pay as You Use' service unlike other cloud services.

The work is carried out in order to Establish a secure platform for maintaining EHR/PHR application in clouds, study the feasibility of this platform for building practical patient record management system in hospitals and health organization in Bangladesh within limited resources and deploying the PHR application in Jelastic cloud for secure, scalable and ease of maintenance of the application.

Themain objective of this work is to:

i. Meet thechallengeofenhancingefficiencyandqualityofhealthcare.Measuresandoutcomeofproceduresfordiagnosisandtherapymustbedocumented,communicatedandevaluated carefully.
ii. Establish asecureplatformformaintainingEHR(ElectronicHealthRecords)/ PHR (Patient HealthRecords) application in jelastic cloud.
iii. Study thefeasibilityof this platform forbuildingpracticalpatientrecordmanagementsysteminhospitalsandhealthorganizationinBangladeshwithinlimited resources.
iv. Deploy thePHRapplicationinJelasticcloudforsecure,scalableandeaseof maintenance of the application.

2. LITERATURE REVIEW

Different types ofsystem for keeping sensitive PHR safe has devolved already by using cloud computing but Jelastic cloud and **JelasticCloudJiffy**are new in this era. Some of related systems and work are noted here.

i. ScalableandSecureSharingofPersonalHealth RecordsinCloudComputingusing Attribute-basedEncryption[26]

Ming Li , ~~Shucheng Yu , Yao Zheng , Kui Ren , Wenjing Lou~~(2012) proposedanovelpatient-centricframeworkandasuiteofmechanismsfor dataaccesscontroltoPHRsstoredinsemi-trustedserverstoachievefinegrainedandscalabledataaccesscontrolforPHRs,they proposedattributebasedencryption(ABE)

Comment [DSA1]: I think it is important that you rewrite your review. E.g.

"In this study and related research, the individuals serving are university studentswho are collaborating with the community partner. The studied benefits to individuals
serving include cultural awareness sharing (Crabtree, 2008), as well as networkingopportunities and application of classroom learning to real-world issues (Bowen et al.,
2009). Ultimately, service-learning stimulates student learning and engages students intheir surrounding communities. Service learning creates new goals for students such aspersonal development, career development, moral development, academic achievement,
and "reflective civic participation" (Lamb et al., 1998). These types of projects allowstudents to utilize material learned in the classroom to improve societal conditions."

Comment [DSA2]: This is not a review. It's supposed to be in the reference section

Comment [DSA3]: I don't see the corresponding reference for this citation. The reference for Ming reads 2013 whereas this is 2012. Please provide the correct reference for this citation. Also, for other in-text citations, you used numbers [1], [2], etc. why did you use a different format for this citation?

Comment [DSA4]: Li et al., (2012)

For three, four or more authors, you use "et al". Do not include all the authors in the in-text citation Also, remember that in the in-text citation you provide only the surname(s) along with the year. E.g.

Li et al., 2012 proposed…

techniquesto encrypteachpatient'sPHR file[26].Inthiswork,theyconsideredtheservertobesemi-trusted,honestbutcurious.Toachieve"*patient-centric*"PHRsharing,acore requirementisthateachpatientcancontrolwhoareauthorizedtoaccesstoherownPHRdocuments.Especially,usercontrolledread/writeaccessandrevocationarethetwocoresecurityobjectivesforanyelectronichealthrecordsystem.Thekeyideaistodividethesystemintomultiplesecuritydomains(namely,*publicdomains*(PUDs)and*personaldomains*(PSDs))accordingtothedifferent users'dataaccessrequirements.Inbothtypesofsecuritydomains,theyutilizedABEto realize cryptographicallyenforced, patient-centric PHRaccess.

ii. ImprovingPerformance ofWebApplications Using Cloud Resources[20]

ManglaN.,Singh.J., Singh,M.(2014,)illustratedthatcloudcomputinghasemergedasoneoftheenablingtechnologiesthatallowsthebusinessandITworldtousecomputerresourceeffectivelyandmoreefficiently.Themainobjectiveofthis work istooutlinethestepsinvolvedindevelopinganddeployingapplicationsforMicrosoftAzureCloudPlatform.Italsoincludestheperformanceanalysis ofcloud hostingovertraditionalwebhosting.Thesampleapplicationisawebsite,designedusingtheMicrosoftVisualStudioenvironmentandutilizingopensource.NETtemplates;inordertoillustratetheservicesandfeaturesassociatedwithMicrosoft Azure Platform.

iii. SecuresharingofpersonalhealthrecordsinJelasticcloudbyAttributebasedencryption[21]

MaheswariSandUpendraGudla (2017)developed a system where they showedthatsecuresharingofpatienthealthrecordsinJelasticcloudprovidesthemorebenefitstothedataownersandendusers. Inthispaper,theyproposeanAttributebasedencryption(ABE)algorithmforencryptionanddecryptionofpatienthealthrecords.ThisalgorithmisencryptingthedatabeforestoringthePHRinformationtothecloudserver.Anddecryptthedatawhileretrievingfromserverbased on the attributeand access policygivenbyData owner.Buildingaspecializeddatacenter'sisverydifficulttaskandmaintenancecostalsoveryhigh.SharingthePHRApplicationinthethirdpartyserverraisesthesecurityandprivacyrisks.Notonlythis,forprovidingtheScalability,Loadbalancingandforeasymaintenancetotheapplication,theydeployedthePersonalhealthrecord'sapplicationintoJelasticcloudbytheuseofServantserver.

iv. Cloud AccessSecurity on File SystemUsingSecurePolicies forJelasticCloud[25]

PriyankaandRakesh (2013)designedandimplementedFADE,asecureoverlaycloudstoragesystemwhichisabletoachievefine-grained,policy-basedaccesscontrolandfileassureddeletion.Itassociatestheoutsourcedfileswithfileaccesspolicies,andassuredlydeletesfilestomakethemunrecoverablebyanyoneuponrevocationsoffileaccesspolicies.Forachievingsuchsecuritygoals,FADEisbuiltuponasetofcryptographickeyoperationsthatareself-maintainedbyaquorumofkeymanagersthatareindependentofthird-partyclouds.Particularly,FADEactsasanoverlaysystemwhichworksseamlesslyatoptoday'scloudstorageservices.Theyimplementedaproof-of-conceptprototypeofFADEJelastic,oneoftoday'scloudstorageservices.Theyconductedextensiveempiricalstudies,anddemonstratedthatFADEprovidessecurityprotectionforoutsourceddata,whileintroducingonlyminimalperformanceandmonetarycostoverhead.

v. SecurityIssues Involvedin Sharingof HealthcareInformation'sThroughCloud Storage[10]

P.Subhasri, Dr.A.Padampriya(2017)showedsomeimportant issues and proposed thattheevolutionofcloudcomputinginhealthcaremanagementsystemsprovidesbetterstorageandsharingofmedicalrecordsthroughthenetwork.Inhealthcaresystems,cloudnotonlyfacilitatestheexchangeofelectronicmedicalrecordsbutitalsoenablestosharethecontentsinasecuredway.Thestorageof HIS(HealthcareInformationSystems)incloudprovides greaterflexibilitybutatthesametimeithassecurityissues.Inthispaperthevariouschallengesinvolvedinsharinghealthcareinformationthroughcloudplatformisdescribed.Theissueassociatedwithsharingofinformationespecially medicalimagesthroughcloud,theexistingsolutionsanditslimitationsarealsodiscussed in this work.

vi. DynamicScalingofWebApplicationsinaVirtualizedCloudComputingEnvironment [29]

Trieu C. Chieu , Ajay Mohindra , Alexei A. Karve ,Alla S. (2009) proposed a model where they showed that scalabilityasacriticalissuetothesuccessofmanyenterprisescurrentlyinvolvedindoingbusinessonthewebandinprovidinginformationthatmayvarydrasticallyfromonetimetoanother.Maintainingsufficientresourcesjusttomeetpeakrequirementscanbecostly.Cloudcomputingprovidesapowerfulcomputing modelthatallowsusers toaccessresourceson-demand.Inthispaper,theydescribedan architectureforthedynamicscalingofwebapplicationsbasedonthresholdsinavirtualizedCloudComputingenvironment.Adynamicscalingalgorithmforautomatedprovisioningofvirtual machineresourcesbasedonthresholdnumberofactivesessionswillbeintroduced.Theon-demandcapabilityoftheCloudtorapidlyprovisionanddynamicallyallocateresources to userswill be discussed. Our workhasdemonstratedthecompellingbenefitsoftheCloudwh

Comment [DSA5]: You cannot classify your review like this. These are names of articles, books, etc. as seen in the references. In this case, you can say " Web applications Using Cloud Resources" and you review various related articles in the literature on Web applications Using Cloud Resources

Comment [DSA7]: You don't put a suffix in the in-text citation

Comment [DSA6]: Again, this is a reference. It's not a category or a theme for review. Please correct this. It's not acceptable.

ichiscapableofhandlingsuddenloadsurges,deliveringITresourceson-demandstousers,andmaintaininghigherresource utilization, thus reducinginfrastructureandmanagementcosts.

vii. ACloudComputingSolutionforPatient'sDataCollectioninHealthCare Institutions[5]

Carlos O. Rolim, Fernando L. Koch, Carlos B. Westphall, Jorge W., Armando F., Giovanni S Salvador (2010)proposedthatexistingprocessesforpatients'vitaldatacollectionrequireagreatdealoflaborworktocollect,inputandanalyzetheinformation.Theseprocessesareusuallyslowanderror prone,introducingalatencythatpreventsreal-timedataaccessibility.Thisscenariorestrainstheclinicaldiagnosticsandmonitoringcapabilities.Theyproposedasolutiontoautomatethisprocessbyusing"sensors"attachedtoexistingmedicalequipmentthatareinter-connectedtoexchangeservice.Theproposalisbasedontheconcepts ofutilitycomputingandwirelesssensornetworks.Theinformationbecomesavailableinthe"cloud"fromwhereitcanbeprocessedbyexpertsystemsand/ordistributedtomedicalstaff.Theproof-of-conceptdesignappliescommoditycomputingintegratedtolegacymedicaldevices,ensuringcosteffectivenessandsimpleintegration.

viii. Healthcare servicesin Cloud Computing[9]

LakshmiPKuchimanchi (2016) discussedthehealthcareservicesavailableinthenewconvergingtechnologycalledcloudcomputing.Thiscomputingtechnologyhadcraveditspathinthedesirablemarketfieldhealthcare.Thisstudyrepresentedanoverviewofthehealthcaretransformationofdifferentapproachesofcloudcomputingoverinformationtechnologyanditsstrategicusage.Furtherenhancingbetterhealthcaretoensurescalable,compatible functions supportingthewell-being,this studyalsoconsiders thetechniques of cloudcomputingand its application,advancement in healthcare.

ix. WebService-Based Trust Management in CloudEnvironments[18]

TalalH.NoorandQuanZ.Sheng (2014)explainedthattrustisoneofthemostconcernedobstacles for the adoptionandgrowth ofcloudcomputing [18].Althoughseveral solutionshavebeenproposedrecentlyinmanaging trustfeedbacksincloudenvironments,howtodeterminethecredibilityoftrustfeedbacksismostlyneglected.Inthispaper,theyproposedaframeworkthatuses webservicestoimprovewaysontrustmanagementincloudenvironments.Inparticular,theyintroducedanadaptivecredibilitymodelthatdistinguishesbetweencredibleandmaliciousfeedbacksbyconsideringthecloudserviceconsumers' capabilityandmajorityconsensusoftheirfeedbacks.Theyalsopresentedareplicationdeterminationmodelthatdynamicallydecidestheoptimalreplicanumberofthetrustmanagementservicesothatthetrustmanagementservicecanbealways maintainedatadesiredavailabilitylevel.Theapproacheshavebeenvalidatedbyaprototype systemandexperimentalresults.

x. MobileHealthcareInformationManagementutilizingCloud ComputingandAndroidOS[28]

Charalampos D., Thomas P., Ilias M. (2010) proposed a system prototype, where they discussed that cloudcomputingprovidesfunctionalityformanaginginformationdatainadistributed,ubiquitousandpervasivemannersupportingseveralplatforms,systemsandapplications [28].Thisworkpresentstheimplementationofamobilesystemthatenableselectronichealthcaredatastorage,updateandretrievalusingCloudComputing.Themobileapplicationisdevelopedusing Google'sAndroidoperatingsystemandprovidesmanagementofpatienthealthrecordsandmedicalimages(supportingDICOMformatandJPEG2000coding).Thedevelopedsystemhasbeenevaluatedusing theAmazon'sS3cloudservice.Thisarticlesummarizestheimplementationdetails and presents initial results of the system in practice.

xi. Mobile Cloud for AidingandHard-WearingHealthcare[16]

SekharT.S.,Kumar,D.K.(2010) stated an argument thatdeployingstate-of-the-arttechnologies is vitalandinevitablein assistivehealthcare tocopewithemergingservicessuchasremotemonitoring,collaborativeconsultation,andelectronichealthrecord [16].ThisworkproposesMobileCloudforAssistiveHealthcare(MoCAsH)asaninfrastructureforassistive healthcare. Besides inheritingtheadvantages of Cloud computing,MoCAsHembracesimportantconceptsofmobilesensing,activesensorrecords,andcollaborativeplanningbydeployingintelligentmobileagents,context-awaremiddleware,andcollaborativeprotocolforefficientresourcesharingandplanning.MoCAsHaddressessecurityandprivacyissuesbydeployingselectiveandfederatedP2PCloudtoprotectdata,preservedataownershipandstrengthenaspectsofsecurity.Italsoaddressesvariousquality-of-serviceissuesconcerningcriticalresponsesandenergyconsumption.

xii. Cloud Computing for EnhancedMobile Health Applications[22]

M.TNkosi,F.Mekuria (2010)explainedthatMobiledevicesarebeingconsideredasserviceplatformsformobilehealthinformationdelivery,accessandcommunication [22].Howevermobilesfacechallengeswithregardtodeliveringsecuremultimediabasedhealthservicesduetolimitations incomputationandpowersupply.Sincemobiledeviceshavelimitedcomputationalcapacityandrunonsmallbatteries;theyareunabletorunheavymultimedia&securityalgorithms.Inthispaperacloudcomputingframeworktorelievemobiledevic

esfromexecutingheaviermultimediaandsecurityalgorithm sindeliveringmobilehealthservicesisdescribed.Thepropos edframeworkusesaCloudComputingprotocolmanagemen tmodelwhichintendstoprovidemultimediasensorsignalpro cessing&securityasaservicetomobiledevices.Ourapproac hsuggeststhatmultimediaandsecurityoperationscanbeper formedinthecloud,allowingmobilehealthserviceproviderst osubscribeandextendthecapabilitiesoftheirmobilehealtha pplicationsbeyondtheexistingmobiledevicelimitations.

xiii. SecurityThreats and Challenges in CloudComputing[3]

Alshammari, A., Alhaidari, S., Alharbi, A., &Zohdy, M. (2017) discussed many important and latest issues in cloud computing and showed thatCloudComputinghasemergedasanewparadigmofcomp utingthatbuildsonthefoundationsofDistributedComputing,G ridComputing,andVirtualization [3].CloudcomputingisInternet-accessiblebusinessmodelwithflexibleresourceallocationon demand,andcomputingonapay-per-useasutilities.Cloudcomputinghasgrowntoprovideapromisi ngbusinessconceptforcomputinginfrastructure,whereconce rnsarebeginningtogrowabouthowsafeanenvironmentis.Sec urityisoneofthemajorissuesinthecloud-computingenvironment.Inthispaperweinvestigatesomeprim esecurityattacksandpossiblesolutionsforclouds:XMLSignat ureWrappingattacks,BrowserSecurity,andVendorLock-in.

xiv. PatientControlledEncryption:EnsuringPriv acyofElectronicMedicalRecords[1]

Benaloh, J., Chase, M., Horvitz, E., &Lauter, K. (2009)exploredthechallengeofpreservingpatients'privacy inelectronichealthrecordsystems.Theyproposedthatsecu rityinsuchsystemsshouldbeenforcedviaencryptionas well asaccess control [1].Furthermore, theystatedapproachesthatenablepatientstogenerateands toreencryptionkeys,sothatthepatients'privacyisprotecteds houldthehostdatacenterbecompromised.Thestandardarg umentagainstsuchanapproachisthatencryptionwouldinter ferewiththefunctionalityofthesystem.However, they showedthattheycanbuildanefficientsystemthatallowspati entsbothtosharepartialaccessrightswithothers,andtoperfo rmsearchesovertheirrecords.Theyformalizedtherequirem entsofaPatientCon-trolledEncryptionscheme,andgiveseveralinstantiations,b asedonexistingcryptographicprimitivesandprotocols,each achievingadifferentsetofproperties.

3. METHODOLOGY

TheproposedmodelconcentratesonprovidingSecurity,Pri vacy,Scalability,Loadbalancing,andEasymaintenancetot hepersonalhealthrecordsapplicationinthecloud.Theelabo rationofthesystemanditsdesignandarchitecture,illustratio noftoolsandmaterialsrequiredtoimplementthesystemandt heworkingprocedureofeachmodules comprisingthesystem are discussed in detail. Toimprovetheoverallconventionalmedicalrecordsystem, wehavedesignedaninteractive,labor-free,paper-lessdigitallymaintainedpatienthealthrecord(PHR)system which will provide benefits to both doctorsand patients to agreater extent.

3.1 Design

Theproposed patient health record application comprises of this two fields: Authority/Admin & Doctor (Or Hospital Authority). Inthis system,firstwehaveketptheregistrationprocesstoaccessthe PHRsystem.Theuser/doctorwillregisterfromthegivensignu poption.Thustheywillbeabletoaccess the PHR system. Afteraccessingtothesystem,doctorsoruserscandynamically create,read,updateanddeletetheirownpatients'healthrecor dswhichtheyhavecreated.Theycancheckpatients'medicalh istoryandallotherinformationpatientshaveprovidedtothem. Followingthis, theycan observe patients overall condition andgive treatment accordingly [8].Alltheinformationwillbereservedinthepatients'database andthusthereisnopossibilityoflosingmedicalrecordsorhavin gwrong,irrelevantinformation in the patient database. Figure1 belowgives an overview of the system.

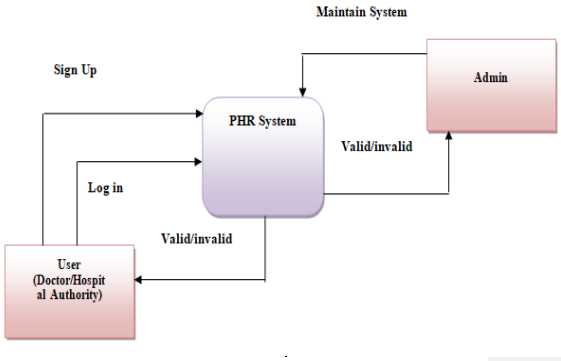

Figure1: Overall Structureof thePHR system

I) WorkflowDiagram

Thetotalsystemwillgivereliefttothepatientsfromkeepingpres criptionpapersorfearoflosingthem.ThePHRsystemwillbehig hlysecure.IfthereisInternetconnectioninthetargetarea,anyh ospitalauthorityordoctorcanaccessthePHRsystemfromany whereand be benefitted. Figure 2 depicts Work FlowDiagram of the PHR System. Fromthestructure of Work FlowDiagram of the PHR System,it isseenthatuserwillfirstloginorsignsuptotheadminpanelthrou ghprovidingtheirusernameandpasswordandfillupotherfield snecessarytoaccessthesystem.Afterloginorsignup,theywill accessthesystem.TheywillperformCRUD

(create,read,update,delete)operationonthedatabase.Any modificationofdatawillbedynamicallystoredinthedatabase. Eachuserwillmaintainandberesponsibleforhisowndatabas erecord.Thus,thePHRsystemwillbedoctor-centricandhighlyaspatientsdon'thavetoprovidehealthinfor mationontheir own and onlythe doctors or hospital authoritywillstore patients' information.

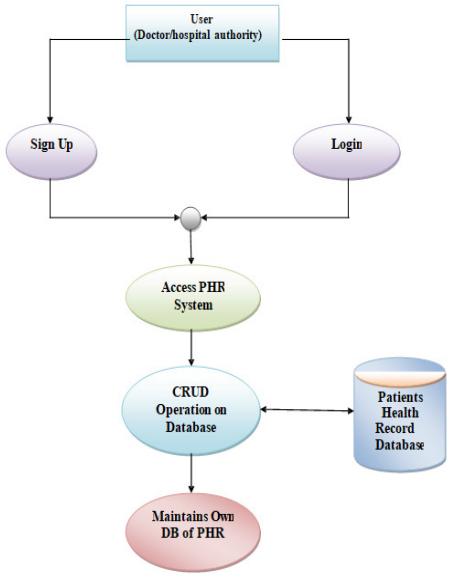

Figure2: Work FlowDiagram of the PHR System

3.2 Deployment in Jelastic Cloud

Afterwe havedevelopedtheinteractivePatientHealthRecord(PHR)a pplication,wewouldperformnecessarystepstodeployitinthe Jelasticcloudserver.Jelasticcloudprovidesuswithhighsecur ity,scalabilityandeasymaintenancetothePHRapplicationinc loud.JelasticCloudalsoprovidestheLoadbalancertoourappli cation.Itcaneasilyscalehorizontallyandvertically inthebothwayswheneveruser loadishigh [9].InordertodeploythePHRapplicationinthe Jelasticcloud,firstweneedtocreateappropriateenvironmentf ordeployingit.WewilluseInMotionhostingserver to create such environment. Wewill also use Nginxas our web server. Asseenfromfigure two,theusersaremarkedaseitherdoctorsoranyhospitalauth ority.They canaccessthesystem,viewandupdatetheirpatients'records. Aswediscussedbefore,thewholesystemishighlysecure.The PHRownermaintainsthesystem,performsanytasksnecessa rytoupdatethesystem.TheownerwilldeploythesystemintheJ elasticcloud [10].First,theownerwillmanagetheapplicationinordertomak eitcompatiblefordeploymentwiththehelpofInMotionHosting Serverandthendeployitinthecloud.Jelasticcloudwillprovide highsecurity,verticalandhorizontal scalability, load balancingto our PHR application. Next figure will show Architectureof PHR Application in Jelastic Cloud. Where two types of users (doctor and/or hospital authority) can log on the PHR system by using their credentials (user id, password, etc.) and it's a two way communication-authentication process. For authenticating the users, PHR system will verify the data with the stored data in InMotion hosting server. Then the users can upload their necessary data. After completing the data if all the information are correct and verified to be authentic then the data will be stored in the jelastic cloud and when user want to download/use the data they have to log on the system and download it.

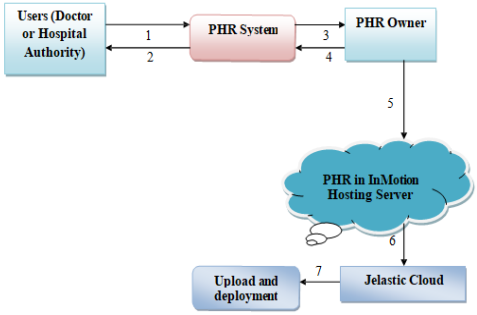

Figure 3: Architecture of PHR system

Next figure will show Jelastic Application deployment method. There are fourmethods for deploying filesin JelasticCloud. Among these four method second method is used for our work.

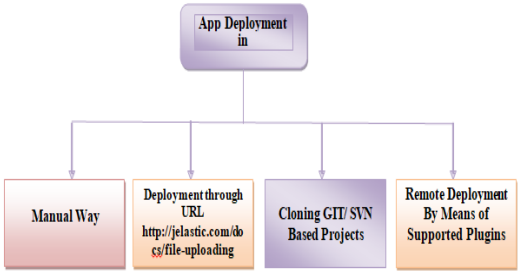

Figure 4: Jelastic ApplicationDeploymentMethods.

4. IMPLEMENTATION AND ANALYSIS

In this part implementation technique and the developed system is analyzed with necessary screenshots. As it's a pretty big system some screenshots are skipped. Following figure five show the LoginPage. For log in user have to insert there credentials like user name and password. But if the user is new then he/ she have to create account first

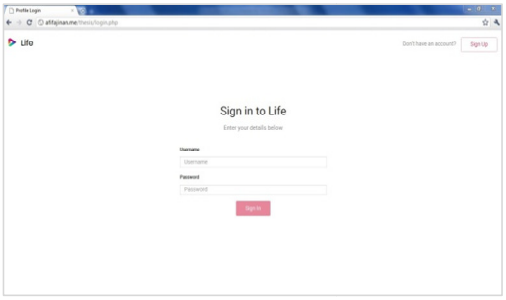

Figure 5: The LoginPage

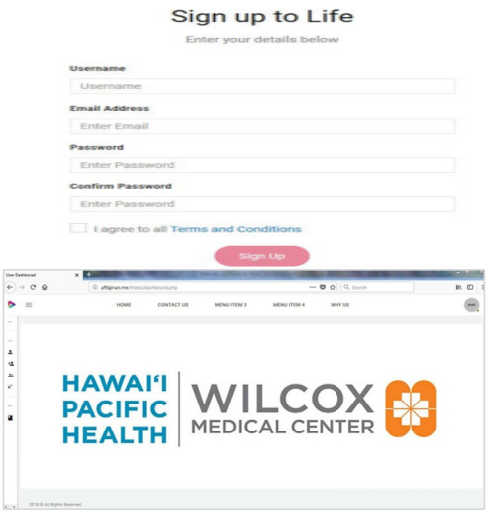

Figure6: The Sign upPage and IndexPage

Afterlogginginorsigningup,wegetthe indexpage like figure 6.Theindexpageprovidesanoverviewofthe PHRapplicationanduserscanstarttheirworkfromit.Theycangothrough patients'database,getanewformforstoringanewpatient' srecordandagaincomebacktotheindexpagesimplybyaccessingthesidebarprovidedinthepage.Theycanalsobeloggedoutfromtheapplicationbyclickingtheoption'LogOut' given in the top right corner.

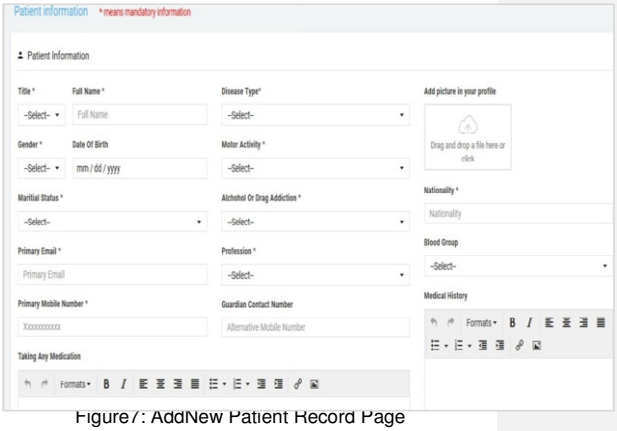

Figure7: AddNew Patient Record Page

Byaccessingthispage,usercanaddanewrecordofpatients' personalandhealthinformation (as figure 7).Theycancreateasmuchnewrecordsastheywant.Some mandatoryinformationaremarkedherewhichmustbeprovidedbythepatients.Afterallthe information hasbeen providedbythepatient, the recordwill be dynamicallystoredtothe database.

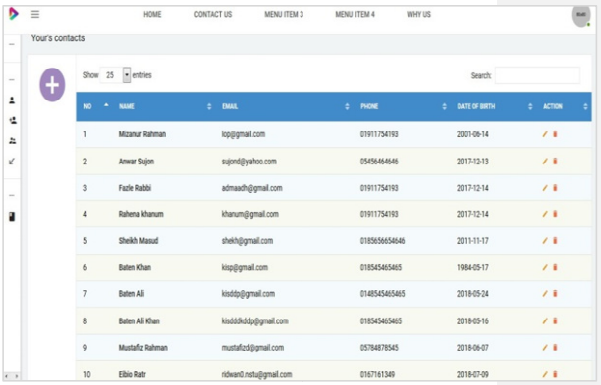

Figure8: Patient Health Record Database Page

Thispage(as figure 8)showsthedatabaseofthepatientsthattheusershavecreatedandstored.Thisdatabaseisdynamic,userscanupdate,deleteanyinformationfromthisdatabase.Whenuserscreate anewpatientrecord,therecordwillbedynamicallyaddedtothedatabase.Thereisalsoasearchbarontopofthepatientslistanduserscansearchby name,IDornumberforaquicksearchtothedatabaseand find aspecificpatient.

I) Update Patient HealthRecord Page

Userscanselectanyhealthrecordlistfromthedatabaseofthepatients'listandupdateexistinginformationthatpatientshaveprovidedearlier.Afteranymodificationofthehealthinformation,theupdatedrecordwillberestoredtothepatients' database of health records.

II) DeploymentProcesses inJelastic Cloud

AfterdevelopingthePHRapplication,wewouldproceedtodeployitintheJelasticcloud.Wehavecreatedappropriateenvironmentwiththehelpof InMotion Server to deployour PHR application. First,wehaveselectedthe"CloudJiffy"Jelasticserviceproviderfordeployment.CloudJiffyisIndiabasedfullyredundant,highperformanceandscalablecloud"Platform-as-a-Service(PaaS)"underJelasticCloudUnionwhichisamulti-cloudPaaS for developers which can be downloaded from the site (https://cloudJiffy.com)[11]

Thefollowingscreenshotsprovidesanoverviewoftheimplementationprocessthatwasperformedstepbystepinordertodeploythe PHRapplicationintheJelasticCloud Jiffyserver:

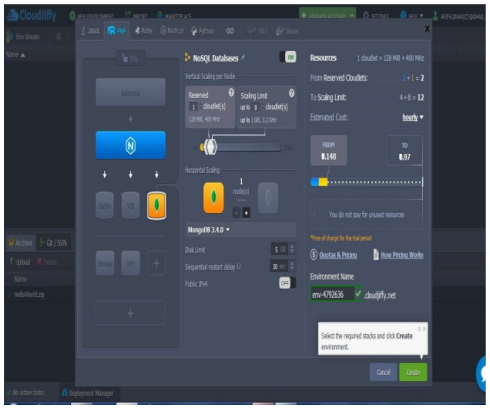

Figure9: JelasticCloudJiffyUser Dashboard

Aftersigninguptothesystem,wehavetheuserdashboardareatoperformourtasksasshowninthefigureabove.Inthedashboardarea,wehavetoselectPHPenvironment,Apacheserver,verticalandhorizontalscalingasperourneeds,chooseasmanycloudletsasrequireduptotwelve.Wegiveanenvironmentnameand finallycreate anenvironment in the cloud. Then we have to create Environment for DeployingPHR Application.

Afterwehaveselectednecessaryinstallationsandserverrequirementstocreateanenvironmentinthecloudserver,wegetanoverviewasshowninthefigureabovewhichshowsusthatanenvironmentnamedafifahasbeencreatedinthecloudserver.Anotificationnamed'Running'alsoshowsusthatthisenvironmentis currentlyrunningamongseveral others.

III) ApplicationUpload

The following screenshotcomesupwiththeuploadingprocessforPHRfileinthecloud.Firstwehavetouploadthe PHRfileinthecloud inzippedformatinordertodeployit later. We have selected theURLand drop the link and leavea comment [12].

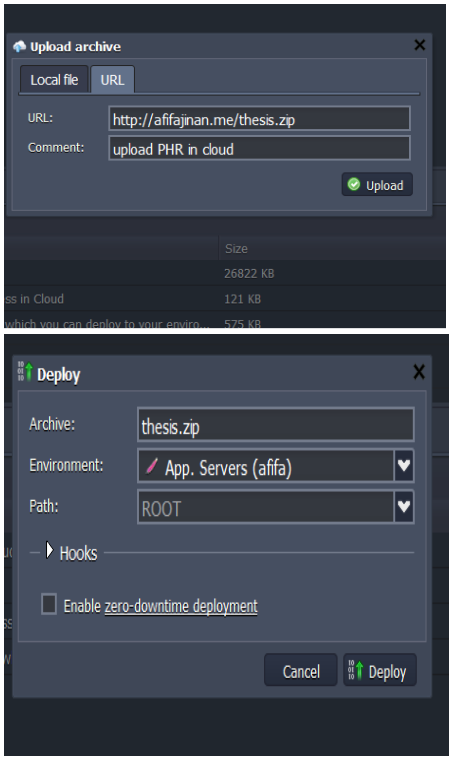

Figure10: Uploading&DeployingPHR application in JelasticCloudJiffy

WehavesuccessfullydeployedourPHRapplicationintheJelasticCloudJiffyserver.WehaveexportedthePHRdatabasefromthehostingservertothecloudenvironmentandmakesomenecessarychangesinthecloudandfinallydeployeditinthecloud.Ourapplicationisworkingfineinthe CloudJiffyserver.ThedeployedPHRapplicationwillbehighlysecure,scalableandloadbalancingwillalso be maintained in this server.

We can access theapplication from the link givenbelow:

For registered user:

node6314-afifa.cloudjiffy.net/project/login.php

For unregistered user:

node6314-afifa.cloudjiffy.net/project/signup.php

IV) Security Implementation

As our system is developed as a prototype here some common and easily available security measures are used[30].All data of the system are sent as zip files and encrypted with a password. To accomplish this password purpose B1 Free Archiver a free multiplatform compression tool is used. For creating the archive just need to check the "Protect with a password" option from the menu, type in the password and only after that the zipped and secured file can be moved to the cloud[32]. Then for some cases the password can be shared with the admin. Note that B1 Free Archiver zips files only in B1 format which makes the overall protection of patient health recordmore reliable. The only software that opens B1 files is B1 Free Archiver, therefore it is not possible to open any B1 archive, even one that isn't password-protected, without this utility. B1 encrypted archives appear to be safer and secure than the usual zip files. Beside password protection a higher level protection for all sensitive information of the system, an open source encryption software TrueCrypt is used[31]. This software creates encrypted file of system information that needed to be kept in the cloud like virtual disk and protected with password. In TrueCrypt AES algorithm is used for encrypting the information. But it is also possible to use Serpent, Twofish etc. for the encryption purpose. As Jelastic Multi-Cloud DevOps PaaS has a built in security measure Shield 5.4, within this release, the platform was upgraded with a new firewall management system, private network isolation and a set of other features demanded by customers. This shield can manage inbound and outbound firewall rules on the container level through a convenient graphical interface. A number of default rules are automatically added to the inbound section to make the node operable. As shown in figure 11, whenever the data from cloud is used the firewall state will be on for security insurance. All the inbound connections are denied by default according to jelastic cloud traffic rules, so that the data stored in the cloud cannot be captured by someone else rather than intended user. And “inbound traffic rules” are set before the system operation. And in case of outbound connections by default all are allowed except those are not allowed according to the rules set (figure 11). Also, automatic network isolation is implemented to prohibit any unallowed connections between different environments. This results in another essential newly added possibility to create secure environment groups, intended to isolate environments of a single account from each other. Platform automatically creates a dedicated IP set for each isolated group, which is composed of the appropriate containers internal addresses. This allows controlling access between nodes of each environment. In figure 12 the group creation is shown. Where some credentials name, parent group and environment must be put and network isolation must be on.

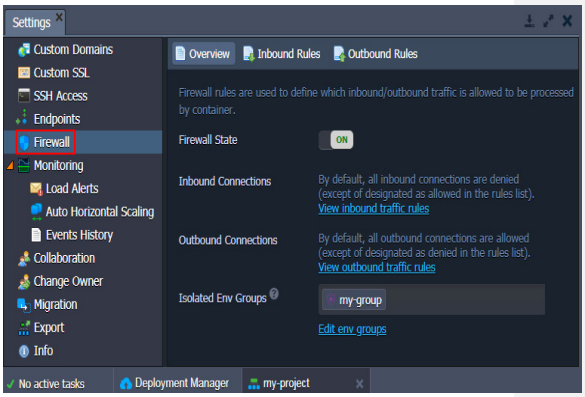

Figure 11: Option of inbound and outbound firewall rules.

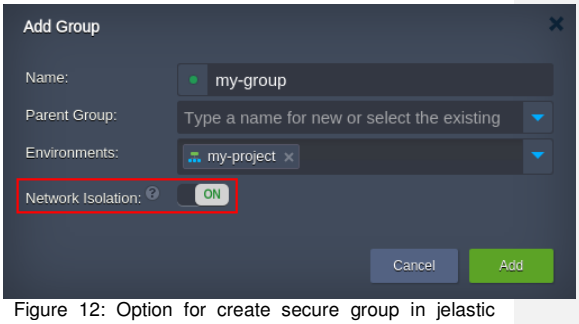

Figure 12: Option for create secure group in jelastic cloud.

In confines of Jelastic Shield version, there were added a number of other demanded features and improvements, among them[33]:

- Extra Environment Layers for All Supported Middleware Stacks.
- Go Language Support via a Specially Packaged Middleware Container.
- Webhooks for Application Build and Deploy Operations.
- Built-In Web SSH Console.
- HTTP 2.0 Support for Jelastic Shared and Dedicated Load Balancers.
- UI/UX Improvements.
- Deployment Improvements.
- Cloud Scripting Engine Optimization for Improved Serverless User Experience.

And in future other high level security algorithms will be implemented for more secure sharing of the patient health record and other information.

5. CONCLUSION AND FUTURE SCOPE

Thisthesisworkfocusesonsecuresharingofpatienthealthrecordsin Jelasticcloud.Wehavedevelopedaninteractive,efficientPHRschemewhichisdynamic,highlysecureanduser-friendly.Multipledoctorsorhospitalauthoritiescanaccessthesystemandhavepersonalaccountswheretheywillstoretheirownpatients'healthinformation.Asthedoctororthehospitalauthorityistheonlyresponsiblepersonorentityforpreserving patients'healthinformation,there isnochanceofprovidinganywronginformationandtherecordsarehighlysecureandkeptconfidential.Thepatientsoftenprovidewronginformationwhentheyarechosentoprovideontheirown.Patienthealthrecordsecurityiscrucialespeciallyforthepro minentfiguresofthecountryorsocietysuchaspoliticians,socialfigures, eminent personswho playamajorroleinsocietyandcountrygovernance.Anyexposureofimpressionablepasthistoryrevolvingmedicalrecordscancreateanunrestsituationinthesociety.Preservingmedicalrecordsofcriminalsisalsoimportantincrimeinvestigation,NationalDefenseandIntelligencedepartments.So,theapplicationthatwehavecreatedwillpreservepatients'healthrecordsinahighlysecurewayandthus the societywill bebenefitted.

Future Scope

The proposedsystemworksondevelopinganefficientpatienthealthrecordschemethatprovideseasy,labor-freerecordofpatienthealthdataelectronically.Itwillserveasaneffectivewayforrecordingpatients'healthhistory,current recordsandthuswilllessendoctors'efforttoagreaterextent. PHRsecurityisamajorissueindevelopedcountriesandsoonitwillemergeinBangladesh too.Currentlywearewokingondevelopingasecurityschemetopreserveandmaintainpatienthealthrecordusingsecure algorithm like AttributeBasedEncryption(ABE)and Truecrypt/ BitLocker finallydeployitonJelasticcloud.ABEisahighlysecurealgorithmforencryptingdataandwewishtoapplyittoourPHRinformationbeforeoutsourcingit to thecloud in nearfuture.

REFERRENCES

[1] Benaloh, J et al., "**Patient controlled encryption: ensuring privacy of electronic medical records**", Proceedings of the 2009 ACM workshop on Cloud computing security (pp. 103-114; 2009, November). http://www.enggjournals.com/ijet/docs/IJET17-09-05-324.pdf , accessed on 13.11.2017

[2] Adrian Bridgwater, "**Java Hosting Platform Jelastic Adds NGINX"**, Dr. Dobb's Journal. Archived from *the original* on September 1, 2015 http://www.drdobbs.com/opensource/javahostingplatform-jelastic-adds- ngin/231901927, accessed on 14.11.2017

[3] Alshammari, A et al., "**Security Threatsand Challenges in Cloud Computing**" 4th International Conference on Cyber Security and Cloud Computing (CSCloud) (pp. 46-51), (2017, June). IEEE. https://ieeexplore.ieee.org/document/7987175, accessed on 10.12.2017

[4] Bangladesh Health Facility Survey, 2014.National Institute of Population Research and Training (NIPORT) ,Ministry of Health and Family Welfare, **"AWS vs. Azure vs. Jelastic in Wordpress Development"** https://blogi.datacenter.fi, accessed on 18.12.2017

[5] Carlos O. Rolim, et al., **"A Cloud Computing Solution for Patient's Data Collection in Health Care Institutions"** 2010 Second International Conference on eHealth, Telemedicine, and Social Medicine https://ieeexplore.ieee.org/document/5432853 accessed on 28.12.2017

[6] Alejandre F., **"Secure exchange of information in electronic health records."** https://ro.uow.edu.au/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=4308&context=theses, accessed on 01.01.2018

[7] Shuo L. et al., **"Implementing Web-based e-Health Portal Systems."** https://www.albany.edu/faculty/hong/pub/eHealthPortal.pdf , accessed on 01.01.2018

[8] Huang, C. et al **"Efficient anonymous attribute-based encryption with access policy hidden for cloud computing."** In Progress in Informatics & Computing (PIC), 2017, December International Conference on (pp. 266-270). IEEE. https://ieeexplore.ieee.org/document/8359555, accessed on 05.01.2018

[9] Kuchimanchi, L. P. (2016). **"Healthcare Services In Cloud Computing"** https://www.researchgate.net/publication/309088652_ accessed on 09.01.2018

[10] Subhasri, P., &Padampriya, "**A Security Issues involved in sharing of Healthcare Information's Through Cloud Storage**" http://www.enggjournals.com/ijet/docs/IJET17-09-05-324.pdf, ISSN (Print) : 2319-8613 accessed on 13.01.2018

[11] Waters, B. (2011, March), "**Ciphertext-policy attribute-based encryption: An expressive, efficient, and provably secure realization."** In *International Workshop on Public Key Cryptography* (pp. 53-70)https://eprint.iacr.org/2008/290.pdf. Springer, Berlin, Heidelberg. accessed on 18.01.2018

[12] **Multi cloud Pass for developers.** https://jelastic.cloud/ accessed on 19.01.2018

[13] Zavattoni,E.,Perez, et al. " **Softwareimplementationofanattribute-basedencryptionscheme".** IEEETransactionsonComputers, Volume 64 Issue 5 , 1429-1441. (2015). https://ieeexplore.ieee.org/document/6827966 accessed on 22.01.2018

[14] Huth, A., &Cebula, J., "**The basics of cloud computing"** https://www.us-cert.gov/sites/default/files/publications/CloudComputingHuthCebula.pdf accessed on 25.01.2018

Comment [DSA8]: Remove

[15] Khandelwal, P., & Sharma, R.. "**Cloud Access Security On File System Using Secure Policies For Jelastic Cloud".** International Journal of Computer Applications in Engineering Sciences, 3(4), 136. (2013) accessed on 26.01.2018

[16] Sekhar, T.S.,&Kumar,D.K.(2010**), "MobileCloudforAidingandHard-wearingHealthcare".** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3892841/ accessed on 31.01.2018

[17] Rolim,C.O.,et al., " **Acloudcomputingsolutionforpatient'sdatacollectioninhealthcareinstitutions"** IneHealth,Telemedicine,andSocialMedicine,2010.ETELEMED'10.SecondInternationalConferenceon(pp. 95-99).IEEE. (2010,February). https://ieeexplore.ieee.org/document/5432853 accessed on 02.02.2018

[18] Noor,T.H.,&Sheng,Q.Z." **Webservice-basedtrustmanagementincloudenvironments".**

In*AdvancedWebServices*(pp.101-120).Springer,NewYork,NY(2014).https://link.Springer .com/Chapter /10.1007/978-1-4614-7535-4_5 accessed on 05.02.2018

[19] Mell, P., &Grance, T. (2011**). "TheNIST definition of cloudcomputing"** https://dl.acm.org/citation.cfm?id=2206223 accessed on 02.02.2018.

[20] Mangla,N., et al., **"Improvingperformanceofwebapplicationsusing cloudresources".** In Reliability,Infocom TechnologiesandOptimization(ICRITO) (TrendsandFutureDirections),2014 3rd InternationalConference on(pp. 1-6).IEEE (2014,October). https://ieeexplore.ieee.org/document/7014765accessed on 06.02.2018.

[21] Maheswari,S.,&Gudla,U.**" Securesharingofpersonalhealthrecordsin Jelasticcloudbyattributebasedencryption".** In*AdvancedComputingandCommunicationSystems(ICACCS),20174thInternationalConferenceon*(pp. 1-4).IEEE. (2017,January), accessed on 07.02.2018.

[22] M.T. Nkosi ; F.Mekuria**"Cloud Computingfor Enhanced Mobile HealthApplications**". IEEE Second International Conference on Cloud Computing Technology and Science, 2010 https://ieeexplore.ieee.org/document/5708511 accessed on 09.02.2018

[23] Li, M.,et al **"Scalableandsecure sharingofpersonalhealthrecordsincloudcomputingusingattribute-basedencryption"**

IEEEtransactionsonparallelanddistributedsystems,24(1),131-143, (2013). accessed on 09.02.2018

[24] Mazhar A. et al., **"Security in cloud computing: Opportunities and challenges"** https://www.sciencedirect.com/science/article/pii/S0020025515000638 accessed on 09.02.2018

[25] Khandelwal,P.,&Sharma,R." **CloudAccessSecurity OnFileSystemUsingSecurePoliciesForJelasticCloud".** InternationalJournalofComputerApplicationsinEngineering Sciences,3(4), 136. (2013), accessed on 10.02.2018

[26] Ming L. et al., **"ScalableandSecureSharingofPersonalHealthRecordsinCloudComputingusing Attribute-basedEncryption".** IEEE Transactions on Parallel and Distributed Systems https://ieeexplore.ieee.org/abstract/document/6171175, accessed on 10.02.2018

[27] **"Cloud Hosting Platform for Developers".**https://jelastic.com/whitepapers/cloud-hosting-platform-for-developers/, accessed on 11.02.2018

[28] Charalampos D. **et al., "Mobile healthcare information management utilizing Cloud Computing and Android OS"** https://ieeexplore.ieee.org/document/5628061 accessed on 12.02.2018

[29] Trieu C. Chieu et al., "**Dynamic Scaling of Web Applications in a Virtualized Cloud Computing Environment".** https://ieeexplore.ieee.org/document/5342101 accessed on 12.02.2018

[30] **"Tips to Keep Your Data Secure on the Cloud"** https://www.cio.com/article/2380182/cloud-security/5-tips-to-keep-your-data-secure-on-the-cloud.html accessed on 12.02.2018

[31] '**TrueCrypt, Migrating from TrueCrypt to BitLocker"** http://truecrypt.sourceforge.net/ accessed on 18.02.2018

[32] **"Study of b1"** https://b1.org/ accessed on 19.02.2018

[33] https://jelastic.com/blog/cloud-protection-with-firewall-management-and-private-network-isolation-shield-54/ accessed on 28.02.2018

[34] https://electronichealthreporter.com/healthcare-will-invest-5-4-billion-in-cloud-computing-by-2017/ accessed on 28.02.2018