A Centralized Health Information System: Effective tool for health record Management

Solomon T. Adagba

Abstract— The process of keeping patient information in different health facilities in a particular country leads to data redundancy, and also affects the time it takes a physician to attend to a patient when they first visit. This work attempt to build a data model where a country can save all its patient record in what is referred to as a centralize electronic medical record, using Microsoft Azure Cosmos DB. Azure Cosmos DB provides the ability to embed data into one single file called JSON with the simplicity to read and write data, and allows such data to be replicated in other regions where intended users can access it..

Index Terms— Cosmos DB, Electronic Medical Record, Health Record.

1 Introduction

Experience has shown that health records of patients are been collected at different health centres at different intervals. Each time a patient visits a new health center or a case is being transferred to another health institution, the patient health information is recorded over again in a process often refer to as file opening in Nigeria. To many health facilities, like those in Nigeria this process is a way of generating revenue for the health centre but in ideal sense, it is just a repetition of information. In addition to information repetition, a lot of time and energy is taken to record this information. Often times, this is done before the patient is attended to by a doctor. If a patient is in a critical condition, then the time it takes in writing information in the file endangers the patient's life. It is in this perspective that the study of [1] postulate that one of the multiple agendas of the healthcare reform movement is the development of a universal system of electronic medical records (EMR) that would allow access to patient information at every potential venue of care while still providing privacy, security, and autonomy of patient information. A related work of [2] opined that there has been a global move to digitise health systems and data over recent years to improve the way clinicians access accurate health information at the point of care. The actualization of these important calls in working with digital health information records will benefit both health institutions and patients as well, owing to their robustness and timely provision of access to data, and this is also echoed by [3] who revealed that the Institute of Medicine and others have suggested that the wide-scale adoption of the EHRs could be pivotal for improving patient safety and health care quality. .

The importance of timely access to patient health information streamlined in a single digital file is significant in a universal EMR system. An EMR system implemented at every medical center will not be much different from the traditional way of keeping medical records. A doctor willing to maintain the general practise which requires that a Doctor thoroughly looks at a patient record at different instances to have a clear view and understanding of a situation, will have to access all EMR systems of the medical centres the patient have visited. The delay in accessing repeated patient health information in different EMR system makes the system ineffective and minimized the time doctors spent on the patients, a view supported by [4] beyond the physical challenge of handling that volume of paper, reliance on paper files and charts often means that the amount and quality of time spent with patients is diminished. A centralized health information system function as a distributed database, which depends on a central Database Management System that manages all its different storage remotely, without having to essentially install the database in the same physical or geographical location. The implementation of an EMR as a distributed database system eliminate data redundancy and minimize the time taking to access patient health information at different medical center.the article is being submitted to and the manuscript identification number. Click the forward arrow in the pop-up tool bar to modify the header or footer on subsequent pages.

This study is aim at developing a data model that provides the universe with system that allows each country to integrate their EMRs into a Centralized Health Information System. The proposed system offers better resource management that increase commercial efficiency and improve processes, service delivery, patient relationships, capital expenditure and above all, profitability and shareholder value.

1.1 Statement of Problem

i. Poor health care productivity and increase in the cost and time in documentation, scheduling appointments and to store records manually.
ii. Increase in data redundancy as a result of different EMRs at various Medical centres within a country.
iii. Diminished the time spent on a patient due to the time taken to access several different EMRs a patient has visited.
iv. To achieve reliable database performance over multiple geographic regions is very difficult especially for relational databases system.

2 Related Work

In [5] Electronic Medical Records, or EMR in simple terms, is a computerized medical record created in an organization that

delivers patient care. This is a legal document and is owned by the health care delivery institutions. With the advance of technology and its ability to simplify processes for operation, health facilities are taking advantage of this technological advancement by automating the processes of medical data collection, storage and dissemination. To this effect, several countries have now called for the implementation of their EMRs. [6] Revealed that several industrialized nations such as Canada, United Kingdom, and the United States of America have either implemented or are in the process of implementing an EHR system because of its possible benefits.

According to [7] The Government of the Northwest Territories is working on adopting one EMR system for the territories such that no matter where a patient goes within the territories, their primary health care data will be accessible to the treating physician or nurse. The study of [8] shows that the U.S. government created a plan to adopt health information technology (IT) in the 2009 Health Information Technology for Economic and Clinical Health Act (HITECH Act). The ultimate plan mandated building a nationwide health information communication infrastructure. From the HITECH Act, 'Meaningful Use' requirements were established with financial incentives to encourage healthcare organizations and providers to adopt the usage of Electronic Health Records (EHRs). In a bid to ascertain readiness in the implementation of EMR in Ethiopia, [9] conducted a study involving 606 participants from January to July 2013 at 3 hospitals in northwest Ethiopia; the result shows that the overall health professionals' readiness for electronic medical record system and utilization was 54.1% and 46.5%, respectively. The statistics again shows just how even third world countries are ready to utilize the technological advancement to incorporate EMR into their health system. [10] Assert that Haiti has a national EMR in use in more than 100 sites and housing records for more than 750 000 patients. The story is not different from the Kenyan government, working with international partners and local organizations developed an eHealth strategy, specified standards, and guidelines for electronic health record adoption in public hospitals [11].

Following this trend, one can estimate that by the year 2030 all the countries of the world must have implemented their EMR. This is noticeable in a presentation made by [12] who in expressing the importance of new technological innovations, opined that in achieving the vision for a digitally-enabled public health system accordance with WA Health Digital Strategy 2020–2030, EMR will be the foundation of one of those innovations Health Digital Strategy 2020–2030 promise to offer. As interesting as this is, without a central EMR system for each country at the speculated time of 2020-2030, there will only be but a duplication of effort. Several studies have discussed about the implementation as well as the barriers accruing to the adoption of EMR but few have offered any solution or method of implementing a central EMR system. The Microsoft HealthVault initiative and Google Health, sometimes refers to as personal health record had their own limitations, [1] posits that Microsoft model creates a platform for uniform EMRs and positions them as a personal health information system that is not physician-managed, Physicians have a central role in the use of the EMRs, as they are the ones who provide much of the information that the systems handle in their automated processes [13], and Google Health was discontinued in 2011. With the discontinuation of Google Health and the limitations of Microsoft's Health Vault, this study comes handy to provide us with a system that strives to meet all the limitations of the past effort; it takes advantage of new technologies such as Microsoft Azure using features like Cosmos database to implement a system with a long-life span. Microsoft Azure Cosmos DB is Microsoft's globally distributed multi-model database service. The service is understandably designed to enable clients to elastically and horizontally scale both throughput and storage across any number of geographical regions, it offers guaranteed <10 ms latencies at the 99th percentile, 99.99% high availability and five well defined consistency models to developers [14].

3 METHODOLOGY

In this study, we took a build methodology approach using Azure Cosmos DB to build an electronic data model for physicians and patients, with a more intelligent and responsive globally distributed serverless capability. According to [15] Cosmos DB is a powerful database as a service system designed to support a variety of data models and work across multiple geographic regions. The Azure Cosmos DB is developed button-up with global distribution and horizontal scale as its foundation. The service provides turnkey global distribution across a good number of Azure regions by transparently scaling and replicating data wherever users are. In addition, it offers the ability to elastically scale throughput and storage worldwide [16].

To build the centralized electronic medical record data model, we first consider the model's data structure access pattern. In general, according to Microsoft documentation, when developing or designing a data model using Microsoft Azure Cosmos DB, it's important to understand which requests the model will have to serve to make sure that the model will serve those requests efficiently. In our case, we are looking at patient medical data, including the patient's medical history and physician who attend to the patient. Henceforth, modelling the same data using Azure Cosmos DB, we consider the data structure of a patient/physician.

To represent the said structure as our electronic medical record model, we created a Cosmos DB account by signing in to the Azure portal. We Select Create a resource > Databases > Azure Cosmos DB. On the Create Azure Cosmos DB Account page, we entered the basic settings for the new Azure Cosmos DB account. We then created our database and named it "centralizedEMR", following that we created a Container with the name "emr" portioned by country. The essence of partitioning by country is to show that each country can have their own individual emr. With the database and the container set up, using the Data Explorer menu, we expand the centralizedEMR database; next we expanded the Items container and selected

Items, the select New Item window now open for us to add the patient/physician structure to the container, this process means that we are writing data into our database.

Patient/Physician Data Structure


```
{
   "id": "1",
   "firstName": "Solomon",
   "middleName": "Terkimbi",
   "lastName": "Adagba",
   "DOB": 12-11-1980,
   "Age": 39,
   "Sex": "Male",
   "MaritalStatus":"Male",
   "RegDate": "2017-08-28",
   "country": "Nigeria",
   "addresses": [
      {
         "line1": "Km 7 Aliade Road",
         "line2": "Kanshio Village",
         "city": "Makurdi",
         "state": "Benue",
               "country": "Nigeria",
         "zip": 98012
      }
   ],
   "contactDetails": [
      {"email": "adagbater@yahoo.com"},
      {"phone": "+234 o7031634673", "extension": 044}
   ],
{
   "id": "1",
   "country":"Nigeria",
   "firstName": "Solomon",
   "middleName": "Terkimbi",
   "lastName": "Adagba",
   "DOB": "12-11-1980",
   "Age": 39,
   "Sex": "Male",
   "MaritalStatus":"Male",
   "RegDate": "2017-08-28",
   "addresses": [
      {
         "line1": "Km 7 Aliade Road",
         "line2": "Kanshio Village",
         "city": "Makurdi",
         "state": "Benue",
               "country": "Nigeria",
         "zip": 98012
      }
   ],
   "contactDetails": [
      {"email": "adagbater@yahoo.com"},
      {"phone": "+234 o7031634673"}
   ],
   "PatientEmployer":"Benue State Government",
"EmergencyContact":[
      {
         "name": "Josephine",
         "relationship": "sister",
         "mobileNum": "+2340835424140",
         "address": "Behind modern makurdi makurdi"
      }
   ],
   "MedicalHistory":[
      {
            "PastMedicalCondition":"Pelvic Ulcer",
         "RegularMedication":"Prescription from doctor",
         "DoctorName":"Dr. Audu",
         "DoctorPhone":"07031634673",
         "medicareNumber":"000854",
         "lastMedicalFacility":"Federal Medical Center, Makurdi",
         "lastAppointmentDate":"2017-08-28"
      }
   ],

   "newObervation":[
      {
            "observation":"Patient has minor ulcer",
         "medication":"gelosine thrice a day",
            "NameofDoctor":"Dr. Vikram",
            "doctorPhone":"07031634673",
         "MedicalFacility":"Indian Specialist Hospital, Delhi",
            "ObservationDate":"2019-08-28",
         "NextAppointmentDate":"2020-08-28"
      }
   ]
}
```


Considering the above model, we have de-normalized the patient/physician data, by embedding all the demographic and health information related to a patient as well as some information about the physician who attended to the patient. The entire information is integrated into one single JSON document, unlike in relational data modelling, where these data would have been broken down into numerous tables. Furthermore, owing to the fact that in Cosmos DB, the model is not confined to a defined schema, hence, we are presented with the flexibility to store data in different shapes. Retrieving a complete patient record from the model is possible with a single read operation against emr container and for a single item. In addition, updating a patient record, with their medical history, contact details and addresses, is also possible with a single write operation against the single item. The advantage of de-normalizing data, in our model is that with few lines of queries we are able to achieve difficult task in a limited time.

4 Result and Discussions

Azure Cosmos DB can be accessed by using five different APIs which are:

i. MongoDB API
ii. Table API
iii. Gremlin API

iv. Apache Cassandra API
v. SQL API

In this paper, the SQL API is used to access our model. The SQL API in Azure Cosmos DB is a JavaScript and JavaScript Object Notation (JSON) native API based on the Azure Cosmos DB database engine. The SQL API also provides query capabilities rooted in the familiar SQL query language. With the SQL statement "SELECT * FROM c" we can read the entire data in our model as shown in the diagram below:

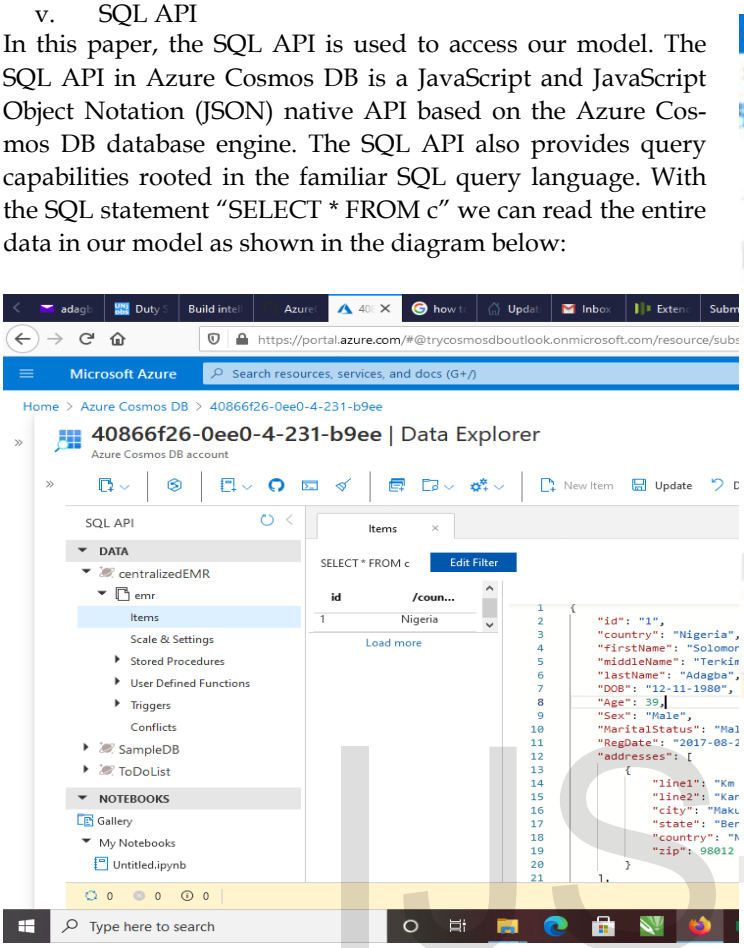

Figure 1. Read statement in Azure Coamos DB displaying patient record

To update data, we simply select the document within the collection (emr) through the interface and update the fields and information directly and click on the update button.

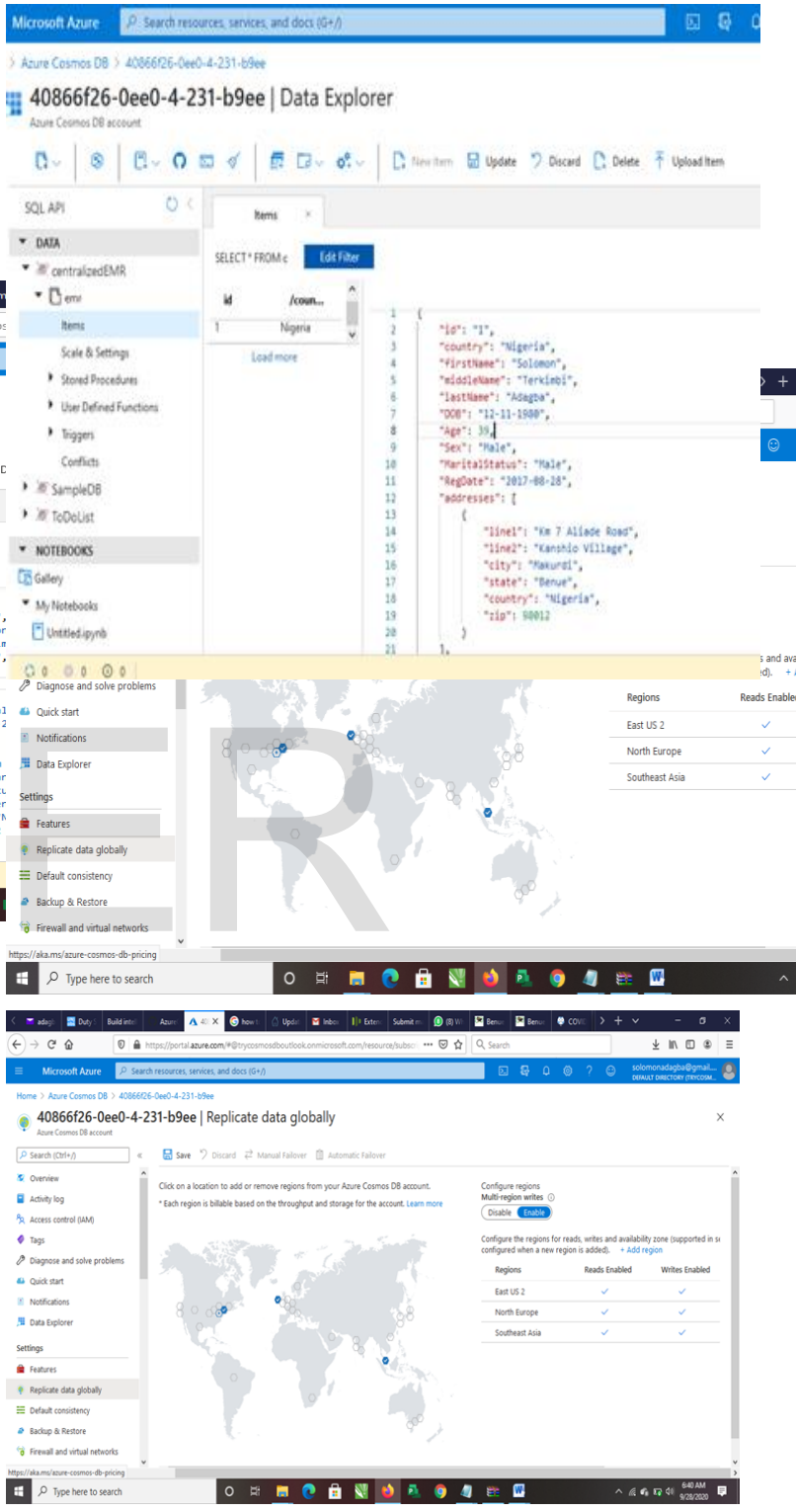

Figure 3. Global Replication of Patient data across three regions

6 Conclusion and Future Work

The data model presented in this work can be adopted by other countries; hence, we will have a common electronic medical

record for each country. The adoption of this model will eliminate data redundancy and facilitate health information management, ensuring physician spend quality time on patients because they are able to access patient information at any time, from anywhere. The Azure Cosmos DB used in this work offers the capability of transparently replicating patient data to all regions associated with each country's account.

In addition, Azure Cosmos DB provides transparent regional failover with multi-homing APIs, and the ability to elastically scale throughput and storage across the universe. This paper also demonstrated how Azure Cosmos DB offers excellent options for scalability, performance, and simplicity that are difficult to address with traditional relational databases.

This work was limited to the development of a data model due to time and limited resources, especially with the Microsoft Azure Cosmos DB subscription. Further research work can be done on developing the frontend of this model where user can interact freely with the model through a graphical user interface.

REFERENCES

[1] A. S. Charles, "Developing universal electronic medical records," Gastroenterology & Hepatology vol. 4, 3, pp. 193-5, Mar. 2008. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3088297/. [Accessed: Sept. 24, 2019].

[2] M. Makeham, "My Health Record: Connecting Australians with their own health information," Health Information Management Journal, 48(3), 113–115, Sept. 6, 2019. [Online]. Available: https://journals.sagepub.com/doi/full/10.1177/1833358319841511#articleCitationDownloadContainer doi:10.1177/1833358319841511. [Accessed: Nov. 11, 2019].

[3] A. Sima, and T. Bagheri-Tadi, "Barriers for Adopting Electronic Health Records (EHRs) by Physicians," Journal of the Society for Medical Informatics of Bosnia & Herzegovina : vol. 21,2 (2013): 129-34. doi:10.5455/aim.2013.21.129-134

[4] J. Stausberg, et al, "Comparing paper-based with electronic patient records: lessons learned during a study on diagnosis and procedure codes," Journal of the American Medical Informatics Association : JAMIA vol. 10,5 (2003): 470-7. doi:10.1197/jamia.M1290

[5] Healthcare informatics online. Electronic patient records. EMRs and EHRs. [Last accessed on 2019 Nov 30]. Available from: Http://www.providersedge.com/ehdocs/ehr_articles/Electronic_Patient_Records-EMRs_and_EHRs.pdf .

[6] F. F. Odekunle, R. O. Odekunle, & S. Shankar, "Why sub-Saharan Africa lags in electronic health record adoption and possible strategies to increase its adoption in this region," International journal of health sciences, vol. 11,4 (2017): 59-64. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5654179/

[7] A. Hoechsmann, "Centralized electronic health records benefit emergency medicine," CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne: vol. 184,1 (2012): 74. doi:10.1503/cmaj.112-2004

[8] H. Wu, and E.M. LaRue, "Linking the health data system in the U.S.: Challenges to the benefits," International Journal of Nursing Sciences, 4 (2017) 410e417, Nov. 11, 2019. [Online]. Available: https://www.sciencedirect.com › science › article › pii

[9] S. Biruk, T.Yilma,M. Andualem & B. Tilahun.(2014,Dec. 12). Health Professionals' readiness to implement electronic medical record system at three hospitals in Ethiopia: a cross sectional study[Online].Available:https://bmcmedinformdecismak.biomedcentral.com/articles/10.1186/s12911-014-0115-5.[Accessed: Nov. 12, 2019].

[10] E. deRiel, N. Puttkammer, N. Hyppolite, J. Diallo, S. Wagner, J. G. Honoré, J. G. Balan, N. Celestin, J. S. Vallès, N. Duval, G. Thimothé, J. Boncy, N. R. L. Coq, S. Barnhart, "Success factors for implementing and sustaining a mature electronic medical record in a low-resource setting: a case study of iSanté in Haiti," Health Policy and Planning, Volume 33, Issue 2, March 2018, Pages 237–246, [Online]. https://doi.org/10.1093/heapol/czx171

[11] N. Muinga, S. Magare, J. Monda, O. Kamau, S. Houston, H. Fraser, C. Paton, "Implementing an Open Source Electronic Health Record System in Kenyan Health Care Facilities: Case Study," JMIR medical informatics, 6(2), e22, 18 Apr. 2018[Online] doi:10.2196/medinform.8403

[12] Government of Western Australia.(nd). WA Health Digital Strategy 2020–2030 [Online].Available:https://ww2.health.wa.gov.au › Reports-and-publications › Digital-strategy [Accessed: Nov. 12, 2019].

[13] S. Ajami, & T. Bagheri-Tadi, "Barriers for Adopting Electronic Health Records (EHRs) by Physicians. Acta informatica medica" Acta informatica medica : AIM : journal of the Society for Medical Informatics of Bosnia & Herzegovina : casopis Drustva za medicinsku informatiku BiH vol. 21,2 (2013): 129-34. doi:10.5455/aim.2013.21.129-134

[14] D. Shukla.(2017, May 10).A technical overview of Azure Cosmos DB [Online].Available:https://azure.microsoft.com/es-es/blog/a-technical-overview-of-azure-cosmos-db/. [Accessed:Sept.23,2020].

[15] J. Bethune. (nd). Introduction to Cosmos DB [online]. Available:https://cloudacademy.com/course/introduction-azure-cosmos-db/intro-azure-cosmos-db/ [Accessed: Sept.23, 2020].

[16] Microsoft (nd). What is Azure Cosmos DB? [Online]. Available:https://gotcosmos.com/about. [Accessed: Sept.23, 2020].