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A Review on Development of GIS and m-Health Based Patient Registration System to Enhance Support for Epidemiological Analysis: A Case Study of Tanzania Hospitals

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A Review on Development of GIS and m-Health Based Patient Registration System to Enhance Support for Epidemiological Analysis: A Case Study of Tanzania Hospitals

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Abstract- **Over the past decades, there has been great advances in ICTs, which has led to the evolution and deployment of mobile phone application technology and GIS in the health sector. Despite of the expanded use of advanced ICT in the health sector, there is still ineffective data collection and presentation of patient and general health data in Tanzanian HIS. This paper shows different proposed and used GIS and mobile applications in perfecting HIS systems. It further proposes the best way on how these technologies can be used to provide effective data collection and presentation. Based on the discussions, a module is proposed to be integrated into the HIS. The ultimate goal of this paper is to improve collection and presentation of health/patient data, in order to enable enhancement of epidemiological analysis.**

I. INTRODUCTION

Healthcare services access, quality and affordability are major problems all around the world especially in developing countries, including Tanzania [1]. These problems are due to ineffective performance of the existing Health Information Systems (HIS). The health systems are no longer adequate for dealing with effective health data collection and presentation. The resulting effect is that epidemiological analyses are wrongly done due to poor data collection and presentation in the HIS [2]. Epidemiology involves studying the distribution and determinants of health-related states or events in a specific population, and the application of this in controlling health problems [3].

Most developing countries, especially Tanzania are reforming their health systems to provide expanded and equitable access to quality services [4] despite the low number of available health workers as reported by Kwesigambo et al. [5]. Figure 1 below shows the number of workers required and available in government healthy facilities in Tanzania.

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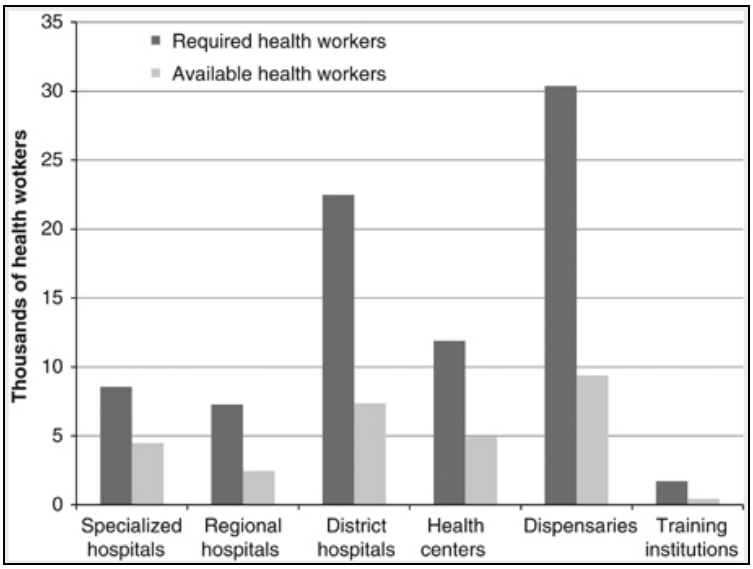

Figure 1. Number of health workers required and available in government facilities in Tanzania

Despite the health sector reforms in Tanzania that aim at reducing the workloads of the available health workers in hospitals, the World Health Organization (WHO) reports that the healthy system still encounters many problems [6] as shown in Table 1 below. However, different studies have been done to solve the health issues but still ineffective data collection and presentation persists in HIS.

Table 1. Problems encountered in existing HIS

Type of Problems Encountered	Village	District	Province	National
Duplication of forms	✓			
Too many record books/forms being filled out at this level	✓			
Lack of constant supply of forms				
Reports not submitted on time				
Inadequate training of health workers on how to fill out forms	✓	✓		
High degree of inaccuracy in data collected	✓	✓		
Lack of technical expertise of staff to properly analyze the data collected	✓	✓	✓	✓
Lack of utilization of data being collected	✓	✓	✓	✓

Taking advantages of the current growing ICT, mobile phone application and Geographical Information System (GIS) have the potential to offer major contribution towards improving the existing HIS services. Therefore, the objective of this paper is to propose the best GIS and mobile based integrated HIS, after reviewing different systems with regard to the use of mobile and GIS applications, whether they are used independently or in combination to improve data collection and presentation in HIS.

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II. REVIEW OF DIFFERENT HIS IN TANZANIA

The Health Information System (HIS) is as a set of components and procedures of the healthy system organized to generate information used in improving management decisions involving health care services delivery at all levels [7]. The main components and standards of HIS as described by World Health Organization (WHO) [8] are provided in the Figure 2 below. HIS allows for transparent decision making supported by evidence, and hence improve the health status of the population. Thus, HIS produces relevant and quality information to support decision making in the health sector [6].

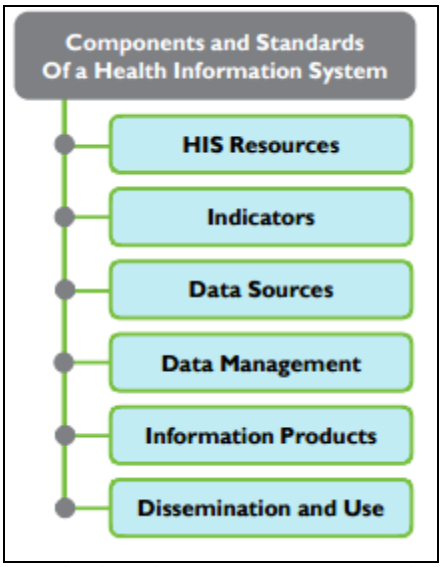

Figure 2.Health Information System's Components and Standards

However, WHO has contributed to positive progress in the health sector by putting up components and standards for all HIS designs to follow, but still the Tanzanian's HIS is currently not sufficiently responsive or effective in general [9]. Figure 3 below shows the topology of the existing HIS in Tanzania, whereby after visiting the hospital for treatment, the patient starts with the registration process then is asked the payment modality as to whether it is by the National Health Insurance Fund (NHIF) card/other insurance card or cash. The patient pays some amount for doctor's consultation and other treatment procedures will follow accordingly. The doctor documents the diagnosis results into the patient's profile. Most of the time, nurses or public officers will compile reports in paper format, which are then submitted to the district health office for analysis. This shows the ineffectiveness of the existing HIS in terms of patient data collection and presentation.

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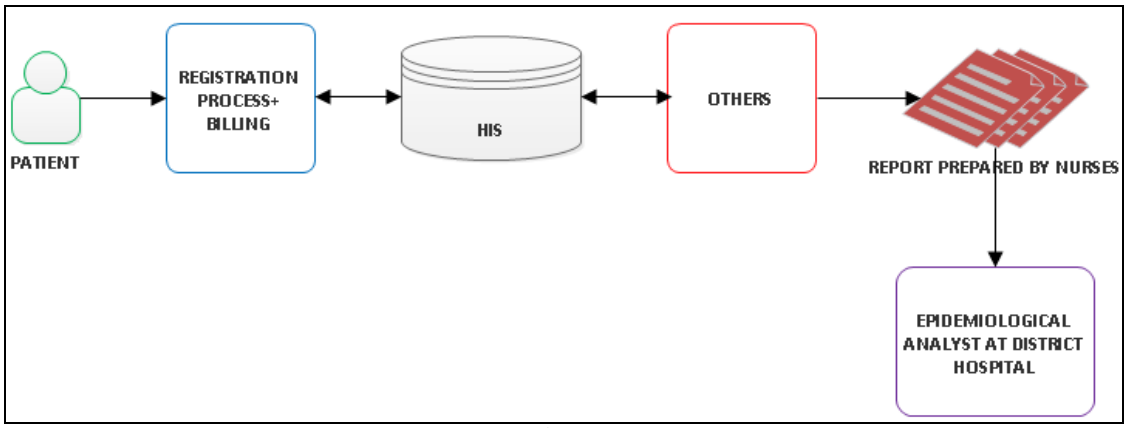

Figure 3. Topology of existing HIS in Tanzania

Many studies have attempted to find the optimal solution for counteracting the existing HIS. We now carry out a fair review of the different studies on mobile application and GIS in health care systems.

A. Mobile application based HIS

Mas et al. [10] proposed an enhanced healthcare multi-collaborative system operation over Third Generation (3G) mobile network. The proposed m-health system's architecture and sub-systems are presented in the block diagram shown in Figure 4 below.

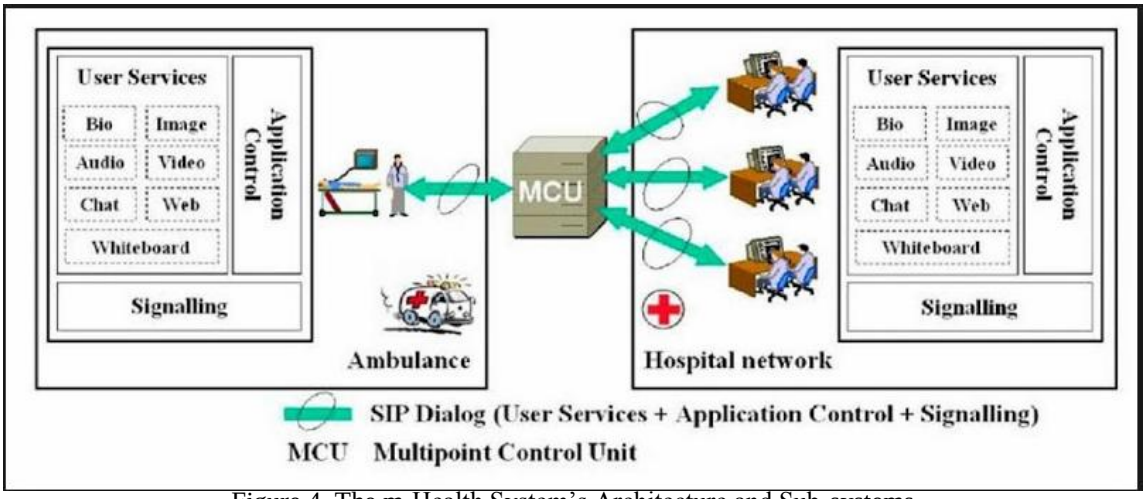

Figure 4. The m-Health System's Architecture and Sub-systems

Another related work as proposed by Ruotsalainen et al. [11] involved the use of personal doctors in a prescribed community in which they adopted the use of trust information-based architecture as shown in Figure 5.

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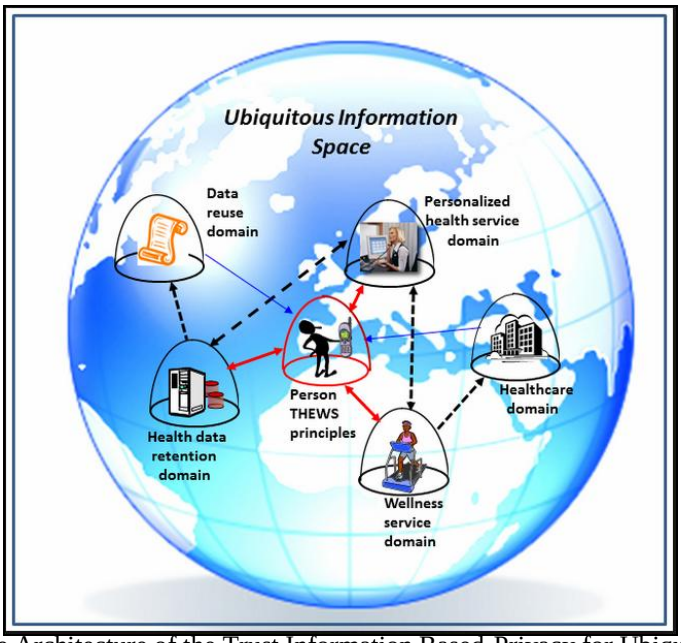

Figure 5. The Architecture of the Trust Information Based-Privacy for Ubiquitous Health

However, the reviewed mobile based applications in healthcare have some limitations in the health sector Tanzania. From Figure 4, we see that the m-Health system architecture and sub-systems are only used between healthcare works and therefore it lacks community participation or involvement. Also Figure 5 shows the architecture of trust information based-privacy for ubiquitous health whereby patient calls his/her personal doctor for treatment. This architecture in Figure 5 is also not suitable for developing countries where the number of available healthcare workers is very low; this system can effectively work in developed countries where the number of available healthcare workers is very large.

B. GIS based HIS

Otto et al. [12] proposed the development of health monitoring system network architecture, whereby each user/patient wears a number of sensors through personal network implemented by ZigBee or Bluetooth. The personal server provides graphical or audio interface to the user, and transfer the information about health status to the medical server through the internet or mobile telephone networks such as the GPRS, 3G etc. It can be implemented on a personal digital assistant (PDA), home personal computer or cell phone, and it is used to set up and control WBAN. Figure 6 shows proposed health monitoring system network architecture by Otto, Chris et al.

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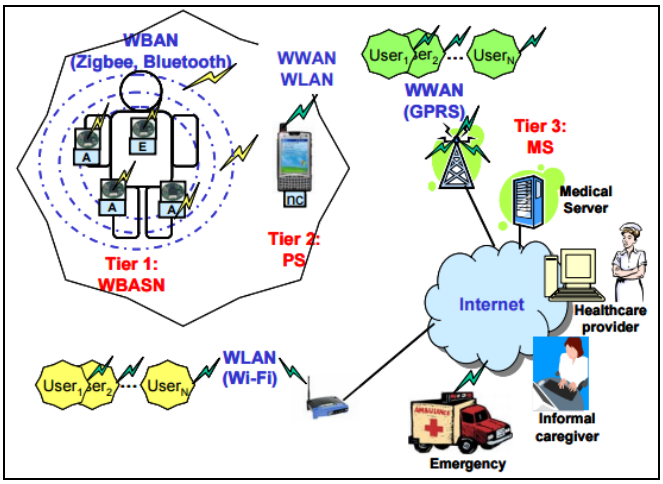

Figure 6. Health Monitoring System Network Architecture

Another use of GIS is the ArcGIS software, which is mostly used in developing countries especially in public health. The ArcGIS Server as explained by Huaiqing, et al. [13] is a platform on which enterprise WebGIS applications are built. Figure 7 below shows the architecture for ArcGIS server system.

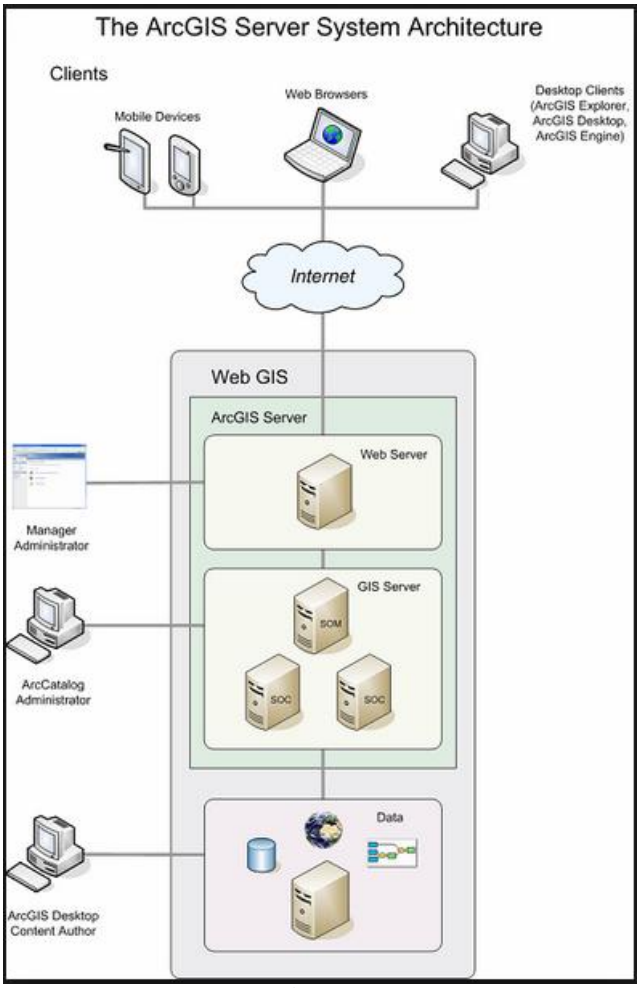

Figure 7. Architecture for the ArcGIS Server System

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However, the reviewed GIS architecture in healthcare has limitations in Tanzania. The health monitoring system is very expensive as it depends on sensor and internet to run its activities full time whereas the ArcGIS is a commercial software, which is also expensive to purchase.

C. Benefits of integrating Mobile application and GIS into HIS

GISs are useful in compiling and presenting data at regional and national levels. They are particularly useful in compiling data for environmental and health outcomes for recording and measuring to the use and impact of health services. Nowadays, GIS is seen to have the potential for improving the population's health and contribute to policy development, implementation and research in public health [14]. On the other hand, the mobile application in HIS has many uses ranging from remote data collection and monitoring, education and awareness, diseases and epidemic outbreak training, diagnostic and treatment support as well as communication and healthcare workers' training [15].

In viewing the benefit of integrating GIS and Mobile application in HIS, the objectives of epidemiology in healthcare systems can be realized. These include identification of the priority health problems in the affected community, determination of the extent to which diseases exists in the community, identification of the causes of diseases and the risk factors, determination of the priority health interventions, determining the capacity of the local infrastructure and the extent of damage, monitoring the health trends of the community, and health programmes' impact evaluation [16].

III. THE PROPOSED SYSTEM

A review of various studies shows that many researchers have used mobile application technology and GIS to enhance health information systems. However, no studies have attempted to integrate the mobile application technology and GIS into the health information infrastructure to provide the basis for data collection and presentation for effective data analysis and decision support [17].

We therefore, propose to develop a system which integrates the mobile application technology and GIS to be used specifically on wireless computing devices, such as smartphones and tablets [18]. Using this system, patients can register for treatment with a hospital. After the registration form is submitted, the data goes into the staging database, which is used to store all submitted patient data. Then from the staging database, the data is pulled into the HIS database only if the patient has visited the hospital for treatment. And then patient treatment procedures take place, whereby the doctor documents the results/status of the patient into the patient profile, and finally the epidemiological analyst is able to automatically view the data in different summaries, reports and visualization using GIS. The GIS is online software, which is free to use; there will be no additional cost for purchasing it. Figure 8 below shows topology of the proposed system.

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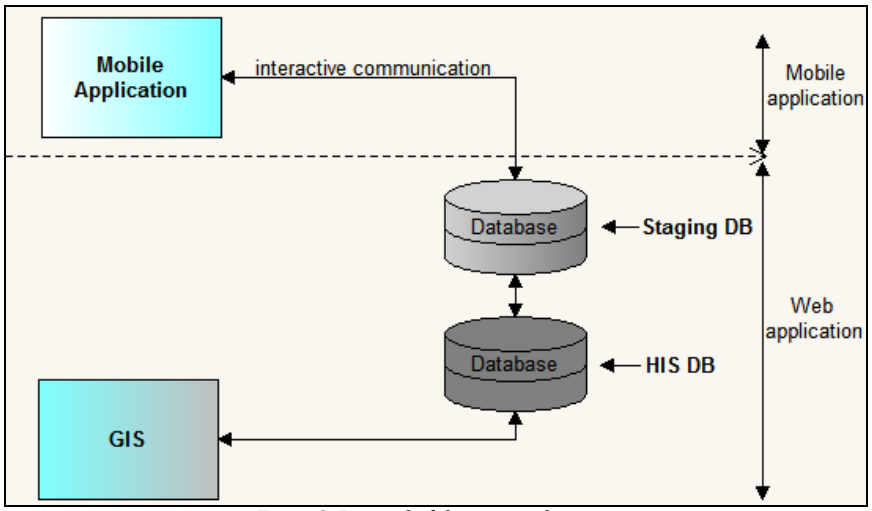

Figure 8. Protocol of the proposed system

IV. CONCLUSION AND RECOMMENDATION

This study has reviewed and analyzed various methods related to the integration of the mobile application technology and GIS with the aim of improving HIS. We have discussed different methods that help to remove inefficiencies in data collection and presentation to enhance decision making in HIS. Although some of the methods are good but very difficult to implement in the Tanzanian environment, we propose the introduction of another method that can match with the Tanzanian context. The method proposed is the use of interactive remote patient registration and integration on GIS in HIS. We recommend that the same system should be further researched using USSD mobile phones and also the related security issues in m-Health application should be research further.

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REFERENCES

[1] D. M. West, "Improving health care through mobile medical devices and sensors," *Brookings Institution Policy Report*, 2013.
[2] S. N. Weingart, R. M. Wilson, R. W. Gibberd, and B. Harrison, "Epidemiology of medical error," *BMJ: British Medical Journal*, vol. 320, p. 774, 2000.
[3] G. M. Stirrat, "Recurrent miscarriage I: definition and epidemiology," *The Lancet*, vol. 336, pp. 673-675, 1990.
[4] D. R. Gwatkin, A. Bhuiya, and C. G. Victora, "Making health systems more equitable," *The Lancet*, vol. 364, pp. 1273-1280, 2004.
[5] G. Kwesigabo, M. A. Mwangu, D. C. Kakoko, I. Warriner, C. A. Mkony, J. Killewo, *et al.*, "Tanzania's health system and workforce crisis," *Journal of public health policy*, pp. S35-S44, 2012.
[6] W. H. Organization, "Developing Health Management Information Systems," *A Practical Guide for Developing Countries. WHO*, 2004.
[7] T. Lippeveld, R. Sauerborn, and C. Bodart, *Design and implementation of health information systems*: World Health Organization Geneva, 2000.
[8] W. H. Organization, "Framework and standards for country health information systems," 2008.
[9] H. Kimaro and J. Nhampossa, "The challenges of sustainability of health information systems in developing countries: comparative case studies of Mozambique and Tanzania," *Journal of Health Informatics in Developing Countries*, vol. 1, 2007.
[10] J. R. Mas, E. A. V. Navarro, C. H. Ramos, Á. A. Iglesias, J. F. Navajas, A. V. Bardají, *et al.*, "Design of an Enhanced 3G-Based Mobile Healthcare System," *Idea Group Publishing, USA*, 2006.
[11] P. S. Ruotsalainen, B. Blobel, A. Seppälä, and P. Nykänen, "Trust Information-Based Privacy Architecture for Ubiquitous Health," *JMIR mHealth and uHealth*, vol. 1, 2013.
[12] C. Otto, A. Milenkovic, C. Sanders, and E. Jovanov, "System architecture of a wireless body area sensor network for ubiquitous health monitoring," *Journal of Mobile Multimedia*, vol. 1, pp. 307-326, 2006.
[13] K. L. F. J. W. Huaiqing and C. Jinsong, "Development of WebGIS Based on ArcGIS Server [J]," *Water Resources and Power*, vol. 1, p. 007, 2007.
[14] P. Wilkinson, C. Grundy, M. Landon, and S. Stevenson, "GIS in public health," *GIS and Health (GISDATA Series 6)*, pp. 179-189, 2003.

[15] C. Liu, Q. Zhu, K. A. Holroyd, and E. K. Seng, "Status and trends of mobile-health applications for iOS devices: A developer's perspective," *Journal of Systems and Software*, vol. 84, pp. 2022-2033, 2011.
[16] D. J. P. Barker and A. J. Hall, *Practical epidemiology*: Churchill Livingstone, 1991.
[17] J. A. Nhavoto and Å. Grönlund, "Mobile technologies and geographic information systems to improve health care systems: a literature review," *JMIR mHealth and uHealth*, vol. 2, 2014.
[18] M. Böhmer, B. Hecht, J. Schöning, A. Krüger, and G. Bauer, "Falling asleep with Angry Birds, Facebook and Kindle: a large scale study on mobile application usage," in *Proceedings of the 13th international conference on Human computer interaction with mobile devices and services*, 2011, pp. 47-56.

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