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Save Lives: The Application of Geolocation-Awareness Service in Iranian Pre-Hospital EMS Information Management System

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***Abstract*—**For emergency and relief service providers such as pre-hospital emergencies, quick arrival at the scene of an accident or any EMS mission is one of the most important requirements of effective service delivery. EMS Response time (the interval between the time of the call and the time of arrival on scene) is a critical factor in determining the quality of pre-hospital Emergency Medical Services (EMS). This is especially important for heart attack, stroke, or accident patients that seconds are vital in saving their lives. Location-based e-services can be broadly defined as any service that provides information pertinent to the current location of an active mobile handset or precise address of landline phone call at a specific time window, regardless of the underlying delivery technology used to convey the information. According to research, one of the effective methods of meeting this goal is determining the location of the caller via the cooperation of landline and mobile phone operators in the country. The follow-up of the Communications Regulatory Authority (CRA) organization has resulted in the receipt of two separate secured electronic web services. Thus, to ensure human privacy, a secure technical architecture was required for launching the services in the pre-hospital EMS information management system. In addition, to quicken medics' arrival at the patient's bedside, rescue vehicles should make use of an intelligent transportation system to estimate road traffic using a GPS-based mobile navigation system independent of the Internet. This paper seeks to illustrate the architecture of the practical national model used by the Iranian EMS organization.

***Keywords*—**Response time, geographic location inquiry service, location-based services, emergency medical services information system.

I. Introduction

EMS response procedure in Iran comprises six steps: (a) receiving an emergency call at 115 (National EMS emergency number), (b) determining caller or patient location, (c) sending notification to rescue vehicles, (d) mobilizing and providing the medical services or transferring the patient to a hospital, (e) filling the Pre-hospital Care Report (PCR) electronic form, and (f) demobilizing the emergency service team. Emergency medical services are vital during all phases of rescue response, crucial roles including mass-casualty triage, on-scene treatment, communication, evacuation, coordination of patient transport, and patient tracking [1]-[4]. Iran has more than 4 million EMS missions every year. Thus, decreasing service delivery time in any step would lead to saving many lives, especially in the case of heart attack or stroke patients where seconds can determine life or its loss [5]. Steps that can save time include the time of getting the caller's address, dispatch unit rapidity in determining the closest rescue vehicle to the patient, and finally, proper vehicle routing. Callers do not always provide their location; this includes situations like traveling, patient semi-consciousness, or a child caller, and intelligent information about the caller's geolocation helps EMS staff to pinpoint the destination.

Mobile information services or applications can be divided into two categories based on information access: general information services that access information without concerning the user's current location, and location-based service (LBS) or mobile location-based applications which use the location information as a key parameter. Location-based services require a definite infrastructure for positioning terminals [8].

There are currently two types of technologies for tracking mobile numbers in the world, one based on the Global Positioning System (GPS), and the other based on SIM card network and providers. The former, GPS, is a technology in which satellites orbiting Earth transmit signals which are received by mobile and other devices [3].

The position of the satellites is such that at least four satellites are placed above any point. Phones are equipped with a special hardware chip that receives signals, and since the three parameters of sending and receiving location, and spatial distance always depend on one another, they determine the location based on satellite location and distance. Therefore, GPS location is independent of mobile network or number, and any signal-receiving device can pinpoint the location. In addition, knowing the location of another device is not possible until that device transmits its location to us. The same applies to smartphones of which the location will be hidden until they send their GPS location to another device. These programs often (but not always) fall in the category of eavesdropping or spying programs that require installation on the target phone.

Instead, radio-based technology utilizes a different type of tracking based on the cellular technology and the operator of the telecommunications service provider, independent of GPS. In radio-locating, signals sent from a source are analyzed and

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presented by at least two receivers (telecommunications towers or operators). To determine the precise location of emergency callers, applying radio-based technology independent of callers and their mobile phones is desirable. The national EMS of Iran, for the purpose of saving lives, uses LBS (location-based services) via radio technology, and the launch process is illustrated in the paper.

II. Method

The Iranian pre-hospital information management system (EMSIS) is a decentralized system installed in more than 64 EMS centers in the country with separate data centers and hardware equipment (one sample of software in every university of medical sciences). On the other hand, the consideration of individuals' location privacy led to the design of a secure technical architecture for Geographic Location Inquiry Service (GLIS) launched in EMSIS.

In addition, inter-organizational services in Iran are based on the e-government infrastructure that is locally called Global/National Service Bus (GSB) and are classified into 14 groups consisting of e-health clusters.

The GLISs should be developed within the e-Government Health Cluster technical framework, which is a committed platform consisting of IP, servers, databases, and monitoring dashboards as an integrated API gateway [9] for Iranian health information exchange locally called DITAS or HIX (Health Information Exchange center).

The steps of the project implementation in the decentralized Iranian EMS Information Management System (EMSIS) are explained in the following:

A. Technical Design

For the purpose of accessing the location of the emergency call from a mobile phone, one of the methods in LBS is Hazel positioning, which is computed based on the delay (Time Difference of Arrival or TDA) between receiving a signal from two masts from the same source (phone) and calculating the distance of each of them from the signal source. With three masts, the X (longitude) and Y (latitude), the coordinates of the phone, and with the fourth mast, its Z (altitude) coordinates are also obtained [6]. The presence of numerous masts means more accurate coordinates of the caller. Indeed, these calculations are conducted and raw information is obtained before the caller is tracked via mobile network operators. Finally, based on the model, the caller location is determined with an accuracy of 60 to 300 meters.

The LBS services use a Base Transceiver Station (BTS) to identify a mobile device location with the aid of radio technology. To this goal, three steps are to be taken: The first is to retrieve the signal strength values from the related BTS [7]. The second step involves approximating the distances from the corresponding BTS with the help of the received signal strength, and the final step is geo-coding which involves finding the actual geographic location of the mobile device. Furthermore, the geographical location of a call from landline phone numbers is determined by the CRA organization with the address.

These results are delivered only at the request of judicial authorities or security forces since this information is restricted for the public and nongovernmental organizations. Thus, access to these top-secret data is provided for the national EMS organization through legal procedures. This information is provided electronically using Application Programming Interface (API) and Software Development Kit (SDK), which are common infrastructures for transferring data between two systems. This way, geolocations of the mobile phone and landline call are provided by two separate APIs. This e-service retrieves the address and geographical location of the caller using the landline phone number. All the addresses of landline phone numbers are stored in the CRA, and access to the data bank based on phone numbers is practicable. These two APIs are managed in a specific obfuscated SDK.

To ensure safety in the exchange of information, DITAS/HIX uses data encryption based on Public Key Infrastructure (PKI), which uses a set of two public and private keys (X.509 certificates) for data protection. The certificate is embedded in the security tokens. In other words, a Certificate Authority (CA) issues the keys and attaches them to the identity of an agent. At first, Registration Authority (RA), which could also be the CA, verifies the agent. In consequence, PKI and digital signature are developed through GLI processes and are implemented in all servers that serve as hosts for EMSIS in each EMS center of medical sciences universities. The schematic representation of the model is illustrated in Fig. 1.

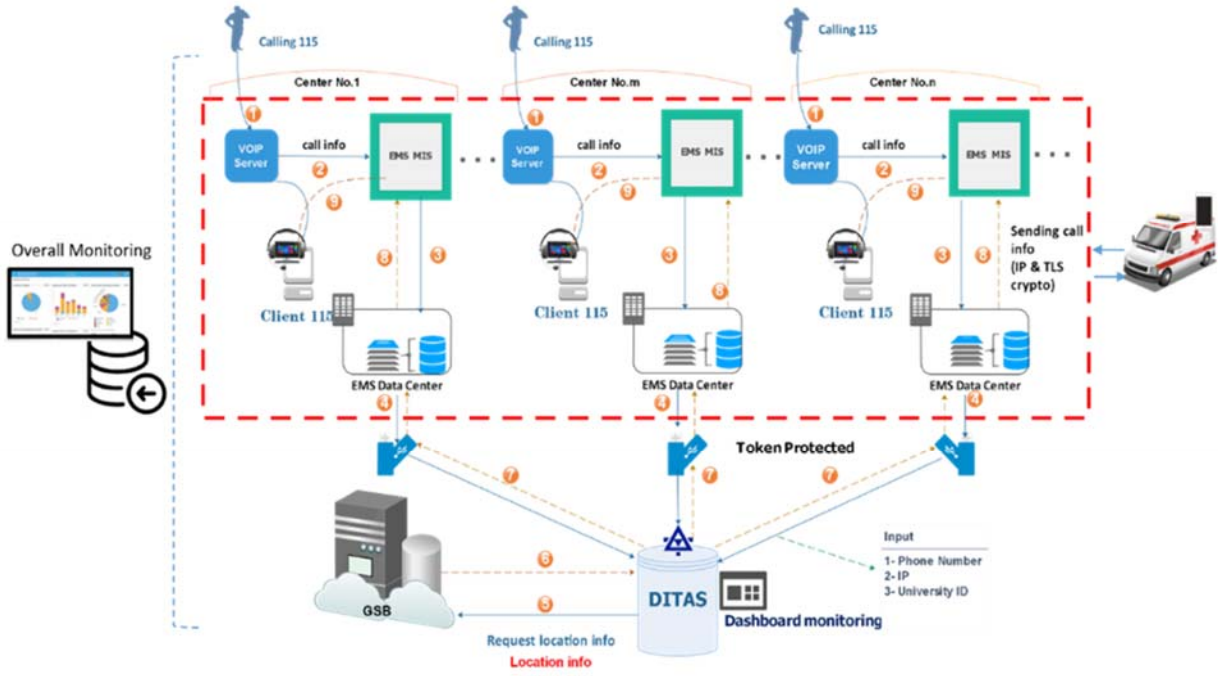

Fig. 1 The technical infrastructure of GLISs implementation at Iranian EMSIS nodes

A. EMSIS Nodes Architecture

Relative security and technical provisions are required for the GLI services to operate in every node of EMSIS in each EMS data center at the universities of medical sciences. In this regard, the following steps are required:

1. The EMS servers are in the national information network without any connection to the Internet.
2. Every edition of the software that is running in the EMS centers has to be PKI-enabled (PKIE) to ensure PKI technology support.
3. Due to the lack of the Internet connection, all SIM cards used in rescue vehicles such as ambulances must be connected to the EMS private APN (Access Point Name) to route the data traffic from mobile devices directly to configured EMS APN or an internal private network.
4. EMS center of a university of medical sciences has to introduce a person in charge of receiving the username and token private key. One signed non-disclosure declaration by the representative for responsibility is obligatory.
5. The token should be activated to authenticate and confirm the data exchange formed on DITAS/HIX.
6. A database for log management system should be configured.
7. A monitoring dashboard should be developed and implemented to show current and reliable transactions submitted directly from EMS centers and the results of GLI services from the CRA organization.
8. A map server should also be developed to determine the accurate address and routing for EMS workers.
9. A local Route Planning Software (RPS) system should be used on the EMS internal network.

B. Use of Map Server

To accurately determine the address, an offline map with movable latitude and longitude is incorporated in the system based on the local navigation map. The map is used in call centers when the caller address is registered and no work via the Internet is required.

C. Monitoring Dashboard Development

After pilot and APIs testing in two EMS centers, EMS developed one multi-resource monitoring dashboard. It shows current and reliable data on transactions (GLI requests and responses) submitted directly from EMS centers and the CRA organization. In addition, the dashboard has a clean and modern interface with several data visualization tools to better grasp the current status of the project.

III. Results

In coordination with the Ministry of ICT, the use of two security APIs regarding location inquiry of calls to 115 (EMS number) was requested. Project implementation relied on the DITAS/HIX infrastructure as a national platform for information transmission between health-related systems in governmental organizations with other systems. Due to APIs information confidentiality and web-based transfer, the technical team designed a trust model for project implementation in EMS data centers. For more security, the APIs are embedded in one dedicated SDK.

According to the Iranian government regulations, DITAS/HIX agrees on a procedure for exchanging healthcare-related information. For communication through DITAS/HIX, a dedicated ID is assigned to EMSIS as a System ID, and for each university of medical sciences to communicate with DITAS/HIX, a unique ID called Location ID is issued. DITAS's

function in the mentioned processes is reception of requests from different EMS centers, authentication and authorization (one SDK and PKI technology in custom X.509 certificates are employed), collection of transaction logs' data, security implementation, and other local privacy instructions.

Moreover, the internal architecture of the EMSIS was changed in a way that the caller's number automatically takes in the electronic inquiry queue without any intervention and then suspended to receive the response from the CRA organization (Simplex mode for data transmission). This form of request does not interfere with the e-service inquiry and use, and minimizes the possibility of abuse and intrusion.

Finally, after six months of a pilot run in two large EMS centers (Tehran and Mashhad), significant results were obtained; response time, the interval between relief call and arrival at patient bedside [10], [11], was reduced three to eight minutes. The saved time depends on various variables such as traffic, weather conditions, city size, and type of EMS mission (intercity or intercity). It is emphasized that all the EMS centers on a national scale are already implementing this technical approach.

IV. Discussion

One of the main healthcare services is emergency medical service as it plays a vital role in saving people's lives and reducing mortality and morbidity rate [12]. Thus, shortening the interval between help requests and EMS's response would improve the quality of pre-hospital medical service delivery. Occasionally, the callers to EMS do not know their accurate location, are semi-consciousness, or children who cannot provide their address. Therefore, the Iranian EMS organization, with the collaboration of the ministry of ICT, attempts to access the geographical location of the EMS callers via mobile or landline phone networks as soon as the call is made. Thus two separate inquiry APIs are shared with the EMS organization. To develop a secure system for GLIS fulfillment at EMSIS nodes in the country, several steps are taken. This paper aims to explicate the process of GLIs services employment.

Conflicts of Interest

This project was supported by the Ministry of Health and Medical Education of Iran (MOHME) and the National EMS organization. The executive results were endorsed and confirmed by "Dr. Pirhossein Kolivand", who was head of the Iranian EMS Organization when the project has been implemented.

Authors' Contributions

As a team, all the authors participated in project launch and approved the final version of the manuscript. It is emphasized that "Somayeh Abedian" is the first author. She was the project manager and chief of the Communications and Information Technology (ICT) office in the Iranian EMS organization during the project.

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References

[1] Committee on Guidance for Establishing Crisis Standards of Care for Use in Disaster Situations; Institute of Medicine. Crisis Standards of Care: A Systems Framework for Catastrophic Disaster Response. Washington (DC): National Academies Press (US); 2012 Mar 21. 6, Prehospital Care Emergency Medical Services (EMS) Available from: https://www.ncbi.nlm.nih.gov/books/NBK201058/

[2] Yoshikazu Goto and Akira Funada and Yumiko Goto, " Relationship Between Emergency Medical Services Response Time and Bystander Intervention in Patients With Out\&\#x2010;of\&\#x2010;Hospital Cardiac Arrest", Journal of the American Heart Association, vol:7, 2018, doi: 10.1161/JAHA.117.007568

[3] Colla, G.A. Oliveira, G.D. Santos, Operations Management in Emergency Medical Services: Response Time in a Brazilian Mobile Emergency Care Service, Procedia Manufacturing, Volume 39, 2019, Pages 932-941, ISSN 2351-9789, https://doi.org/10.1016/j.promfg.2020.01.396.

[4] Aloudat, A. & Michael, K. (2011). The application of location-based services in national emergency warning systems: SMS, cell broadcast services, and beyond. In P. Mendis & A. Yates (Eds.), Recent Advances in National Security Technology and Research: Proceedings of the 2010 National Security Science and Innovation Conference (pp. 21-49). Canberra: Australian Security Research Centre.

[5] Madadipouya, Kasra. (2014). An Examination and Report On Potential Methods of Strategic Location-Based Service Applications On Mobile Networks and Devices. International Journal of Managing Public Sector Information and Communication Technologies. 5. 10.5121/ijmpict.2014.5303.

[6] Yousuf Rebeeh, Shaligram Pokharel, Galal M. Abdella, Abdelmagid Hammuda, "A framework based on location hazard index for optimizing operational performance of emergency response strategies: The case of petrochemical industrial cities", Volume 117, 2019, Pages 33-42, ISSN 0925-7535, https://doi.org/10.1016/j.ssci.2019.03.020.

[7] Siddieq, A. and Nurhaida, I. (2019), "Mobile application of BTS tower search build upon location-based service (LBS)", Library Hi Tech News, Vol. 36 No. 3, pp. 1-6. https://doi.org/10.1108/LHTN-08-2018-0049

[8] Renuka, B & Poojary, Manjula & Babu, B."Location-Based Services on Mobile E-Commerce", 2012, International Journal of Computer Science and Information Technologies, Vol. 3

[9] Al-Shaqsi SZ. Response time as a sole performance indicator in EMS: Pitfalls and solutions. Open Access EmergMed.2010;2:1-6 https://doi.org/10.2147/OAEM.S8510

[10] Ashrafi, Noushin, Jean-Pierre Kuilboer, and Tristan Stull. "Semantic Interoperability in Healthcare: Challenges and Roadblocks, 2018, STPIS@CAiSE.

[11] Colla, Marcos & Oliveira, G. A. & Santos, G. D. (2019). Operations Management in Emergency Medical Services: Response Time in a Brazilian Mobile Emergency Care Service. Procedia Manufacturing. 39. 932-941. 10.1016/j.promfg.2020.01.396.

[12] R. Aringhieri, M. E. Bruni, S. Khodaparasti, J. T. van Essen, Emergency medical services and beyond: Addressing new challenges through a wide literature review, Computers & Operations Research, Volume 78, 2017, Pages 349-368, https://doi.org/10.1016/j.cor.2016.09.016.