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Hybrid Geodesic System Architecture for Communication and Tracking Tactical Offline

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Abstract. This paper describes the development of a hybrid system under a client-server architecture of multi-Tiers and logical multilayers, development with Nodejs-Express-Angular with Object Relational Mapping and Data Transfer Object with MariaDB. Generally, tracking systems with Global Navigation Satellite System technology are slow without a base architecture and adequate development tools and require an internet connection in some of their stages. The results showed its functionality in different situations applied in problems of aeronautic and terrestrial tracking, guaranteeing a projection of personalized geodetic maps and OpenStreetMap in an agile way, efficient, and secure communication in real-time. The proposed architecture allows native development, integration of new modules, and cross-platform implementation in an easy way. Nowadays, hybrid (air and land) tactical are applied in military and medical communications with tracking in real-time, public or private security of objects and people. The hybrid system can be applied in the syndemic problem, which has caused millions of deaths.

Keywords: Geodesic system, tracking, communication offline.

1 Introduction

Currently, the public safety communications and tactical applications have used the hybrid aerial and terrestrial communication systems because they are fast deployment and large coverage capabilities [1]. For two decades there has been the need to track objects, people, and robots to maintain communication between organizations, centralized and remote control. This allows coordinating different activities in a safe way avoiding the intrusion in the transmitted information [2, 3, 4, 5].

The lack of monitoring during the transfer of a patient by aircraft or terrestrial, the need to provide medical assistance in real-time without an internet connection are frequent problems in the medical area. In addition, the objects tracking (germicidal

Table 1. a) EDLP-SMS Interpretation. b) TCLP Example.

T-Hello everybody	User text message, "Hello everybody"
X-1	Predefined message, "All good", addressed to the controller
N-2	Controller message, operation authorization notification
S-1-ROBOTL20	User message, "Request for authorization" To start operation with invoice "User20"

Sender	Use ID = 10
Addressee	User-Controller-ID=01
Position date	01-abr-2020
Position time	13:00:01 (UTC)
Latitude	20.12345 ° North
Longitude	90.12345 ° West
Altitude	7,000 ft
Speed	123 knot
Azimuth:	45 ° with respect to geographic north
Message	Open text
Message sent	Hello everybody

Table 2. Encrypted DLP-SMS format.

Attribute		Label	No. Chars	Format
ID	1	Sender	2	99
	2	Addressee	2	99
	3	UTC	12	AAMMDDhhmmss
Object-Geoposition (G-User)	4	Latitude	8	+ggddddd
	5	Longitude	9	-gggddddd
	6	Elevation	5	99999
	7	Speed	3	999
	8	Azimuth	3	999
Tactical Chat Link Package (TCLP)	9	kind of message	2	X-
	10	Message sent	76	Hello everybody

robots, ambulances, medicine, and so on), the operation, the permanent communication with its operators, and compliance with mandatory health procedures to reduce infections during syndemic problems are challenges that must be solved in the hospitals. Merrill Singer (1990) defines the syndemic as a set of epidemics with implications at the biological and social levels. The syndemic is a consequence of the social type, which is spread in the world by a virus (COVID-19).

The aim of this paper is to propose a model with multilayer client-server architecture used to develop a multiplatform geodetic application to track the tactical operations of a transport fleet, aircraft, objects, and so on; give technical support and make decisions during the execution of its operations by means of secure data link communication (GSM / GPRS / GPS). Development with Nodejs-Express-Angular with Object Relational Mapping (TypeORM) and Data Transfer Object (DTO) with MariaDB. Telecommunications and cryptography have been an integral part of information

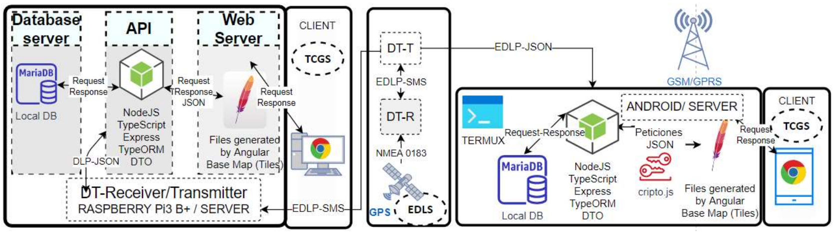

Fig. 1 a) Model of TCGS and EDLS.

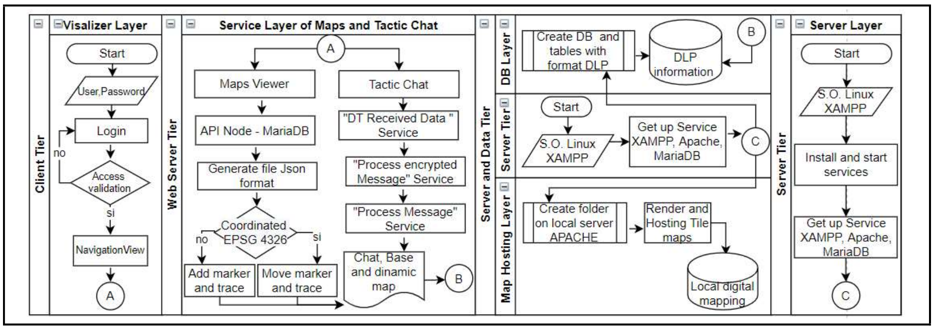

Fig. 2 Tiers and Layers generals of the application.

security, avoiding the intrusion and reception of unwanted or malicious messages [6, 7, 8].

2 Background

In recent years, portable tracking systems, geographic information (GIS), or commercial graphical interfaces [9] have been developed to facilitate the collection, visualization of data on a map [10, 11] and the patterns analysis [12] of objects or people for decision-making. Geographical information [13] is used through digital cartography and recovered from physical sensors such as: Global Navigation Satellite System (GNSS), GPS [2, 14, 15, 16]. GPS digital mapping and geodetics enable geographic data processing and are essential for ground and aerial remote sensing applications. GPS is a space-based radio-navigation system of the United States of America that provides reliable, free, and uninterrupted positioning, navigation, and chronometry services to civil users around the world. It is supported by absolute precision and reliability [17].

China began exploring telemedicine services in the 1980’s. Recently, some researchers have developed telemetric systems with Global System for Mobile Communications (GSM) controlled remotely in an encrypted way through SMS [7, 8, 9] and applications Web. This has become a standardized infrastructure for remote monitoring [24, 25].

Related lightweight cryptographic hash functions of the United States National Security Agency and published by the National Institute of Standards and Technology (NIST) provide security on devices with limited resources.

Table 3. TCLP format.

Kind of message	TCLP
Free text[T]	[T-'menssage']. Example: T- Hello everybody
Predefined message [X]	"X-" + key. Example: + [X-1]: all very well + [X-2]: Process started + [X-3]: …
Operation notification [N]	"N" + Event: + [N-0]: operating + [N-1]: Reject + [N-2-'id_Operation']: authorized + [N-3]: Started + [N-4]: Finished + [N-5]: Canceled
Send Operation Request [S]	"S" + Request. Example: + [S-0]: Request of status + [S-1-'Folio of Operation']: Request authorization to start operation

Table 4. Required Disk Space of ECW and Tiles Geomaps.

Geomap	ECW (KB)	Tiles (KB)	Zoom
HP	24,874	131,404,089	7
LP	21,504	134,078,092	7
Relief	431,530	3,285,341,.642	10

Hash algorithms are among the most widespread cryptographic primitives and are currently used in multiple cryptographic schemes and security protocols. They guarantee the integrity and authenticity of the data to achieve a higher level of security.

Boriani and colleagues [26], used the SHA-256 and SHA-512 algorithms with the round pipe technique and obtained a higher yield per cut of 57% and 17%, respectively in comparison to other implementations. S. L. a. K. Shin [16] used SHA-512, which is based on a 32-bit data path. The result is an efficient implementation that can use in IoT security applications. Also, Rote and Selvakumar [27], the authors implemented the SHA-252 hash function in different FPGA families to compare the performance metrics such as area, memory, latency, and clock frequency. This allows a selection of the most suitable FPGA for an application and the implementation of SHA-256 and SHA-512 algorithms.

A decade ago, the N-Tier architecture of physical distribution and n-layers of logical distribution with reusable modules and components emerged in software engineering. Telemetry is a technology that allows the remote measurement of physical quantities and the sending of the information to the operator. This information relates to the data necessary to maintain control of all computer equipment. The operator would be aware of any irregularity or problem that may arise, responding quickly to any mishap, reducing the probability of loss of information or damage to hardware.

Currently, communication can be established from a control center with any portable module to send or receive information and give instructions to operate remotely. In addition, the design and creation of complex systems with maximum scalability,

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0100210518153125 +1974983 -0990148307380000314
0100210518153315 +1974983 -0990148207381000314 -T -hello
0100210518153415 +1974982 -0990148207383000314 -T -Operation start
0100210518153819 +1976058 -0989797608657099093 -T -Route start
0100210518154650 +1977832 -0988317409057042131 -T -Heading to Santamaria Ajoloapan
0100210518154750 +1977493 -0988273608811001113 -T -Heading to San Cristóbal
0100210518155158 +1980363 -0988247508687098065 -T -Heading to Santa Maria México
0100210518155209 +1980559 -0988201708637092071 -T -First stop
0100210518155817 +1980644 -0988017408363081013 -T -Second stop
0100210518160251 +1980798 -0987976808392079014 -T -in path
0100210518160626 +1981431 -0987962008199000027 -T -Fourth stop
0100210518161242 +1977898 -0987327508214033267
0100210518163142 +1982360 -0989015808655112257 -T -Fifth stop
0100210518163242 +1981381 -0989308108612109246 -T -Heading to San Pablo
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Latitude	Longitude	Altitude	Speed	TrackTrue	Time UTC	Satellite
19.533.902	-99.202.227	7253	0.22	102.2	181312.9	5
19.533.908	-99.202.226	7253	0.25	102.2	181313.9	5
19.533.994	-99.202.263	7281	2.49	0.8	181320.0	6
19.534.049	-99.202.315	7308	3.34	270.8	181327.0	7
19.534.144	-99.202.500	7378	0.03	282.3	181338.0	8
19.534.168	-99.202.533	7394	0.58	282.3	181352.1	11
19.535.872	-99.201.157	7421	22.29	94.4	181545.3	12
19.535.276	-99.191.453	7421	8.25	97.2	181734.0	13
19.535.270	-99.191.411	7421	8.45	97.9	181735.1	13
19.535.265	-99.191.368	7420	10.14	97.6	181736.1	13
19.517.191	-99.143.325	7377	24.61	198.3	182749.0	15
19.516.088	-99.143.443	7370	1.98	155	182806.2	15

Fig. 3. a) EDLP-SMS obtained from DT, b) data obtained from Garmin Glo.

reliability, high performance, and integration are required for different applications [17].

On the other hand, the outbreak of the SARS-CoV-2 pandemic has disrupted health, social and economic systems worldwide, giving rise to urgent needs for technical solutions, thus emerging various robotic platforms with an intelligent and autonomous control system [18, 19]. The germicidal SARS-CoV-2 robot used in this project has a real-time tactical communication module and cryptography to ensure bidirectional communication. It has an integrated geodetic web viewer that can monitor a fleet of robots from any device (desktop or mobile) regardless of the S.O. (Windows, Linux, Android). The type of architecture used in this work is another share. The germicidal SARS-CoV-2 robots usually use commercial software and hardware.

3 Proposed Model

The embedded system is shown in Fig. 1. The principal modules are:

Tactical Communication and Geolocation System (TCGS). It is built with N-Layers for the sub-modules: a) *Viewer Interface*. - Shows static layer (base map) and dynamic layer (base map load with markers and routes in real time). b) *Tactical chat interface*. - it communicates with the data tier or server Tier, starts a service to consult user data, manages EDLP-Json of free or predefined text and sends it to the DT. c) E*ncryption* performs the EDLP-Json encryption process with the Hash252 algorithm to avoid intrusions in the client Tier.

Encrypted Data Link System (EDLS). The EDLS has *Data Transceiver (DT)*. have Middleware with technology GNSS and Encrypted*,* was built on Arduino ATmega328P or Raspberry Pi3 B + 32GB (DT), a data transmission module with GSM / GPRS / GPS technology and antenna (SIM800L and SIM808L, respectively). Its function is to send Encrypted Data Link Package (EDLP-SMS) to georeferenced positions and establish secure communication between DT-Transmitter (DT-T) and DT-Receiver (DT-R). The connection of the DT components is serial with AT commands. The transmission and reception pins (TXD, RXD) are used in a crossway of both circuits and a cellular protocol SIM card, both selected by high sensitivity level (-108dBm, 23dBm). Furthermore, has personalized cryptogram and use 256 bits with standard NMEA-0183.

3.1 Architecture Server-Client with Multi-Layer and Multi-Tier

The embedded system was built with four tiers, and each has *N* logical layers (Fig. 2).

Client Tier. The web application will work on GNU / Linux, and Microsoft Windows; it must be able to authenticate the operator, object, and controller. In addition, it will display the geomaps with relevant information (latitude, longitude, altitude, UTC, and so on) and route of operation in real time. It will Manage operations and data link communication through a tactical chat to provide technical support and make operational decisions.

Web Server Tier. To build a TCGS with the proposed model architecture we require n logical layers to develop API and services, we required: Linux, Nodejs-Express-Angular (Backend, Frontend; respectively), Leaflet plugin to interact with raster and vector maps with EPSG coordinate systems: 4326 and TERMUX: a terminal emulator for Android, it is used to execute Linux commands and install the application on mobiles.

The selection of the tools required a deep analysis on the different map processors: Geoserver, Mapserver, Mapwingis, Luciad, and so on; geographic viewers: Arcmap, Leaflet, Carto.js, D3, Google Maps, Cesium, Node.js, Turf.js, Mapwingis, Luciad, GDAL Python, and so on; and plugins to display dynamic maps in the web browser: Open Layers and Leaflet.

Data Tier. It builds and manages DB with a persistence engine using MariaDB through Object-Relational mapping (TypeORM) and Data Transfer Object (DTO). These tools guarantee database migration in an easy way. Furthermore, we have local map hosting.

Server Tier. Configured with Apache Tomcat to host and manage geomaps in Tiles format at different scales and zoom levels. If they are not in the tiles format, they are preprocessed with Maptiler. It can be hosted on a microprocessor, PC, server or mobile.

Table 2 shows the criteria of the cryptogram "ID / Robot-Position / TCLP" for the security of the data output. The SMS sends 140 characters, and the proposal sends the Encrypted Data Link Package (EDLP) of 45 and 76 chars for predefined or free text messages. Example: EDLP-SMS = "1001201201130001 + 2012345-090123450700013045T-Hello everybody", see Table 1.

ID (1-3) first block with user identifier Sender-Addressee, 100 user's max; UTC.

G-User (4-8) Latitude: North/South & 7 digits: degrees (0-90), tenths of a degree (0.00001-0.99999)/0.1 arcseconds=3m. Longitude: East/West & 8 digits: degrees (0-180), tenths of a degree / 0.00001 degrees approximately 1m. Altitude: Maximum 99999 ft=30480m, Speed: Maximum 999 knots=1850 km/h. Azimuth: Range 1-360°.

TCLP (9-10) identifies operation geodata, the type of data message sent: a) personalized. - Maximum 76 chars, b) predefined. - they use a key, and they will be hosted in the DB local.

La Table shows the structure of the instructions, operation trace, open message unencrypted or predefined messages. The latter is technical content and just sends a key.

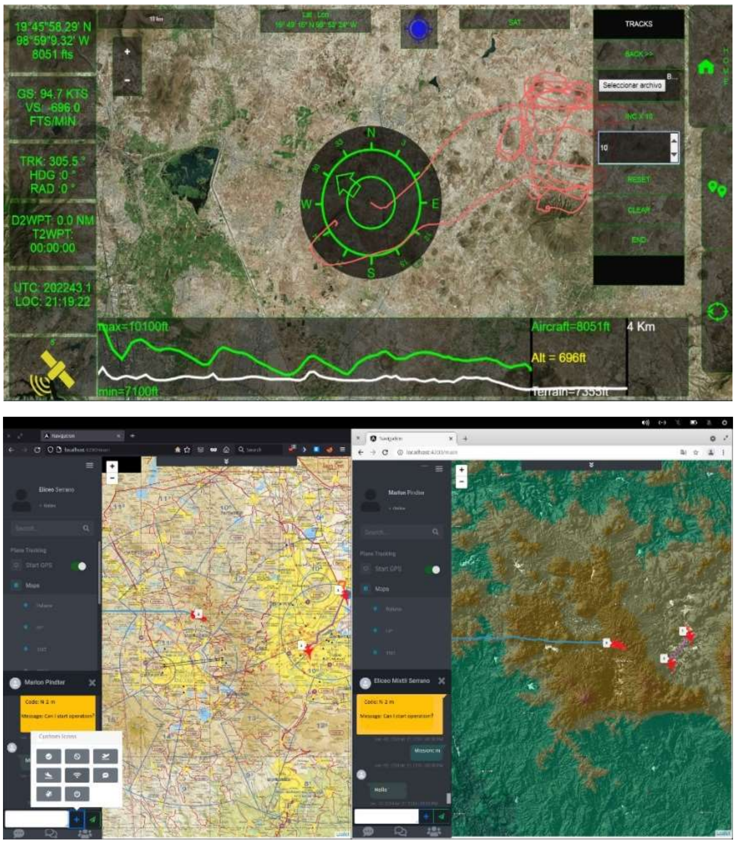

Fig. 4. Visualizer of base geomaps a) with one route b) more of the one route.

Finally, the crypto.js library was used in DLP-Json to continue maintaining the security at the client layer of the data received from the DT-R or DT-T (EDLP-SMS) to the viewer.

4 Results

The proposed EDLS guarantees to send / receive EDLP-SMS, with enough space to send open text messages. The DT allow to generate DLP-SMS of different waypoints and routes (Fig. 3a), the SIM808L module had less data loss, better performance and communication compared to SIM800L and commercial devices such as Garmin Glo (Fig. 3b).

The TCGS visualizes vectorial geomaps (50KT, 100KT, 250KT, 500KT, 1MKT, and so on) with geodetic data offline (Fig. 4b) in an easy way. It was compared with an application that works on Windows 8.1, Tomcat 9, Java, Nodejs, MySQL, GDAL and GeoServer 2.0.8 as a geomaps web Server; It process maps in high compression ratio format, Enhanced Compression Wavelet (ECW), these pre-processed by the Mexican Air Force, Table 4 shows the used hard disk space.

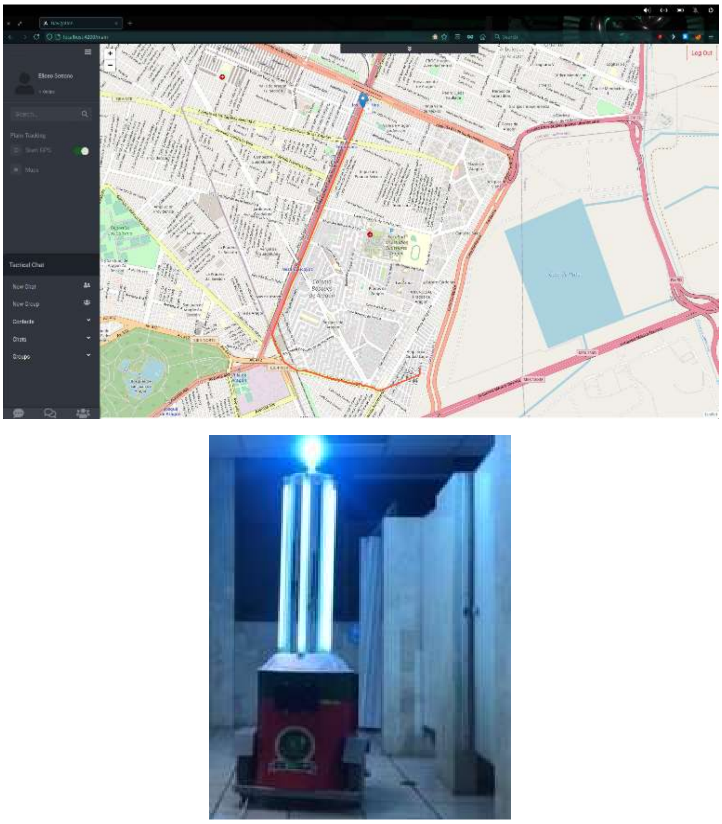

Fig. 5. Tracking of the germicidal Robot.

Unfortunately, the exchange of base layers is very slow, and it crashes when interchanging the dynamic layers or does several processes at a time (Fig. 4a). The proposal is configured on a microcomputer, PC, server or mobile and only requires enough space to host the same base maps in tiles to speed up the work of the cartographic server.

The dynamic maps are successfully graphed, it supports more of one route at the same time, uses custom markers, and can use the tactical chat, all this operates in real- time.

The architecture is validated by installing the application on a HUAWEI Android 8.0 Tablet, 32GB, 256GB; We only require TERMUX and APT package manager for an easy configuration and installation. Also, functionality tests were carried out with waypoints and tracking obtained from an aircraft, achieving its tracking and communication from the control tower in real-time without internet (Fig. 4b).

The same architecture a germicidal robotic platform of the SARS-Cov-2 was integrated, complementing its functionality, supported by OpenStreetMaps. The embedded system allows remote control of the robot, manages, monitors the operations carried out, and provides technical support to the operator in case of failures through tactical chat (Fig. 5).

5 Conclusions and Future Work

This paper achievement the goal and we develop a by using tools opensource, client-server architecture with N-tiler and N-layer, it was developed with innovative tools of high-performance, easy-maintenance, lightweight, robust, and scalable. Furthermore, it solves medical and tactical communication problems (air and land) and tracking of fleets of robots, aircraft, transport, and so on in real time without internet connection, all through GNSS technology. The EDLS achieve to secure, control, encrypt, and guaranteed the predefined or open text EDLP-SMS and permit to send / receive a single packet avoiding the loss or intrusion of this. Also, it maintains security at the client level by using the Hash-512 algorithm and can be installed on any device with GNU / Linux, and Microsoft Windows.

The TCGS was integrate and proof in military aircraft and had good performance. In attention to COVID-19 syndemic to social level, we prevent the spread of the coronavirus, by mean of integration of the TCGS to germicidal robot to track its operation when it to work in hospitals, education institutions, industry, and so on.

The future works it is intended to use the app modules in other projects in any aspect independently, this is possible due to the paradigm of the tools used. On the DT side, it is intended to build a hybrid transceiver (GPS, Radiofrecuency, and Iridium) that always guarantees communication.

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