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Telemetry System Proposal for Remote and Real-Time Measurements in a Multimodal Transport System

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Abstract- Multimodal transport systems are requiring efficient management due to growth they present when considering fully electric or hybrid vehicles. Comprehensive, flexible and robust models are required to manage transport systems information, which help to efficiently optimize resources. This article shows a telemetry system proposal to measure remote variables -and in real time-, but according to models proposed for smart grids. The proposal includes revision of layers of the Smart Grid Reference Architecture Model (SGAM) applied to the telemetry system.

Keywords – Watermarking, Haar Wavelet, DWT, PSNR.

I. INTRODUCTION

Multimodal transport is the one in which it is necessary to use more than one type of vehicle to transport merchandise from its place of origin to its destination. The telemetry system design of a multimodal transport system that considers fully electric or hybrid vehicles, must contemplate the different technologies available to be implemented in the cities of the future, always considering interoperability, safety, ease of deployment and end user requirements.

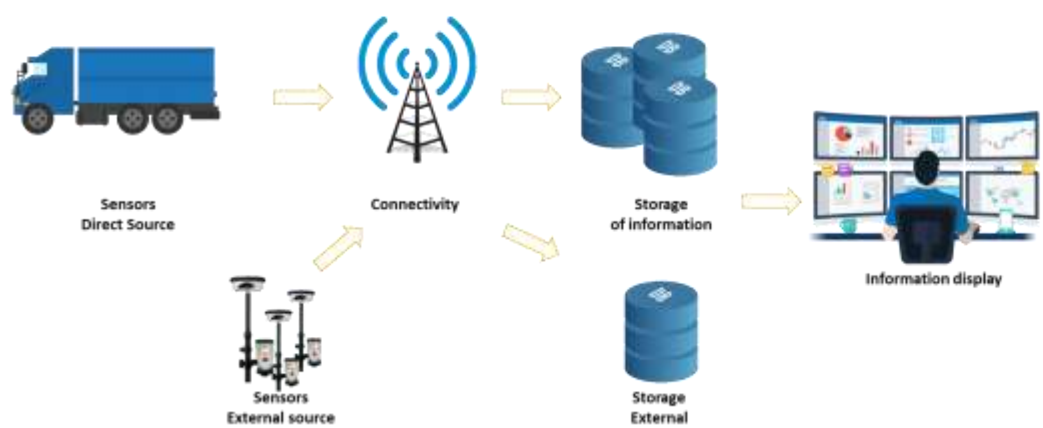

Figure 1. Composition telemetry system multimodal system (Direct Source Sensors, External Source Sensors, Connectivity, External Storage, Data Storage, Visualization

Information generation in a multimodal system can be varied, including direct source of data generation and external sources, which also include different components or sensors that acquire information in real time, and through some device, send the information to the data storage systems (local or in the Cloud), to later be processed and analyzed to generate added value to the multimodal system. Figure 1 shows a basic composition that must be considered by the telemetry system for remote and real-time measurements, where each of them can be another system with inputs and outputs, made up of different elements. The generated information must have value for the system organization and optimization, allowing to improve the available resources in its configuration.

Telemetry is the technology that allows physical quantities to be monitored in real time (Example: humidity, temperature, electrical conductivity, electrical consumption, or weather station parameters such as wind, rain, room temperature, moisture, radiation, and atmospheric pressure), and its subsequent transfer to the operator or system manager [1]. With telemetry, it is possible to carry out more precise management of the metrics related to a device and today, with the wide variety of technological resources, it is possible to generate valuable information for transport systems under the sustainable cities concept. Figure 2 shows the basic phases of signal processing in a telemetry system.

Figure 2. Basic phases of signal processing in a telemetry system. Measurement Variables: Physical quantity to be measured, sensor, signal conditioning, signal transmission, signal storage, user read exit

The figure, among others, shows the direct information source, e.g., if there is a hybrid motorcycle (fuel-electric) which has different sensors that obtain data to be used locally in control strategies, and to be sent to the control and display, it is also possible the acquisition of external signals that support the construction of knowledge regarding the hybrid bike performance. Connectivity must consider the different technologies available in cities to improve data transmission efficacy (mobile network, Wi-Fi, SigFox, and others), and the technology support in terms of connecting the sensor data in a grouped way with the information storage engines; synchronously and asynchronously identifying transmission possibilities. Information storage can be varied and will depend on the type of information used, and the interconnection easiness of the database engines, which allow working safely from a visualization and monitoring center of the system's telemetry. Tools must be established for information analysis to optimize the multimodal transport system.

II. PROPOSAL

2.1 Functional Analysis

To assess whether a telemetry system is adequate, the following characteristics should be analyzed:

- The number of process variables to be monitored is high.
- The process is geographically distributed.
- The process information is needed at the time that the changes take place in it, i.e., the information is required in real time.
- The need to optimize and facilitate the operations of the multimodal mobility system, as well as decision-making, both managerial and operational.
- The benefits obtained in the process justify the investment in telemetry. These benefits can be reflected as increased effectiveness, safety levels and others.
- The complexity and speed of the process allow most of the control actions to be initiated by an operator.

2.2 Methodology for Establishing the Model

Smart Grid Reference Architecture Model (SGAM) is a methodology that aims to offer support for the design of use cases for smart grids and provide clear and concise documentation of the application, with principles such as universality, location, consistency, flexibility, scalability, extensibility and interoperability. SGAM can be used as a common basis for developments, with an architectural approach that allows for a technology-neutral representation of interoperability, both for current grid deployment and for future smart grid deployments [2] [3]. The SGAM model will be used for the proposal of the telemetry system, since it offers an articulation between different elements of a multimodal system that considers operation with different subsystems and remains in constant growth and development.

Created because of the "European Commission Standardization Mandate M / 490 for European Standardization Organizations for European Standardization Organizations (ESO)", SGAM provides a layered approach to developing a smart grid architecture. SGAM's foundation is a three-dimensional framework consisting of domains, zones, and layers. In the domains, there is the traditional design of the electrical energy infrastructure: generation, transmission, distribution, distributed energy resources (DER), and local clients. The zones represent the typical management of the hierarchical energy system: market, company, operation, station, field and process. At the top of the component layer, four interoperability layers are placed: communication layer, information layer, function layer, and business layer. An overview of this three-dimensional model is provided in Figure 2 [4]. Each of the layers is shown below:

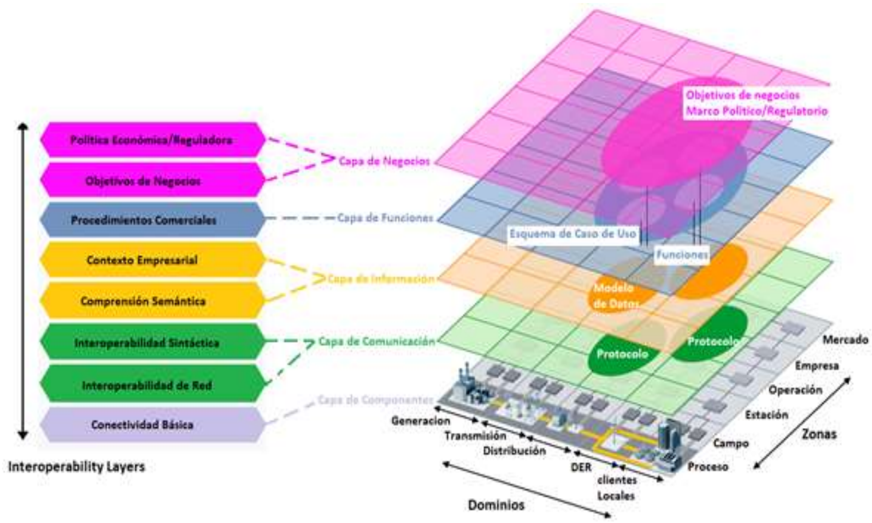

Figure 3. Overview of the network of the Smart Grids architecture model (SGAM). Taken from [2]

Business layer: The business layer represents the business view on the information exchange related to smart grids. SGAM can be used to map regulatory and economic (market) structures and policies, business models, business portfolios (products and services) of the market parties involved. The layer can support decision-making related to (new) business models and specific business projects (business case), as well as regulators in defining new market models. In the proposal, it is represented by the dashboard with the telemetry information and the analyzes generated.

Function layer: The function layer describes functions and services, including their relationships from an architectural point of view. Functions are represented independently of actors and physical implementations in applications, systems, and components.

Information layer: The information layer describes the information used and exchanged between functions, services, and components. It contains information objects and the underlying canonical data models. These canonical data models and information objects represent the common semantics for functions and services to allow interoperable information exchange through the media.

Communication layer: The emphasis of the communication layer is to describe protocols and mechanisms for the interoperable exchange of information between components in the context of the underlying use case, function or service, and related information objects or data models.

Component layer: The emphasis of the component layer is the physical distribution of all participating components in the smart grid context. This includes system actors, applications, power system equipment (generally located at process and field level), protection and remote-control devices, network infrastructure (wired/wireless communication connections, routers, switches, servers).

2.3 IoT Communication Models

Internet of Things (Internet of Things - IoT) is a recent communication paradigm that foresees a near future in which everyday objects will be equipped with microcontrollers, sensors, transceivers for digital communication, and a set of protocols enabling communication with each other and with users, becoming an integral part of the Internet [5]. IoT is basically the convergence of two technologies: The internet and sensor networks. This allows new possibilities, such as direct machine-to-machine communication over the Internet network. The paradigm has allowed researchers to suggest new sustainable proposals in smart cities (autonomous networks and services, and others). Therefore, easy access and interaction of a wide variety of devices is possible, such as household appliances, surveillance cameras, sensors, actuators, displays, vehicles, and others, which generates a lot of information [6].

From an operational perspective, it is useful to think about how IoT devices connect and communicate in terms of their technical communication models [7]:

- The device-to-device communication model represents two or more devices that connect and communicate directly with each other, rather than through an intermediary application server. These devices communicate over many types of networks, including IP networks or the Internet. Nonetheless, these devices often use protocols like Bluetooth, Z-Wave, or ZigBee to establish direct device-to-device communications.
- In a device-to-cloud communication model, the IoT device connects directly to an Internet cloud service such as an application service provider to exchange data and control message traffic. This approach often takes advantage of existing communication mechanisms, such as traditional wired Ethernet or Wi-Fi connections, to establish a connection between the device and the IP network, which eventually connects to the cloud service.
- In the device-to-gateway model, or more typically, the device-to-application-layer gateway model (ALG), the IoT device connects through a service as a conduit to reach a service in the Cloud; i.e., there is an application software that operates on a local gateway device, which acts as an intermediary between the device and the cloud service and provides security and other functions, such as data or protocols translation.

The data exchange model in IoT refers to a communication architecture that allows users to export and analyze smart object data from a cloud service in combination with data from other sources. This approach is an extension of the unique device-to-cloud communication model, which can lead to data warehouses where "IoT devices upload data only to a single application service provider. A back-end exchange architecture allows Data collected from individual IoT device data streams to be aggregated and analyzed, and it suggests a federated cloud services approach, or Cloud Application Programmer Interfaces (APIs), to achieve interoperability of data from smart devices hosted on the Cloud.

By allowing the user to gain better access to an IoT device and its data, the overall value of the device is clearly amplified. Nevertheless, these network benefits come with tradeoffs. Attention should be paid to the cost burdens incurred by users to connect to cloud resources when considering an architecture, especially in regions where user connectivity costs are high.

III. RESULTS

Figure 4 shows the telemetry system architecture proposed for the multimodal transport system, to generate and acquire information in real time, send it to an information system, process the information to visualize it, and run optimization models that allow for efficient system management of transport. The figure shows what is proposed by each of the SGAM model layers: component layer, communication layer, information layer, function layer and business layer. Next, each one of them is described.

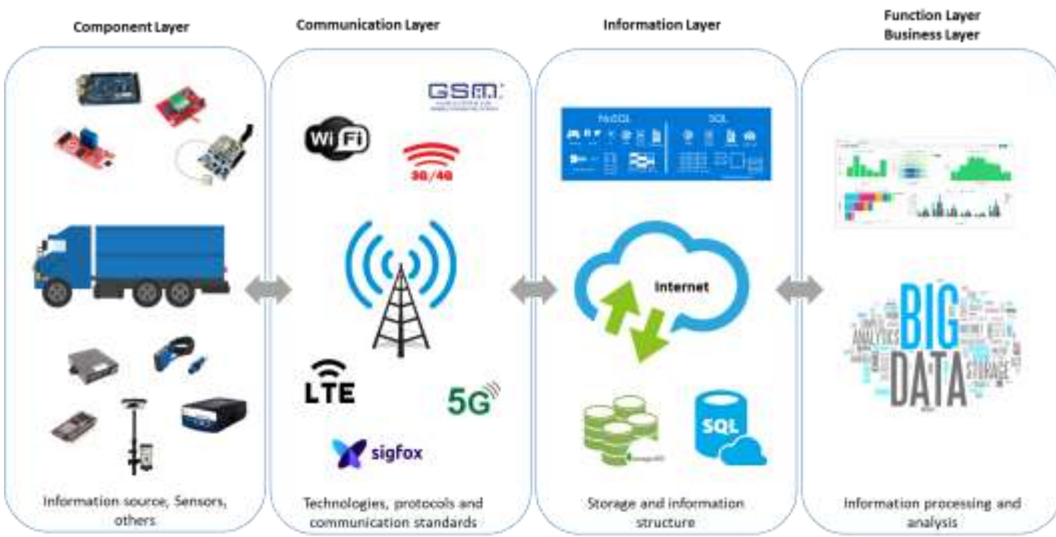

Figure 4. Proposed architecture of telemetry system (Component layer - Information Source, sensors, others; Communication Layer - Technologies, protocols, communication standards; Information layer - storage and structure of information; Function Layer/Business Layer -, information processing and analysis)

3.1 Component Layer

The component layer must consider different equipment and technologies depending on the vehicle (motorcycle, car, boat, other) and its most relevant variables for system management. Sensors must be installed according to the needs, grouping the information in a datalogger with equipment to connect to the communication layer by one of the technologies available with their respective standards. The interoperability of the communications system must be considered, providing options for connections in wireless networks.

An example of interconnection of the component layer with the communications layer is shown in Figure 5. The example shows a system that allows to acquire the vehicle location (Ubicación), through an Arduino and a GPS module. The Arduino was configured to send the signals through a GSM / GPRS SIM 900 module to an Application Programming Interface (API). The prototype allows the addition of other sensors to organize the information sent to the information system.

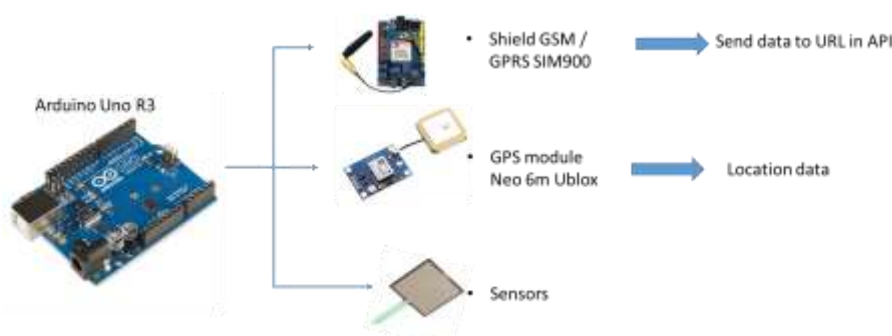

Figure 5. Component layer and communications interconnection example

3.2 Communications Layer

Regarding the context of the multimodal system and the requirements described above, communication in the telemetry system must take place through wireless technologies. Communication between devices on the same motorcycle, as well as between motorcycle devices with external communication equipment, may be required in the system. For information management, it must be guaranteed that the data will be available in real time in the management and monitoring system.

3.2.1 Wireless Technologies

Wireless technology refers to technology that enables communication without using cables or wires. With wireless technologies, people and other devices can communicate at different distances. Wireless technology includes radio frequency (RF) and infrared (IR) waves. Wireless networks are basically classified into 4 types and this classification depends on the scope that each one achieves [8]. Table 1 shows a comparison of available networks and protocols that can be used at the communications layer [9], [10], [11], [12].

Table 1. Comparison of networks and protocols available for communication layer

Type	Coverage	Performance	Standards	Applications
Wireless PAN	Within easy reach of a person	Moderate	Moderate replacement of Bluetooth, IEEE 802.15 and IrDa, as well as wires for peripherals	Replacement of peripheral cables
Wireless LAN	Inside a Building or field	High	IEEE 802.11, Wi-Fi and HiperLAN	Mobile extension of wired networks
Wireless MAN	Within a city	High	Owner, IEEE 802.16, and WIMAX	Mobile extension of wired networks
Wireless WAN	Around the world	Low/Moderate/High	CDPD and Cellular 2G, 2.5G, 3G, 4G, 5G	Mobile Internet access from outside areas.
			Sigfox	IoT network designed to have low consumption and be independent of telephone deployments

3.3 Information, Function and Business layers

The information layer should allow data integration in a dynamic and flexible information system, which allows not only entry of information but its reading in an integrated way with information analysis tools, including big data software and competitive intelligence. The proposal includes modules and APIs so that the information can be obtained directly from sensors or data loggers installed in the vehicles.

According to Web of Things models [13], development of a NoSQL database in MongoDB Atlas is proposed, where different variables related to basic vehicle data are configured (user name, motorcycle type, license plate, year and others) and some fields related to sensor variables (location, temperature, consumption, current, weight and others) are established. The database advantage is that it allows new variables to be added in real time. Figure 6 shows the proposed system, which also includes information acquisition from other relational databases (SQL) through a DB Collector, such as weather station temperature sensors, traffic lights, and others. Once the information is available in the database, a dashboard is built with the information from the sensors and this information is analyzed through big data or business intelligence software in the business layers.

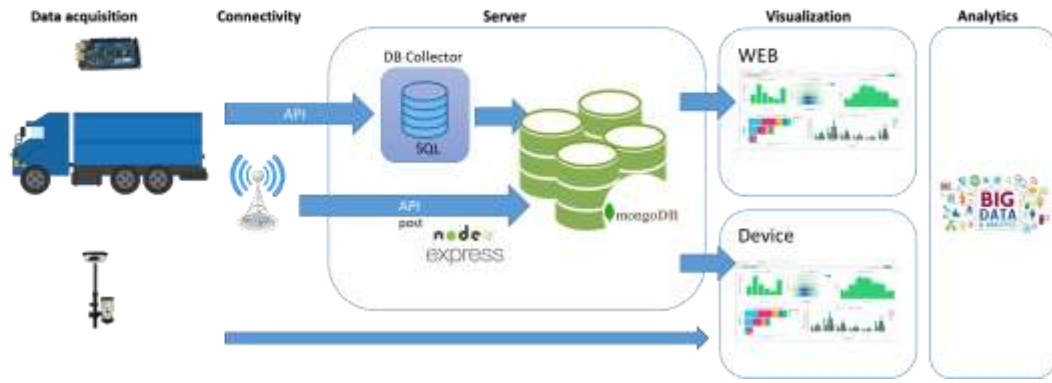

Figure 6. Web server with data collector for platform integration. (Data Acquisition, Connectivity, Server, Visualization, Analytics)

IV.CONCLUSION

Multimodal transport systems that include fully electric or hybrid vehicles must consider the different technologies available to be implemented in the cities of the future, including those used for the Internet of Things. The Smart Grid Reference Architecture Model (SGAM) is a validated model that allows articulation of different layers to implement a comprehensive and flexible model. Using the model to model the telemetry system, efficiently allows mobility management in the cities of the future.

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