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ARTICLE TYPE

Smart Transport and Logistic: a Node-RED implementation

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Abstract

A clever and efficient management of transport and logistic are fundamental for manufacturer companies, which are starting to adopt new methodologies, inspired to the concepts of the emerging industry 4.0. Such concepts are influenced by the spreading of the Internet of Things (IoT) paradigm, which would help to automate many aspects, if not all, of products' management, from raw materials' order to the final delivery to customers. Small and medium industries (SMEs) must face design issues and non-customized solutions may not fit with their habitual data flow. Hence, it would be useful to put in act an adequate tool, able to support designers and developers in defining the network architecture and messages' exchange, easily following the need of the interested company. To this end, the use of Node-RED, a flow-based programming tool for the IoT, is proposed in this paper. A comprehensive case study targeted to smart transport and logistic is developed.

KEYWORDS:
Smart Transport; Smart Logistic; Internet of Things; Node-RED

1 | INTRODUCTION

Many application contexts are affected by the diffusion of the Internet of Things (IoT) vision (1). IoT devices embed sensing and actuating capabilities, making them "smart" and enabling them to interact with the surrounding environment. They are usually managed by a controller application, providing the logic of the data flow, processing, and decision making. Different technologies and communication protocols must be integrated and orchestrated, to realize an efficient IoT infrastructures regulating the information exchange. Some issues emerge, regarding the management of huge amounts of data, security&privacy, and scalability (2). Proper tools must be adopted to perform a preliminary evaluation of the new designed solutions, before real deployment. The work presented in this paper embraces: (i) the realization of an IoT application targeted to the smart transport and logistic scenario; (ii) the emerging initiatives of the industry 4.0 (3) tailored to the small and medium industries (SMEs); (iii) the use of Node-RED tool for comprehensive representing the considered case study (i.e., involved entities, relationships, behavior). Smart transport and logistic fields are chosen due to their emerging importance for companies, since a better management of products' order and delivery would seriously improve the overall efficiency of the warehouses and of the means of transport. Such enhancements may have a great impact on productivity, costs, and on customers' satisfaction. The paper is organized as follows: Sec. 2 presents the background on IoT applications in the transport and logistic fields; Sec. 3 details the case study; while Sec. 4 describes the Node-RED design and implementation; Sec. 5 ends the paper.

2 | BACKGROUND ON SMART TRANSPORT AND LOGISTIC AND MOTIVATION

Transports and logistic play a fundamental role among the IoT applications. In (4), a case study has been used to clarify the functionalities of the DNS Architecture for the IoT. The behavior of a DNS infrastructure, which adopts a three-tier hierarchy of domain name servers and a three-level caching strategy, has been simulated. Preliminary results indicated that such an approach could be feasible for object tracking in the IoT domain. A logistic cloud-based framework has been presented in (5), which mainly makes use of RFID technology in order to monitor the goods and pallets in the analyzed warehouse. The main drawback of such a solution is that the experimental evaluation is limited to the simulations of RFID; without considering the whole conceived architecture, which also consists of private and public cloud, and other service provider modules (e.g., a security management and authorization module). Even adopting RFID, the work in (6) details a web-based embedded system to control vehicle access from a university campus. Unfortunately, the authors did not carried out a performance evaluation of the proposed application. The same is for the authors of (7), who propose possible software and hardware technologies to implement their proposed smart public transport system, but no performance evaluation is fulfilled. (8) limits to envision a future era of "Internet of Vehicles", where advances in the IoT principles' application will foster intelligent transport and vehicles will be increasingly autonomous and able to take decisions without the human intervention. Hence, only design perspectives are highlighted, promoting the adoption of a vehicular cloud model. As emerged from the aforementioned analysis, the proposed solutions always no provide an effective implementation, able to evaluate their correctness and consistency. In general, the works available in literature try to validate and test the performance of their proposed approaches by means of different programming languages and tools. Often researchers make also use of existing data-sets in order to operate with real data. The main drawback is that often it is not the whole system to be tested, but only a part of it. Such a choice due to a lack in the use of a comprehensive tool, able to represent the new-defined IoT architecture close as much as possible to the future real working system. To cope with such an issue, the adoption of Node-RED tool is proposed in this paper, to represent a smart transport and logistic case study. Other tools targeted to IoT have also been proposed in literature; for a complete description, please refer to (9).

3 | THE SMART TRANSPORT CASE STUDY

Referring to the smart transport and logistic field, the goal of the presented case study is to realize an IoT application for guaranteeing the control of products' delivery, through the management of smart vehicles and tracking of the products, handled within the warehouse of a generic SME. Products are supposed to be tracked by means of RFID tags; while smart vehicles are supposed to be equipped with a set of sensors, which automatically perform different tasks, depending on the information contained in the RFID tag associated to the delivery packages. The fundamental components of the system are the followings: (i) the smart vehicles; (ii) the RFID tags; (iii) the RFID scanners; (iv) the warehouse. Hence, the products can be associated with the following status: (i) *TO SELL*, if the corresponding product in the warehouse is waiting to be purchased; (ii) *IN DELIVERY*, if the corresponding product in the warehouse is waiting to be delivered (i.e., it has just been sold); (iii) *DELIVERED*, if the corresponding product has already been delivered. The smart vehicles are supposed to be equipped with the following sensors and devices: GPS, vibration sensor (inspired by Arduino SW-420), humidity sensor, temperature sensor, dehumidifier, motor fridge. Different kinds of delivery can be carried out, depending on the features of the transported product: (i) *STANDARD*, in case of "standard" products - only provides the execution of a geographical coordinates' check for set up the route; (ii) *FRIGO*, in case of fresh or frozen products - which provides a check on the coordinates, the temperature and the humidity of the smart vehicle; (iii) *FRAGILE*, in case of fragile products - which provides a check on the coordinates and on the level of vibration of the smart vehicle. Moreover, each vehicle must be in one of the following status: (i) *AVAILABLE*, if the corresponding vehicle is not engaged in any delivery; (ii) *IN DELIVERING*, if the corresponding vehicle is engaged in a delivery. In the next section, the just detailed scenario will be properly designed and developed within Node-RED tool.

4 | NODE-RED DESIGN AND DEVELOPMENT

Node-RED[1] results from an open project, developed by IBM, which proposes a flow-based and event-driven programming tool. The application's behavior is thus represented as a network of black-boxes, which may communicate with each others and regulate the flow of the information within the designed system. Moreover, a visual browser-based representation supports, during the design and development, in better understanding the happening interactions within the whole IoT network. In fact, many entities may be involved, both hardware (e.g., sensors) and software (e.g., services) ones. Node-RED also enables the real connection of hardware devices and APIs. Since Node-RED allows the integration of different technologies, thanks to proper libraries, the following ones have been adopted in the presented solution: (i) MongoDB[2], as database engine, instead of a relational database, due to its greater efficiency in responding to a large number of queries in a short time; (ii) Java as programming language, due

[1] https://nodered.org
[2] http://www.mongodb.org

to its widely adoption in actual real implementations; (iii) MQTT[3], as lightweight publish&subscribe method, for information sharing and system's notifications. Note that Node-RED is responsible for controlling the data flow and for providing the logic of the whole IoT application. More in detail, MongoDB has the active role of identifying the current status of the products (i.e., *TO SELL*, *IN DELIVERY*, *DELIVERED*) and the status of the smart vehicles (i.e., *AVAILABLE*, *IN DELIVERING*). A Java program simulates the communications, via proper TCP connections, with sensors and RFID tags towards the Node-RED control application. Instead, communications among the involved entities components only take place via MQTT protocol, exploiting a well-defined topic hierarchy, which is sketched in Fig. 1 . As revealed by Fig. 1 and by the flows presented in the following, the adopted publish&subscribe system manages both messages useful for the management of the logistics and anomalies, which are reported as alarms to the warehouse.

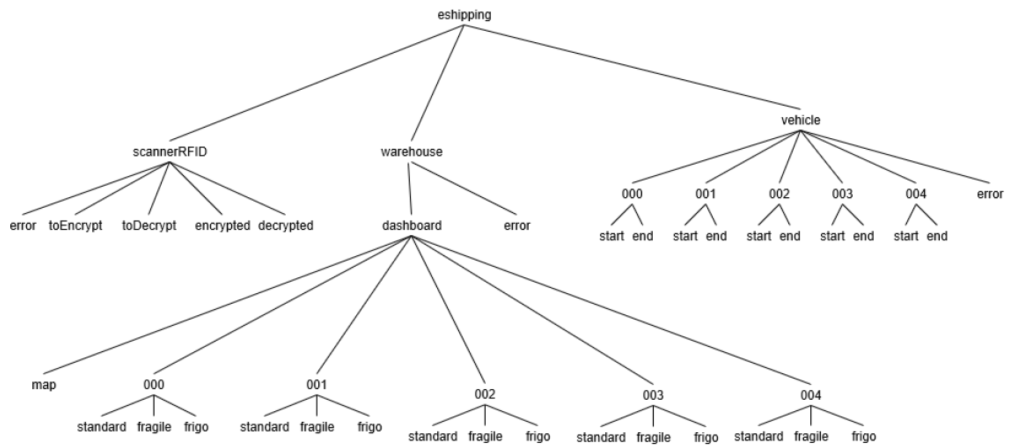

FIGURE 1 Topics' hierarchy

The dashboard in Fig. 2 allows to dynamically simulate: (i) a purchase notify; (ii) a delivery attempt; (iii) the visualization of the vehicles' location. In this way, the behavior of the system can be evaluated by means of concrete tests, which can be not only be performed by the developers themselves, but also by the SME's managers, due to the user-friendly features of the graphics. As an alternative, the purchases can also be simulated by means of an automated programming running in background.

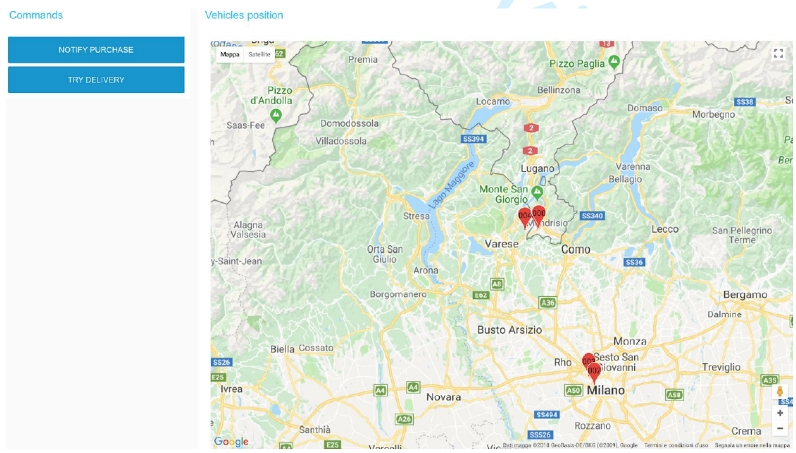

FIGURE 2 Dashboard for simulations

Three main Node-RED flows are needed to manage the smart transport and logistic system:

- The flow related to the central system that manages the purchase's orders; such orders are then sent to the warehouse which is notified by the fact that one or more products have been sold, and, then, are ready to be delivered (see Fig. 3);

[3]http://public.dhe.ibm.com/software/dw/webservices/ws-mqtt/ mqtt-v3r1.html

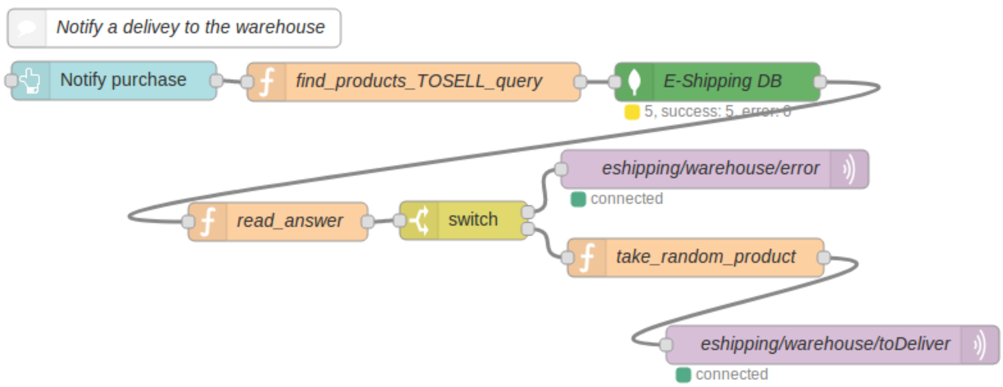

FIGURE 3 Flow - notification of a deliver to the warehouse

- The flows related to the warehouse and to the RFID scanner, which are composed by a series of alternating sub-flows:
  - *(warehouse)* Once a purchased product is notified, the warehouse converts it into a Javascript object and passes its information to the RFID scanner, always via MQTT. If the encryption and tag's write tasks are successful, the warehouse receives a notify and updates the status of the product in the database (see Fig. 4);

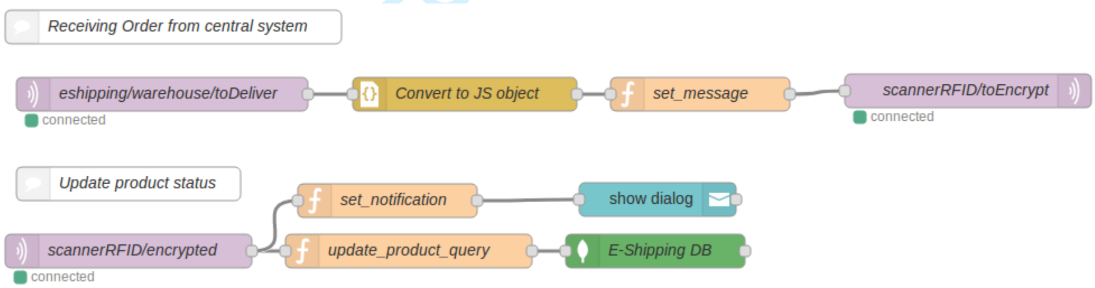

FIGURE 4 Flow - reception of a purchase's order notification

  - *(RFID scanner)* When the scanner receives the products' information, it encrypts and writes them on the tag's memory (such a behavior is simulated by a direct TCP connection to the Java program - see Fig. 5);

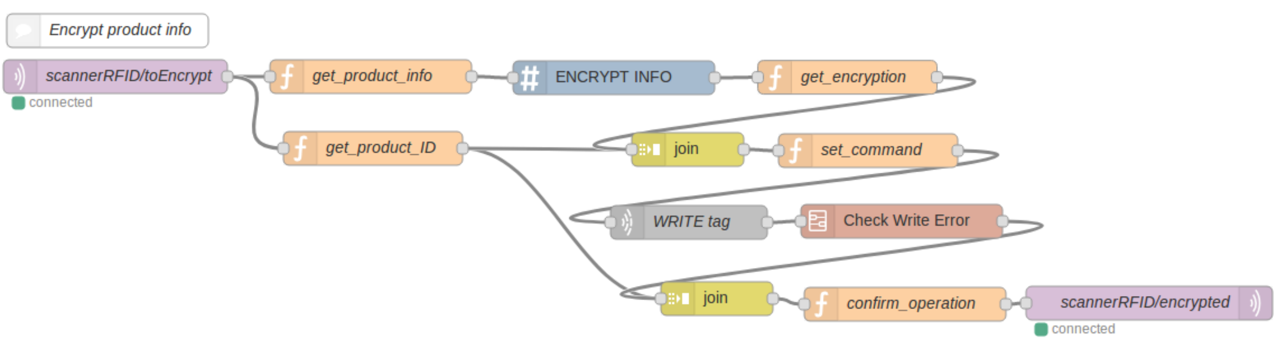

FIGURE 5 Flow - scanner's product encryption and write

  - *(warehouse)* The warehouse starts the delivery of ready products, if there is an available vehicle (see Fig. 6);

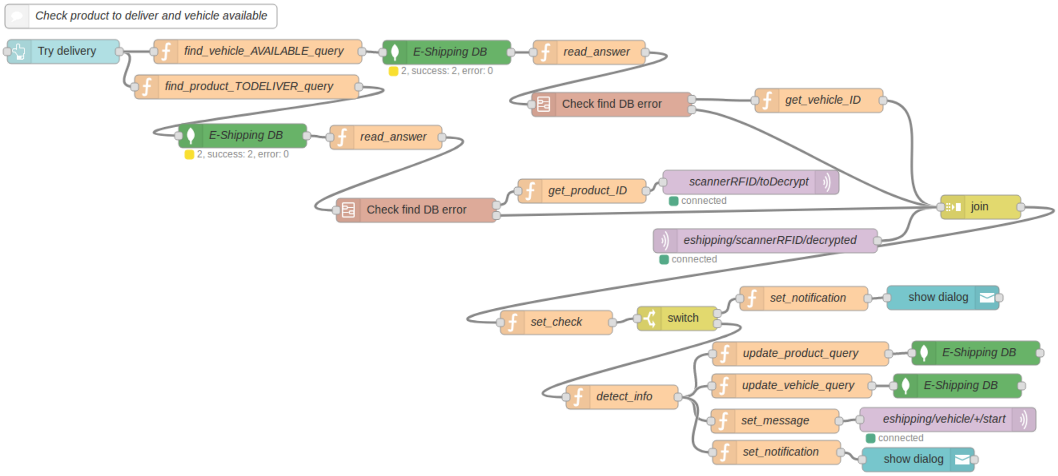

FIGURE 6 Flow - products' delivery

– *(RFID scanner)* The tag containing the information of the "in delivering" product is decrypted and read, in order to know if it needs a transport of type *FRIGO* or *FRAGILE* (see Fig. 7);

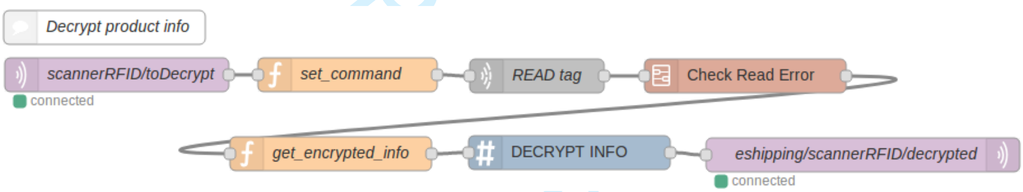

FIGURE 7 Flow - scanner's product decryption and read

- The flow (one per vehicle) associated to the behavior of each smart vehicle. Note that the way-points are gathered from the database, which contains the possible routes.

Another dashboard provides real-time information about the status of the vehicles (coordinates, temperature, humidity, vibration), as sketched in Fig. 9 , which also shows statistics about the status of the products and the alarms. Note that also the creation and update of the dashboards are managed via proper Node-RED flows.

5 | CONCLUSION

This paper presented a possible smart transport and logistic scenario, designed and developed by means of Node-RED tool. It aimed at demonstrating the feasibility and usability of Node-RED in representing and testing the behavior of IoT environments, due to the user-friendly interface and easy-to-use components.

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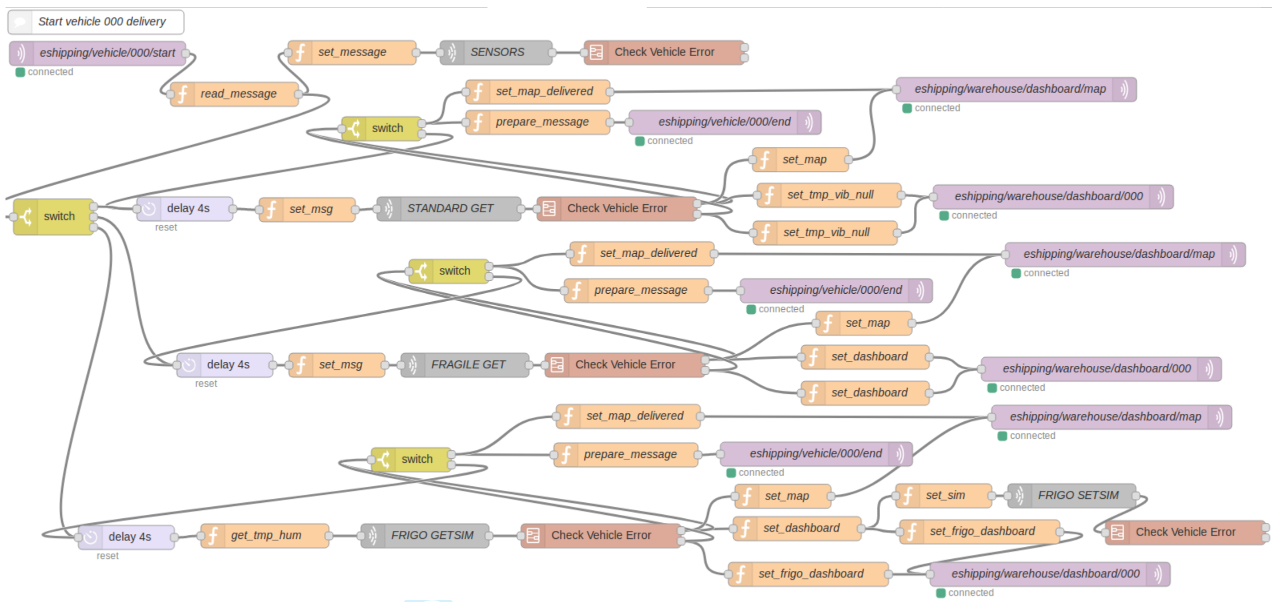

FIGURE 8 Flow - smart vehicle behavior

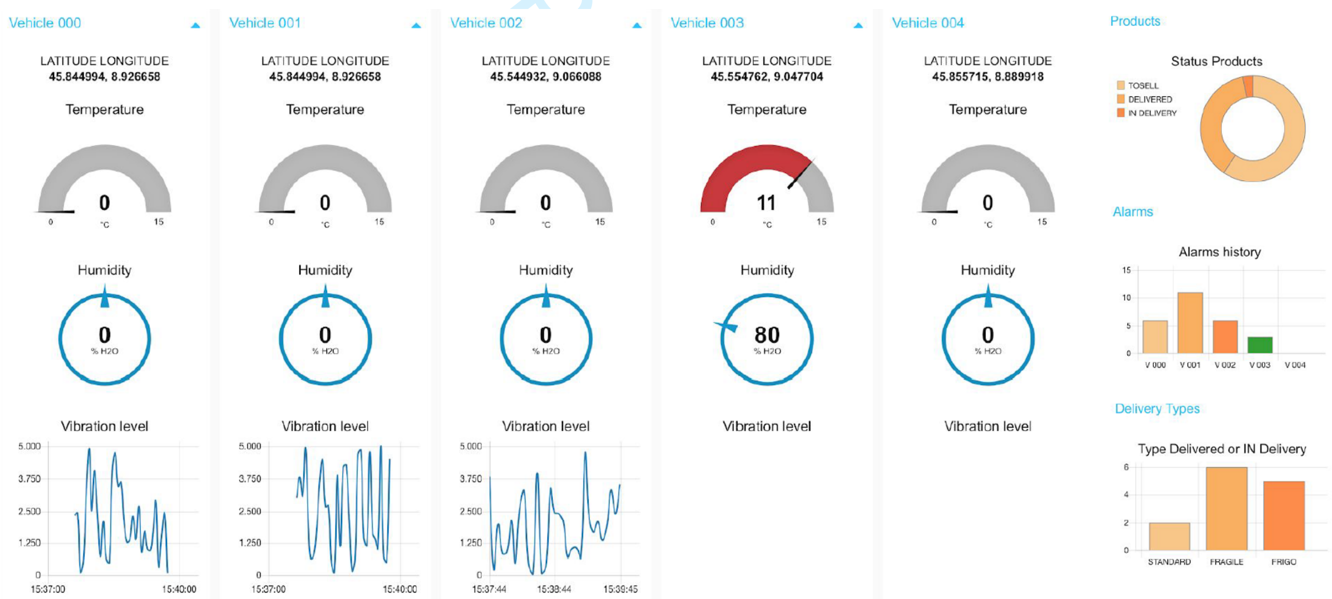

FIGURE 9 Dashboard showing information about the vehicles and statistics about products and alarms

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