Automated delivery of shipments in urban areas

Franz Kopica, Walter Morales-Alvarez and Cristina Olaverri-Monreal
Chair for Sustainable Transport Logistics 4.0

JOHANNES KEPLER UNIVERSITÄT LINZ

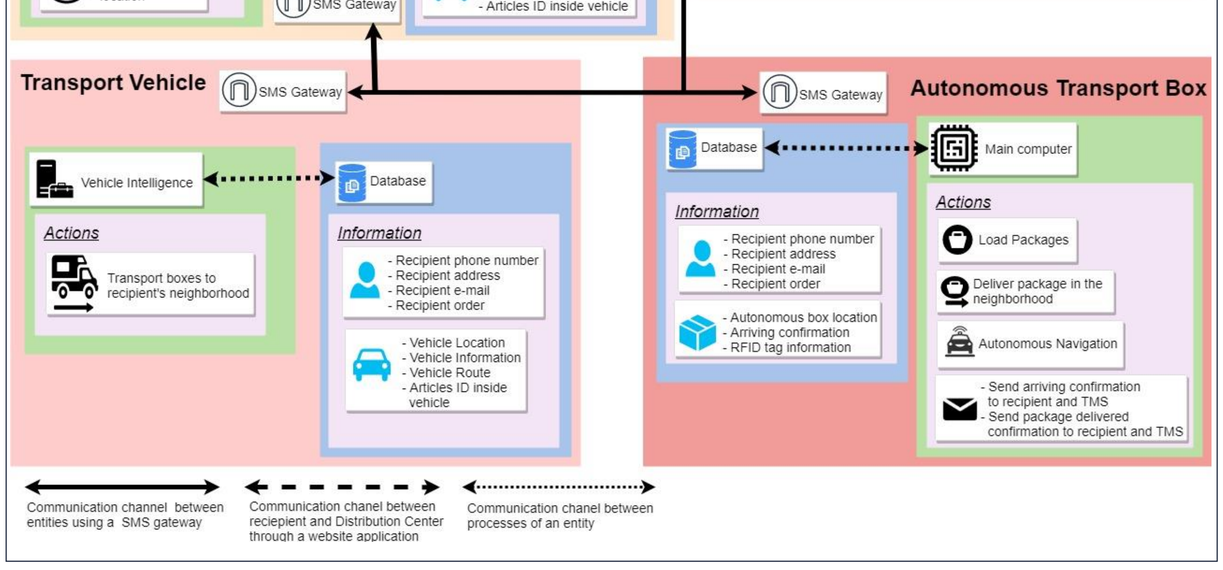
Introduction

Urban agglomerations are continuously growing, testing the limits of transport and infrastructure resources and causing extremely congested traffic areas in cities. As a consequence, travel time increases, which results in higher CO2 emissions.

Fuel consumption and CO2 emissions reduction requires new vehicle concepts as well as efficient transportation systems. The expansion of fully electric vehicles into the market provides opportunities for sustainable mobility and a new technological era while also presenting a promising alternative to vehicles with internal combustion engines for urban goods mobility demands. In addition, time-critical deliveries can hardly be realized if the vehicles have to charge for hours in the middle of the delivery process, or are subject to an insufficient charging infrastructure. Therefore, small hybrid or electric vehicles are an optimal approach for the urban area. In line with this, we contribute to the “last mile and city logistics” topic by proposing a case study describing the application of an autonomous logistics system for delivering packages and mail. By using delivery hybrid- or electric vehicles that contain standardized autonomous transport boxes with electronic labels it is possible to optimize delivery cost and times. They drive from a strategically located logistic or central operating platform (distribution center or hubs) to a predefined destination where their load is distributed according to the information that they receive.

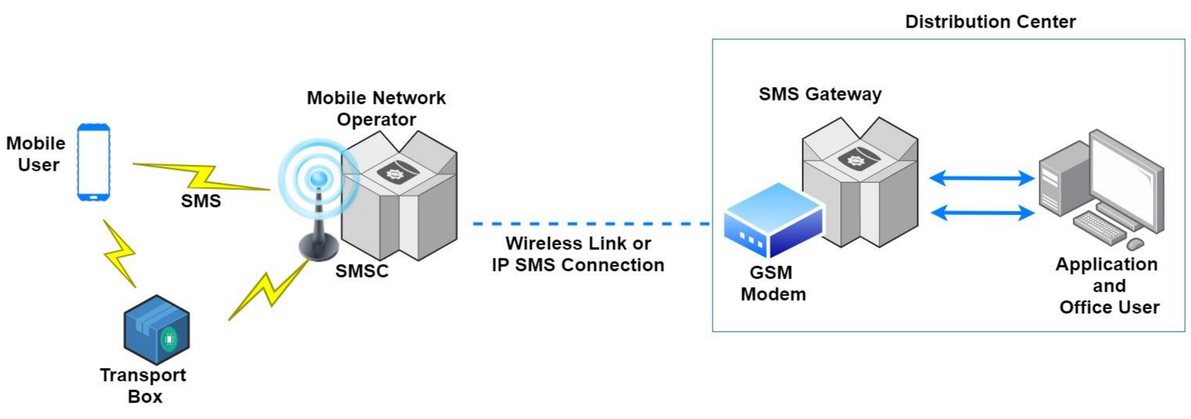
The proposed autonomous system for transport logistics relies on a multi-agent architecture. The different entities in the architecture are interconnected through mobile networks for the internal exchange of information (e.g. the state of the processes of each unit or its location) or for external communication to acquire data related to the surrounding road users or customer information to which the delivery is scheduled.

System General Architecture



System Communication

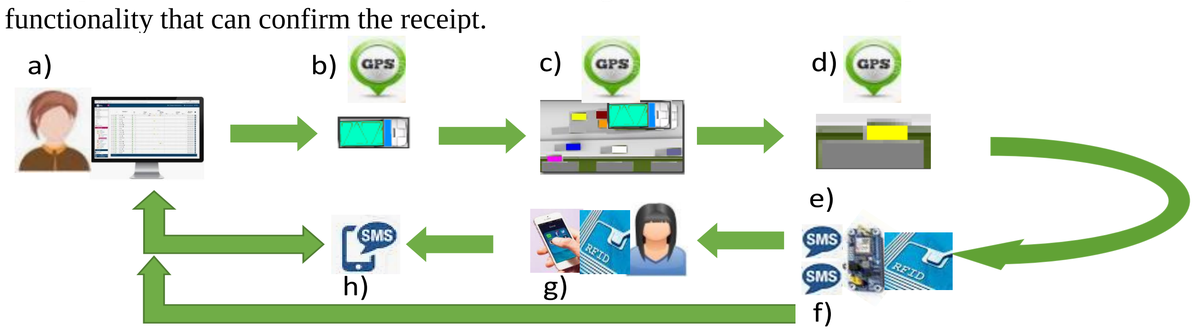
For the communication between the entities in our system, a transport management system in the hub DC includes additional communication capabilities through GPS and short message service (SMS). This communication is achieved thanks to the fact that on the autonomous transport box side there is a SIM7000E device that works as a GSM module and that together with the program SMS Server tools generates an SMS Gateway that connects with the DC’s SMS gateway. The SMS gateway is an interface for communication that uses mobile networks between smart entities. It offers a framework to process the messages transmitted between the devices and it can handle the data acquire through the HTTP protocol from the network or the email to SMS functionality.



Use Case

The goods are unloaded from the carriers in the distribution center into a hybrid or electric van that drives to a target destination determined by the central operating platform following the information from the leading IT system. The autonomous transport boxes then receive an updated destination with new coordinates via text message (SMS) or email that is read and interpreted automatically by the box without a third party intervention, in cases where the recipient changes the destination address. In this scenario, the change is stored in the database of the transport managing system and sent to the autonomous transport box through the communication channels mentioned.

After the autonomous transport boxes have left the delivery van they drive towards the destination. A confirmation that the destination has been reached and the box can take a parked position is made through the RFID tag located inside the transport box where a customer ID is stored. This information is transferred to the database application in the box and triggers the transmission of an SMS message with the delivery time information to the package’s recipient (as listed on the database). The operator receives the same information. Eligible receivers are smartphones with RFID/NFC functionality that can confirm the receipt.



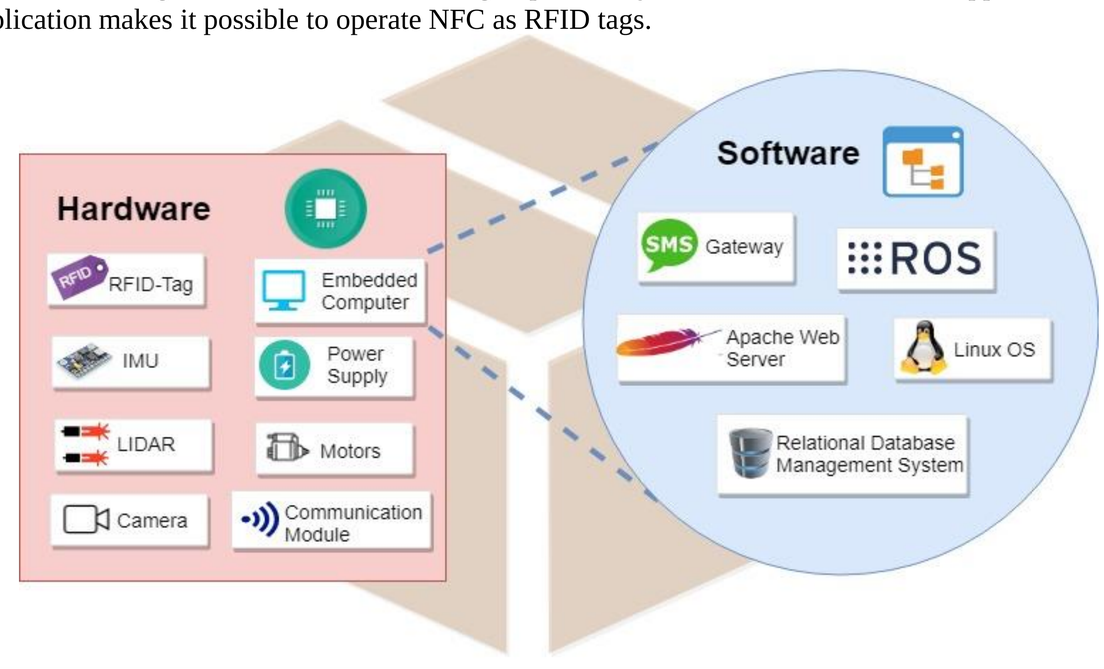
(a) The leading IT system
(b) The transport vehicles
(c) The autonomous boxes traveling
(d) Taking their parked position
(e) The delivery of the message to the database
(f) The delivery of the message to the recipient
(g) The smartphone to unblock the box
(h) The confirmation of the delivery

Proposed Prototype

The prototypes proposed are equipped with all the required technology for a smooth autonomous operation. They are capable of simultaneous localization and mapping (SLAM) by constructing and/or updating a map of an unknown environment while simultaneously keeping track of their location through GPS. They are also able to perceive their surroundings through several active and passive mounted sensors. All units communicate changes in the delivery plan or schedule with the parent system. In addition, the autonomous transport boxes are equipped with a GPS module for localization and a global system for mobile communication (GSM) module that acts as a mobile communication modem for sending and receiving messages from the hub.

A RFID reader/writer unit is installed in the autonomous transport box. The goods are equipped with a RFID-tag that contain a microchip to store and retrieve the information from the inventory database records in the central operating platform. Through this technology, the autonomous boxes are also labeled with unique identifiers that can contain a large amount of information and make inventory tracking a faster process. To complete the system, the boxes have a embedded computer that stores and processes the information, enabling communication between all the peripherals and processes explained above.

Recipients are able to open the box through the use of radio waves to read and capture information stored on the tag attached to the box using a previously installed mobile device application. This application makes it possible to operate NFC as RFID tags.



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