A solution for the management of the passengers' shuttle buses of the port Tanger MED Passagers.

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Abstract. The present paper discusses a solution for managing the fleet of vehicles destined to servicing the passengers of the harbour station of the port Tanger MED Passagers. This solution can be divided on two components: first, we formulate a linear program describing the current situation at the station using a variant of the vehicle routing problem – multi-trip vehicle routing problem with divisible pickups and deliveries, and we solve it, then we have un package of web and mobile applications destined to improve the communication and data transfer between all users of the system, that is, the driver of the shuttle bus, the field operator and the operator of the control room. The simulations show that indeed this system answers the need of the port.
Keywords: Tanger MED Passagers, Tanger MED, VRP, Vehicle Routing Problem, linear programming, shuttle bus, fleet management.

1 Introduction

With the emergence of the Internet of Vehicles, ports shuttle buses are not only vehicles destined to transporting passengers to the different terminals, but now, they become a key factor for increasing efficiency, improving the usage of ports resources and growing customer satisfaction. Nowadays, the most successful ports are those that integrate an innovation initiative in their culture and are willing to integrate the emergent technologies onto their systems. In this context, the port Tanger Med Passagers wants to enhance their shuttle buses management system.

This rest of this paper is divided into the following sections: a diagnosis of the port current operations for managing its shuttle buses. Existing solutions implemented on international airports and ports. The proposed solution which is a combination of the resolution of the multi-trip vehicle routing problem with divisible pickups and deliveries, and a set of application packages destined to enhancing communication between all users of the system. And finally, a conclusion and future work are discussed at the end of the paper.

2 Diagnosis of current port operations for managing its shuttle buses.

According to a visit done to the harbour station, currently, managing the shuttle buses is done in the following way:

- Passengers must travel, on average, 2 km, from the harbour station to the docks, as we see on figure 1.

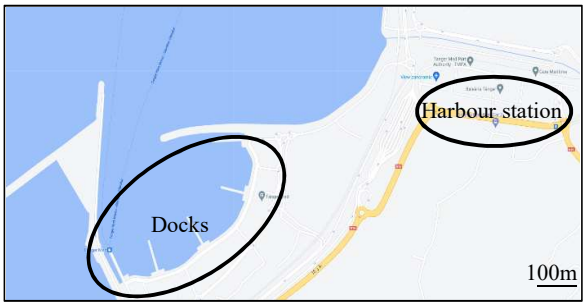

Fig. 1. Map of the port Tanger MED Passagers.

- The dispatcher at the control room waits until it is time for an arrival or a departure to ask the passengers to get in the shuttle buses, without taking into account how many they are. The assignment of shuttle buses is done manually and on the spot.
- Field operators communicate with each other through radio in order to ask for shuttle buses, and in person with the drivers in order to tell them where to go.
- There isn't a surveillance of the current state of shuttle buses, field operators need to be in person with the driver to tell their next task.
- The control room knows the current state of the field only through field operators.

With this diagnosis, two problems arise:

- The assignment problem: the current way is inefficient, the dispatcher doesn't take advantage of available data such as number of passengers.

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- The lack of communication: currently, the control room knows the state of the field only through TETRA radios, it is not enough. We need a centralized system of information so that all its users have the same information, updated and on real time.

3 Existing solutions implemented on international airports and ports.

Among existing solutions that are currently implemented on international airports and ports, we have Advantech and INFORM GbmH solutions [1-3]. These solutions are a combination of hardware and software, namely:

- Advantech in-vehicle rugged computers that allow real time monitoring of the state of the shuttle buses in terms of GPS, destination, number of passengers, ETA, fuel level, etc. And real time communication with the control room about the situation in the field.
- A Fleet management software that uses the data sent by the computers, adjusts the schedule of the fleet in a flexible and optimal manner and helps decision making.

Finally, adopting these solutions meant an increase in operations efficiency, a decrease in costs and customer satisfaction growth.

Motivated by these solutions we propose ours in the following section.

4 Proposed solution.

In order to respond to the problems, found on the previous section, we propose the solution schematized on figure 2.

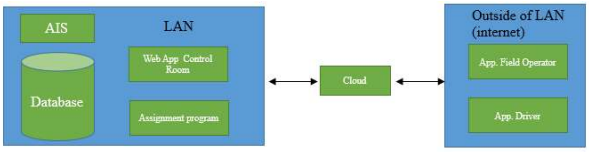

Fig. 2. Software architecture of proposed solution.

We will enumerate each component of the proposed solution and its role:

- The field operator mobile application and the control room web application will allow us to display relevant information such as geolocation of shuttle buses and operators on a map, future arrivals and departures, shuttle buses routes, etc. Also will permit us to send/receive inputs such as number of passengers.
- The driver mobile application will allow us to send the current geolocation of shuttle buses and display the route drivers must follow.
- The assignment program is responsible for gathering the necessary data for the scheduling of the shuttle buses, making the assignments and sending it to the system.
- The cloud will allow us the connect and synchronize the different applications through the internet.
- The automatic identification system (AIS), will allow us to correct the ETAs of incoming ships, this way our assignments will be more reliable.
- The database will allow us to store relevant information such as the speed of drivers, number of passengers vs time, etc.

Finally, these applications will be installed on rugged tablets, this will make the system reliable and more robust to failure.

5 The assignment problem: solving the vehicle routing problem.

5.1 Problem formulation.

We consider a set of ships to serve, these ships can be either an arrival (pickup) or a departure (delivery) – can't be both to which is associated a positive number of passengers. The position of each ship is known.

We have a set of homogenous shuttle buses for moving the passengers to the terminals, these buses have a finite capacity and can visit a terminal more than once. their position is known, and they don't necessarily start from the harbour station on the first trip, in the second trip and so on the vehicles start on the station.

With this description, we chose to use the MT-VRPDPD formulation to solve the assignment problem:

- Multi-trip: a shuttle bus can visit the same terminal multiple times.
- VRP: we have a set of vehicles that need to move a set of loads (passengers) to a set of clients (ships).
- Divisible pickups and deliveries: pickups are arrival ships, deliveries are departure ships, finally, divisible because passengers can be divided between multiple buses.

5.2 Problem resolution.

For the resolution of the linear program, we used COIN-OR CBC open source MILP solver.

An example solution is seen in figure 3, we have a 2 vehicles in standby at the harbour station, and one that is already on route to terminal 2 with 20 departure passengers.

We have a set of 4 ships that needs service, 2 departure ships (out) and 2 arrival ships (in), out 40 means 40 passengers going outside Morocco.

Each route is given by (origin, destination, passengers_departure, passengers_pickup) and as we see all constraints are respected.

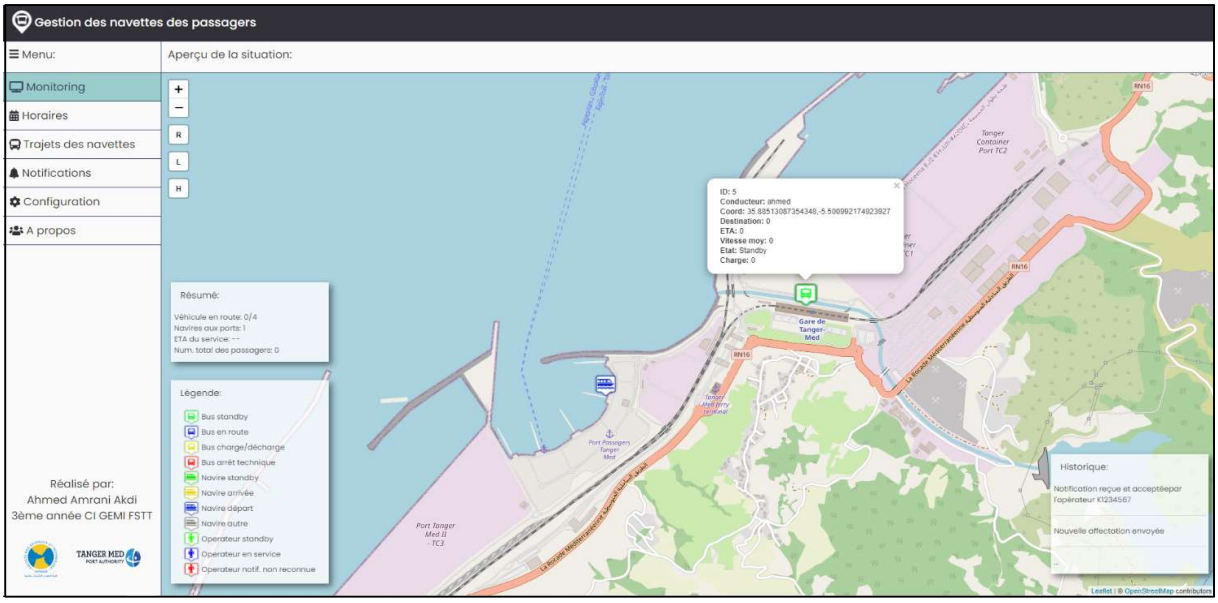

Fig. 4. Home screen of control room web application.

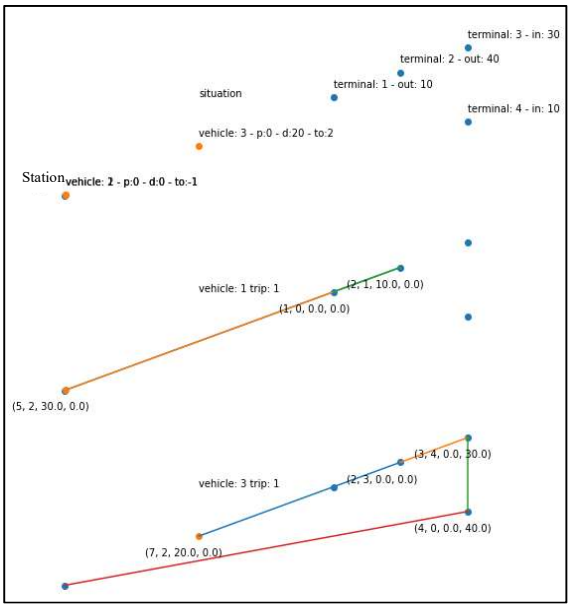

Fig. 3. Example of MT-VRPDPD resolution.

6 Communication mastery.

As we said on the proposed solution, in order to master the communication and to make data more accessible, a package of applications is proposed.

In figure 4, we see the web application destined to the control room, it will allow the operator to monitor the current state of the field in real time, and it will display relevant information concerning departures and arrivals, shuttle bus assignments and notifications.

In figure 5, on the left, we see the application destined to the field operators, it is similar to the control room application, and it will allow the operator to introduce the number of passengers taking a determined ship, this number will be used to determine the shuttle bus assignments. And finally, on the right, we see the application destined to the driver, it will display the routes to follow and their relevant information, also, it will allow the driver to express the current state of the bus.

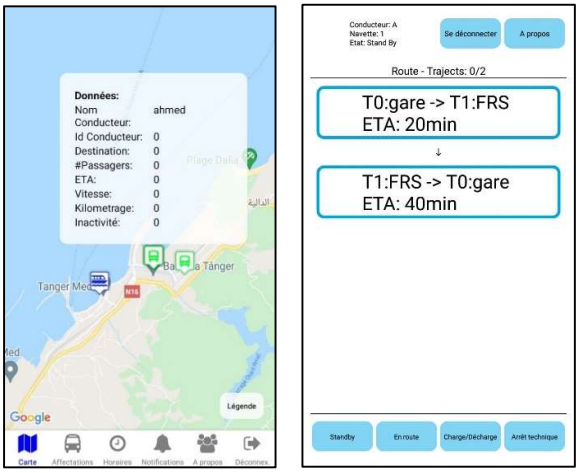

Fig. 5. Mobile applications, left: field operator mobile application, right: driver mobile application.

7 Conclusion

A solution for the management of passenger's shuttle buses of the port Tanger Med Passagers is introduced in this paper, a system for addressing the problems concerning current operations is presented, this system responds to the two primary found problems: the assignment problem and the communication mastery problem.

For the first a linear programming formulation is proposed based on the multi-trip vehicle routing problem with divisible pickups and deliveries and solved using COIN-OR CBC open source solver.

Secondly, in order to make data more accessible and available, and to enhance the communication capabilities of the port, a set of applications is introduced, namely, a web application for the control room, a mobile application for field operators, and a mobile application for shuttle bus drivers.
Simulations show that indeed the proposed system is able to respond to the needs of the port.

To conclude, interconnecting the whole system as in figure 2 will be done in the future.

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