Bluetooth-Low-Energy based System for Automatic Public-Transport passengers' Movement data collection

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The quality and availability of data collection systems are essential for a high-quality planning and operations of public transport (PT) systems. Passengers' demand (both spatial and temporal) is a key component in those phases. Unfortunately, acquiring accurate and complete passengers' demand is a complex and time-consuming process. Various information technologies are used to assist in the planning and operations phases. The main systems being used are: a) Automatic Vehicle Location (AVL) systems b) Automatic Passenger counting (APC) systems, and c) AFC (Automatic Fare Collection) systems (Acumen Bulding Enterprise Inc., Booz Allen Hamilton Inc. et al. 2006, Furth, Hemily et al. 2006, Strathman, Kimpel et al. 2008). Each of those Automatic Data Collection systems (ADC) has a specific contribution: AVL systems provide tracking of buses, APC systems provide passenger loads, and AFC systems assist with ticketing and monetary transactions. The data acquired can be used for analysis, as well as to enhance the performance of PT systems, and the introduction of advanced models. Unfortunately, those systems are not capable of completely tracking passengers' movements throughout the system: arrival at a stop, boarding/alighting (unless swipe-in/out is performed on all trip legs), in-vehicle positioning, and transferring. Global Navigation Satellite System (GNSS) technology can overcome some of the disadvantages of AVL, APC, and AFC technologies (Yilin 2000). The main drawback of such an approach is the high-energy consumption (user-side). Economical GNSS energy consumption management reduces tracking accuracy, hence prohibit precise positioning (Carrel, Lau et al. 2012). Other wireless options exist, such as WLAN and Bluetooth, which are more energy efficient. The main advantages of Bluetooth Low Energy (BLE) is low energy consumption (both user and transmitter-side), positioning accuracy in close range to the transmitters (indoor and outdoor), and low-cost.

In our work, a BLE based system for automatic passengers tracking is introduced. The system is composed of the following components: a) low-cost, small size, and battery-operated tags attached to bus stops and PT vehicles, b) a smartphone application, c) data server. Based on the proximity to the tags, it is possible to automatically identify all the above-mentioned events (arrival, boarding, alighting, etc.), as well as to estimate OD matrices, arrival rate, vehicle load,
etc.. The aim of the work is to test and validate the system (technologies and algorithms) in a small scale scenario (one route, 16 stops). The following figures illustrated the results of a small scale demonstration at Bar-Ilan University's campus.

![Single passenger tracking](image)

![Passengers waiting at stop 3](image)

References


