An IoT-based Data Collection and Analytics Framework using Bluetooth Proximity Beacons

Background :

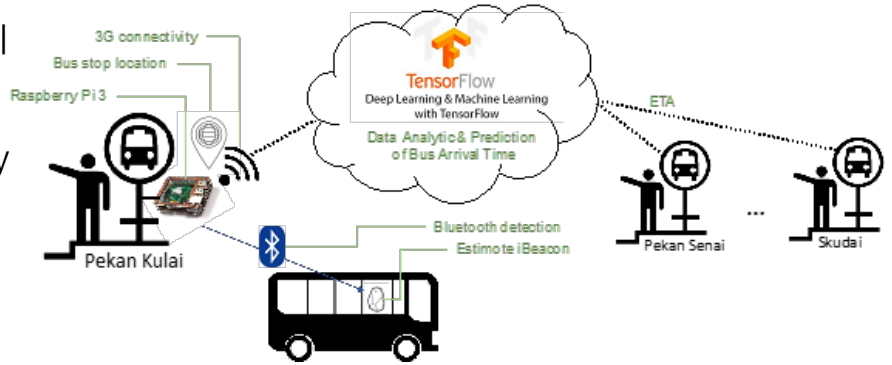
Tracking of public bus location requires a GPS device to be installed, and many bus operators in developing countries do not have such a solution in place to provide an accurate estimated time of arrival (ETA)

This project proposes an innovative IoT solution to track the location of buses to collect transportation data without requiring the deployment of GPS devices. It uses Bluetooth Low Energy (BLE) proximity beacon to track the journey of a bus by deploying an *Estimote* proximity beacon on the bus

Targets:

Bus operators in Johor (PAJ Bus) in Malaysia and School bus operator in Malang Indonesia

Benefit general public who commutes everyday by public transport



Speaker:

Prof Sharul Kamal bin Abdul Rahim
Universiti Teknologi Malaysia (UTM)

An IoT-based Data Collection and Analytics Framework using Bluetooth Proximity Beacons

Project Members :

Members	Affiliation
Sharul Kamal bin Abdul Rahim (Project Leader), Abu Sahmah bin Md Supa'at, Jafri Bin Din, Mohd Adib bin Sarijari, Omar bin Abdul Aziz, Olakunle Elijah, Siti Fatimah Bte Ausordin, Muhammad Zairil bin Muhammad Nor	UTM, Malaysia
Sye Loong Keoh, Chee Kiat Seow, Qi Cao	UGS, Singapore
Somnuk Phon-Amnuaisuk, Md Saiful bin Haji Omar, Soon-Jiann Tan, Haji Idham Maswadi bin Haji Mashud	UTB, Brunei

Members	Affiliation
Achmad Basuki, Adhitya Bhawiyuga, Eko Setiawan, Agung Setia Budi	UB, Indonesia
Yung-Wey Chong, Mohd Najwadi Yusoff, Noor Farizah Binti Ibrahim	USM, Malaysia
Kok Chin Khor, Mau Luen Tham	UTAR, Malaysia

Project Duration :

June 2022 – May 2024 (2 years)

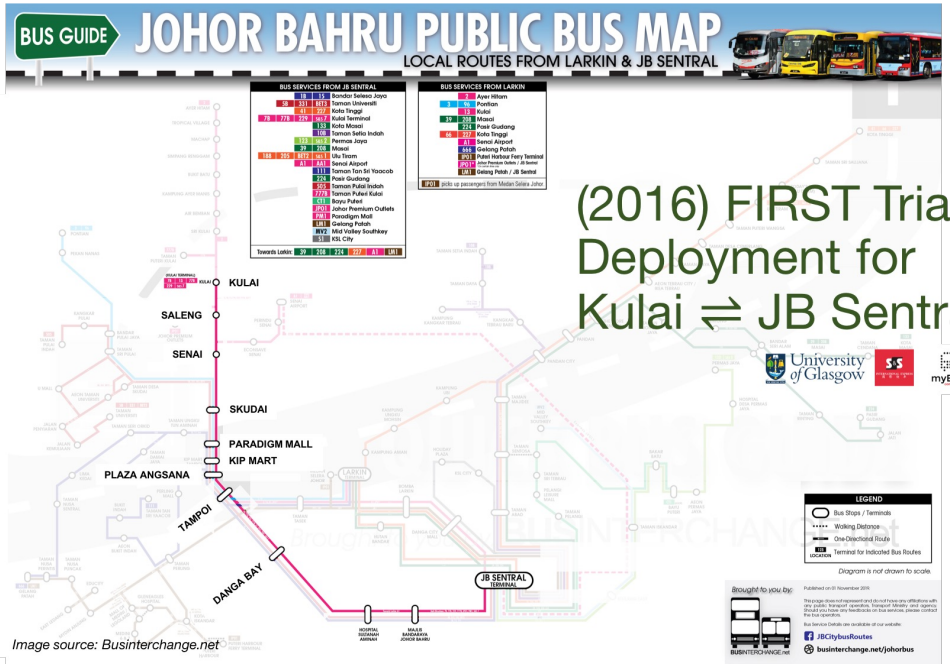
Project Budget:

US$80,000

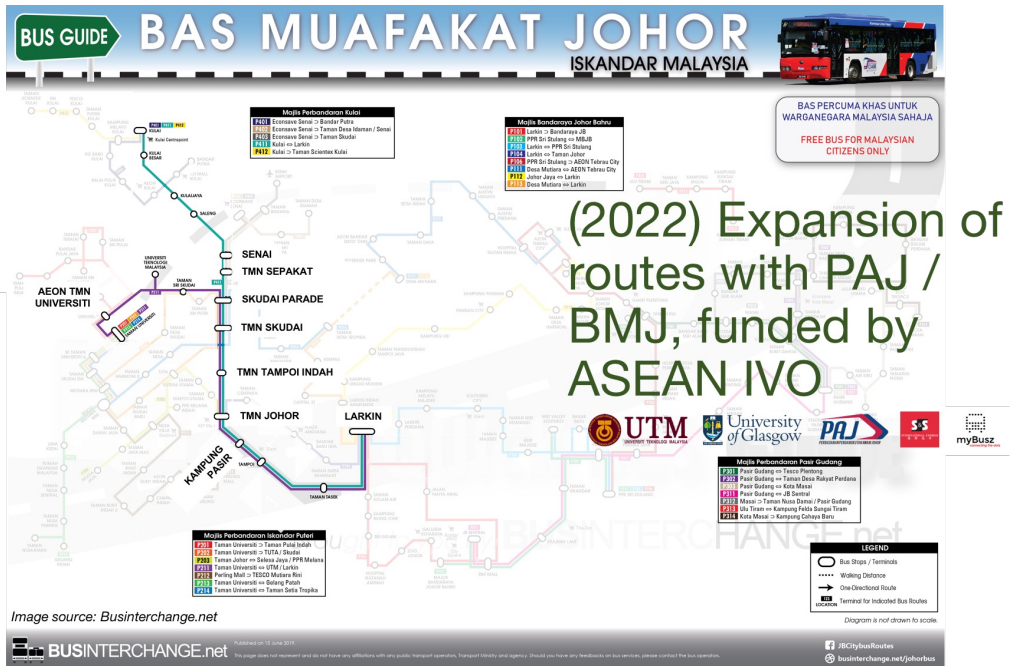
Project Activities:

Site Survey and Bus Route Identification (UTM, UGS)

- Identify locations (Bus Stops) for the installation of Raspberry Pi in Johor
- Identify bus service routes for the project in Johor, there are P-211, P-411, SnS 7



SnS 7 route

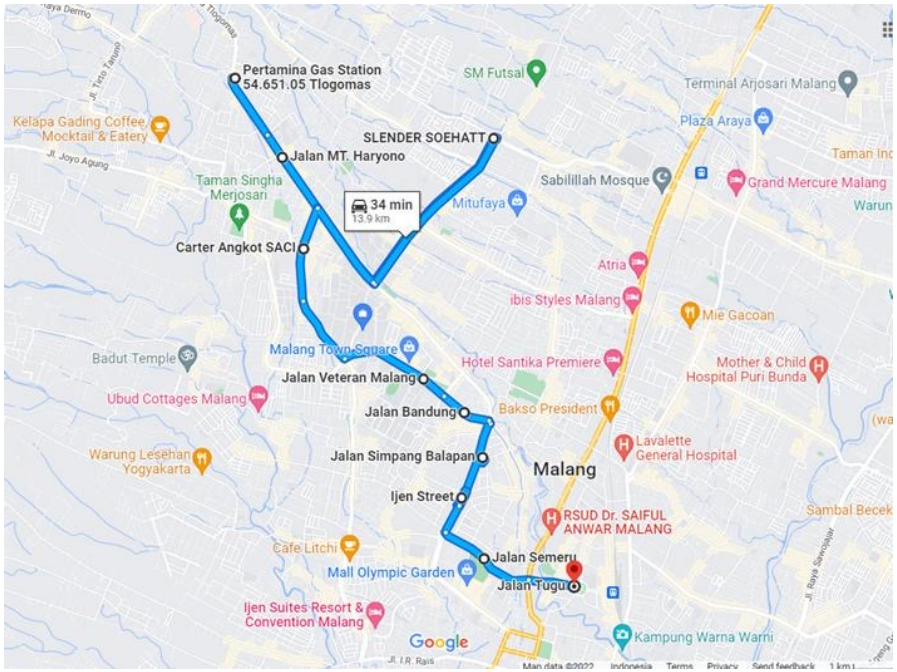


P-211 and P-411 routes

Project Activities:

Site Survey and Bus Route Identification (UB)

- Propose to use a school bus route (Pool A) for Malang City deployment with a distance of 13.9 km
- Deploy raspberry Pi on RSU such as CCTV poles administered by the government agency on Media / Infocomm



Malang School Bus Route

CCTV Pole and Bus Stop

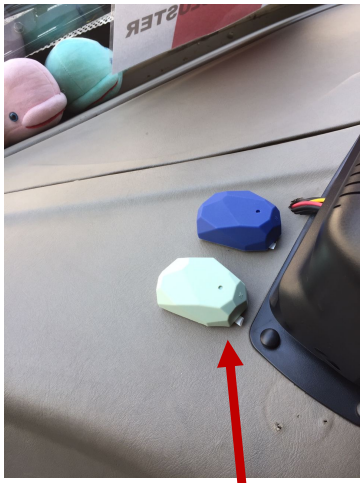
Project Activities:

Field Test (UTM, UGS)

- Developed a prototype to run test the following at UTM campus:
  - Tapping of electricity from street lighting to charge battery at night (7pm – 7 am)
  - Use battery to power the Raspberry Pi during day time (7am – 7pm)
  - Measure the accuracy of beacon detection
  - Measure the reliability of Raspberry Pi

Raspberry Pi Zero + EC20 4G Dongle

Metal Box installed at UTM/FABU bus stop



Estimote Beacons

Fixing the beacon onto a UTM bus

Project Activities:

Project Kick-off Meeting (ALL)

- UTM organised a one-day Hybrid project kick-off meeting at Pulai Spring Resort, Skudai, Johor Malaysia on 15 June 2022.



Workshop Organisation (UTB)

- UTB will also propose a Special Session on Computational Intelligence and Transportation Systems (CITS 2023) in conjunction with the IEEE 8th International Conference on Business & Industrial Research (ICBIR)

Urban Mobility Survey (USM)

- In the process of conducting a survey on the current state / use of public transport systems in Asia.
- Survey the target journals, and submit a survey paper at a later stage

Measurement of Beacon Detection (UTM, UGS)

- Measured the RSSI for two cases (1) with a metal cover (2) without a metal cover
  - (1) BLE beacon signals can be detected without any issues up to 40m. For distance > 40m, there was some delay in detecting the beacon
  - (2) BLE beacon signals can be detected up to 90-100m without any issues

Distance (m)	RSSI
10	83
20	85
30	86
40	82
60	87
90	97

(1) With Cover

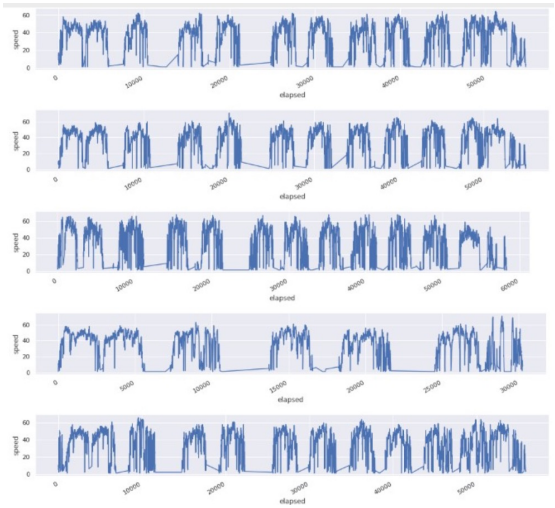
Distance (m)	RSSI
10	-83
20	-75
30	-98
40	-98
60	-97
90	-100

(2) Without Cover

R&D results:

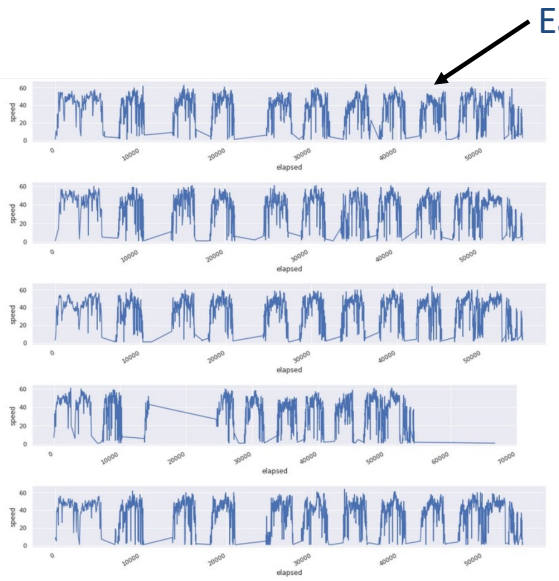
Data Analytics (UTB, UTAR)

- Datasets from Johor (12-month P-411, P-211 and 1-month SnS 7) have been shared with the team by UTM / UGS
- Preliminary visualization and cleaning of the datasets in progress



P-411

Each bus trip

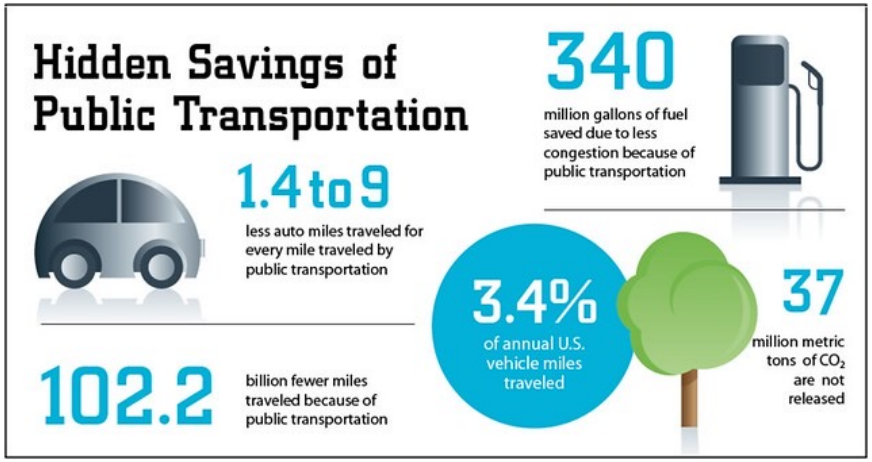


P-211

Societal Impact:

- Aims to improve the use of public transport systems in developing countries through the following:
  - Easy access to the bus departure and arrival data
  - Shorten the passenger waiting time if the ETA is known in advanced
  - Effective monitoring of the bus services from the operator's perspective

- With the increase usage of public transport, it will result in less carbon emission, and less traffic congestion



Source: https://thegreendivas.com/2015/09/28/green-transportation-4-tips-for-navigating-public-transit/

Conclusions:

- Great collaboration among the project members and other project stakeholders:
  - Physical kick-off meeting was held in UTM, Malaysia in June 2022
  - Two proposed deployment sites in Johor Malaysia and Malang Indonesia
  - Support from the bus operators, city councils and government agency

- Project progress is smooth and on-track:
  - Technical works of the project are progressing well
  - Monthly virtual meeting to discuss project updates and to share experience
  - Currently in equipment purchase phase, working with NICT on equipment procurement
  - CRDA has been concluded, and waiting for final copy to be signed by all parties.

- Some of the Issues faced:
  - Shortage of Raspberry Pi devices world wide, and required time to experiment with other platform, e.g., Raspberry Pi Zero, Pi 3B+.
  - City council mayors have a very busy schedule and it is taking a longer time to get approval for the installation of Raspberry Pi.

Future works:

- Complete the procurement of Equipment / Software / Hardware
- Field Trials:
  - Install Raspberry Pi at selected bus stops / light poles / CCTV in Johor and Malang
  - Ensure that BLE detection is accurate
- System Development:
  - Develop the backend on cloud to process the bus location data
  - Develop an algorithm to compute the bus Estimated Time of Arrival (ETA)
- Data Analytics:
  - Cleaning data
  - Develop a base Machine Learning model to predict bus arrival time at bus stops
- Field Trips:
  - Organize field trips to Johor and Malang before May 2023
  - Run a workshop on data analytics for knowledge sharing
  - Submit a survey paper