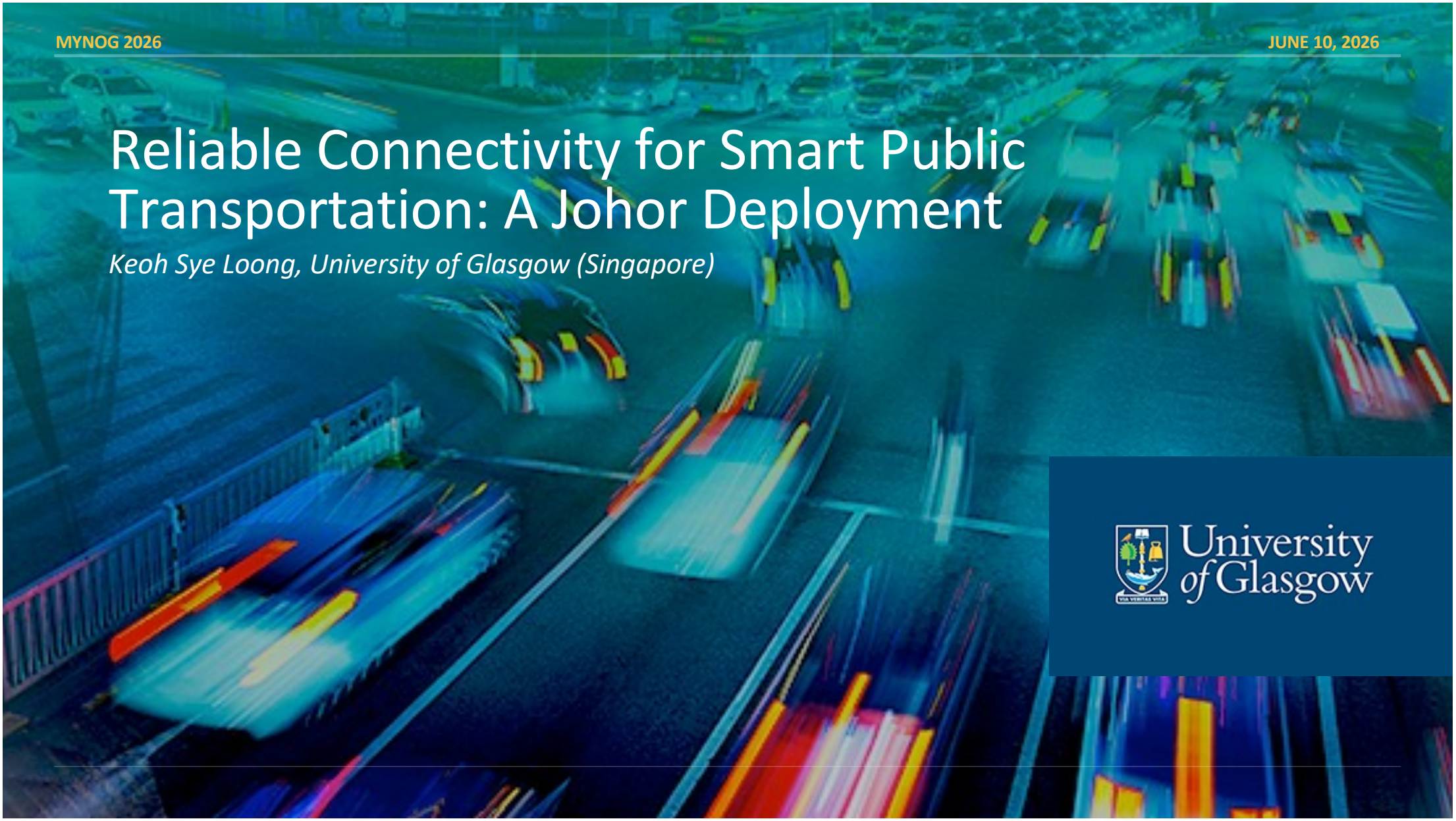
Reliable Connectivity for Smart Public Transportation: A Johor Deployment

Keoh Sye Loong, University of Glasgow (Singapore)



University of Glasgow

outline

- Improving urban mobility for developing countries
- Connectivity as the core technology for smart city applications
- IoT-AI based bus tracking: deployment experience and insights
- Network performance results
- Collaboration with network operators and providers

in developing countries

Johor Baru on track to leading smart city status

By YEE XIANG YUN and RHEMA SENG

METRO NEWS

Source: The Star Metro News, 14 Jul 2025

Taman Johor, Johor (Malaysia)

can we improve the public transport with Connectivity, IoT and AI?

connectivity + iot + ai automation

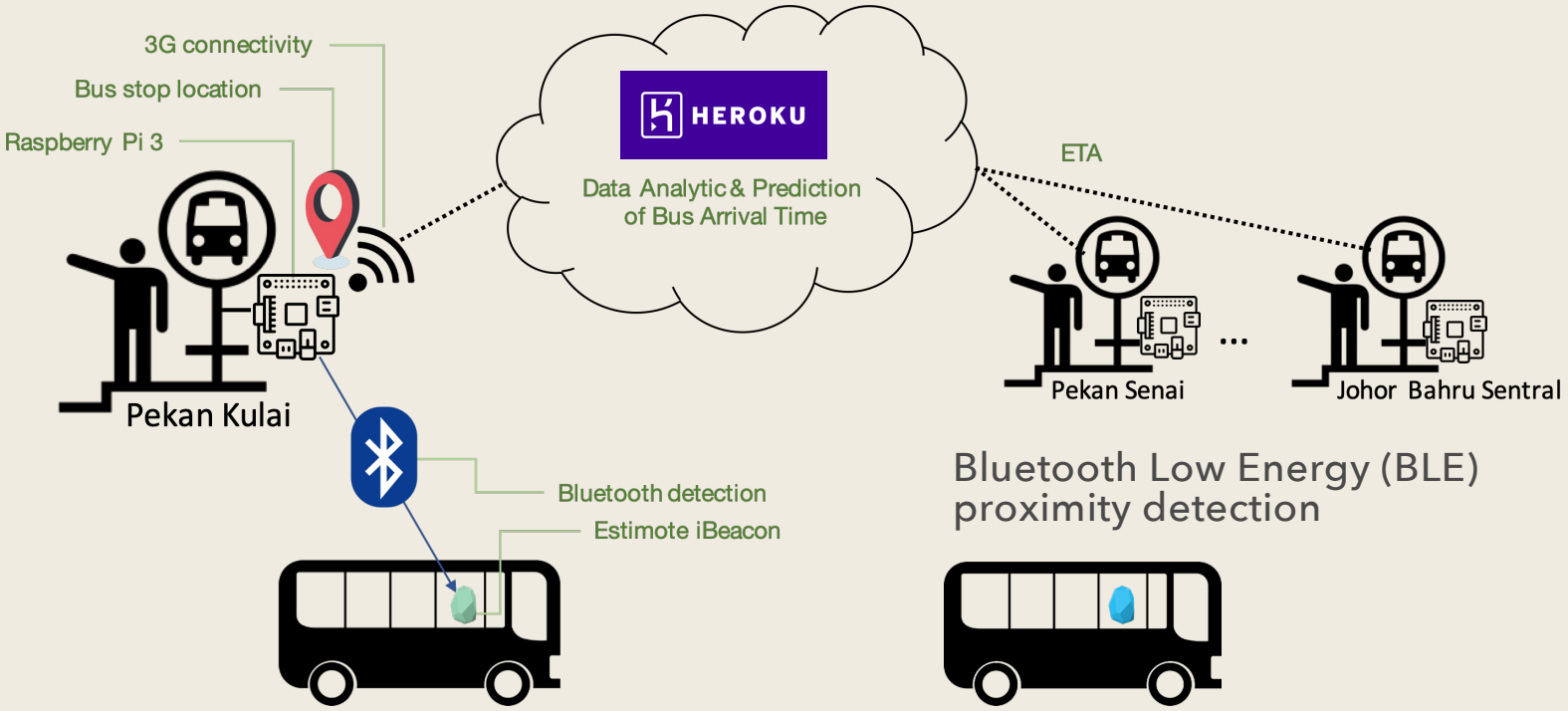
take the human out of the loop!

Raspberry Pi 3

BLE Beacon - Estimote

Heroku Cloud Platform

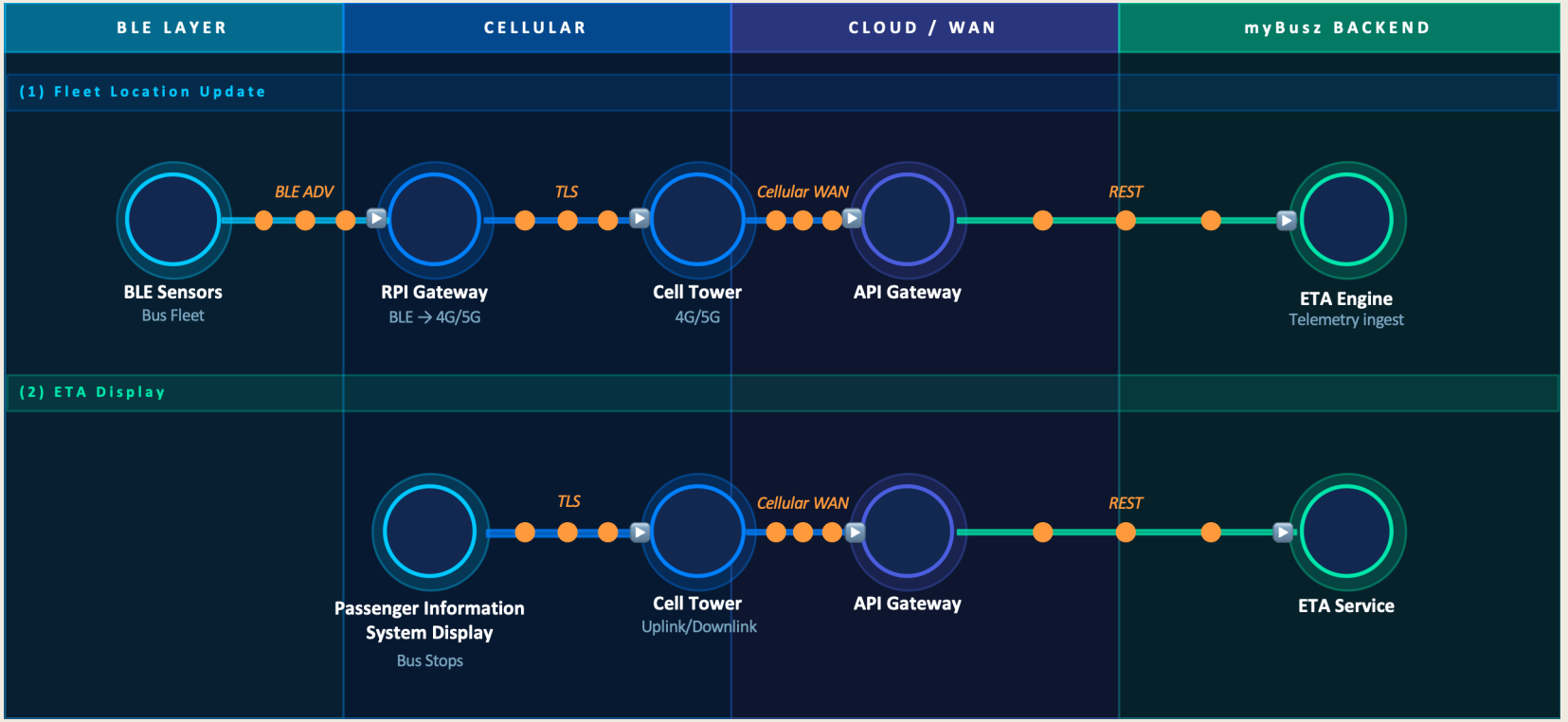
myBusz 2.0 architecture



S. Gunady and S. L. Keoh, "A Non-GPS based Location Tracking of Public Buses using Bluetooth Proximity Beacons," IEEE 5th World Forum on Internet of Things (WF-IoT), Limerick, Ireland, 2019

myBusz
connecting the dots

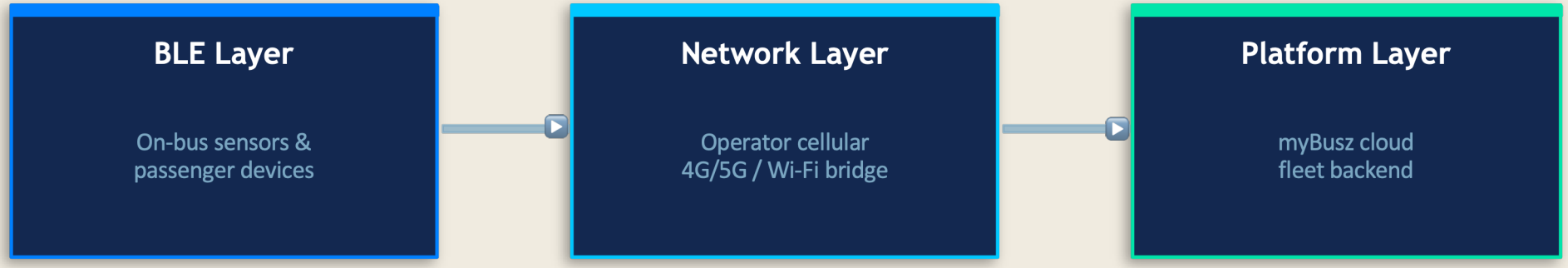
data flow architecture



network design consideration

- Low network latency
  - BLE detection (RPI and Beacon).
  - Sending location data to the cloud (RPI to the cloud via 3G/4G/5G).
  - ETA prediction / calculation.
- Packet loss
  - No packet loss must be guaranteed because location data is important.
  - RPI is configured to perform re-transmission if not successful.
- Reliability of network connectivity
  - Very crucial, as the location data are sent to the cloud via 3G/4G/5G network.
  - RPI restarts itself everyday and performs some forms of self-diagnostic to check Internet connectivity.
  - In Europe, it uses roaming SIM to ensure availability in case one of the network operators is down. But this is expensive.

role of network operators

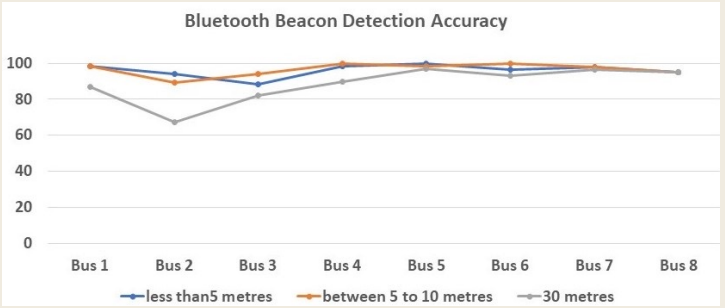


Connectivity backbone	BLE captures on-bus data; operator cellular/Wi-Fi bridges relay telemetry to the cloud
Layered role separation	BLE for short-range device-to-gateway; operator handles wide-area data transport bus↔RPI↔cloud↔platform
SIM & data provisioning	Each RPI to gateway requires a managed SIM/eSIM from the operator on a fleet-dedicated IoT APN
Integration partner	Operators expose managed IoT platforms (device mgmt, SIM orchestration, dashboards) via APIs into myBusz
Redundancy & roaming	Require multi-operator fallback or seamless roaming to guarantee uninterrupted telemetry

network performance

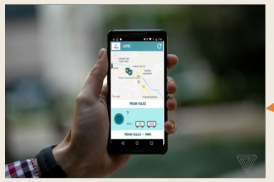
- BLE detection accuracy is approximately 90% and above for all buses when the distance between the RPI to the bus stop is (<5m) and between 5 to10m.
- Bus ID 2 recorded a detection accuracy of 67%. The reason for the outlier could be due to the fast speed of the bus/did not stop at the bus stop.

- Network latency (RPI to Cloud via 3G) [*Note: approximate measurement for 1 day, 2 RPIs*]
  - Average: 0.592s
  - Min: 0.01s
  - Max: 1.4s
- Packet loss = 0% as all detection were recorded in the DB.



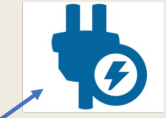
field trial

Info Panel on Bus Arrival Time



myBusz Mobile App

Bus Stop Opposite Kulai Hospital

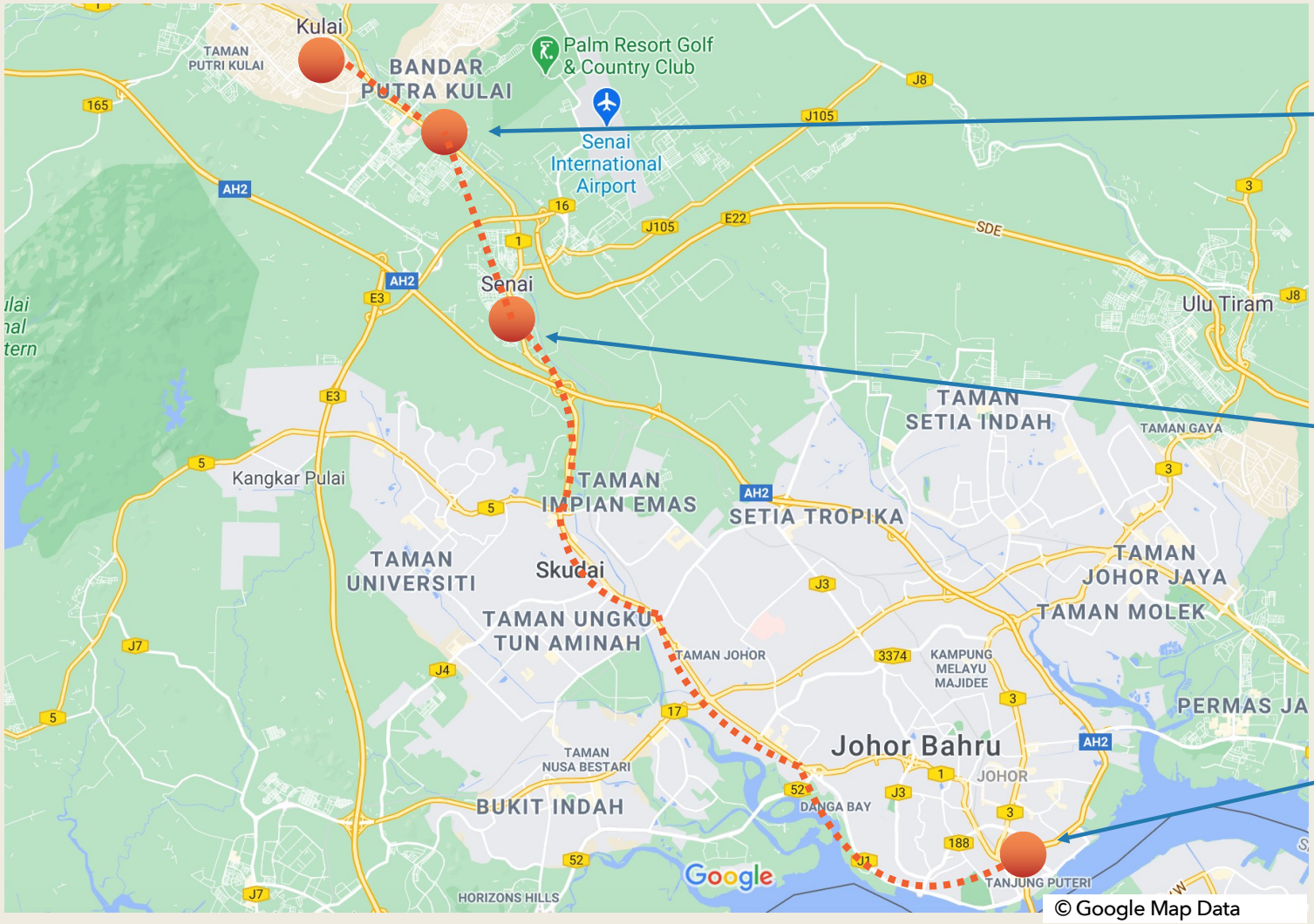


Installation of power supply

Installation of Raspberry Pi for detection of bus

Internet Connectivity

- Accuracy up to ± 3 minutes in non-congested time, as the ETA was derived based on historical data.


Kulai
TAMAN PUTRI KULAI
BANDAR PUTRA KULAI
Palm Resort Golf & Country Club
Senai International Airport
Senai
Ulu Tiram
Kangkar Pulai
TAMAN IMPIAN EMAS
TAMAN UNIVERSITI
Skudai
TAMAN UNGKU TUN AMINAH
SETIA TROPIKA
TAMAN SETIA INDAH
TAMAN GAYA
TAMAN JOHOR JAYA
TAMAN MOLEK
TAMAN JOHOR
KAMPUNG MELAYU MAJIDEE
PERMAS JA
Johor Bahru
JOHOR
DANGA BAY
TANJUNG PUTERI
TAMAN NUSA BESTARI
BUKIT INDAH
HORIZONS HILLS
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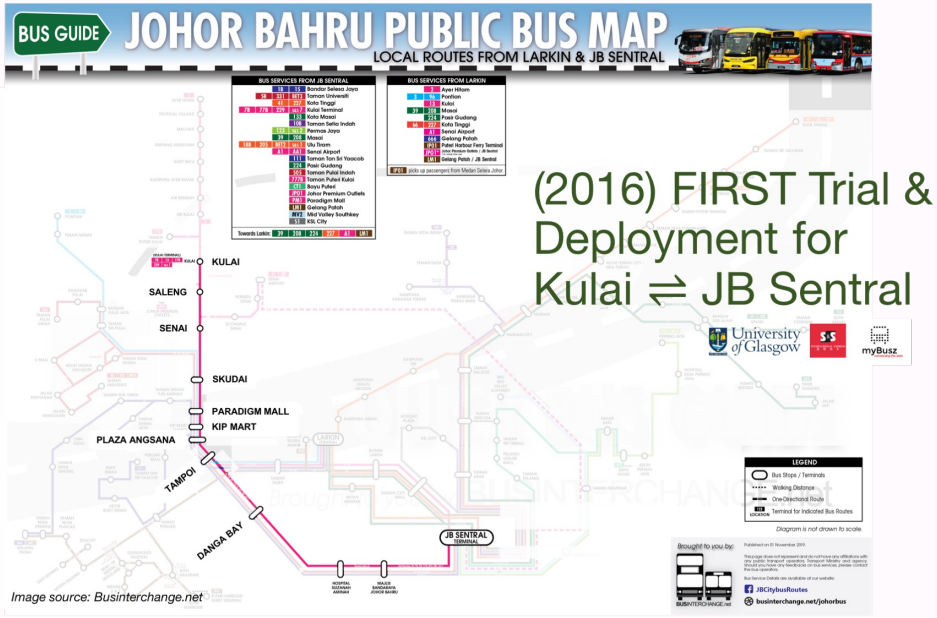
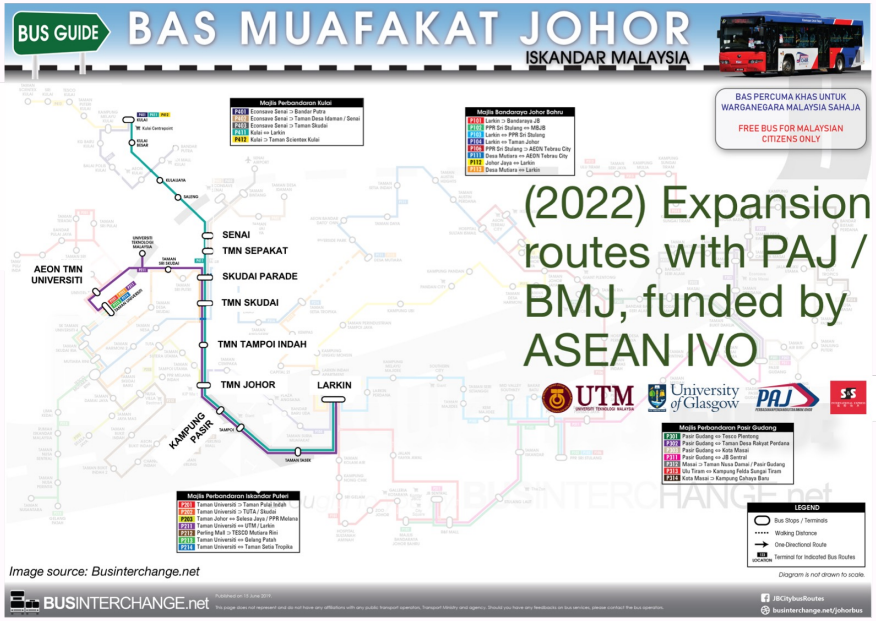
RESTORAN KIM WAH
SONY


THANK YOU!
11:28AM
POINT

ASEAN ivo project (2022-2025)



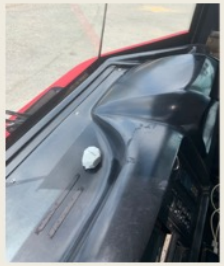
SnS 7 route

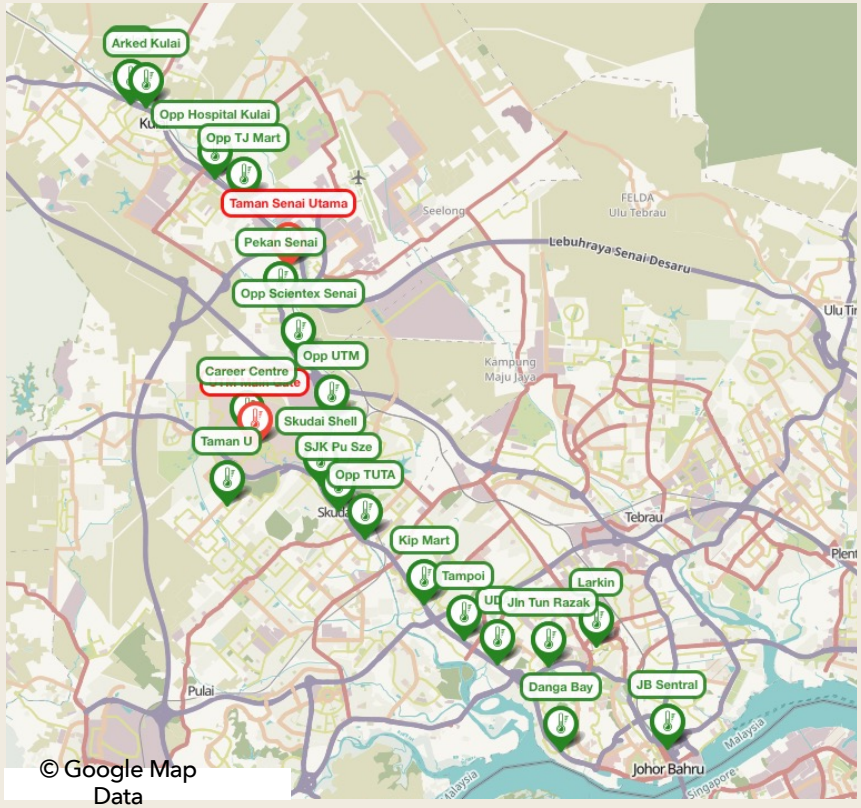


P-211 and P-411 routes

deployment in Johor

- Raspberry Pi Zero and its battery charging system are deployed on 21 bus stops/terminals across three city councils (Johor Bahru, Iskandar Puteri and Kulai)
- Bus routes include:
  - BMJ (PAJ): P211, P411
  - BAS.MY (myBas/Causeway Link): J30, J31





installation (rpi zero + battery)


Opp UTM Gate

Arked Kulai


Taman Universiti Terminal

FABU UTM


Skudai Shell Petro Station

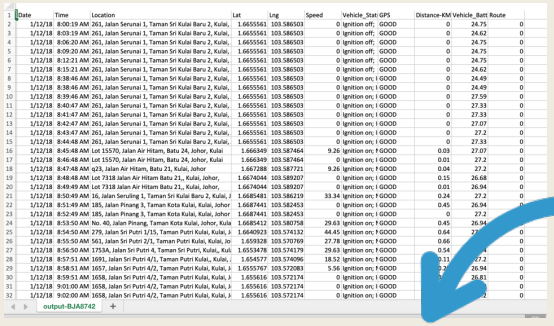
SJK Pu Sze



Larkin Sentral Terminal

Battery Charging System

bus arrival time prediction



Historical data from PAJ

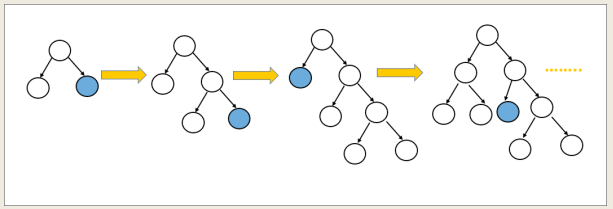
Bus location data collected from deployment

data cleansing
data processing
calculation of distance/speed
data transformation

training dataset

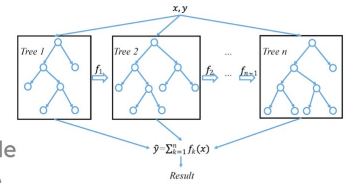
Bus stop	Duration	Hour	Mins	Bin
01-02	352	8	9	5
02-03	128	8	14	6
03-04	26	8	17	6
05-06	36	8	17	6
06-07	95	8	18	6
07-08	96	8	19	6
08-09	78	8	21	7

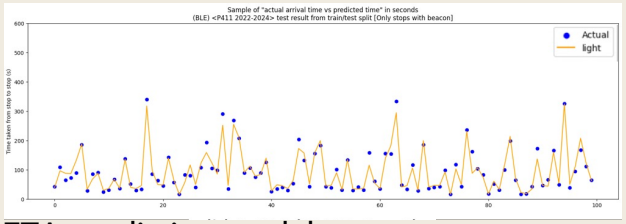
LightGBM



XGBoost Regression

"Comprehensive guide to deploying on edge devices."





ETA prediction model

deploy

first installation of passenger information display system in johor

larkin sentral bus terminal (nov’24)

opp hospital kulai bus stop (dec’24)

senai bus stops (dec’24)





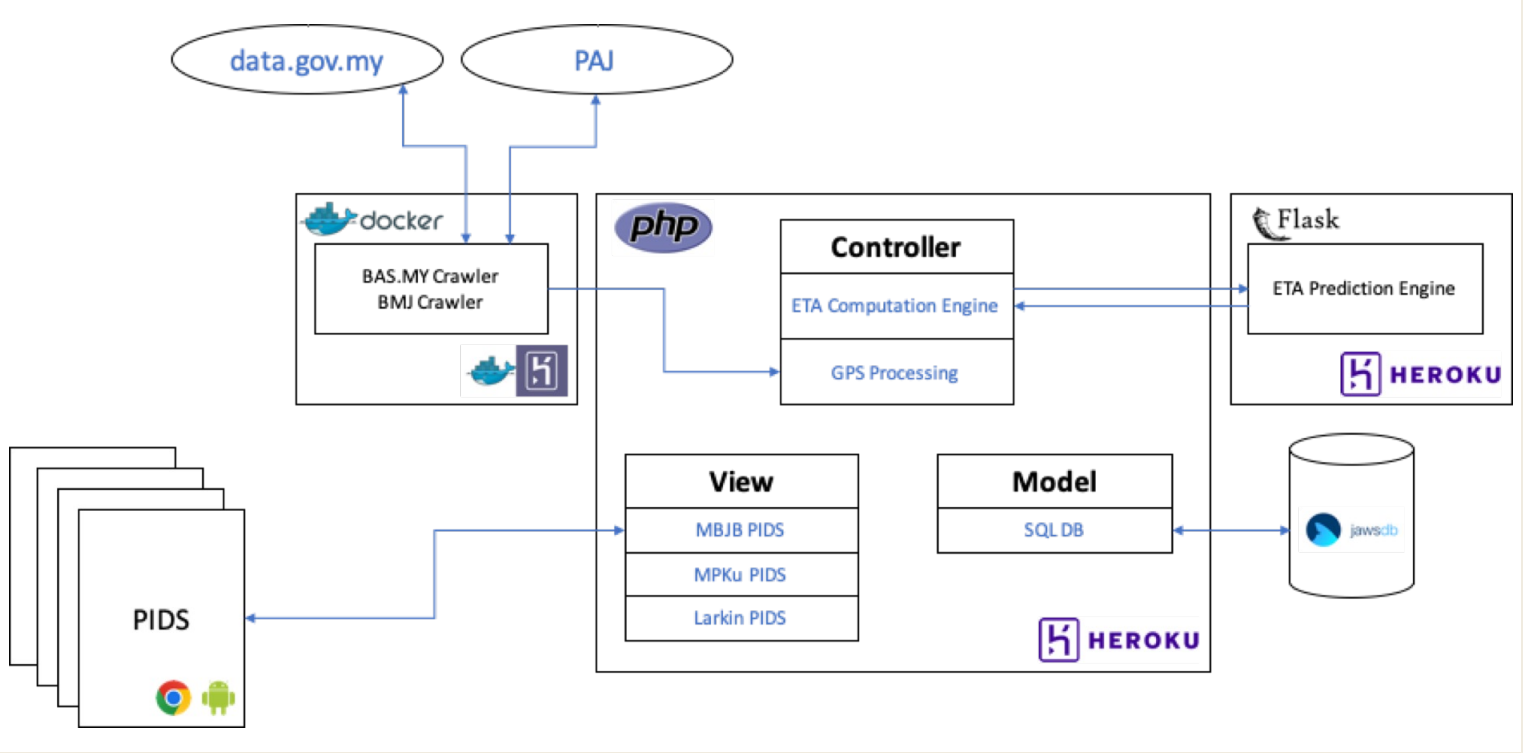


senai bus stops (dec’24)

open data

gtfs-static, gtfs-rt, cellular network, cloud-based deployment

myBusz 2.5 architecture



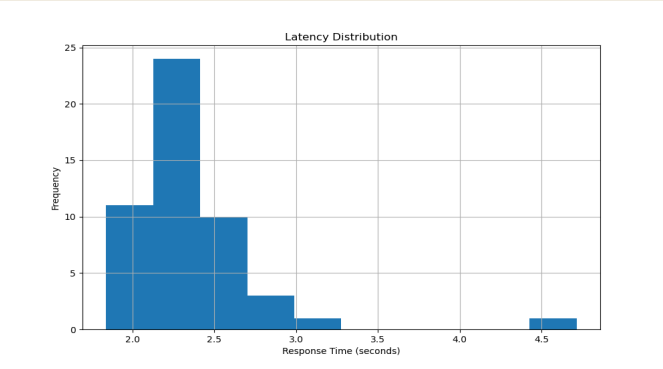
- Next version of myBusz 3.0 will move to microservice architecture

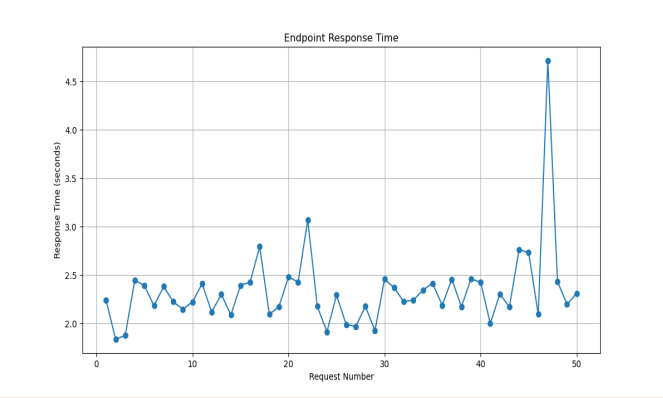
myBusz
connecting the dots

network performance

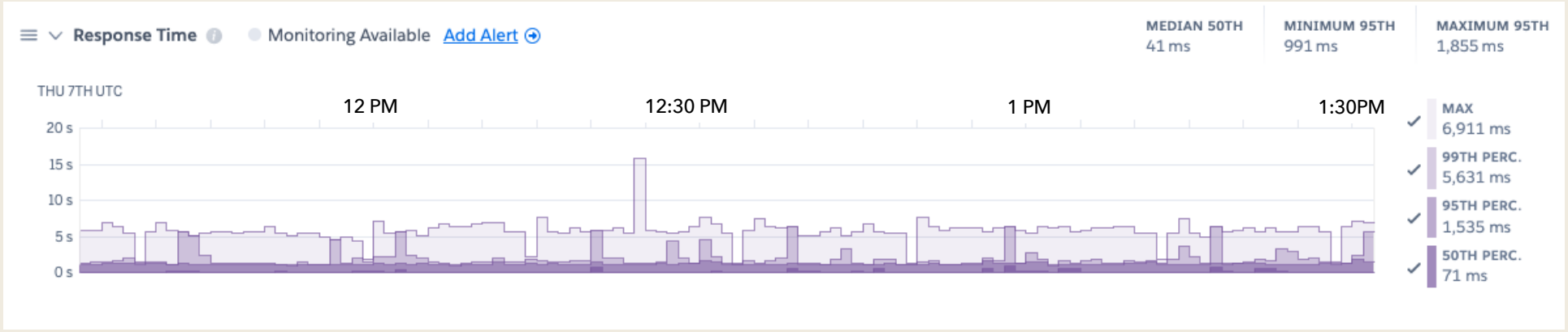
- Heroku server is in the US region.
- ETA data is refreshed every 30 seconds.
- Network latency statistics:
  - Min: 1.839s
  - Max: 4.715s
  - Avg: 2.335s
  - P95: 2.764s
  - P99: 3.072s

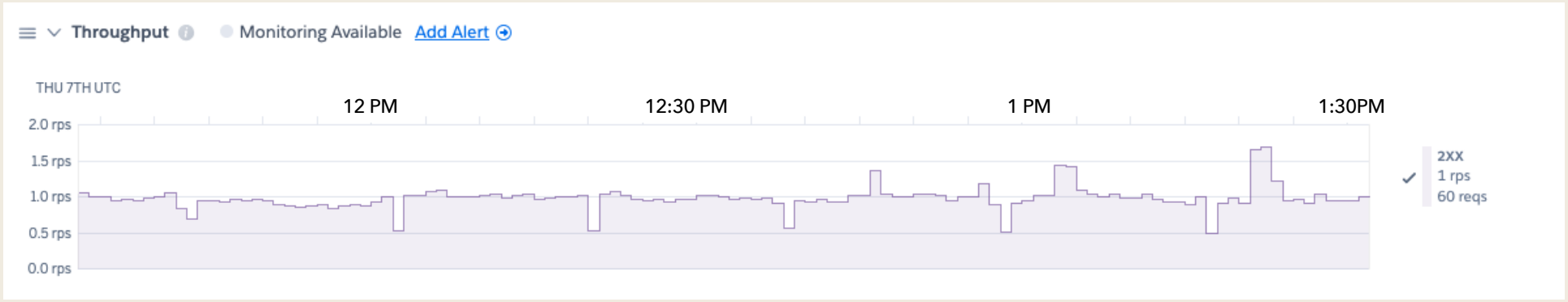
- Improvement to be done:
  - Move the web service to be closer to Malaysia.
  - Further test on the scalability to support multiple PIDS. Currently < 10 PIDS deployed.
  - Improve latency with minimal cost.
  - Service redundancy using Kubernetes.





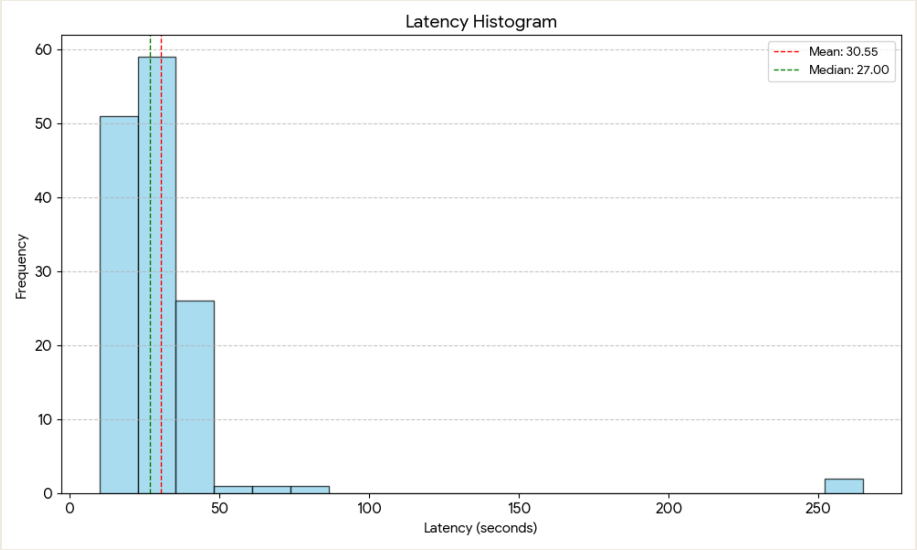
cloud server performance





end-to-end performance

- End-to-end latency was measured through: GPS location update [timestamp recorded] → MQTT Server → Heroku MQTT Subscriber → Heroku Web → ETA Computation.
- ETA is calculated every 30s.
- Performance:
  - Average: 30.55s
  - Minimum: 10s
  - Maximum: 265s
  - P95: 46s
- Essentially this means that the ETA is updated and refreshed around every 30s.



bus stops in johor bahru (mar’26)

Kipmall Tampoi

Taman Johor

Skudai Kiri

bus stops in skudai (apr’26)

discussion

security, network connectivity, resilience, availability

challenges & lesson learnt

- Unavailability of power supply for RPI:
  - Tapping on street lighting's power supply, only from 7pm-7am. Power cut may last for weeks.
  - Required a battery to power the RPI during the day.
  - Battery level drops below 6V, insufficient to power 4G connectivity.
- Reliability of RPI:
  - Not industry grade devices.
  - Restart RPI daily and a cronjob to send heart-beat to report 'alive'.
  - Remote access to RPI to remote diagnostic (provided that connectivity is available).
- Internet connectivity:
  - Network coverage along Jalan Skudai is good.
  - Mostly reliable, unless there is a hardware failure or power cut.
  - There were instances where the Internet was down due to the wrong APN setting.
- Coordination with stakeholders
  - Engagement with city councils, bus operators, land transport agency.
  - City council to get permission to install RPI, and to provide power supply.
  - Safety of the devices to be ensured, hence requiring a locked metal box to be used.

collaboration with network operators

- Having a smart device like RPI at the bus stop to perform "sensing", we will need **reliable** cellular connectivity.
- What are the back-up options available if cellular service is disrupted? Inter-operator roaming is possible?
- Network operators to help manage IoT devices ?
  - Commissioning: device is to be connected
  - Monitoring: self-diagnostic and self-recover if network is down
  - De-commissioning: disabling the connectivity
- QoS for real-time passenger apps is ideally 5-10s for an accurate arrival. This means a MQTT model might be suitable:
  - More frequent location data updates (currently 30s – 1min)
  - Higher volume of data to be sent from fleet/RPI to the cloud
  - Push ETA updates to PIDS more frequently as well, e.g., whenever the ETA is updated, push down to PIDS.
  - Update ETA whenever new bus location data is received.

operational & architectural readiness

IoT APN / Network Slicing

Dedicated APN or network slice for fleet traffic — isolates bus telemetry from consumer traffic and guarantees QoS for real-time data

Low-Latency Data Pipeline

Near-real-time packet delivery for event-driven BLE triggers, location updates, and in the future (door open/close, passenger count, alerts)

Device Management Readiness

Remote SIM provisioning (eUICC/eSIM), OTA firmware updates, and remote diagnostics for gateway devices on the fleet or Raspberry Pi at bus stops

API & Integration Layer

REST/MQTT APIs compatible with myBusz backend for automated SIM activation, usage monitoring, and fault alerting — no manual provisioning at scale

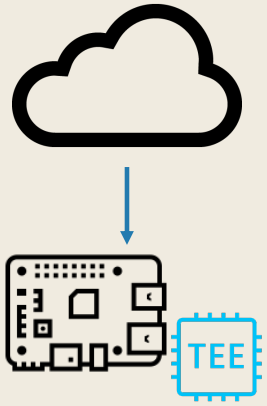
Coverage SLA & Route Mapping

Verified coverage across all bus routes with uptime SLAs. Gaps must be flagged upfront

Security & Compliance

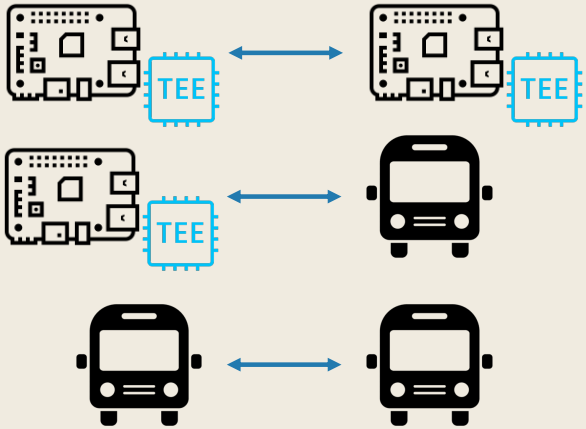
TLS/DTLS encrypted transport, DDoS protection, compliance with local data sovereignty regulations

collaboration with network operators



- Protection of keying materials
- Security Management, device lifecycle management
- Lightweight / post-PQC crypto for IoT devices

IoT Platform-Cloud Security



- 5G New Radio Sidelink for Device to Device /V2X/ Autonomous Vehicle communication
- Combination of cloud, D2D protocols for securing IoT ecosystem

Secure D2D Communication

Video streaming for object / bus service detection

AI Inference, LLM and RAG

- Real-time detection of car plate / bus service number for fleet tracking
- video, spatial, image (multimodal data) to be used for AI-baed decision making
- Robust connectivity for smart city applications

Resilient, Robustness for High Volume of Data

key takeaways

- Reliable network connectivity is key to the success of this sort of smart city application.
- Too many parties and components involved and they all may use different network infrastructure and the inter-connectivity resulted in higher end-to-end latency.
- Deployment of sensors are not sufficiently dense enough to create a highly reliable mesh network.
- Dedicated IoT 5G network slicing to be separated from consumer network would improve the bandwidth.
- Move the cloud server to be closer to home to reduce latency. Operators could consider deploying MEC nodes.
- QCI prioritization for smart city applications as the data packet is small and should be pushed to the front of the queue.

thanks to our partners

- City councils: MPKu, MBJB, MBIP



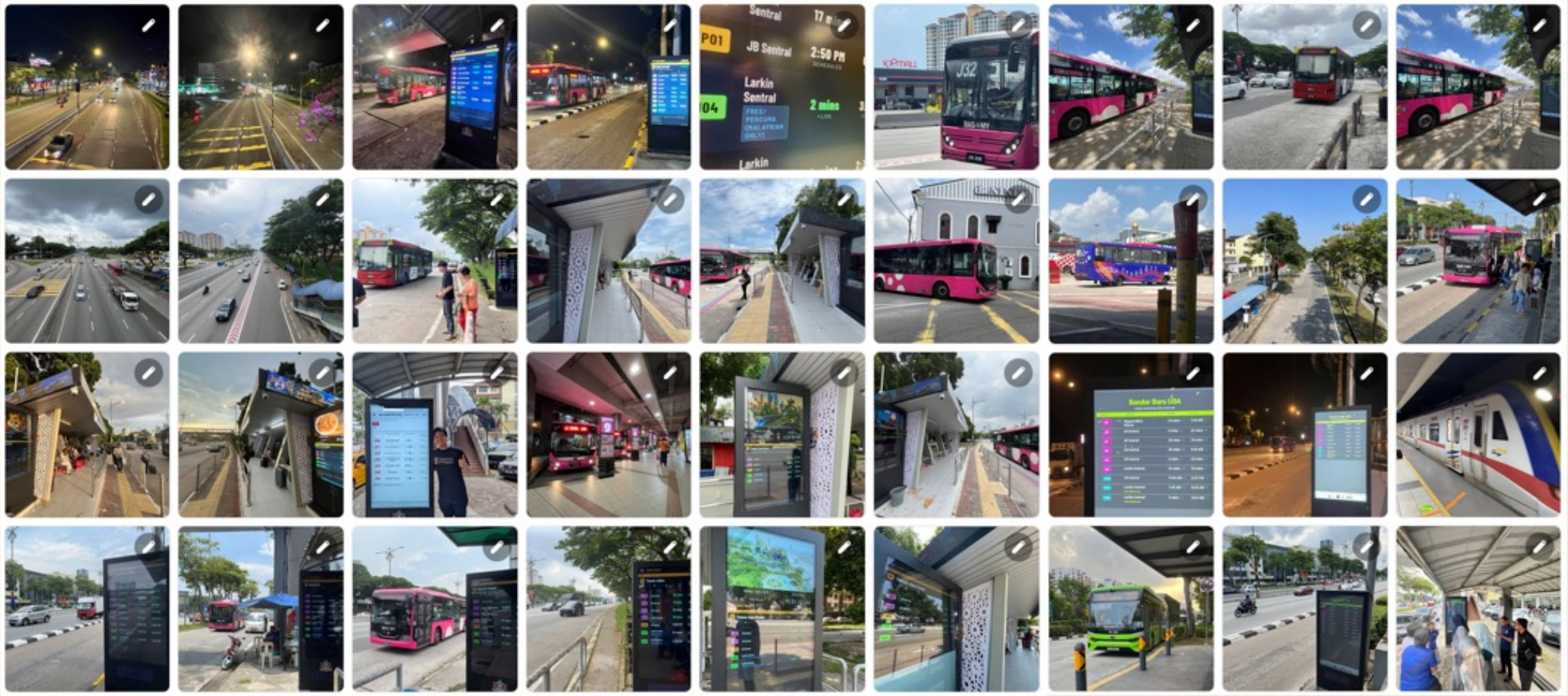
- Pengangkutan Awam Johor (PAJ)

- myBAS, BAS.MY and bus operators


- Larkin Sentral Bus Terminal Operator

- Academic Collaborators & Funder

University of Glasgow



https://www.facebook.com/myBusz/