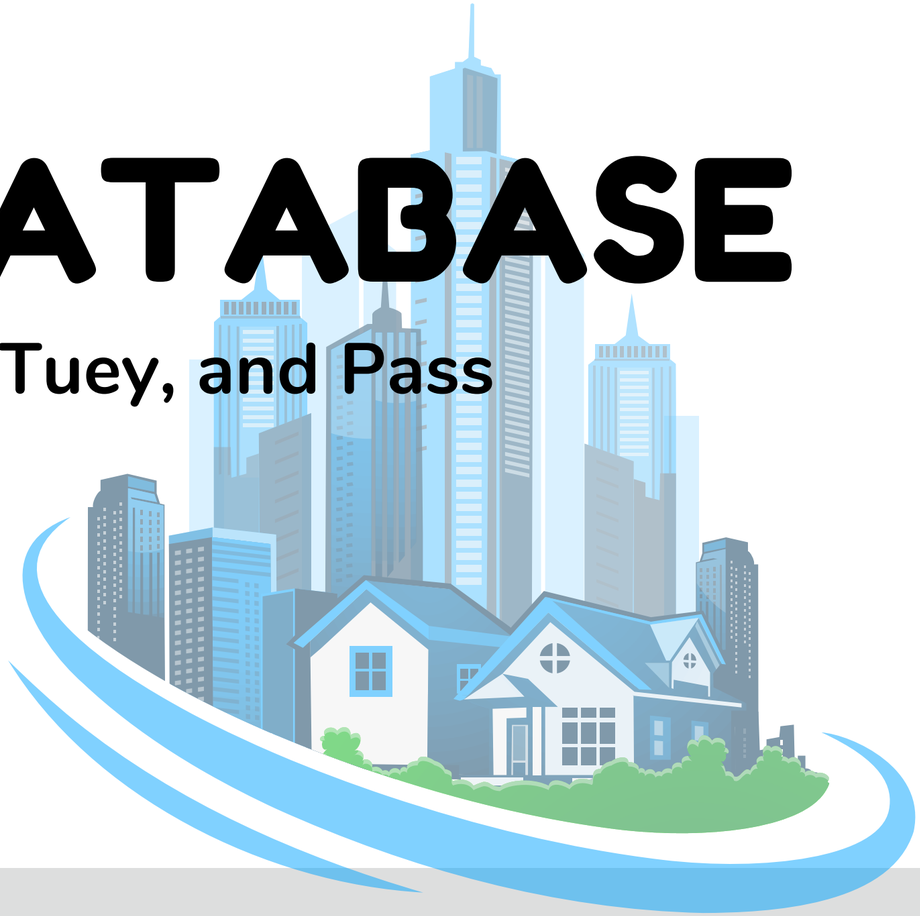
INTELLICITY DATABASE

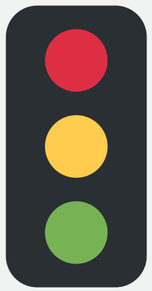
Presentation by Poon, Win, Tuey, and Pass



INTRODUCTION

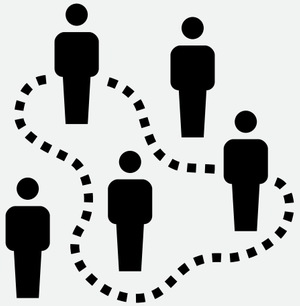
Our project aims to to design and implement a Smart City Infrastructure Database System that integrates PostgreSQL (Relational Database) and MongoDB (NoSQL Database) to demonstrate how both technologies can work together to manage complex urban data efficiently. The system models and stores information from four major domains

Public Transit



Traffic and IOT

Public Facilities



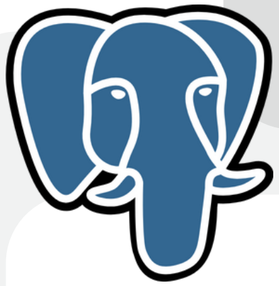
Citizen Feedback

BACKGROUND

Modern cities systems produce massive data streams from public transport networks and traffic sensors to energy usage, facilities, and citizen feedback. They contain both structured and unstructured data. Managing these heterogeneous data sources efficiently is vital for sustainable urban planning, faster response to incidents, and better public service delivery.

Poon, Win, Tuey, and Pass 2025

SYSTEM ARCHITECTURE



Relational (SQL)

We use PostgreSQL (relational) for strongly structured data and transactional integrity for the transport, facilities, core registries.

Non-Relational (NoSQL)

In our architecture, we use MongoDB for our non-relationship / NoSQL databases. We use MongoDB for storing semi-structural data and for quick reads and writes, e.g. Logs, Alerts, Timestamps, Locations and etc.

MODULES OVERVIEW

The IntelliCity Database integrates PostgreSQL (SQL) and MongoDB (NoSQL).
Divided into 7 key modules supporting urban management:

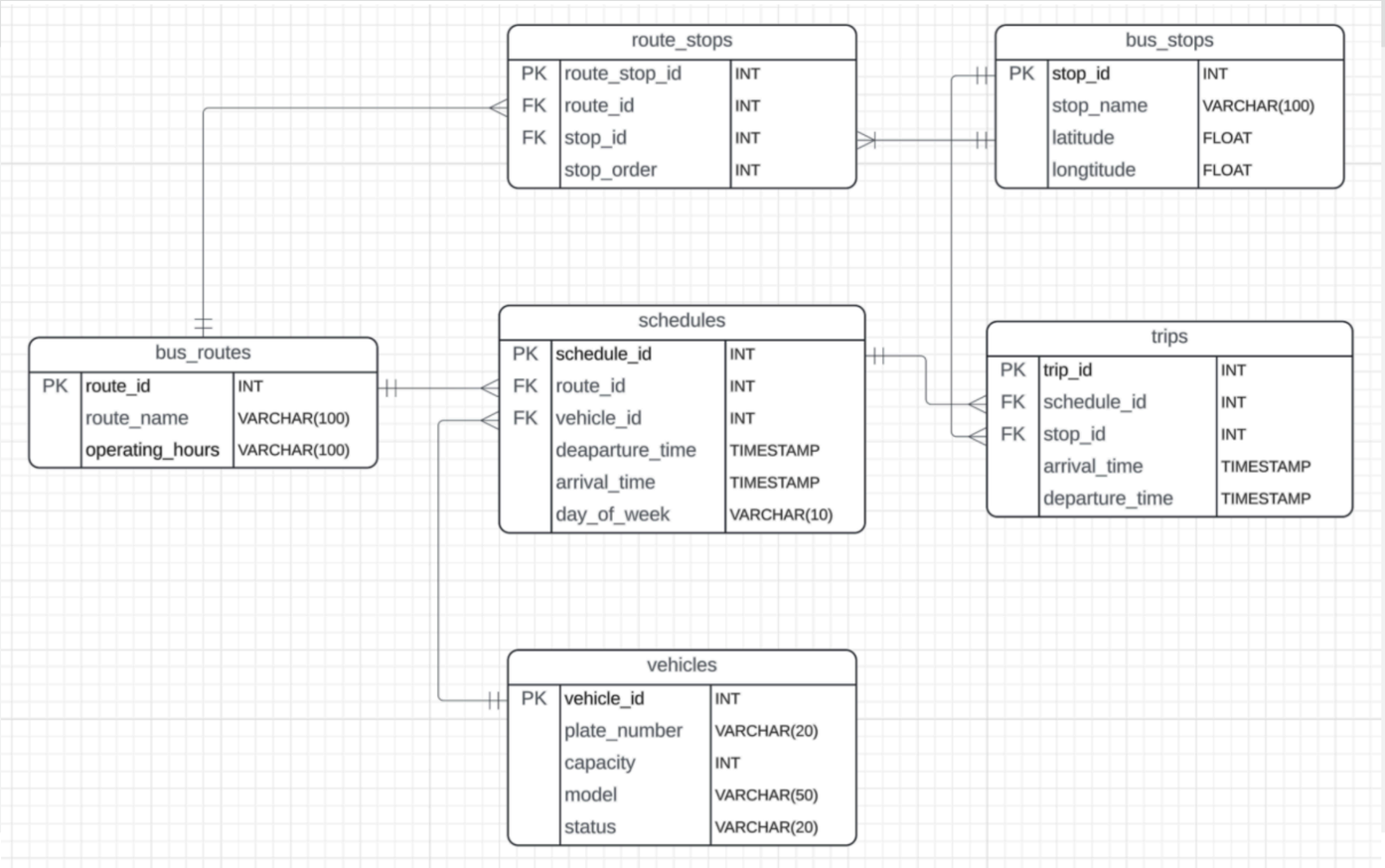
SQL

Public Transportation
Public Facilities
Citizen Registry
Sensor Registry

NoSQL

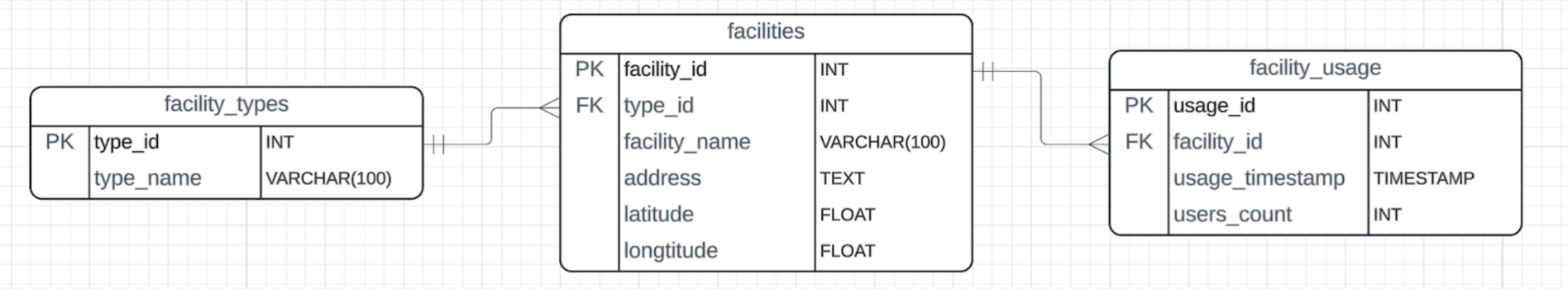
Traffic & IoT Sensors
Emergency Services
Citizen Feedback

SQL ER DIAGRAM

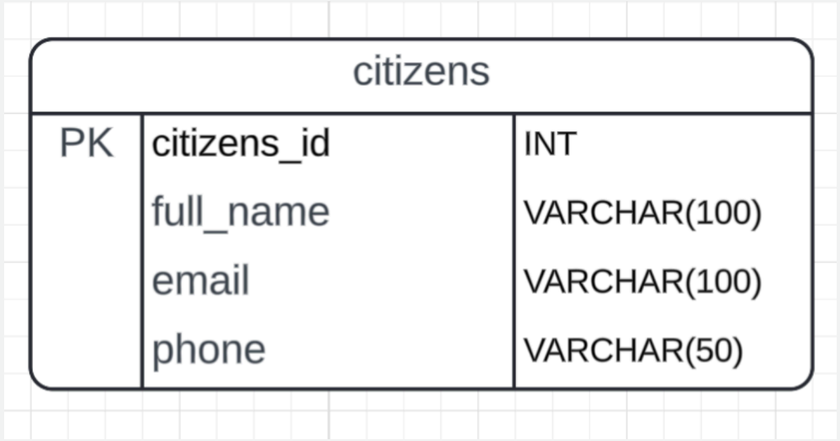


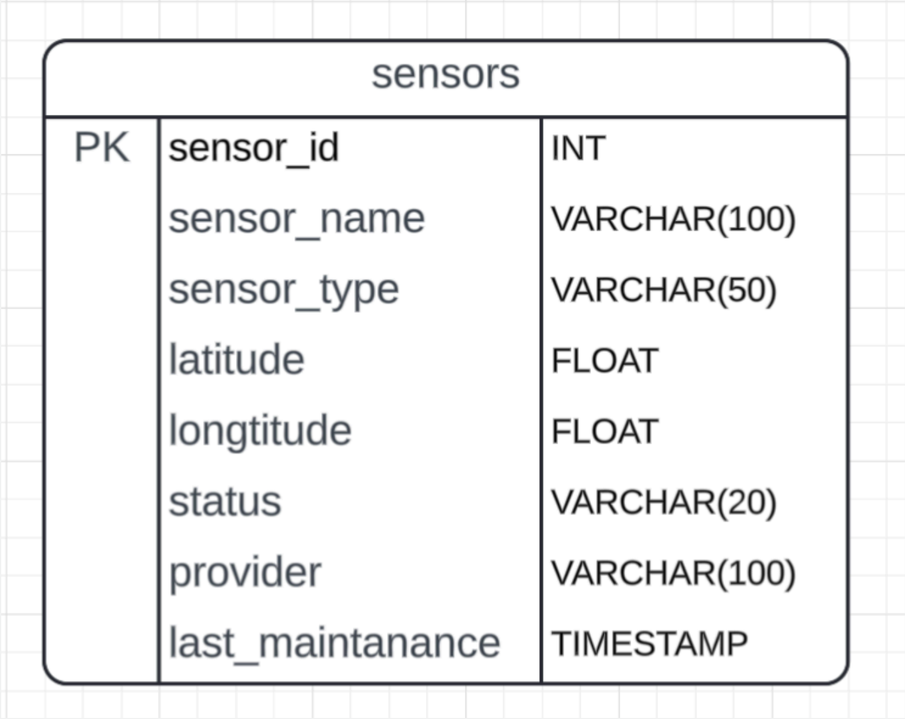
Poon, Win, Tuey, and Pass 2025

SQL ER DIAGRAM



SQL ER DIAGRAM





NOSQL DOCUMENT SCHEMA

sensors

```
{
 "_id": "sensor_021",
 "sensor_type": "AirQuality",
 "vendor": "Bangkok IoT Ltd.",
 "model": "AQ-500",
 "battery_pct": 86,
 "installed_at": "2025-10-15T07:00:00Z",
 "location": {
   "latitude": 13.739812,
   "longitude": 100.525104,
   "district": "Pathum Wan",
   "road_name": "Rama I"
 },
 "geo": { "type": "Point", "coordinates": [100.525104, 13.739812] },
 "status": "active",
 "readings": [
   { "timestamp": "2025-11-07T08:30Z", "pm2_5": 23.4, "vehicles": 320 },
   { "timestamp": "2025-11-07T08:35Z", "pm2_5": 24.1, "vehicles": 354 }
 ]
}
```

emergency_reports

```
{
 "_id": "incident_10045",
 "type": "Fire",
 "location": { "lat": 13.7451, "lon": 100.5346, "district": "Pathum Wan" },
 "reported_time": "2025-11-07T14:20Z",
 "severity": "High",
 "status": "Resolved",
 "responders": [
   { "unit_id": "FireDept-01", "arrival_time": "2025-11-07T14:32Z" },
   { "unit_id": "Ambulance-07", "arrival_time": "2025-11-07T14:35Z" }
 ],
 "logs": [
   { "timestamp": "2025-11-07T14:25Z", "message": "Perimeter secured." },
   { "timestamp": "2025-11-07T14:40Z", "message": "Fire extinguished." }
 ],
 "casualties": { "injured": 0, "fatal": 0 }
}
```

NOSQL DOCUMENT SCHEMA

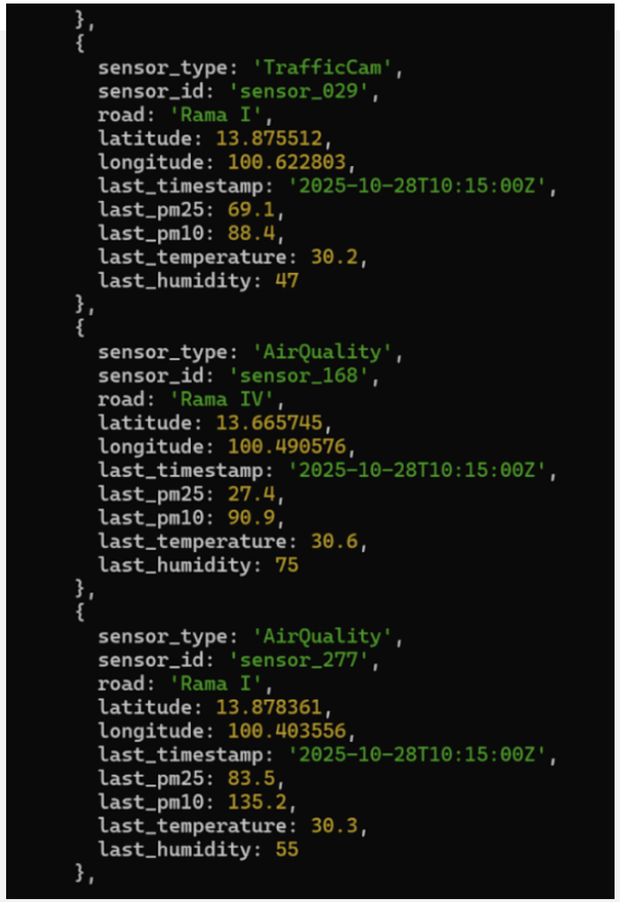
citizen_feedback


```
{
 "_id": "user_3009",
 "name": "Somchai Wattanakul",
 "verified": true,
 "contact": { "email": "somchai@example.com", "phone": "+66-89-123-4567" },
 "feedbacks": [
   {
     "feedback_id": "fb001",
     "category": "Traffic Light",
     "message": "Signal too short for pedestrians.",
     "timestamp": "2025-11-06T10:05Z",
     "status": "Under Review",
     "location_hint": { "district": "Ratchathewi", "road": "Phaya Thai Rd" },
     "attachments": [{ "type": "photo", "url": ".../att_1.jpg" }]
   },
   {
     "feedback_id": "fb002",
     "category": "Public Safety",
     "message": "Street lights near BTS On Nut flicker at night.",
     "timestamp": "2025-11-07T09:15Z",
     "status": "Resolved"
   }
 ]
}
```

LIVE DEMO

```
local> const cfDoc = {
...   _id: "user_demo_01",
...   name: "Demo User",
...   verified: true,
...   contact: { email: "demo.user@example.com", phone: "+66-89-000-0000" },
...   feedbacks: [{
...     feedback_id: "fb_demo_1",
...     category: "Transport",
...     message: "Bus delays at Sukhumvit 24 stop near Emporium.",
...     timestamp: ISODate("2025-11-09T12:00:00Z"),
...     status: "Open",
...     location_hint: { district: "Khlong Toei", road: "Sukhumvit Rd", landmark: "Emporium" },
...     attachments: [],
...     tags: ["traffic","lighting"]
...   }]
... };
... print("\n[CF] CREATE/UPSERT:");
... printjson(db.citizen_feedback.replaceOne({ _id: cfDoc._id }, cfDoc, { upsert: true }));

[CF] CREATE/UPSERT:
{
  acknowledged: true,
  insertedId: null,
  matchedCount: 1,
  modifiedCount: 1,
  upsertedCount: 0
}

local>
```

```
local> // --- UPDATE (arrayFilters: resolve the feedback + add photo attachment)
... print("\n[CF] UPDATE (set status=Resolved and push attachment):");
... printjson(
...   db.citizen_feedback.updateOne(
...     { _id: "user_demo_01" },
...     {
...       $set: { "feedbacks.$[fb].status": "Resolved" },
...       $push: {
...         "feedbacks.$[fb].attachments": {
...           type: "photo",
...           url: "https://example.org/media/user_demo_01/fb_demo_1.jpg",
...           uploaded_at: ISODate("2025-11-09T12:05:00Z")
...         }
...       }
...     },
...     { arrayFilters: [{ "fb.feedback_id": "fb_demo_1" }] }
...   )
... );

[CF] UPDATE (set status=Resolved and push attachment):
{
  acknowledged: true,
  insertedId: null,
  matchedCount: 1,
  modifiedCount: 1,
  upsertedCount: 0
}

local>
```


},
{
sensor_type: 'TrafficCam',
sensor_id: 'sensor_029',
road: 'Rama I',
latitude: 13.875512,
longitude: 100.622803,
last_timestamp: '2025-10-28T10:15:00Z',
last_pm25: 69.1,
last_pm10: 88.4,
last_temperature: 30.2,
last_humidity: 47
},
{
sensor_type: 'AirQuality',
sensor_id: 'sensor_168',
road: 'Rama IV',
latitude: 13.665745,
longitude: 100.490576,
last_timestamp: '2025-10-28T10:15:00Z',
last_pm25: 27.4,
last_pm10: 90.9,
last_temperature: 30.6,
last_humidity: 75
},
{
sensor_type: 'AirQuality',
sensor_id: 'sensor_277',
road: 'Rama I',
latitude: 13.878361,
longitude: 100.403556,
last_timestamp: '2025-10-28T10:15:00Z',
last_pm25: 83.5,
last_pm10: 135.2,
last_temperature: 30.3,
last_humidity: 55
},

OPTIMIZATION

MongoDB Optimization

- Embedded documents and arrays reduce joins (location, readings, logs).
- Compound + geospatial indexes speed up time–space queries.
- $facet pipelines enable multi-metric analytics in one pass.

PostgreSQL Optimization

- Added indexes on route_name, route_id, and stop_id to speed up join and filtering operations.
- Replaced nested subqueries with explicit JOINs for better readability and query planning.

REFLECTION

1. We had to balance detail vs. speed, keeping full readings gave flexibility but slowed queries, so we filtered data by date for faster analysis.

2. We split the tasks into two main sections, Poon and Win worked on the SQL part for the structured data, Tuey and Pass worked on the NoSQL part with unstructured data. Overall team distribution is being shared equally and fairly.

THANK YOU

For listening!

Poon, Win, Tuey, and Pass 2025