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Milestone 1
Traffic Data Simulation and Ingestion

Overview

This system simulates real-world vehicle traffic data and streams it to Microsoft Azure for real-time processing and analysis.
This milestone consists of:

1. Data Generation (Python Simulator)

2. Data Ingestion (Azure Event Hub)

Data Generation

- Implemented in a Python script (traffic_data_simulator.py)

- Generates simulated traffic events with realistic parameters such as:

    - Vehicle type, model, color

    - Speed, direction, and location

    - Sensor and road information (ID, coordinates, road type, city, etc.)

- Each event is represented as a JSON object.

- Events are both:

    - Saved locally to data/events.json for offline backup.

    - Sent in real time to Azure Event Hub using the azure-eventhub SDK.

Generating Events

```python
from datetime import datetime
from faker import Faker
from azure.eventhub import EventHubProducerClient, EventData

fake = Faker()

# --------------- CONFIG ---------------
NUM_LOCATIONS = 1000
SENSOR_COVERAGE_RATIO = 0.55
NUM_VEHICLES = 2000
TOTAL_EVENTS = 150_000
EVENT_INTERVAL_SECONDS = 0
DATA_DIR = "data"
LOCATIONS_FILE = os.path.join(DATA_DIR, "locations.json")
SENSORS_FILE = os.path.join(DATA_DIR, "sensors.json")
VEHICLES_FILE = os.path.join(DATA_DIR, "vehicles.json")
EVENTS_FILE = os.path.join(DATA_DIR, "events.json")

# ======== AZURE EVENT HUB CONFIG ========
#  ◆ Replace these with your actual values
EVENTHUB_CONNECTION_STR = (
    "Endpoint=sb://Traffic.servicebus.windows.net/;"
    "SharedAccessKeyName=RootManageSharedAccessKey;"
    "SharedAccessKey=UGoejj9CUi2MToINgOoe+W6oUf8Zpybd9+AEhDCTfv4="
)
EVENTHUB_NAME = "events"
# ========================================

ROAD_TYPE_WEIGHTS = {
    "Highway": 0.20,
    "Main Road": 0.30,
    "Intersection": 0.25,
    "Bridge": 0.10,
    "Urban Road": 0.15
}
```

```
PROBLEMS    OUTPUT    DEBUG CONSOLE    TERMINAL    PORTS

Event 6936 sent: VUB 817 - 50 km/h
Event 6937 sent: QLN 483 - 64 km/h
Event 6938 sent: 4BM96 - 67 km/h
Event 6939 sent: 897476 - 53 km/h
Event 6940 sent: 313-VSH - 80 km/h
Event 6941 sent: RR 21768 - 59 km/h
Event 6942 sent: SI-2487 - 54 km/h
Event 6943 sent: 200-NVQ - 149 km/h
Event 6944 sent: 15W•196 - 89 km/h
Event 6945 sent: 4246 - 99 km/h
Event 6946 sent: 9-Y7013 - 54 km/h
Event 6947 sent: IWN 772 - 51 km/h
Event 6948 sent: 6N 4E7MGZ - 68 km/h
Event 6949 sent: I99 2LD - 100 km/h
Event 6950 sent: RU3 M3N - 83 km/h
```

A view from the files that have been created

C: > Users > abdal > data > {} sensors.json > ...

```json
[
    {
        "sensor_id": "TrafficCounter_El_Nasr_Road_0001",
        "numeric_id": 1,
        "lat": 29.750803,
        "lon": 31.372785,
        "location_id": 604,
        "install_date": "2024-02-17",
        "status": "Active",
        "sensor_type": "TrafficCounter"
    },
    {
        "sensor_id": "TrafficCounter_El_Tayaran_segment_657_0002",
        "numeric_id": 2,
        "lat": 29.886803,
        "lon": 31.497808,
        "location_id": 657,
        "install_date": "2024-10-23",
        "status": "Inactive",
        "sensor_type": "TrafficCounter"
    },
    {
        "sensor_id": "CCTV_El_Omraniya_segment_922_0003",
        "numeric_id": 3,
        "lat": 29.995359,
        "lon": 31.057975,
        "location_id": 922,
        "install_date": "2021-09-25",
        "status": "Active",
        "sensor_type": "CCTV"
    },
    {
        "sensor_id": "MultiSensor_El_Nozha_0004",
        "numeric_id": 4,
        "lat": 30.168251,
        "lon": 31.498424,
        "location_id": 350,
        "install_date": "2022-02-22",
        "status": "Active",
        "sensor_type": "MultiSensor"
    },
    {
        "sensor_id": "Radar_Corniche_El_Nil_segment_248_0005",
        "numeric_id": 5,
        "lat": 29.956072,
        "lon": 31.363056,
        "location_id": 248,
        "install_date": "2022-07-21",
        "status": "Under Maintenance",
        "sensor_type": "Radar"
    },
```

C: > Users > abdal > data > {} vehicles.json > ...

```json
[
    {
        "owner_id": "09e76b59-967f-458e-bd3d-7bfee68a08cd",
        "plate_number": "3SW 787",
        "vehicle_type": "Truck",
        "model": "Volvo FH16",
        "color": "Black"
    },
    {
        "owner_id": "414a9d93-44a9-456d-8fdf-f78d16e34d20",
        "plate_number": "ZQM-887",
        "vehicle_type": "Car",
        "model": "BYD F3",
        "color": "Silver"
    },
    {
        "owner_id": "d0d379bf-368a-4405-9824-ecc5cefd4cae",
        "plate_number": "DWB 187",
        "vehicle_type": "Bus",
        "model": "Isuzu City Bus",
        "color": "Silver"
    },
    {
        "owner_id": "7cf66343-4b7d-4a51-89a1-574ef93c82a7",
        "plate_number": "GTN 406",
        "vehicle_type": "Car",
        "model": "Hyundai Elantra",
        "color": "Blue"
    },
    {
        "owner_id": "a7eb2237-c7a0-4140-b8a6-9066e35c4627",
        "plate_number": "7HI51",
        "vehicle_type": "Motorcycle",
        "model": "Bajaj Pulsar",
        "color": "Gray"
    },
    {
        "owner_id": "e0f46bd2-609e-448f-adda-68a97c189b15",
        "plate_number": "POX 564",
        "vehicle_type": "Car",
        "model": "Volkswagen Passat",
        "color": "Orange"
    },
    {
        "owner_id": "61d3e444-3009-4b6b-b47e-1100ffe344bb",
        "plate_number": "J38-53G",
        "vehicle_type": "Bus",
        "model": "Isuzu City Bus",
        "color": "Black"
    },
```

C: > Users > abdal > data > {} events.json > timestamp

```json
{"event_id": 1, "timestamp": "2025-10-13T13:09:11.8380192", "sensor_id": "MultiSensor_Abdel_Aziz_Fahmy_0156", "sensor_numeric_id": 156, "sensor_lat": 30.149205, "sensor_lon": 31.523269, "plate_number": "6S-AGXO", "owner_id": "2b45daaa-af2d-408b-95ef-b48106af7516", "vehicle_type": "Motorcycle", "model": "Honda CBR500R", "color": "Yellow", "speed": 125, "direction": "W", "location_id": 353, "location_name": "Abdel Aziz Fahmy", "location_lat": 30.14954, "location_lon": 31.523864, "road_type": "Intersection", "street_direction": "EW"}
{"event_id": 2, "timestamp": "2025-10-13T13:09:13.3542392", "sensor_id": "TrafficCounter_El_Obour_Road_0395", "sensor_numeric_id": 395, "sensor_lat": 29.906752, "sensor_lon": 31.236424, "plate_number": "ZZ 5807", "owner_id": "9079f97f-1551-4ffb-8b64-387a0f32bef8", "vehicle_type": "Van", "model": "Mercedes Sprinter", "color": "Gray", "speed": 73, "direction": "S", "location_id": 302, "location_name": "El Obour Road", "location_lat": 29.906365, "location_lon": 31.236264, "road_type": "Intersection", "street_direction": "NS"}
{"event_id": 3, "timestamp": "2025-10-13T13:09:13.4163912", "sensor_id": "MultiSensor_26_July_segment_517_0215", "sensor_numeric_id": 215, "sensor_lat": 29.819760, "sensor_lon": 31.070184, "plate_number": "556-PCT", "owner_id": "b44d21c6-946d-4d76-a3e7-7be84da9e729", "vehicle_type": "Car", "model": "Skoda Octavia", "color": "Green", "speed": 122, "direction": "W", "location_id": 517, "location_name": "26 July (segment 517)", "location_lat": 29.819099, "location_lon": 31.069925, "road_type": "Urban Road", "street_direction": "CIRCULAR"}
{"event_id": 4, "timestamp": "2025-10-13T13:09:13.4761562", "sensor_id": "Radar_Wahat_Road_segment_532_0129", "sensor_numeric_id": 129, "sensor_lat": 30.078867, "sensor_lon": 31.289039, "plate_number": "2IG Q50", "owner_id": "6f4ee75f-60da-4f81-a905-57788ea0eb65", "vehicle_type": "Van", "model": "Peugeot Boxer", "color": "Silver", "speed": 103, "direction": "N", "location_id": 532, "location_name": "Wahat Road (segment 532)", "location_lat": 30.079154, "location_lon": 31.288603, "road_type": "Highway", "street_direction": "CIRCULAR"}
{"event_id": 5, "timestamp": "2025-10-13T13:09:13.5355487", "sensor_id": "Radar_Wahat_Road_segment_573_0310", "sensor_numeric_id": 310, "sensor_lat": 30.077842, "sensor_lon": 31.287812, "plate_number": "4ENF273", "owner_id": "b712e72e-4db2-42ef-bbb1-0dee04f3ae33", "vehicle_type": "Motorcycle", "model": "Kawasaki Ninja 400", "color": "Brown", "speed": 58, "direction": "N", "location_id": 573, "location_name": "Wahat Road (segment 573)", "location_lat": 30.078143, "location_lon": 31.288597, "road_type": "Main Road", "street_direction": "CIRCULAR"}
{"event_id": 6, "timestamp": "2025-10-13T13:09:13.5966562", "sensor_id": "Radar_El_Maadi_Corniche_segment_644_0297", "sensor_numeric_id": 297, "sensor_lat": 30.168132, "sensor_lon": 31.292995, "plate_number": "875 T70", "owner_id": "1b3599b9-bd25-4784-9d7f-ce15172ce65a", "vehicle_type": "Motorcycle", "model": "Kawasaki Ninja 400", "color": "Blue", "speed": 39, "direction": "N", "location_id": 644, "location_name": "El Maadi Corniche (segment 644)", "location_lat": 30.169010, "location_lon": 31.292274, "road_type": "Urban Road", "street_direction": "NS"}
{"event_id": 7, "timestamp": "2025-10-13T13:09:13.6570762", "sensor_id": "MultiSensor_El_Tayaran_segment_450_0343", "sensor_numeric_id": 343, "sensor_lat": 29.886872, "sensor_lon": 31.498145, "plate_number": "XUX4768", "owner_id": "174bc66f-d980-4b30-b674-b255747bf790", "vehicle_type": "Van", "model": "Mercedes Sprinter", "color": "Silver", "speed": 60, "direction": "E", "location_id": 450, "location_name": "El Tayaran (segment 450)", "location_lat": 29.886807, "location_lon": 31.4985, "road_type": "Intersection", "street_direction": "EW"}
{"event_id": 8, "timestamp": "2025-10-13T13:09:13.7367742", "sensor_id": "CCTV_Mohandessin_0071", "sensor_numeric_id": 71, "sensor_lat": 29.779677, "sensor_lon": 31.
```

C: > Users > abdal > data > {} locations.json > ...

```json
[
    {
        "location_id": 1,
        "street_name": "Al Haram",
        "city": "Giza",
        "lat": 29.919020,
        "lon": 31.199206,
        "road_type": "Main Road",
        "speed_limit": 40,
        "direction": "CIRCULAR"
    },
    {
        "location_id": 2,
        "street_name": "Smart Village Road",
        "city": "6th October",
        "lat": 30.106209,
        "lon": 31.147797,
        "road_type": "Main Road",
        "speed_limit": 70,
        "direction": "EW"
    },
    {
        "location_id": 3,
        "street_name": "El Obour Road",
        "city": "Cairo",
        "lat": 29.905327,
        "lon": 31.23635,
        "road_type": "Main Road",
        "speed_limit": 60,
        "direction": "NS"
    },
    {
        "location_id": 4,
        "street_name": "Al Haram (segment 4)",
        "city": "Giza",
        "lat": 29.919761,
        "lon": 31.198902,
        "road_type": "Main Road",
        "speed_limit": 50,
        "direction": "CIRCULAR"
    },
    {
        "location_id": 5,
        "street_name": "October Corridor",
        "city": "6th October",
        "lat": 29.780005,
        "lon": 31.442483,
        "road_type": "Main Road",
        "speed_limit": 40,
        "direction": "EW"
    },
```

Azure event hub tables for the data that is being sent

Requests

- Incoming Requests (Sum), traffic | 7.99k
- Successful Requests (Sum), traffic | 7.99k
- Server Errors. (Sum), traffic | 0
- User Errors. (Sum), traffic | 0
- Throttled Requests. (Sum), traffic | 0

Messages

- Incoming Messages (Sum), traffic | 7.98k
- Outgoing Messages (Sum), traffic | 0
- Captured Messages. (Sum), traffic | 0
- Capture Backlog. (Avg), traffic | 0

Throughput

- Incoming Bytes. (Sum), traffic | 4.46MB
- Outgoing Bytes. (Sum), traffic | 0B
- Captured Bytes. (Sum), traffic | 0B