رواد مصر الرقمية

وزارة الاتصالات
وتكنولوجيا المعلومات

Project Title:

Smart Traffic Management System + Solar Powered Street Lighting

Presenter's Name:

- **Hassan Gamal Ghanem**
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Project Idea:

Problem Description:

- Modern cities suffer from uncontrolled traffic congestion and high energy waste from street lighting.
- Lack of real-time monitoring causes delays, accidents, and unnecessary power consumption.

Proposed Solution:

- A fully automated real-time data pipeline:
- IoT Sensors → MQTT → Kafka → Spark Streaming → ML Models → Smart Dashboard.
- Predict traffic, detect congestion, generate alerts, and optimize lighting consumption.

Unique Value Proposition:

- Real-time streaming data processing.
- Machine-learning-based traffic prediction (Milestone 4).
- Automated energy-saving lighting control.
- End-to-end scalable pipeline using Big Data technologies.

Project Wireframe:

User Interfaces & Workflow:

- Dashboard Home: live monitoring of traffic speed, count, congestion, and energy status.
- Alerts Panel: shows real-time warnings (High congestion / High lighting load).
- Analytics View: visualization of processed windowed results and historical trends.
- Admin Tools: view predicted next-minute traffic + predicted lighting levels.

User Journey

1. System ingests city sensor data through MQTT.
2. Kafka stores and streams messages.
3. Spark processes data and updates live dashboards.
4. ML model predicts future traffic + lighting demand.
5. Dashboard displays analytics + actuator triggers lighting adjustments.

End Users + Features:

Primary End Users:

- City Traffic Management Authority
- Smart City Energy Department
- Emergency Control Units
- Urban Planners & Data Analysts

Key Features:

- Live traffic metrics (count, speed, congestion level).
- Real-time alerts (traffic congestion / energy overuse).
- Predictive analytics for upcoming traffic flow.
- Automated lighting load estimation & optimization.
- Data lake and SQL storage for historical analysis.

How Features Solve User Problems:

- Reduces traffic jams using predictions + alerts.
- Reduces electricity waste using dynamic lighting control.
- Improves decision-making with accurate data and trends.
- Enables long-term planning based on historical data.
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Data Structure:

Database Architecture

- **Hybrid Structure:**
  - SQL Server for structured cleaned data (3 main fact tables).
  - Parquet Data Lake for streaming results + raw analytics.

Main Entities (SQL):

1. traffic_sensors_data
2. traffic_weather_conditions
3. traffic_energy_analysis

ERD Relationships:

- All three tables linked by:
- timestamp + street_name (composite natural key).

Data Flow:

MQTT → Kafka → Spark Structured Streaming →
→ Cleaned tables (SQL Server) + Parquet data lake
→ ML Model (Milestone 4) → Dashboard Insights

Programming Languages + Frameworks:

Languages:

Python (Spark, ML, automation scripts)
SQL (ETL, transformations, SSIS)
YAML (configurations)

Frameworks & Tools:

Apache Kafka (real-time messaging)
Apache Spark Structured Streaming (processing)
MQTT (Paho client) (IoT ingestion)
Docker Compose (orchestration)
SSIS (ETL to SQL Server)
Joblib + Scikit-Learn + LightGBM (ML models)
Jupyter notebook (development)

Supporting Technologies:

HiveMQ Public Broker
Python Kafka-Producer
Docker Volumes for persistence
Parquet storage format

"street_name": "El-Tahrir",
"vehicles_per_window": 92,
"avg_speed": 18.4,
"alert_level": "HIGH",
"is_alert": true

Live Application + Test:

Current Live System State:

Fully running pipeline on Docker & Spark.
Real-time streaming from MQTT → Kafka → Spark → SQL/Parquet.
ML prediction pipeline works on incoming live data.

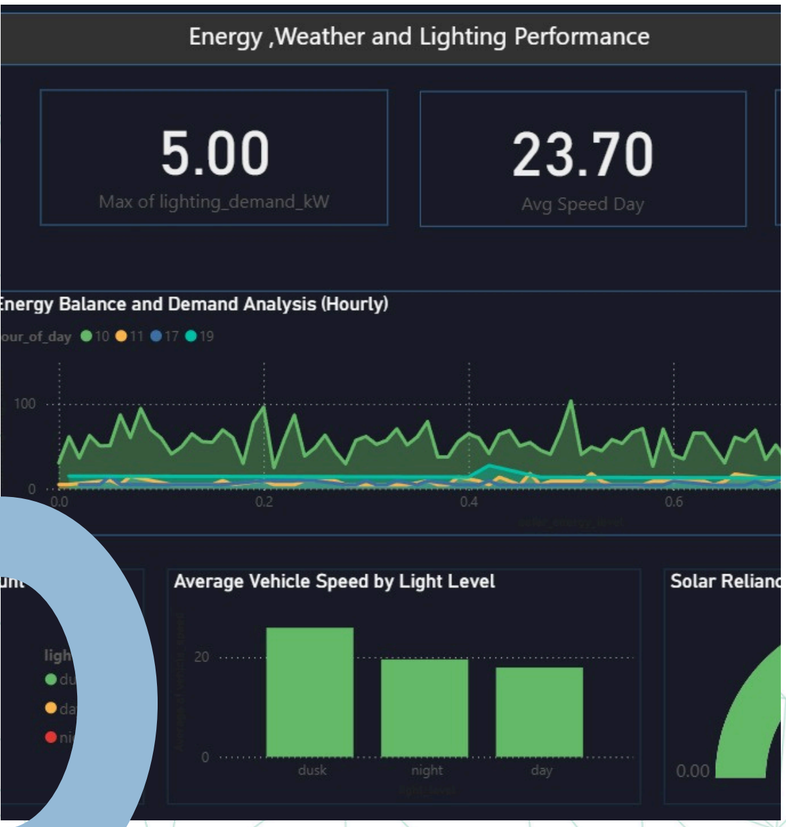
Testing Phases:

Unit Testing: message parsing, schema validation, ML inference.
Integration Testing: MQTT → Kafka → Spark end-to-end.
User Testing: dashboard validation & alert monitoring.
Load Testing: Kafka throughput; Spark micro-batch size.

Feedback

Stable under continuous streaming.
Low latency (<1.5 sec).
Prediction accuracy validated across test dataset.

Deliverables



Provided Deliverables:

System Documentation (architecture, ERD, data flow).
Source Code (full project ZIP).
Live Running Application (dashboard + streaming).
SQL Database Backup + SSIS ETL Package.
ML Models + Evaluation Reports.
Parquet Data Lake outputs.
PPT Presentation (this one).

Timeline (Milestones):

Data Ingestion & Kafka setup
Spark Transformations
Data Lake + SQL ETL
Predictive Models
Dashboard + Final Integration

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Team Members + Roles:

Team Lead

Hassan Gamal Ghanem —(millstone 1 , millstone 3)

Members

- **Maya Yaser Amin—** (millstone 2, millstone 3)
- **Mohammed Mohammed Sobhy —**(millstone 2, dashboard)
- **Amr Mohammed Youssef—**(millstone 1, Testing & documentation)
- **Radwa Hany Sobhy—(**millstone 2, millstone 4)
- **Habiba Ashraf Elboghdady —**(millstone 2)

Collaboration Methods

GitHub
Trello for task management
Agile method (Weekly Sprints)
WhatsApp coordination

Thank You Slide

Thank You!

💬 Feel free to ask questions.

For inquiries or further details:

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