

Under the patronage of **HRH Prince Khalid Al-Faisal**  
Advisor to the Custodian of the Two Holy Mosques & Governor of Makkah Region



المؤتمر الدولي الثاني والعشرون لإدارة الأصول والمرافق والصيانة  
The 22<sup>nd</sup> International Asset, Facility & Maintenance  
Management Conference

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# Building a Smart Operating System for Facilities Management

Leveraging Data Engineering, 5G, Machine Learning, and LLMs for  
Futuristic Facility Management

**26-28 January 2025**

The Ritz-Carlton Jeddah, Kingdom of Saudi Arabia

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**Who here is the first to walk into their office in the morning?"**



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# Life with FMOS



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## Problems of Current FM



**Reactive FM**



**Inefficient space utilization**



**Resource mismanagement**



**Fragment Systems**



## Abstract

- **Facility Management (FM) technologies.**
- **Proposed Smart Facility Management Operating System (FMOS)** integrates:
  - Data Engineering
  - 5G Networks
  - Machine Learning (ML)
  - Large Language Models (LLMs)
- FMOS enables predictive maintenance, energy efficiency, and cost savings.

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## Introduction

**800,000 \$**

Estimated Annual Saving for Medium to Large Facility

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## Introduction

- FM shift from manual to strategic.
- Current FM systems struggle with:
  - Predictive maintenance
  - Space utilization
  - Resource management
- Opportunity: IoT, 5G, ML, and LLMs can transform FM.
- Goal: Build a **Smart FMOS** for autonomous, real-time facility management.



## History of Technologies in FM



**Early FM**  
Manual & Reactive



**CAFM**  
Digitizing facility  
management



**IWMS**  
Centralizing facility  
management functions.



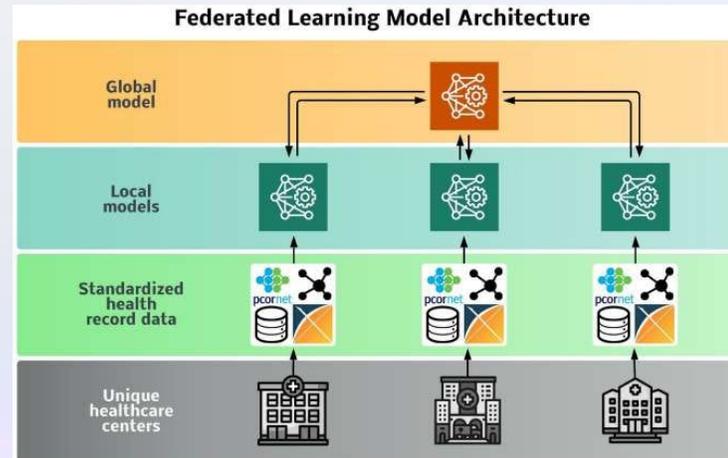
**AI & 5G Edge**  
Intelligent automation and  
optimization

## Technological Framework for FMOS



### 5G Mesh & Iot

Real-time data collection & Localized Data Processing



### Machine Federated Learning

Predictive maintenance, energy optimization



### Large Language Models (LLMs)

Natural language interfaces, automated reporting.

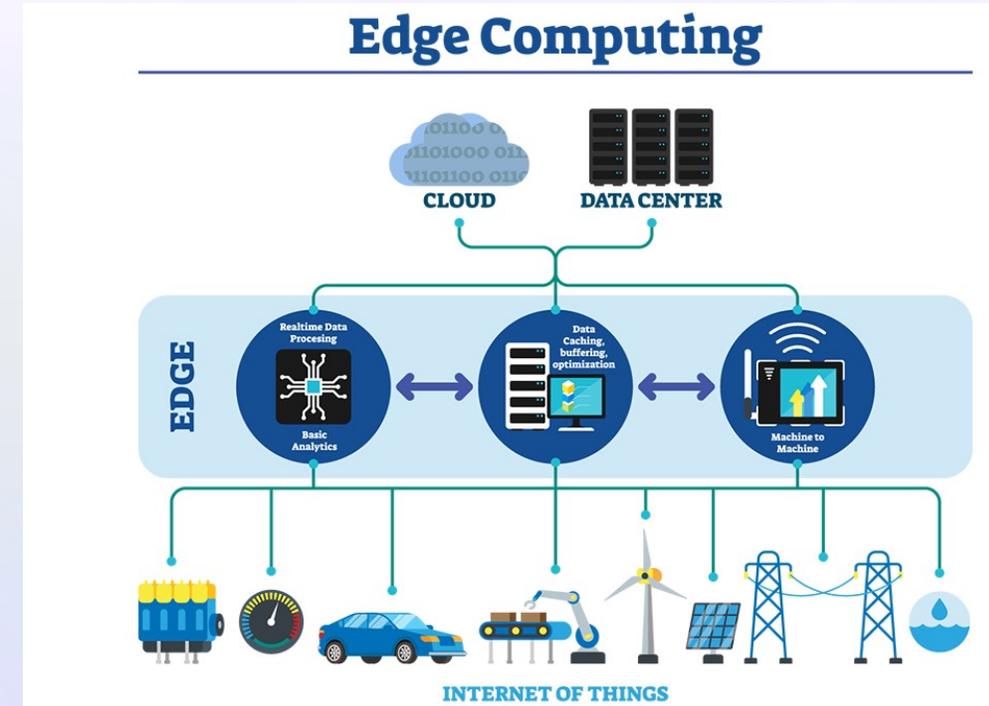
## Sensor Networks & IoT Integration

- **Types of Sensors:**
  - Environmental sensors (temperature, humidity).
  - Motion and occupancy sensors.
  - Equipment health monitors (vibration, energy usage).
- **Data Collection:**
  - Real-time streams to detect anomalies or predict maintenance needs.
  - Example: Sensors detect unusual energy spikes in equipment.
- **Integration:**
  - Sensors communicate seamlessly through the 5G network.

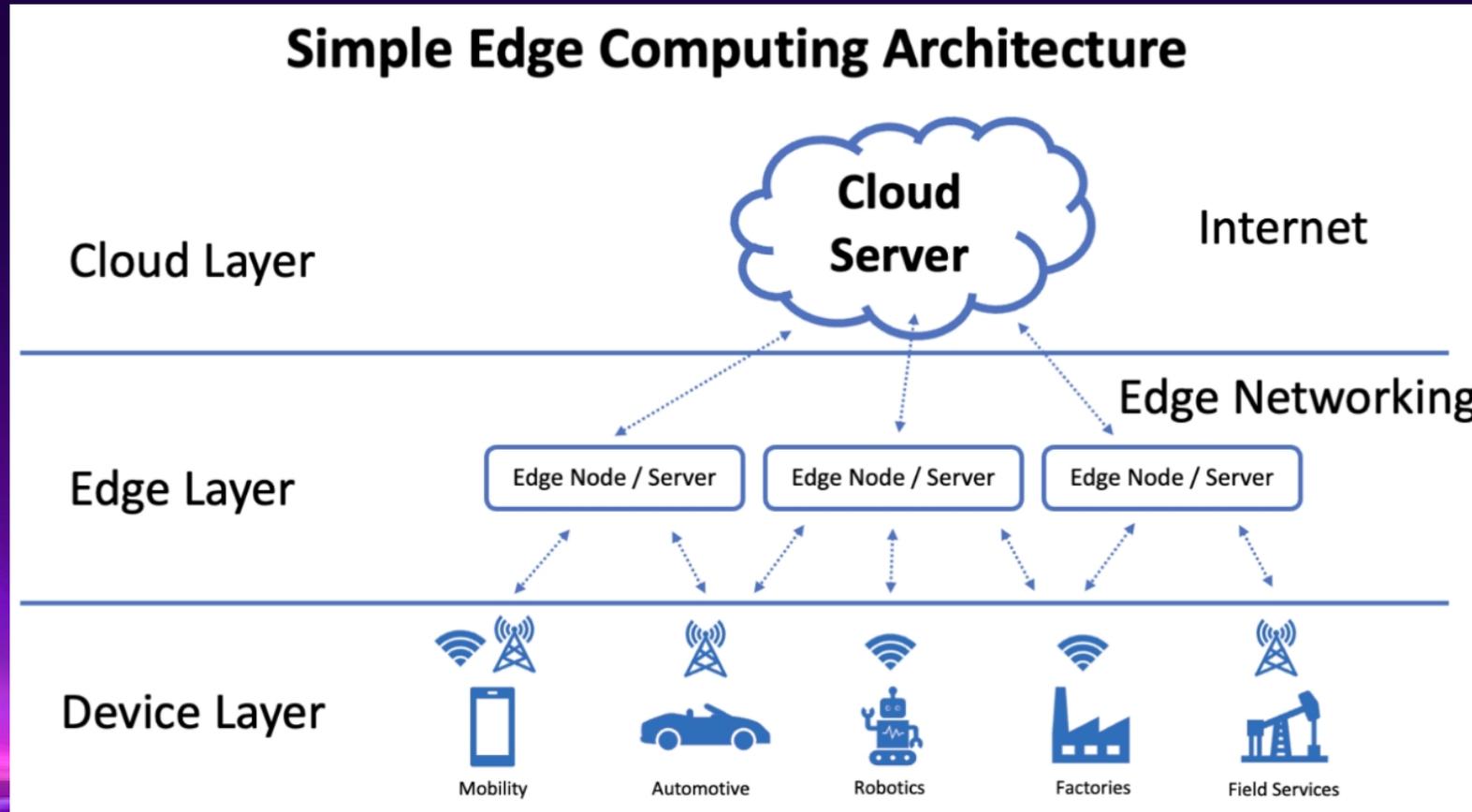


## Edge Computing & Federated Learning

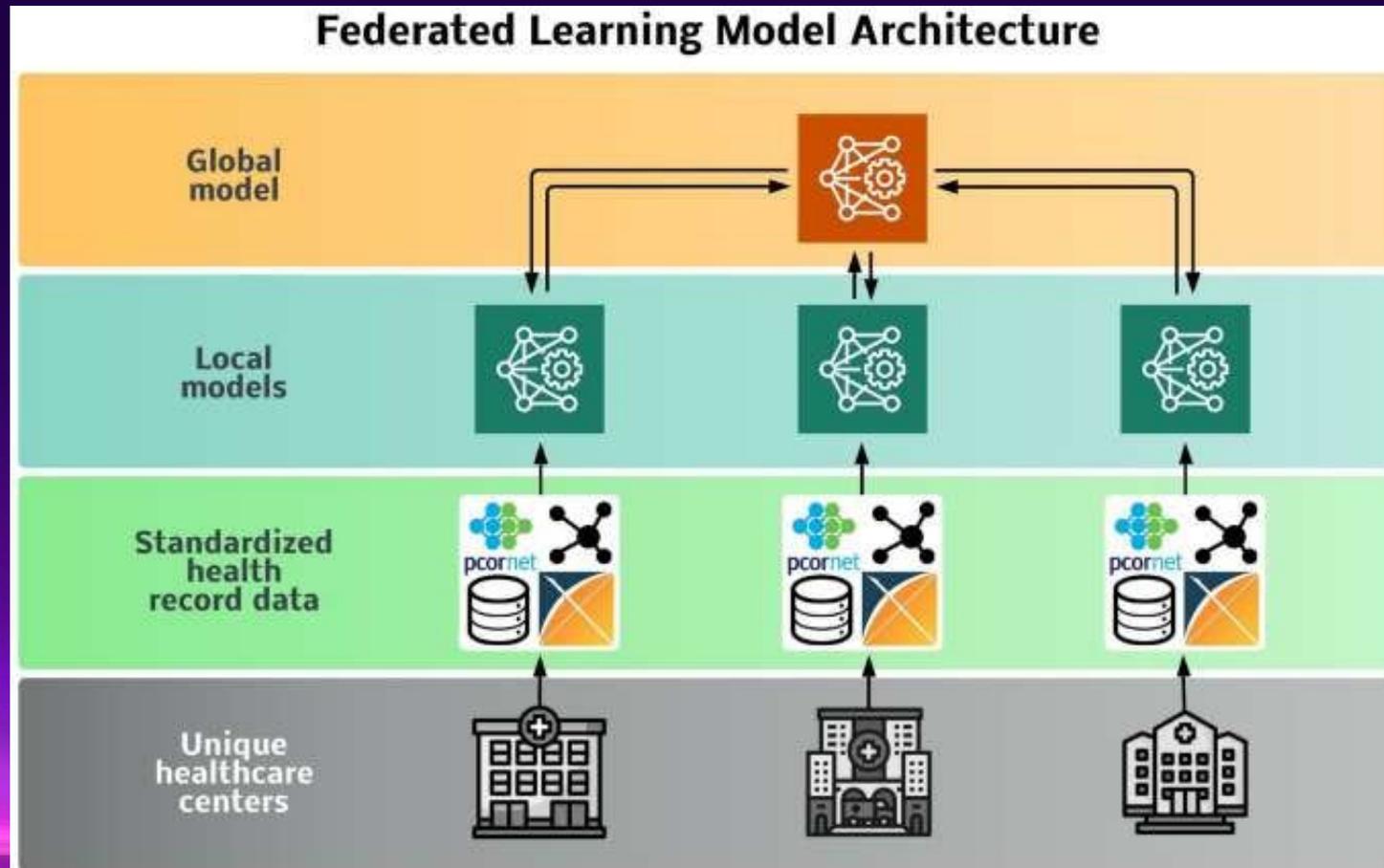
- **Edge Computing:** Local processing for real-time decision-making.
- **Federated Learning:** Local model training, preserving data privacy.
- **Example:** Port of Hamburg uses 5G for real-time traffic and environmental monitoring.



# Edge Computing

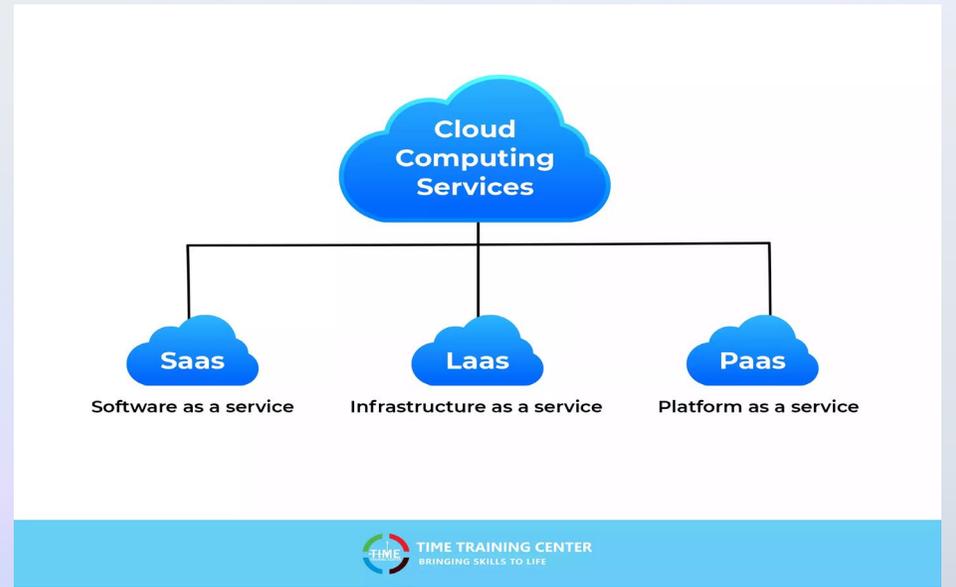


# Federated Learning



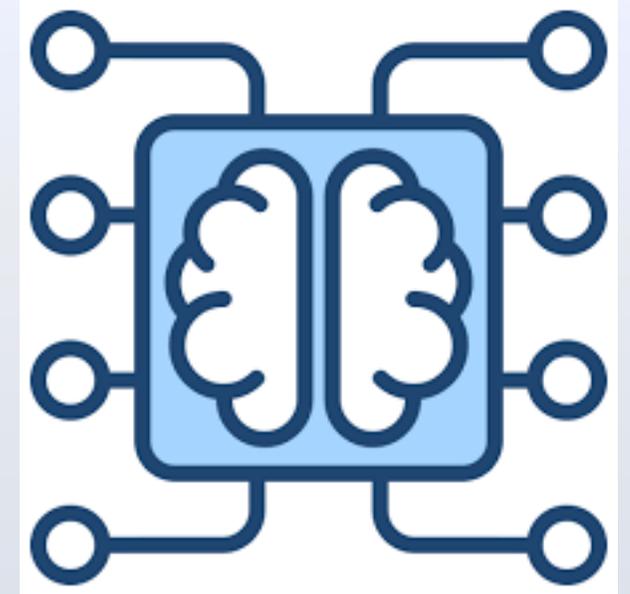
## 5G Networks & Cloud Services

- **5G:** Enables ultra-low latency, high bandwidth for IoT devices.
- **Cloud Services:** Scalable storage and analytics (AWS, Azure, Google Cloud).
- **Example:** Siemens uses cloud-based digital twins for predictive maintenance.



## Machine Learning in FMOS

- **Predictive Maintenance:** ML models predict equipment failures (e.g., HVAC, elevators).
- **Energy Optimization:** ML reduces energy consumption by 15-30%.
- **Space Utilization:** ML analyzes occupancy patterns for dynamic space planning.
- **Tools:** XGBoost, TensorFlow, Scikit-learn.



## ChatGPT for your Facility

- *“Which HVAC units are most likely to fail in the next 30 days based on usage and maintenance records?”*
- *“What are the top three patterns in vibration data from motors that indicate early-stage failure?”*
- *“Can you generate a step-by-step maintenance checklist tailored for this week’s forecasted weather conditions?”*



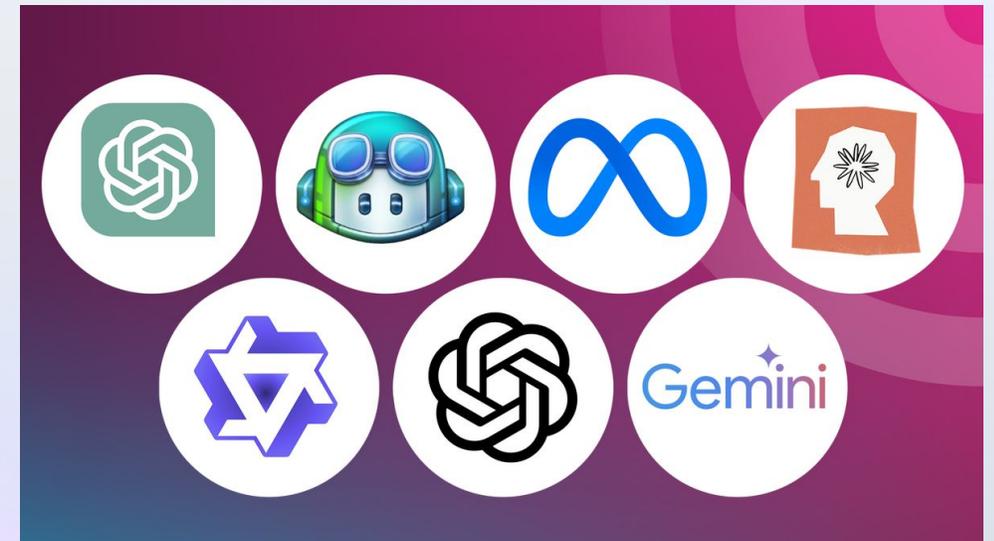
## ChatGPT for your Facility

*“Under what conditions are my employees most productive?”*

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## Large Language Models (LLMs)

- **Natural Language Interfaces:** Facility managers can query FMOS in plain language.
- **Automated Reporting:** LLMs generate reports on energy usage, maintenance schedules, etc.
- **Example:** LLMs like GPT-4 can handle tenant requests and automate routine tasks.



# Implementation & Cost Analysis



**IoT Sensor**  
 50,000\$



**Cloud Infrastructure**  
 7,000/ month \$



**Edge Computation Nodes**  
 50,000\$



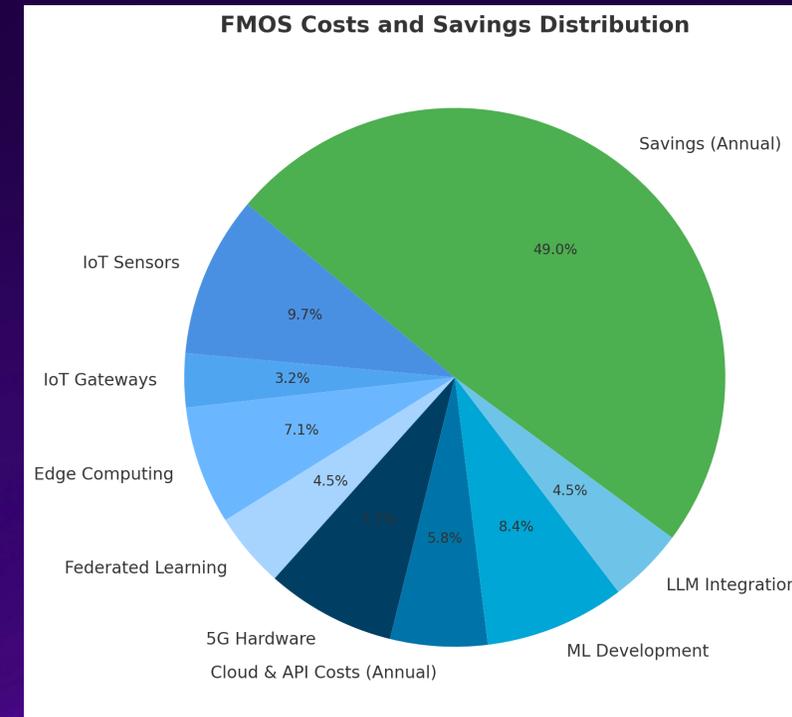
**LLM integration**  
 20,000\$



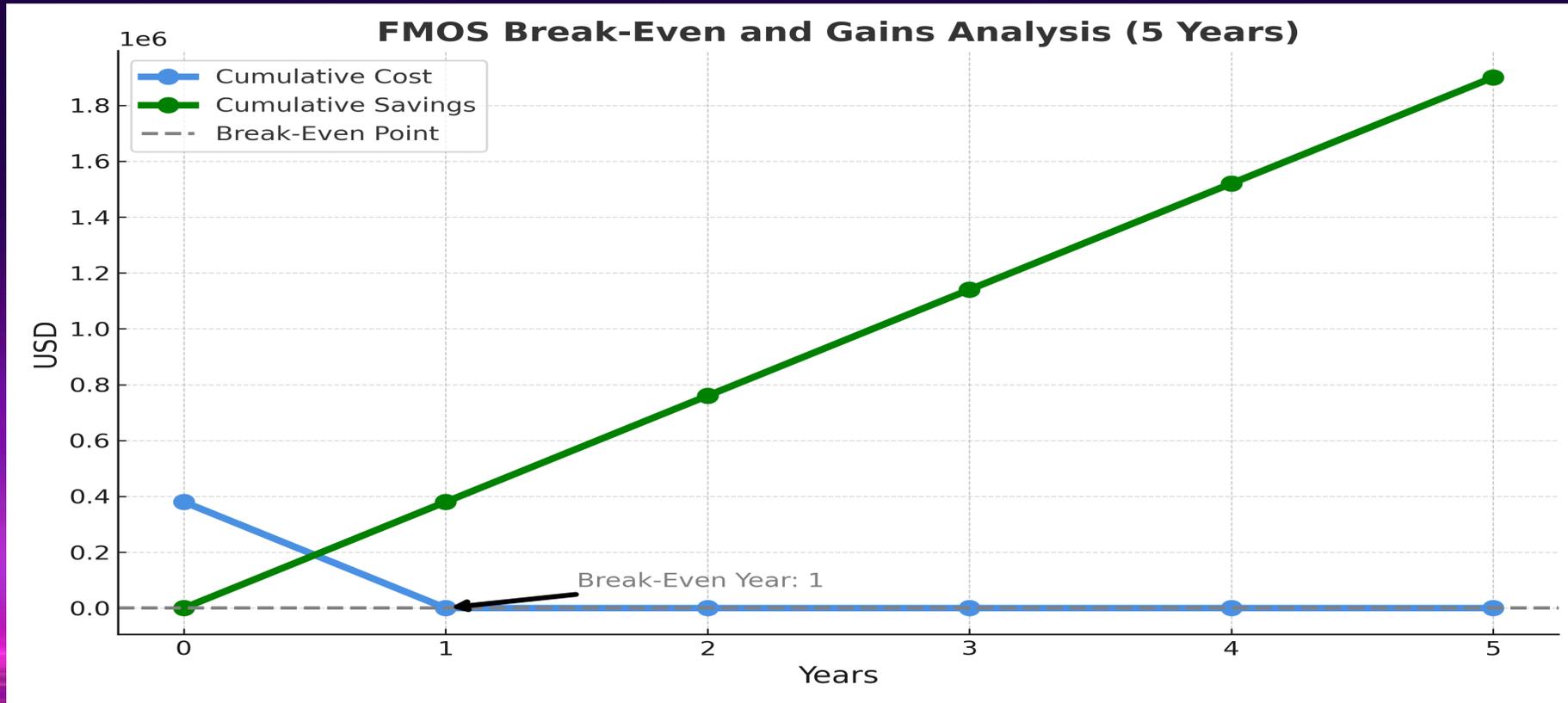
**5G Network Setup**  
 20,000 \$



**LLM API**  
 2,000\$



# Potential Savings



## Case Studies



**Port of Hamburg**



**BMW's Plant in Landshut**







## Future Outlook

6G

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## Future Outlook

**Digital Twins:** Real-time virtual replicas of facilities.

**Holographic Interfaces:** Immersive 3D visualization for facility management.

6G

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