Smart Building Digital Twin (Lite): HVAC Energy & Comfort Optimization for KFUPM Building 54

TEAM M076

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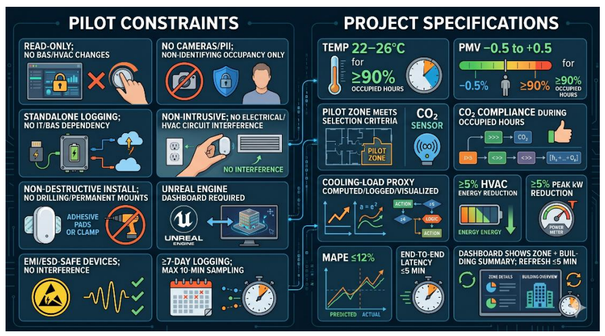
Introduction/Background

- HVAC systems are major energy consumers in buildings
- A digital twin is a virtual model that uses real data to monitor, simulate, and optimize performance
- Enables comfort, IAQ, and energy analysis through simulation and visualization

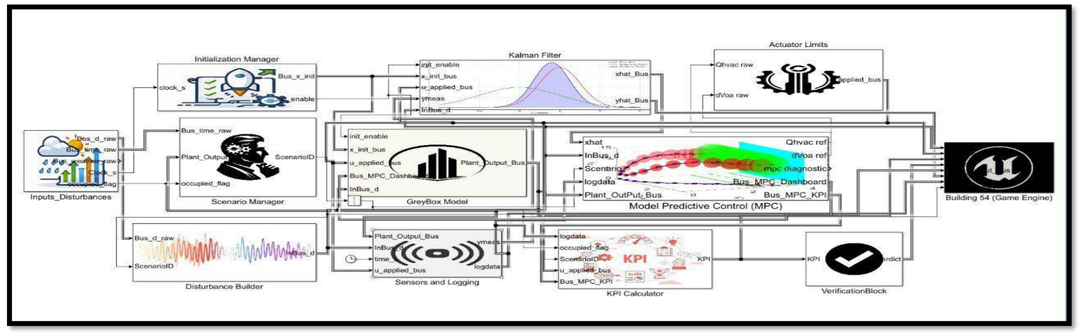
Problem Statement

- HVAC operates conservatively without zone feedback
- Causes overcooling, discomfort, and energy waste
- No non-intrusive way to assess occupancy, IAQ, or performance
- Limits data-driven decisions without BAS modification

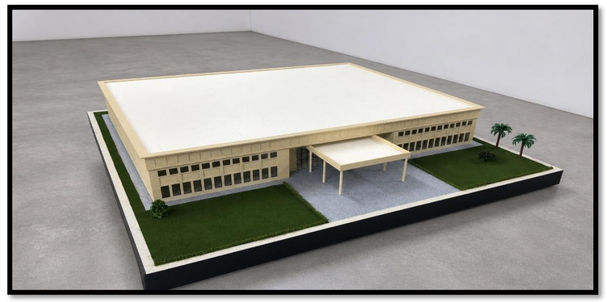
Constraints & Specifications



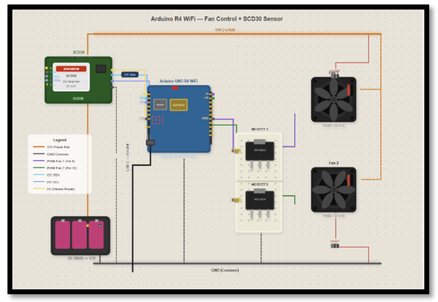
Prototype Design



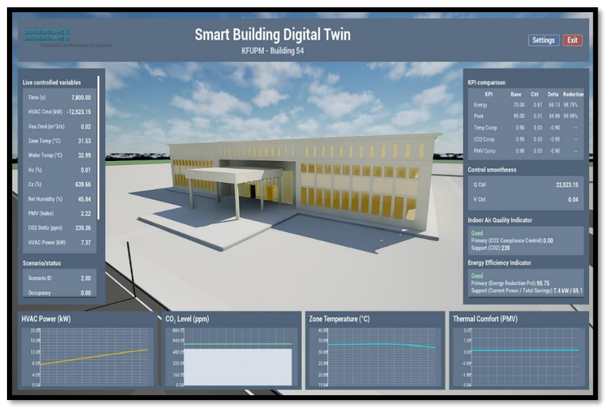
HVAC Digital Twin Core Model (Simulink)



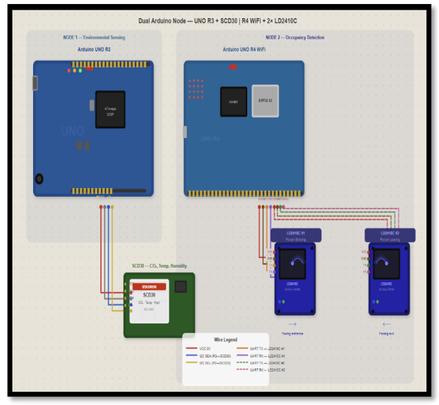
Scaled Building 54



Semi-HVAC

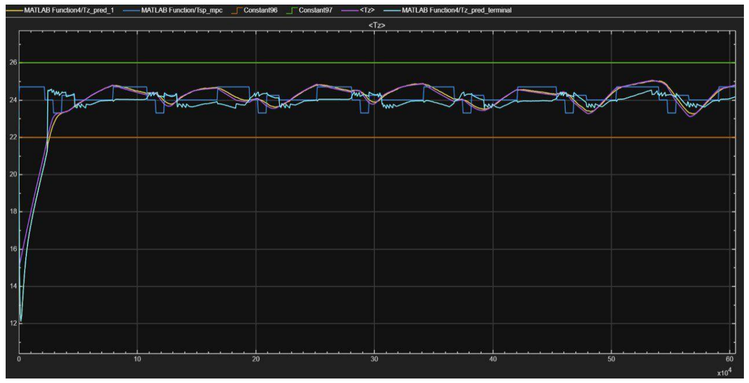


Unreal Engine Dashboard



Dataset Sensors

Testing & Validation



- **Planning & Scope Definition** – define goals, requirements, and data needs
- **Design & Setup** – develop digital twin model and sensing strategy
- **Data Collection** – gather sensor and system performance data
- **Model Development** – build and calibrate the digital twin
- **Analysis & Simulation** – run scenarios (comfort, IAQ, energy)
- **Visualization** – create dashboards and insights
- **Evaluation & Recommendations** – generate data-driven improvements

Conclusion

- Built a read-only HVAC digital twin for Building 54
- Enabled comfort, IAQ, and energy analysis
- Used sensing, simulations, and dashboards
- Supported data-driven operational decisions