

Lighting System Data – What are we learning?

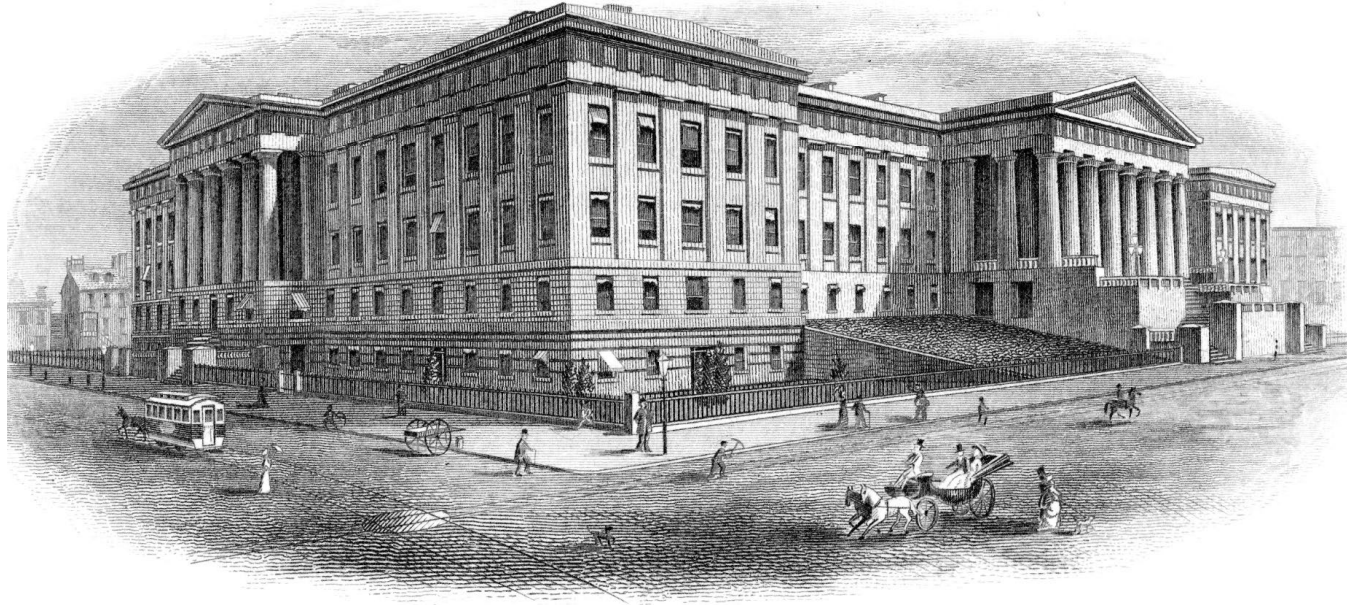
A Smithsonian Case Study in Connected Lighting

Alexander Cooper – Head of Exhibits Technology

National Portrait Gallery

Lighting System Data

The Donald W. Reynolds Center



Lighting System Data

The Donald W. Reynolds Center



The Great Hall – Third Floor South Wing



The Robert and Arlene Kogod Courtyard

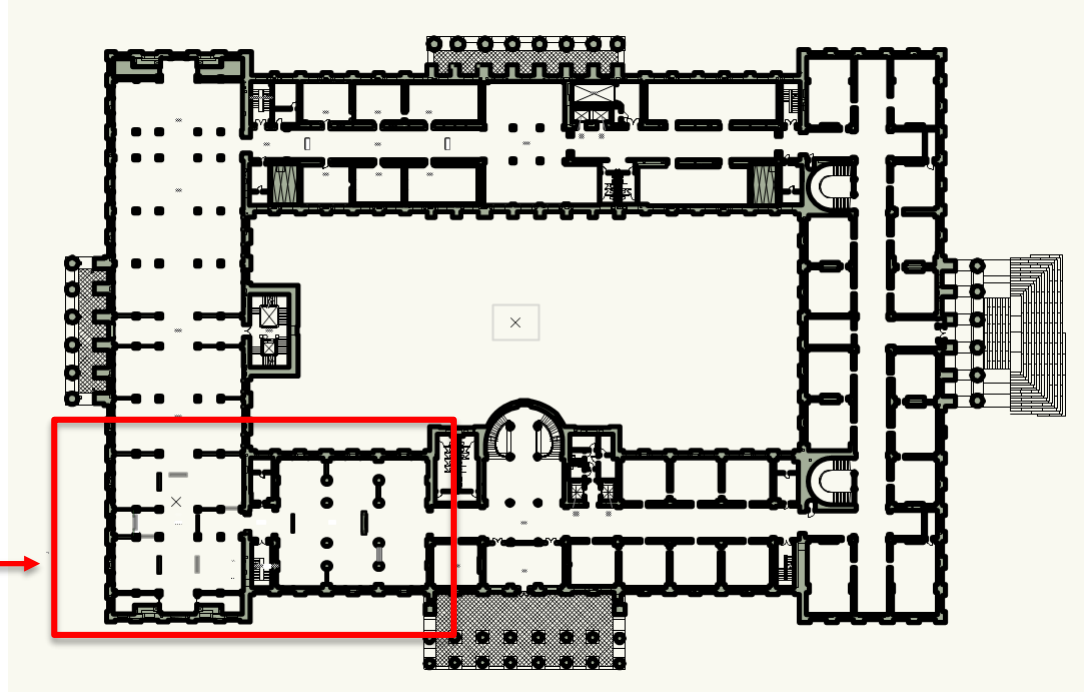
Lighting System Data

America's Presidents Gallery



Lighting System Data

America's Presidents Pilot Lighting Project



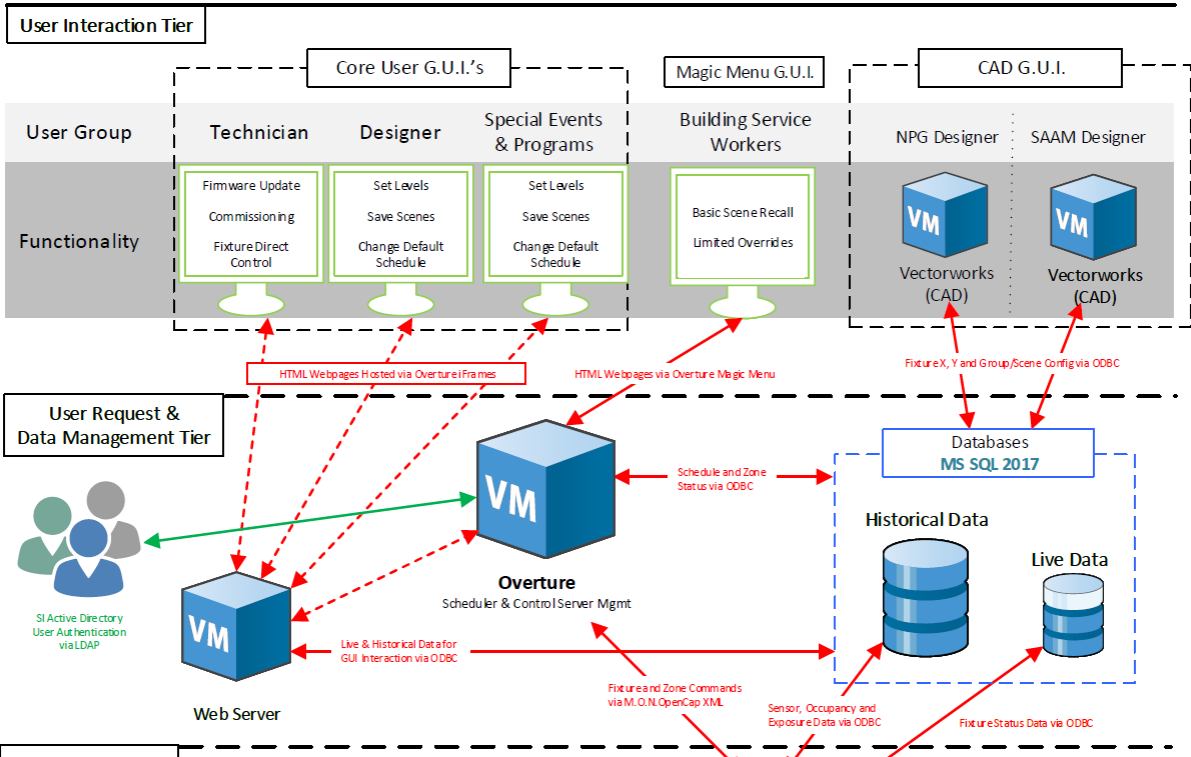
Pilot Project ~10,000 SqFt.

**The Donald W Reynolds Center For
American Art and Portraiture – 2nd Floor**

Lighting System Data

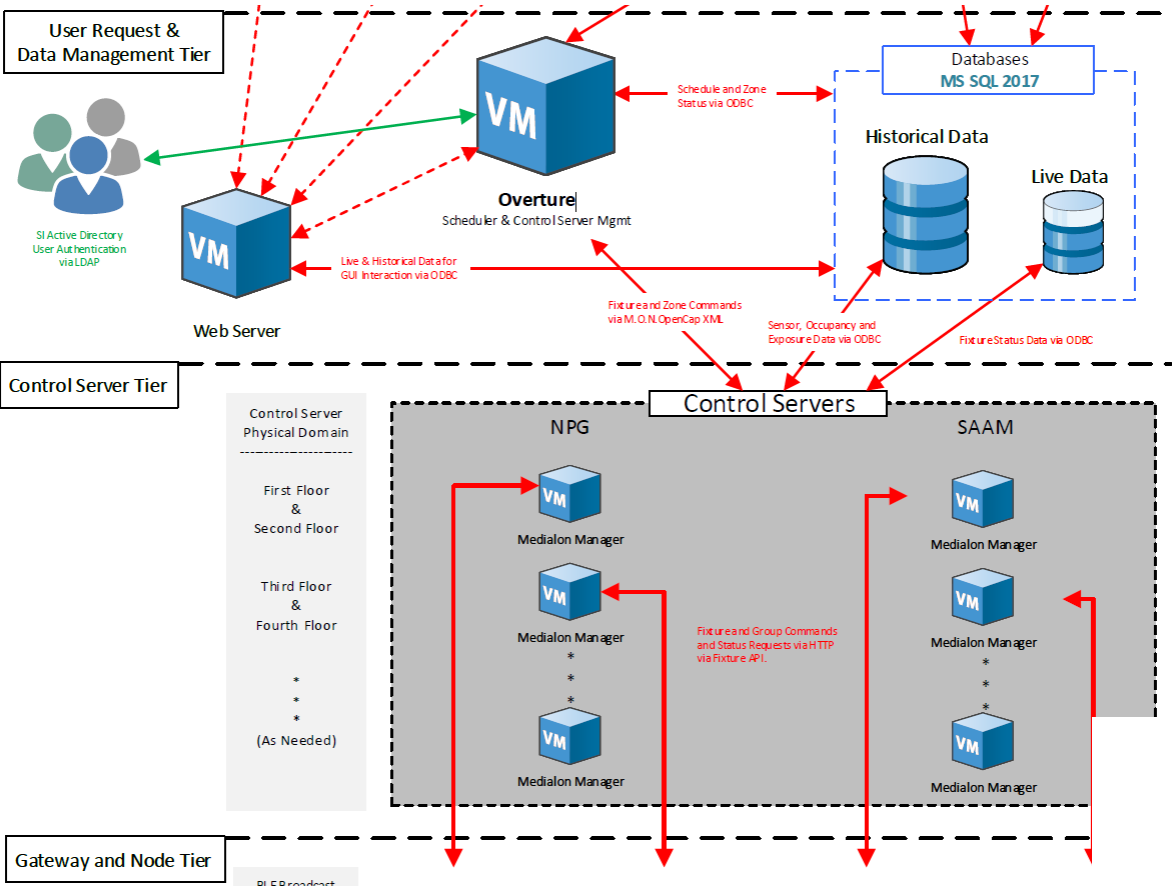
System Architecture

DWRC Lighting Control Management System Schematic



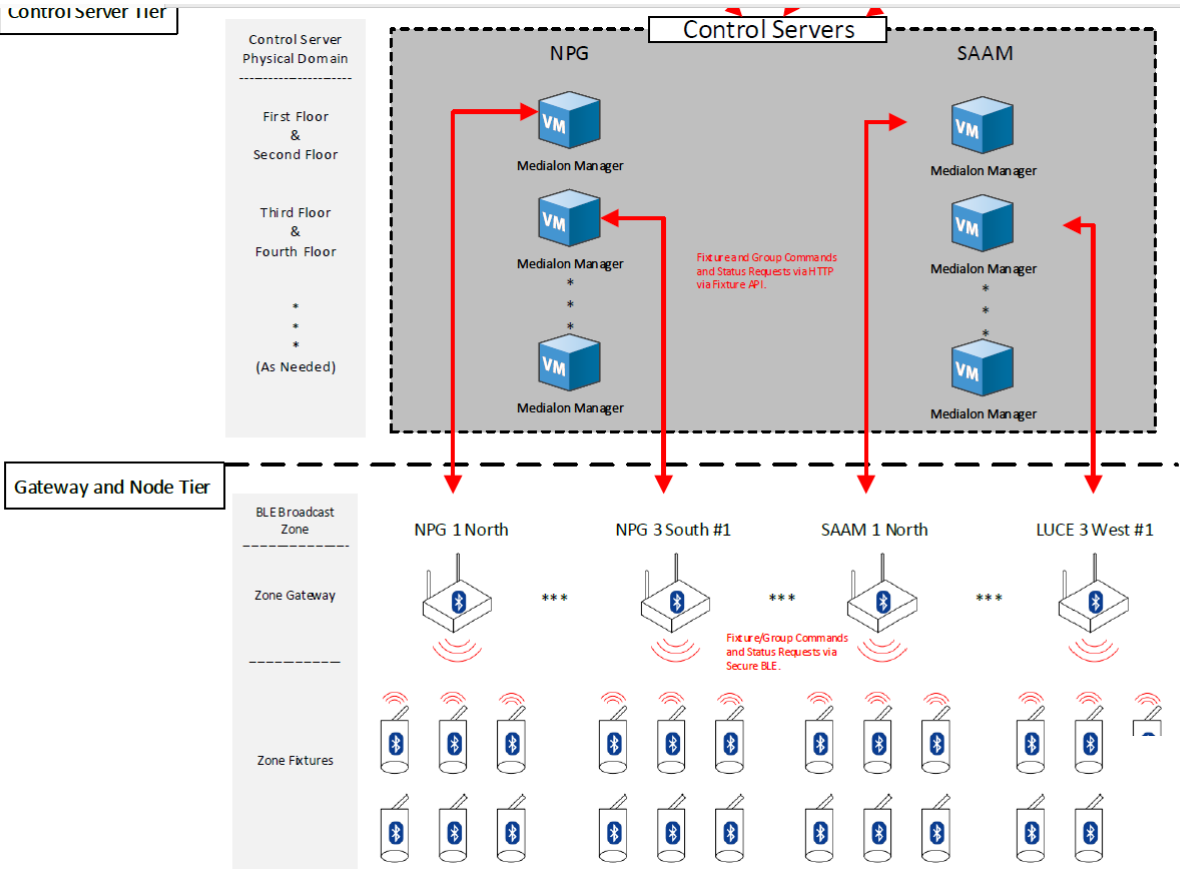
Lighting System Data

System Architecture



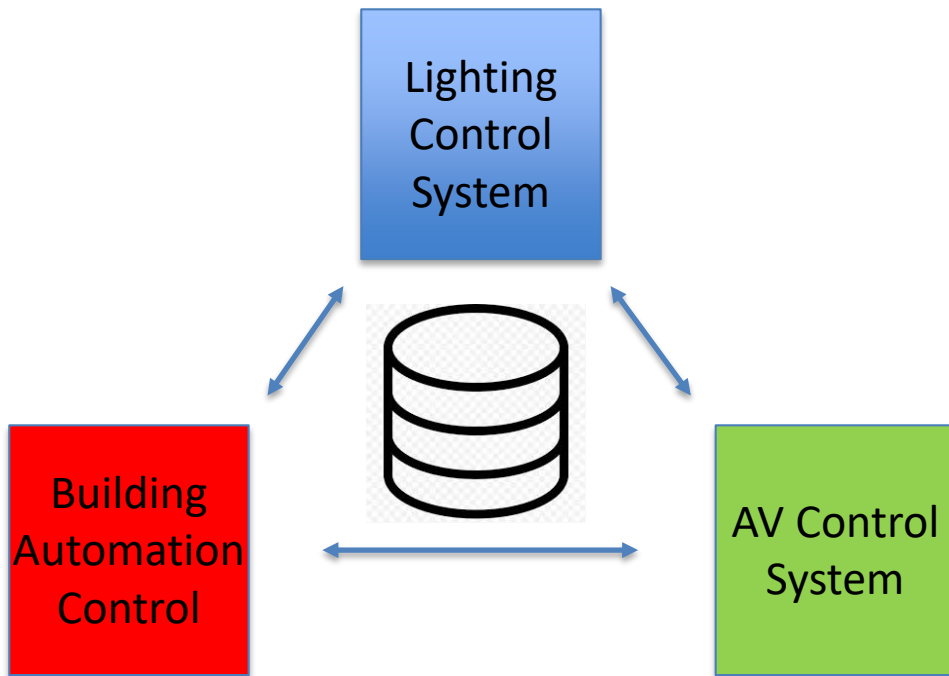
Lighting System Data

System Architecture



Lighting System Data

System Architecture Integration



Lighting System Data

System Nodes – Fixtures and Sensors

Broadcast Topology

BLE Fixtures



BLE Sensors



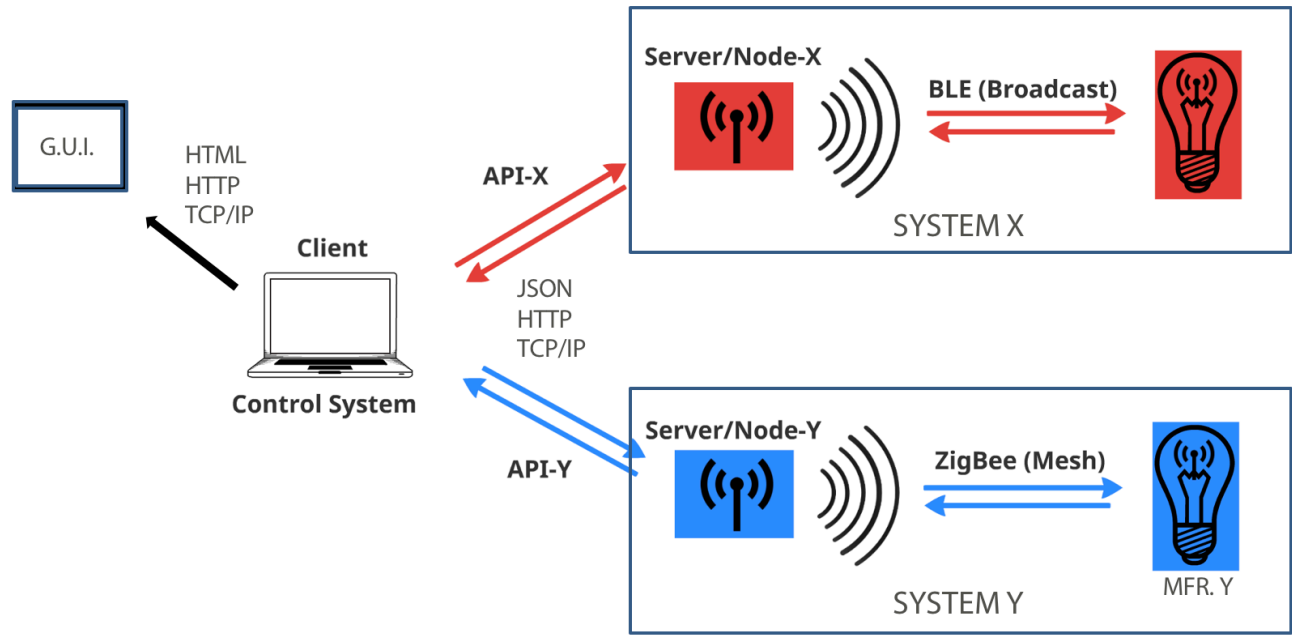
Mesh Topology

Zig Fixtures



Lighting System Data

Data Protocol Schematic



Lighting System Data

System Nodes – Fixtures and Sensors

Broadcast Topology

BLE Fixtures

```
{ "00. Index" : Integer
, "01. Device ID" : String*
, "02. Name" : Nullable String
9
, "03. Device" : Nullable String
, "04. Intensity" : Float
, "05. Power" : Nullable Float
, "06. Tc temperature" : Integer
, "07. supply_voltage" : Nullable Float
, "08. on_hours" : Nullable Integer
, "09. signal_strength" : Nullable
Integer
, "10. status" : Nullable Integer
, "11. Last Update" : Nullable Float
, "12. Adv Interval" : Nullable Float
, "NetworkName" : Nullable String}
```

BLE Sensors

```
{ "01. Device ID" : String
, "02. Name" : Nullable String
, "03. Device" : Nullable String
, "04. Lux" : List (Nullable Int)
, "05. Motion" : List (Nullable Float)
, "06. Temperature" : Nullable Int
, "07. supply_voltage" : Nullable Float
, "08. Humidity" : Nullable Float
, "09. signal_strength" : Nullable Integer
, "10. status" : Nullable Integer
, "11. Last Update" : Nullable Float
, "12. Adv Interval" : Nullable Float
, "NetworkName" : Nullable String
, "LuxHours": List (Nullable Float)}
```

Mesh Topology

Zig Fixtures

```
{ "ID" : String,
"Name" : Nullable String,
"State" : {
    "Brightness" : Integer,
    "CCT" : Integer,
    "Power On" : Boolean,
    "TransitionTime" : Integer,
    "Vibrancy" : Integer,
    "xchromaticity" : float,
    "ychromaticity" : float},
}
```

Lighting System Data

System Nodes – Fixtures and Sensors

Broadcast Topology

BLE Fixtures

```
{ "00. Index" : Integer
, "01. Device ID" : String*
, "02. Name" : Nullable String
, "03. Device" : Nullable String
, "04. Supply Voltage" : Nullable Float
, "05. on_hours" : Nullable Integer
, "06. signal_strength" : Nullable Integer
, "07. status" : Nullable Integer
, "08. Last Update" : Nullable Float
, "09. Adv Interval" : Nullable Float
, "10. NetworkName" : Nullable String }
```

Fixture Status Data

BLE Sensors

```
{ "01. Device ID" : String
, "02. Name" : Nullable String
, "03. Device" : Nullable String
, "04. Supply Voltage" : Nullable Float
, "05. on_hours" : Nullable Integer
, "06. signal_strength" : Nullable Integer
, "07. status" : Nullable Integer
, "08. Last Update" : Nullable Float
, "09. Adv Interval" : Nullable Float
, "10. NetworkName" : Nullable String
, "11. LuxHours" : List (Nullable Float) }
```

Environmental Data

at

Mesh Topology

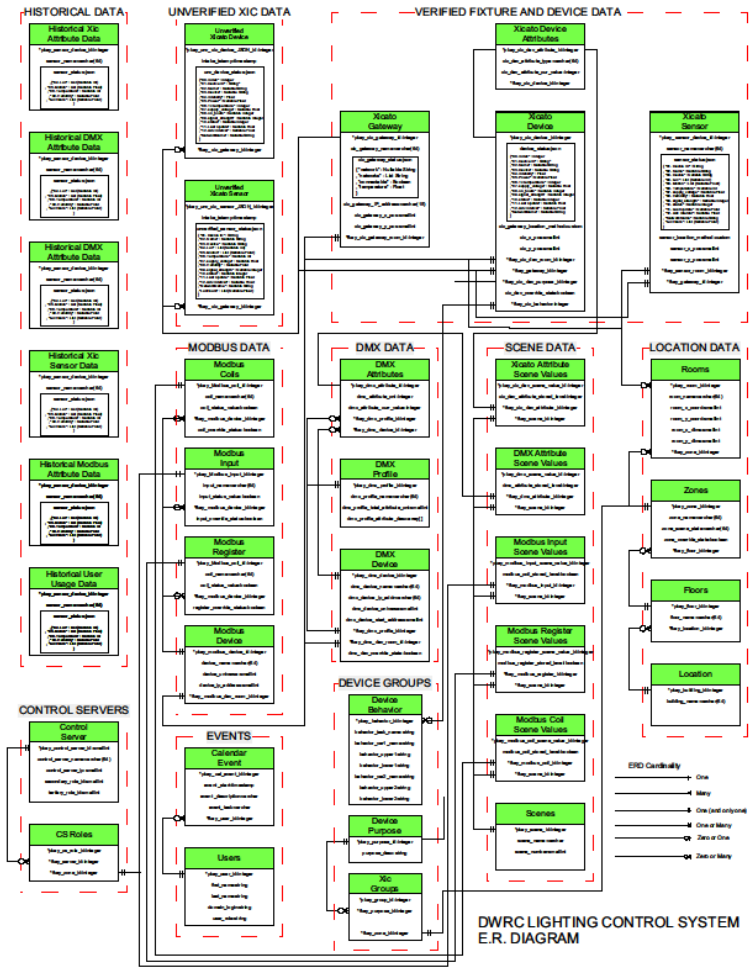
Zig Fixtures

```
{ "ID" : String,
"Name" : Nullable String,
"State" : Integer,
"chromaticity" : float,
"xchromaticity" : float,
"ychromaticity" : float },
```

Fixture Status Data

Lighting System Data

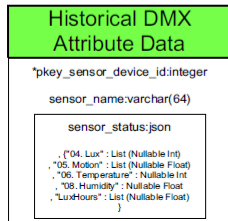
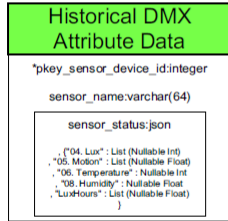
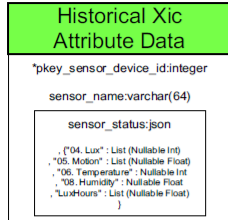
ER Model and Database



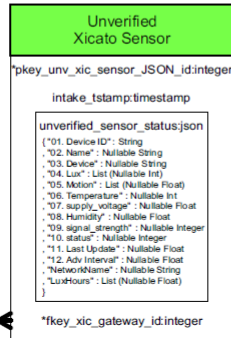
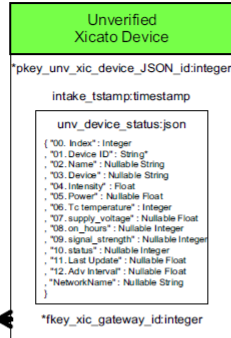
Lighting System Data

ER Model and Database

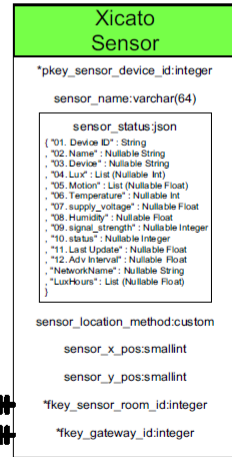
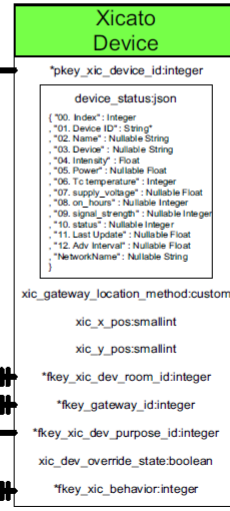
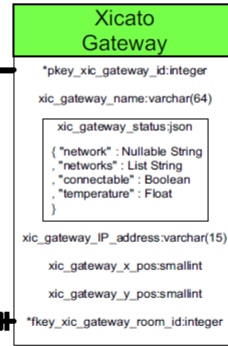
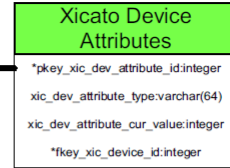
HISTORICAL DATA



UNVERIFIED XIC DATA

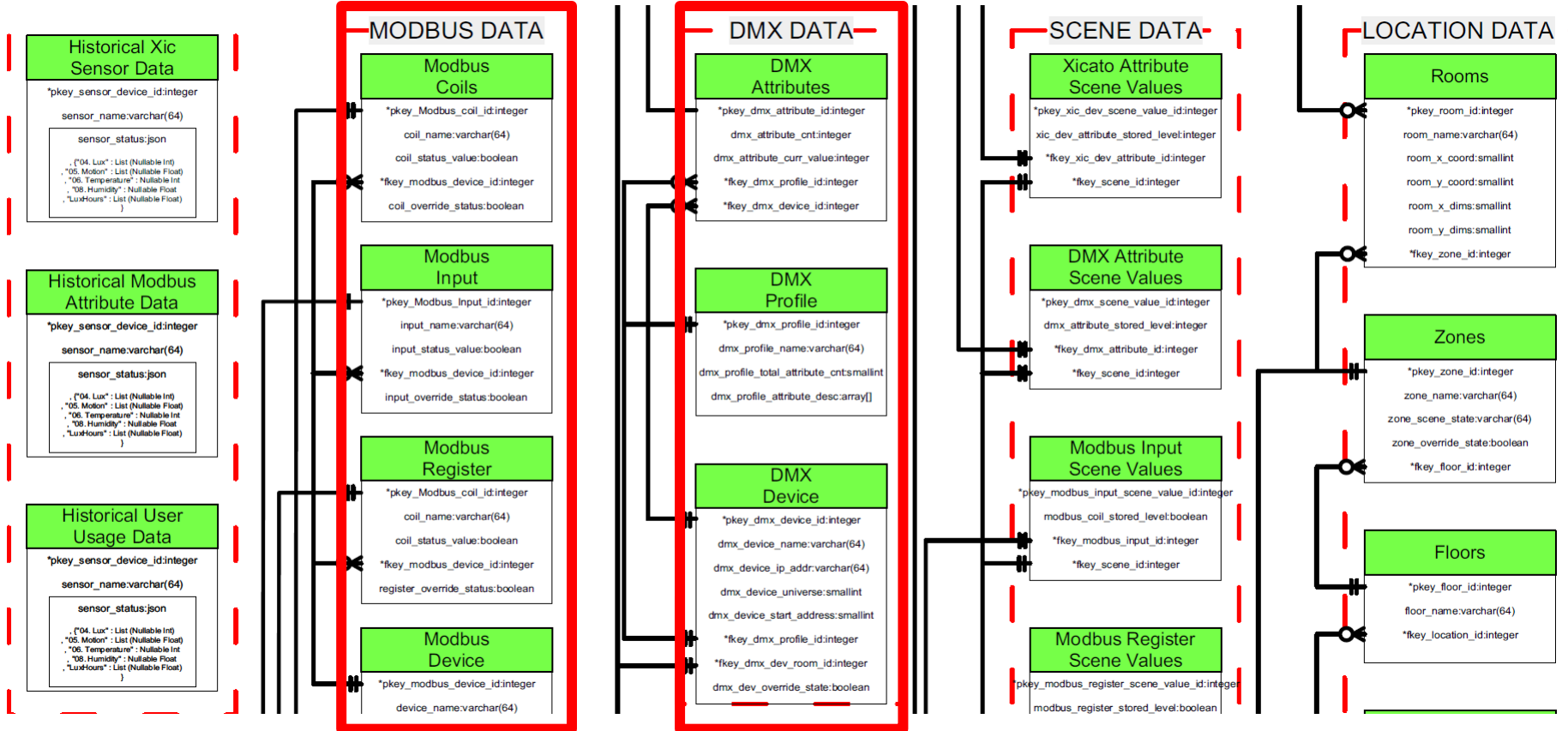


VERIFIED FIXTURE AND DEVICE DATA



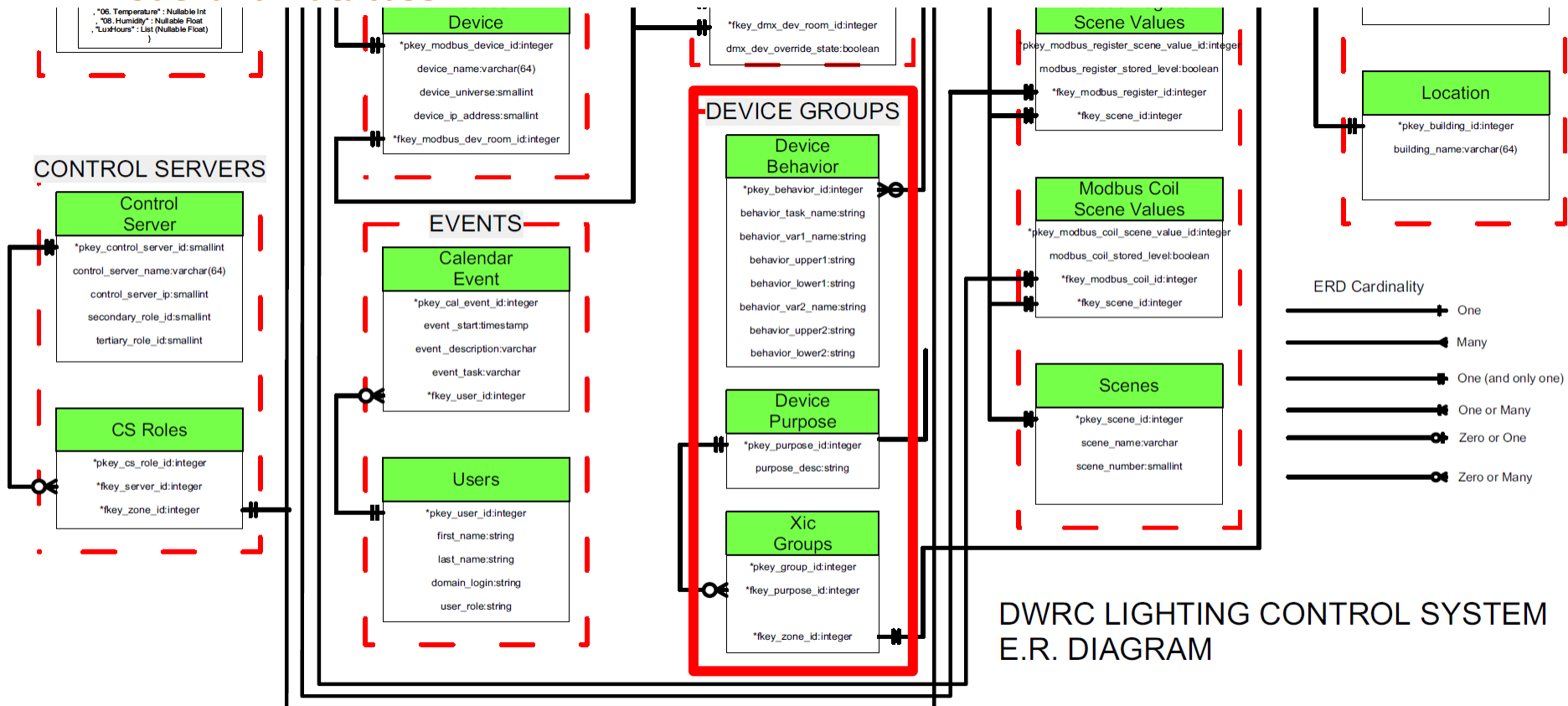
Lighting System Data

ER Model and Database



Lighting System Data

ER Model and Database



Wow – That Was a Lot of Work

Benefits: Who Cares?

**So
What?**

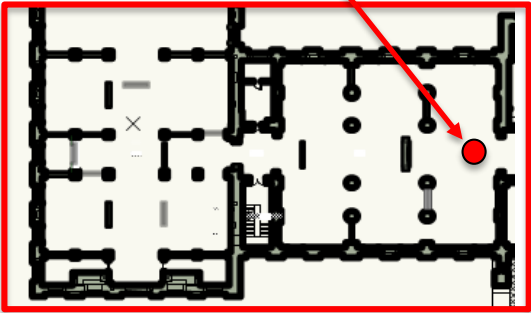
Lighting System Data

Benefits: Environmental Data

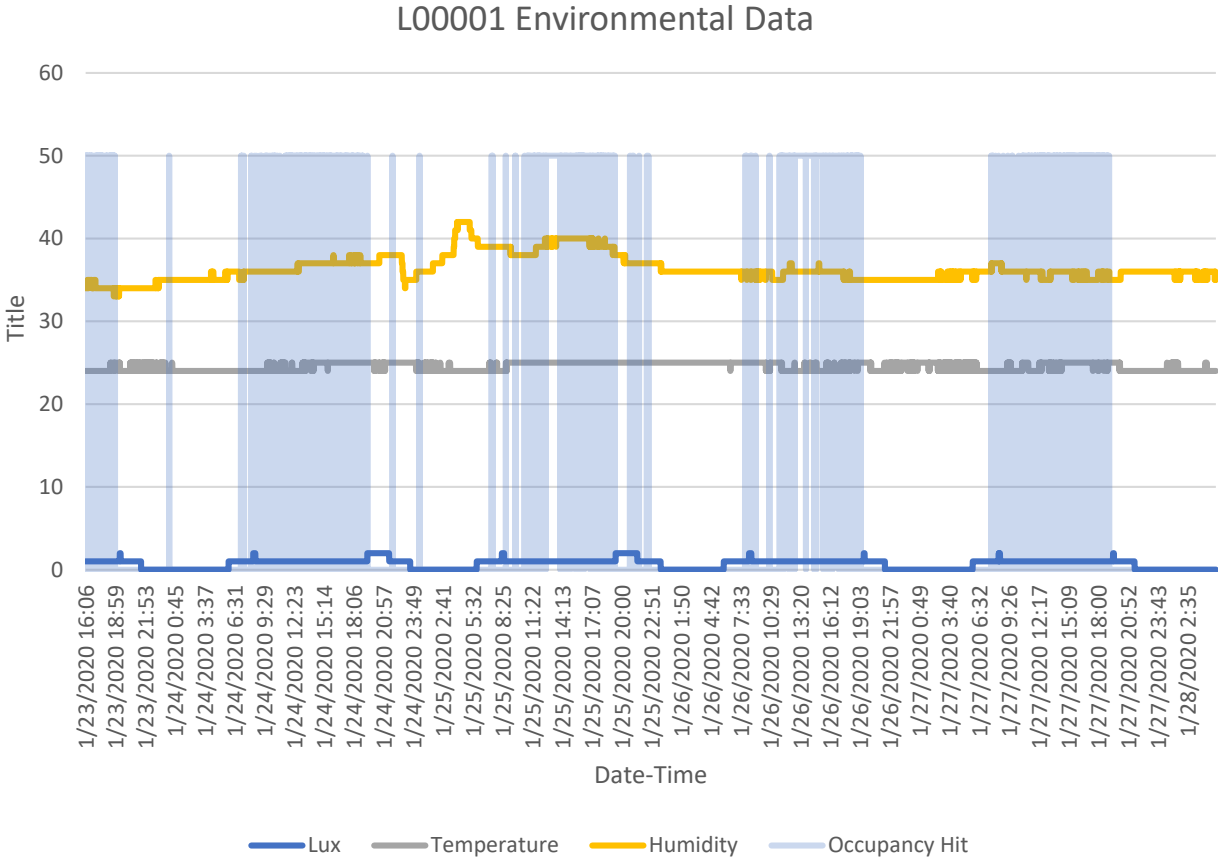
Environmental Data Analysis

Lighting System Data

Environmental Data

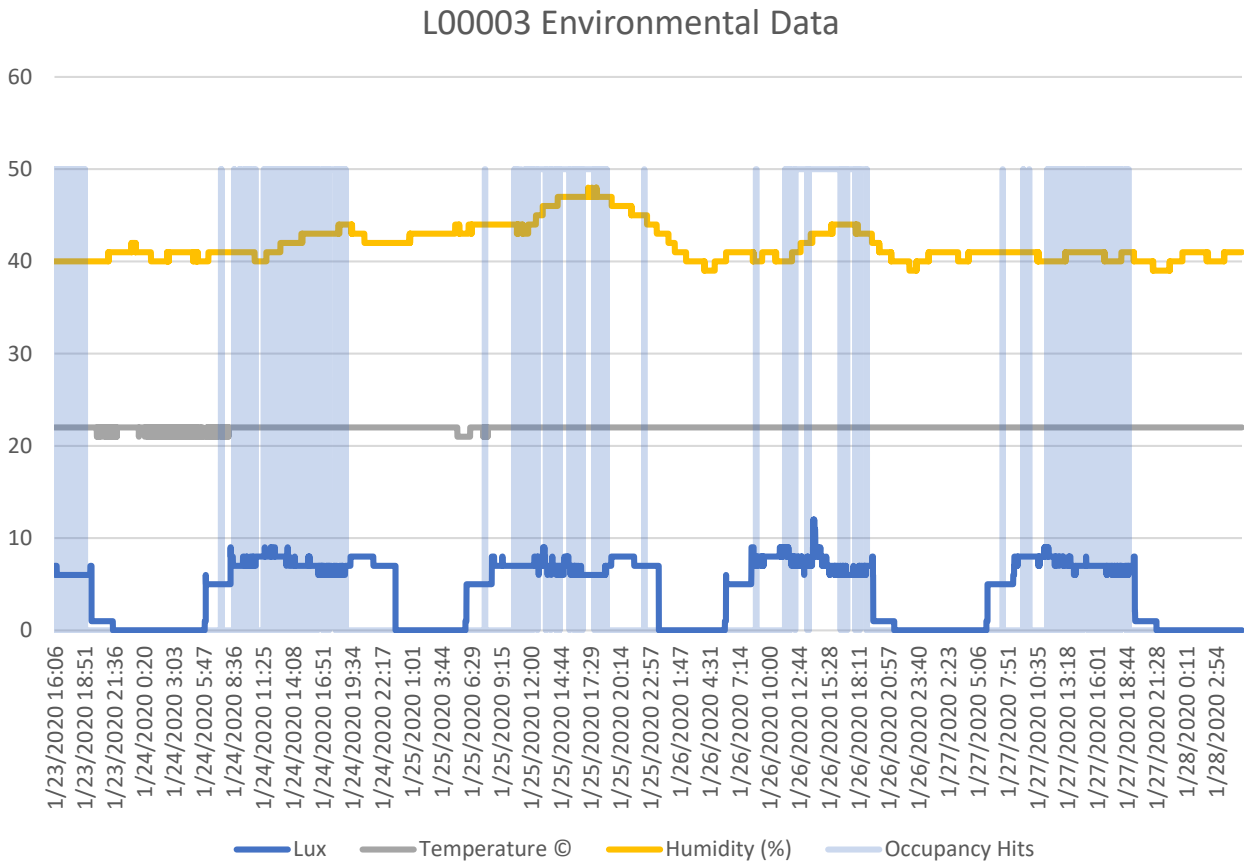
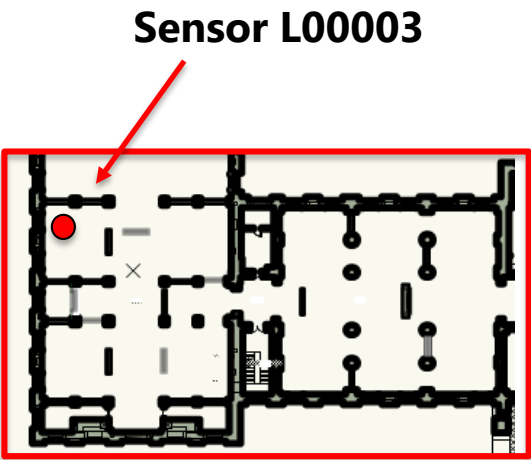


Sensor L00001



Lighting System Data

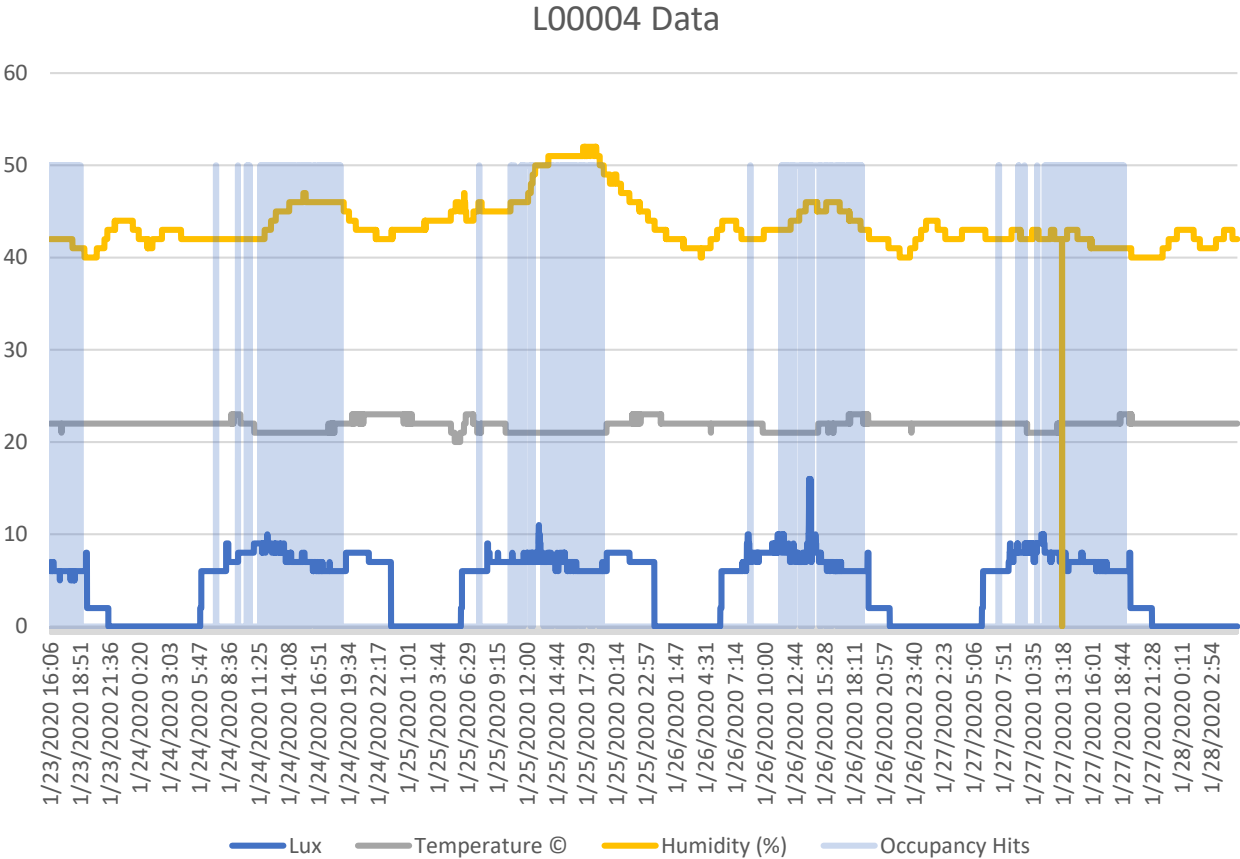
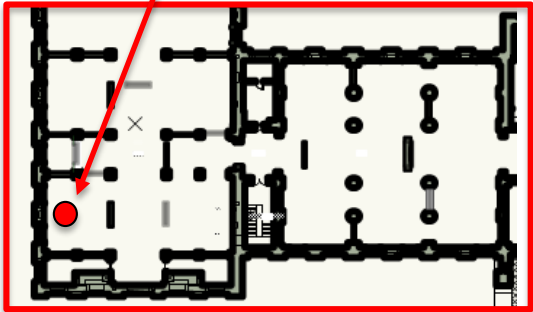
Environmental Data



Lighting System Data

Environmental Data

Sensor L00004



Lighting System Data

Environmental Data

What Can We Learn? What are the Benefits?

- Verify Temperature and Rx levels adhere to museum standards.
- Target areas where Temp/Rx improvement is needed.
- Identify visitor patterns.
- Identify unnecessary object exposure.
- Target locations for data driven exposure reduction.

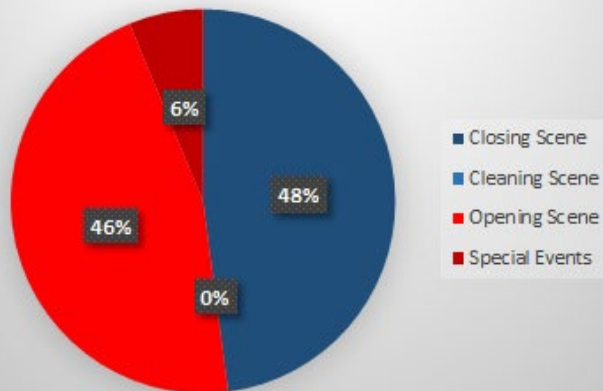
Lighting System Data

Environmental Data

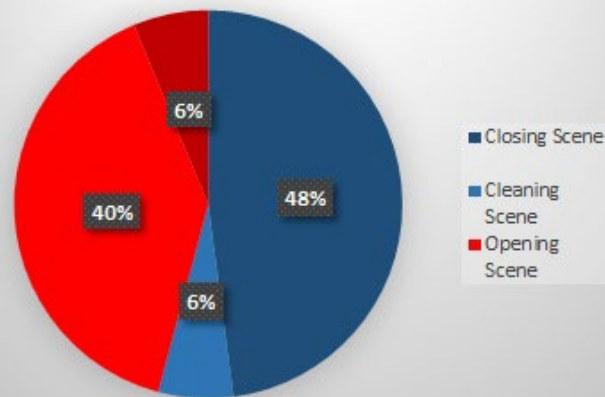
Big Deal!

- 15% Light Exposure Reduction

Pre-Renovation Schedule



Post-Renovation Schedule



Lighting System Data

Benefits: Reliability and Maintenance

**Improve Reliability &
Reduce/Restructure Maintenance Burden***

Lighting System Data

Benefits: Reliability and Maintenance

Bi-Directional Communication

From: [DWRC_Lighting_Medialon](#)
Sent: Friday, January 17, 2020 3:40 PM
To: [Cooper, Alexander](#); [Lazer, Grant](#); [Rosenfeld, Scott](#); [Lipscomb, Scott](#)
Subject: 01/17/2020 2nd Floor DWRC Siemens Override Enable

Medialon has detected that the DWRC 2nd floor Siemens override has been enabled.

Lighting System Data

Benefits: Reliability and Maintenance

Pre-Renovation Lighting maintenance



\$



\$



\$

Post-Renovation Lighting Maintenance

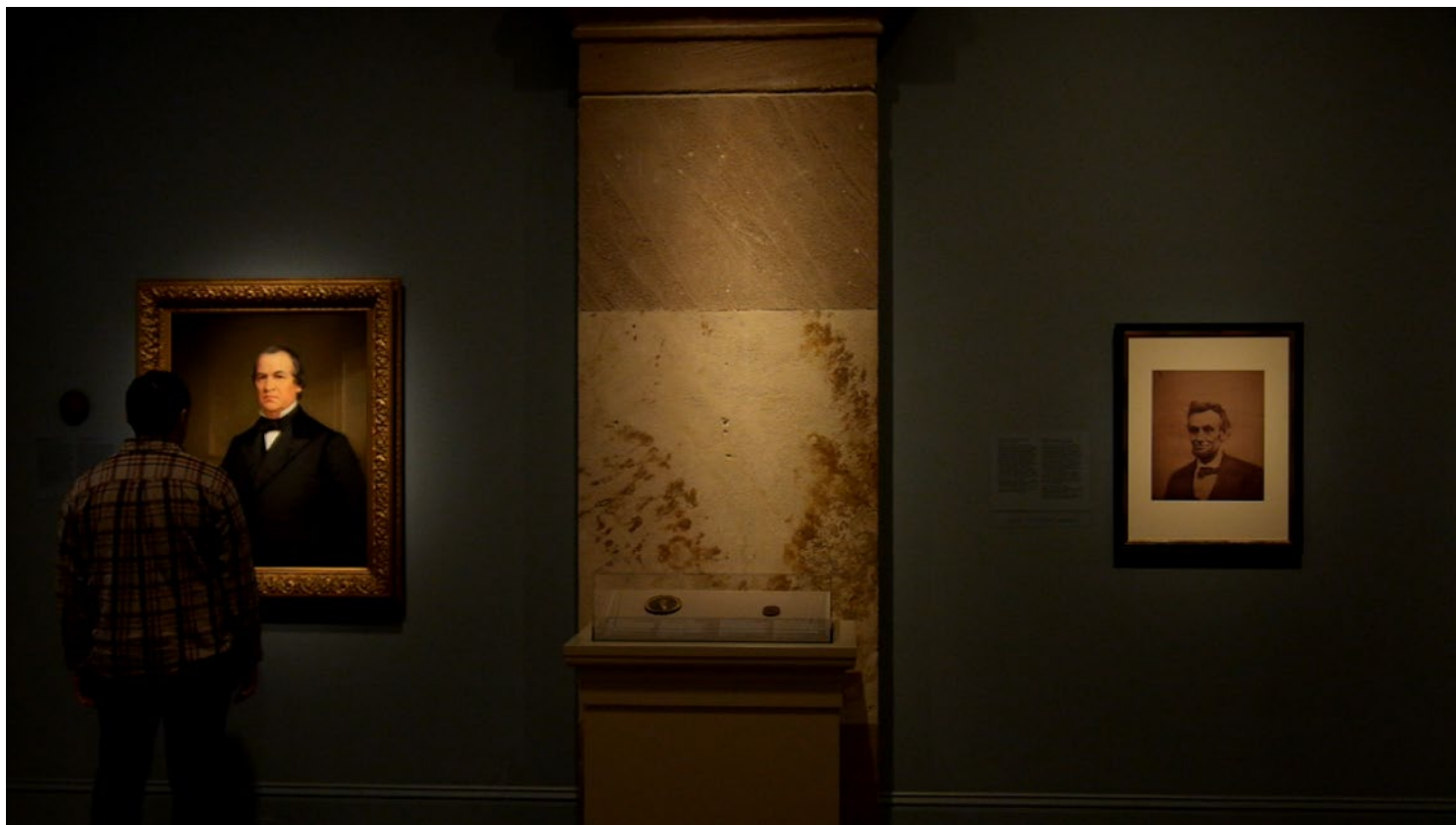


\$ + \$

Lighting System Data

Benefits: Reliability and Maintenance

Interactive Visitor Experience



Lighting System Data

Conclusion

Enormous Potential:

- Extensible Infrastructure & Functionality.
- Low-level integration with other BAS systems.
- Interactive Experience are now possible. Increased possibilities to engage the visitor.
- Sophisticated Analysis of Usage Data.

Lighting System Data

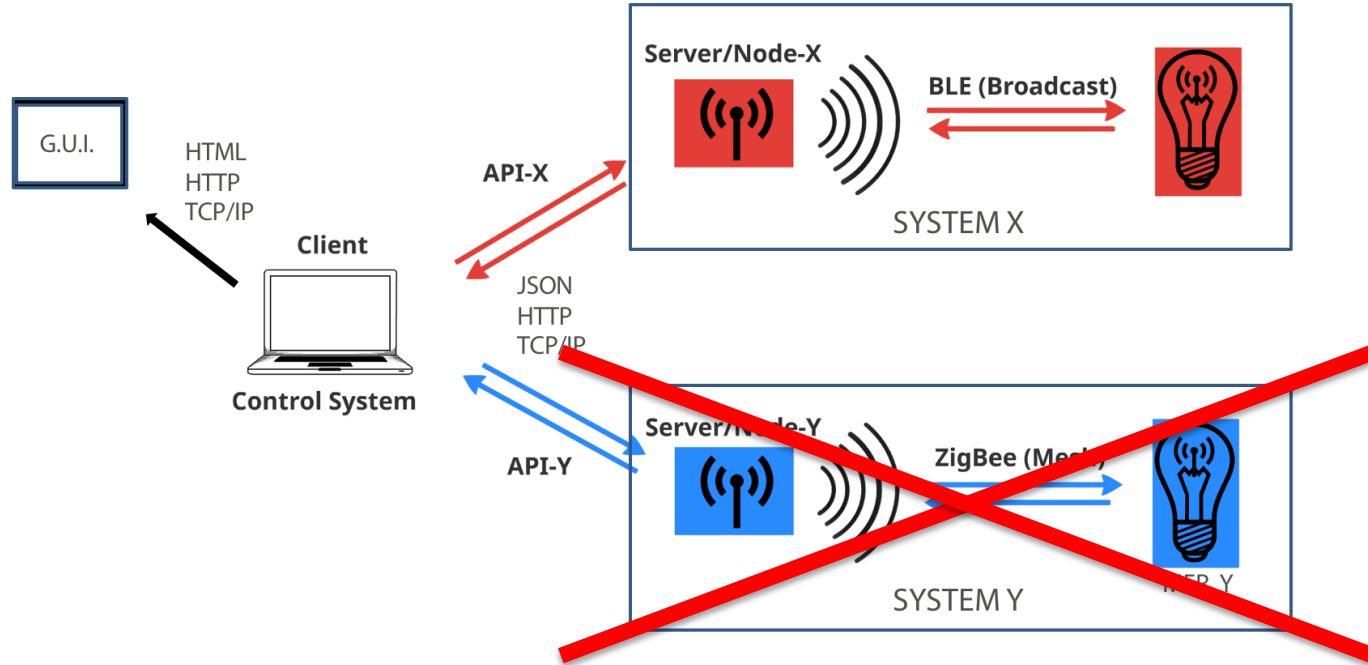
Conclusion

Caveat Emptor

- DDLS require significant investment in control development.
- Operation and maintenance of DDLS require new categories of staff (more client side cost).
- Assumes Inter-Operability, Bi-directional Communications, and Open Protocol Standards are adopted by all components.
- DDLS do not “scale-down” cost effectively for mid or small-scale projects.

The Presidents Get Connected

Interoperability?



Lighting System Data

Conclusion

My Takeaway's

- This is an entirely New Design (Everything) Process.
- "God is in the Details" (M.V.R.)
- "*Carpe Data*"
- Inter-Operability, Bi-directional Communications, and Open Protocol Standards are not widely adopted.
- Broadcast Networks = Fast, hard to adopt. Mesh Networks = Slow, Easy to adopt.
- Carefully Designed, Centralized Database is Essential.

Lighting System Data

Conclusion

Whats Next For SI?

- Full Scale Implementation of DWRC Pilot Project.
- Data-driven Circadian Lighting Design for Interior Spaces.
- Fidelity/Gamut Experiments. (e.g. low lux, high vibrancy)
- LM-80, TM-21 correlated analysis from fixture data.
- Coordinating Lighting Heat Load with BAS Temp & Rx.
- Granular Heat Maps of visitor movements.
- Advanced Sensor Applications.