# Sensor-Based Configuration of Lighting Controls

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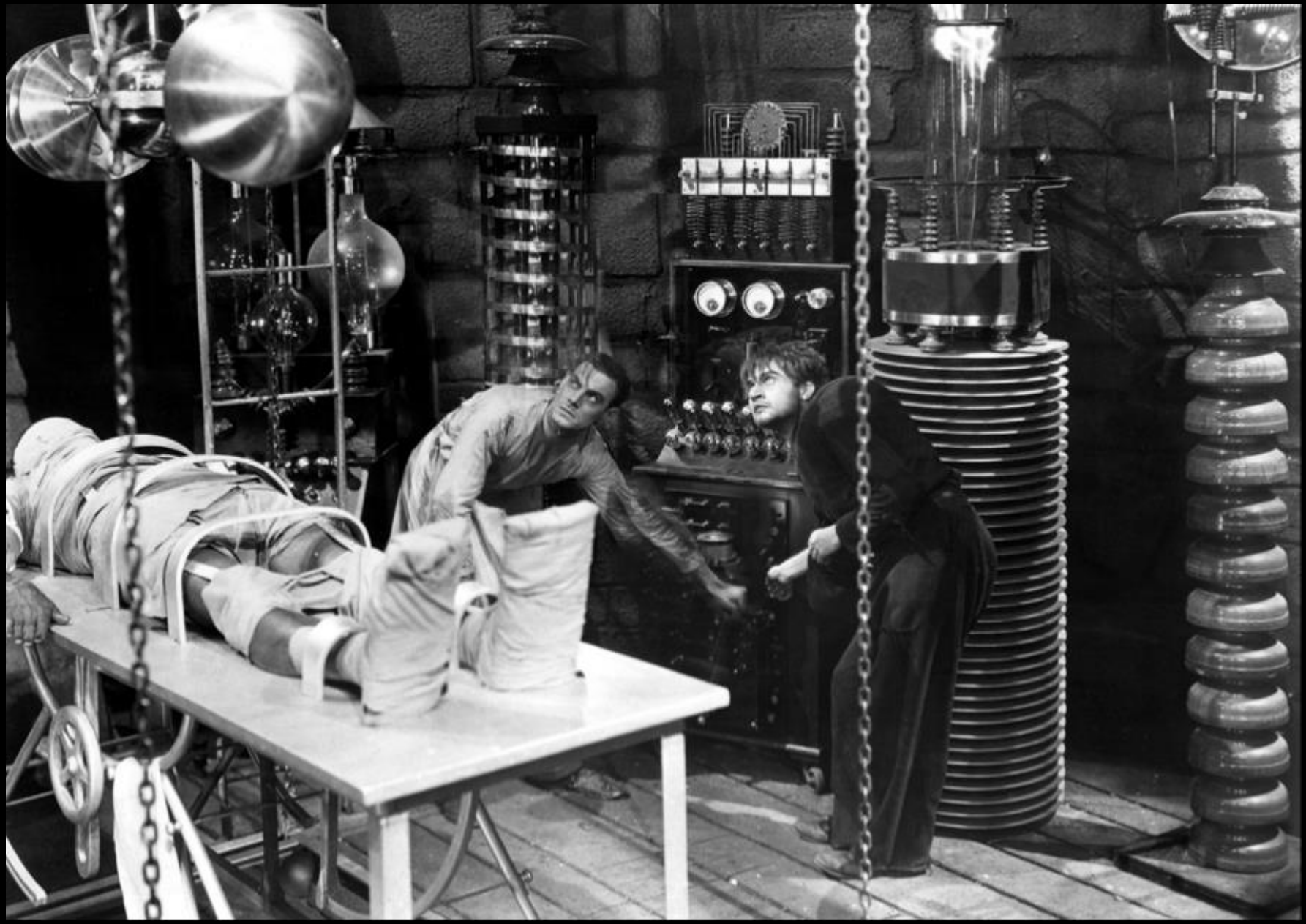
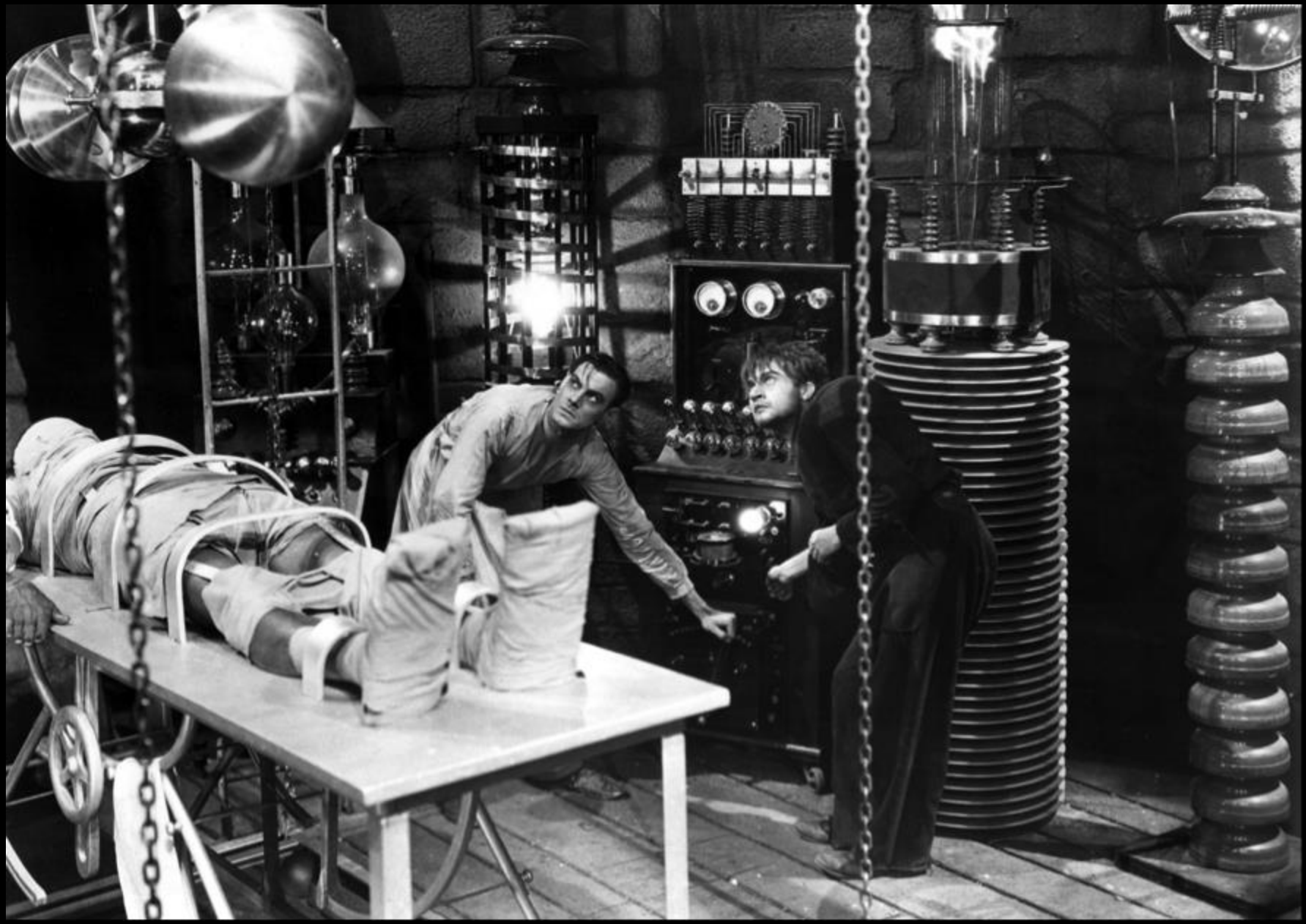
# Four Paradigm Shifts

- Software Driven Control
- Distributed Intelligence
- Sensor Integration
- Internet of Things





Once we break the connection between how lighting is powered and how it is controlled…

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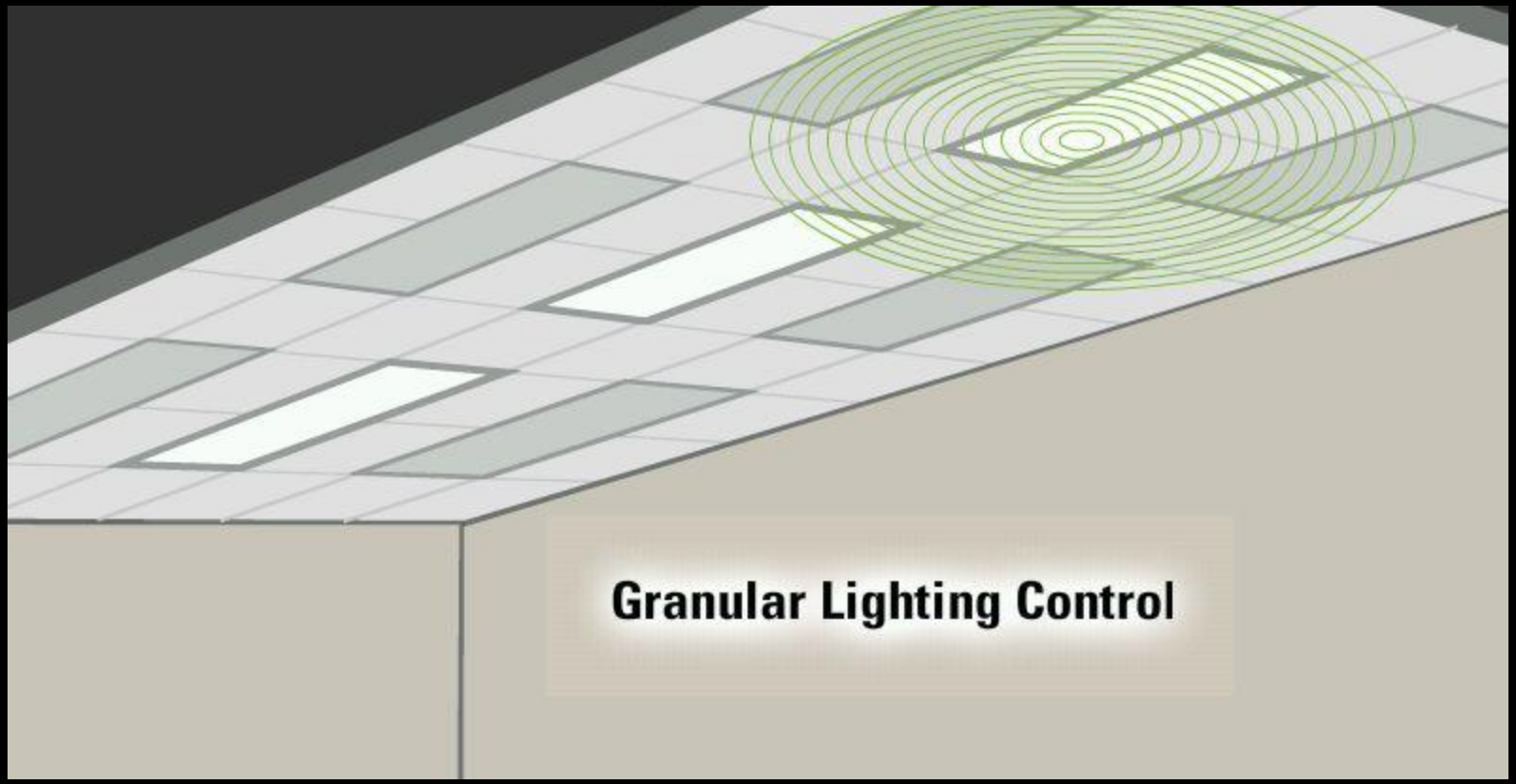


Once we break the connection between how lighting is powered and how it is controlled…

Once we break the connection between how lighting is powered and how it is controlled…

… we move from hardware-based control to software-based control.


Software is a new frontier for the Lighting Industry

# Paradigm Shift #1

Software

# Hardware vs. Software Development

| | Hardware | Software |
|---|---|---|
| Design Process | Linear | Iterative |
| Defects | Expensive | Inexpensive |
| Testing | Simple | Complex |

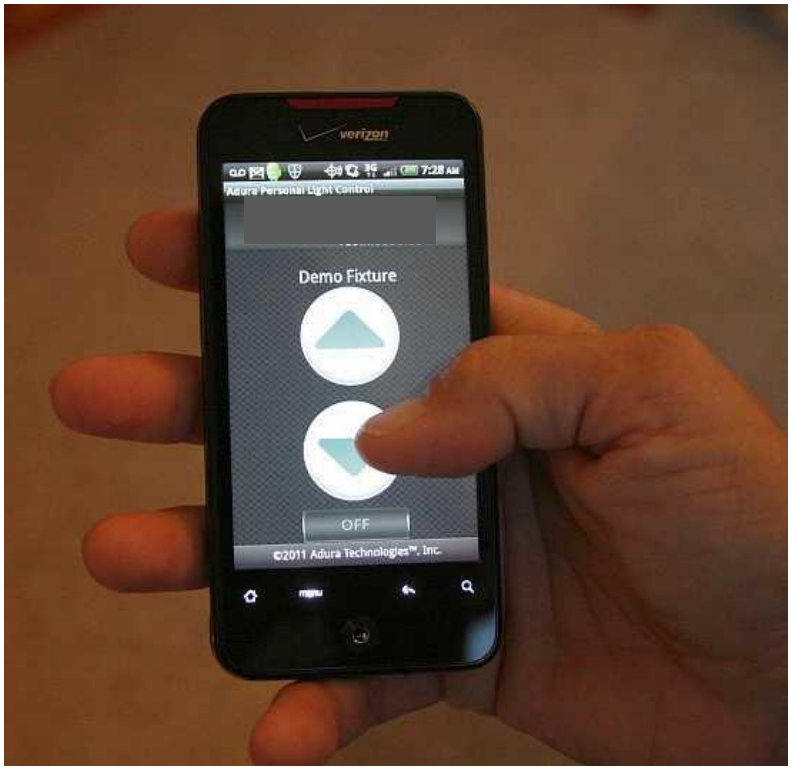
# Software

- Design
- Configuration
- Management
- EMS Integration
- Mobile apps
- Cloud integration
- Sensor-rich data stream

# Empowering Users with Software

Desktop Apps


Mobile Apps

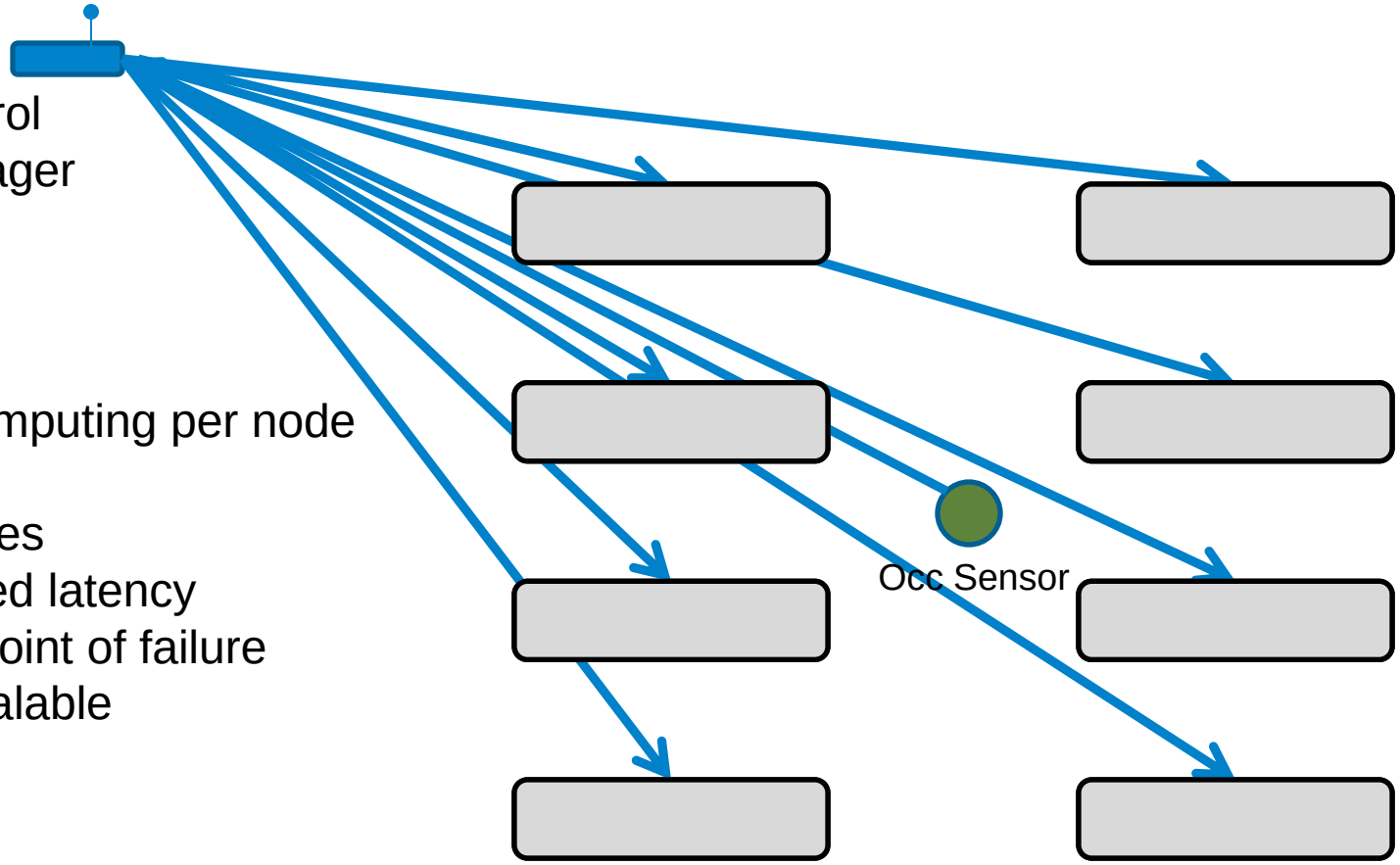



Smart Lighting ≠ No user control

# Paradigm Shift #2

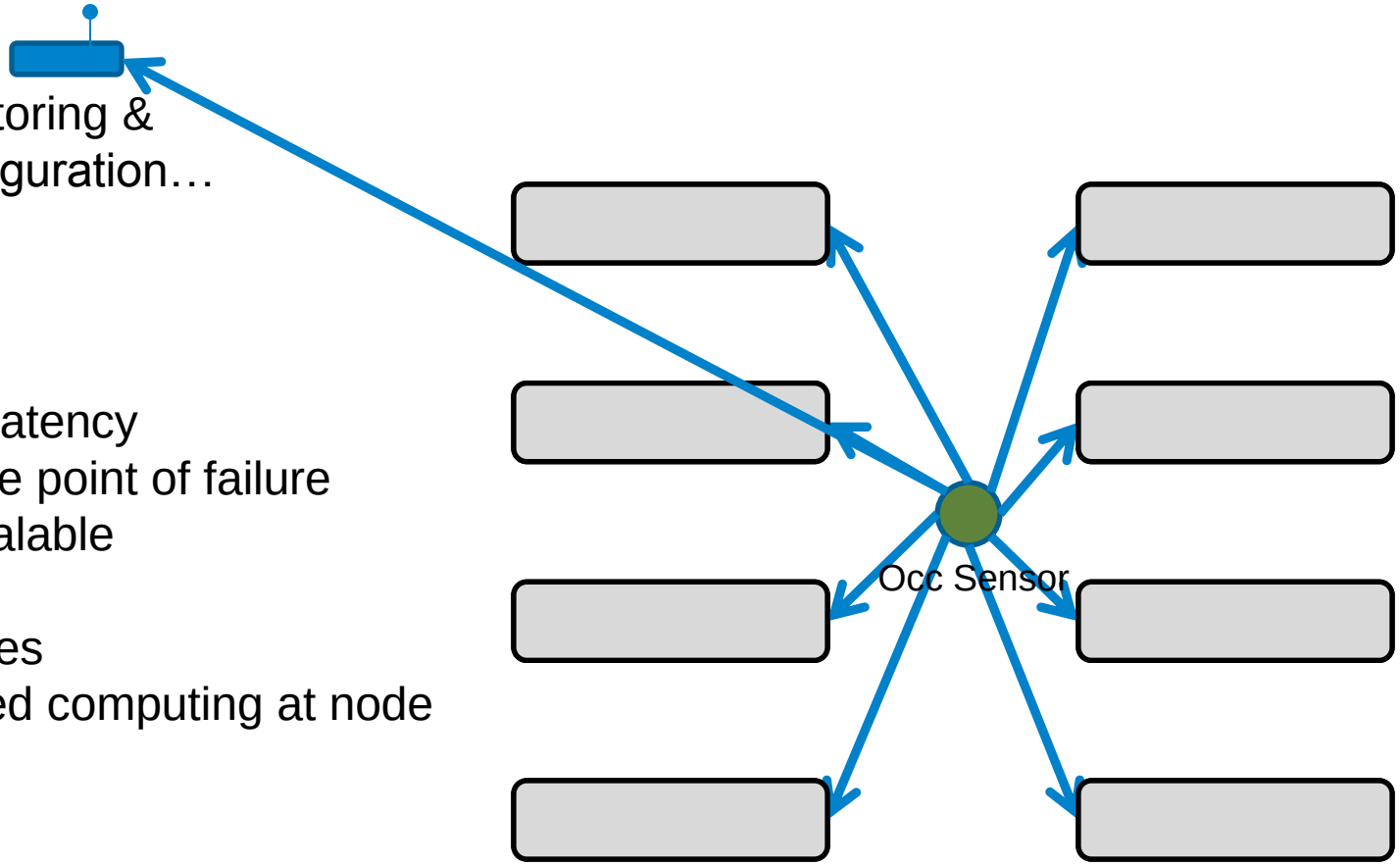
Distributed Intelligence

# Centralized control




- Advantages
  - Less computing per node
- Disadvantages
  - Increased latency
  - Single point of failure
  - Less scalable

# Distributed control




- Advantages
  - Lowest latency
  - No single point of failure
  - Most scalable
- Disadvantages
  - Increased computing at node

# Paradigm Shift #3

Integration

# Traditional industry model

# Issues with traditional model

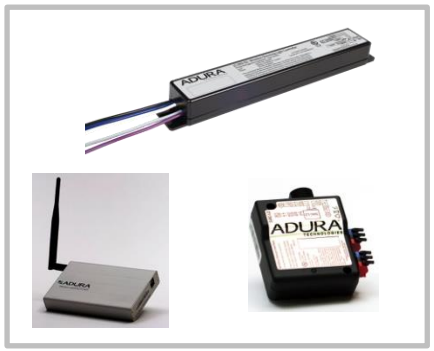
- Higher Cost
  - Multiple AC/DC conversions
  - Excess labor for assembly/installation/planning
  - SKU management
  - Interoperability problems
- Reduced Performance  and Reliability

# Fixtures, Sensors and Controls Are Merging

Independent Fixture

**Yesterday**

Independent Controls/Sensors




**Today**

Combined Fixture/Sensors/Controls Solution

# Integration Benefits

- Lower hardware cost
- Lower assembly cost
- Lower installation cost
- Lower design cost
- Optimized performance
- Higher reliability

# What is driving system cost?

- Fixture costs are going down
- Controls costs are going down
- Start-up costs are going…. Up?

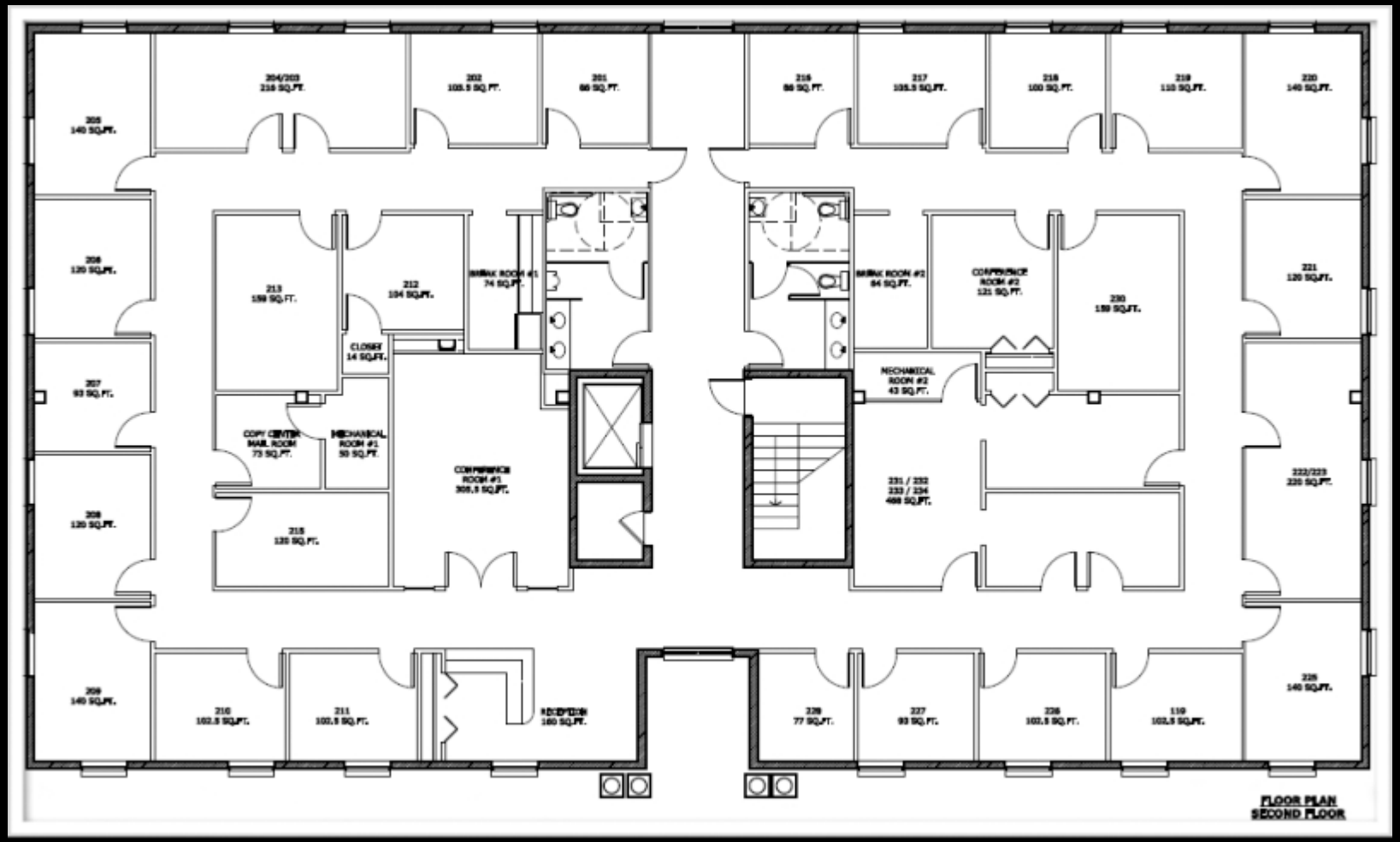
Why?

Location

Location

Location

# Location, Location, Location…



# Location, Location, Location…

# How do we get location?

- Manual
  - Barcode stickers/floorplan
  - Predefined locations
  - “Blinky blinky”

Labor/time Intensive

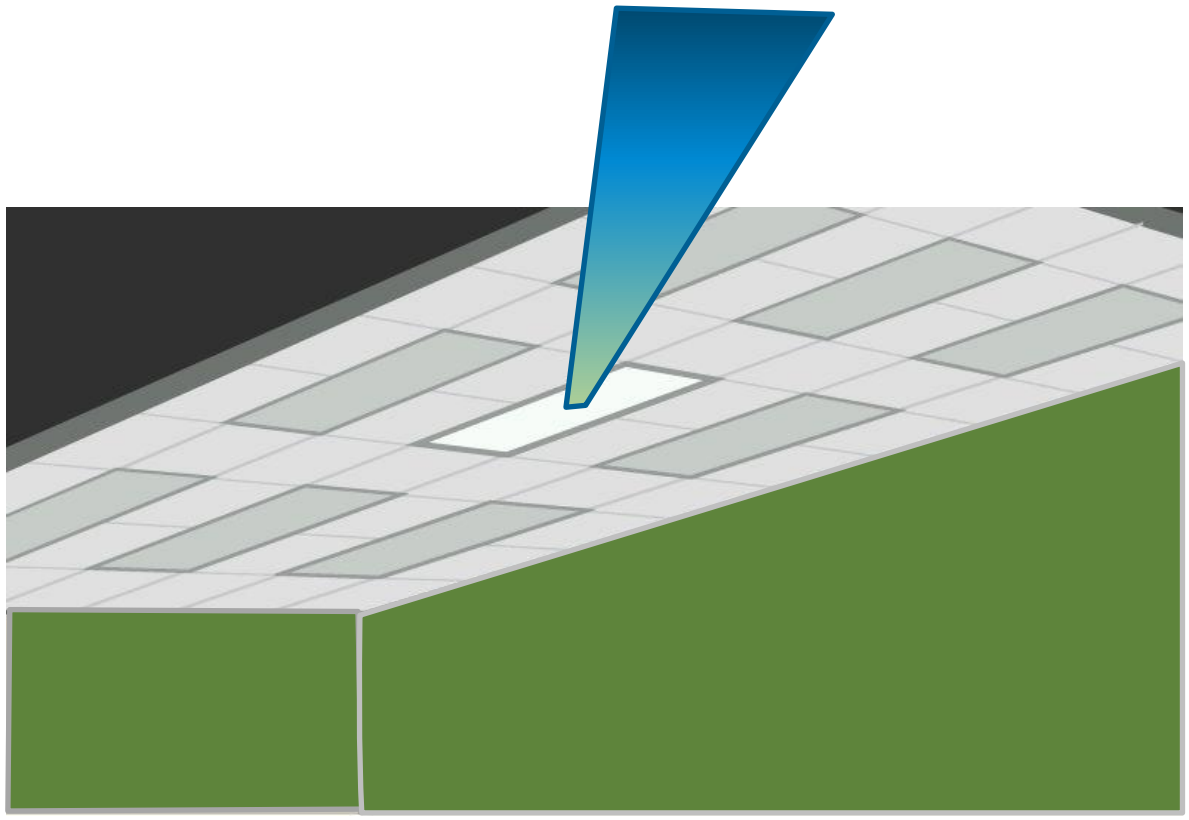
- Automatic
  - Neighbor detection
    - Light sensors
    - RF signal strength

Error Prone:
80%-90% accuracy is not good enough

- Hybrid
  - Automated start
  - Easy manual correction

Best

# Configuration data



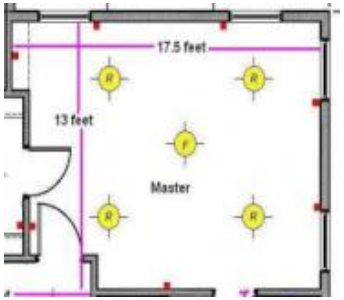
Low bandwidth… perfect “aim”

# Sensor Technology for Configuration

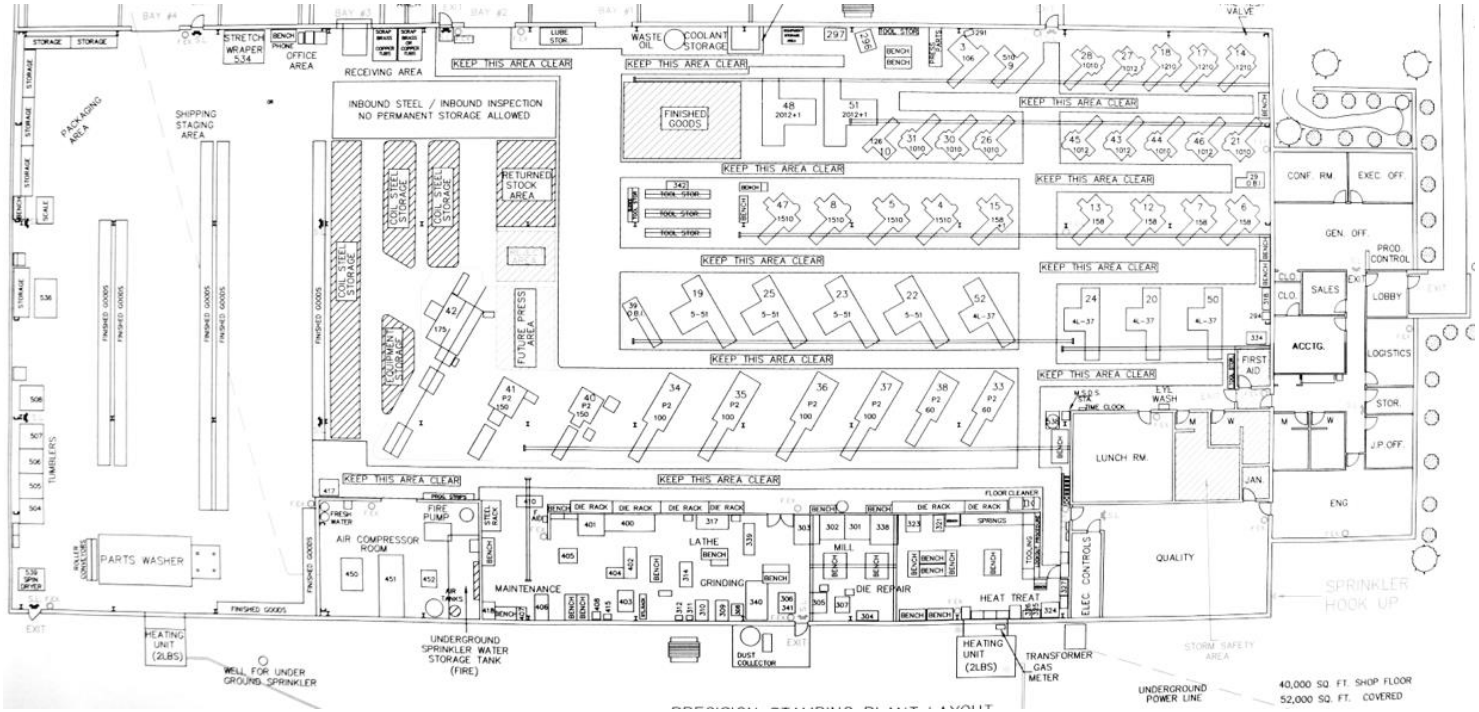
| Technology | Bandwidth | Aim |
|---|---|---|
| Light level | Low | Low |
| BLE or WiFi | High | Low |
| VLC | High | Low |
| VLC w/ beaconing | High | High |
| Laser | Low | High |
| Image sensor | High | High |

# Scaling

- From demo




- to



# Paradigm Shift #4

IoT

# Internet of Things

- Sensors are at the heart of IoT
- Sensor/fixture integration can lead to rich data
  - Light
  - Energy use
  - Thermal
  - Occupancy patterns
  - Space utilization
  - Thermal
  - New control concepts
    - Dynamic control
    - Personalized response
    - Color

# What do we need?

- ✓ Standards
  - Communication
    - Networking
    - Bandwidth management
  - Application
    - Settings – common language
    - Control Behavior
- ✓ Sensor Research
  - Low-cost sensors
  - Image sensing/processing