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Designers Light Forum

Mixed Signals: Animating lighting with different protocols

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

At the end of the this course, participants will be able to:

1. Track the shift of lighting controls from stage to architecture.
2. Distinguish between controls protocols, focusing on mesh networks.
3. Assess whether an application has critical latency requirements.
4. Detail the advantages and potential disadvantages of wireless controls.
5. Evaluate impact of building materials on RF signal strength.

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Animating lighting with different protocols

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Panelists:

Ted Case-Hayes
Director Interactive Electronics
RAB Lighting

Chuck Cameron
Lighting Controls Manager
Stan Deutsch Associates (SDA)

Shaun Fillion, LC
Program Director | MPS-L Lighting Design
New York School of Interior Design

Jeff Hoenig
Associate Lighting Designer
Cline Bettridge Bernstein Lighting Design (CBBLD)

The Lighting Cue

Theatrical roots, architectural trends

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Spring Awakening, 2007 Tony Awards

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Page	Cue #	Line/Action	Description	Time	Notes
3	**1**		Preset		
	HH		House to half		
	10		Blackout, house out	5	
	15		Lights up	2.5	
9	**20**	Fav leaves	Isolate on Tim/Scott	7	
10	**25**	Scott starts to sing	Add color	5	
13	**30**	Sound cue	XF to transition	12	
	35	Guys settle into bed	Blackout	3	
14	**40**	Fav/Farah/Haidar enter	Lights up	4	
15	**45**	Fav turns on desk lamp	Add Favoriti's desk	0	
17	**50**	Fav leaves (or goes to his desk)	Isolate on Haidar/Farah	10	
19	**55**	Haidar starts to pray	Focus on Hadair	8	
	60	Hadair finishes praying	Blackout	5	
20	**65**	Scott/Tim enter	Lights up	8	
24	**70**	Fav enters	Add Favoriti's desk	7	
25	**75**	Scott/Tim leave	Take down DS area	9	
33	**80**	Scott/Tim go to their beds	Bring up DS area	7	
35	**85**	Scott starts to sing	Add color	5	
	90	Tim: "Lady!"	Take out color	5	
37	**95**	With sound cue	Daymare	0	Follow 7
	100	AUTFOLLOW	Return	12	
40	**110**	Scott starts to sing	Add color	5	
	115	Scott finishes his song	Take out color	5	
43	**120**	After Scott: "…gonna forget - never!"	XF to transition	9	
44	**125**	Fav goes to his desk	Dictation light	4	
	150	After Fav: "…dictation on Reilly, Tim."	Add color	7	
45	**155**	Scott finishes his song	Take out color	5	
51	**160**	Scott/Fav go to Fav's desk	Tighten on Fav's desk	12	
53	**165**	Scott/Tim go to their beds	Open up entire stage	7	

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Empire State Building

New York, NY

https://www.youtube.com/watch?v=vqRPD_45q_E

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Empire State Building

New York, NY

https://www.youtube.com/watch?v=vqRPD_45q_E

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Spark

Choreographer: Erin Reck

Torque Dance

Dancenow Mainevent, John Jay College Theater

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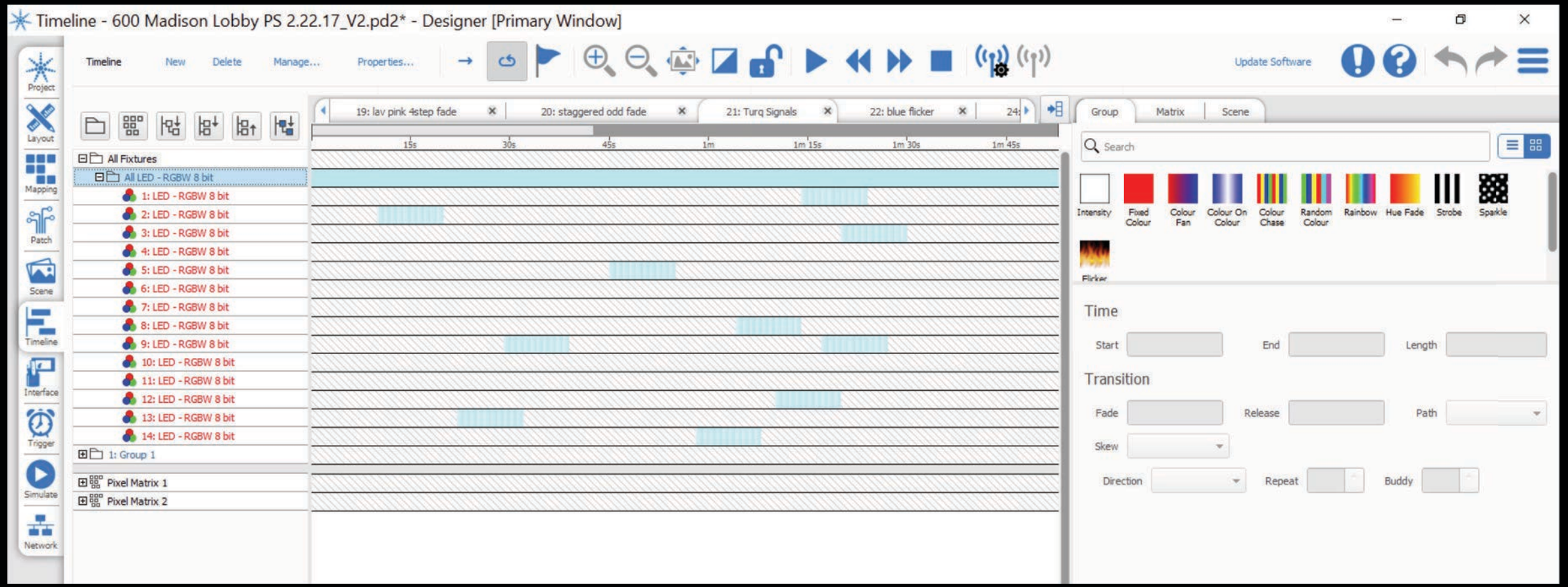

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Control System Quandaries

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Video Control

2.1 Million Pixels
(1920x1080x 3 colors)
=6.3 Million Addresses
>50 Hz Refresh Rate
No wireless

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Video Control in Action

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DMX Control

- Theatrical Standard
- 8 bits / address = 256 levels
- 512 addresses / universe or data stream (170 pixels)
- 256 levels x 3 colors = 16.7 Million Colors
- Update 22.7 to 44 times per second (Film is 24 fps)
- Ethernet can be used to transmit multiple universes
- Wireless is possible
  - Using Wi-Fi band
  - Good quality systems keep latency to under 10ms

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Alternate control strategies

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Mesh Networks 101

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hi, i’m tedbot

- product architect at lightcloud

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what is zigbee?

- A wireless mesh-networking protocol
- Specifies the PHY, MAC and NWK layers
- 2.4 ghz
- Built on 802.15.4

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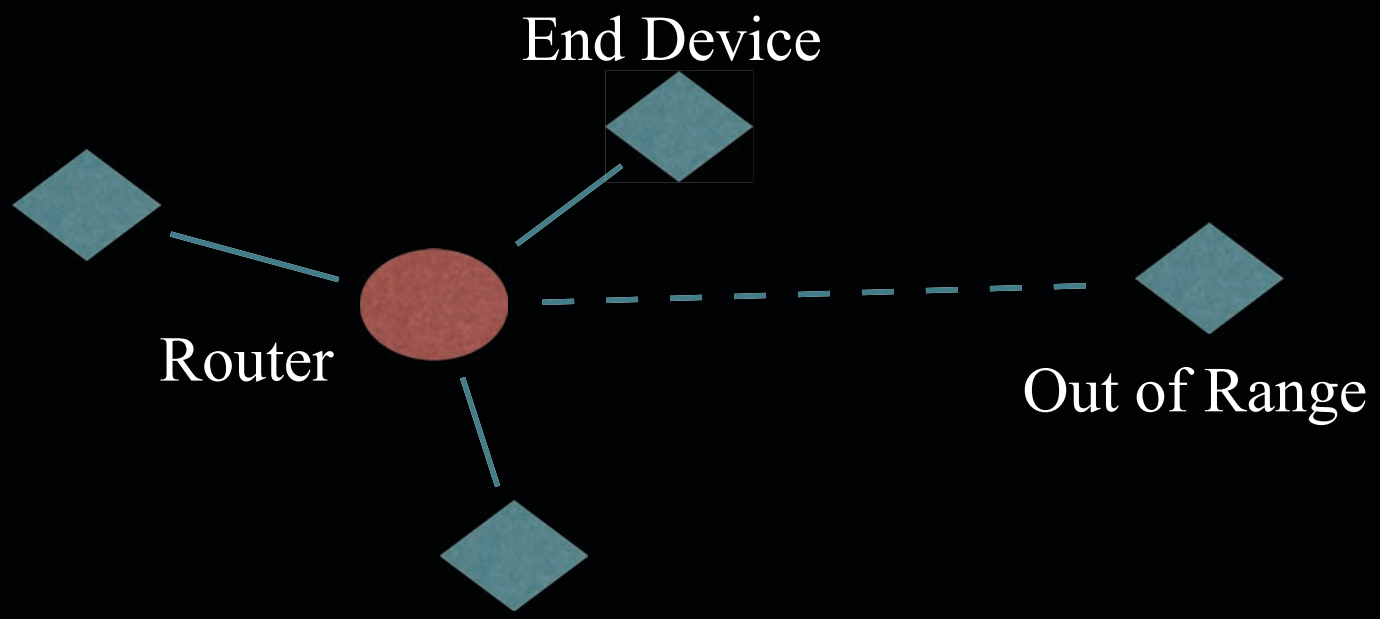
star topology



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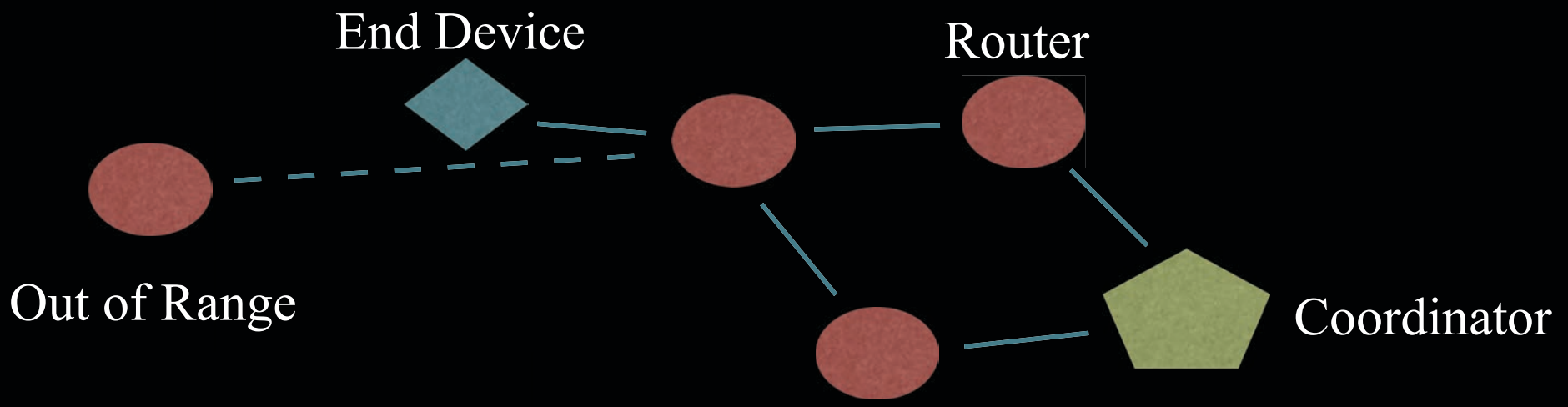
let's mesh



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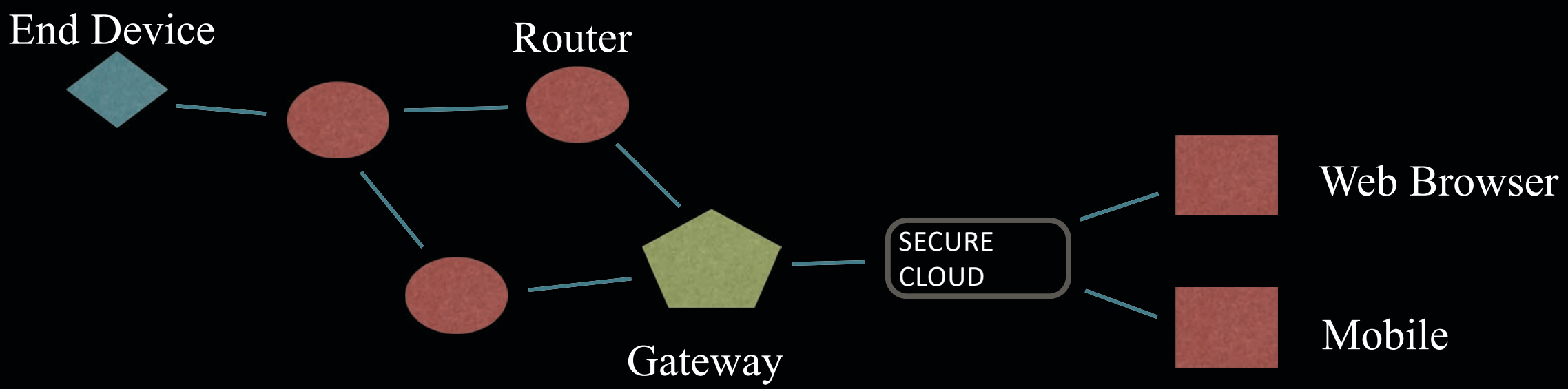
lightcloud



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Benefits

- Short- to Medium- to Long-range*
- Low Power
- Meshing
- No new wiring!

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Caveats

- Low-bandwidth
- Variable latency

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Range

- Anywhere from 25-250 feet with typical obstructions
- Transmitter power level
- Avoid metal and dense, solid materials like brick & concrete
- Mesh around obstructions if necessary
- 900mhz can go potentially much farther - more expensive
- Fresnel Zone

LEDucation® Latency

- The time between request and response
- Wired (point-to-point) systems have lowest possible latency - the speed of light!
- Traversing each node in a mesh adds time
  - Plus more if encrypted
- Retransmissions - RF interference is a given
- Latency can be highly variable

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thanks!

@t3db0t

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Controls by Intent

Choosing the right controls protocol for your design

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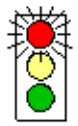
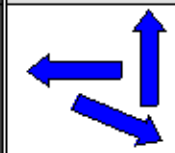
OSI MODEL		
7		**Application Layer** Type of communication: E-mail, file transfer, client/server.
6		**Presentation Layer** Encryption, data conversion: ASCII to EBCDIC, BCD to binary, etc.
5		**Session Layer** Starts, stops session. Maintains order.
4		**Transport Layer** Ensures delivery of entire file or message.
3		**Network Layer** Routes data to different LANs and WANs based on network address.
2		**Data Link (MAC) Layer** Transmits packets from node to node based on station address.
1		**Physical Layer** Electrical signals and cabling.

Open Systems Interconnection

(OSI Model)

Conceptual model that outlines digital communication functions irrespective of the technology or internal structure.

Developed by International Standards Organization (IS) in 1984.

https://www.pcmag.com/encyclopedia/term/45246/internet-protocol

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Huge installation base, most devices have a WiFi antenna

Star Topology requires a central router – single point of failure.

Fast data transfer, 100 Mbps+ (overkill for most IoT functions)

Syncing new devices with the network is complex.

WiFi doesn't define an application layer, so interoperability between devices isn't ensured without additional layers.

WiFi HaLow improves efficiency, but still uses star topology.

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1,300 certified devices, 35M in circulation, primarily used in the residential market.

Mesh topology, source based routing, 4 hop limit to messages.

Up to 232 nodes in a network.

Slowest data transfer, 9.6, 40 or 100 kbit/s. Significant latency.

Does not self-heal, the mesh needs to be reconfigured if a node is lost. This can lead to lapses in operability for an hour.

Z-Wave defines an application layer, reinforced over a decade – interoperability is solid and backwards compatible.

Z-Wave needs a hub for connection with Smartphones.

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Install base is in commercial market, with some residential, good market penetration growth since 2004.

Mesh topology, destination based routing, ZigBee network can detect changed locations for controllers and self-heal.

Up to 65,000 nodes in a network, 10-20M indoors makes it scalable for large commercial applications.

Uses IEEE 802.15.4 used for data transport, 250 kbit/s. However destination routing can produce clogs, resulting in latency.

Multicasting allows a single transmission to target multiple nodes, but only 9 messages can be sent in 9 seconds. Can cause further delays in complex systems.

Application profiles include ZigBee Light Link, ZHA, etc. but proprietary applications can also be built. ZigBee 3.0 intended to unify the applications to solve cross-vendor communication.

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Installed in cell phones, computers, deep base like WiFi.

Bluetooth Classic was short range, but Bluetooth Smart intro'd in 2010, intended for low power smart devices. Star Topology.

Bluetooth 5.0 (2017) adds mesh topology capabilities.

Transfer rate of 1 Mbit/s. Coupled with compact packets, 2,500 messages could be sent per second. 10x faster than ZigBee.

Frequency hopping between 40 channels can avoid interference.

Bluetooth covers Application, Network/Transport and link.

Bluetooth Beacon allows for proximity sensing as well, capable of identifying adjacent Bluetooth radios the vicinity.

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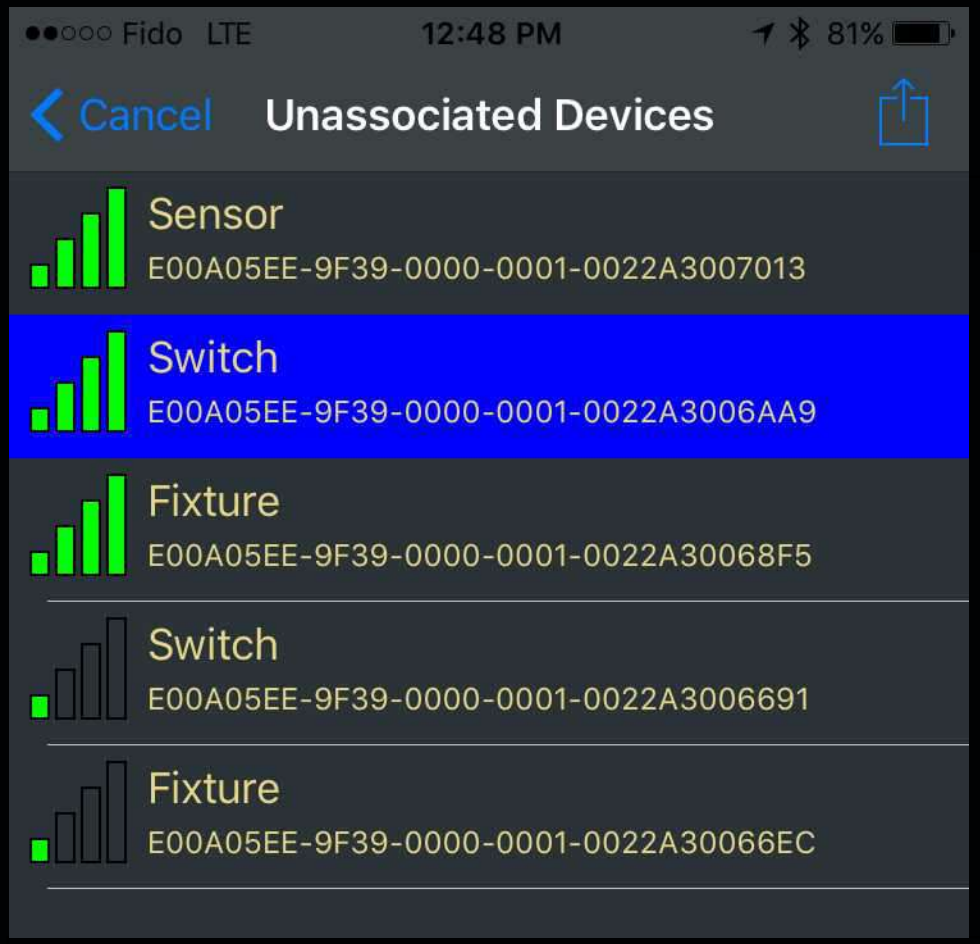

Bluetooth Beacon

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OSI Model	Wi Fi™	Z-WAVE®	zigbee	Bluetooth® 5.0
Application	Needs Ad-Hoc	Z-Wave	ZLL, ZHA, Other	Bluetooth
Network/Transport	TCP/UDP IP	Z-Wave	ZigBee	Bluetooth
Physical/Link	IEEE 802.11x	Z-Wave	IEEE 802.15.4	Bluetooth
Topology	Star Topology	Mesh Source	Mesh Destination	Mesh Mapped
Range	50 FT	4 hops, 50M each	10-20M	100M Line of Sight
Scalability	Can link hubs	232 nodes	65,000 nodes	Can link clusters
Interoperability	Needs Ad-Hoc	Strong, Backwards compatible.	ZLL, ZHA, Proprietary ZigBee 3.0 will consolidate	Nodes need mapping
Latency	Very Little	High	4 ms	0.4 ms
Bandwidth	100 Mbps+	9-40 Kbps	250 Kbps	2 Mbps
Power Consumed	Power-hungry	Very Low	Low	Very Low
Installation Base	PCs and Phones	35M, Smart Home	Commercial	PCs and Phones
Beacon				Proximity Sensing

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Lessons Learned

Practical tips on mesh network applications


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COLLEGE

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NAZARETH COLLEGE

Issues

- Shrubs, trees and hills look nice
- Weather
- Concrete basement walls
- Trying to turn a corner, wall material
- Installing Controllers in clusters of electrical cabinets
- Equipment surrounding the Controller
- Controller signal blocked by metal pole
- 5pm communication loss
- Controller installed on “Load Side” of time clock

Solutions

- Added Gateways
- Removed time clocks from controller circuits
- Add repeaters to get multi path mesh networks
- Repositioned repeaters

Slide graphics and info courtesy of RAB Lighting

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NAZARETH COLLEGE

Lessons Learned

- Think of RF as a beam of light - a directional beam.
- Be very careful using one Gateway for multiple buildings.
- Understand pathways and line of sight - indoors and out.
- To avoid foliage-related issues, place Controllers on the tops of roofs.
- Know the complete circuit. Eg. Don’t put devices downstream of a time clock.

Slide graphics and info courtesy of RAB Lighting


NISSAN
Lexington Park
NISSAN
Service
Express
Service

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Issues

- Gateway inside a metal enclosure
- Controllers outside on poles

Solutions

- Place Gateway in line of site of poles
- Place repeater outside building

Lessons Learned

- Don’t put Gateways in metal boxes.
- Create lines of sight, preferably two.
- Place repeaters outside buildings.

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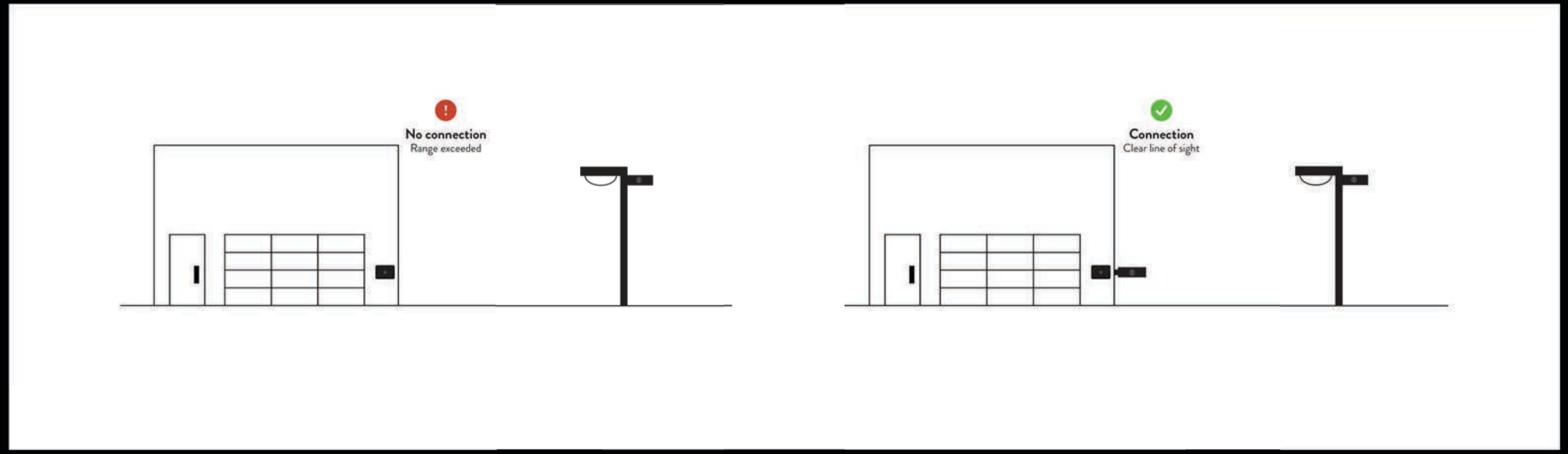

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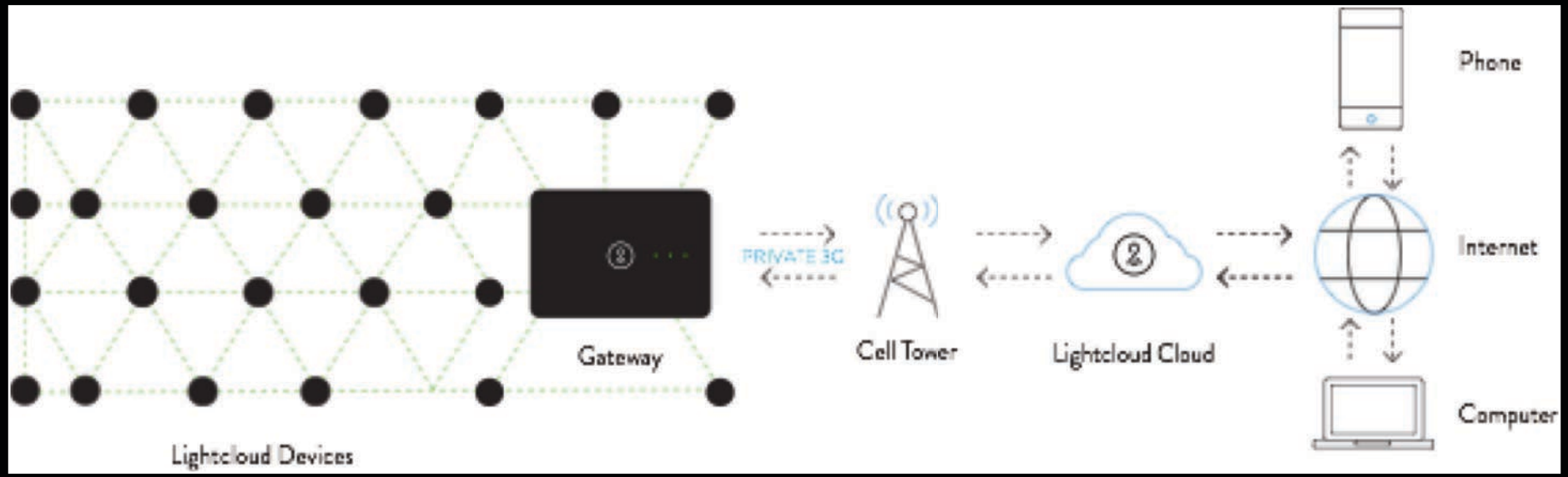
Lightcloud Operates on Two Networks



Mesh

Private Cellular

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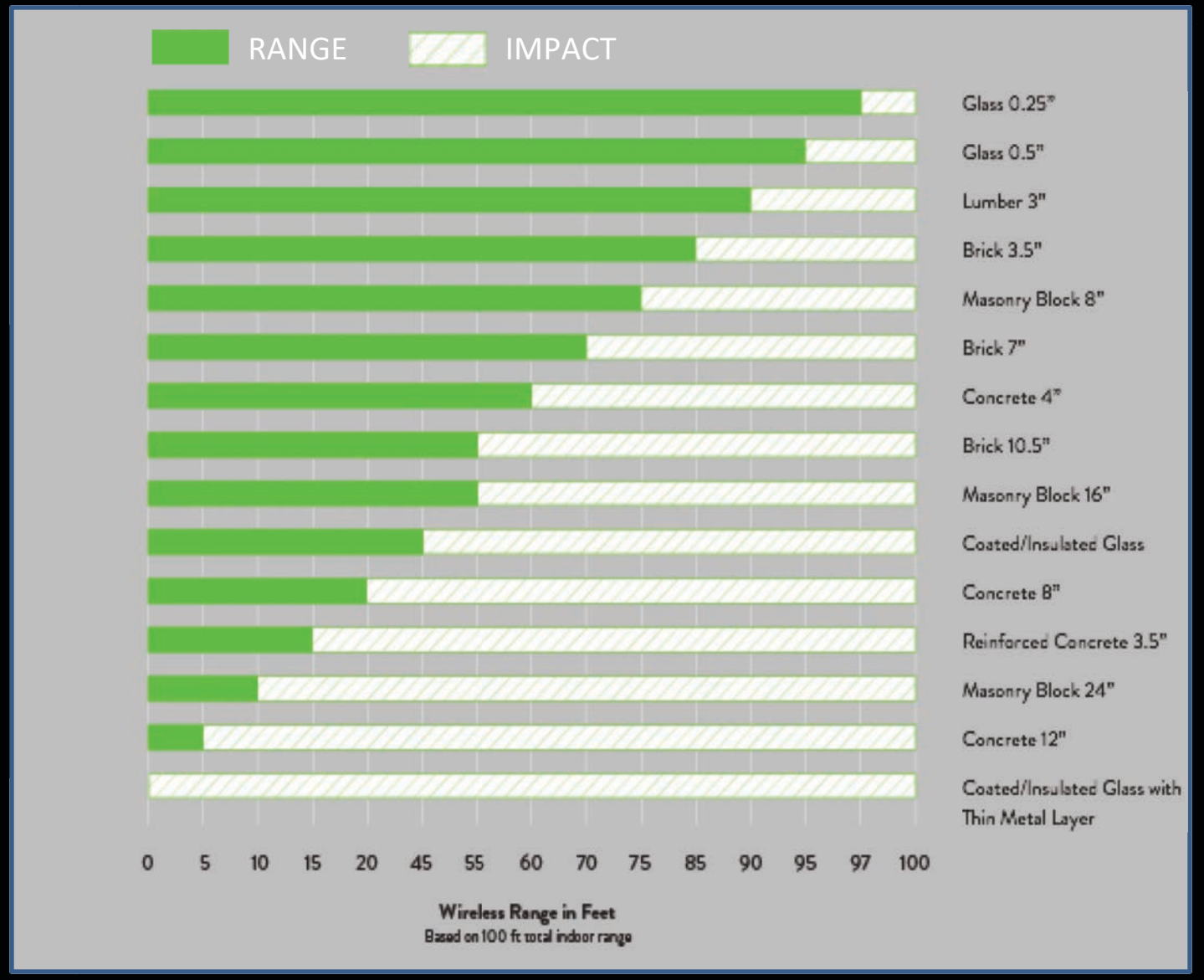
Wireless Range Through Building Materials



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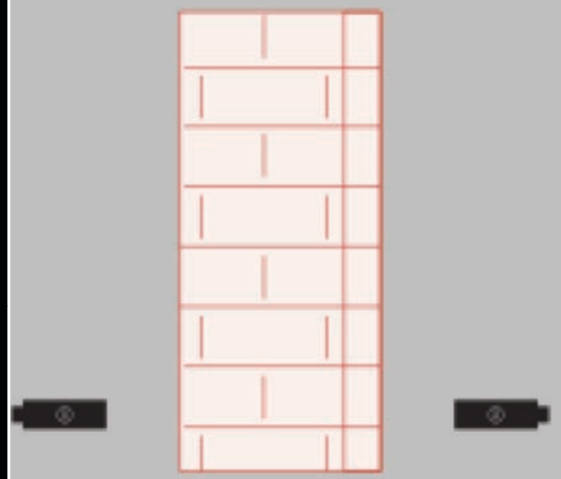
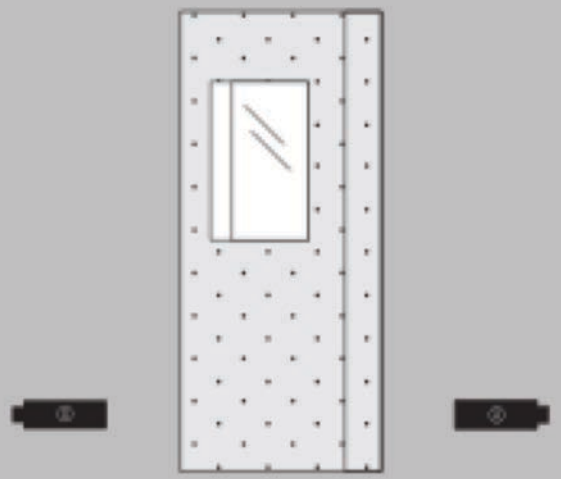
Brick Walls & Concrete Wall



Less than 85ft

Two Devices are separated by a 3.5"-thick brick wall: 100' - 15' = 85'. Don't place these devices farther than 85' apart.

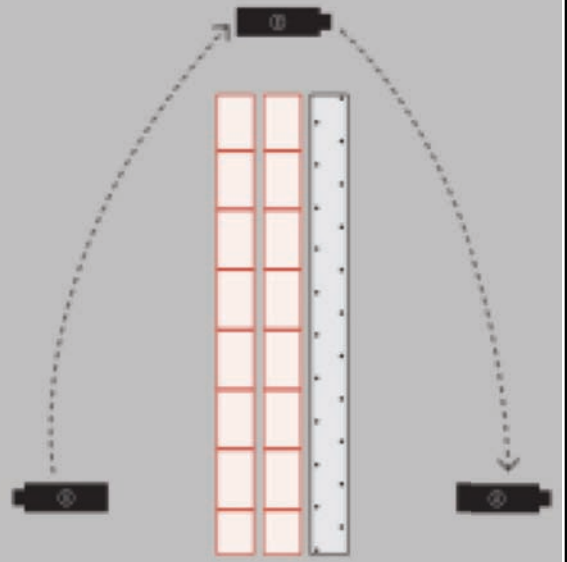
Concrete Wall & Glass Window



Less than 57ft

Two Devices are separated by a 4"-thick concrete wall and glass window: 100ft - 40ft - 3ft = 57ft. Don't place these devices farther than 57ft apart.

Brick Wall



Introduce additional devices

Two Devices are separated by two 7" brick walls and a 4"-thick concrete wall: 100' - 30' - 30' - 40' = 0'. You will need to introduce additional Devices to route around or through these obstructions.

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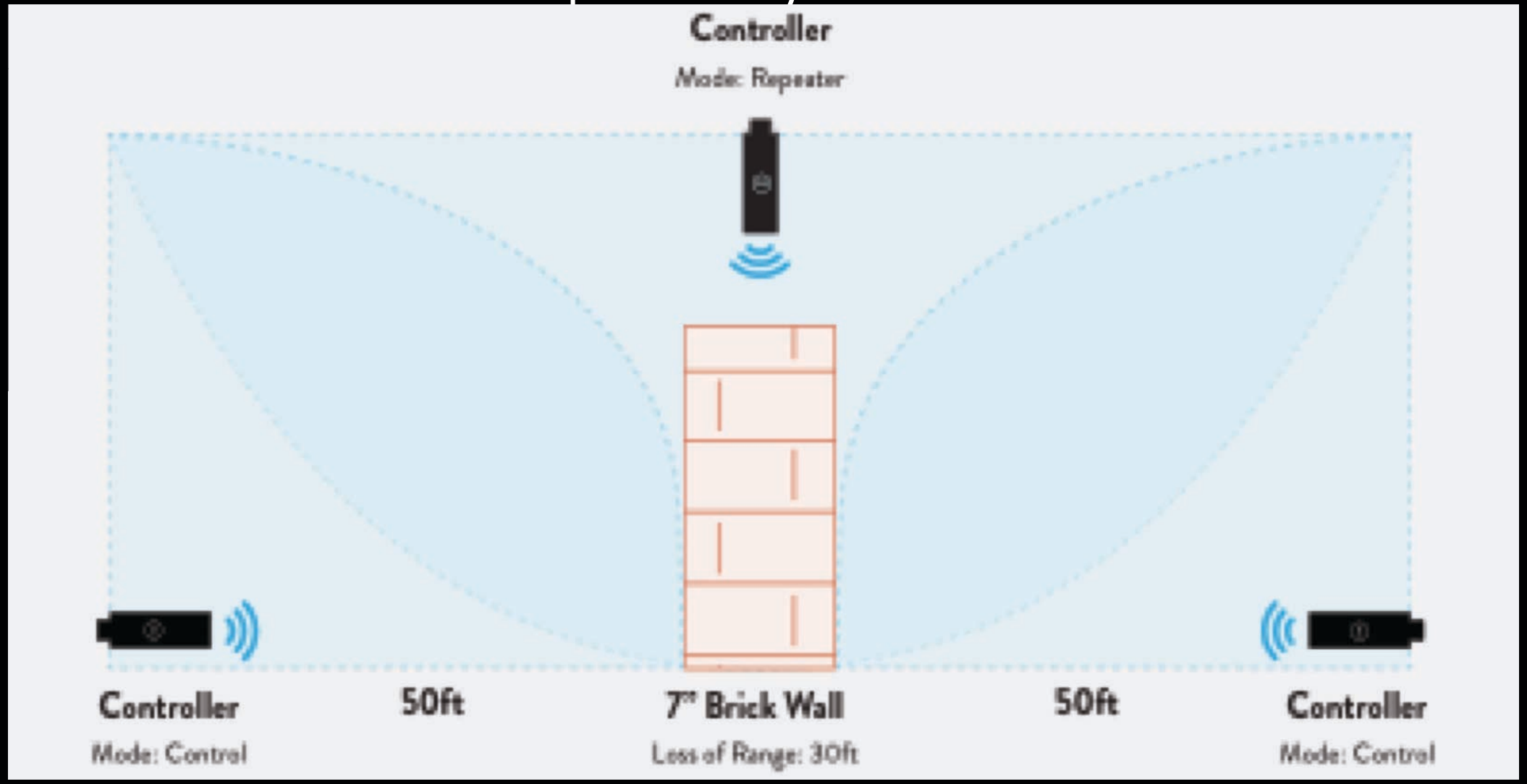
Devices Separated by an Obstruction



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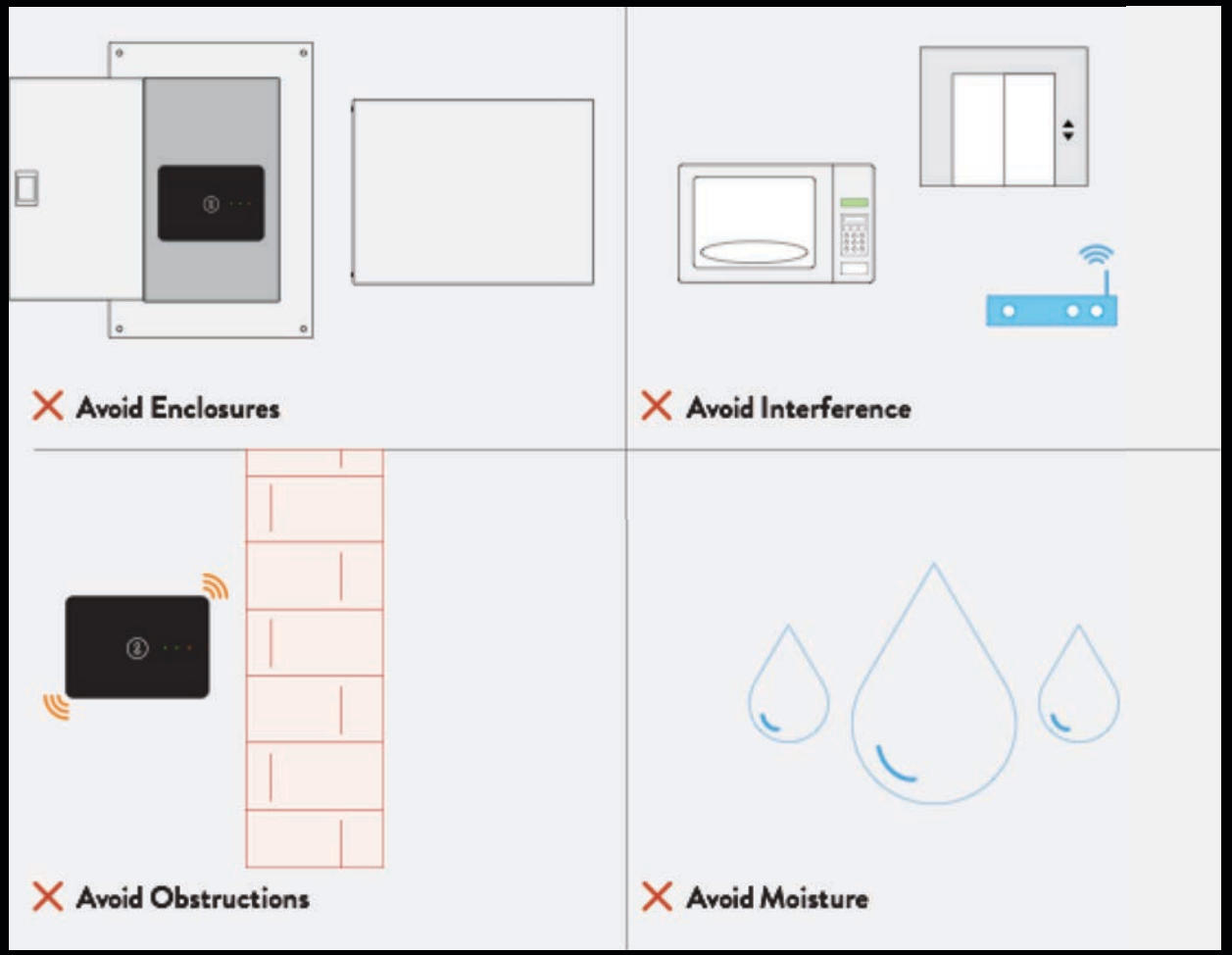
Wireless Network Considerations



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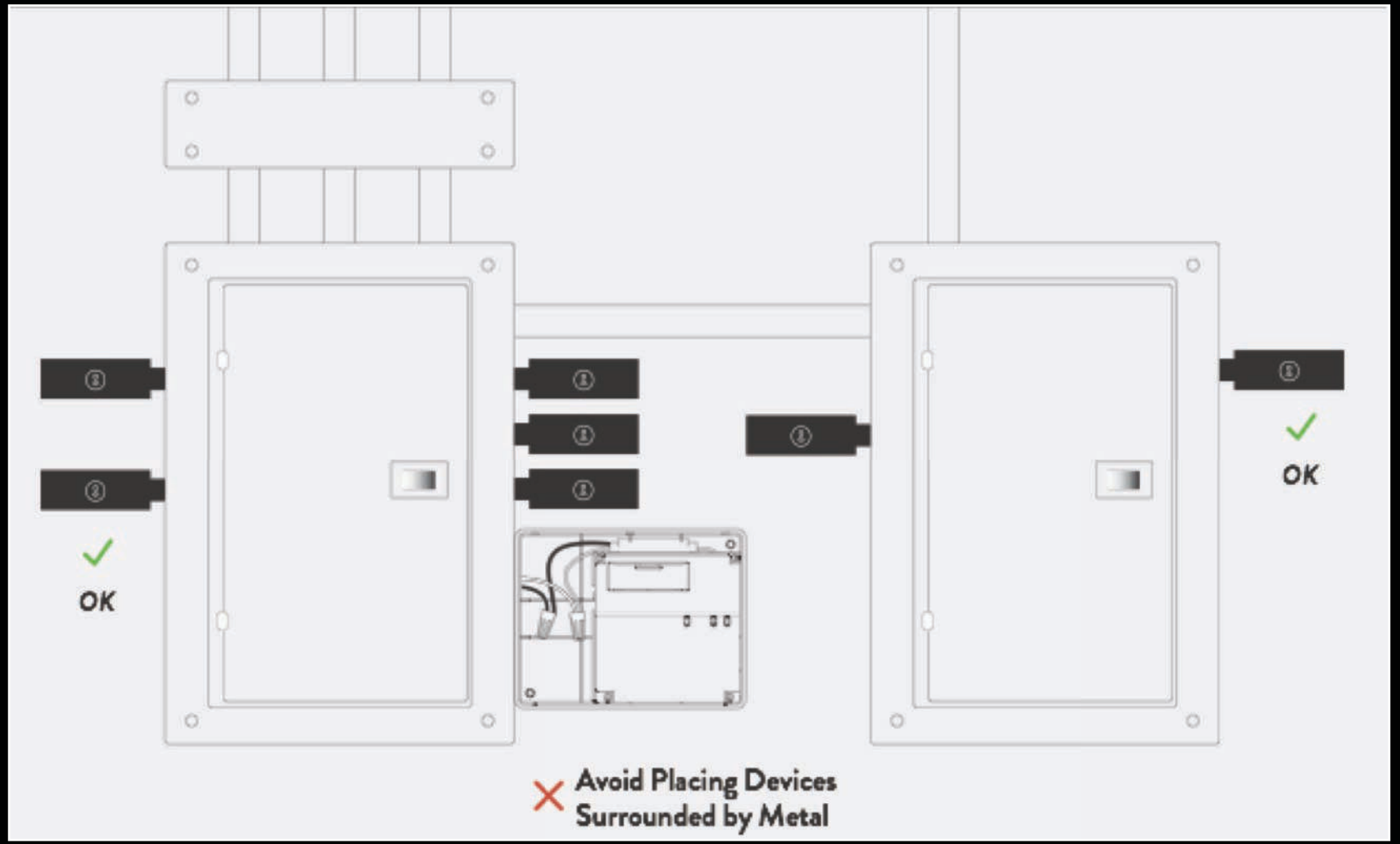
Wireless Network Considerations



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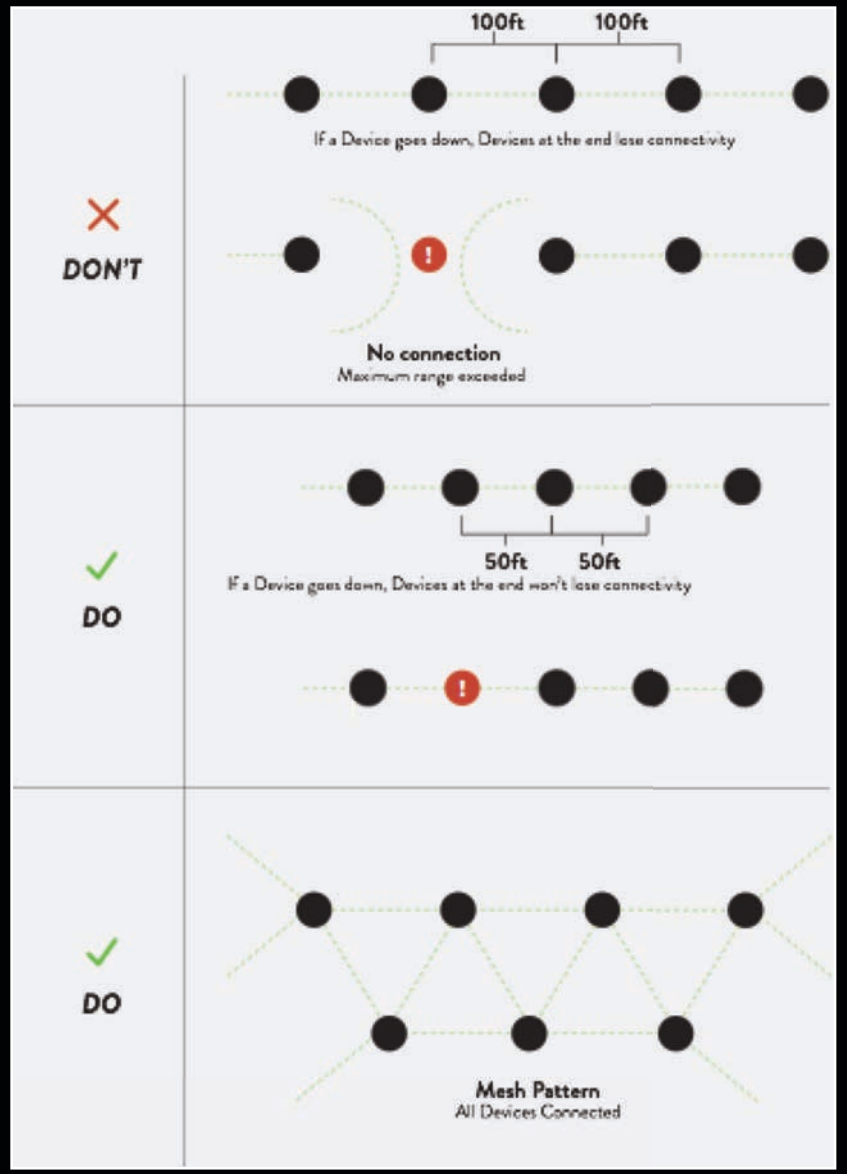
Mesh Network Device Layout



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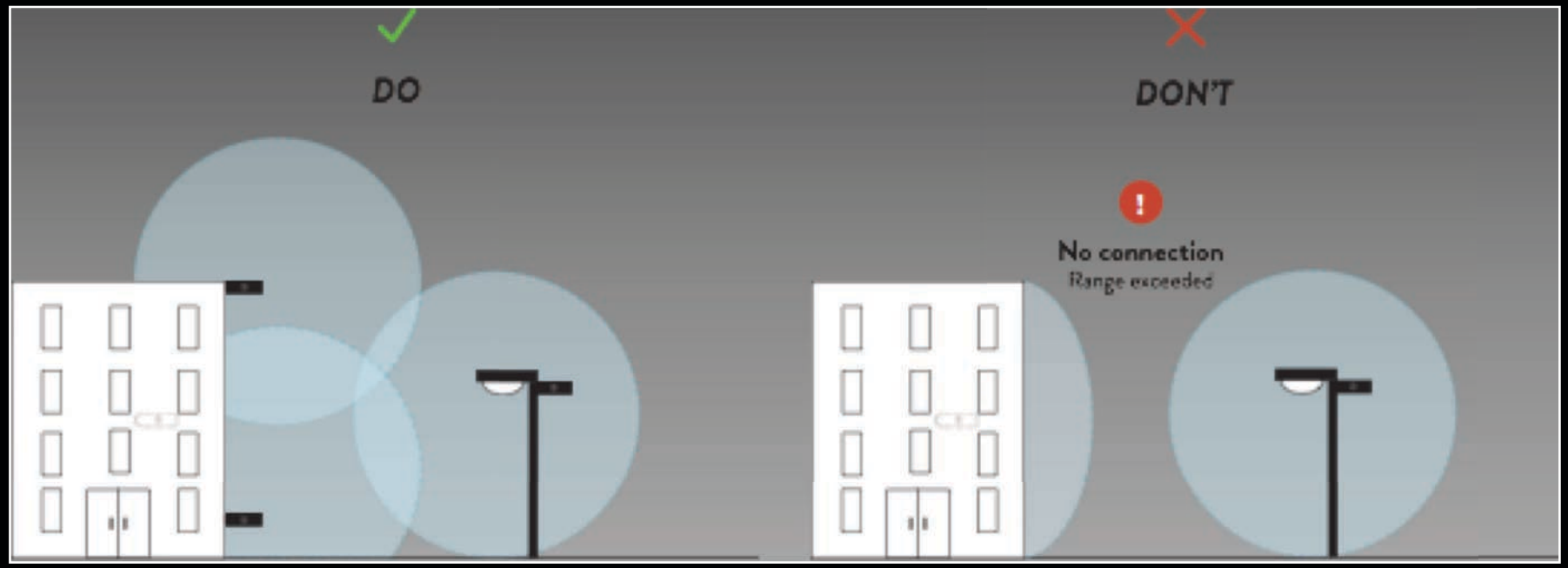
Configuration for a Building and an Outdoor Space



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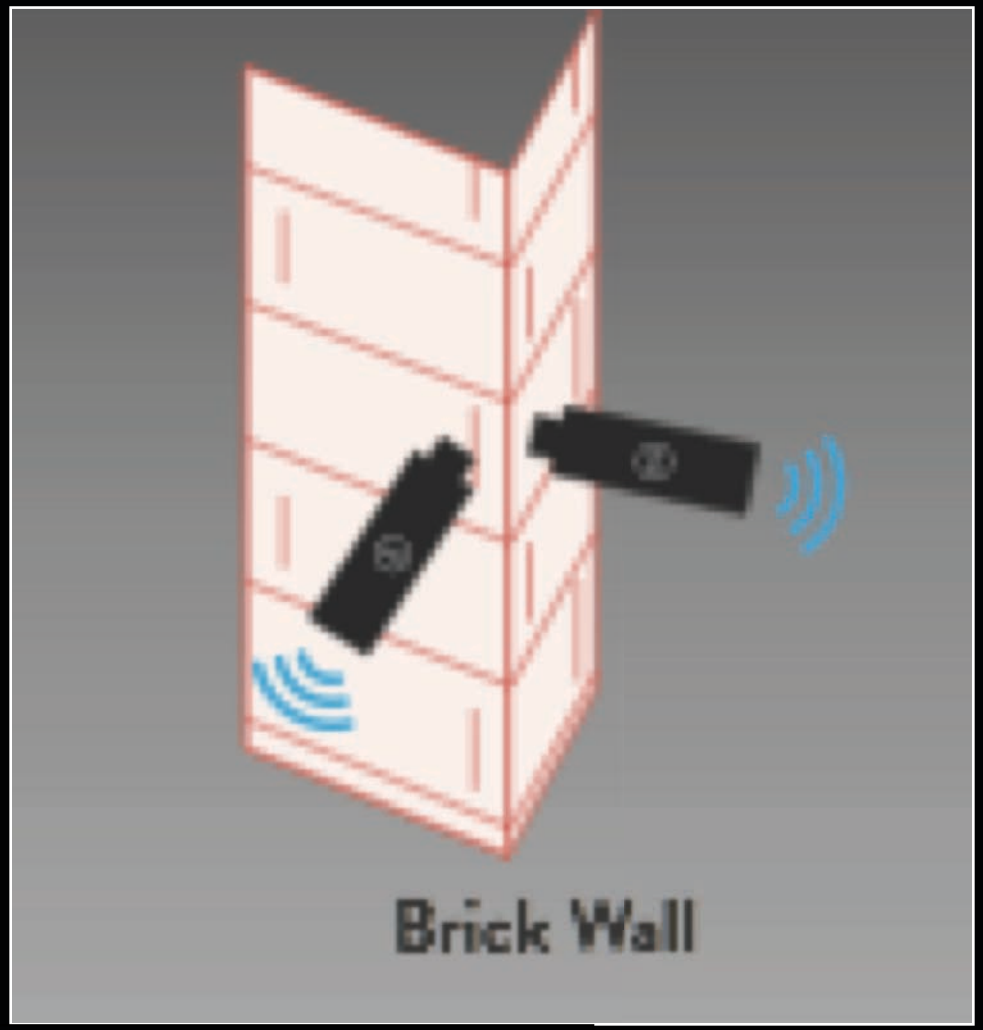
Devices Around Corners



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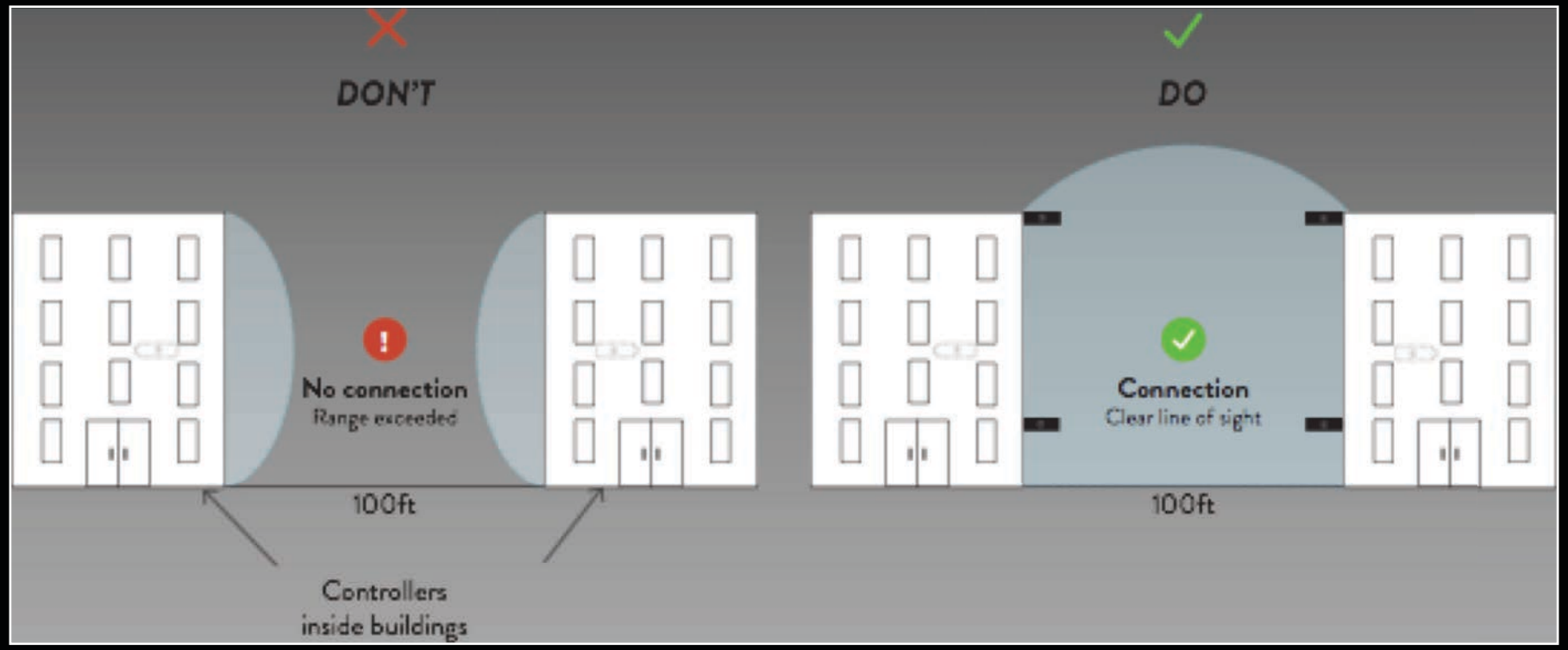
Controller Configuration for Connection Two Buildings



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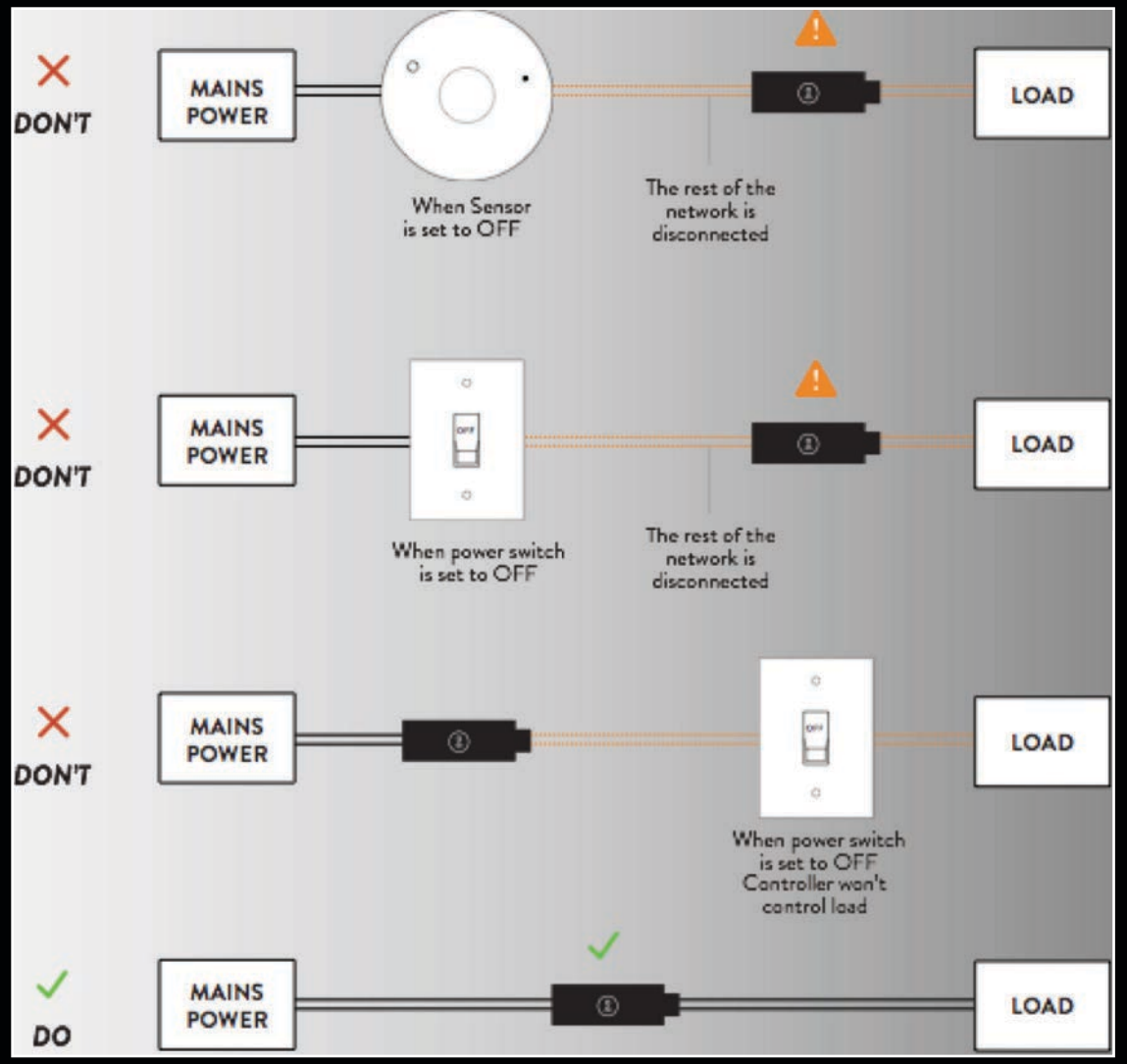
Wireless Mesh Devices Often Require a Constant Hot Feed



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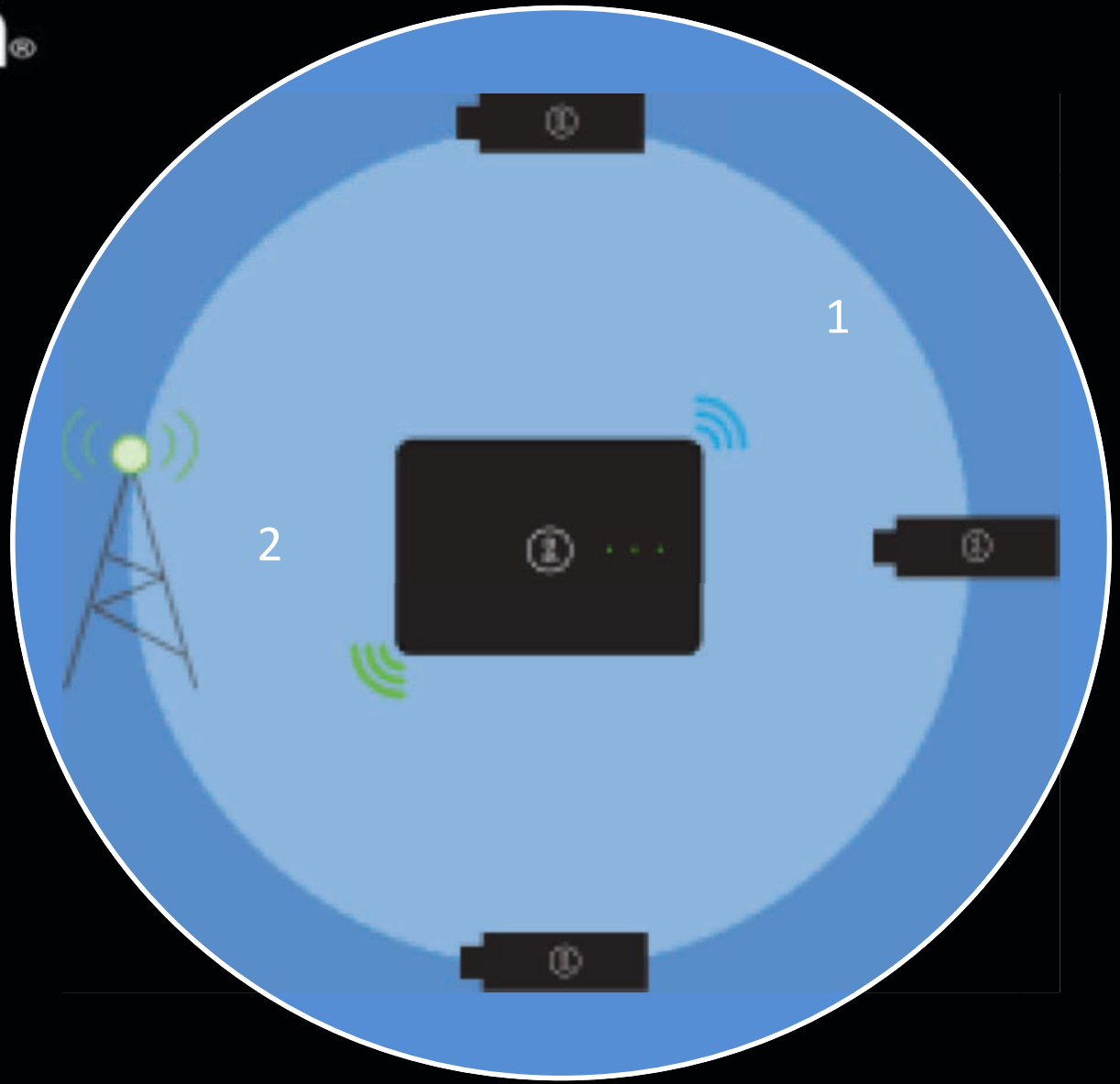
Placing the Gateway

1. Within Range of Mesh Network
2. Within Range of Cellular Network



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Timing is Everything

Repeaters, latency and mixed signals

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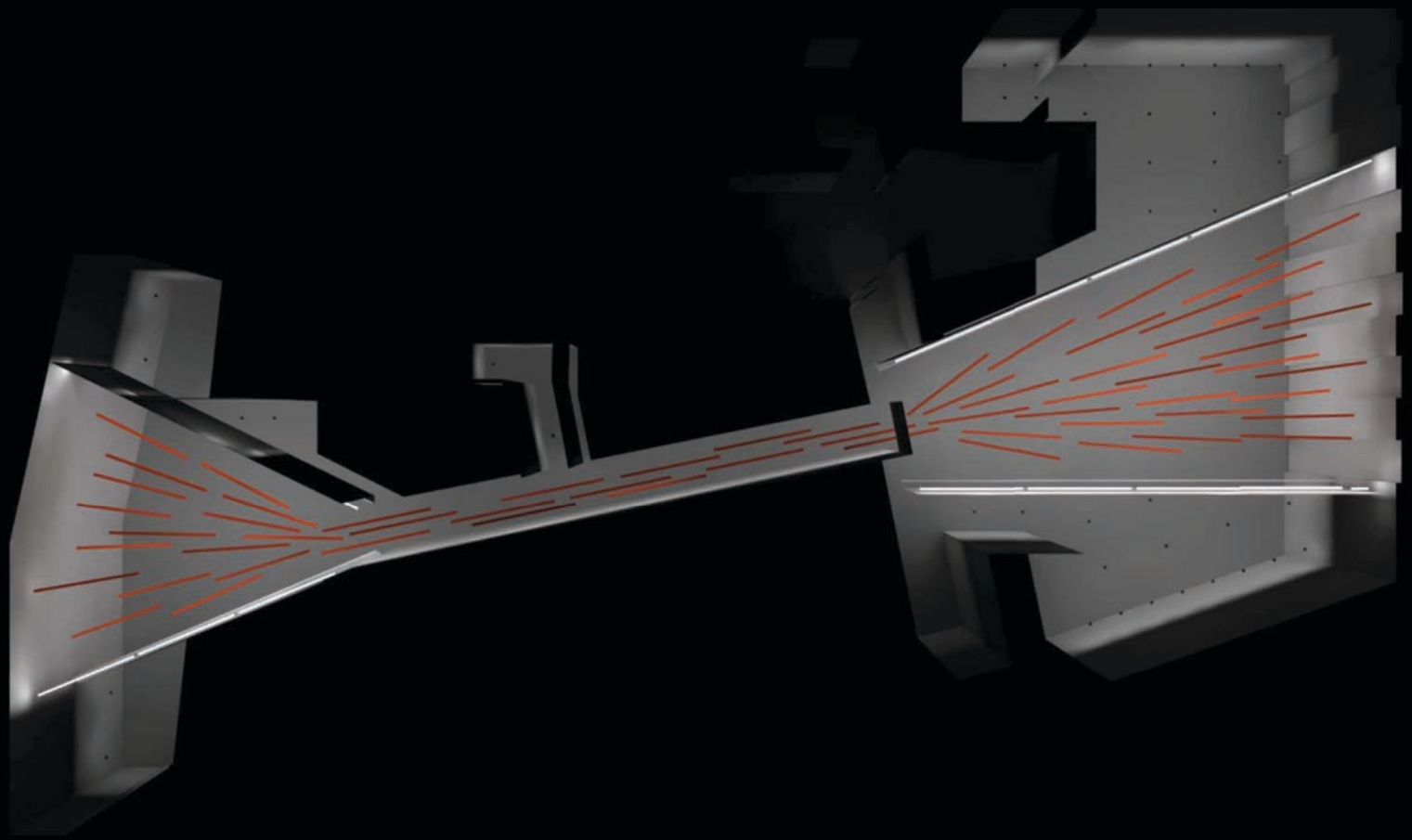
BOA Light Sculpture



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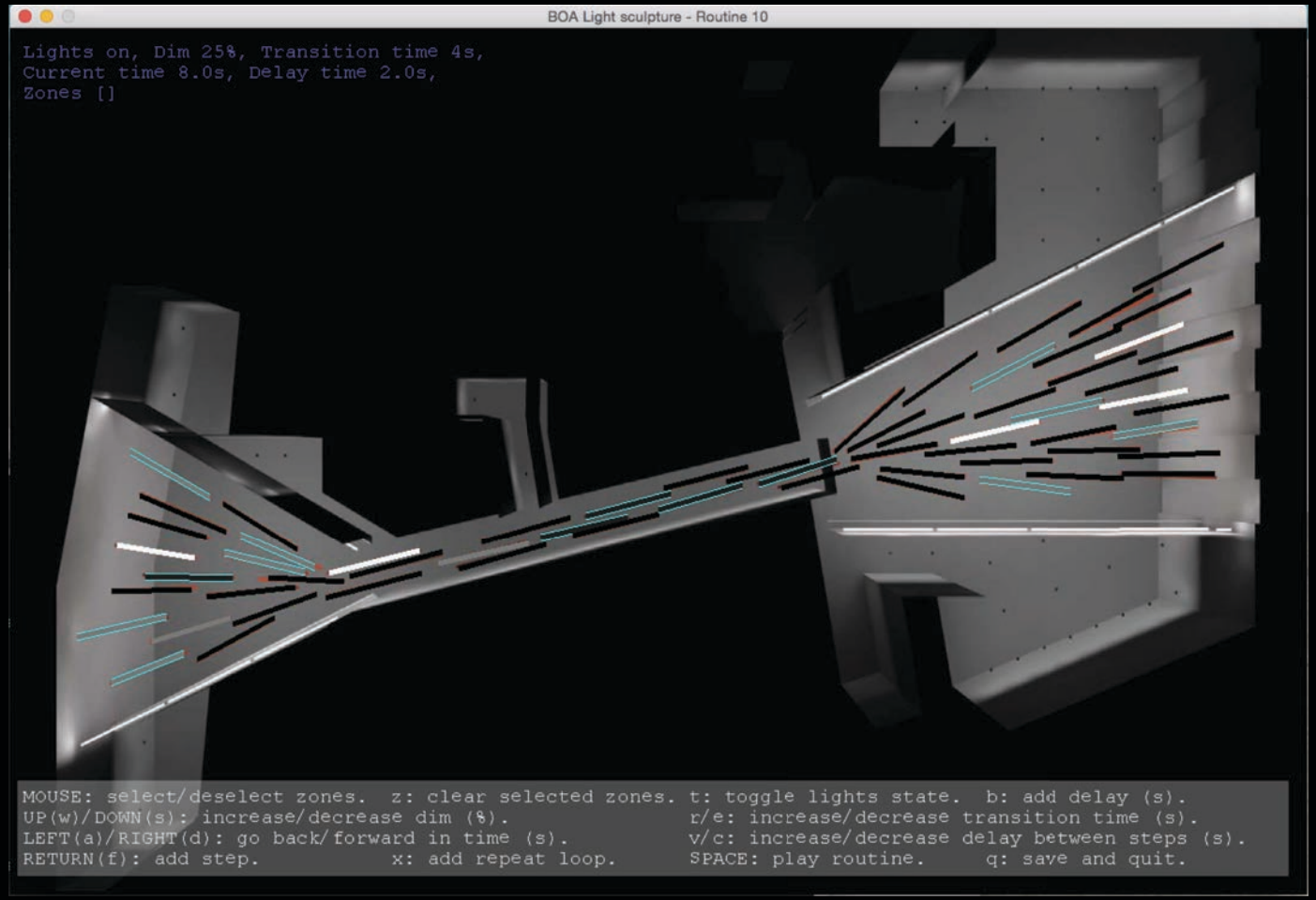

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BOA Light Sculpture Demo

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BOA Light Sculpture Demonstration

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The Peachblossom Fan

Redcat Theater, Los Angeles

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Hotel Eventi Façade

New York, NY

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ON THE CIRA CENTRE

April 5-6, 2014

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Before selecting controls, consider the following:

- What are the design goals for the application?
- What effects must the lighting achieve?
- How critical is the timing of lighting scenes or effects?
- Can the goals be accomplished with a single control system?
- If multiple control systems are needed, should they talk or be isolated?
- HOW TO ADDRESS BAS, OTHER SYSTEMS IN ONE ECOSYSTEM

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Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

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