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Large lighting installations recommendations

Application Note

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0. Introduction

This document aims to support users in the proper configuration of large lighting installations. The recommendations from this document should be used in projects:

- Exhibiting issues with the lighting control functions
- Containing > 200 nodes
- Where the spatial organization of the nodes is at least partially linear (as opposed to a grid)
- Where the distances between individual nodes is large, approx. >60% the maximum radio range of the components
- Utilizing a Gateway and Silvair connected services: Energy / Occupancy monitoring, or Scheduling

1. What is a large lighting installation

A *Large installation* is not necessarily one that physically occupies a big space or has a large number of nodes. It is determined in part by:

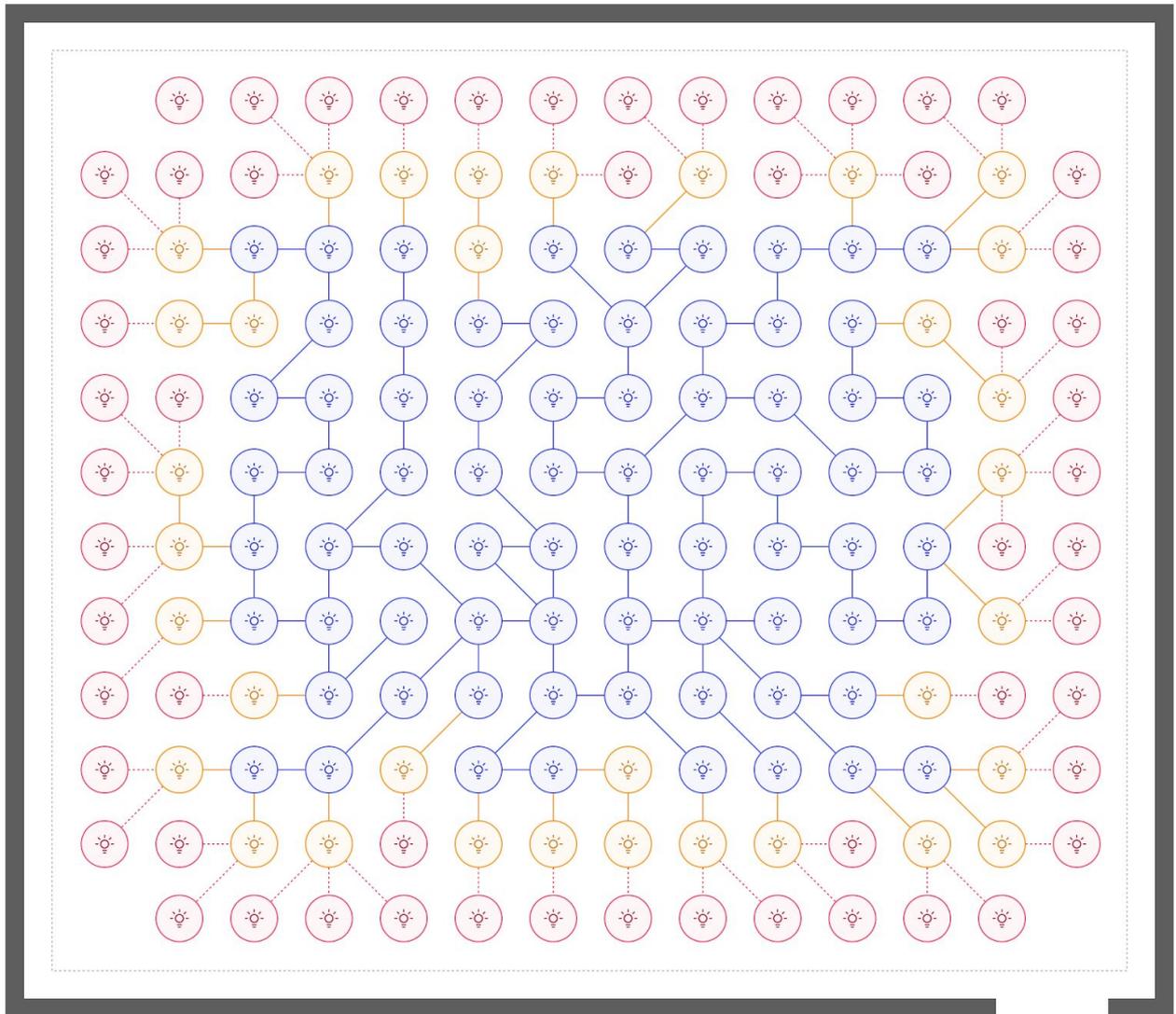
- the number of nodes added to the network,
- the distances between the nodes and their spatial distribution
- the lighting control profiles used in the project.

In general, if you have an installation with nodes not distributed in a grid (linear installation type), or an installation consisting of approximately > 200 nodes, **follow the tips described in this document.**

The performance of a mesh network depends on the complexity of lighting profiles used in the project. For example, for a very simple lighting profile used in the network (e.g. Manual On / Off) the project consisting of more than 200 nodes may work fine, but in the case when more advanced lighting profiles are used (e.g. Occupancy with Daylight Harvesting) such a network is prone to failures.

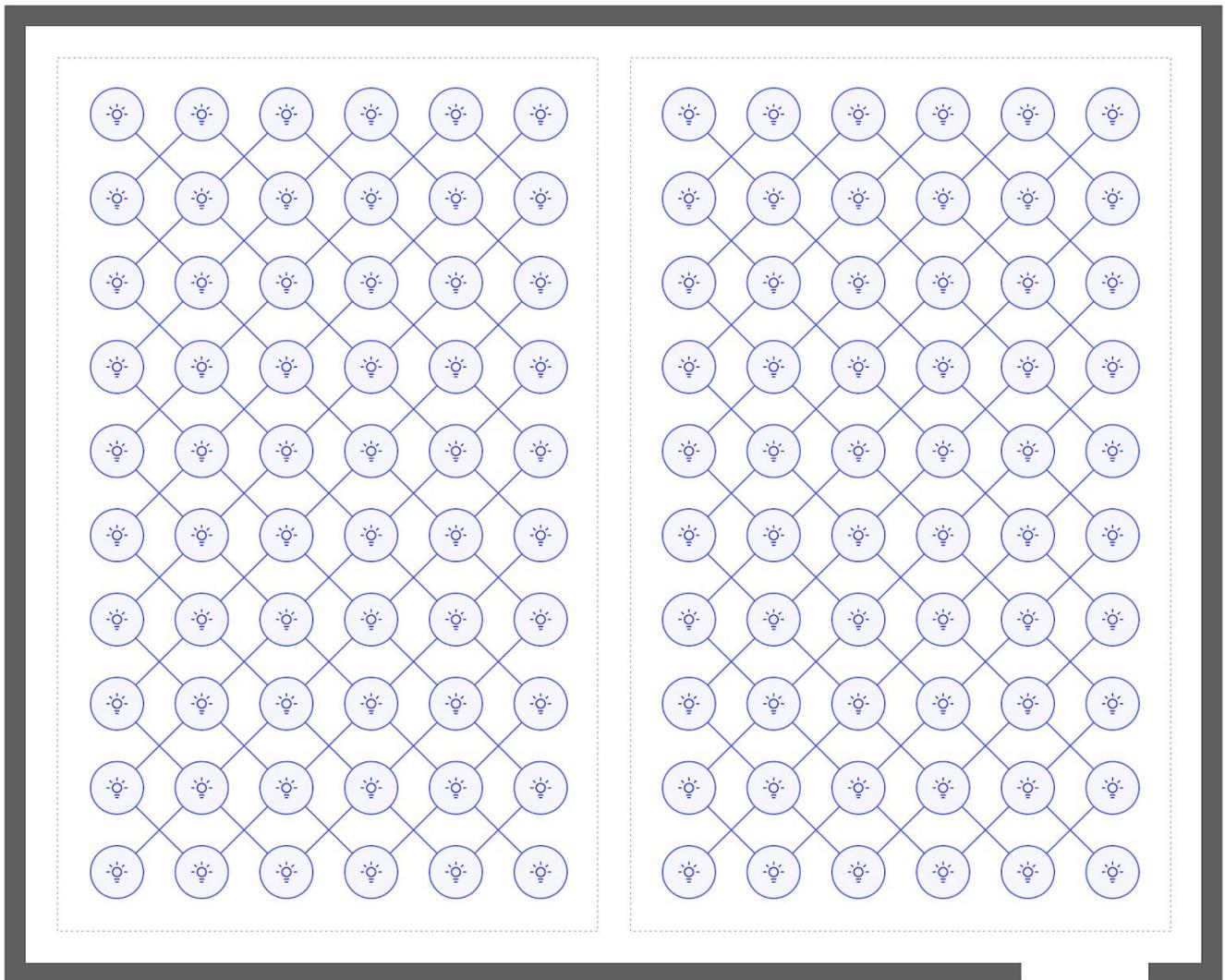
1.1 Installations with large number of nodes

The below image ([img.1](#)) shows a sample view of a large grid-type installation that will experience problems with the delivery of messages between nodes due to the large amount of network traffic. This installation has not been divided into separate *areas*. The red devices indicate nodes that have issues with receiving mesh messages.



Img.1 A large grid installation with no areas (subnets)

The image below ([img.2](#)) shows the installation from [img.1](#) split into two *areas* (which will divide the network into two subnets). The message delivery rate is substantially improved by the separation of the nodes in the network into two areas.



Img.2 A grid installation divided in two areas (subnets)

2. What are subnets and why are they important?

To lower the traffic in a large network, Silvair uses [subnets mechanism](#) that allows to make large installations highly effective. Subnets logically separate traffic of messages between nodes. This is achieved by dividing a large network into smaller units that can easily handle the number of mesh messages and their repetitions in one area. The subnets mechanism cuts the number of Relays and reduces the range of mesh messages only to the designated area. The number of mesh messages sent by a node does not change.

To grasp the idea of potential issues occurring in large installations, you need to consider the Bluetooth mesh operation mechanism. A sample single network of 400 nodes is working: the nodes constantly send and receive mesh messages, Relay nodes work to transmit the messages further. The traffic in the network is huge and the number of messages in the network depends on the number of messages sent by each of the nodes per second and the number of Relay nodes enabled in the network. Additionally, to

increase the high delivery rate (delivery of information between nodes), the retransmission mechanism is used in the network which obviously increases the traffic.

Relay nodes help to achieve high delivery of messages by multiplying the number of messages sent from single nodes and sending them to the remote parts of the network. More messages sent and more relaying in the network helps to achieve high network performance in the Bluetooth mesh, but it also increases the overall traffic which in turn increases the message collision probability and ultimately lowers the information delivery rate. Because of that, some lighting scenarios may not work as expected. Also, such a huge traffic may result in misinformation gathered by e.g. energy monitoring systems.

2.1 Subnets in large installations

Subnets can be compared to “logical walls” that divide a single, large installation into smaller areas. Dividing a large network into separate areas improves the quality of the mesh network by increasing the delivery rate for all nodes.

In this document the term “areas” is analogous to “subnets”. Each area in the Silvair Commissioning is treated as a subnet.

The subnet mechanism in mesh networks allows for the creation of large projects by splitting them up into multiple areas that form a lighting installation.

- Each area has a plan (floorplan) and contains multiple zones, each with a different profile
- Nodes from one area cannot control lighting in other areas through zone linking or other mechanisms
 - Zones can be linked **only with other zones inside the same area** (cross-area zone linking is impossible)

2.2 Subnet configuration Recommendation

- Split projects into smaller areas (up to 200 devices)
- Split areas into smaller zones
- Do not link too many zones (up to 20 small zones)
- Installations consisting of more than 200 nodes are treated as large installations that must be split into smaller areas within one project
 - Examples:
 - An installation (project) of 300 nodes is split into 2 areas of approx. 150 nodes each)
 - 400 nodes installation - two areas of 200 nodes per each area
 - 600 nodes installation - 3 areas of 200 nodes each, or 4 areas 150 nodes per each area etc.

- Remember that zone linking works only within a single area. (Cross-area linking is not supported)

2.3 How to set up subnets in new projects

No special actions are required.

Silvair Web app

- Design the project using multiple areas such that a single area contains less than 200 devices.

Silvair Mobile App

- Add devices to the separate areas created via the web app (e.g. 150 devices in area FLOOR 1 and another 150 devices in area FLOOR 2).
- Do not add more than 200 devices per area

2.4 How to set up subnets in existing projects

Subnets are present in all projects starting from the 201908 Silvair web & 1.17 mobile app releases.

Users with existing projects containing more than 200 nodes must check the following:

Silvair Web app

- Ensure the project version is 201908 or higher
 - more information on how to update projects is available in the *Silvair Commissioning User Manual* in the [Knowledge Base](#)
- Divide this project in multiple areas such that a single area contains less than 200 nodes.

Silvair Mobile App

- Remove devices from areas with more than 200 nodes
- Add the removed devices to the separate areas created via the web app (e.g. 150 devices in area FLOOR 1 and another 150 devices in area FLOOR 2).
- Do not add more than 200 devices per area

3. Projects containing Silvair Gateways

IMPORTANT: A Gateway is required only in installations utilizing the following services: Energy Monitoring, Occupancy Monitoring, Scheduling.

The Silvair Gateway is a device that allows our partners to collect data from their Bluetooth mesh lighting networks and transmit them to the Silvair Cloud, from where it can be visualised and analysed.

One Gateway can:

- control and monitor multiple areas
- Monitor data (energy or occupancy) from a mesh network of approximately 200 bluetooth mesh devices.

Installations with Energy / Occupancy Monitoring:

One gateway can monitor a maximum of **200 nodes** in all areas. Having a gateway monitoring more than 200 nodes total will not guarantee good reporting and will cause poor performance of the mesh network in that project.

Installations with only Scheduling:

More than 200 devices can be scheduled as long as the areas satisfy the 200 node per area limit

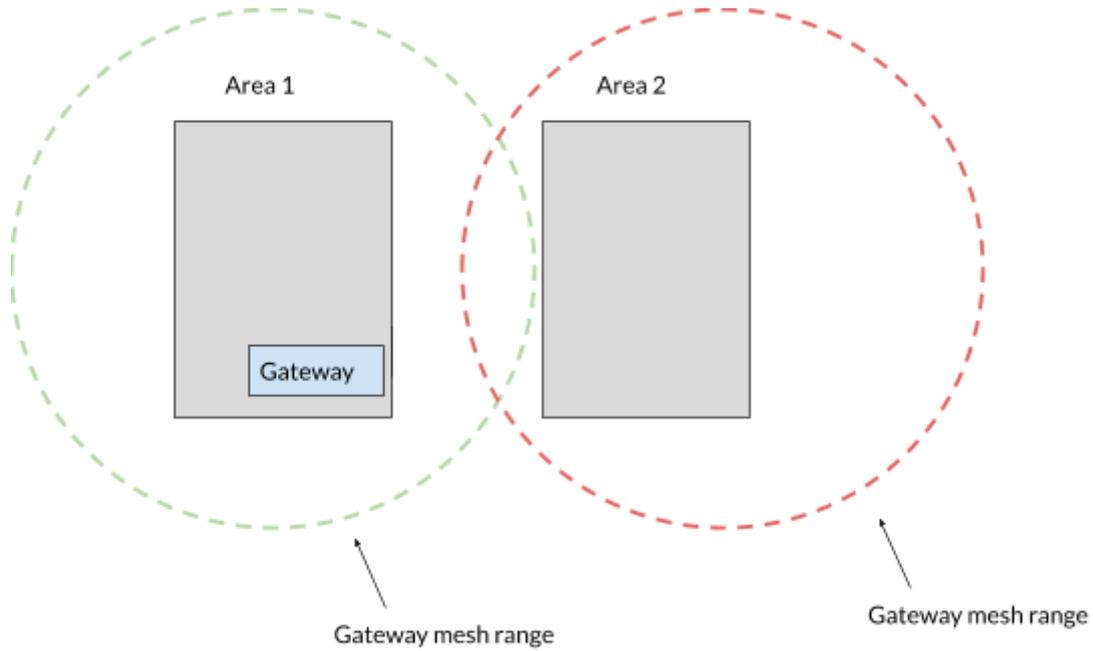
3.1 Gateways monitoring/scheduling multiple areas

The number of gateways used in an installation depend on the following:

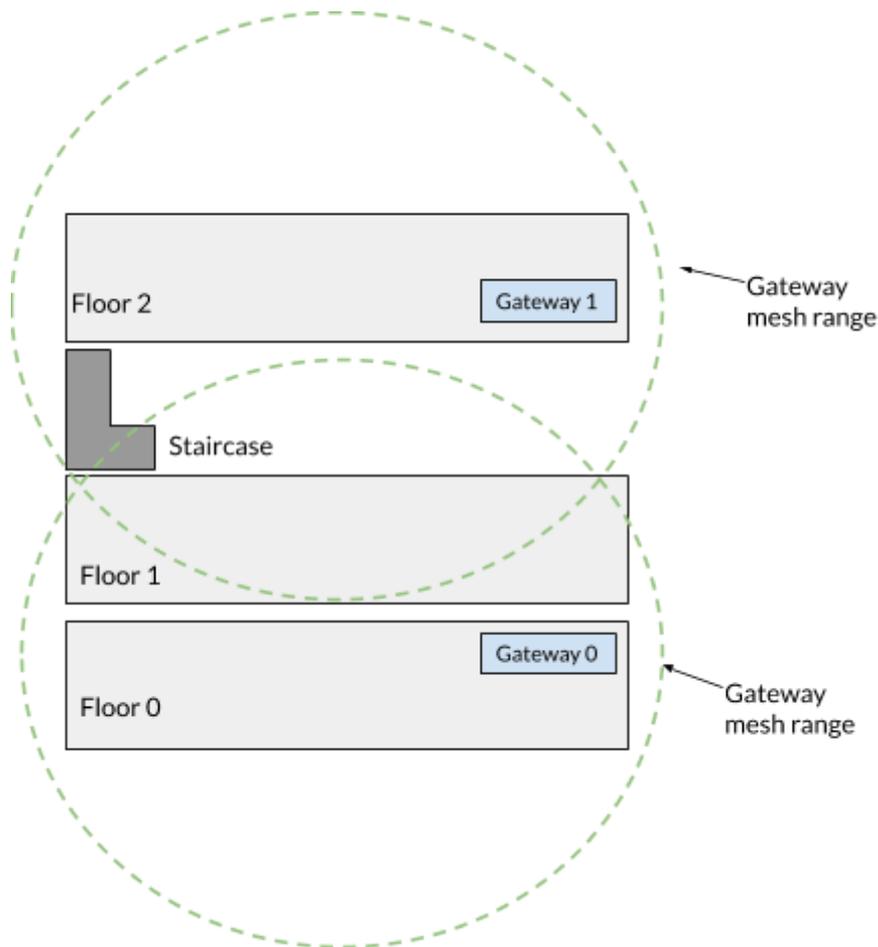
- number of mesh nodes in areas
- building construction and arrangement of zones in the building
- services used (monitoring services, or scheduling service)

Consider the arrangement of areas in the project. If a Gateway controls more than one area, it must have a direct connection to at least one node in each controlled area. If there is a poor or nonexistent connection between the Gateway and a controlled area, the Gateway function may work in one area but not in another.

Example:



Img.3 - Incorrect gateway placement for controlling multiple areas.

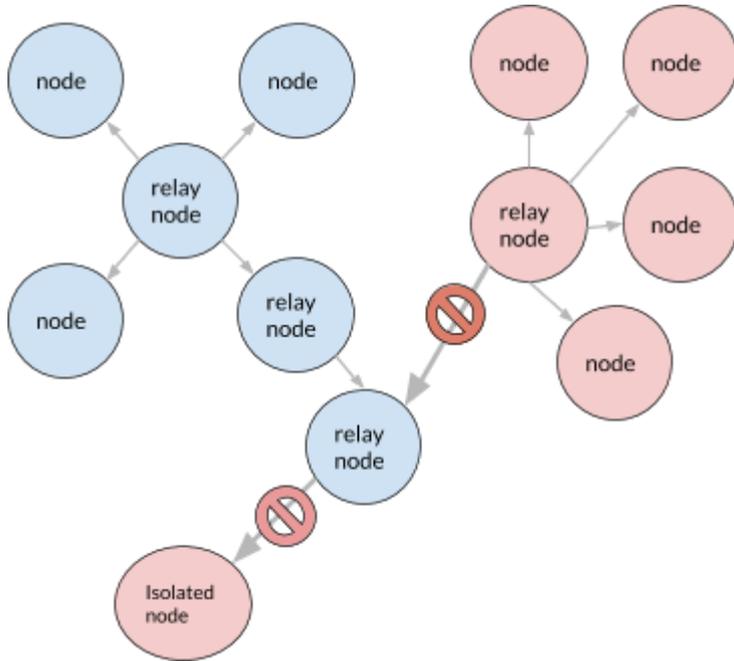


Img.4 - Correct gateway placement for controlling multiple areas

3.2 Other considerations

Q: Can relays from one area route mesh traffic for another area?

A: No. The relays in one area will only route traffic from nodes in that area. In the case below, consider moving the isolated node into the blue area



Q: Do I always need to create separate areas (subnets) in my project ?

A: No. If you have an installation of < 200 nodes there is no need to divide it into areas. Create a project in the Silvair web app, and then create one area where you will add all devices into as many zones are required

Q: Does zone-linking work with zones in different areas?

A: Zone linking works **ONLY** within a particular subnet/area. Zone linking does **not work** between zones in separate areas.

Q: I have a 700 nodes network. Can I divide it into 2 subnets of 350 nodes each?

A: No, it is not recommended. 350 nodes in one subnet where each device is a sensor-controller node is too high load for a single subnet to work. In this case, we recommend to use at least 4 areas with no more than 200 nodes each.

Q: Do I need to have a Gateway for subnets to work ?

A: No, Gateway installation is required only when you are using any of the connected services (Scheduling, Energy / Occupancy Monitoring) features in that area.

Q: Is the maximum number of nodes in an area 200?

A: 200 nodes is an estimated number. In some cases it is possible that a single network of more than 200 nodes will function correctly without dividing it into smaller subnets. However, the function of the network depends on various factors such as: types of sensors used, sensor data publishing frequency, arrangement of nodes, and environmental conditions such as walls' thickness, ceiling thickness, and construction material.

4. Replay Protection List (RPL)

What is RPL (Replay Protection List) and why it is important in lighting installations.

Every message sent in the Bluetooth mesh network consists of source and destination addresses and a sequence number. To be protected from replay attack every node must remember the last seen sequence number for every source address sending messages to it. The list of those information is called replay protection list (RPL). Each Bluetooth mesh device (e.g. controller, sensor, mobile device,) has an individual RPL list and RPL capacity. It is possible to count the RPL size for each mesh device. This can prevent from filling up and blocking this list, as well as from the RPL attacks. Silvair firmware has an RPL of the following sizes:

- 126 for firmware versions up to 2.13
- 255 for firmware versions 2.14 -2.17
- 350 for firmware version 2.18 and higher

The RPL size limits the number of devices a device can subscribe to (the number of devices controlling it), which translates into the number of devices in the zone and the number of devices in linked zones.

Examples (for firmware version 2.18 and higher):

- A single zone without any linking but with daylight harvesting profile - up to **170 devices** where each device is an occupancy sensor-controller
- Two similar zones with daylight harvesting linked together - up to **110 devices**
- A single zone with manual control - up to 340 devices due to the RPL limit, but **up to 200 devices** due to the maximum number of devices in the area

Please note that zones that big are not recommended.

NOTE: The number of slots used in RPL per node depends on the number of devices in the zone, composition data, complexity of zone linking configuration and scenarios used.

4.1 Rules for counting the slots used in RPL:

- 1 slot for each motion sensor controlling the desired node (from the same or a linked zone)
- 1 slot for each lightness controller (luminaire) working together with the desired node (the same zone) in Daylight Harvesting (DH) type of scenario
- 1 slot for each switch node used for controlling the desired node (from the same or a linked zone)
- 1 slot for an ALS node used for maintaining desired level in the zone where this node is in Daylight Harvesting type of scenario
- up to 5 slots (typically no more than 2) for each mobile application used for commissioning/reconfiguration

RPL in nodes is persistent and it is periodically cleaned from irrelevant devices during IV index update procedure.

4.2 RPL counting formula and rules

The required number of the RPL entries needs to be at least equal to:

$$N_{\text{MotionSensor}} + N_{\text{SW}} + N_{\text{Luminaire}} + N_{\text{ALS}} + 5 * N_{\text{mob}}$$

$N_{\text{MotionSensor}}$	Total number of motion sensors in all linked zones
N_{SW}	Total number of switches in all linked zones
$N_{\text{Luminaire}}$	Total number of luminaires in the zone where we want to count the RPL size (in Daylight Harvesting type of scenario)
N_{ALS}	Total number of Ambient Light Sensors in the zone where we want to count the RPL size
N_{mob}	Total number of mobile devices with commissioning app, each able to commission and configure up to 5 devices in parallel in the zone where we want to count the RPL size.

4.3 Number of devices per linked zone

It is important not to exceed the number of **concurrent** linked zones in a single project due to RPL limitations. Please note that:

- The number of concurrent linked zones in a single project should **not** exceed 20.
 - This is due to limitation in the subscription group messaging number which is equal to 64.
- Less zone linking in a single project = more devices can be added in one zone.

- The below numbers are estimated examples including minor margins of error.

Average no of devices in one zone	Max no of linked zones
≤40	5
≤30	7
≤20	11
≤12	20

5. Linear Installations

As mentioned at the beginning of this document, a large installation is not necessarily an installation that physically occupies a big space. The size of an installation is mostly determined by the number of nodes added to the network, their distribution density as well as the lighting control profiles used in the project.

The shape of the installation is linear thus the communication between nodes is one-directional and goes in a straight line. Also, in linear installations the distance separating individual nodes is huge, for example 30 metres. Such a long distance between nodes **requires** enabling **Relays** on individual devices manually.

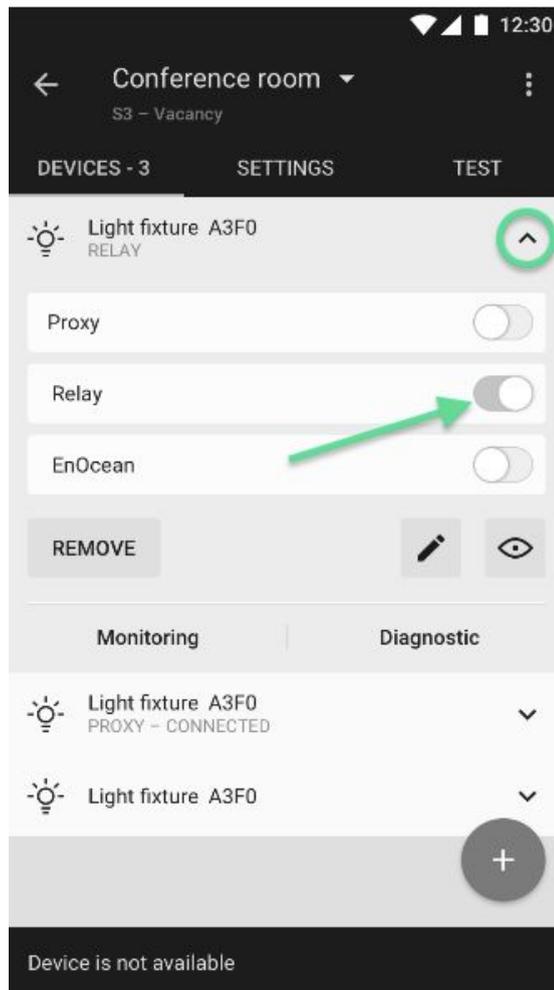
The role of Relays in a lighting installation is vital. They act as accelerators in delivering mesh messages between nodes and transmit the messages further into the zone. If the Relays are improperly placed and nodes aren't within range of at least one relay, the mesh network will be disjoint and the **zone will not function correctly**.

Automatic Relay mechanism

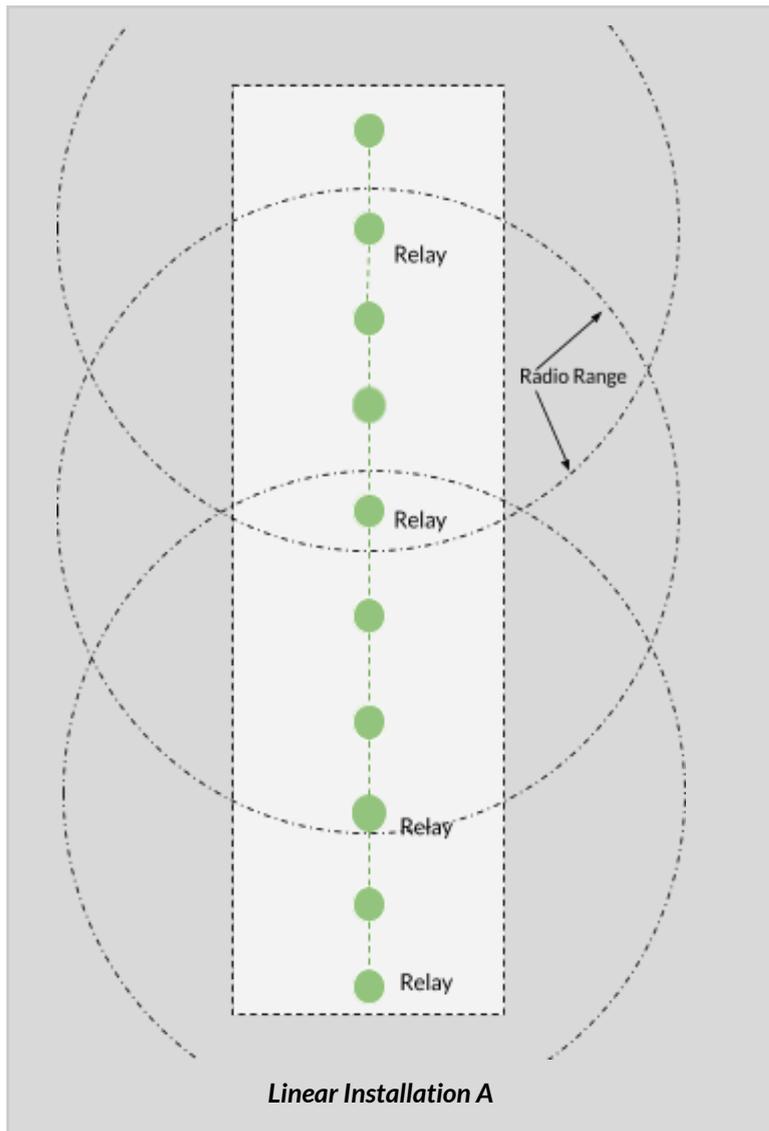
- The mesh network is automatically configured while the user adds a new device to a zone. This mechanism runs in the background and sets approx. 10% of all devices added to the zone(s) as Relays.

Do not use automatic Relay mechanism in linear installations

- In the case of **linear** installations automatic Relay mechanism will not work, especially if distance between individual nodes is huge
- User should use the Silvair mobile app to set Relays manually on selected nodes in the zone
- The Relay toggle is available in the mobile app > Project view > Zones view > select device > expand device settings > enable Relay

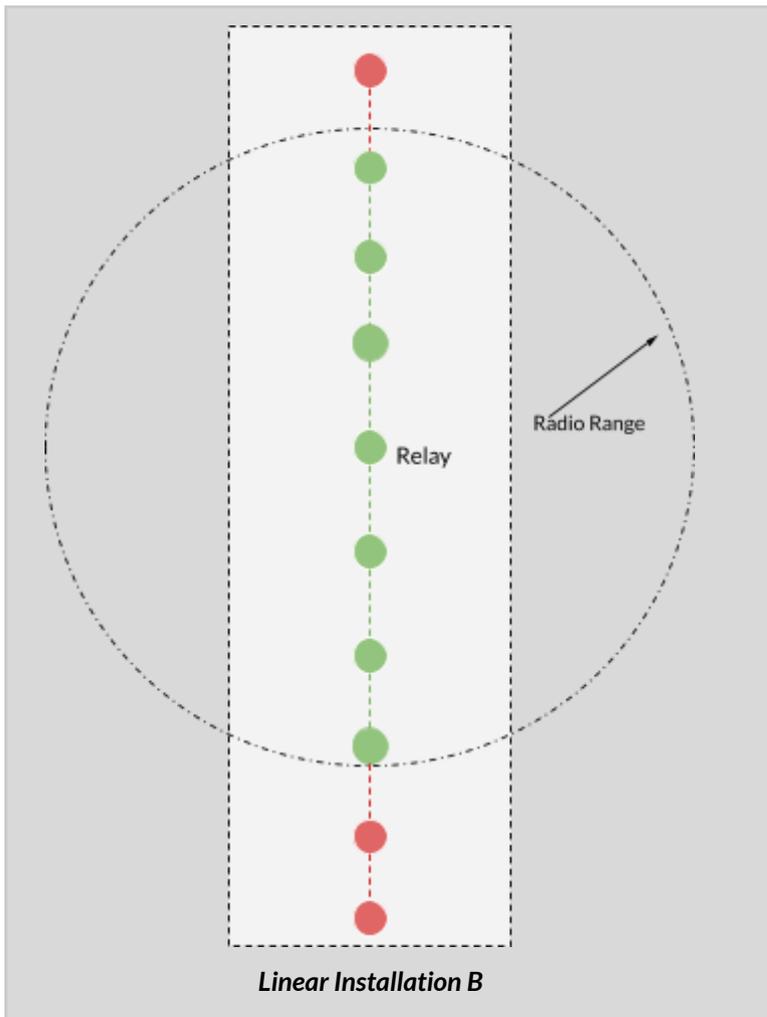


Relays have a giant role in linear, distributed installations types. If they are set up in a wrong way, the functioning of a mesh lighting installation may not work properly. Consider the below examples:



Linear Installation A : recommended Relay placement

- The distance between each node in this installation is ~ 10 metres each
- Approximate radio range in this case is 35m
- Relays are placed such that each relay is within radio range of the next relay.
- This ensures messages can be forwarded further through the network
- Relays must be placed manually using the Silvair mobile app. The installer **can not** rely on the automatic Relay selection mechanism



Linear Installation B : incorrect Relay placement

- The distance between each node in this installation is ~ 10 metres
- Approximate radio range in this case is 35m
- The automatic mechanism turned on one relay
- The relays on the edge are not within radio range of at least one relay. They do not receive mesh messages and are not part of the mesh network.
- Lighting control in the system will not function correctly

Linear Installations summary:

Do

- Set up Relay manually with the Silvair mobile app. Do not use only automatic modes of setting Relays
- Place relays such that each node in the network is within range of at least one relay
- Always consider distance between nodes. Huge distance requires enabling more Relays in the zone

Don't

- Never set up "Proxy" and "Relay" functions on one device
- Do not squash Relays in one place as illustrated on "Linear Installation B"

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