

# Optimizing mesh network performance

*Considerations for designing, implementing, and maintaining mesh networks*

Application note

16 November 2023	SN-202 rev. 7.1
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# 1. Introduction

To make sure that a lighting system based on a Bluetooth mesh network works correctly, all devices in the network must be able to communicate with each other. This document explains how Bluetooth mesh networks work which will help you optimize their performance.

## 1.1 Bluetooth mesh network

A qualified Bluetooth mesh network consists of devices that communicate with each other using the official Bluetooth SIG mesh protocol designed specifically for large, commercial networks. The Bluetooth mesh standard allows any device running qualified Bluetooth mesh software, such as a luminaire, sensor, or switch, to act as a node in the network.

Bluetooth mesh networks can be characterized as follows.

- Nodes communicate by radio (BLE).
- Nodes share the same address space.
- Nodes use the publish-subscribe paradigm.
- Nodes communicate using managed flooding (that is, there is no routing).
- Node messages have a default Time to Live (TTL) of 8.

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 For details of Bluetooth mesh networks, see [Bluetooth Mesh Networking](#).





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## 1.2 Mesh functions

A device can perform different network functions. It can be set up to act as a proxy, a relay, an EnOcean adapter, or a time authority.

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To ensure that the device performance is optimal, do not use these functions on the same device at a time:


-   Static proxy and relay
  -  Static proxy and EnOcean adapter
  -  Relay and EnOcean adapter
- 

### 1.2.1 Relay

A relay is a function assigned to a device which allows it to improve communication between devices by sending messages further into the Bluetooth mesh network. There are two purposes for relays:

- To extend the range of the network by sending messages further to devices that are not in the direct radio range of the original sender.
- To increase the message delivery rate by sending the same message a few times.

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 By default, approximately 10% of devices in the network are automatically set up to act as relays when they are added to a zone. They are set up as relays randomly, regardless of their location in the network. Thus, in some cases you may need to [manually set up some devices to act as relays](#) to make sure that the signal coverage is sufficient.

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For examples of how to arrange relays, see [Device placement based on the network layout](#).

## 1.2.2 Proxy

A proxy is a function assigned to a device that allows mobile devices, such as smartphones and tablets with the Silvair mobile app installed, to connect to it. The connection allows the mobile devices to communicate with the Bluetooth mesh network and configure or control devices.





Depending on the firmware version and project version, a device can act as a static proxy or auto proxy.


### 1.2.2.1 Auto proxy

 The auto proxy requires firmware version 2.17 or later, and project version 202005 or later.


A device set up to act as an auto proxy acts as a proxy only on demand, when the Silvair mobile app in range wants to communicate with the mesh network. If a device supports the auto proxy function, it will be set up as an auto proxy automatically when added to a zone.

You can use these functions on the same device at a time:


-   Auto proxy and relay
-  Auto proxy and EnOcean adapter
-  Auto proxy and time authority


 To use the auto proxy function in projects that have already been commissioned, update the firmware of devices and update the project in the Silvair web app. Then, remove all devices from all zones in the project and add them again. For details, see [SN-208 OTA firmware update for provisioned devices](#).


### 1.2.2.2 Static proxy


 The static proxy is available in firmware version 2.16 or earlier, or project version 202004 or earlier.


A device set up to act as a static proxy always allows the Silvair mobile app to communicate with the mesh network. The static proxy function is available only in devices that do not support the auto proxy function. In this case, the static proxy function will be set up in some of the devices automatically when they are added to a zone.

 Do not use the static proxy and relay function on the same device at a time because it will reduce the performance of the device.

 Do not use the static proxy and EnOcean adapter function on the same device at a time because it will cause issues with the reception of packets from the EnOcean switch. Thus, the devices in the mesh network may not respond as intended when the switch is pressed.


 One proxy supports connection to only one mobile device (iPad/iPhone) at a time. If you want to use two mobile devices at the same time, enable the static proxy function on at least two devices in the mesh network, each in range of one mobile device.


 To manage the mesh network, at least one device must be set up to act as a proxy. Without it, the mobile app would not be able to connect to the network. Thus, if there is only one proxy, the mobile app will not allow it to be removed or disabled until the proxy function has been enabled in a different device.

 Although it is **not recommended**, you can disable the static proxy function on a device manually if at least one proxy remains in the network and enable it on a different device.





### 1.2.3 EnOcean adapter

An EnOcean adapter is a function assigned to a device which allows a Bluetooth EnOcean switch to communicate with a Bluetooth mesh network. A device that acts as an EnOcean adapter receives data packets from the EnOcean switch, changes them into mesh messages, and sends the messages into the mesh network.

 We recommend setting up two devices as EnOcean adapters in the zone. Thus, if one device fails, the EnOcean switch will still be able to communicate with the mesh network using the second device. But the more devices you set up as adapters, the more network traffic comes from the switch, which decreases the quality of the mesh network.

 An EnOcean switch can control one or more zones at a time when you assign it to multiple EnOcean adapters or when you assign it to one EnOcean adapter and use zone linking.

Do not use these functions on the same device at a time:

-   EnOcean adapter and static proxy
-   EnOcean adapter and relay

If you combine these functions, it will cause issues with the reception of packets from the EnOcean switch. Thus, the devices in the mesh network may not respond as intended when the switch is pressed.

For more information, see [SN-203 EnOcean switch](#).

### 1.2.4 Time authority

 The time authority is available in firmware version 2.20.2 or later, and project version 202101 or later.


The time authority (TA) is a function assigned to one device which makes it act as the source of the current time that is shared with other devices in the network. The network receives the current time from the mobile app when a device is set up as a time authority automatically by the app or manually using the Silvair mobile app for iOS/iPadOS. The time is then kept by this device (with a battery, if available) and all the other devices sync their time with it.

The current time is necessary for the [in-node scheduling](#) and [emergency lighting testing](#) features.





After a power outage, the network can receive the current time from a device with a battery, even if this device is not set up as the TA, but there must be a relay in its zone.

The Silvair app sets up the first device as the TA. When each next device is added to a zone, it can become the new TA if it has a battery and a more accurate real-time clock. The app chooses the TA in the following sequence:

1. Device with a battery and the most accurate real-time clock (RTC)
2. Device with a battery
3. Device with an RTC and without a battery
4. Any other device in the project

 The Silvair app may not always be able to detect if the device has a battery. If the necessary device has not been automatically set up as the TA, [set up the device as the TA manually](#).

You can use these functions on the same device at a time:

-   Time authority and auto/static proxy
-  Time authority and relay
-  Time authority and EnOcean adapter


## 2. Mesh network considerations

Each project is unique and should be treated separately, but there are guidelines that apply in all cases. This chapter describes the elements necessary for a successful Bluetooth mesh-based lighting system.

### 2.1 Project specification and design

Planning phase is the foundation of any project. If the foundation is not solid, the project may require extra money, resources, time, and may not achieve its intended purpose. That is why we recommend looking at the lighting system not only as a source of lighting but also as a network of connected devices. If you ignore this, your network and lighting may not work as intended. There can also be problems with adding or removing devices.

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 When planning a project, make sure that area-to-area<sup>1</sup> communication is available. If an area would be separated from other areas, create a separate project only for that area.

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The key factors when planning any wireless-based system are radio range and placement of devices.

#### 2.1.1 Radio range

Before you identify the range of devices you want to use, keep in mind that the signal strength and thus the device range specified by the manufacturer can be reduced by these elements:

- Device casings
- Obstacles between devices (ceilings, walls, doors, and their materials, boxes, plants, equipment)
- Sources of radio interference (routers, microwaves, cellphones)

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 Some obstacles, like leaves growing on trees, may not be obvious but can weaken or even block the radio signal between devices. This is something to remember when you are commissioning a project in winter.

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To identify the range of your device, use the Silvair mobile app.

1. Install the device in a real-case installation.
2. Open the Silvair mobile app, and create a project, area, and zone.
3. Go to the zone and tap + to go to the 'Add device' view.
4. Move away from the device to find the maximum distance at which the device is still shown on a white background in the app. Measure that distance. If the device is shown on a gray background, it is out of range.
5. Install a second device at the measured distance from the first device.
6. Add the two devices to the zone.
7. Move away from the first device so that the mobile app is out of the direct radio range of the second device.
8. Go to the 'Test' tab and try to control all devices by using buttons and sliders.
9. If the second device responds as intended, consider the distance between the first and the second device as the range. If the second device does not respond as intended, install the second device closer to the first device and repeat steps 7-8.

However, to ensure connectivity, it is a good idea to add a range buffer in your planning. So, for example, if the tested device has a range of 11 meters, you should plan for a range of 10 meters instead.

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<sup>1</sup> A project can be divided into areas for better clarity and easier navigation. For example, an area can be a room, a floor, or a whole site, or a part of a floor, site, or building.



## 2.1.2 Device placement based on the network layout

Each network layout requires that the devices are placed so that they are able to communicate with each other. To achieve this, plan the network so that each device is in the direct radio range of at least two other devices. Thus, even if one of these devices fails, the other will still allow communication in the mesh network.

See the next sections for examples of network layouts with the placement of relays. These examples will help you understand how placement of devices can affect network communication.

### 2.1.2.1 Grid network layout (dense)



**Fig. 1.** Example of relay placement in a dense, grid network layout

General considerations:

- The radio range of a device is much larger than the distance between devices.
- Radio signals do not degrade.
- Most of the devices are in the direct radio range of other devices.

Conclusions:

- Only a few relays (less than 10%) are sufficient.
- Too many relays can make the communication worse. This is because relays receive messages and send them further into the network, which increases the overall traffic but also the interference.

### 2.1.2.2 Grid network layout (sparse)

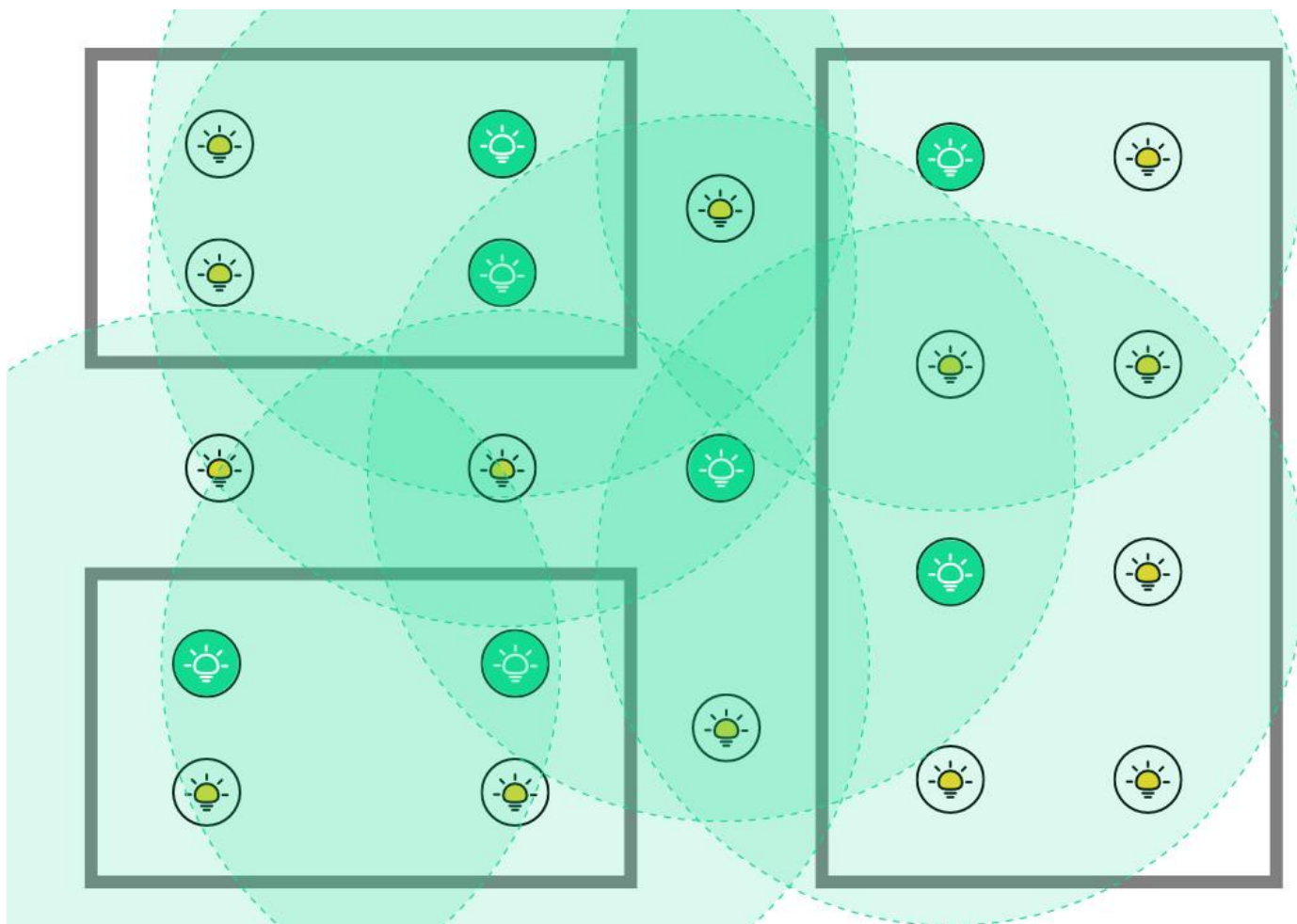


Fig. 2. Example of relay placement in a sparse, grid network layout

#### General considerations:

- Radio signals do not degrade.
- Not many devices are in the direct radio range of other devices.

#### Conclusions:

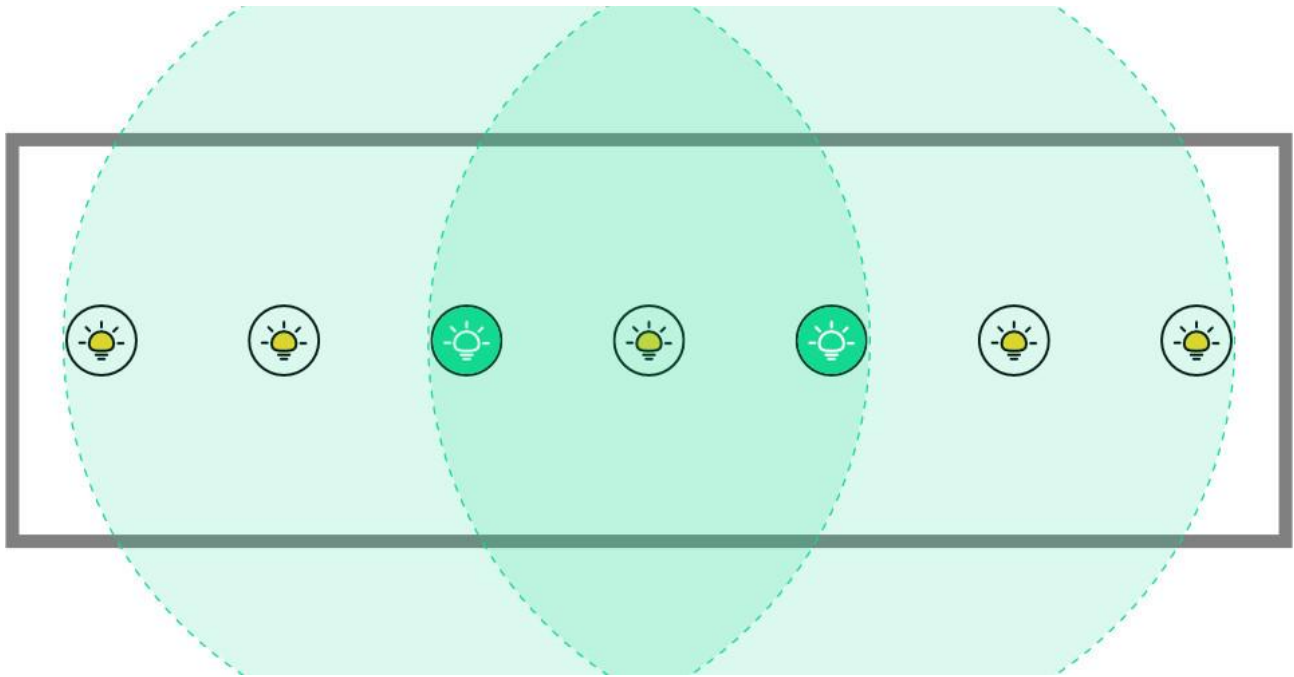
- Many devices must be [manually set up to act as relays](#) because the 10% of devices that are set up as relays automatically will not provide sufficient signal coverage.



Identify the radio range of devices before you set them up to act as relays. In some cases, all devices may need to be set up as relays to provide sufficient signal coverage.

- Many relays are necessary to ensure communication between the farthest points of the network.

### 2.1.2.3 Line network layout (dense)



**Fig. 3.** Example of relay placement in a dense, line network layout

#### General considerations:

- The radio range of a device is larger than the distance between devices.
- Radio signals do not degrade.
- Most of the devices are in the direct radio range of other devices.

#### Conclusions:

- Only a few relays are sufficient.
- Too many relays can make the communication worse. This is because relays receive messages and send them further into the network, which increases the overall traffic but also the interference.

### 2.1.2.4 Line network layout (sparse)

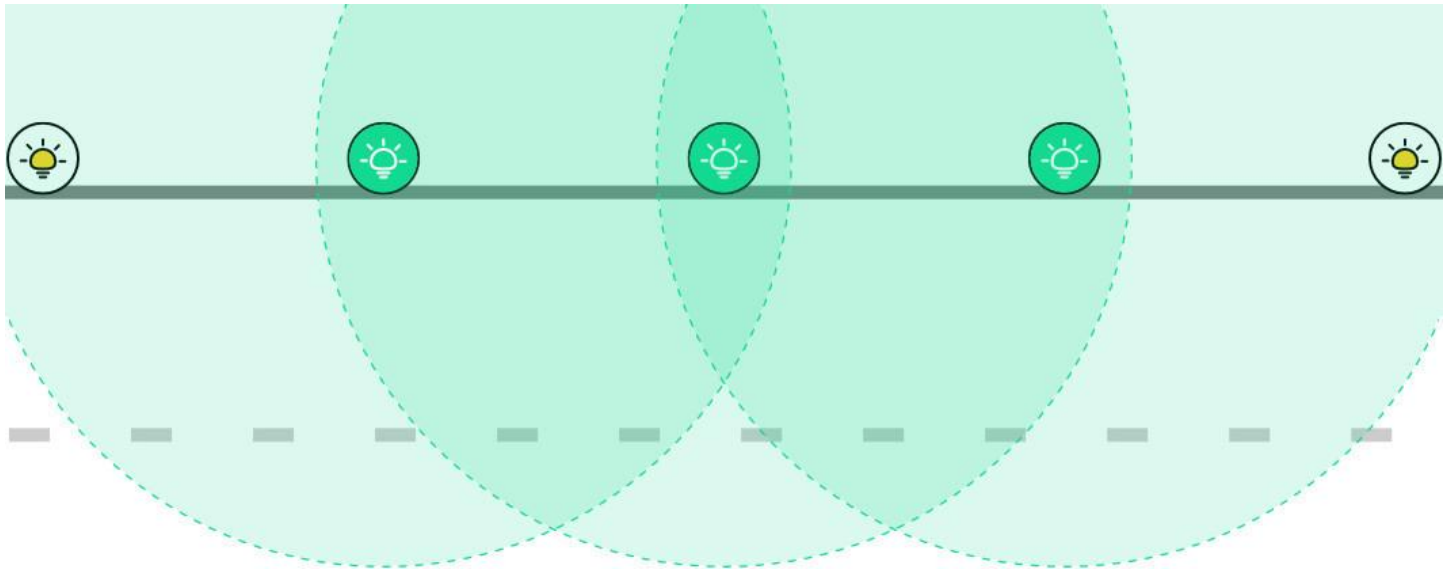


Fig. 4. Example of relay placement in a sparse, line network layout

#### General considerations:

- Radio signals do not degrade.
- Not many devices are in the direct radio range of other devices.

#### Conclusions:

- Many devices must be [manually set up to act as relays](#) because the 10% of devices that are set up as relays automatically would not provide sufficient signal coverage.



Identify the radio range of devices before you set them up to act as relays. In some cases, all devices may need to be set up as relays to provide sufficient signal coverage.

- Many relays are necessary to ensure communication between the farthest points of the network.

### 2.1.2.5 Layout with obstacles

If there are no obstacles and the antenna of a device is installed correctly and omnidirectional, the radio signal of the device has the same range in all directions. Thus, only two relays are needed to cover the whole network.

However, if there is an obstacle between the relays that blocks the radio signal, such as an elevator shaft, two relays for the whole network are not enough. As a result, more devices must be set up to act as relays to bypass the elevator and allow communication in the network.

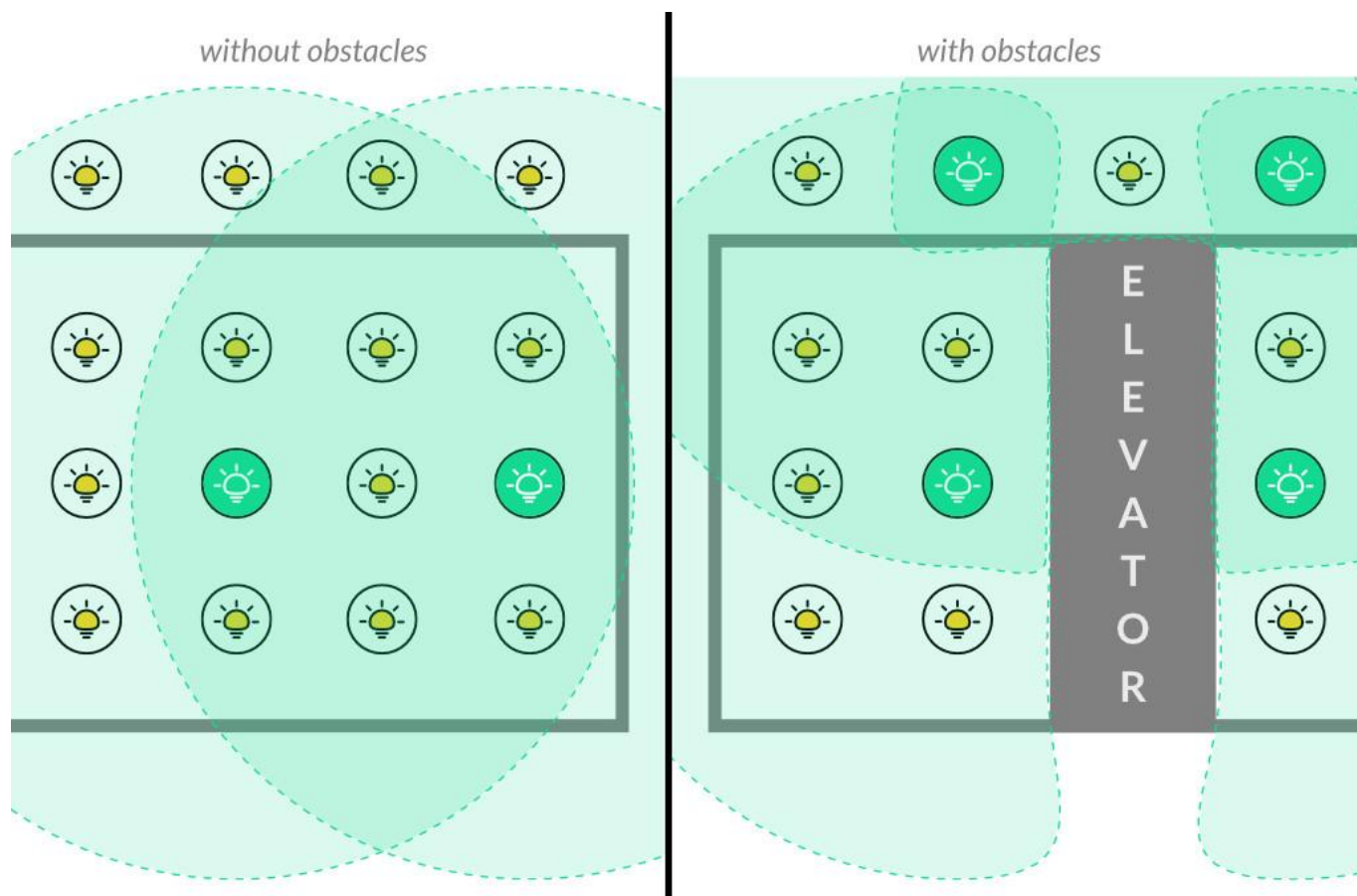


Fig. 5. Example of relay placement without and with obstacles

## 2.2 Implementing your design

### 2.2.1 Installing the devices

Install the devices as planned. Keep in mind that the following elements can limit the radio range more:

- Incorrect device orientation. Do not point the built-in antenna of the device to a ceiling, wall, or other surface that can block the radio signal and thus reduce the range of the device.
- Incorrect placement of external antennas. If the device has an external antenna, install it according to the recommendations of the manufacturer.

**i** To ensure connectivity, make sure that each device is in range of at least two other devices.



## 2.2.2 Commissioning the devices

Use the Silvair mobile app to add devices to the zones. The mesh network will be configured automatically. By default, approximately 10% of devices in the network are automatically set up to act as relays when they are added to a zone. They are set up as relays randomly, regardless of their location in the network.

Make sure that all devices in each area can communicate with each other. To do this, perform [mesh quality tests](#) and make sure that their results in each area are 100%. To perform a test, open the **Silvair mobile app for iOS/iPadOS**, go to the project, and in the area field, tap **⋮ > Mesh quality > Start test**. After each test is completed, make sure that the result is 100% (all zones are shown in green).

If the result is not 100% (some devices are shown in red), try these steps and perform the mesh quality tests again:

- make sure that the devices shown in red are in radio range of the devices shown in green,
- change the placement of relays so that the devices shown in red receive the radio signal,
- install a new device between the devices shown in green and the devices shown in red, and [set up this device to act as a relay](#).


If a project supports the auto proxy function (project version 202005 or later), all devices that run Silvair firmware version 2.17 or later are set up to act as an auto proxy. Otherwise, the static proxy function is enabled automatically in some of the devices when they are added to the zone.

## 2.3 Maintenance

Even if the lighting control works correctly after commissioning, monitor the network and react to problems that may reduce its performance.

- Minimize radio noise that can result, for example, from using Wi-Fi networks.
- Replace devices that do not work as intended. When devices that are set up to act as a relay, static proxy, or EnOcean adapter stop working, luminaires may behave erratically or not respond, a mobile app may have issues connecting to the mesh network, or a switch may no longer control the luminaires.


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 After removing or adding a device, perform the [mesh quality tests](#) again.

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- If a device with an assigned network function has been replaced, make sure that the function has been assigned to the new device.
- Use the latest version of firmware and project wherever possible. The latest version may include bug and security fixes, new features, stability and performance improvements, and will be supported for a longer period of time. See [SN-208 OTA firmware update for provisioned devices](#) for how to update the firmware.

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 Network performance can decrease as a result of using electronic devices, adding furniture, changing the location of office equipment or internet access points, and even increased human activity and thus sensor readings.


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## 3. Mesh quality test (for iOS/iPadOS)







### 3.1 Overview

The mesh quality test calculates the percentage of devices in an area that can communicate with each other. The test is performed using the Silvair mobile app for iOS/iPadOS from where the app is connected to the network. If the test is performed from a different location in the network, the test result may be different.


The proxy that is the closest or has the strongest signal in the radio range sends a ping message to all devices in the area. If a device does not respond to the first ping message, the message is sent again up to four times.

 To perform the test, add at least one device to the area.

After the test is completed or canceled, the results can be as follows:

	Good connection. All devices in the zone responded. No relay in the zone.
	Good connection. All devices in the zone responded. Zone with a relay.
	Connection problem. At least one device in the zone did not respond. No relay in the zone.
	Connection problem. At least one device in the zone did not respond. Zone with a relay.
	Zone with no devices.
	Zone from which the app is connected to the network.





 The result of the last mesh quality test for each area can be found in the *commissioning report* available in the Silvair web app.

We recommend that you perform the mesh quality tests in an area in the following cases:

- After commissioning a zone.
- After adding or removing devices, or enabling or disabling a function of a device.
- After making changes that may affect the signal coverage in the zones.
- If the luminaires do not behave as intended (for example, luminaries in the linked zone do not turn on).


### 3.2 Performing the test (for iOS/iPadOS)

1. Go on site so that you are in the direct radio range of a proxy.
2. Open the Silvair mobile app for iOS/iPadOS and go to your project.
3. In the area field, tap  > **Mesh quality** > **Start test**. A ping message is sent to all devices commissioned in the area with Time to Live (TTL) set to 8 hops.
4. To see the test results per device in a zone, tap that zone.
5. To identify a device, tap  next to the device name.
6. Repeat the test from at least one more location in the same area.


## 4. Enabling or disabling a function of a device

1. Go on site.
2. Open the Silvair mobile app.


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 If the auto proxy function is not supported by the devices, make sure that you are in the direct radio range of a static proxy.


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3. Go to the zone and tap the device (iOS/iPadOS) or tap  to open the context menu (Android).
4. To enable a function, tap the toggle switch to move it to the right (iOS/iPadOS) or select Enable Relay / Enable EnOcean (Android).


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 To enable the static proxy or time authority function, use the Silvair mobile app for iOS/iPadOS.

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 Static proxy is available only in firmware version 2.16 or earlier, or project version 202004 or earlier.


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 Time authority is available in firmware version 2.20.2 or later, and project version 202101 or later.


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5. To disable a function, tap the toggle switch to move it to the left (iOS/iPadOS) or select Disable Relay / Disable EnOcean (Android).


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 To disable the static proxy or time authority function, use the Silvair mobile app for iOS/iPadOS.

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 To disable the time authority function of a device, set up a different device in the area to act as the Time Authority. Then, the time authority function of the first device will be disabled.

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 If the auto proxy function is available, it is always enabled and cannot be disabled.

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6. If you have enabled or disabled the relay function, perform [mesh quality tests](#) in the area and make sure that their results are 100% (all zones are shown in green).
7. Go to the zone and then to the 'Test' tab and make sure that the luminaires behave as intended.

Mobile app for iOS/iPadOS:

Static Proxy	<input type="checkbox"/>
Relay	<input type="checkbox"/>
EnOcean	<input type="checkbox"/>
Time Authority	<input type="checkbox"/>

OFF	ON
<input type="checkbox"/>	<input checked="" type="checkbox"/>

Mobile app for Android:

Enable Relay

Enable EnOcean

Remove




## 5. Configuration best practices

To maintain the optimal performance of the mesh network, follow these guidelines:




1. Do not set up more than 10% of devices to act as relays in dense, grid network layouts. Relays increase the mesh network traffic and too many of them will decrease the overall performance of the network.

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 However, to provide sufficient signal coverage in sparse layouts, for example outdoor projects, it may be necessary to [set up more than 10% of the devices to act as relays](#).


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2. Do not use these functions on the same device at a time:

-  Static proxy and relay
-  Static proxy and EnOcean adapter
-  Relay and EnOcean adapter

3. If possible, position relays evenly across the network.
4. Minimize the number of devices that act as a static proxy, or use the [auto proxy function](#).
5. Make sure that all devices in each area can communicate with each other. To do this, [perform mesh quality tests](#) and make sure that their results in each area are always 100%. If their results are not 100%, continue as described in the [Commissioning the devices](#) section.

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 If an area is separated from other areas in the project and cannot communicate with them, set up the area as a separate project.

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6. If there are any issues in the mesh network, such as erratic, uneven, or delayed lighting control, see [troubleshooting](#).

## 6. Troubleshooting


If there are issues in the mesh network, such as erratic, uneven, or delayed lighting control, continue as follows.

1. [Perform mesh quality tests](#).
2. Determine your [network layout](#) to make sure that there are enough relays and they are placed correctly.
3. Make sure that all devices are installed correctly so that their antennas are not obstructed.
4. Find and remove potential sources of radio interference and obstacles that prevent communication.
5. Enable the relay function on more devices near the edges of the zones shown in green that are close to the zones shown in red. This will allow the relays to send mesh messages further to the devices shown in red. When enabling relay functions, take these factors into account:
  - a. [Radio range](#).
  - b. [Device placement based on the network layout](#).
6. [Perform the mesh quality tests](#) again.
  - a. If all zones are no longer shown in red, keep the relay function enabled on the devices from step 5.
  - b. If some zones are still shown in red, disable the relay function on the devices from step 5 and enable the relay function on different devices.

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If you set up too many devices to act as relays, the overall performance of the mesh network may decrease.

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7. If the issues persist, tap  and select **Send logs > More... > Save to files**. Then, send the logs with a detailed description of the issues to Silvair Support.

## 7. Document revisions

Revision	Date	Editor	Changes
7.1	16 November 2023	GM	Clarified where the mobile app for iOS/iPadOS is required. Corrected links to external documents. Minor edits.
7.0	30 May 2023	GM	Redrafted and updated the document. Added <a href="#">time authority mesh function</a> . Added instructions to test the device range and to avoid possible connectivity problems.
6.7	25 October 2022	GM	Added that the results of mesh quality tests are available in the commissioning report.
6.6	21 June 2022	GM	Corrected the number of retries during the mesh quality test. Included that results are now shown also after canceling the test.
6.5	12 August 2021	PS, ZZ	Updated the document subtitle to <i>Considerations for Designing, Implementing, and Maintaining Mesh Networks</i> , rearranged the document structure, and added the <a href="#">Mesh Network Considerations</a> section along with small changes.
6.4	14 June 2021	PH, ZZ	Made a general update of the document and added the following sections: <ul style="list-style-type: none"> <li>• <a href="#">Bluetooth Mesh Network</a></li> <li>• <a href="#">Examples of Relay Node Placement</a></li> <li>• <a href="#">Mesh Network Troubleshooting</a></li> </ul>
6.3	27 May 2021	LR, ZZ	Added the <a href="#">Document Revisions</a> section and made corrections regarding mesh node functions (EnOcean adapter, proxy, relay).

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