SIEMENS

Thread planning and installation guide

Installation

Planning

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Table of Contents

1 About this document

1.1 Purpose

The document describes best practices for planning, installing, testing, troubleshooting, and optimizing Thread wireless systems.

The information provided in this document helps to provide reliable Thread wireless networks to our customers.

1.2 Scope

The document applies to Thread wireless room solutions.

The information in this document is intended as a guideline and does not cover or describe all possible deployments or contingencies.

1.3 Target audience

- Sales engineers
- Support engineers
- Planners

1.4 Disclaimer

The information is not exhaustive with regard to applicable hardware and software, nor does it cover all possible contingencies encountered during installation, operation, maintenance, or updates. Some descriptions may vary from actual hardware, software, and services.

The data in this document is reviewed on a regular basis and updated as applicable but may not always represent the latest information.

1.5 Abbreviations

BMS	Building management system
OTA update	Over the air update
SED	Sleepy end device
TBR	Thread border router
TME	Thread mesh extender
WRS	Wireless room sensor
YABE	Yet another BACnet explorer

2 Related documentation

The documents can be downloaded from https://siemens.com/bt/download using the respective document ID as search parameter.

Document ID	Title	Type of document
A6V13058284	KNX IoT to BACnet IP gateway, Thread mesh extender, Wireless room sensor	Operational manual
A6V14143075	Thread border router	Datasheet
A6V14143084	Thread border router	Quick start guide
A6V14143080	Thread mesh extender	Quick start guide
A6V14455022	KNX IoT and Thread system limits	System description
A6V13434938	KNX IoT to BACnet IP gateway OCT200.KNBA	Datasheet
A6V13434940	KNX IoT to BACnet IP gateway OCT200.KNBA	Mounting instructions
A6V12816395	Wireless room sensor, KNX IoT/Thread, Temperature QAA2890/WI	Mounting instructions
A6V12816395	Wireless room sensor, KNX IoT/Thread, Temperature & Humidity QFA2890/WI	Mounting instructions
A6V12816395	Wireless room sensor, KNX IoT/Thread, Temperature, Humidity & CO2 QPA2892/WI	Mounting instructions

SharePoint and tools

Name	Details
Thread group website	https://www.threadgroup.org/
Thread range testing app	Contact your local Siemens sales representative
Thread Site Acceptance Test (SAT) template	https://see-siemens.highspot.com/items/64c4222acb48a6a534cd55a8?lfrm=ssrp.7
Wireless basic training	Contact your local Siemens sales representative
Wireless room solution: FAQ	https://see-siemens.highspot.com/items/6499f1d55c33c8a9aa27f076?lfrm=ssrp.3
Wireless room solution, sales presentation	https://see-siemens.highspot.com/items/6490b73e0a6e8083298580fc?lfrm=ssrp.2

Name	Details
Wireless room solution, market entry deck	https://see-siemens.highspot.com/items/6449861fee82efcc9246e427?lfrm=ssrp.4
WLAN network analyzer	WLAN Analyzer for Windows and Android: https://apps.microsoft.com/detail/wifi-analyzer/9NBLGGH33N0N?hl=de-de&gl=de NetSpot WLAN for Android: https://play.google.com/store/apps/details?id=com.etwok.netspotapp Professional tools, Metageek: https://play.google.com/store/apps/details?id=com.etwok.netspotapp
ZigBee and WLAN coexistence	https://www.metageek.com/training/resources/zigbee-wifi-coexistence/
Metageek	https://www.metageek.com/
Free space loss online calculator	https://www.everythingrf.com/rf-calculators/free-space-path-loss-calculator

3 Overview

3.1 What is Thread technology?

Thread is an open standard for wireless communication providing an IPv6-based solution for reliable, cost-effective, low-power, secure, device-to-device communication that is agnostic as to the application layer.

Thread is specifically designed for smart home and commercial applications with IP-based networking and supports multiple application layers on the same network.

True mesh network technology creates a highly reliable, self-healing network.

Thread is future-proof and widely supported by top-tech companies and leading Silicon vendors around the world.

For additional information on Thread and the wireless room solutions, see 'Related documentation [→ 7]'.

Fig. 1: Thread logo

3.2 Thread device types

Thread wireless systems consist at a minimum of the following device types.

Thread border router (TBR)	
 	• Thread border routers (TBR) are the starting point of the wireless network. • TBRs are connected via LAN to a Northbound system (e.g. an Edge device) and form the border between the LAN and the Thread wireless network with an integrated Thread wireless interface. TBRs are comparable to WLAN access points. • One TBR is required for each Thread system to setup a wireless network. • The TBR can be a separate device or integrated on another device (e.g. on the KNX IoT to BACnet/IP gateway). • TBRs are mains-powered (in most cases 230 V or 24 V) and always on.

Thread mesh extender (TME) (optional)	
	• Thread mesh extenders (TME) extend the signal range. They repeat or extend the wireless signal to build strong and reliable mesh networks. • TMEs are similar to WLAN repeaters. • TMEs are mains powered (in most cases 230 V or 24 V) and always on.

Thread end devices (SED and MED)	
	• Most Thread end devices are sleepy end devices (SEDs) and are generally battery-powered. Typical SEDs include wireless room sensors, wireless radiator actuators, or wireless room units. • SEDs connect directly to a TBR or via a TME. • The battery-powered SEDs are optimized for low-power consumption and are usually in low-power/sleep mode. They only wake up periodically for measuring and communication. • Thread end devices can be mains-powered and are not in sleep mode (e.g. mains-powered sensors). They are always available to transmit messages.

For detailed information on the Thread devices, see 'Related documentation [→ 7]'.

3.3 Thread topology

The wireless network starts at the TBR. It is the border between the Thread wireless and Ethernet network at the Northbound Edge gateway. TBRs change the communication media from wireless to wired but have no gateway functionality.

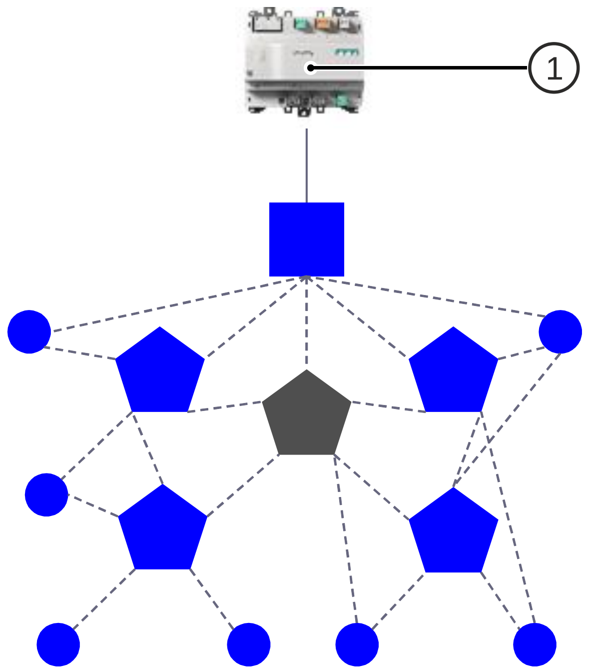


Fig. 2: Typical system topology of a self-healing Thread network

1 Northbound system (e.g. edge gateway)

TBR	TME	SED
Thread leader	Thread link (wireless)	Ethernet link (wired)

The TBR is connected directly to sleepy end devices (SED) and mesh extenders (TME).

TMEs extend the Thread radio range to connect additional TMEs and SEDs located further away from the TBR.

The radio coverage of the TME and TBR may overlap so that some SEDs and TMEs are located within the reception area of more than one TME or TBR. This is not a problem on a mesh network.

During operation, only one radio link is active. The Thread leader identifies the active radio link and the organization of the mesh network. All the TME and TBR devices dynamically elect the Thread leader.

Self-healing

Devices communicate with each other, and channels are automatically allocated, based on usage and noise level (minimizing interference).

For example, a communication failure between two devices because a TME was removed from the Thread network or powered-off: In this case, the Thread network dynamically adapts the radio links to reestablish communication between working devices. The self-healing function makes Thread networks very robust.

See figure below.

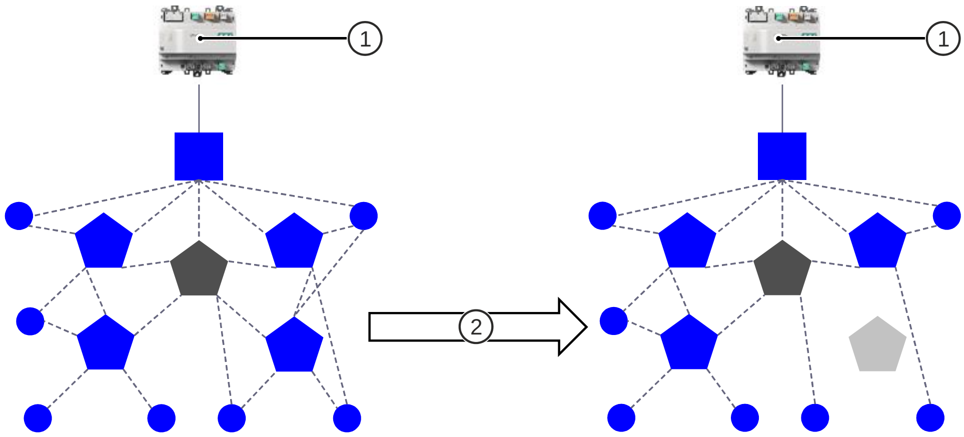


Fig. 3: Self-healing Thread network behavior

1	Northbound system (e.g. edge gateway)
2	Remove TME

TBR

TME

SED

Thread leader

Removed TME

Thread link (wireless)

Ethernet link (wired)

3.4 System topology in the field

The following figure shows a typical system topology in the field: The ground floor at a new school in the final planning phase.

See 'Workflow (planning and installation) [→ 21].

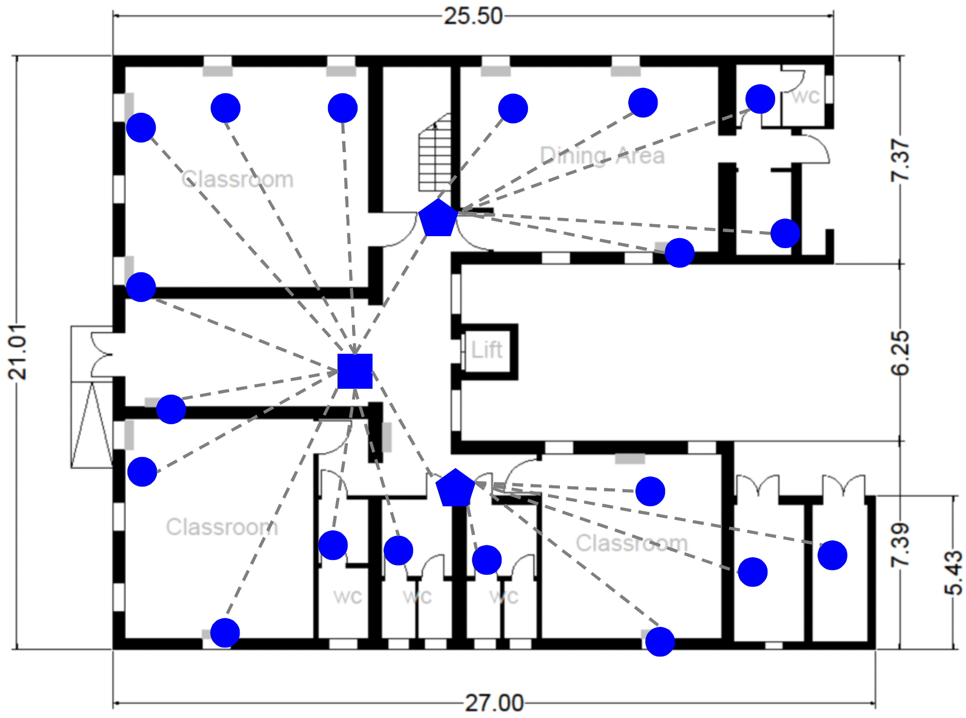
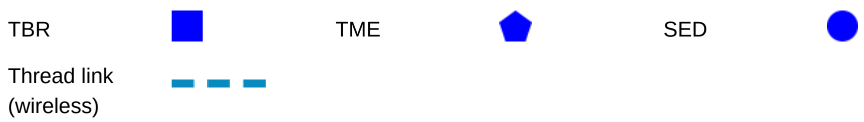


Fig. 4: Typical installation of Thread system topology in the field



3.5 Basic rules on how to set up Thread networks

This chapter lists the 11 most important rules for setting up stable and reliable Thread wireless networks.

Always consider the following when planning, selling, installing, maintaining, or troubleshooting Thread networks:

1. Obstacles reduce Thread wireless signal strength.
2. Metal and thick concrete structures significantly reduce Thread wireless signal strength.
3. Clear lines of sight between devices minimize the damping effect.
4. Environmental conditions can change over time.
5. Other wireless technologies can cause interference.
6. Mounting wireless device higher minimizes the damping effect.
7. Always plan network overlap.
8. Low link quality and low signal strength adversely affect stability and shorten battery life.
9. Comply with all system limits to improve operation.
10. Use off-the-shelf tools to plan, install, test, and troubleshoot wireless systems.
11. Conduct a site acceptance test after installation. Have the customer confirm the results and approve the installation.

3.6 Obstacles

An obstacle is a physical object that hinders the passage of the Thread radio signal.

Place Thread devices in a clear line of sight between devices as much as possible.

Typical obstacles:

- Fire safety zones, walls, and doors
- Concrete structures (e.g. elevators, staircases)
- Kitchens and bathrooms
- Standing water
- People

The following chapters go into greater detail on the obstacles and how they impact signal strength. They also give suggestions on how to mitigate the impact.

For additional information on the damping effect refer to the Wireless basic training. See 'Related documentation [→ 7]'.

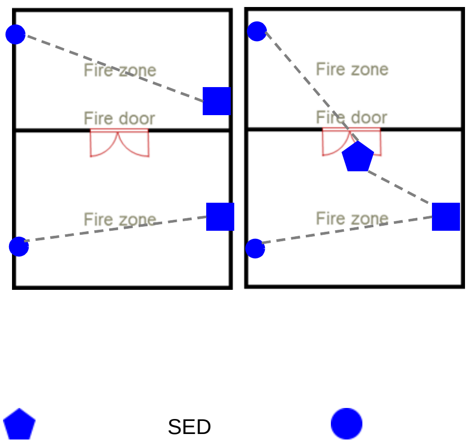
3.6.1 Fire safety zones, walls, and doors

Fire safety zones in buildings are separated by fire walls and fire doors to prevent a fire from spreading.

Fire safety doors have a significant negative effect on wireless signal strength. To minimize the damping effect, consider the following:

- Install separate TBRs for each fire zone, where possible.
- Install TMEs where the above is not possible, but remember:
  – Install TMEs as close to the fire safety doors as possible to increase signal strength at the fire safety door.
  – Place Thread devices in a clear line of sight to one another.
  – Where possible, place TMEs above the top edge of the fire safety door to permit as much of the signal as possible pass by the fire door.

    For additional information on the mounting heights see 'Installation [→ 40]'.
- Close all doors, especially the fire safety doors, before measuring signal strength for the most accurate measurements (particular in the event of a worst case scenario, e.g. fire).

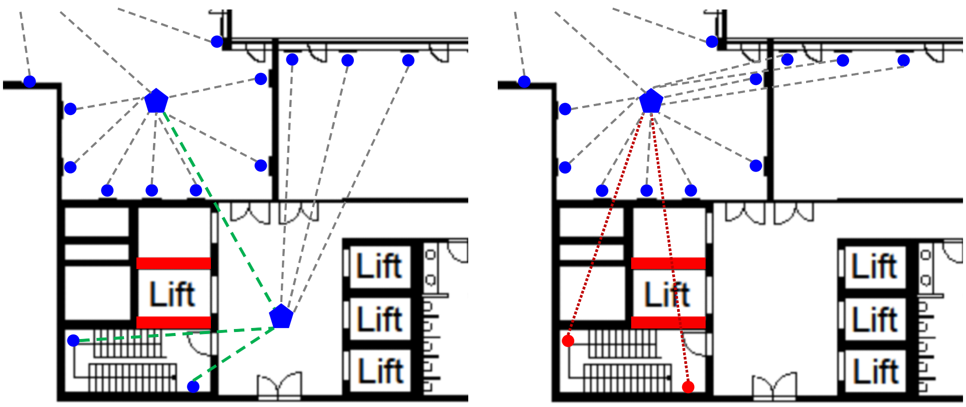


3.6.2 Concrete structures

Building codes often require concrete walls for elevator shafts and staircases; the walls hinder wireless communication. We recommend adding an extra TME per area to mitigate this.

The following figures show correct (left) and incorrect (right) TBR positioning near concrete structures.

Recommended **Not recommended**



Recommended setup for concrete structures

TBR	SED	Obstacle wall
Successful connection	Failed connection	

3.6.3 Kitchens and bathrooms

Walls with water (pipes, drainage, etc.) in kitchens or bathrooms can significantly lower signal strength. Connecting devices through walls containing water lower signal quality, whereas connecting devices parallel to the same walls does not.

Where possible, avoid placing TMEs that need to communicate through walls containing water. An extra TME is needed in this case, placed in a clear line of sight to the next device.

Figures a) and b) below illustrate connections through walls containing water. In figure b), an extra TME is added to improve signal strength.
Conversely, figure c) illustrates a connection that runs through a wall parallel to the water installations (no extra TME required).

a) b) c)

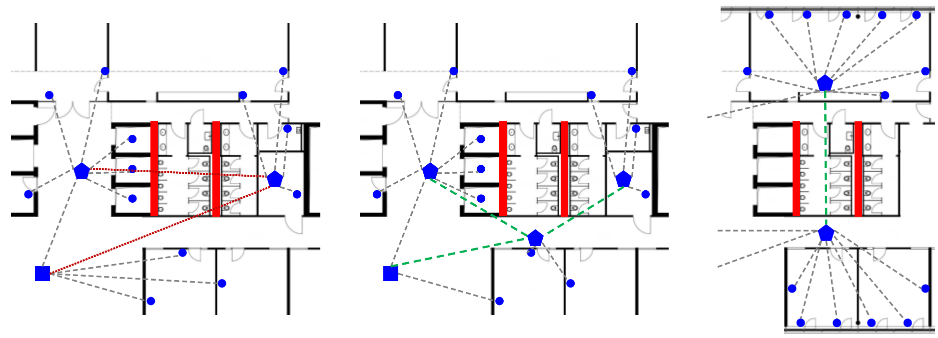


Fig. 5: Recommended setup for kitchens and bathrooms

TME	TBR	SED
Obstacle wall	Failed connection	Successful connection

3.6.4 Large metal or copper structures

Large metal or copper structures, such as metal ceilings, vending machines, conduit boxes, fridges, elevators, or convoluted cables lower Thread signal strength.

For additional information on the damping effect of different materials, see 'Damping effect of materials [→ 16]'.

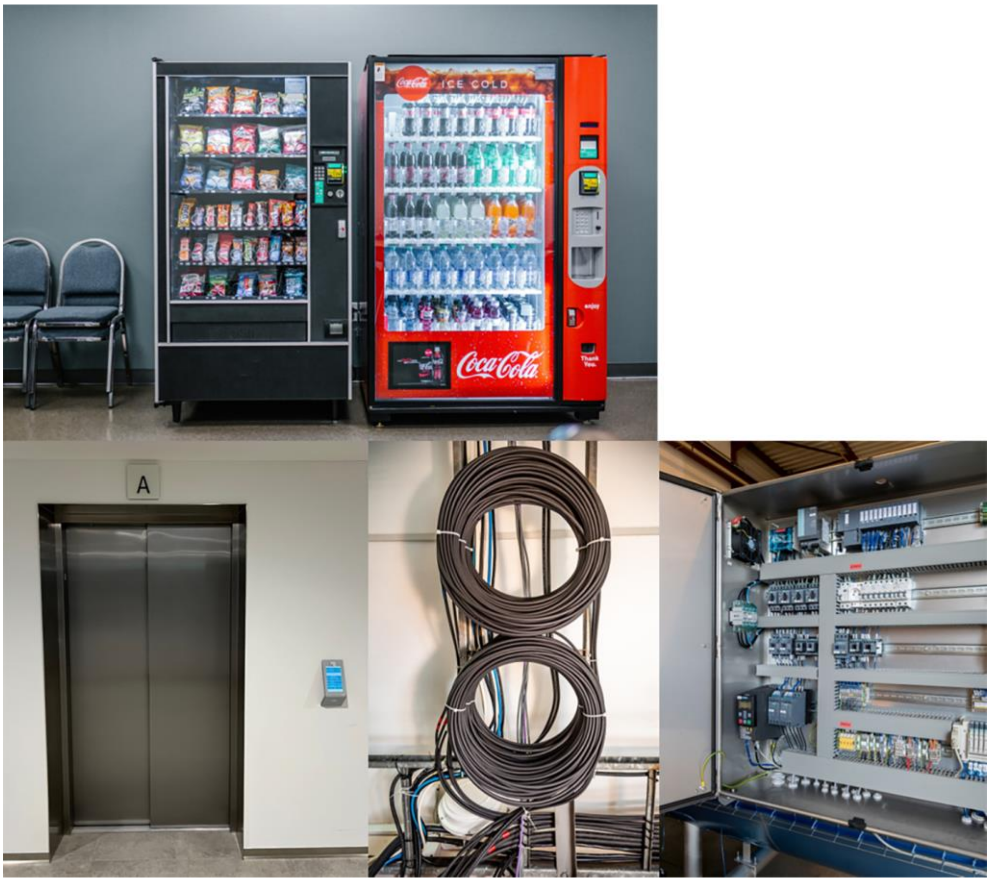


Fig. 6: Large metal or copper structures

3.6.5 Dynamic obstacles

Metal claddings and cupboards, furniture, or electronic devices, such as TV screens, can diminish communication quality.

Obstacles are displayed on the operation dashboard. To avoid device connection through obstacles, add an extra TME or TBR, where necessary. Avoid placing TMEs close to obstacles and place Thread devices in a clear line of sight between devices.

Empty shelves can be filled with material, open doors may be closed, or empty spaces can become crowded with people during normal operating hours, all of which lower signal strength on the network. See figure below.

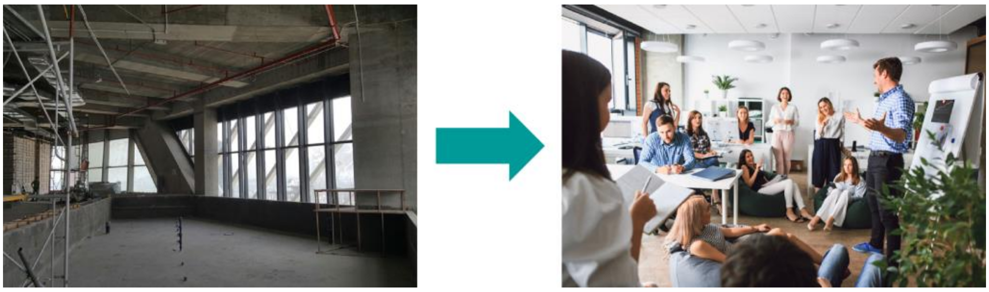


Fig. 7: Dynamic obstacles: Planning/installation vs. operational phase

3.6.6 Damping effect of materials

Concrete structures, metal, and water significantly impact signal strength.

Other materials such as wood, plywood, and glass have only a negligible impact on signal strength and are not considered as obstacles for the planning process.

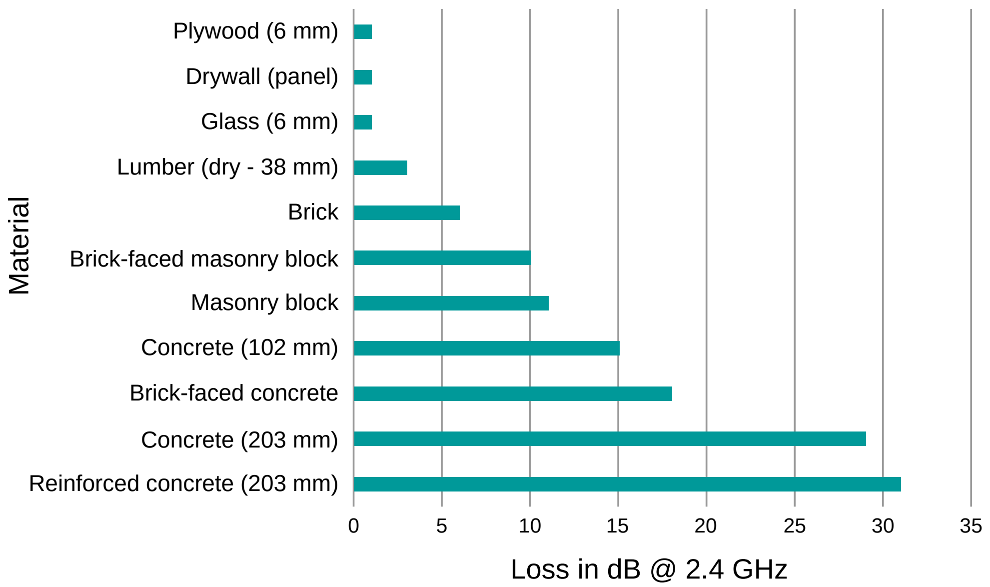


Fig. 8: Damping effect of different materials

Consider the following to minimize damping:

- Keep wireless communication to a single floor as much as possible and avoid staircases, or thick walls in concrete buildings.
- Place Thread devices in a clear line of sight between devices.

3.7 Interference

Information is transmitted on mesh networks via electromagnetic waves.

Other wireless (communication) systems can also emit electromagnetic waves and interfere with the Thread radio signal.

Typical systems that may cause interference are:

- WLAN access points or repeaters
- Computers or mobile phones with active WLAN or Bluetooth connection
- Other wireless networks (e.g., Zigbee networks, smart door locks, etc.)
- Mobile network antennas or repeaters
- Microwaves
- Fridges

The following chapters describe potential interference and how to minimize it.

3.7.1 WLAN access points

WLAN access points generally operate on the same frequency band as Thread (2.4 GHz) and may directly interfere with the Thread radio signal.

As a rule, WLAN only minimally interferes with signal strength on a Thread network since Thread operates outside the normal WLAN frequency band (by default over channel 25 or channel 26).

However, a crowded incorrectly configured WLAN network can significantly affect the Thread radio communication.

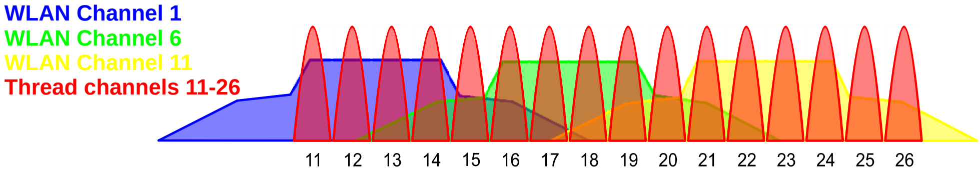


Fig. 9: WLAN and Thread channel overlapping

For additional information on interference from WLAN, Thread and Zigbee networks see 'Wireless basics training' and 'ZigBee and WLAN coexistence'. See also 'Related documentation [→ 7]'.

Consider the following measures on highly crowded networks (as shown in the figure below):

- Use WLAN channels 1 and 6 for WLAN devices.
- Free up WLAN channel 11 and configure the Thread network to channels 25 or 26, so that the Thread network has sufficient frequency spectrum to establish a stable and reliable communication.
- Do not mount TBR, TME, and SED devices directly next to WLAN access points or repeaters.
- Separate TBR, TME and SED devices from each other as far as possible.
- Move some WLAN services to 5 GHz range to free up part of the spectrum in the 2.4 GHz range for Thread.
- See if devices operating on WLAN, such as WLAN repeaters, WebEx conference stations, smart/digital white boards, may also be operated over Ethernet.

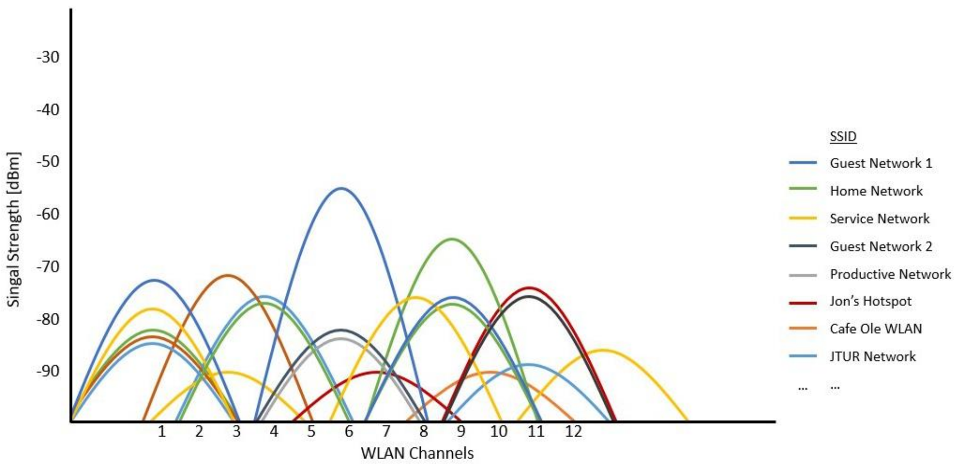


Fig. 10: Network scan of crowded WLAN infrastructure

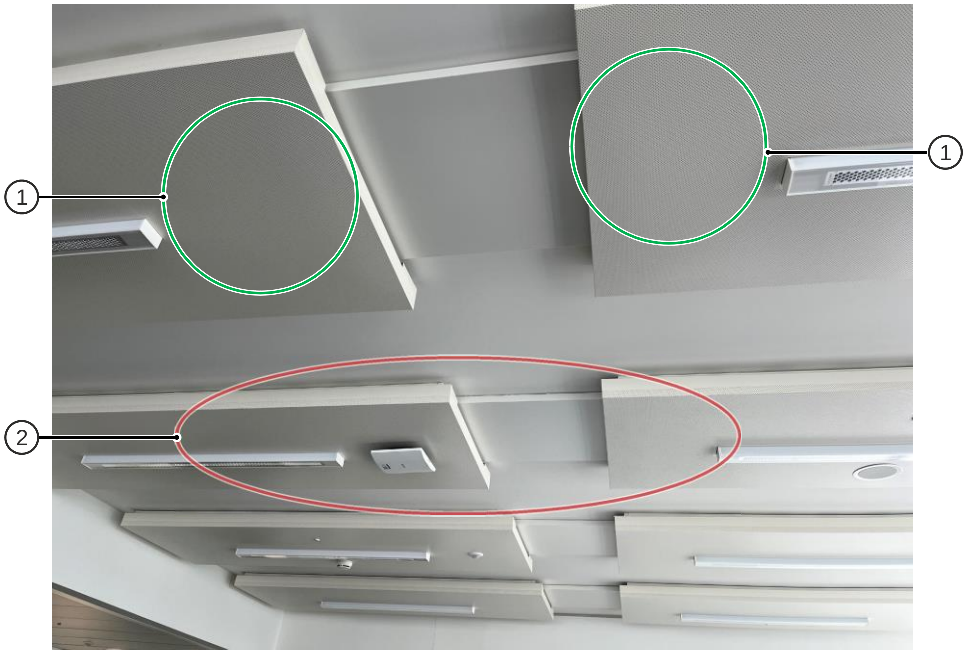


Fig. 11: Mounting location next to WLAN access points

1	Recommended mounting location (enough distance to WLAN access point)
2	Not recommended mounting location (too close to WLAN access point)

3.7.2 Devices with active WLAN and Bluetooth connection

Devices with active WLAN and Bluetooth connections, such as computers, mobile phones, tablets, and headphones, usually operate on the same frequency band as Thread devices.

In other words, every wireless end device communicating with WLAN or Bluetooth causes additional interference.

For additional information on WLAN, see 'WLAN access points [→ 17]'.

Fig. 12: WLAN and / or Bluetooth interference

3.7.3 Other wireless networks

The following wireless networks may also interfere with Thread radio signal:

- Lighting solutions operating via Zigbee or Z-Wave
- Mobile networks or mobile network repeaters

- Smart door locks or locker systems operating via WLAN
- Other sensor networks operating via Zigbee or LoRaWAN
- Proprietary radio technology

Fig. 13: Interference caused by other wireless networks

Consider the following in areas with a high level of interference on the wireless networks:

- Do not mount devices next to each other.
- Remove any unused devices where appropriate.
- Optimize the communication channels on other wireless device networks and WLAN networks.

3.7.4 Microwaves, fridges, and other electronic devices

Large electronic devices, such as vending machines, fridges, and especially microwaves that use electromagnetic waves to heat up food and beverages, may also cause interference.

Fig. 14: Interference by microwaves, fridges and other electronic devices

4 Workflow (planning and installation)

Visit the building on-site before starting the planning process to identify any differences between the floor plan and the actual operational environment.

Note all differences and obstacles on your floor plan.

For detailed information on obstacles, see 'Obstacles [→ 13]'.

The following flowchart lists the main steps. Plan and install your Thread wireless system according to this workflow.

The workflow steps also correspond to the chapters in this document.

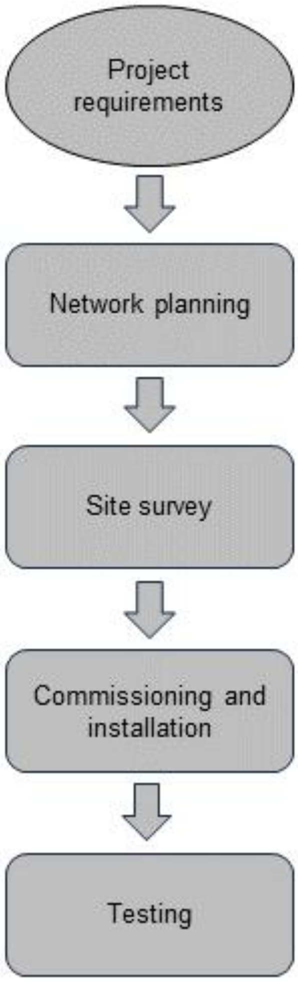


Fig. 15: Planning and installation workflow

5 Planning (off-site)

This chapter describes how to create Thread network plans based on system limits, and start identifying potential locations for the TBR, TME, and SED devices.

5.1 System limits

Always comply with system limits when designing wireless systems. Remember that system limits are normally based on optimum performance/conditions, and each subsystem has its own limits.

For details on KNX IoT Thread system limits, see 'Related documentation [→ 7]', document A6V14455022.

5.1.1 Thread radio range

The distance between SEDs and TMEs or the TBR must be well within the Thread signal range.

The Thread signal range in buildings is between 15 m and 50 m, depending on the individual building conditions.

As a rule of thumb, the Thread radio range between two Thread devices[1] is:

Range (R) = 30 m

[1] SED to TME / SED; TBR / TME to TME;

On all the calculation and planning steps in this document assume a range (R) = 30 m.

The circles below represent the radio range of the devices. Where the TBR and TME devices are cascaded, the cascading devices must be within each other's field.

Range (R) = 30 m

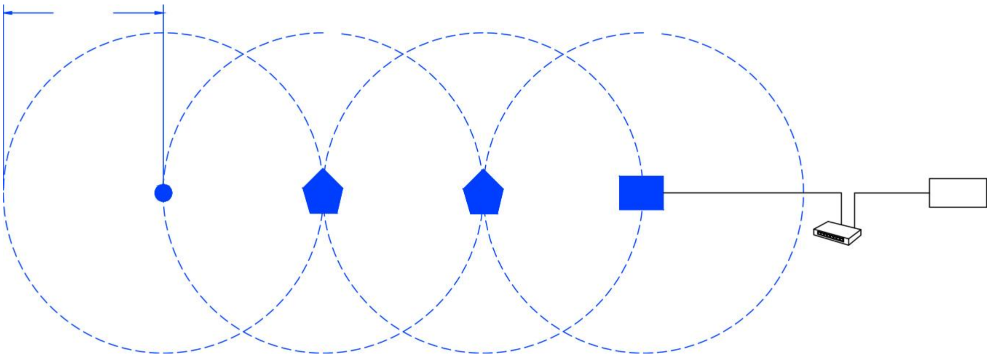


Fig. 16: Radio/signal range between Thread devices

SED		TME		TBR	
Wireless range		Wired connectio n			

5.1.2 Hops between TME devices

A hop is a segment of the path between routers. Data passes from one network device to another.

The hop count refers to the number of devices through which data passes, starting from source (TBR) to the destination (end device).

The maximum recommended number of hops in a Thread system is 4 so that the maximum recommended number of TMEs between a TBR and an end device is 3.

The Thread system still operates if the maximum number of 4 hops is exceeded but system stability noticeably deteriorates beyond 4 hops.

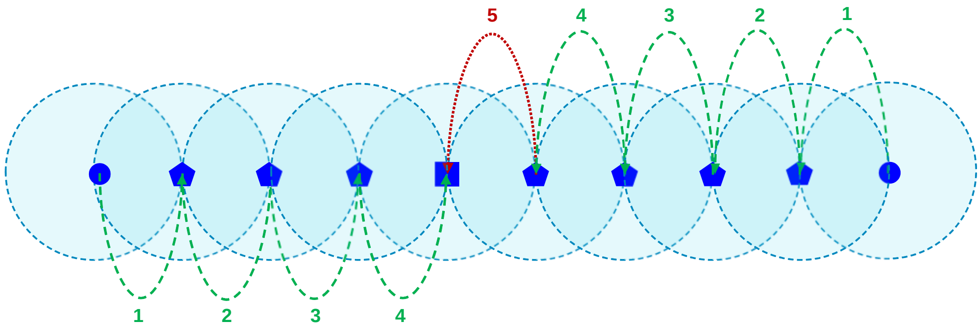
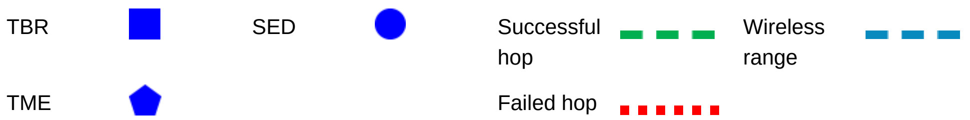


Fig. 17: Maximum number of hops in a Thread system



5.2 Gathering available information

Gather the following information before planning a Thread network.

Relevant information includes (by floor):

- Floor plan
- Walls
- Standing water
- Furniture
- People density over time
- Shelves, desks, vending machines
- Microwaves
- Other wireless systems, such as WLAN, Zigbee, mobile networks
- Other obstacles or possible sources of interference for wireless communication

Visit the building to identify any differences between the floor plan and actual conditions.

Note any differences and possible obstacles on your floor plan.

For additional information on obstacles, see 'Obstacles [→ 13]'.

Perform an on-site scan to find any source of interference and existing WLAN networks using the 2.4 GHz band of a Thread wireless system.

For additional information, see 'On-site scans [→ 31]'.

5.3 Building floor plans

Thread technology automatically provides reliable and continuous network operation as well as self-healing and dynamic routing.

However, Thread devices must be installed manually during the basic planning. Every SED device has to be within the radio range of a TBR or TME to establish reliable wireless communication.

For detailed information on TBRs, TMEs and SEDs, see 'Thread device types [→ 9]'.

Use building floor plans as a basis for the planning process prior to installation. The floor plan can be on paper, PDF, CAD, or another format. Use a digital tool where possible as the floor plan will likely be edited multiple times during the process and shared with the customer at a later stage.

The following sections outline basic planning for Thread devices.

The figure on the left shows the theoretical planning principle based on a generic simplified floor plan, while the figure on the right demonstrates planning principles applied on a real floor plan.

Generic simplified schema **Real floorplan**

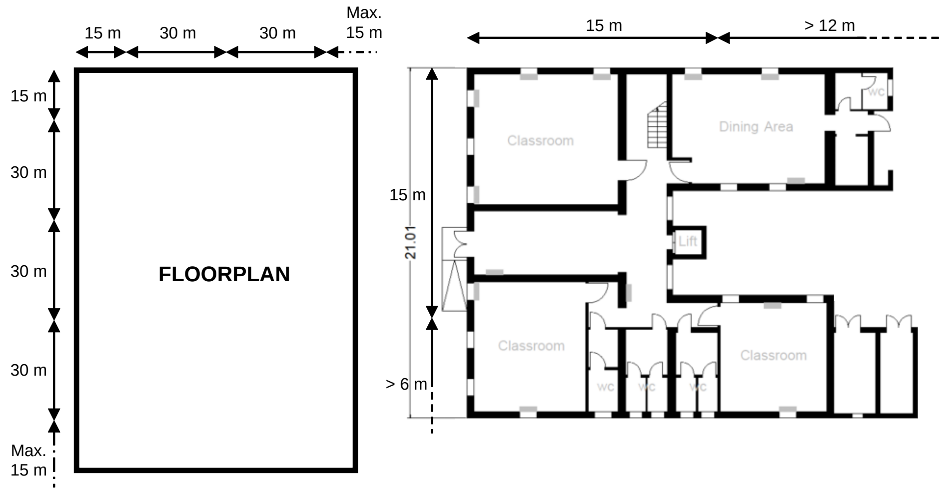


Fig. 18: Wireless planning with generic simplified scheme and real floor plan

5.3.1 Locating SED devices in the floor plan

Mark the location of every SED in the floor plan (e.g. wireless room sensor, radiator actuator, room unit, etc.) as shown in the figure below.

The grid points mark the positions of the TBRs and TMEs (without obstacles).

See 'Drawing the grid [→ 25]'.

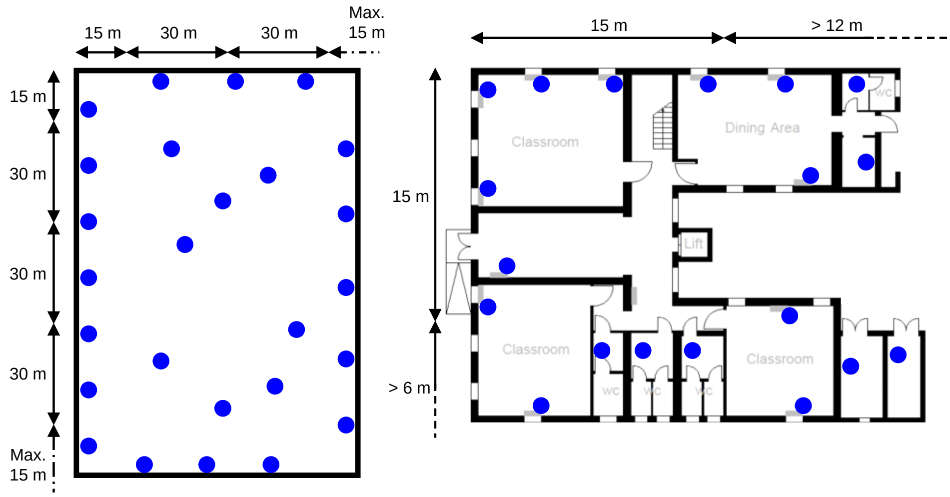


Fig. 19: End device location in floorplan

5.3.2 Drawing the grid

Draw the grid with horizontal and vertical lines at a distance of 30 m to the preliminary TME and TBR locations, starting in the top left corner of the floor plan.

Start the planning grid at 15 m from the building's walls and then continue to create a grid of R = 30 m x 30 m. This prevents 'dead spots' or zones in building corners.

Not recommended | Recommended

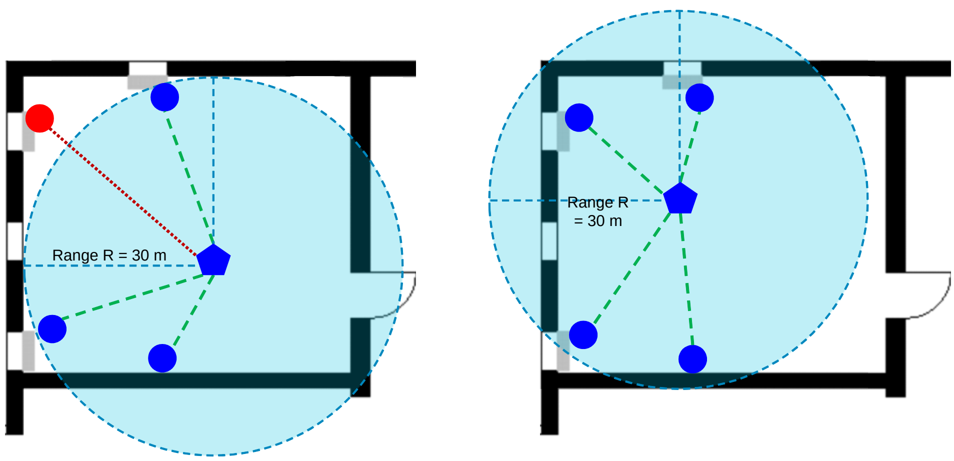


Fig. 20: Possible 'dead spots' in building corners

TME		Successful connection, in range		Wireless range	
SED		Failed connection, out of range		SED out of range	

The figure below is an example of grid planning.

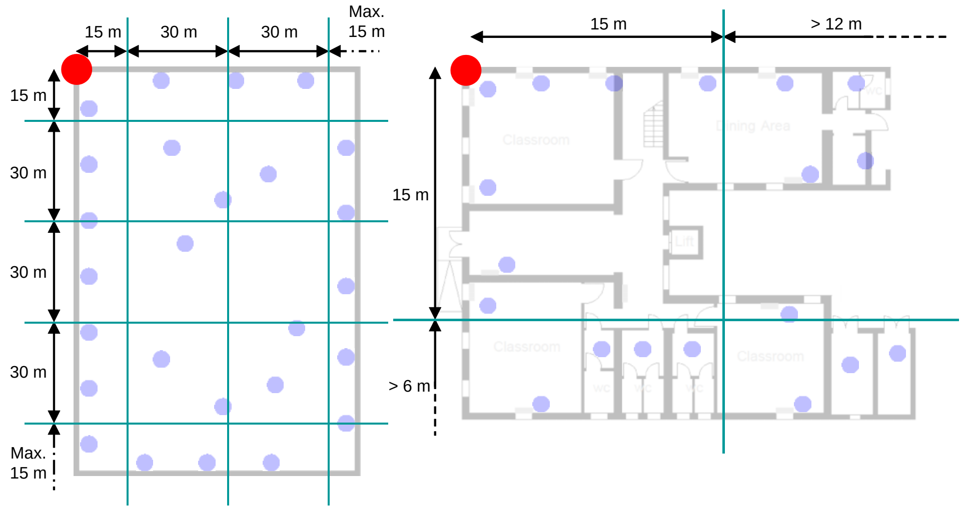


Fig. 21: Floorplan with initial planning grid

Starting position for grid

SED

Planning grid

5.3.3 Marking preliminary TME or TBR locations

The grid's intersections mark the preliminary TME or TBR locations for a powerful mesh network. Note there are virtually no gaps in coverage.

See figures below.

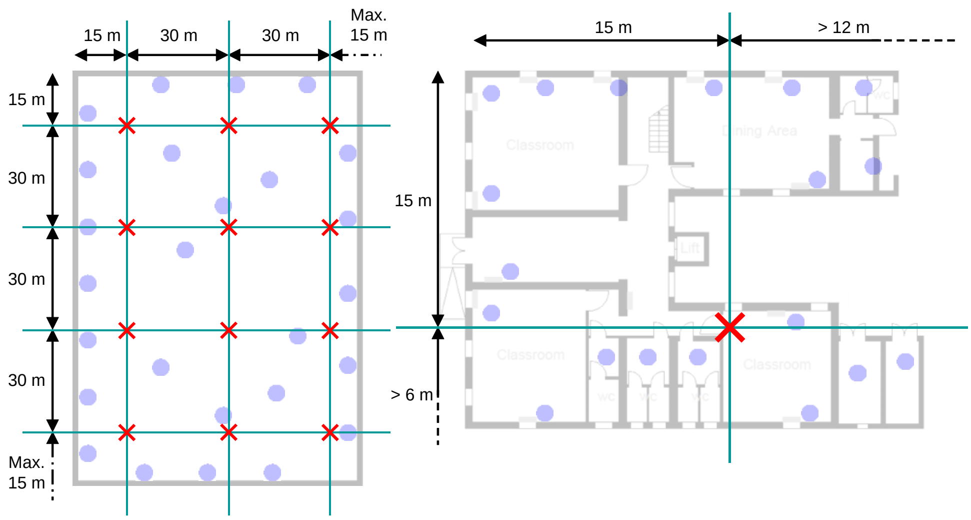


Fig. 22: Floorplan with planning grid and preliminary TBR and TME locations

Planning grid

Possible position of TBR/TME

SED

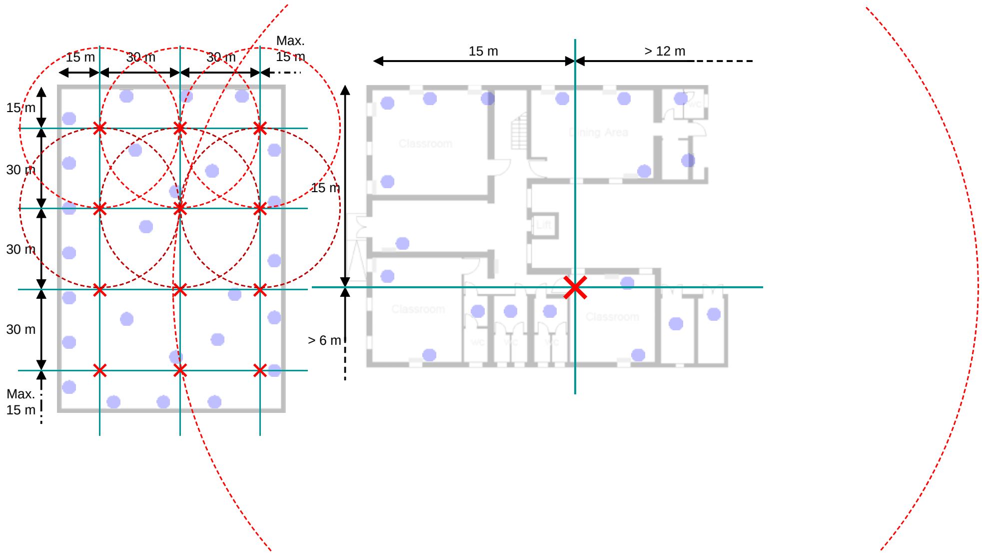


Fig. 23: Floorplan with planning grid preliminary TBR/TME locations and radio range

Planning grid

Possible position of TBR/TME

SED

5.3.4 Highlighting obstacles

Review the floor plan and identify any possible obstacles, e.g. elevator shafts, concrete walls, vending machines, staircases, etc., based on customer feedback as well as the on-site visit. Mark any large obstacles on the floor plan. See figure below.

For additional information on obstacles, see 'Obstacles [→ 13]'.

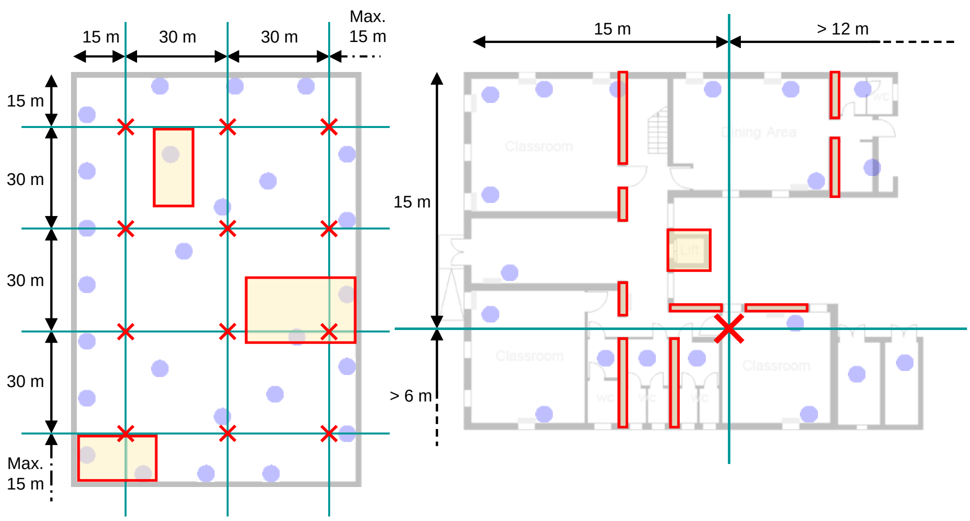


Fig. 24: Floorplan with highlighted obstacles

Planning grid

Possible position of TBR/TME

Obstacle area

SED

5.3.5 Adjusting the preliminary TME or TBR locations

Adjust the positions of the TMEs or TBRs to account for existing obstacles.

For example, if the preliminary TME/TBR location is in a corner, behind a wall or directly next to an existing WLAN access point, adjust the TME/TBR position to improve Thread signal coverage. Recheck to ensure that SEDs stay within TME/TBR signal range.

The figure below indicates that some TBRs and/or TMEs must be moved to account for obstacles, walls, or the lack of power and/or Ethernet connection. Move the TBRs and/or TMEs to locations with a clearer line of sight, and a location free of obstacles. Check for 230 V and Ethernet ports at the new location.

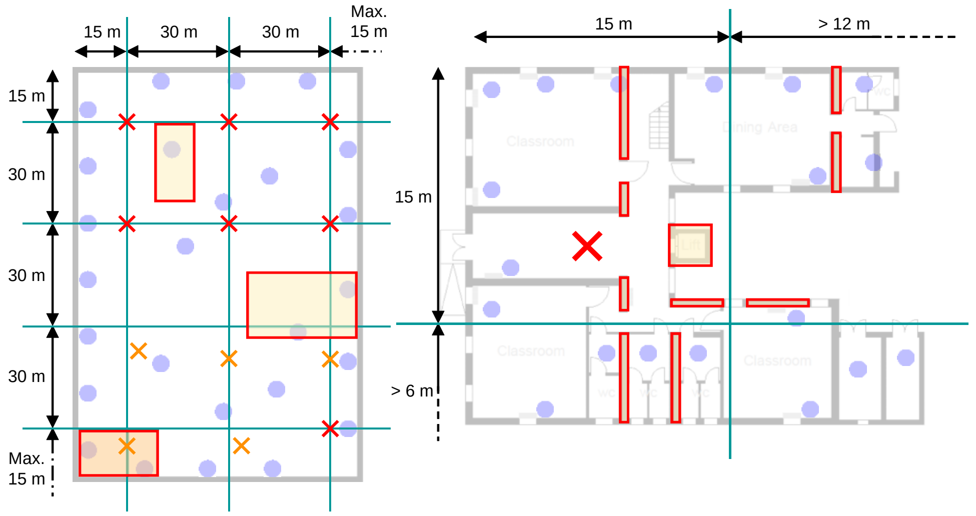
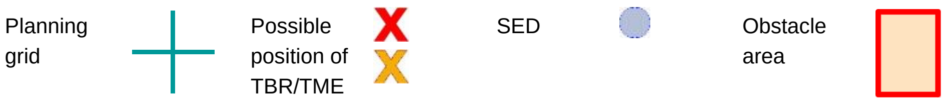


Fig. 25: Floorplan with adjusted preliminary TBR and TME locations



5.3.6 Planning additional TME or TBR devices

You can plan additional TBRs and TMEs as needed to close any gaps in Thread coverage.

Draw in additional TBR and TME locations in the floor plan. Make sure that 230 V power sockets and Ethernet connection are available.

The figure below shows TBRs and TMEs that are out of range, after the grid was adjusted. Obstacles can deteriorate signal quality to the point that communication between TBRs and TMEs is no longer reliable.

Add extra TBRs or TMEs to account for devices behind obstacles.

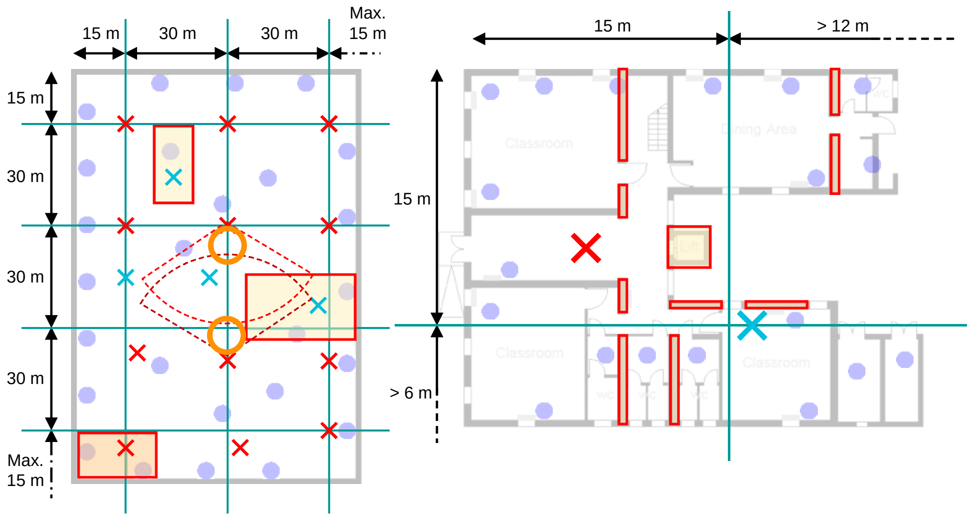


Fig. 26: Floor plan with additional TBRs and TMEs

Planning grid

Possible position of TBR/TME

SED

Obstacle area

TBR/TME out of range

Range of TBR/TME

5.3.7 Locating the TME and TBR devices

Decide in advance where to install TBR or TME devices. Note the device locations and type on the floor plan. See figure below.

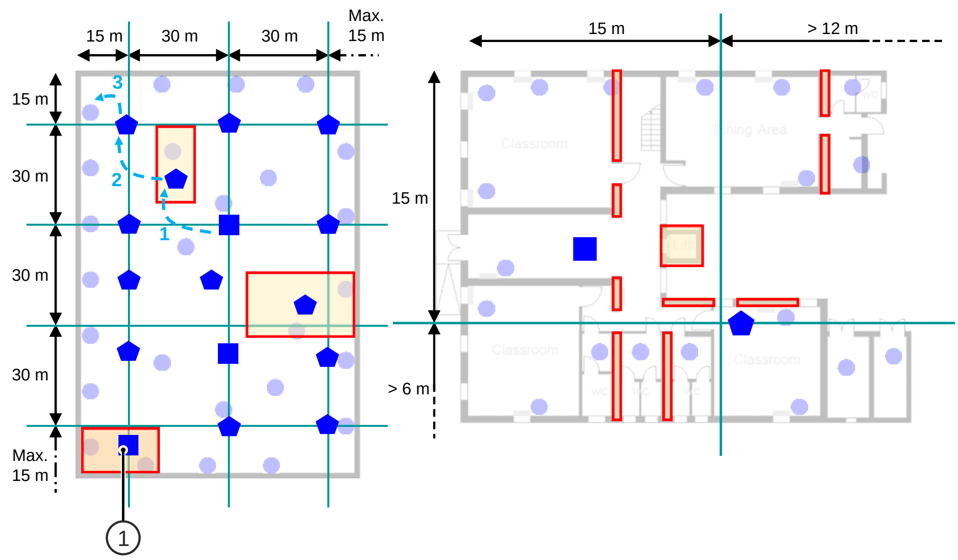


Fig. 27: Floor plan with defined TBR and TME locations

1 Separate TBRs are useful in case SEDs are in detached obstacle areas (isolated rooms) with high damping effect, where they can hardly be reached from outside.

TBR

TME

SED

Planning grid

Obstacle area

Consider the following:

- TBRs are slightly more expensive than TMEs.
- TBRs require 230 V power and an Ethernet connection.
- TBRs expand the Thread range via Ethernet to Thread connection, similar to WLAN access points.
- The Thread network requires at least one TBR.
- Max. 20 devices (SEDs and TMEs) can be connected to a single TBR.
- TBRs render your Thread network more robust due to a direct Ethernet connection to the Northbound system. This means:
  - TMEs do not increase latency nor hops.
  - Ensure no obstacles are in the line of sight of the Edge gateway (interference, strong damping due to concrete, metal, or fire protection doors).
- TMEs only need one 230 V power socket.
- TMEs expand the Thread range via Thread-to-Thread connection, similar to WLAN repeaters.
- The maximum recommended number of hops in a Thread system is 4, or 3 TMEs between a TBR and an end device. See also 'Hops between TME devices [→ 22]'.

5.4 Reviewing the final Thread network off-site plan

Review the final Thread network off-site plan after the planning phase and recheck one last time after completing the following steps:

- Draw the preliminary grid and the TME/TBR locations
- Identify obstacles
- Adjust the TME/TBR locations
- Plan additional TME/TBR locations
- Decide if TMEs or TBRs can be used at the identified locations

Mark or note possible exceptional cases to verify them on-site. See figure below.

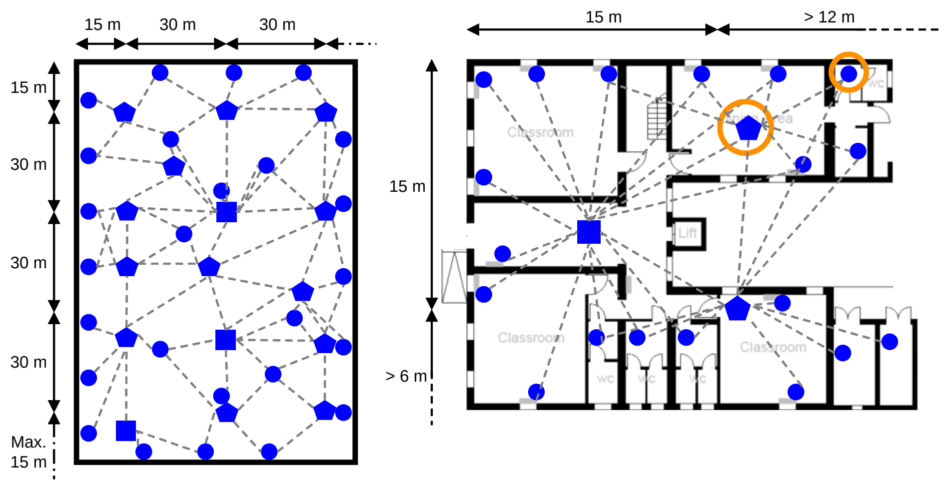


Fig. 28: Final Thread network plan after on-site verification

6 Site survey

A site survey is conducted to verify the preliminary network plan.

6.1 Performing a site survey

Inspect the installation locations on-site and verify your Thread network plan.

Verify the following during the site survey:

- Is access to 230 V power and to Ethernet network available and within max. cable reach?
- Is the next device in a signal path visible from the previous device? Is there a clear line of sight without any obstacles between devices?
- Are there any changes or obstacles you did not consider in your off-site planning? For additional information on obstacles see 'Obstacles [→ 13]'.
- Are there any other wireless networks or devices which can cause interference? For additional information on interference see 'Interference [→ 17]'.
- Is the Thread signal strength sufficient?
- Is the Thread network planning robust enough for an operational building (with more people, wireless devices, etc.)?

Document the network to include device details, location, and photographs from the planning phase to the final deployment.

6.2 On-site scans

Consider the following steps:

- Install a WLAN network analyzer tool on your Windows PC or Android smartphone.
  For additional information on the WLAN Analyzer, see 'Related documentation [→ 7]'.
- Start scanning for WLAN SSIDs on-site.
  You can begin to get a general idea of network load on the 2.4 GHz band based on the number of identified SSIS.

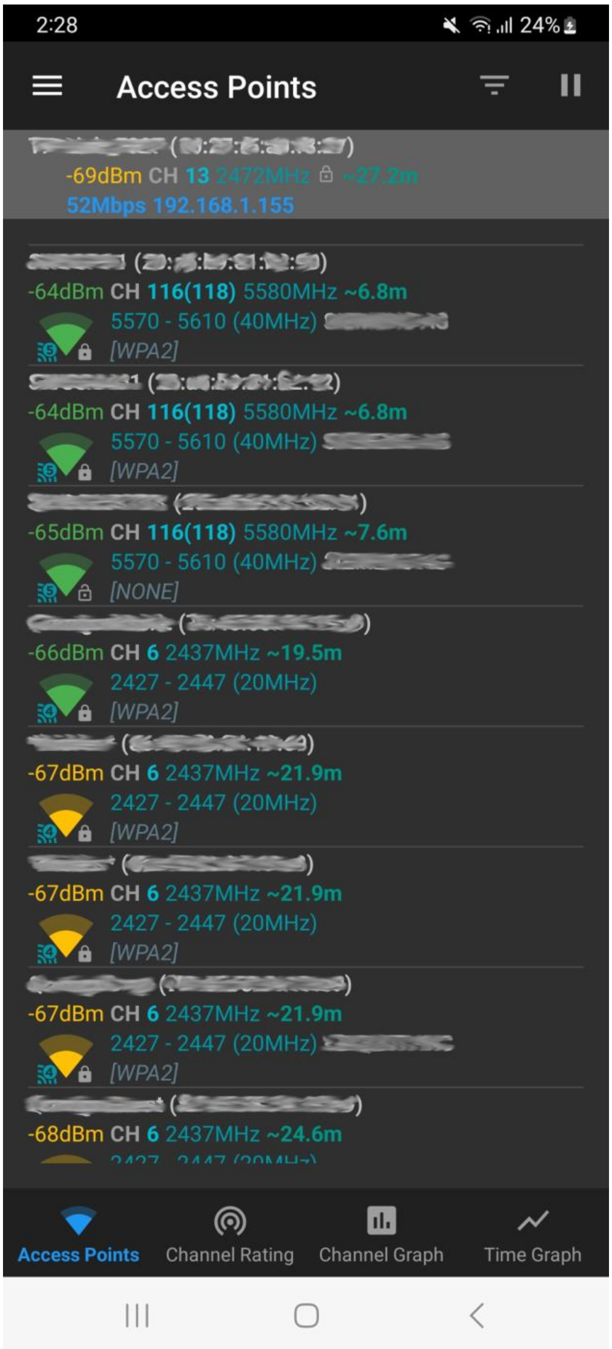


Fig. 29: SSID scan with WLAN Analyzer for Android

- Start scanning for WLAN channel usage.
  The load on specific WLAN channels and signal strength help identify potential channels for the Thread network.

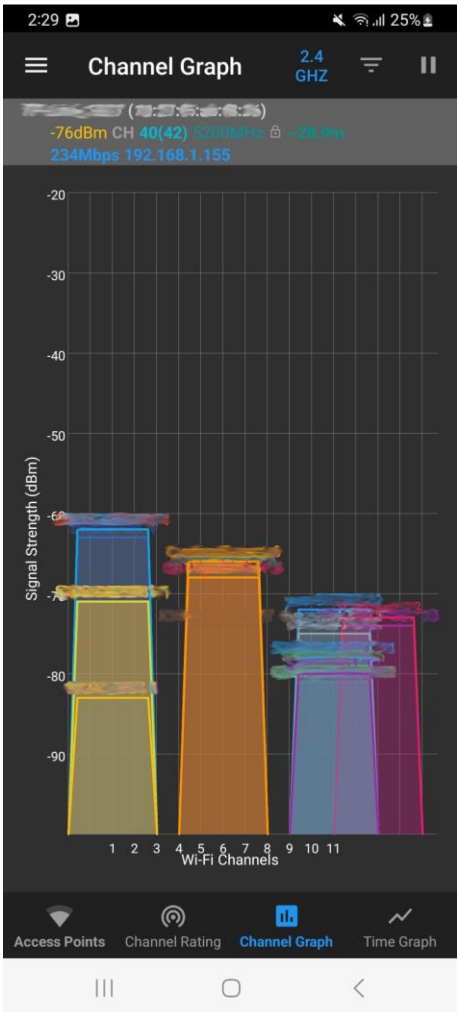


Fig. 30: WLAN channel usage scan with WLAN Analyzer for Windows

The figure below illustrates WLAN and Thread channels overlap.

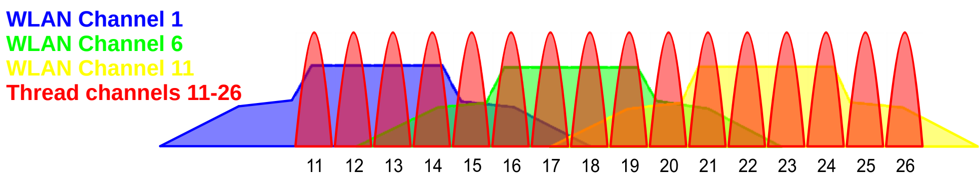


Fig. 31: WLAN and Thread channel overlapping

Better on-site interference analysis results can be achieved with professional hardware and software, e.g. from Metageek, see 'Related documentation [→ 7]'.

6.3 Performance parameters

Reliable wireless communication requires high signal strength.

Signal strength depends on many factors, such as applications, data rate and background noise. High noise levels minimize the performance of wireless signal strength.

The signal-to-noise ratio (SNR) refers to the power ratio between the signal strength and the noise level.

6.3.1 Signal strength and radio conditions

The signal strength is measured in decibels relative to a milliwatt and is represented in –dBm format (0 to -100). The closer the value is to 0, the higher the signal strength. See figure below.

Signal strength	Radio condition
-30 dBm	Near maximum Thread signal strength. Achievable only very close to the source.
-67 dBm	Good radio conditions for high bandwidth applications.
-70 dBm	Minimum signal strength for reliable packet delivery.
-80 dBm	Minimum signal strength for connectivity. Packet delivery may be unreliable.
-90 dBm	Signal too weak to be useful – considered as noise.

The required signal strength depends on the application. Building automation networks use a narrow bandwidth so that signal strength normally suffices.

Typically, the signal strength for Thread systems ranges from -30 dBm to -100 dBm.

The signal strength of Thread radio communication is most accurately expressed in milliwatts (mW). However, as the transmision power of Thread and other wireless communication technologies, such as Zigbee, WLAN and others, is rather low, it would be difficult to read signal strength in mW. Therefore, the signal strength is measured in –dBm.

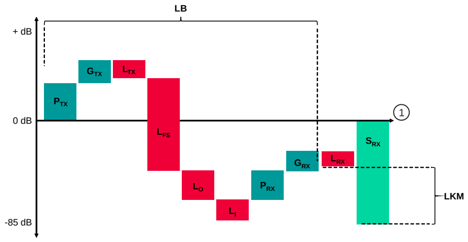
6.3.2 Link budget and link margin

Link budget (LB) calculates the transmitting power gains and losses that a communication signal experiences in a telecommunication system. It describes the delta between the power transmitted through a communication medium, such as air or a cable versus the received power.

Link margin (LKM) is measured in dB and describes the difference between the minimum signal power that is expected at the receiver and the minimum sensitivity of the receiver to read communication signals. The minimum sensitivity of the receiver refers to the signal power at which the receiver stops working reliably.

In a Thread system, a LKM of 20 dB, in exceptional cases 15 dB, must be planned to ensure that the system still works in case of extra signal loss.

The figure below shows the relevant power gains and losses and the resulting link margin in a Thread wireless communication.



Link budget and link margin

① Transmission path

P_{TX} = Transmitter power (dBm)

G_{TX} = Antenna gain of transmitter (dBi)

L_{TX} = Losses at transmitter (dB), (e.g. housing, coax, connectors, cables)

L_{FS} = Free space loss (db)

L_{O} = Obstacle loss (db), (e.g. wall, door, window)

G_{RX} = Antenna gain of receiver (dBi)

L_{RX} = Losses at receiver (dB), (e.g. housing, coax, connectors, cables)

P_{RX} = Receiver power (dBm)

S_{RX} = Receiver sensitivity (dBm)

LKM = Link margin (dBm)

LB = Link budget (dBm)

Calculating link budget and link margin

The link budget helps estimate signal levels.

Perform the steps below, taking a typical receiver sensitivity (SRX) of between 90 dBm and 106 dBm for a Thread component to calculate link budget and margin in a Thread system.

- Add the transmitter and receiver output power of your Thread devices. Typically, these are values between 6 dBm and 10 dBm.
- Subtract the signal loss in free space (L_{FS}). This can be calculated with the free space loss online calculator, see 'Related documentation [→ 7]'.
- Enter the distance of your device in meters.
- Enter 2400 MHz for the frequency.
- Set the transmitting antenna gain (GTx) to 0.
- Set the receiving antenna gain (GRx) to 0.
- Subtract the signal loss in obstacles. This can be calculated using the diagram in 'Damping effect of materials [→ 16]'.
- Subtract the signal loss due to interference (difficult to calculate). Ideally, avoid direct interference with other radio signals. For additional information, see 'Signal to noise ratio [→ 37]'.

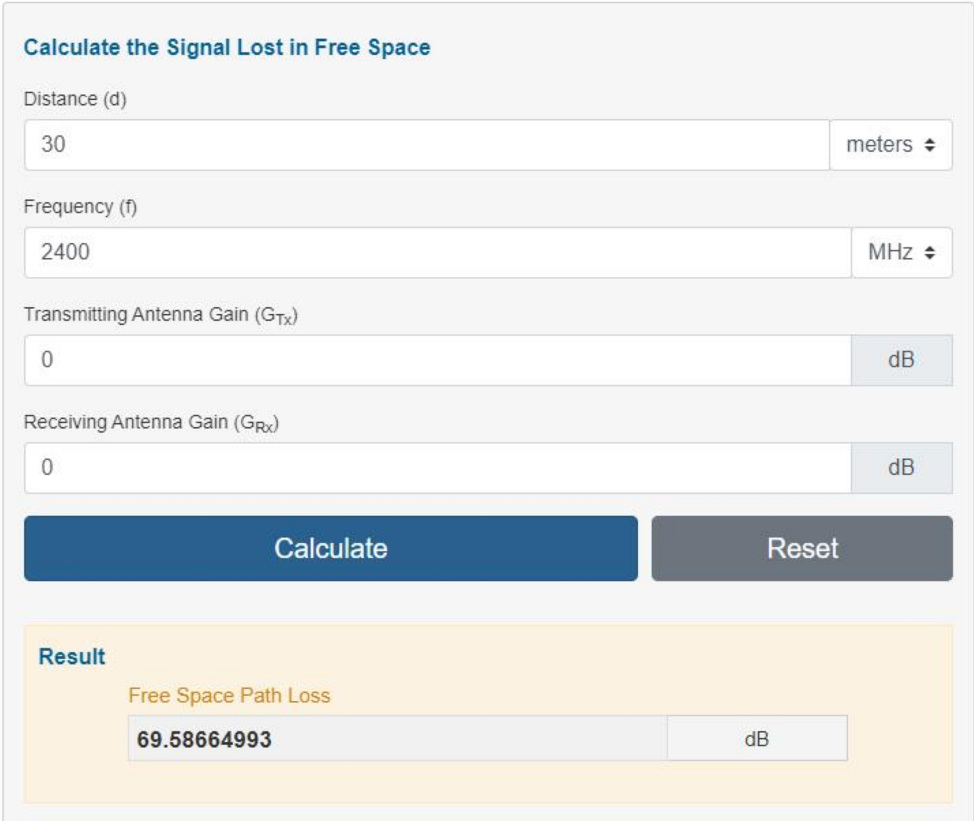


Fig. 32: [Free Space Path Loss Calculator (FSPL) - everything RF]

The resulting number is your link margin (LKM) in dBm. Your Thread system will be reliable and stable if the link margin is higher than 20 dBm.

NOTICE	
!	This is a theoretical calculation. Real world scenarios may differ.

$$S_{RX} + \overbrace{P_{TX} + P_{TX} - L_{FS} - L_{O} - L_{I}}^{LB\ \ -60\ dBm} = LKM$$

S_{RX}	P_{TX}	P_{TX}	L_{FS}	L_O	L_I	LKM
85 dBm	8 dBm	8 dBm	62 dB	8 dB	6 dB	25 dBm

Fig. 33: Example of link margin calculation

S_{RX} = Receiver sensitivity (dBm)
P_{TX} = Transmitter power (dBm)
P_{RX} = Receiver power (dBm)
L_{FS} = Free space loss (db)
L_O = Obstacle loss (db)
L_I = Interference loss (db)
LKM = Link margin (dBm)
LB = Link budget (dBm)

>20: Good
10 - 15: Fair
< 10: Poor

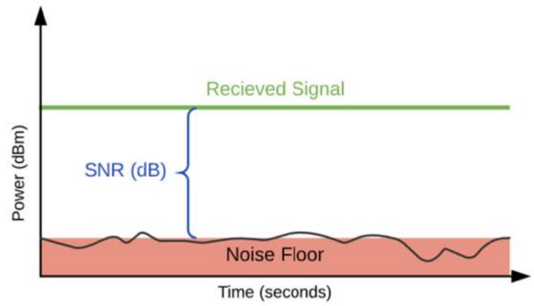
6.3.3 Signal to noise ratio

The signal-to-noise ratio (SNR) is a measure to compare the level of the desired Thread radio signal strength to the level of background noise or signal strength of other interfering signals in the same frequency band.

The SNR is calculated by dividing the signal strength (S) by noise signal strength (N).

You can also subtract logarithms to calculate the SNR. The difference between the numbers equals the SNR.
An example for a radio signal with a strength of -10 dB and a noise signal of -50 dB would be:
-10 minus -50 dB equals 40 dB.

SNR must be higher than 10 dB to achieve stable communication; higher than 20 is ideal. See figure below.



Measure	Range
Signal to noise ratio SNR (dB)	10 - 20: Good
	0 - 10: Fair
	< 0: Poor

Fig. 34: Signal-to-noise-ratio (SNR)

6.4 Testing Thread range

You can use the Thread range testing app, shown in the figure below, with your smartphone to verify and measure signal strength, see 'Related documentation [→ 7]'.

The workflow is:

- Install and open the Thread Range test app on your smartphone (Android only).
- Connect the Thread dongle to your smartphone.
- Pair the Thread Range test app to another Thread device (e.g. a TME).
- Monitor and log the Thread signal strength.
- Check Thread signal strength.
  – If the Thread signal strength is strong enough: Write down the signal strength on your Thread network plan and proceed to the next device for the range test.
  – If Thread signal strength is not strong enough: Adjust Thread network configuration or environment parameters and repeat the Thread signal strength test.
- Save the Thread signal strength log.
- Export the Thread signal strength log and add it to project documentation.

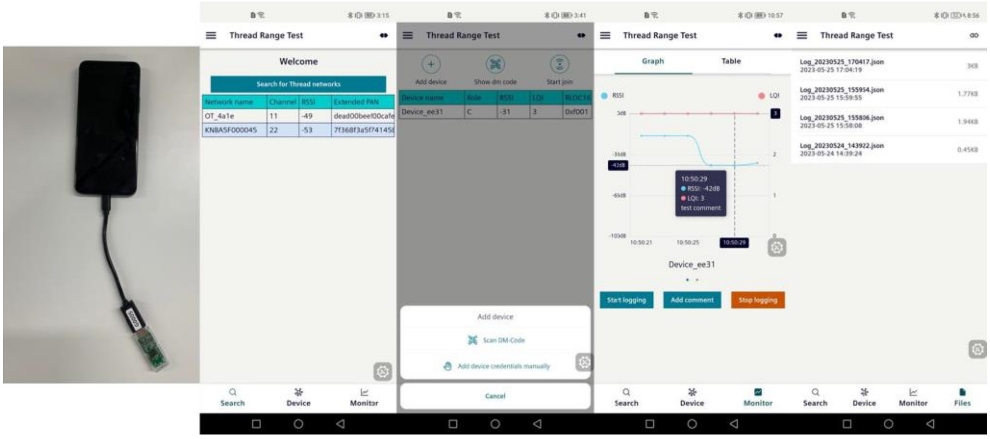


Fig. 35: Thread range test app

6.5 Finalizing the Thread network plan

Adjust your Thread network plan, based on your site survey results. See figure below.

After finalizing the Thread network plan, archive and share the network plan with relevant stakeholders (e.g., customer, installer, and service technician).

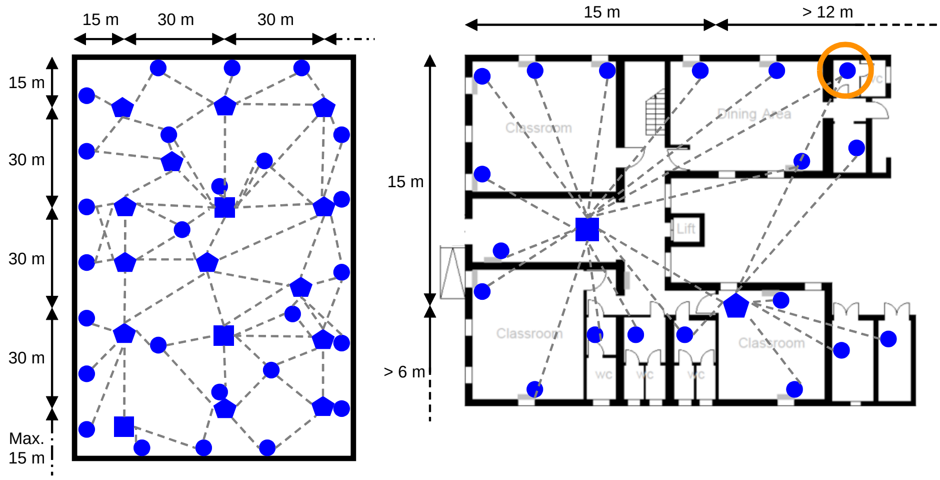
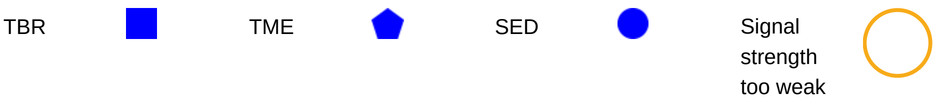


Fig. 36: Final Thread network off-site plan



7 Commissioning

You can either commission the system remotely or on-site. We recommend commissioning the system remotely.

Collect static IP addresses, subnet and standard gateway information beforehand to remotely configure static IP addresses and network information.

- Commission the system.
  For additional information, see 'Related documentation [→ 7]'.
- Pre-configure the system as far as possible.
- Add name and ID to the devices.

Clearly label the device with name and ID (printed), based on location and customer requirements. This simplifies recommissioning and installing the system at the customer site.

- Run pre-tests.

For additional information, refer to the product or system manual in 'Related documentation [→ 7]'.

NOTICE	
!	Always update firmware to latest version during commissioning.

For additional information on how to perform firmware updates and on latest firmware files, see 'Related documentation [→ 7]'.

8 Installation

Installing the TBR, TME and SED devices.

8.1 Mounting TBR and TME devices

Place the TBR and TME devices as close to the ceiling as possible (at least two meters above floor level) to avoid interference or damping.

- Do NOT mount the devices:
  - Behind walls or ceilings, especially behind metal or concrete walls or ceilings
  - Inside metal cabinets
  - Directly next to other wireless devices or other devices emitting electromagnetic waves, such as WLAN access points, mobile network antennas, Zigbee hubs, other wireless sensors, microwaves, or fridges
  - Behind other obstacles, such as shelves, standing water, fire safety doors or walls, elevators, vending machines, covers, tables, etc.

For additional information on mounting, see 'Related documentation [→ 7]'.

8.2 Mounting SED devices

Place SED devices as high as possible (at least 1.1 meters above the floor) to avoid interference or damping.

- Do NOT mount the devices:
  - Behind walls or ceilings, especially behind metal or concrete walls or ceilings
  - Inside metal cabinets
  - Directly next to other wireless devices or other devices emitting electromagnetic waves, such as WLAN access points, mobile network antennas, Zigbee hubs, other wireless sensors, microwaves, or fridges
  - Behind other obstacles, such as shelves, standing water, fire safety doors or walls, elevators, vending machines, covers, tables, etc.

For additional information on mounting, see 'Related documentation [→ 7]'.

9 Site Acceptance Testing

After the Thread system has successfully been planned, commissioned, and installed, proceed as follows:

- Test the system using the Site Acceptance Test (SAT) template.
  For details on the SAT template, see 'Related documentation [→ 7]'.
- Handover the system to your customer. Handover documentation may include the following:
  - Project specification and system configuration
  - Floorplan including Thread network plan
  - Thread network overview
  - Site Acceptance Test
- Have the customer document that the handover is complete and the system is fully functional and accepted.

NOTICE	
!	The customer must acknowledge with a valid signature that the system is operational. Failure to do so may expose the installer or manufacturer to unnecessary liability, namely if the Thread system does not work after a certain period (e.g. due to changes in device locations or configuration changes to the network by the customer, etc.).

10 Troubleshooting

First determine the root cause and then correct the issue.

Identify root cause

Proceed as follows in the event of failure or performance issues on the Thread network:

1. Check the heartbeat interval of the SEDs:
   Check whether the SEDs are in sleep mode. To save energy, battery powered end devices are in sleep mode most of the time. Even if they wake up every 10 minutes to measure values, they do not always send them to the superposed system. If the values do not change, the SEDs go back to sleep mode, without sending data.
2. Check if the SEDs are connected and registered at the TBR.
   SEDs and TBR must be paired and have the correct credentials (on both ends).
3. Check the SED battery status:
   Replace the battery if drained.
4. Check TBR or TME status:
   Check that the TBR or TME devices are connected to the mains supply and turned on. Also check the network cable on the TBR and the IP settings for the local network.
5. Check the signal strength between SEDs and TMEs or TBRs:
   Reliable communication is not possible if the signal strength is too weak. Weak signal strength may be caused by obstacles, poor mounting position, crowded areas, signal interference or other reasons. Use the Siemens Thread range testing app to test signal strength. For more information on the Siemens Thread range testing app, see 'Related documentation [→ 7]'.
6. Check for signal interference:
   Other wireless signals may interfere with Thread wireless communication, including WLAN networks, Zigbee networks, Thread networks, mobile networks, or other electronic devices, such as microwaves.
7. Check whether operations have changed over time:
   Operational conditions may change over time. For example, everything works perfectly after mounting a wireless system in a new building and the SAT, but then starts to deteriorate once the building is operational: Furniture, such as shelves, may be added, vending machines or fridges, may be installed, more people in the building cause interference with their body and mobile devices, open doors may be closed, shelves filled with more goods, etc. All these changes may deteriorate signal quality or interfere with the wireless signals.

Measures to improve system performance or fixing root cause

1. Adapt the mounting location of SEDs, TMEs or TBRs:
   Slight changes in the mounting location of wireless devices can significantly improve the wireless signal strength (clear line of sight is the key).
2. Change location or remove obstacles:
   Obstacles, such as vending machines, cause interference. Changing the location or removing the obstacle may help to improve signal strength.

3. Optimize the WLAN network:
   WLAN network infrastructures may be quite chaotic. Optimizing WLAN networks by managing the WLAN channels on 2.4 GHz band or even moving some WLAN networks to the 5 GHz band frees up bandwidth for Thread wireless networks (more bandwidth means more data).
4. Optimize Thread channel selection:
   By default, the wireless Thread system uses Thread channel 26. However, in certain applications this channel might be already blocked by other wireless systems. Change the Thread network channel in this case.
5. Install additional TBR or TME devices:
   Install additional TBR or TME devices to create a more powerful Thread mesh network.

Contact our global support team if you are unable to troubleshoot network performance.

11 Advanced topics

Optimization of individual measurement and communication settings

You can edit the default settings for the following parameters to fine-tune the Thread wireless system to application requirements:

- Change of value threshold (COV)
- Wake-up cycle
- Measurement interval factor
- Heartbeat factor
- Application time-out factor

NOTICE	
!	Only advanced users should adjust default settings.

List of Figures

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