User Manual

3rd Generation Active RFID

Ambient Systems B.V.

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1 Table of Contents

1 Preface

1.1 What is 3rd Generation Active RFID?

First there was conventional active RFID where a battery in the tag permits it to initiate a signal, give longer range, manage a sensor or otherwise improve on the capability of a passive RFID tag. Second generation active RFID is the Real Time Locating System (RTLS) where people or things are located almost continuously from 30-300 meters away, usually by using many emitters. The third generation of active RFID build on the power of mesh networking – also known as Wireless Sensor Networks (WSN) – that provide better scalability, self-healing functionalities, increased capabilities and are affordable. The third generation of active RFID tags combine all functionalities of previous active RFID systems, identification and localization, and add to it with sensor extensions, file systems, and so forth.

Ambient Systems, with its 3000 Series product line, provides 3rd Generation Active RFID products that combine check, track, and trace functionalities:

•**Check** – Monitor the status of objects using e.g. temperature sensors

•**Track** – Locate your objects using RTLS functionality

•**Trace** – Maintain history of your objects using e.g. temperature logs and consignment notes.

The 3000 Series 3rd Generation Active RFID products are based on Ambient Wireless Sensor Network (WSN) technology and communicate using IEEE PHY 802.15.4 at a frequency of 2.4 GHz.

1.2 What is Ambient Studio?

Ambient Studio 3000 is PC software that is used in conjunction with the 3000 Series 3rd Generation Active RFID. Ambient Studio is used for deployment and configuration of a 3000 Series network, data collection and data dissemination. It builds on the Ambient Device Driver Interface (DDI). DDI allows addressing *all* nodes in your network as well as their resources in a uniform manner. Ambient Studio also provides tools for e.g. remotely upgrading your infrastructure, managing the Remote File System, and so forth.

The 3000-Series network products can operate standalone or use Ambient Studio as an intermediate.

1.3 3000 Series Features

- Easy to install 3rd Generate Active RFID
- Conforms to IEEE 802.15.4 PHY
- Benefits from the power of Wireless Mesh Networking
  - Multi-hop
  - Self-configuring
  - Self-healing
- SmartPoints can be used to check, track and trace assets
  - Built-in Temperature Sensor
  - Built-in RTLS 3D Location Engine

- Typical battery life of >3 years[1]
- User-configurable temperature & positioning intervals
- User-configurable security features
- User-configurable sleep modes
- User-configurable alerts
- Dynamic Event Reporting
  - Temperature Alerts
  - Low Battery Alerts
- Single screw Mounting
- SensIO Connector
  - SPI
  - I2C
  - 1-Wire®[2]

1.4 Conventions

This user manual uses the following typographical conventions to mark certain portions of text: new terms, foreign phrases, and other important passages are emphasized in *italics*.

Everything that represents input or output of the computer, in particular commands, program code, and screen output, is shown in a mono-spaced font (`example`) and separated by borders. Within such passages, italics (*`example`*) indicate place-holders; you must insert an actual value instead of the place-holder. On occasion, parts of program code are emphasized in bold face (**`example`**), if they have been added or changed since the preceding example.

Important comments or reminders are indicated in bold and separated by borders, as follows:

Example

An *administrator* is generally a person who is in charge of installing and running Ambient Studio. A *user* could be anyone who is using, or wants to use, any part of the Ambient Studio system. These terms should not be interpreted too narrowly; this user manual does not have fixed presumptions about system administration procedures.

1.5 Definitions

Short-hand	Description
AGW	Auxiliary Gateway
AS	Ambient Studio
DDI	Device Driver Interface
DDIP	DDI Processor (a processor capable of interpreting DDI)

1 Depending on configuration, battery condition, network setup and environmental conditions. Default configuration for this setup is sampling, logging and transmitting the temperature sensor every 5 minutes, localization once per hour.

2 1-Wire® is a registered trademark of Dallas Semiconductor Corporation

DNCP	Dynamic Node Configuration Protocol
GUI	Graphical User Interface
GW	Gateway
MGW	Master Gateway
MR	MicroRouter
OTA	Over-the-air
PA	Power Amplifier
RF	Radio Frequency
RR	Rapid Reader
RTLS	Real-Time Location System
SP	SmartPoint
SPI	Serial Peripheral Interface
SPP	Serial Port Protocol
WSN	Wireless Sensor Network

1.6 Further Information

Besides the documentation, that is, this user manual, there are other resources about Ambient Studio:

•**FAQ** – The FAQ list contains continuously updated answers to frequently asked questions.

•**Web Site** – The Ambient Systems support web site carries details on the latest release and other information to make your work or play with Ambient Studio more productive.

2 Introduction

This Ambient Systems 3000-Series User Manual describes how to use Ambient Systems products. This manual covers the complete 3000-Series product range and includes Gateways, MicroRouters and SmartPoints.

The 3000-Series network products can operate stand-alone. Ambient Studio can be used for deployment, configuration and maintenance of the network. Please read the Ambient Studio user manual on how to install and use Ambient Studio, see **"Ambient Studio User Manual"**.

The 3000 Series products are based on Ambient Wireless Sensor Network (WSN) technology and communicate using IEEE 802.15.4 at a frequency of 2.4 GHz.

2.1 About This Manual

This manual provides practical information for installing 3rd Generation Active RFID systems using Ambient products. The manual provides an overview of the 3000 Series product range, a short theoretical background on WSN technology and detailed information on how to install each product of the 3000 Series.

2.2 Related Documentation

Document	Description
Data Sheet: GW3000	Contains detailed information about the 3000-Series Gateway.
Data Sheet: MR3000	Contains detailed information about the 3000-Series MicroRouter.
Data Sheet: SP3000	Any of the data sheets of 3000-Series SmartPoints, such as the SP3000
White Paper: Ambient 3000 Series Network	This white paper explains in detail how the Ambient 3000-Series network works. It provides information that is useful when installing a network.
White Paper: Ambient 3000 Series Localization	This white paper explains in detail how the Ambient 3000-Series localization mechanism works. It provides detailed information that is useful when installing a localization-enabled network.
User Manual: 3000 Series 3rd Generation Active RFID	Contains detailed information about installing, deploying and configuring 3000 Series network products.
Specification: Serial Port Protocol	This specification describes the underlying serial line protocol that Gateways use to communicate over RS232
Specification: Device Driver Interface	This specification describes the Device Driver Interface protocol and message encapsulation scheme that is used to access resources on Ambient products and peripheral devices attached to Ambient products.

Data sheets and white papers can be downloaded from our website (see www.ambient-systems.net/partners), user manuals and specifications are provided with 3000 Series products upon request (contact support@ambient-systems.net).

3 Product Overview

The 3000-Series products provide a 3rd Generation Active RFID system based on Ambient wireless multi-hop mesh network technology.

An Ambient network consists of GateWays (GW), MicroRouters (MR), and SmartPoints (SP). GWs and MRs are normally powered by mains. They have a rechargeable back-up power supply that takes over in case of a temporary power blackout. Battery warnings of such an event are given immediately. SPs are fully battery-operated and – using typical settings – last for more than 5 years (SP3000). Battery warnings are given well in advance of the eventual depletion of the battery. Upon battery depletion SmartPoints can be returned to Ambient Systems for refurbishing or replaced with new SmartPoints.

A GW connects to a peripheral device using a RS232 serial cable. Ambient Studio is a software application that is used to monitor and configure the network using various Graphical User Interface (GUI) components.

WARNING: Any modifications to the units, unless expressly approved by the party responsible for compliance, could void the user's authority to operate the equipment.

Element	Description
GateWay: *GW3000*	The heart of the Ambient Network is the GW. It controls the network configuration and provides an interface to the network for the outside world by means of a RS232 serial communication port. There needs to be at least 1 GW per network which is the *Master Gateway*; a network cannot operate without one. *Auxiliary Gateways*[1] can be used to increase redundancy and network bandwidth.
MicroRouter: *MR3000*	MRs build up the rest of the network infrastructure. A MR can join a network when in range. As a part of the network it is able to receive and send data to other nodes. If the MR has no direct connection to the GW its messages are relayed by intermediate MRs. Depending on the type of GW, up to 255 MRs can join a single network.
SmartPoint: *SP3000*	SPs are battery-operated Active RFID tags. SPs have one or more sensors attached which allows it to monitor environmental parameters. The SP3000, for example, has an on-board EN12830 compliant temperature sensor. Using various configuration mechanisms, the behaviour of the SP can be modified Over-the-Air (OTA). The beacon messages of the GWs and MRs provide information which the SP uses to obtain a position estimate; as a result a SP knows its own location.

1 Auxiliary Gateways are not yet commercially available

Ambient Studio: *AS3000*	Ambient Studio is PC software that is used to deploy, monitor, maintain and configure the network. Using various GUI components *every* device in the network and every resource of that device is wireless accessible. Ambient Studio is also used to set up all the localization peripherals; once set up, the network operates standalone.
RapidReader: *Not yet commercially available*	A RapidReader[2] is a standalone device that is capable of creating a point-to-point connection with an Ambient device, providing an improved bandwidth, making it easier to configure and update devices.

3.1 System Requirements

3.1.1 3000 Series

Power	Mains power connections at locations where infrastructure (Gateway and MicroRouters) need to be placed
Connectivity	RS232 SUB-D9 connection with 115200 baud and hardware flow control enabled for communicating with the Gateway

3.1.2 Ambient Studio

Operating System	Windows XP® SP3 or Vista®
Processor	300 MHz or higher
Memory	128 MB RAM or higher
Storage	500 MB available hard disk space (for logging purposes)
Display	1024 x 600 or higher resolution video adapter and monitor
Peripherals	•Keyboard •Mouse or compatible pointing device •1 or more RS232 serial ports OR •1 or more USB port[2]

3.2 Compliance(s)

The SmartPoint SP3000, MicroRouter MR3000 and Gateway GW3000 are compliant with FCC part 15.247 and part 15B, IC RSS-210 and RSS GEN and have safety certification according to CB and $_{c}CSA_{us.}$ All three devices above are marked on the product or packaging label with the following statements:

2 The RapidReader is not yet commercially available
2 If no COM port is available on your system, you can purchase a USB to serial converter at any electronics shop

"This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation." This is described in Part 15.19 (a)(3) and (5)."

"This Class B digital apparatus complies with Canadian ICES-003. Cet appareil numerique del la classe B est conforme al norme NMB-003 du Canada."

Note (applicable for all above devices): This equipment has been tested and found to comply with the limits for a Class B digital device pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance wit the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try and correct the interference by one or more of the following measures:

-Reorient or relocate the receiving antenna.

-Increase the separation between the equipment and the receiver.

-Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

-Consult the dealer or an experienced radio/TV technician for help.

Additionally compliances:

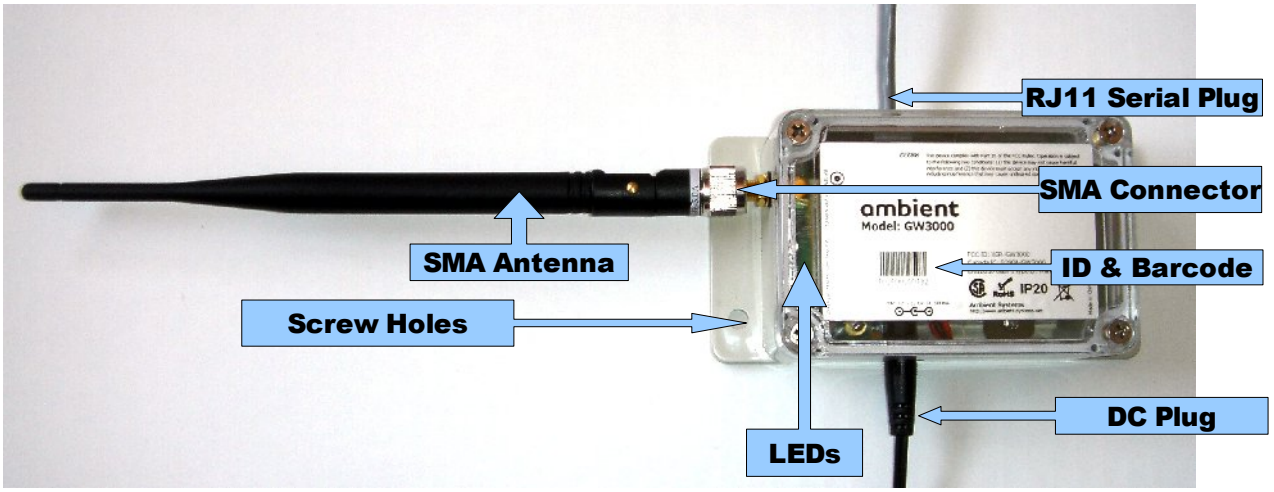
- EN12830 (Excluding GW3000)
- RoHS

A copy of the certificates can be obtained by sending an email to support@ambient-systems.net.
EN12830 (Class 1 accuracy, class D climatic environment, suitable for transportation)

3.3 Hardware Overview and Specifications

This section provides an overview of the various hardware components that make up an Ambient 3000 Series network including a summary of the technical specifications of each device.

3.3.1 Gateway GW3000



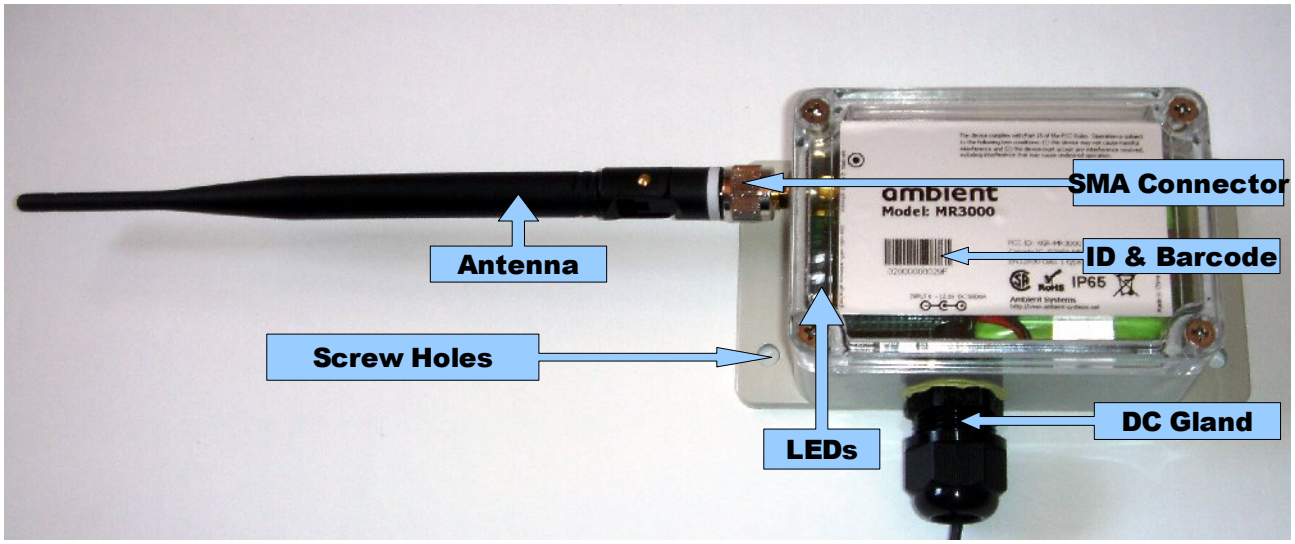
Supplied Accessories:

- Swivel Antenna
  - SubMinature version A Reverse Polarity Connector (RP-SMA)
- RS232 Serial Cable
  - Registered Jack 11 (RJ11) to SUB9
- AC / DC Adapter (100-240VAC, 12VDC, max 500 mA), 60950-1 certified

	Technical Specifications
Frequency Range*	2.42 to 2.455 GHz, IEEE 802.15.4 PHY compliant
TX (Maximum radiated power(EIRP))	TBD
RX sensitivity	-103.6 dBm @ 1%PER
Typical Range indoor	TBD
Typical Range outdoor	TBD
Typical Backup Battery Life	5 days[1]
Interface	RS232
	Physical Specifications
Mounting	Enclosure with 4 screw mounting holes
Dimensions (H x W x D)	50 x 68 x 131 mm (excluding antenna)
Dimensions without flanges (H x W x D)	50 x 68 x 100 mm (excluding antenna)
Weight	232 gr (excluding adapter)
Colour	Gray
Power Source	External, 6.0 – 12.6 V, 500 mA
Backup Battery	3 x rechargeable AA Nickel Metal Hybrid
Antenna	External omni-directional swivel antenna (RP-SMA connector), see 3.3.3
Operating Temperature	-20˚C to +50˚C
Storage Temperature	-20˚C to +50˚C
Ingress Protection	IP20
RoHS	yes

*the radio frequency range is restricted to the above in accordance with FCC certification

3.3.2 MicroRouter MR3000



Supplied Accessories:

- Swivel Antenna
  - SubMinature version A Reverse Polarity Connector (RP-SMA)
- AC / DC Adapter (100-240VAC, 12VDC, max 500 mA), 60950-1 certified
  - For outdoors use, the AC/DC adapter needs to be outdoors rated

1 Typical reporting intervals, always in network, backup battery fully charged

	Technical Specifications
Frequency Range*	2.42 to 2.455 GHz, IEEE 802.15.4 PHY compliant
TX (Maximum radiated power(EIRP))	TBD
RX sensitivity	-103.6 dBm @ 1%PER
Typical Range indoor	TBD
Typical Range outdoor	TBD
Typical Backup Battery Life	5 days[1]
	Physical Specifications
Mounting	Enclosure with 4 screw mounting holes
Dimensions (H x W x D)	50 x 97 x 131 mm (excluding antenna)
Dimensions without flanges/gland (H x W x D)	50 x 68 x 100 mm (excluding antenna)
Weight	232 gr (excluding adapter)
Colour	Gray
Power Source	External, 6.0 – 12.6 V, 500 mA
Backup Battery	3 x rechargeable AA Nickel Metal Hybrid
Antenna	External omni-directional swivel antenna (RP-SMA connector), see 3.3.3
Operating Temperature	-40°C to +85°C
Storage Temperature	-40°C to +85°C
Ingress Protection	IP65
RoHS	yes

*the radio frequency range is restricted to the above in accordance with FCC certification

3.3.3 Important note, GW3000 and MR3000 antennas

The GW3000 and MR3000 devices have been designed to operate with the antennas listed below, and having a maximum gain of 5 dBi. Antennas not included in this list or having a gain greater than 5 dBi are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

- 2.2dBi gain, swivel antenna – TLB-2400-900LD-2.2A
- 5dBi gain, swivel antenna – TLB-2400-900LD-5A

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.

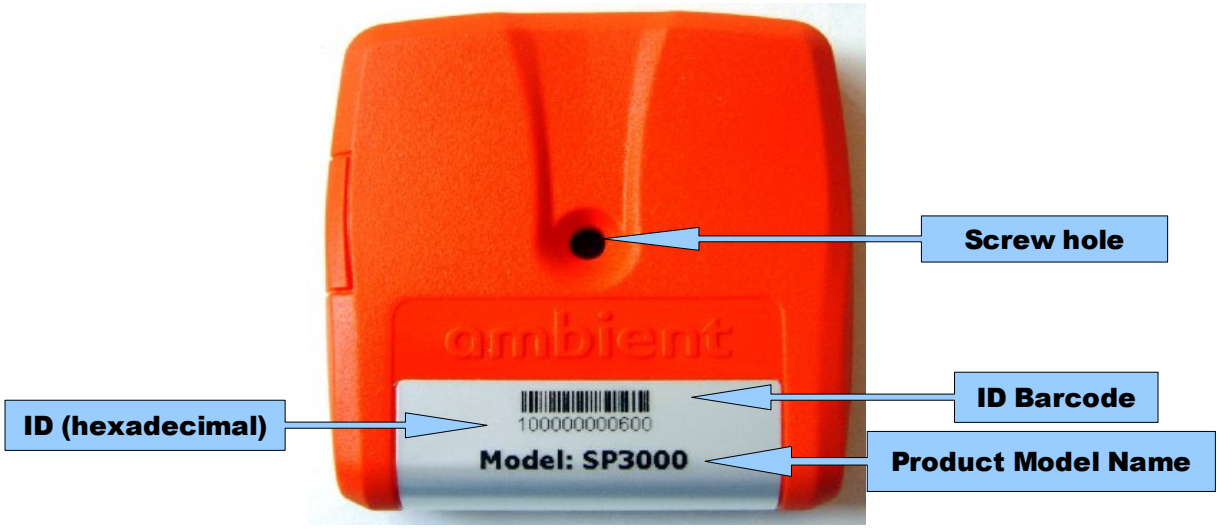
WARNING: Any modifications to the units, unless expressly approved by the party responsible for compliance, could void the user's authority to operate the equipment.

In order to comply with the RF Exposure requirements of Industry Canada and the FCC, a minimum of 20cm separation distance must be maintained between the antenna of this device and all persons.

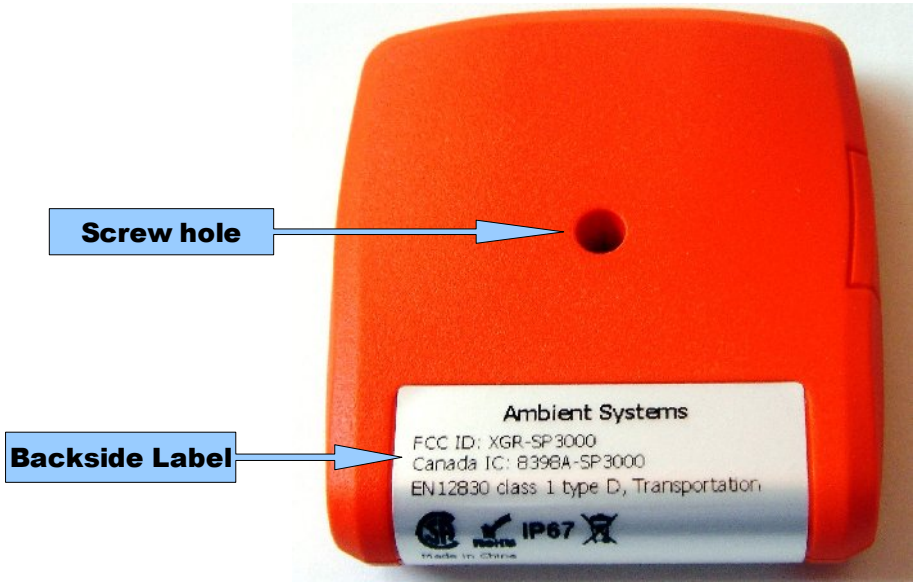
1 Typical reporting intervals, always in network, backup batteries fully charged

3.3.4 SmartPoint SP3000

FRONT



BACK



	Technical Specifications
Frequency Range*	2.405 to 2.475 GHz, IEEE 802.15.4 PHY compliant
TX (Maximum radiated power(EIRP))	+4.6dBm (including PCB antenna gain)
RX	-85.0 dBm @ 1%PER
Typical Range indoor	25 m
Typical Range outdoor	50 m
Typical Battery Life	5 years[1]
Typical Reporting Rate	5 minutes (2 seconds – 18 hours)
	Physical Specifications
Mounting	Single screw mounting hole
Dimensions (H x W x D)	59.6 x 56.6 x 14.0 mm
Weight	44 gr
Colour	Orange
Battery	2 x AAA Lithium Thionyl Chloride
Antenna	Integrated on PCB, Omni-directional
Operating Temperature	-40°C to +85°C
Storage Temperature	-40°C to +85°C
Ingress Protection	IP67 (Dust tight, water tight)
	Temperature
Typical accuracy	±0.5°C from -25°C to +85°C ±1.0°C from -40°C to +85°C
Resolution	0.0625°C
RoHS	yes

*the radio frequency range is restricted to the above in accordance with FCC certification

1 Sample & send temperature every 5 minutes, always in network with multiple routers in range.

4 Ambient Network

This section explains what an Ambient Network is and where it consists of.

4.1 Nodes

An Ambient Network consists of a number of so-called 'nodes'. A combination of these nodes are used to build an Ambient Network. As mentioned before, there are three (3) types of nodes which are the Master Gateway, the MicroRouter, and the SmartPoint. A Gateway is considered to be a Master Gateway unless indicated otherwise.

The GW is connected using a RS232 serial cable to a peripheral device (e.g. a PC or a GPRS logger). GWs and MRs build up a network by creating dynamic links with each other. These links adapt to the current deployment set up and environmental changes. SPs only communicate periodically with one of the infrastructure nodes – i.e. GWs and MRs – when they have data to send (e.g. temperature reading, location information, etc.).

An overview of the symbols used for these nodes throughout this document is given in Illustration 1[1].

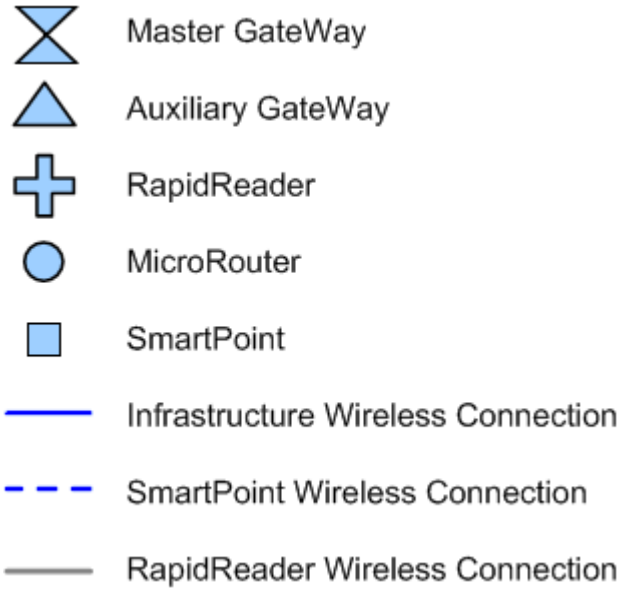


Illustration 1: Overview of Ambient network nodes

4.2 Network Layout

An example network layout is given in Illustration 2. The illustration shows a network with a GW, MRs, and SPs. GWs and MRs maintain a permanent wireless connection with each other. In this way they built up a backbone infrastructure.

The network is build up originating from the GW outward. SPs use short beacon messages that are transmitted by both GWs and MRs to communicate with the infrastructure. These links are not permanent but only exist only while the SP is communicating with the infrastructure.

1 The products Auxiliary Gateway and RapidReader will be released in 2009-2010. Auxiliary gateways can be used for load balancing purposes in heavily loaded network. The RapidReader can be used to set-up a point to point connection to a device for faster uploading/downloading files or configuration purposes.

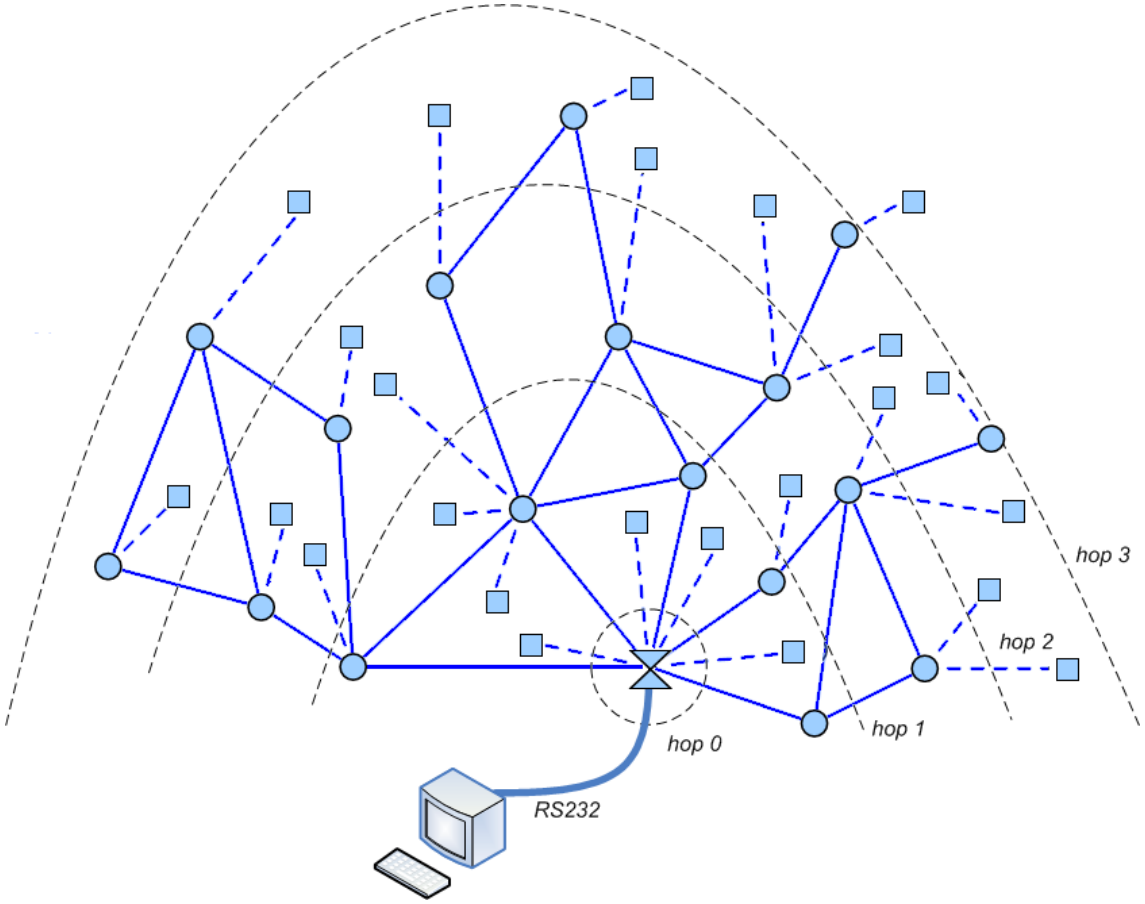


Illustration 2: Example Ambient network layout with Hop Counts and Wired PC

As mentioned before, an Ambient network is a multi-hop network. Each GW and MR in the network has a so-called hop count value. This value represents the number of times a message needs to be forwarded by other MRs, to reach the GW.

Hop counts are measured from the GW. The GW has hop count 0. MRs in direct communication range of the GW are on hop 1. MRs that are in range of a MR at hop 1 but are not in range with the GW are on hop 2, and so forth. Maximum 15 hops are supported.

Eventually, the GW is connected to an PC or other device using an RS232 serial connection. The GW thus provides the bridge between an Ambient network and your application.

5 Installation

This section will guide you through the installation process. Placement of the GWs, MRs and SPs is very important. The performance (range) of radio products is influenced by the objects which are located between sender and receiver. This is explained in more detail in the next sections.

5.1 Before you Begin

Below is a list of items to consider before you begin the installation process. Ensure you have all the equipment needed to perform an installation:

- PC or any other device running Windows XP or Windows Vista with a RS232 COM port
- Ambient Studio installation CD, *or*
- an Internet connection in order to download the installer from our website
- Gateway(s), MicroRouter(s), and SmartPoint(s)
  (including AC/DC adaptors, SMA antennas, serial cables)
- Screws with a diameter of 5 mm and screwdriver to be used both for mounting the GW and MRs
- Screws with a diameter of 4 mm and screwdriver to be used for mounting the SP

If your system does not have an RS232 COM port, you can purchase a USB to Serial converter which is available at any regular electronics store.

5.2 Wireless Considerations

An Ambient network can be installed at basically any location. The network is built up solely on wireless connections – with the exception of the GW and its serial connection – and mains. Individual nodes can be added to the network from virtually anywhere within the operating range of the individual nodes. Keep in mind, however, that the number, thickness and location of walls, ceilings, or other objects that the wireless signals must pass through, may limit the range. Typical ranges described in the data sheets vary depending on the types of materials and background Radio Frequency (RF) noise in your home, business, warehouse, or any other place you are installing a network. The key to maximizing wireless range is to follow these basic guidelines;

1. Keep the number of walls and ceilings between the different nodes (GW, MR, SP) to a minimum – each wall or ceiling can reduce the range from a node. Position your devices so that the number of walls or ceilings is minimized.
2. Be aware of the straight line between network nodes. A wall that is 0.5 meters (1.5 feet) thick , at a 45-degree angle appears to be more than 1 meter (3 feet) thick. At a 2-degree angle it looks over 14 meters (42 feet) thick! Position nodes so that the signal will travel straight through a wall or ceiling (instead of an an angle) for better reception.
3. Building materials make a difference. A solid metal door or aluminium studs may have a negative effect on range. Try to position nodes such that the signal passes through drywall or open doorways. Material and objects such as glass, steel, metal, walls with insulation, water (fish tanks), mirrors, file cabinets, brick, and concrete will degrade your wireless signal considerably.
4. Keep your nodes away 1-2 meters (3-6 feet) from electrical devices or appliances that

generate RF noise.

5. If you are using 2.4 GHz cordless phones, WLAN, or X-10 (wireless products such as ceiling fans, lights, and home security systems), your wireless connection may degrade dramatically or drop completely. Make sure your 2.4 GHz phone base is as far away from your wireless nodes as possible. The base station transmits a signal even if the phone is not in use.
6. SPs have a shorter range than infrastructure nodes (GWs, MRs) due to the fact that they have an integrated PCB antenna. When installing your infrastructure nodes, make sure you take into account the fact that they are placed in such a fashion that they provide enough coverage for SPs to communicate.
7. Mount the GW or MR in such way that the antenna is in vertical position. It points always to the ceiling (or floor). This is depicted in Illustration 3.

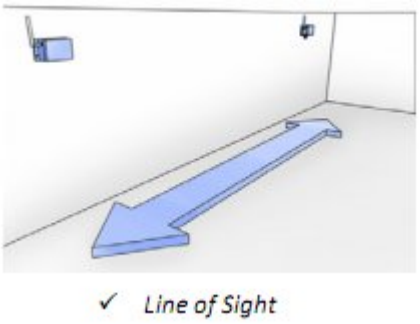


Illustration 3: Correct antenna orientation, vertical

More information regarding deployment can be found in the remaining chapters of this document.

5.3 Getting Started: Ambient Studio

Ambient Studio 3000 can be purchased from Ambient. The software can be downloaded from the support section our website, at www.ambient-systems.net/partners. Make sure you download the latest version of Ambient Studio. Use the 'Save As' option to store the installer file on your local hard drive.

If you have older versions of Ambient Studio installed on your system, first uninstall those before continuing with the new installation.

Once downloaded, go to:

```
Start -> Run
```

In the box that appears type:

```
C:\My Downloads\Ambient_Studio_3000_[X.YpZ].exe
```

where

```
C:\My Downloads
```

represents the location where you downloaded the installer to, and

```
[X.YpZ]
```

the version of the Ambient Studio installer.

When the installer wizard appears, follow the on-screen instructions in order to install Ambient Studio like you would with any other Windows software. During installation you can cancel the process at any time by pressing 'Cancel'.

5.4 Getting Started: Nodes

5.4.1 Gateway GW3000

When installing a GW3000[1], first make sure that you have the right device, it should state GW3000 on the label, followed by a hardware version ID (see Illustration 4).

The GW3000 is installed in a few steps that are listed below;

1. Screw on the SMA antenna on the SMA connector (see Illustration 5)

   NOTE: Do not turn on the GW30xx when the SMA antenna is not connected, it could damage the device!

2. Push the RJ11 connector of the serial cable into the RJ11 socket (see Illustration 6).

   NOTE: Make sure the RJ11 'clicks' in place to ensure that it is properly connected!

3. Connect the SUB9 connector of the serial cable to the COM port of your PC. Where possible, use the screws of the serial connector to ensure it is tightly connected. The same applies when you connect the GW to another peripheral device.

   NOTE: Make sure the SUB9 connector is tightly connected, otherwise it may result in packet errors over the serial line!

4. Push the jack of the AC/DC adapter in the AC/DC socket (see Illustration 7) and place the adapter in a mains socket.

   NOTE: If you do not push the jack fully in the socket, it might not be connected correctly!

   NOTE: If you decide to use a different AC/DC adapter for the GW3000, it needs to be of class 2-II with a cable length less than 3 meter, and with the correct specifications (DC voltage & amperage, polarity and plug-size).

Mounting the GW is described in the deployment section of this user manual.

1 GW3000= GW3000, GW3120 or GW3250

Illustration 4: GW3000 Installation preparation

Illustration 5: GW3000 Installation step 1

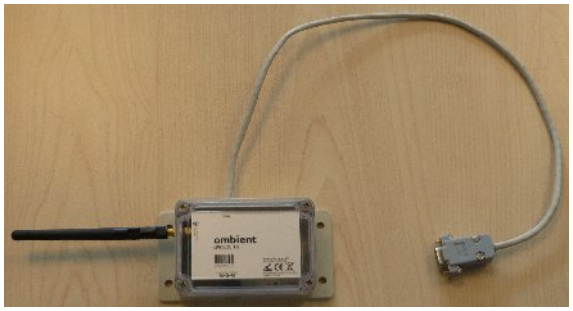


Illustration 6: GW3000 Installation step 2

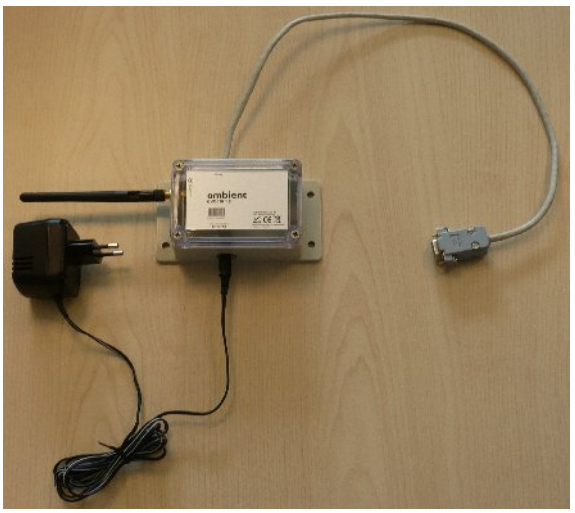


Illustration 7: GW3000 Installation step 3

5.4.2 MicroRouter MR3000

When installing an MR, first make sure that you have the right device, it should state MR3000 on the label, followed by a hardware version ID (see Illustration 8).

The MR3000 is installed in a few steps that are listed below;

1. Screw on the SMA antenna on the SMA connector (see Illustration 9)

   NOTE: Do not turn on the MR3000 when the SMA antenna is not connected, it could damage the device!

2. Remove the cap from the DC gland (see Illustration 10).
3. Push the DC jack of the adapter through the cap (see Illustration 11).
4. Push the DC jack through the DC gland until it fits tightly in its socket (see Illustration 12).

   NOTE: The AC/DC gland opening may be a bit rigid when used for the first time, you can carefully widen it to make jack go through easier.

   NOTE: If you do not push the jack fully in the socket, it might not be connected correctly!

   NOTE: Make sure the rubber ring on the inside of the gland stays in place, if it is not in its right position it may result in the connector not being water tight!

   NOTE: If you decide to use a different AC/DC adapter for the GW3000, it needs to be of class 2-II with a cable length less than 3 meter, and with the correct specifications (DC voltage & amperage, polarity and plug-size).

5. Screw the cap back on the gland (see Illustration 13).

   NOTE: If you do not tightly screw on the cap of the gland, it may result in the connector not being water tight!

6. Place the DC adapter in a mains socket.

Mounting the MR3000 is described in the deployment section of this user manual.

Illustration 8: MR3000 Installation, preparation

Illustration 9: MR3000 Installation, step 1

Illustration 10: MR3000 Installation, step 2, left is gland with cap, right is gland without cap

Illustration 11: MR3000 Installation, step 3

Illustration 12: MR3000 Installation, step 4

Illustration 13: MR3000 Installation, step 5

5.4.3 SmartPoint SP3000

The SP3000 does not require separate installation. It is 'always-on', meaning that when it wakes up from its deep-sleep mode[1] and it hears a network it will become a part of the network.

Please take into account that upon arrival, the SmartPoints are likely to be in a deep sleep mode to save energy during transport. Once you have turned on your network, it can take up to **two hours** for all SPs to awake[2].

Mounting the SP is described in the deployment section of this user manual.

1 The deep-sleep mode is the default mode of the SmartPoint. In this mode it consumes as less energy as possible. Based on the configuration of the various drivers, it wakes up to execute a task (like sampling the temperature driver). There are no other sleep modes.

2 Assuming that no packets are missed.

6 Configuration

This section discusses the configuration of the Ambient Systems 3000 series network through Ambient Studio. Please, refer to Section 4.3 or Ambient Studio User Manual for installing Ambient Studio. Throughout this section, we assume that Ambient Studio is successfully installed and is running.

6.1 Connecting to the Serial Device

In order to have Ambient Studio communicate with your Series 3000 network, it is key to configure the Serial Port. Typically, you only need to set the Serial Port options once. Below we describe how to set the Serial Port configuration manually and how to check its settings.

6.1.1 Determine to which COM port your GW3000 is connected

First, we will determine to which COM port your GW3000 is connected. If you already know the COM port, you can skip the remainder of Section 6.1.1 and go ahead to Section 6.1.2.

If your system does not have a serial port you can purchase e.g. a USB to RS232 converter from any PC store. In case of a USB to RS232 converter, the USB driver (in Windows) will assign a COM identifier to the serial port. You can ascertain this COM identifier by browsing to your device manager. This is achieved using the following steps:

1. Select Windows Start Menu
2. Select 'Control Panel'. A new window will open up.
3. Select 'System'. A new dialogue will open up.
4. Select the 'Hardware' tab.
5. Select the button 'Device Manager'. A new dialogue will open up. The dialogue shows all installed hardware components in a tree view.
6. Look for the entry 'Ports (COM & LPT) and expand it.
7. The expanded view will show you the list of COM ports installed, indicating some USB remark as well, for example:
   Prolific USB-to-Serial Comm Port (COM4)
8. You now know that your system has a COM4 installed and you can use this COM port in Ambient Studio.

NOTE: In some cases Windows will immediately identify the USB-to-Serial device without needing to install specific USB driver software, but some USB-to-Serial converters can cause problems when incorrect drivers are installed. Make sure you always use the recommended and latest drivers available to prevent problems with your serial interface.

6.1.2 Setting Serial Port Configuration

Use the Serial Port Configuration dialogue in Ambient Studio to establish a connection between

Ambient Studio and your network. The Serial Port Configuration dialogue is opened by clicking the menu entry:

Connectivity → Serial Port → Configure.

This dialogue can be used to add, remove and rename serial aliases, as well as open and close individual aliases. For every serial alias specific settings can be set. Ambient Studio will automatically fill in standard settings required to open a connection to a GW3000.

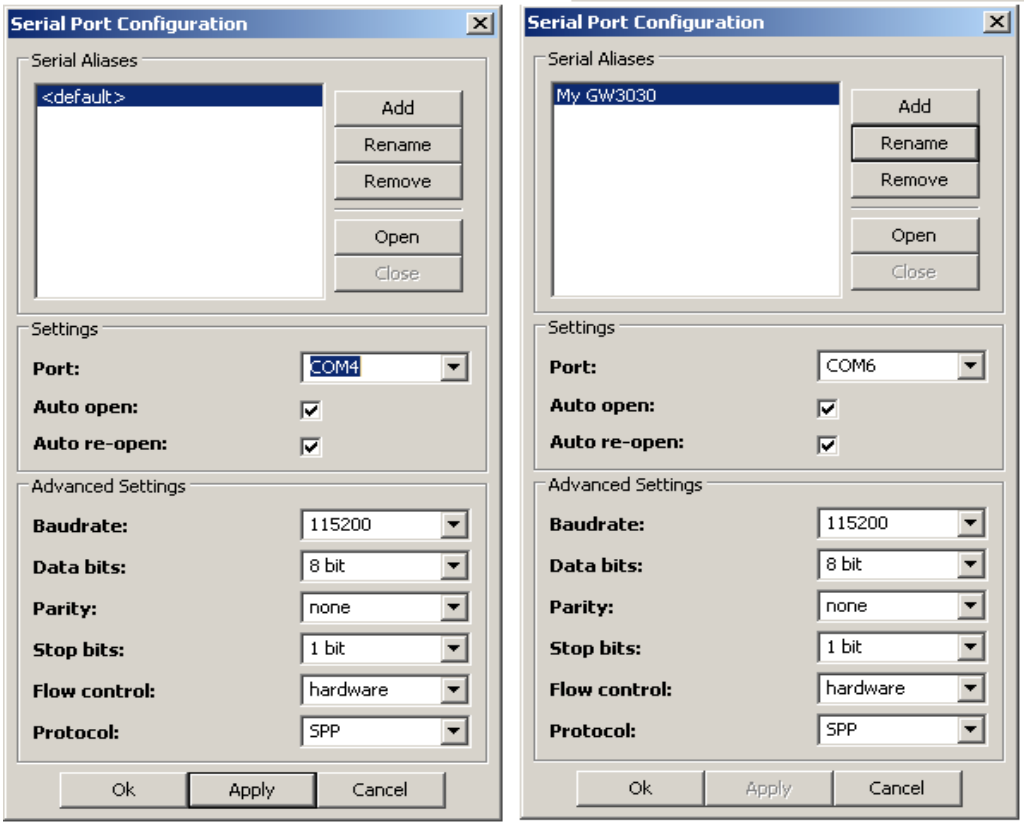


Illustration 14: Serial port configuration

If you use Ambient Studio for the first time, it will automatically create a serial alias named '<default>', that works on COM1, and attempt to open it. Using the buttons in the Serial Aliases section, you can respectively add, rename, remove, open and close a serial alias.

In the 'Settings' section you can select the actual system Serial Port to connect to and indicate whether the serial port should be automatically opened upon start up (recommended). In the example, 'COM4' has been selected.

In the 'Advanced Settings' section, you can modify parameters of the serial port. Normally, you do not need to change these. See Illustration 14.

For your convenience, you can rename '<default>' to e.g. 'My GW3000'.

Press 'OK' to apply your changes to the Serial Port configuration.

6.1.3 Checking the connection between Ambient Studio and your GW3000

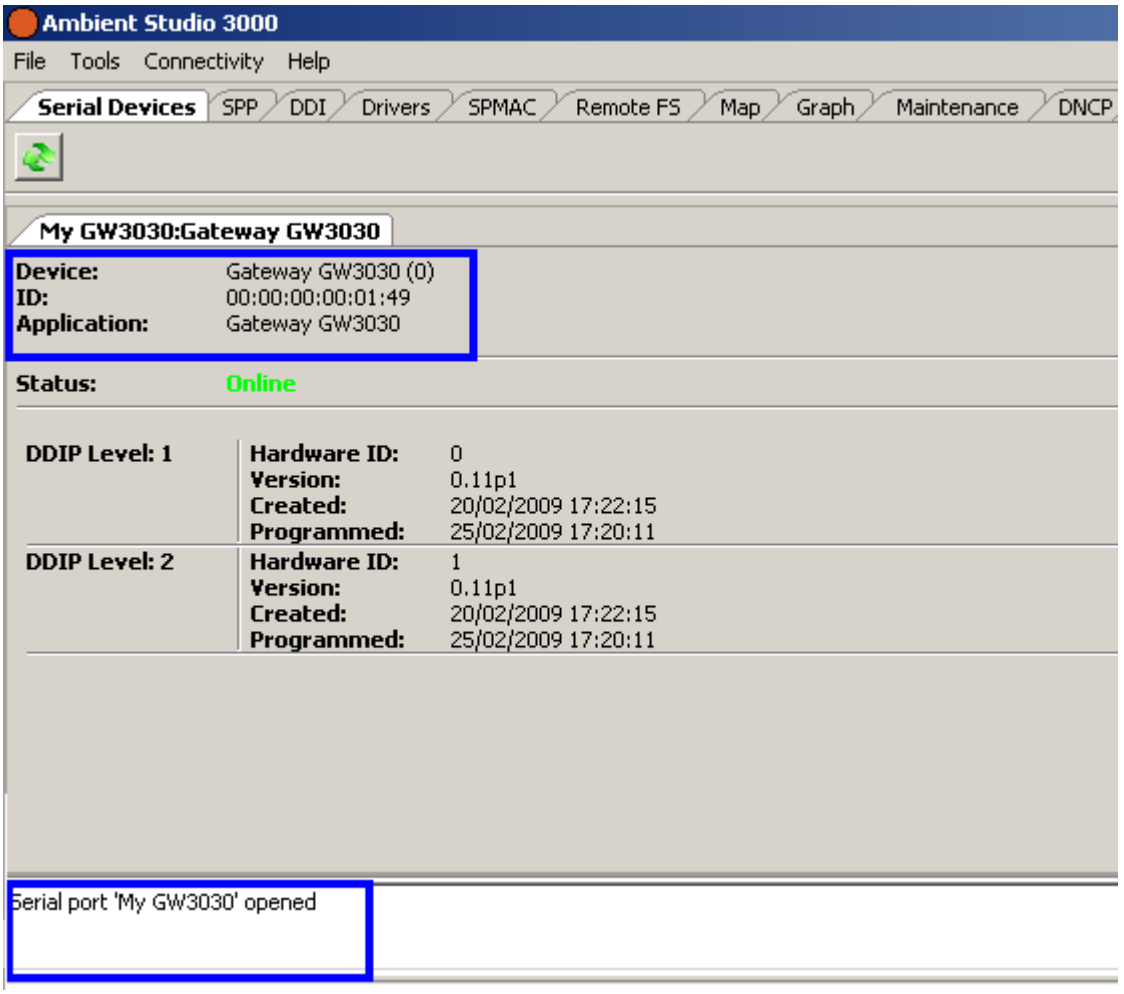


Illustration 15: Serial tab, connected Gateway

The Serial Devices tab in Ambient Studio is used to display information of the currently connected serial devices to your system.

Press the refresh button to show up-to-date information.

Ambient Studio successfully connected to your GW3000 if:

1. Check if **Device** reads "**Gateway GW3000 (…)**", the **ID** displayed matches the ID of your GW3000 and Application ID equals GW3000, GW3120 (or any other GateWay type).
2. The status window shows "**Serial port … opened**" (you may need to scroll in the status window, before you can read the message). Check if the message displays the alias you entered in the Serial Port settings (Section 5.1.2).

3.Status shows "**Online".** This is illustrated in Illustration 15.

If the connection between Ambient Studio and the GW3000 is not successful, please check the Troubleshooting section of this document.

6.2 Set date and time

All devices in the Series 3000 network have built-in clocks that keep track of the date and time. When devices report for example temperature readings, timestamps are included with the temperature samples. Even if SmartPoints leave the network, their internal clocks make sure that logged events or sensor readings carry accurate time information.

You need to set the time and date once in the gateway device. The time and date information is automatically propagated to other devices in the Series 3000 network.

To set the time and date:

1.Ensure that the PC running Ambient Studio has correct time and date.

2.Select the "**Maintenance**" tab in Ambient Studio.

3.Find your GW3000 in the device list. The type field of the device reads "**Master gateway**" and it displays the ID of your GW3000. Select the device by left clicking on it.

4.Press the following button:  The time and date set panel appears.

5.Press "**Synchronize**" to copy the date and time settings from the PC to the Gateway GW3000. It can take a few minutes before the time and date settings have propagated to all devices in the Series 3000 network[1][2].

6.Press "**Close**" to confirm the time and date settings.

6.3 Deployment

Ambient Studio provides convenient ways of visualizing your Series 3000 network deployment by means of the Map View. It provides an overview of the devices of your network and how they are interconnected. Especially the connectivity of the individual devices is of importance as typical ranges of devices vary between different environments.

Note: Chapter 7 provides useful hints on how to deploy the Series 3000 network.

In Ambient Studio, select the "**Map**" tab to visualize your deployment. The view can be used for the following:

- **Check if all your devices join your network** – The left side of the Ambient Studio window shows a list of all devices present in your network. The view is automatically updated when devices join or leave the network.

1 By pressing the option button, Ambient Studio can be configured such way that it can synchronize the gateway time automatically.
2 SmartPoints will use the new time after the first succefull communication

Note: It can take up to two hours[1] before all SmartPoints report in new deployments. MicroRouters needs to be powered by mains before they report.

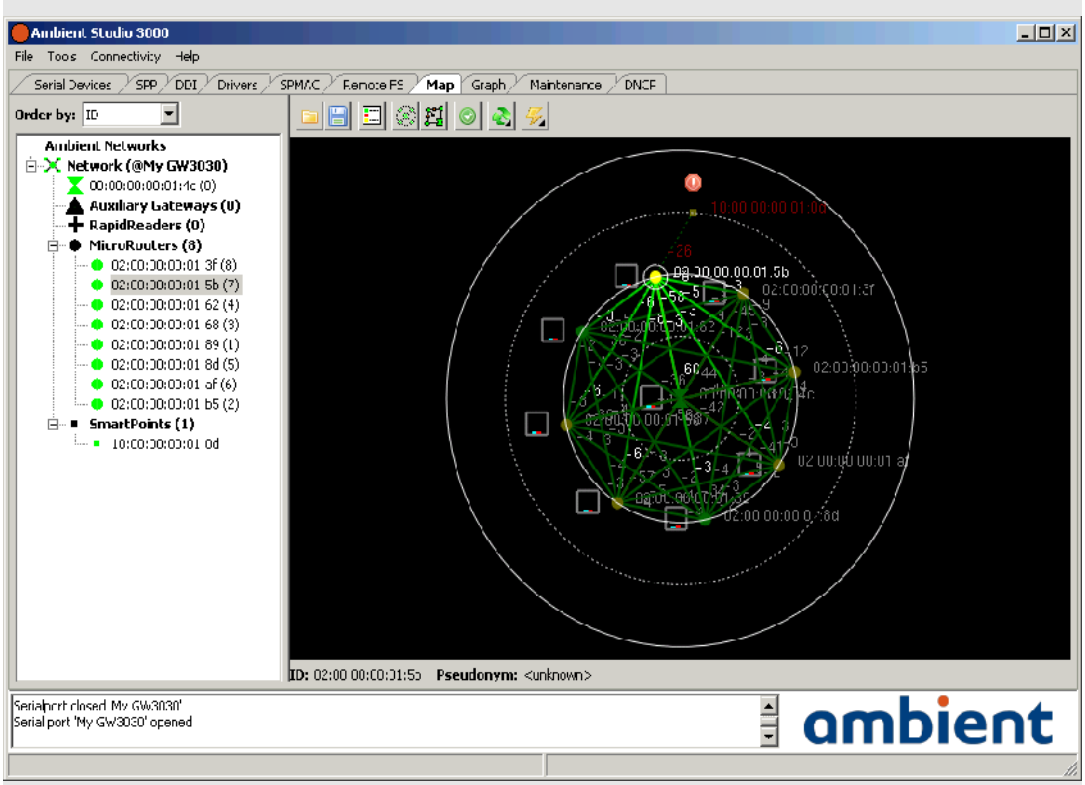


Illustration 16: Circular network view

- **Check if all nodes have acceptable link qualities –** You can check link qualities between nodes by looking at the colouring of nodes and lines between them. See Chapter 6 for more information on deploying a network. (By pressing the configuration button, various options exists in order to hide certain lines).

- **Check networking status** – You can visually check if devices are congested and whether you need to deploy additional devices to remove bottlenecks from your deployment.

- **Check power status** – You can visually check the power status of all devices. You can remotely inspect if devices operate on batteries and if the batteries have sufficient capacity. Press  to view the information. Since the information is retrieved from the network, it can take a while before the information is displayed.

If you select a device in the list, it will be highlighted in the map and information about the device is displayed. You can obtain detailed information about a particular device by selecting it in the list and right click on it. Choose the "**Properties**" option. A panel with detailed information appears (or right click a node in the map view). Press "OK" to dismiss the panel.

Wait until all devices appear in the Map View before continuing network configuration.

1 Assuming that there is no package loss of the SmartPoint

6.4 Enabling built-in backup batteries

When Gateways and MicroRouters are shipped, their backup battery has been disabled. You have to enable the backup battery to make sure that the Series 3000 network remains functional during short power shortage.

You need to perform this action only once per Gateway or MicroRouter.

Note: The backup battery must be enabled once to keep the network functional during short mains outages.

To enable the backup battery:

1. Select the "**Drivers**" tab in Ambient Studio.
2. Select a Gateway or a MicroRouter from the device list (make sure DDIP level 2 is selected)
3. Select the "**Power**" from the DDI tree view (Illustration 18).
4. Press  to configure the power driver. The power driver configuration panel appears (Illustration 17)
5. To download the current configuration settings press download driver button, marked as A. in Illustration 17. Wait until "**Pending**" returns to 0 and the values in the view are updated.
6. Set the check mark at "**[backup_enabled]**" (B.) under "**flags**".
7. Press  in front of "**Power driver flags**" at C. Wait until "**Pending**" returns to 0. The backup battery has now been enabled for the selected device.

Tip: In the Ambient Studio Series 3000 User Manual is described how the configurations of multiple devices can be set at once.

Note: The panels might look different in your network, depending on your configuration and available DDI drivers.

6.5 localization

localization is discussed in the localization white paper which can be obtained on our support

website. Please take a look at this document for more detailed information. The text in this section discusses only localization set-up.

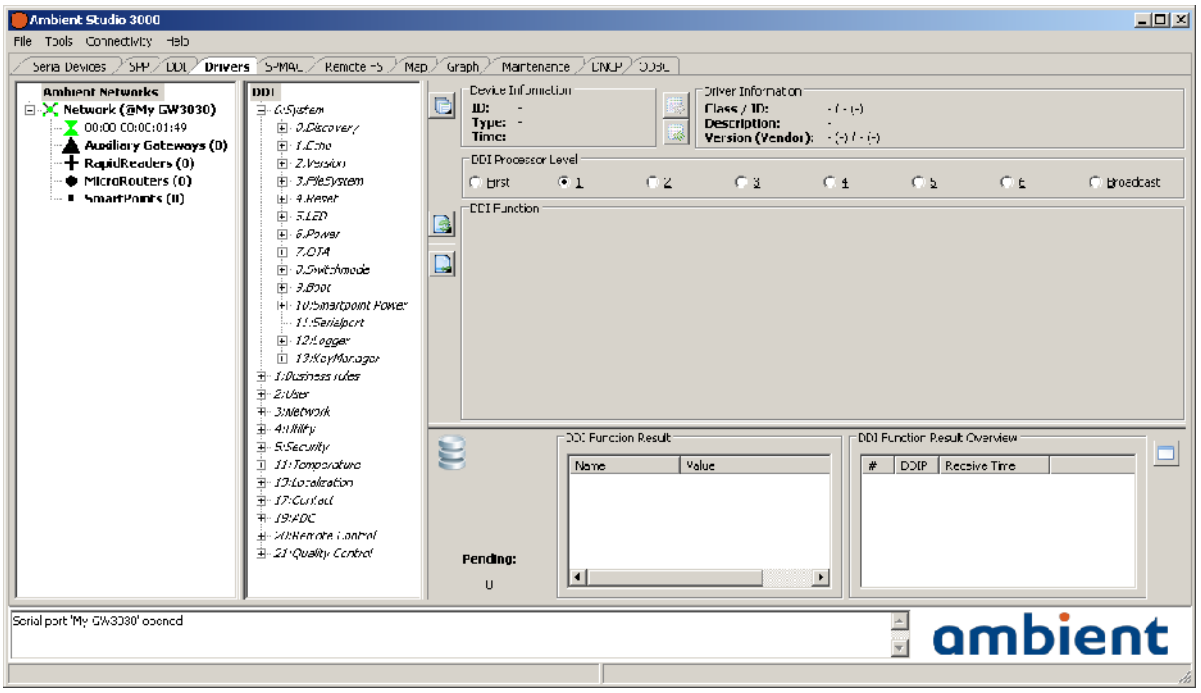


Illustration 17: tree view of available drivers

6.5.1 localization deployment.

Deploying a 3000 Series localization network is similar in many aspects to deploying a regular network for e.g. temperature monitoring or inventory management. When deploying a network with localization functionality enabled, you should try and take into account a few more aspects than you would normally do for a monitoring deployment. In general, deploying localization infrastructure is done by performing the following steps:

1. Place the Gateway and MicroRouters in the localization environment.
2. Configure the locations of the Gateway and the MicroRouters.
3. Configure and enable localization parameters on the SmartPoints.

   In the following subsections we cover the aforementioned steps in more detail.

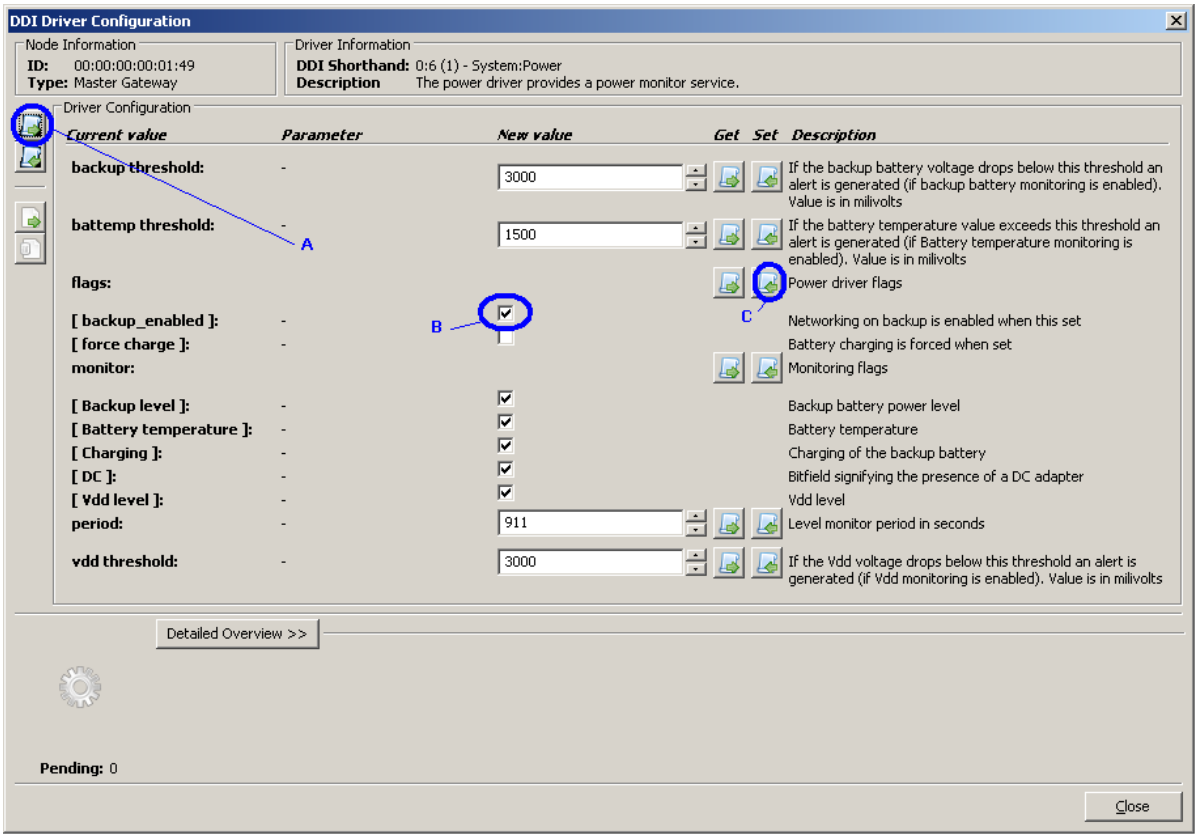


Illustration 18: Power driver of Gateway/Microrouter

6.5.2 Place Gateway and MicroRouters

First you need to physically place and mount the Gateway and the MicroRouters in the localization environment. Take into account the following additional considerations:

- SmartPoints have to be surrounded by Gateways and MicroRouters **otherwise localization will not work correctly.** Placing the Gateways and MicroRouters at the corners and along the borders of the localization area and evenly distributed throughout the deployment area will ensure this.
- Ensure that SmartPoints are always in range of at least one infrastructure device in order to obtain a position estimate and communicate with the network. However, the more infrastructure devices you hear, the better your position estimate.

In order to get the **BEST** localization performance:

- Place the Gateway and MicroRouters in a uniform distributed grid.
- Place the Gateway and MicroRouters in such a fashion that they have an optimal line of sight with SmartPoints.
- Place the Gateway and MicroRouters at the same height.
- Mount SmartPoints at the same height as the MicroRouters (if possible, else not close to the floor, ceiling, preferable in the middle).
- Ensure that the antennas of the Gateway, MicroRouters and SmartPoints have a similar orientation.

Ideally this means that antennas of GWs and MRs are oriented vertically, and that SmartPoints are mounted upright, i.e. when holding the SmartPoint in one hand with your arm outstretched, you should be able to correctly read the Ambient logo.

- Ensure that SmartPoints are in range of at least four infrastructure devices.

6.5.3 Set coordinates of Gateway & MicroRouters

After you have deployed your 3000 Series network you need to configure the positions of the Gateway and MicroRouters in/with Ambient Studio so they match the physical real-life position of the devices in the deployment area. Please make sure you read the 3000 Series Ambient Studio User Manual for detailed information. This requires the following steps:

1. In Ambient Studio, navigate to the 'map' tab.
2. Load a map of the localization area.
3. Drag Gateway and MicroRouters to coordinates on the map that match their real-life positions and send it to the device by pressing the 'Set Position' button (red flag). Make sure their real-life position matches the position in Ambient Studio as best as possible.
4. Optionally, you can set the position of the device by using the Node Information dialogue: right-click on any device to open the dialogue.
    1. Navigate to the 'Localization' tab.
    2. Fill in the real-life position of the device in the provided fields.
    3. Press the 'Set Position' button to commit the position to the device.

The accuracy of the 3000 Series localization system depends on the MicroRouter density. For example, for room level localization accuracy the MicroRouters are best positioned in each room, or every other room. Also, you should take care when dealing with support walls which often surround (emergency) staircases. It is advised to place additional MicroRouters in such areas.

Illustration 19 shows the 'Map' tab of Ambient Studio with an example deployment:

- The white figure on the background is the loaded floor plan.
- The circles represent the MicroRouters.

  For detailed information about Ambient Studio, please read the 3000 Series Ambient Studio User Manual.

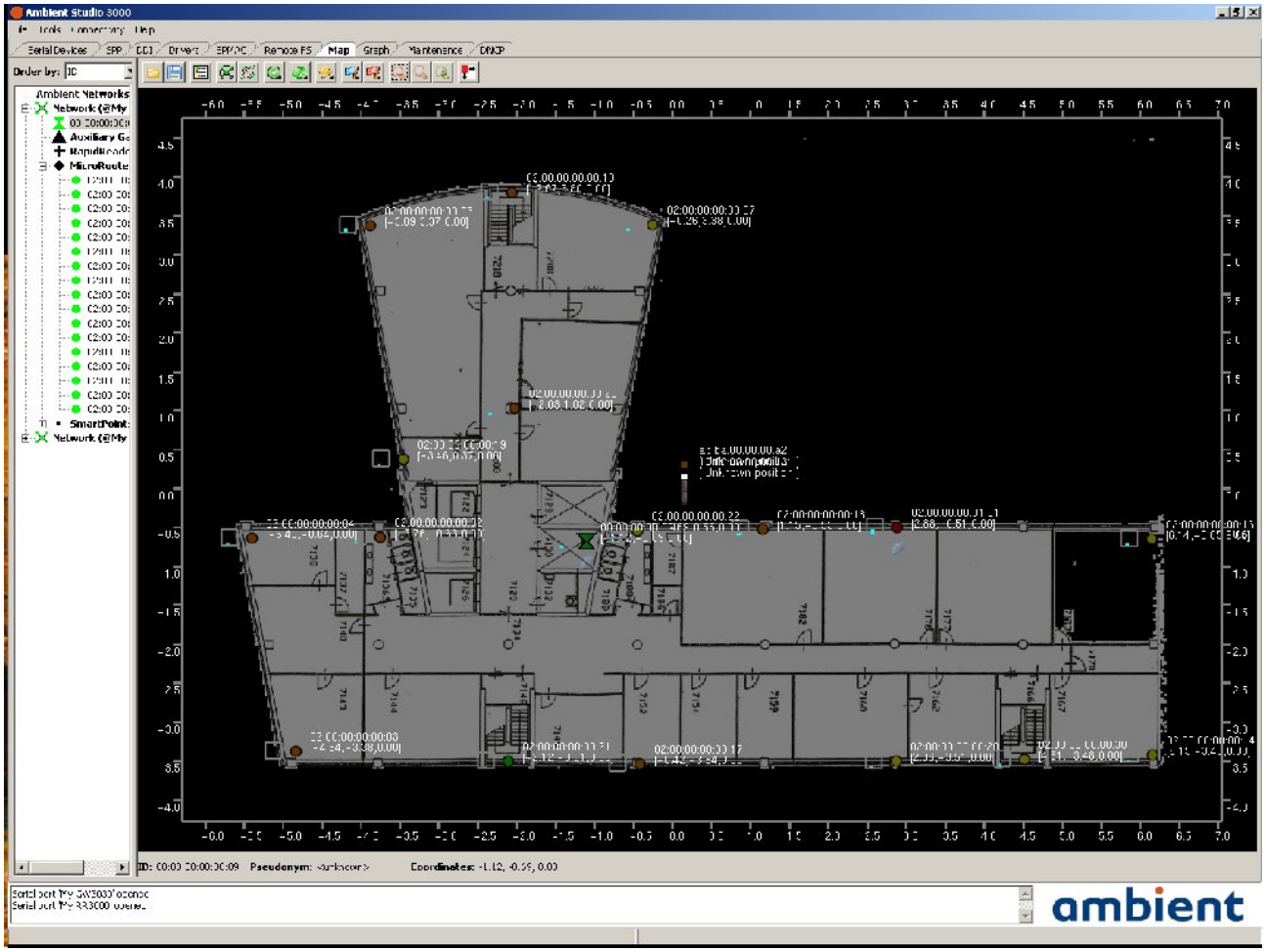


Illustration 19: Map tab of Ambient Studio with example floor plan and infrastructure devices

6.5.4 Enable localization of SmartPoints

In order to enable SmartPoints to locate themselves, you have to activate their location engine driver. The 'Drivers' tab of Ambient Studio can be used to do that. Perform the following steps to configure the localization engine:

1. In the left network tree control select a SmartPoint.
2. In the second DDI tree control navigate to driver class '13:Localization' and expand the field.
3. Navigate to driver '2:Engine'.
4. Press the 'Configure Driver' button to the upper right. A dialogue will open. See Illustration 20
5. Fill in the appropriate driver parameters (see explanation below).
6. Set the configuration of the engine by pressing the 'Set Full Configuration of Driver'
7. button to the left side of the dialogue. Wait for the request to complete: the icon to the lower left should indicate a green 'OK' icon.

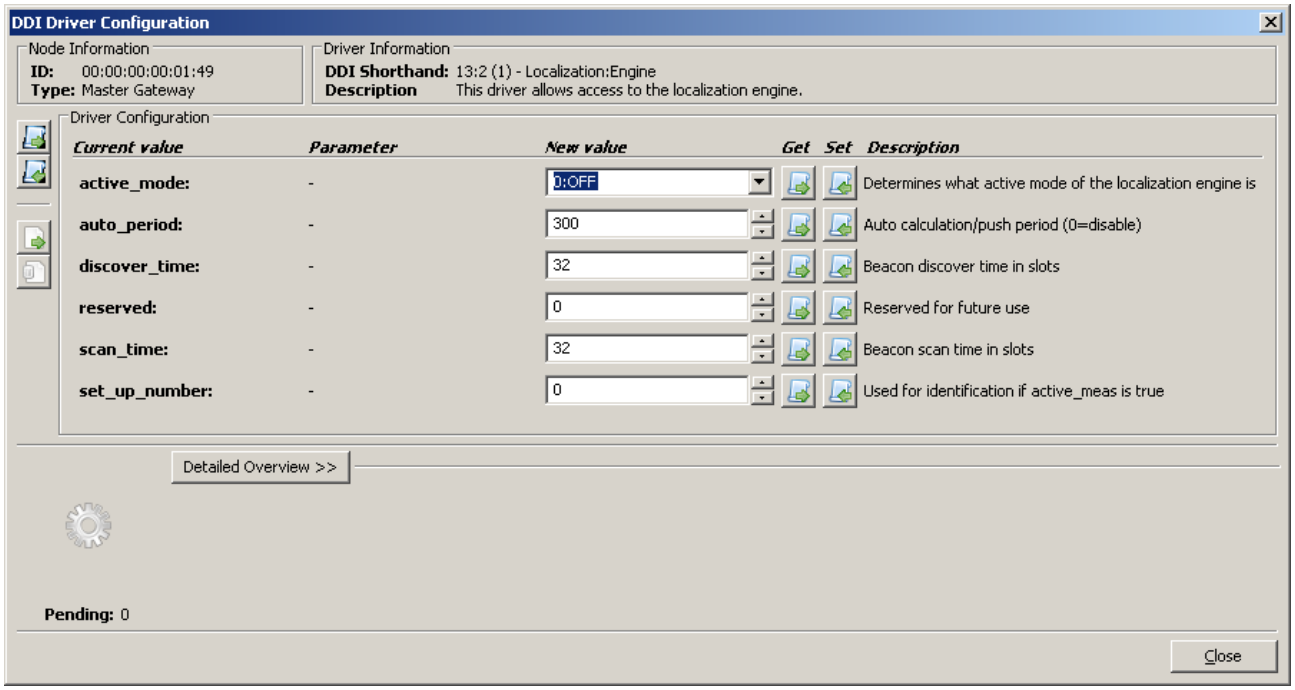


Illustration 20: Setting parameters of SmartPoint Localization Engine in Ambient Studio

The parameters of the localization engine consists of the following:

- **active_mode**
  Selects whether localisation is switched off, or the position or measurement mode is selected.
  Default value: off.
  - **Position**
    This parameter enables the SmartPoint to perform RSS measurements for centralized calculation. Only X,Y,Z and timestamp values are pushed.
  - **Measurement**
    This parameter enables the SmartPoint to perform RSS measurements for centralized calculation, debug or research purposes. The raw RSS measurements are pushed along with the location (X,Y,Z, timestamp)

- **auto_period**
  This parameter represents the period in seconds in which the SmartPoint locates itself or performs RSS measurements. Decreasing this parameter increases the energy consumption. The minimum value of *auto_period* is set to 10 seconds.
  Default value: 300.
- **discover_time**
  This parameter represents the time the Smartpoint searches for a 3000 Series network.
  Default value: 32.
- **scan_time**
  This parameter represents the time the SmartPoint listens to MicroRouters for obtaining RSSI information. Increasing this parameter increases the energy consumption of the SmartPoint.

Default value: 32.

- **setup_number**
  This parameter is used for identification purposes when performing RSS measurements. The setup number can be used to identify, for example, groups of SmartPoints based on their configuration. In normal circumstances you will not use this parameter at all.
  Default value: 0.

Once you have enabled localization, you will immediately start receiving position updates from SmartPoints. You can use Ambient Studio to visualize this information. In the 'map' tab in Ambient Studio the SmartPoints are displayed. When you select the 'User View' option Gateways, MicroRouters and SmartPoints are displayed with their virtual coordinates. If any new position information is received, the SmartPoint will be redrawn to resemble its location in real-life.

6.6 DNCP

Dynamic Network Configuration protocol, or DNCP for short is the protocol for assigning slots to the MicroRouters. A MicroRouters needs at least one slot for proper operation. This protocol is hosted by the GateWay. With the DNCP driver, slots can be made static and multiple slots can be assigned to MicroRouters. It is not advised to change device without consulting Ambient Systems support. Contact support@ambient-systems.net for more information.

6.7 Security

Contact support@ambient-systems.net regarding the security features of the 3000 Series.

6.8 Temperature monitoring

SmartPoints SP3000 have built-in temperature sensors that sense the ambient temperature of the device. The sensors have been pre-calibrated in order to provide accurate temperature readings. The behaviour of the temperature monitoring capabilities of the SP3000 can be controlled through the Temperature DDI driver. This section describes how the temperature driver can be configured to meet your requirements. By default, SPs report temperature once every 5 minutes.

The following alerts are generated by the temperature DDI driver:

- **Temperature range**: An alert range can be set and an alert will be generated when the temperature is *in* the alert range. Or an alert can be generated when temperature is *outside* the range. E.g. food needs to be stored between +2°C and +7°C. When temperature is lower than +2°C OR higher than +7°C, an alert should be given.
- **Temperature change**: An alert can be generated when the temperature changes more rapid than a given range. E.g. a greenhouse is heated to +30°C. Due to fluctuations of the heating system, the temperature drifts up to 3°C in 5 minutes, but when a door is left open, the temperature changes more than 0°C to 3°C in 5 minutes and an alert should be generated.
- **Combination**: Range and change alerts can be combined. E.g. food needs to be stored between +2°C and +7°C and temperature might not fluctuate more than 2°C per 5 minutes.

The following sections explain the two types of alarms in more detail.

6.8.1 Range alarms

Range alarms are generated based on the absolute measured temperature. The measured temperature is compared to the range specified by MIN_{range} and MAX_{range}. If the temperature is not less than MIN_{range} and not greater than MAX_{range} the temperature is *in* range. If the temperature is less than MIN_{range} it is *below* range and if it is greater than MAX_{range} it is *above* range. A temperature driver can be configured to generate alarms if the temperature is within range or outside (below or above) range.

The range also has a hysteresis value *Hr*. This value is relative to the MIN_{range} and MAX_{range} thresholds. In the case that the temperature is outside the specified range it must change at least *Hr* degrees beyond the MIN_{range} or MAX_{range} threshold to be considered in range again. Having this hysteresis can prevent rapid change in alarm status when there is a small fluctuation in temperature around a threshold value.

The values for the range alarm driver settings are expressed in degrees Celsius (°C).

The following picture depicts the behaviour of the range alarm for a specific temperature curve.

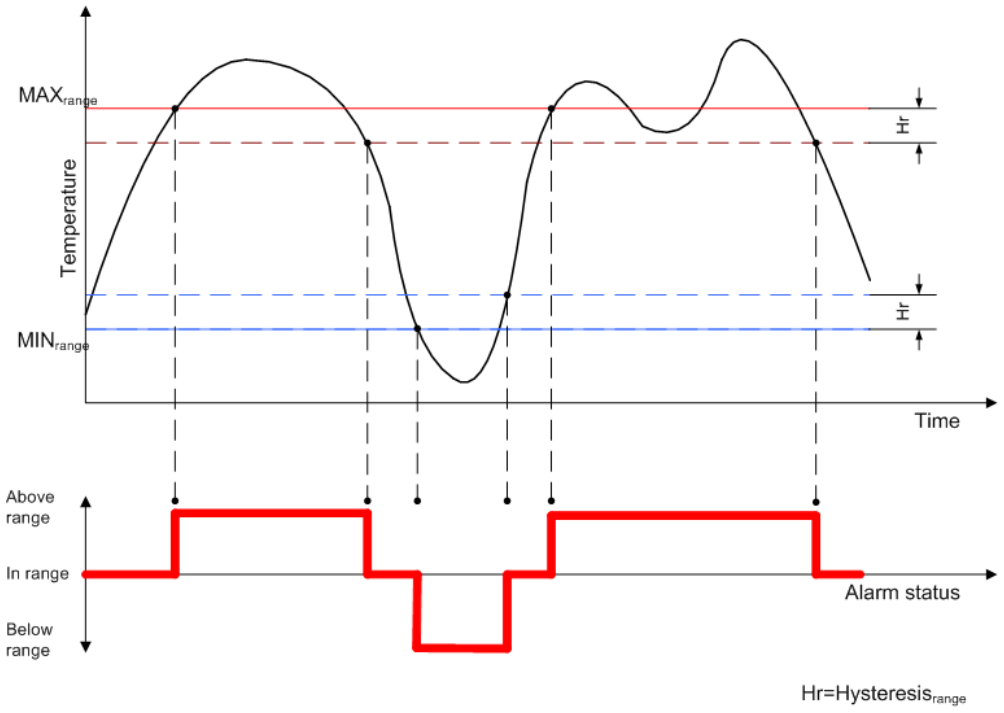


Illustration 21: Temperature range alarms example

6.8.2 Change alarms

Change alarms are generated by the amount of change in temperature between two sample periods. A temperature driver will sample its sensor with a configured period. The change in temperature between two samples is compared to the MIN_{change} and MAX_{change} thresholds. If the temperature is decreased more than MIN_{change} it is *below* the change range, if it is increased more than MAX_{change} it is *above* the change range. Otherwise the temperature change is *in* range.

Like with the range alarm a temperature driver can be configured to send an alarm if the temperature change is within range or outside (above or below) range.

The change range has a hysteresis value *Hc*. This value is relative to the MIN_{change} and MAX_{change} thresholds. In the case that the temperature change was outside the specified range the change of temperature of the next sample must be at least *Hc* degrees beyond the MIN_{change} or MAX_{change} threshold to be considered in range again. Having this hysteresis can prevent rapid change in alarm status when there is a small fluctuation in temperature change around the threshold value.

The values for the change alarm driver settings are expressed as degrees Celsius per sample period.

The following graph (Illustration 22) depicts the generic behaviour of the change alarm mechanism. The graph shows the time interval between two samples. The sample at T_{now} is tested for its position relative to the value of the MAX_{change} and MIN_{change} lines at T_{now}.

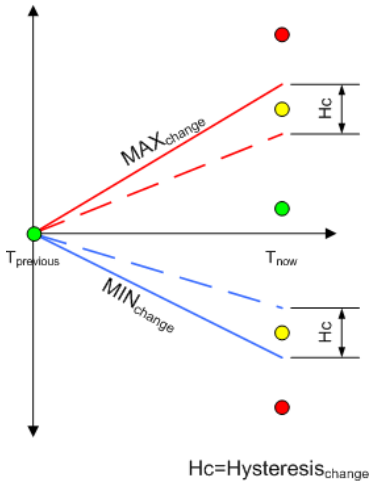


Illustration 22: Hysteresis

The following graph (Illustration 23) depicts the behaviour of the change alarm mechanism for a specific temperature curve. In this case alarms are configured to be generated when the temperature is outside the specified range. For every sample (the green dot) the generic picture above is drawn to visualize the change relative to the chosen thresholds.

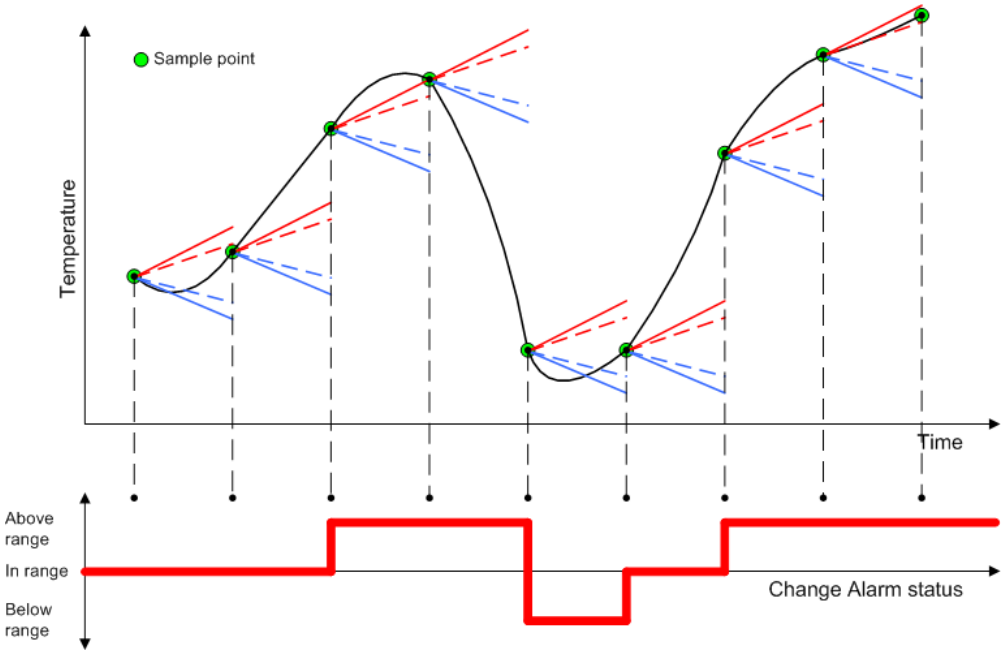


Illustration 23: Temperature change alarm example

6.8.3 Configuration

Ambient Studio allows you to configure (driver panel) the following parameters:

field	min	max	default	description
sample period	10	65535	300	Sample period in seconds
send period	10	65535	300	Set the sending periodic of automatic pushing of readings
Alarm period	10	65535	300	The period with which temperatures are sent in case of an alarm (in seconds)
Behaviour	-	-	0	Determines the behaviour of alarms and periods. See Ambient Studio Temperature Driver Configuration Panel for more details.
calibration	-128	+127	0	Calibration value of the sensor
range min value	-2048	2047	0	Minimum value of the alarm temperature range in degrees Celsius
range max value	-2048	2047	50	Maximum value of the alarm temperature range degrees Celsius
change range min value	-2048	2047	-5	Minimum value of the alarm temperature change range in degrees Celsius per sample period
change range max value	-2048	2047	5	Maximum value of the alarm temperature change range in degrees Celsius per sample period
hysteresis	-2048	+2047	0.5	Hysteresis value of the alarm temperature range in degrees Celsius

change hysteresis	-2048	+2047	1.0	Hysteresis value of the alarm temperature change range in degrees Celsius per sample period

6.9 Logging and flushing

In dynamic environments where SmartPoints enter and leave the network, the log and flush drivers can be used to retrieve all 'missing' samples/measurements. For example, when a SmartPoint is attached to a truck, all temperature measurements are lost when the SmartPoint is not in range of the network. With logging and flushing these measurements can be restored.

In order to describe how to set-up the logging and flushing functionality, a short introduction of DDI (Device Driver Interface) is required. For detailed DDI information, please take a look at the DDI specification which can be obtained from the Ambient Systems Support website.

DDI has the following operations:

1. Request/return. A device can sent a request message to a certain driver, the receiver checks validity, executes the function and the result of the function is sent in return.
2. Invoke. A device can sent an invoke message to a certain driver, the receiver checks validity, executes the function. No return is sent.
3. Push. Certain drivers, like the temperature driver on the SmartPoint can sample the temperature at certain intervals and 'push' this message into the network.
4. Error. The error message type is used whenever a request or invoke is issued and the ddi call is invalid (e.g it doe not exist or the payload is wrong).
5. Alert. Certain drivers, like the temperature driver on the SmartPoint can sample the temperature at certain intervals and 'push' this message into the network. However if the alarm driver of, in this case the temperature driver is configured as well and there is an alarm situation, the message type is not a push message but an alert message. Alert messages have higher priority and travel therefore faster through the network.
6. FlushPush. This message type is use to indicate that a message is a measurement from the past and the original message type was a push.
7. FlushAlert. This message type is use to indicate that a message is a measurement from the past and the original message type was an alert.

Only push and alert messages can be logged (and flushed). Please note that the payload of the flush (alert) and flushpush (flushalert) is exactly the same. Only the message type is changed[1].

6.9.1 Configuration of the log and flush driver

In release 1.0 of the 3000 series, two drivers can be logged in parallel. These log is stored in the log file log_0 and log_1. The maximum amount of samples which can be logged is configurable, 2048 samples per log file is the upper limit.

In Ambient Studio, select a SmartPoint in the tree view of the Driver panel. Unfold the the available drivers and select 0:System, 12:Logger and 1:SetLogConfig. Select whether log-index 0 or 1 has to be used, the size of the log file and select which driver has to be logged. For the temperature driver this

1 the DDI-timestamp as this is attached to sample when receiving it in Ambient Studio

is 11:1. Select whether only pushes, alerts or both message types have to be logged. This is illustrated in Illustration 24.

Secondly, the flush functionality has to be configured. Select 0:System, 12:Logger and 1:SetFlushConfig for the same SmartPoint. Select direction 'oldest first', select logindex 0 and select flush_push and flush_alert. This is illustrated in Illustration 25.

Third, flushing has to be enabled on the SmartPoint, this can be done by pressing the configure driver button (of driver 0:System, 12:Logger). Select flush enable. The rate of flushing is defined as *M* messages per period *P*, where M and P are adjustable at runtime. So each period P the flushing mechanism will try to send at most M messages. For now the default values are M=1 and P=150. P is expressed in seconds. If flushing is enabled for more than one function; F > 1, then P is divided by F and in each sub period M messages from a single function are flushed. So effectively each function is still flushed at rate M/P but the network load is spread over time per function. The configuration is illustrated in Illustration 26.

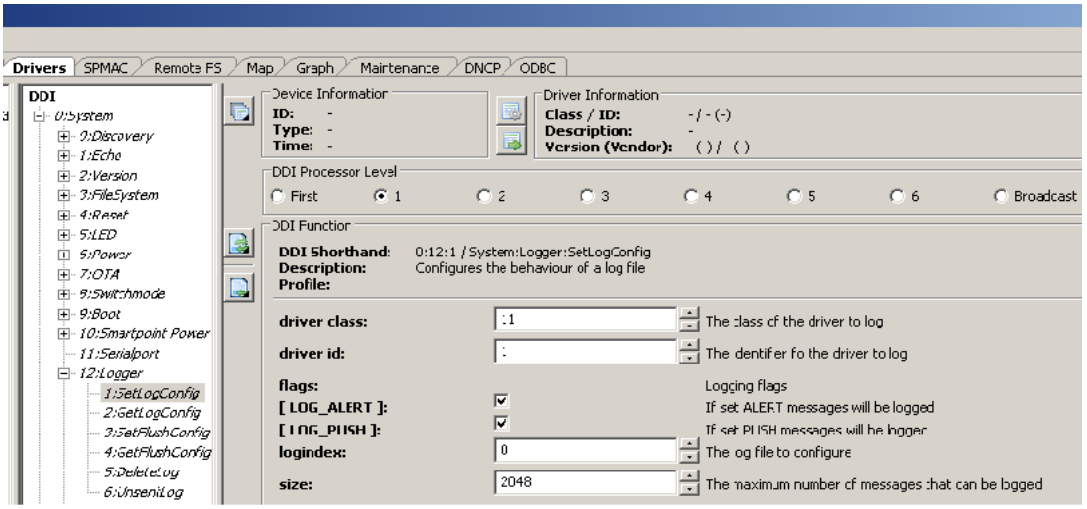


Illustration 24: Setting the log driver

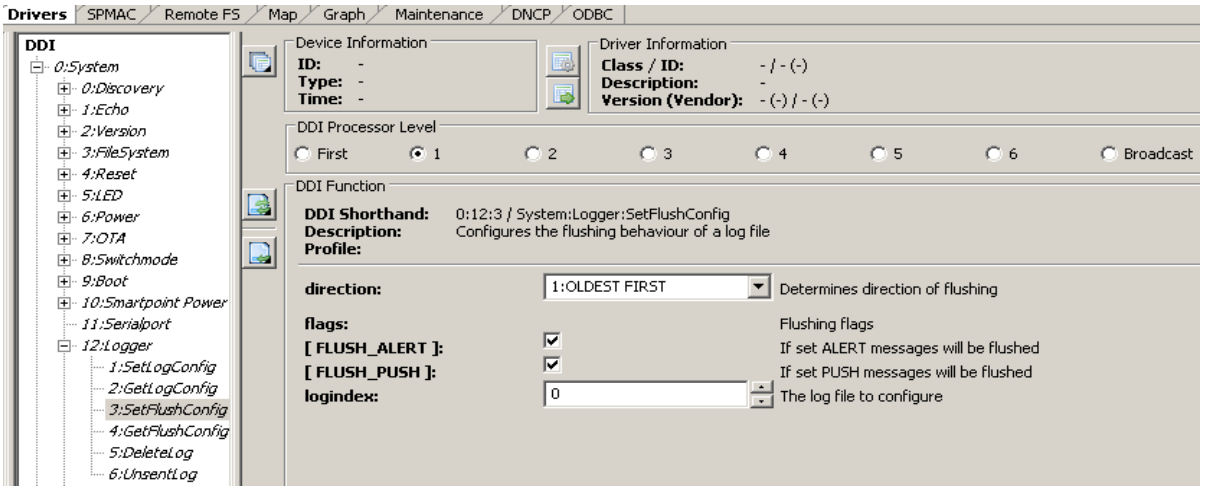


Illustration 25: Setting the flush driver

6.10 Coexisting Networks

At this moment two (or more) networks cannot run at the same physical location. Both networks will use the same frequency. Radio messages will collide and routers will (likely) lose their connection with the gateway. The delivery rate of the SmartPoint will likely drop and it might be possible that messages are coming in via both(all) gateways.

Therefore, make sure that there is maximum one GateWay switched on a single location.

Contact support@ambient-systems.net for more information.

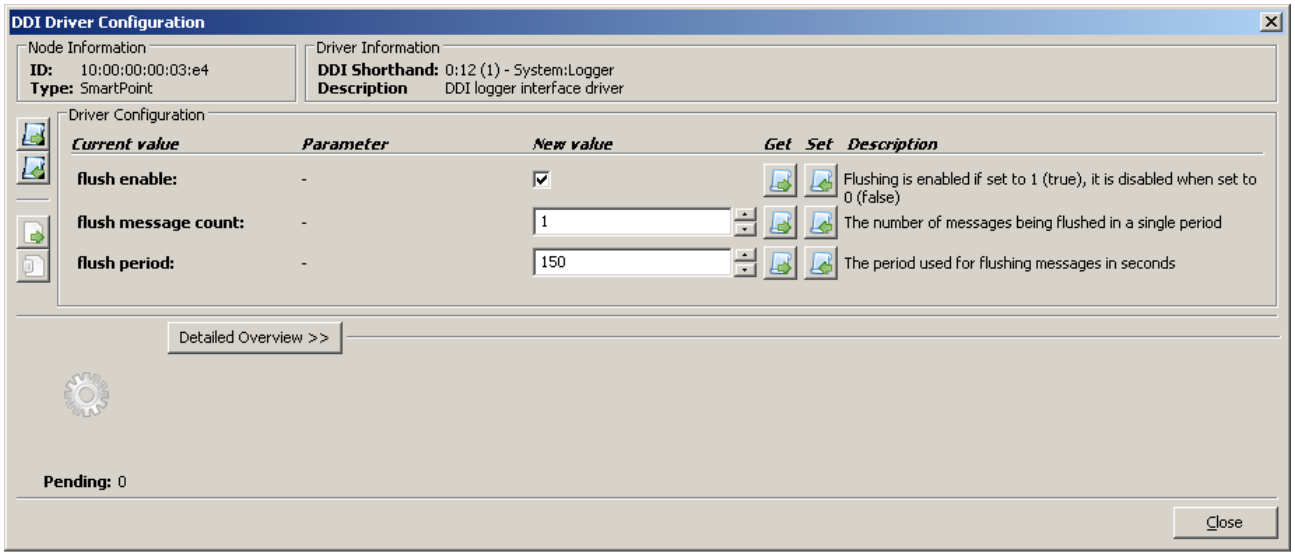


Illustration 26: Configuration of the flush driver

7 Deployment

As with every wireless technology, deploying the devices physically in the environment requires considerations of environmental parameters like thickness and material of walls, metal objects, glass (coated) windows, people moving around, environmental conditions such as temperature and humidity, doors; they all influence radio wave propagation. WSNs are not an exception to this rule. However, with a bit of planning, some background knowledge about multi-hop networks it shouldn't take long to deploy an Ambient Network.

7.1 Preparations

It is important to deploy the network well prepared; take your time. It is vital that, prior to deployment, detailed site information is obtained; where possible, obtain maps or blueprints with detailed information (AC power outlets, supporting versus non-supporting walls, etc.). If no maps are available, draw one by exploring the site before deploying a single node.

Find available AC power outlets and also mark these down on the map. Make sure that these outlets are active for 24 hours every day and not included in nightly energy savings schemes. Some outlets are better suited than others; outlets above ceiling plates (in office environments) are preferable, such that people won't use the outlet for other purposes and the MR could be disconnected. Although an Ambient infrastructure has a rechargeable backup power source, they need to be recharged periodically. If this situation arises, confirm that the outlet is active long enough to charge the backup power source.

Identify possible problematic structures, for example walls with a lot of metal, strengthened glass, elevator shafts and so forth. Also identify any equipment that could potentially generate RF signals/interference.

The following list summarizes the steps that should ensure you have made the appropriate preparations;

1. Obtain detailed blueprints / maps of the target site (see example in Illustration 32)
2. Mark down AC outlets
3. Mark down any building materials or objects that could reduce the range of the nodes, such as thick concrete walls, windows, metal doors, electrical equipment, and so forth
4. Make sure you are aware to the best of your knowledge of other wireless devices in the target environment that use the 2.4 GHz band, such as cordless phones, WiFi access points, IEEE 802.15.4 or ZigBee® enabled networks, and so forth. These devices may interfere with the Ambient Systems 3000 series or the Ambient Systems 3000 series may interference on these wireless devices in the 2.4 GHz band. If performance loss is noted, please contact support@ambient-systems.net.

Always make a Deployment Plan before deployment!

Always obtain Site Information before making a Deployment Plan!

7.2 Deployment Planning

Although an Ambient network is built up from the GW outward, a deployment planning is built up the other way around; starting from the SPs. As SPs have a shorter range than infrastructure nodes, they determine the positions where infrastructure nodes should be placed. In order for SPs to communicate with an MR, it needs to be in range of the MR.

Mark the locations on the sitemap that require network coverage, i.e. the locations where you want to deploy SPs. SPs are deployed at those locations where you wish to measure environmental parameters. If you are using the Real Time Location System (RTLS) functionality of the SPs, mark the area where the SPs will need to be located.

Having the SPs marked down and the SP location area marked down, you can now use their typical radio coverage to identify the areas where you need to place MRs. Draw circles around each SP. Use as diameter typical value of 15 meter. Each SP should be in range of at least 1 MR or the GW, but preferably more to ensure good connectivity. The areas on the map that are covered by several circles are good locations to place MRs. As a rule of thumb, it is preferable for every SP to be in range of at least 3 Infrastructure nodes. The SP has multiple paths to the gateway and there is enough redundancy in case one router is congested or off-line due to whatever reason.

For larger sites it makes sense to perform some range tests prior to planning the installations. Deployment tooling can be used for this purpose. Contact support@ambient-systems.net for more information about deployment tools.

Ensure that every SP is always in range of at least 3-4 Infrastructure Nodes

Print the Deployment Sheets part 1 and 2[1] to keep track of the deployed nodes. During the process of planning your deployment, write down the unique ID of the GW/MR/SP and its respective location on the map as well as a short description of the area in which it is placed, for example:

Node Type	Node ID	Description
MicroRouter	02:00:00:12:34:56	Above the door, placed in the centre, powered using the AC outlet from the ceiling lighting

Now after having collected the maps and pictures and having marked all important locations on it, we are ready to make a first Infrastructure deployment plan.

Start with placing the Gateway preferably somewhere in the centre of the environment; this is critical to the structure of your network. If you place the Gateway at the centre of the network, you will have less hop counts and thus less latency; if you place the Gateway at the corner of the network, you will introduce higher hop counts and as a result have more latency and increased the probability of creating bottlenecks.

Now, using the positions and areas of the SP, place an MR near an AC outlet in areas that are in range of the SPs. On a separate map, place the MRs at exactly the same locations. Now try to make an estimation whether the network is well connected by drawing circles around the MR based on their typical radio range. Ensure that each MR is in range of at least 2 other MRs and that there is

1 The Deployment sheets part 1 and 2 accompany this user manual as separate documents.

always a path to the GW for each MR. Ensure that the GW has at least 3 hop 1 connections to reduce the chance of bottlenecks. Plan additional MRs between MRs that are expected to be too far apart.

Always leave some margin for reduced radio range due to changes in your environment when making a Deployment Plan!

Always ensure that each MR is in range of at least 2 other MRs with the same or lower expected hop count!

Always ensure that each GW has at least 3 hop 1 connections!

7.2.1 Infrastructure Bottlenecks

In each deployment, there is a chance of introducing so-called bottlenecks. Metaphorically speaking bottlenecks are a section of a path with a carrying capacity substantially below that characterising other sections of the same route. This is often a single connection between two MRs that separate larger portions of a network (see Illustration 27).

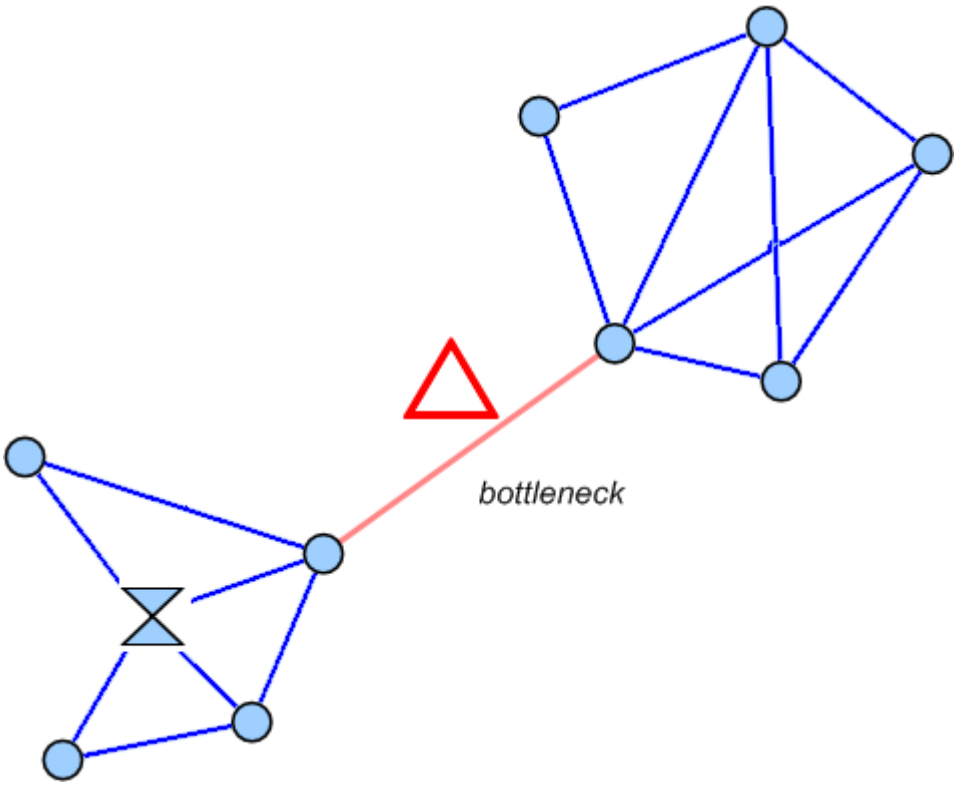


Illustration 27: Example Bottleneck situation

The aforementioned bottleneck is a typical Infrastructure bottleneck and can easily be avoided by placing additional MRs around the problem area.

Avoid Infrastructure bottlenecks by all means.

7.2.2 SP Load Bottleneck

Another type of bottleneck can be introduced by SPs, but these are a bit harder to find and depend heavily on the configuration of an SP. By default, a SP3000 will send a message every 5 minutes. By default, a GW and MR can handle 2 SP interactions per second[1]. As a result you should then be able to place 60*5*2 = 600 SPs around a single Infrastructure node. However, packet loss can occur, SPs can wake up at the same time, and so forth. As a rule-of-thumb, it is advisable not to exceed the load of a GW or MR with more than 50 SPs in its range. Your Infrastructure deployment needs to incorporate this SP load and provide enough bandwidth to handle the SP payload. A way of determining the network load is described below.

We determine the load of a GW or MR, indicated as the 'SP Load', by determining how many SPs are in range of an Infrastructure node. With this approach we assume that every SP is configured similarly, i.e. all SPs transmit the same number of packets within the same time period. A single SP provides an SP Load of 1. If an SP is in range of more Infrastructure nodes, we calculate the load by dividing 1 by the number of Infrastructure nodes in its range. We can now determine the SP load of an infrastructure node by summing the SP loads of the SPs in its range. For the Infrastructure nodes we can now determine an *accumulative* load by summing all the SP loads of Infrastructure nodes that are one hop further away. As with the SPs, depending on the number of Infrastructure nodes in range the SP load is divided by the number of Infrastructure nodes that are one hop closer to the GW (see Illustration 28).

1 This can be change to 4 by configuring the appropriate driver, driver network:DNCP

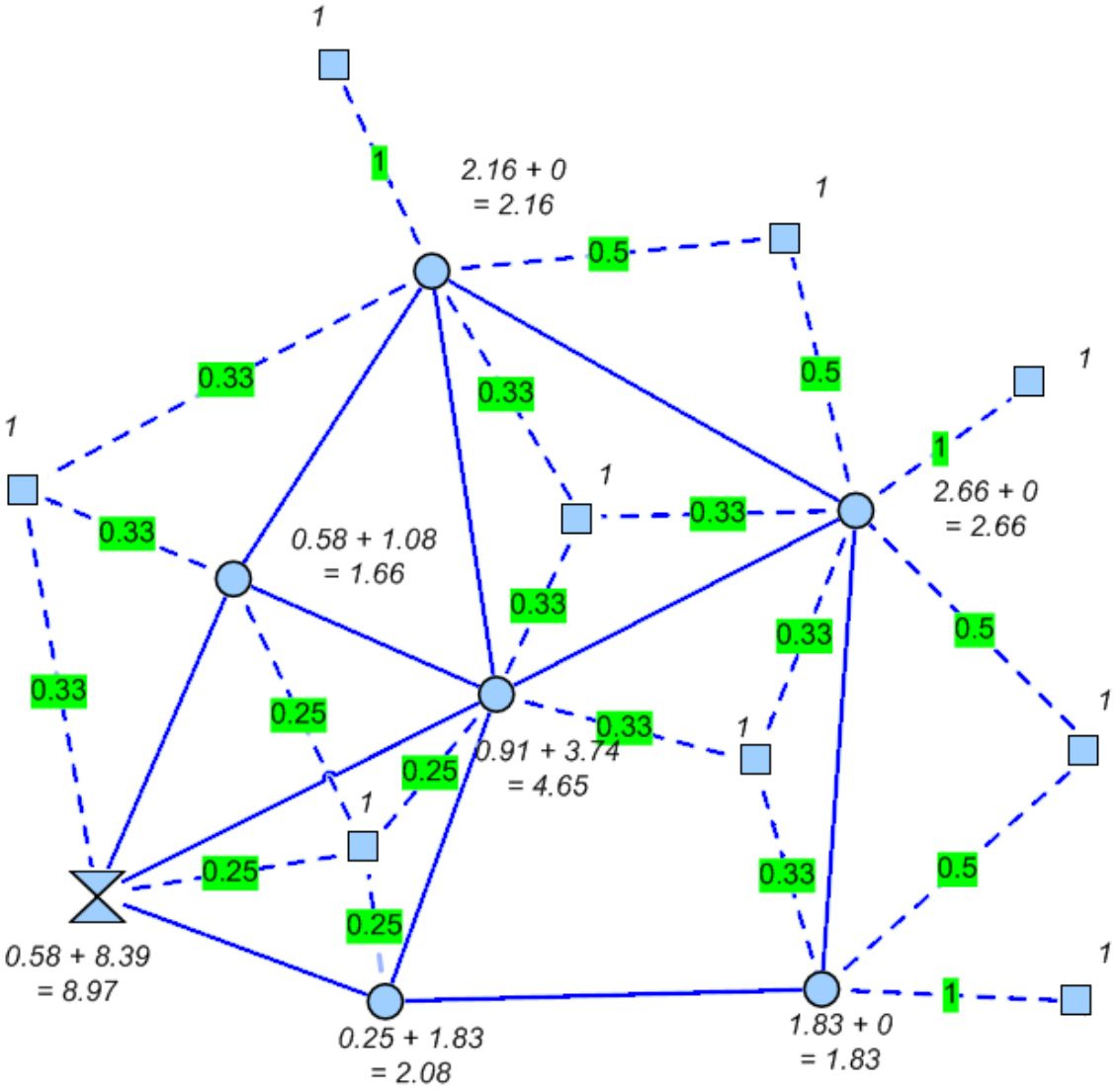


Illustration 28: Example SP Load calculations, with every SP default at load 1, every Infrastructure node combination of its own SP load and additional accumulative SP Load

Now using the default SP values, a SP load of 1 means '1 message per 5 minutes'. If we convert this to the number of messages per second, we get the value 1 / (5 * 60) = 0.003 messages per second. A single MR-SP link is capable of handling 2 messages per second by default. However a single MR-MR links is capable of handling 1 message per second. This results in a SP load capability of 1 * 5 * 60 = 300. The network itself consumes some of this bandwidth to establish and maintain the network coherence and layout. Also, packet loss or retries can occur. As a rule of thumb, roughly 10% of the available bandwidth is consumed by internal use and packet loss or retries, assuming stable connections between Infrastructure nodes. The further away an MR is from the GW (in hops), the more bandwidth is consumed by the intermediate MRs. As a result, an Infrastructure node is capable of handling a SP load of 0.90 * 300 = 270. If the SP load that you calculated gets close to this number, you should place an additional MR to increase the available bandwidth.

It should be noted, however, that there is a chance that SPs do not consume the beacons provided by the Infrastructure nodes in a evenly distributed way, so some margin for error needs to be taken into account.

Calculate the accumulative SP load to identify potential congestion bottlenecks!

If an accumulative SP Load nears the maximum network bandwidth, place additional Infrastructure nodes to introduce additional bandwidth!

7.3 Deployment Execution

After the Deployment Plan has been set up, it is time to start deploying the nodes according to the plan. Every deployment starts with the GW since a network can not exist without it. Then, after the Gateway has been set up, the MRs are added to the network. Finally, after the Infrastructure has been deployed, we place the SPs at their target locations.

7.3.1 Mounting the Gateway / MicroRouter

Generally the GW and MR should be mounted such that the swivel antenna is always in vertical position. This ensures the same polarization for all the antennas and in consequence best connectivity. The above statement holds for both indoor and outdoor networks. Also, all MRs and GWs should preferably be placed at the same height above the ground. For best radio performance 1.5 meters above the ground or higher but not closer than 1 meter to the ceiling.

Ensure all antennas are in vertical position for best radio performance.

As the GW and MR comes with a swivel antenna there are a number of considerations for placing the MR and GW. Always try to place the GW or MR as far as possible from surrounding objects as possible, such as large metallic objects, walls, pylons or other obstacles. Placing the antenna too close to objects will alter the radiation efficiency so that less power is radiated into free space, effectively reducing the range of the GW and/or MR.

Mount the GW and MR in such a way that its antenna has a good clearance. This ensures the best performances and radiation efficiency. Keep in mind to avoid placing the antenna too close to corners of the room. Mount the GWs and MRs at a height such that it radiates above most obstacles such as metal cabinets for maximum performance.

Once you have selected a good position and orientation for mounting a GW or MR, use screws and a screwdriver[1] to fix it in place. Then connect the node to the power using the AC adapter and wait for it the go through the right sequence of the start-up procedure by observing its LEDs. The LED[2] sequences can be found in Illustration 29.

1 Only use screws of 5 mm diameter or thinner. If you use screws that are thicker, you risk damaging the enclosure.
2 When printing in grey colours, the led colours are from left to right, blue, green, orange and red.

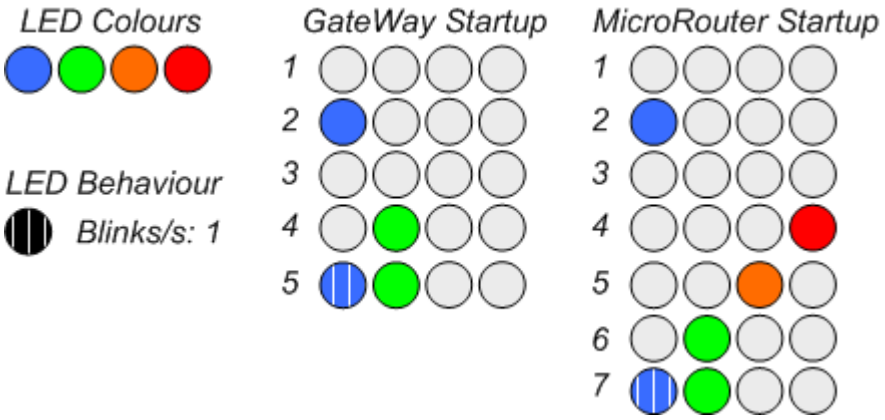


Illustration 29: LED Behaviour for the Gateway and MicroRouter

If the MR remains in start up phase 4, it means that it does not hear any network. Ensure that the SMA antenna is fitted correctly and that you are within range of another active node (e.g. the GW). If the MR remains in start up phase 5 and then goes back to 4, it means that it did hear a network, but could not join. This can be due to various reasons. One possibility is that it can not obtain a good link to the nearest active Infrastructure node. Try a different position closer to the nearest active Infrastructure node and retry the procedure.

Always place the GW and MR as far away from obstacles as possible!

Prevent placing GWs and MRs in corners of ceilings and walls!

When placing GWs and MRs high on walls and ceilings, ensure you have taken all safety measures possible!

7.3.2 Mounting a SmartPoint

A SP is mounted easily. There are several ways to go about this: 1) simply place it at the intended location without fixing it, or 2) use the single-screw hole and fix it by screwing it to the surface of a wall or object. For different ways of mounting, check our website.

Make sure you use screws of 4 mm or less. If you use screws thicker than that, you can damage the enclosure.

Once the SP is in place, check with Ambient Studio that it is reporting data and has a good connection. You can confirm this by navigating to the 'Map' component tab and exploring the tree view to the left of the screen. Your SP will show up in the tree. Additionally, you can request its link quality by pushing the button 'Request Link Information from SmartPoints'. It may take some time for the response to arrive (by default, up to 5 minutes), but now the Map will also show the

SmartPoint and its available links to neighbouring Infrastructure nodes. It is placed correctly when all the indicated RSSI values of all links are -80 or higher (i.e less negative numbers).

7.4 A Few More Pointers

7.4.1 Placing a Gateway

As said before, always start network deployment by placing the GW. The optimal place for the GW is in the center of the network. A small example in Illustration 30 gives an idea why this is so important.

In network A the GW is placed at the edge of the network. In this case only one MR has a direct connection to the GW. The maximum hop count is 2. Furthermore all MRs have only one path towards the GW. There is a clear bottleneck situation at hop 1.

In network B the GW is placed in the centre. All three MRs have a direct connection to the GW so the maximum hop count is 1. Also, no direct bottlenecks are visible, though the SP load still needs to be taken into account.

In general, placing the GW in the middle of a network will minimize the maximum hop-count and it will result in (at least in the first hop) more paths towards the GW. Latency is reduced and more bandwidth is available.

Place the Gateway as much in the centre of the network as possible!

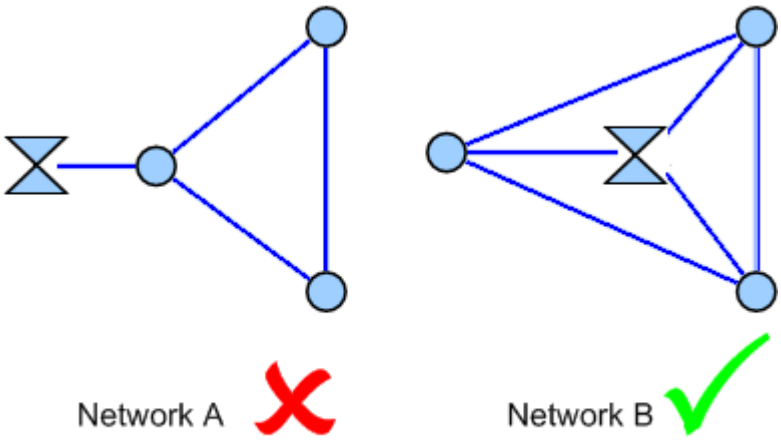


Illustration 30: Pointer for placing your Gateway

7.4.2 Placing a MicroRouter

You will encounter situations where it is very beneficial to place an additional, albeit redundant, MR. Network stability and coherence, bandwidth, coverage, latency, these are all aspects that can benefit the network performance greatly by simply adding an additional MR. See Illustration 31 for an example.

Network A is a connected network of 5 MRs. It is somewhat shaped as a straight line. However, there are not many paths available and this network could suffer from bottlenecks. There are in total 6 connections. The GW has only 1 hop 1 connection. There are 3 potential bottlenecks.

In network B two additional MRs are placed at strategic locations. Placing them in such a way you introduce 7 more connections, bringing the total to 13. The most important improvement is that the GW now has 2 hop 1 connections. Furthermore, the new situation results in all MRs having at least 2 available connections, and most have more. Also, no direct bottlenecks are visible, though the SP load still needs to be taken into account.

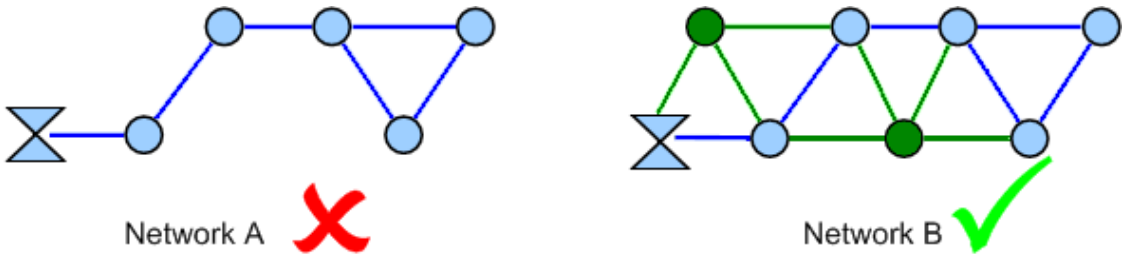


Illustration 31: Pointer for placing your MicroRouters

Of course, preferably in this situation, it is even better to move the gateway to the center of the network to reduce the hop count.

7.4.3 Avoid Interference

Make sure you place GWs and MRs as far away as possible from appliances such as cordless telephones, microwaves, televisions and such. This will significantly reduce any interferences that the appliances might cause since they operate on the same frequency.

7.4.4 Security

Don't give other parties the chance to affect the stability of your networks. Change the default keys of your nodes prior to deployment so you have a secure network. Please refer to the Ambient Studio User Manual on how to perform such changes. Make sure you keep track of your network keys!

8 Example Deployments

In this section we address a few example deployments and take you through the necessary steps required to deploy a network. It can be used as a reference for creating your own Deployment Plan and the installation after that.

8.1 Example: Office Building

As indicated in the previous sections, we start with an empty map (see Illustration 32). We visually inspected the site and found plenty of locations for mounting the MRs. Additionally, we checked for AC power outlets and marked all the outlets on the map (see Illustration 33).

Next, we identified all the locations where we want to place our SPs. For this example we use SP3000 and they need to be placed in every room in order to monitor the different room temperatures. A PC is connected to the Ethernet and placed centrally in the building and used for connecting to the GW (see Illustration 34).

Following that, a few locations for placing the MRs are selected, making sure that every SmartPoint was covered and that most MRs were in range of at least one other MR (see Illustration 35), depicted with the circles. In this example the range of the MicroRouter-MicroRouter is not depicted.

8.2 Example: Warehouse

The approach for a large warehouse is more or less the same. Please see Illustration 36. In the warehouse environment there is not always the opportunity to place the gateway in the center of the building, therefore it will be placed in one of the offices on the right bottom side of the illustration. On all 'regular' and 'loading' doors SmartPoints will be placed as well as a relative large number of SmartPoints in the center of the building. Routers will be placed on sites were AC outlets were available. In the corners of the building and on 3 places in the centre.

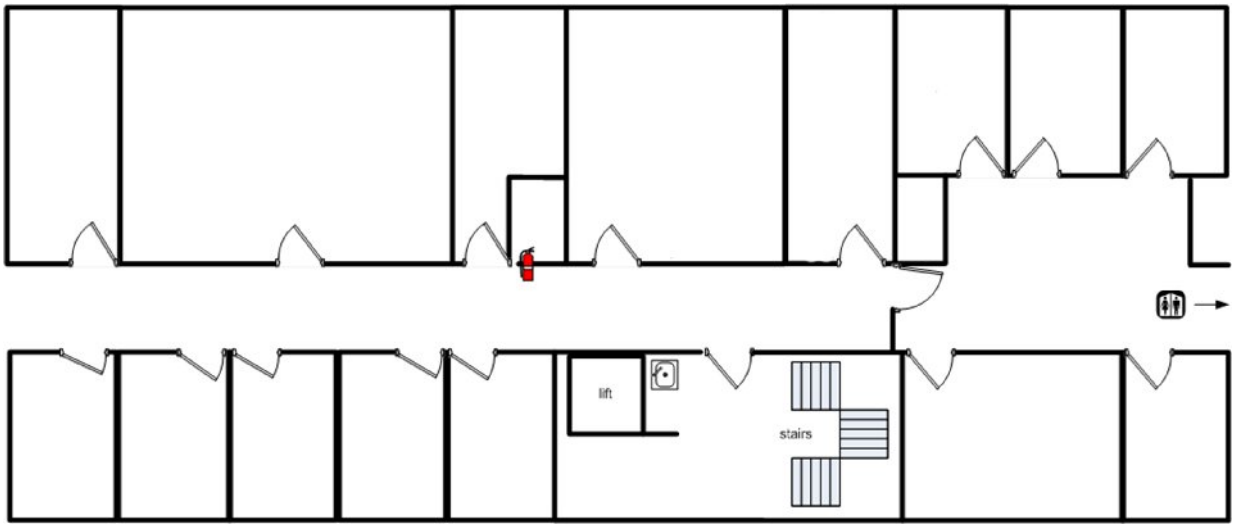


Illustration 32: Deployment Map

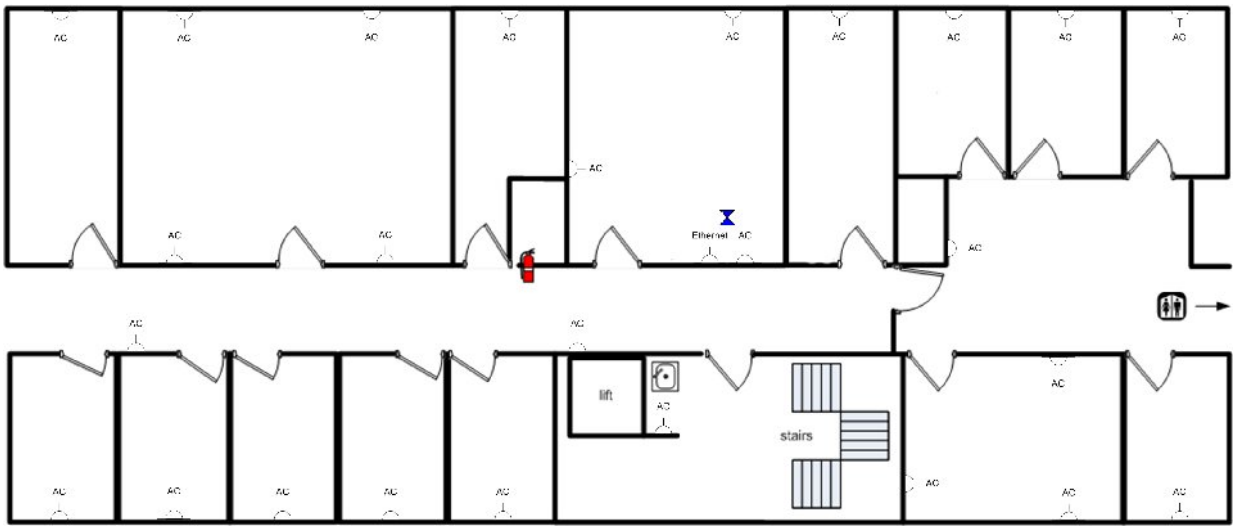


Illustration 33: Deployment Map, AC/DC Power Outlets marked

Illustration 34: Deployment Map, SmartPoints marked

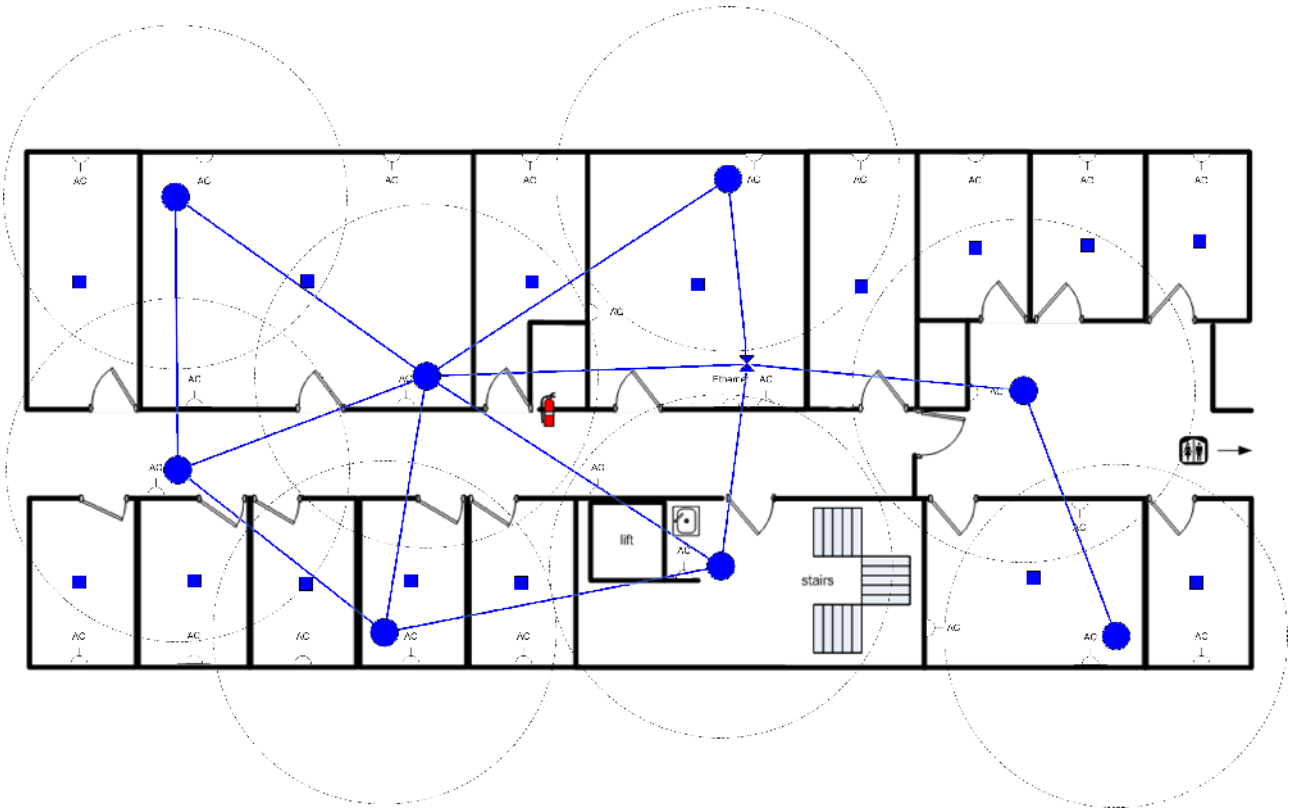


Illustration 35: Deployment Map, MicroRouters marked

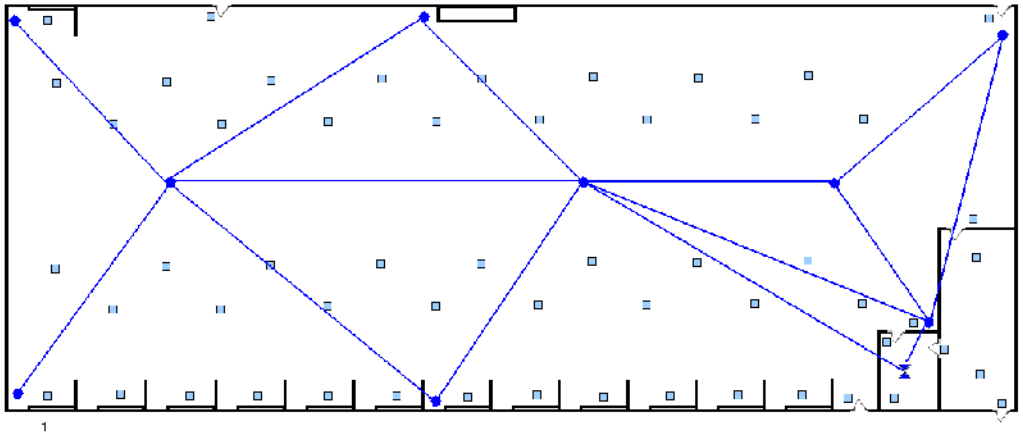


Illustration 36: Example of network deployment in warehouse

9 Firmware Upgrades

This section describes the firmware upgrade procedure for all devices in an Ambient Systems network. This upgrade has to be carried out using Ambient Studio. Basic knowledge and experience with Ambient Studio is assumed. More information regarding Ambient Studio can be found in the Ambient Studio user manual.

9.1 Gateway

Upgrading the firmware of the gateway has to be done by uploading the new firmware image to the file system of the Gateway. When the complete image is uploaded, the gateway has to be reset.

Below is a step-by-step description on how to go about upgrading your Gateway firmware.

1. Obtain the latest firmware version from Ambient Systems and store it on your hard disk. The firmware image of the gateway is always called **Ambient0000.ota**
2. Connect the gateway to Ambient Studio. Go to the Remote File System panel. On the left side of the panel, select the gateway. On the right side of the screen, browse to the firmware image and select it. On the right bottom of the screen, version information of this firmware image is depicted (Illustration 37).

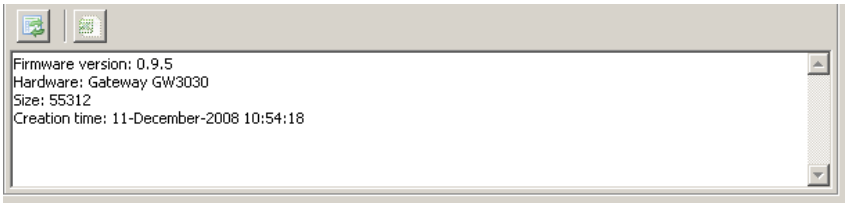


Illustration 37: Version information of firmware.

3. Press the upload file button. The file upload process should start. Confirm that you want to upload the file to the device. Confirm if there is a warning that the file already exist and that it will overwrite the file. The progress can be followed on the bottom of the screen. The upload to the gateway goes relative fast (30 seconds) (Illustration 38). When the upload is completed, the file is listed in the File List view of the Remote File System panel.

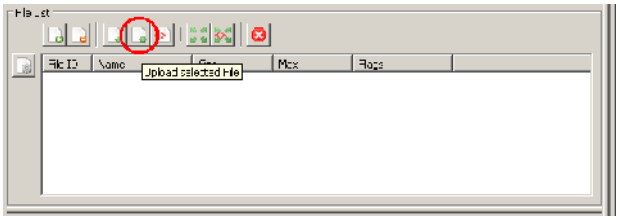


Illustration 38: Upload file button

4. Go to the maintenance panel, select the gateway and press the reset button(Illustration 39).

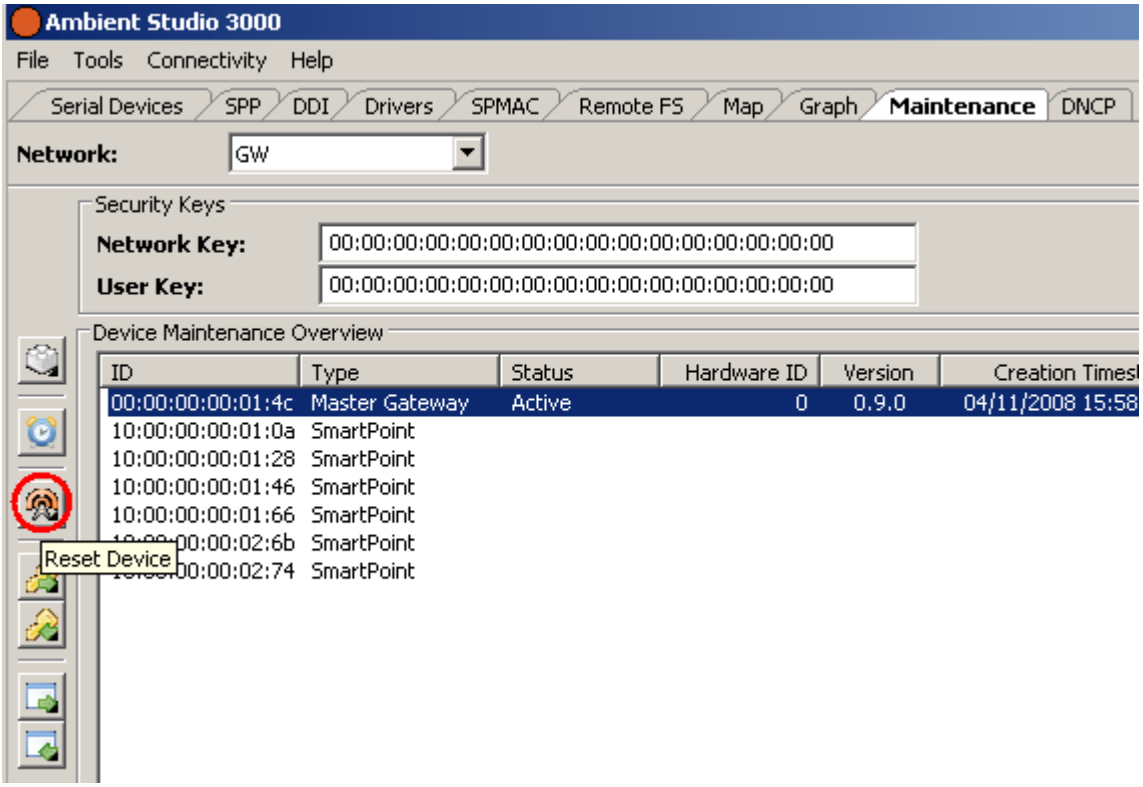


Illustration 39: Reset button to reset the gateway

5. When the gateway resets, it will boot again and the new firmware version is depicted in the maintenance tab. Verify that it equals the version shown in step 2 of this section.

9.2 MicroRouter

In order to upload a new firmware image to the MircoRouter, two approaches can be chosen The file upload approach as described above and the Data Dissemination approach.

9.2.1 File upload approach

In case only one MicroRouter has to be updated the File upload approach can be chosen, in any other case the Data Dissemination approach should be chosen as it is faster.

Exactly the same steps compared to upgrading the firmware of the gateway have to be executed. The firmware image of the MicroRouter is called **Ambient0100.ota**. When uploading the firmware and resetting the device, the targeted MicroRouter has to be selected and **not** the GateWay. As there is 'limited' bandwidth between the Gateway and MicroRouter, the upload might take a while (15-20 minutes for a hop 1 node).

9.2.2 Data Dissemination approach

Whenever a network of a couple (of more) MicroRouters should be updated, the Data Dissemination(DD) approach should be chosen as it is the fasted may to disseminate a file, the firmware image, to all routers in the network. After the firmware image is disseminated, all routers in the network have to be reset.

1. The firmware image **Ambient0100.ota** (of the MicroRouter) has to be uploaded to the to the **GateWay.** See step 2 of 'upgrading gateway'. If the file already exist, overwrite it. If the file

system is full, delete some large files. The upload should go relative fast (30-60 seconds).

2. Select the uploaded File in the File list and press the 'Disseminate Selected File' button (see Illustration 40).

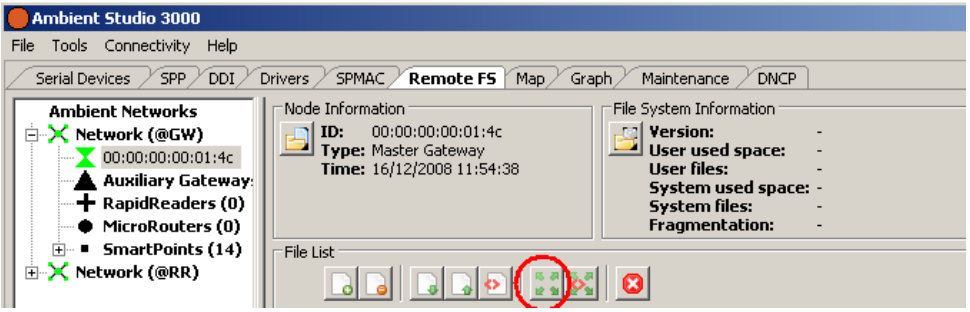


Illustration 40: Dissemination button in order to disseminate a file to all routers

3. Go to the Dissemination panel on the bottom of the screen(File interaction). The gateway will disseminate the file to maximum 4 MicroRouters. When completed, these 4 MicroRouters will disseminate the firmware image to each 4 other MicroRouters. Up to the moment that the file, the firmware image exist on the File System of all MicroRouters in the network. For a multi-hop network with 20+ MicroRouters this might take up to a couple of hours, depending on the topology of the network.

4. When the image has been disseminated to all routers within the network, the routers should be reset. This can be done via the maintenance tab. When right-clicking the reset button, the option all Infrastructure nodes should appear. When pressing this button all MicroRouters (including gateway) will be reset.

5. As all routers transmit their version information at start up, all routers should report their new firmware version.

9.3 SmartPoint

Upgrading the firmware of the SmartPoints has to be done using a rapid reader[1] and Ambient Studio.

The rapid reader has to be connected to Ambient Studio, the serial port has to be setup correctly and it has to be activated, this can be done by right clicking the rapid reader and selecting a channel (the default channel should be OK). Note that the gateway is still connected to Ambient Studio in order to keep the network running.

Secondly, a SmartPoint has to be placed in rapid read mode, this can be done by right clicking the SmartPoint and select 'Initiate Rapid Read Client' and select the same channel as the rapid reader. A message is sent through the gateway towards the SmartPoint. Depending on the report period of the SmartPoint, it will take time before the messages is received by the SmartPoint. When the message is received it goes to rapid read mode. The rapid reader connects to the SmartPoint and one is able to select the SmartPoint (in the tree of the Rapid Reader) and upload the firmware image Ambient1000.ota via the file upload approach as described above. After the upload a reset is required. Select the rapid reader network in the maintenance tab, it should list the Rapid Reader and the SmartPoint which is in rapid reader mode.

1 Note that the rapid reader is not commercially available, only for evaluation and support purposes.

When Switching to the 'gateway' network in the maintenance tab, one should see the updated SmartPoint with the new firmware version.

If multiple SmartPoints have to be updated/upgraded a separated tool, the mass updater, can be used as this tool runs unattended. This tool is described in the the white paper 'using the mass updater' which can be found on the support website or by sending an email to support@ambient-systems.net.

9.4 Remarks

- When upgrading the firmware of the gateway and the routers, it is probably easier to upload the firmware image to the gateway but reset it after the firmware dissemination of the MircoRouters is completed. In this case one is sure that the firmware version of all routers and gateway is equal during the update process.
- Contact Ambient Systems Support in order to obtain a change log of the firmware version and a list of known issues.
- If the dissemination process fails:
  - Verify that the File System is not full. If the File System is full, delete some file and start the DD process a second time, or upload the image to this MicroRouter using the File upload approach.
  - Verify that the MircoRouter has at least one, but preferable multiple good links to a number of routers.

10 Troubleshooting

This section describes solutions to the most common problems you might run into. Please, try the solutions proposed in this section first before contacting the Ambient Support Team. Most solutions take only a few minutes of your time and get your network up an running.

10.1 Troubleshooting the serial connection

If the serial connection fails:

1. Check if the GW3000 device is powered and correctly connected to the PC (see Section 4.4).
2. Make sure that no other PC program (such as HyperTerminal) is using the COM port associated with your Gateway. Close all open programs and restart Ambient Studio.
3. If this is the first time that you a USB to RS232 device, you might need to reboot your PC to enable the software drivers for the USB to RS232 device.
4. Remove all other serial and USB equipment from the PC, except the GW3000. Verify again the COM port as described in Section 5.1.1. Make changes in Ambient Studio, if required.
5. Reopen the Serial Port in Ambient Studio by selecting
   Connectivity → Serial Port → Open → All.
6. Verify the serial connection
7. Contact the Ambient Support Team if the serial connection remains offline.

11 Appendices

11.1 Appendix A: WSN Basics

Ambient Systems wireless products are based on industry standards to provide easy-to-use and compatible Wireless Sensor Networks (WSN) within your home, business, warehouse, transport vehicles and so forth. Strictly adhering to the IEEE 802.15.4 standard, the Ambient Systems wireless family of products will allow you to securely access the data you want, when and where you want it. You will be able to enjoy the freedom that Wireless Sensor Networking delivers.

11.1.1 What is Wireless?

Wireless technology is a means of communication without using wires. WSNs use a certain radio frequency to connect wirelessly, so you have the freedom to connect WSN nodes anywhere in your warehouse, transport unit, office, and so forth.

11.1.2 What is a Wireless Sensor Network?

A Wireless Sensor Network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. The development of WSNs was originally motivated by military applications such as battlefield surveillance. However, WSNs are now used in many civilian application areas, including environment and habitat monitoring, healthcare applications, home automation, traffic control, in-transport monitoring, cold chain, and so forth.

In addition to one or more sensors, each node in a WSN is typically equipped with a radio transceiver or other wireless communications device, a small micro controller, and an energy source, usually a battery. The envisaged size of a single sensor node can vary from shoebox-sized nodes down to devices the size of grain of dust, although functioning 'nodes' of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from hundreds of dollars to a few cents, depending on the size of the WSN and the complexity required within individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and bandwidth.

A WSN normally constitutes a wireless ad-hoc network, meaning that each sensor supports a multi-hop routing algorithm, in other words: several nodes may forward data packets to the base station or gateway.

In computer science and telecommunications, WSNs are an active research area with numerous workshops and conferences arranged each year. Since the start of the millennium, WSN technology has also found its way to commercial markets, clearly indicating that it has matured to a level in which the technology is deemed fit for real-world applications.

11.1.3 Why Ambient Systems?

Ambient Systems is one of the worlds first 3rd Generation Active RFID providers that utilize this WSN technology. It provides new possibilities that were previously hard to combine in a single network; identification, monitoring, location determination, logging. And all this in a secure way. Ambient Systems has developed its own network stack on top of IEEE 802.15.4. The stack has been developed over the last years, originally as a deliverable of one of Europe's biggest research projects into WSN (the EYES project, see www.eyes.eu.org). Ambient Systems modified the stack in such a

way that it is ideally suited for large scale WSNs that have highly dynamic sensor nodes. As location is such an important aspect, this has been incorporated into the network stack itself, enabling SmartPoints to compute their position themselves, therefore you do not require any complex or expensive back office software to calculate positions.

11.1.4 Who uses Wireless Sensor Networks?

WSN technology is becoming more and more popular, but primarily industrial users have adopted it. Nevertheless, whether it is for home, office, warehouse, transport vehicles, Ambient Systems has a solution for it.

Generally

- No need for cables
- Simple and easy to use
- Can operate for years on batteries, automatically indicates battery depletion by means of alerts
- All-in-1

Small Office

- Temperature Monitoring
- Humidity Monitoring
- Localization of valuable Assets, such as laptops, beamers, and so forth

Warehouses

- Temperature Monitoring, for example in climate controlled storage
- Humidity Monitoring
- Door Monitoring
- Localization of valuable assets, such as forklifts, containers, and so forth.

In-Transit

- Used for Returnable Transport Items (RTIs) such as rolling containers, pallets, and so forth, in order to check their temperature, track their location, and trace their history using 1 MB of data storage
- Provided detailed information about what RTIs are in your transport vehicle

11.1.5 Where are Wireless Sensor Networks used?

WSN technology is expanding everywhere. The power of self-organizing, self-healing, ad-hoc, mesh networks can be applied in almost every application scenarios.

Ambient Systems Channel Partners have applied the technology in many diverse applications.

- ... in cold chain scenarios, monitoring the temperature and logging weeks of data which is flushed upon return,
- in the Great Barrier Reef, monitoring the status of buoys which communicate using the WSN back bone infrastructure, before transmitting the data to the shore,

- in large warehouses, where they monitor the temperature inside of large piles of bulk material such as cocoa,
- in trucks and trailers, monitoring the real-time temperature and presence of RTIs in the back of the truck,
- in remote nature reserves, monitoring the status of rattraps enormously increasing the efficiency of park rangers,
- in greenhouses, monitoring the ground moisture levels,
- on golf courses to monitor ground moisture levels of the green, and so forth.

It is safe to say that WSN technology can be applied in almost any application area.

11.2 Appendix B: Networking Basics

This chapter is intended as an introduction to wireless mesh networking in general and to an Ambient network in specific. For a detailed overview please look at the White Paper **"Ambient 3000-Series Network"**.

11.2.1 Wireless Sensor Networks

An Ambient network is classified as a so-called Wireless Sensor Network (WSN). WSNs typically consist of small devices, called sensor *nodes*. These nodes have an on-board microprocessor that allows interfacing with other devices such as temperature sensors. An additional key feature of such a node is the radio transceiver. Typically a sensor node is battery powered requiring energy efficient behaviour to guarantee a long lifetime. The most power consuming part of a node is its radio, so the more a node uses its radio, the more energy it consumes. As a rule of thumb, non-meshing nodes have a lifetime in the range of years, whereas meshing node batteries have a lifetime in the range of months.

The concept of a WSN is known in the Computer Science field called 'Ubiquitous Computing' which is also known as 'Pervasive Computing'. WSNs are regarded as the next evolution in telecommunication and Computer Science, enabling an entirely new field of research and commercial possibilities. Most important aspect is that it offers the possibility for back office systems to obtain information about the physical world.

For more information about WSNs, visit our website at www.ambient-systems.net.

11.2.2 Characteristics

There are many different types of WSNs that are grouped by various characteristics. This section describes a subset of these characteristics that are implemented in Ambient networks.

The strength of an Ambient network is that it provides a wireless mesh networking solution which is easy to install and self organizing. Making use of this functionality, specific application behaviour can be implemented without requiring detailed technical background information about wireless mesh networks.

The following table sums up some of the key characteristics of an Ambient network.

Characteristic	Description
Multi-hop	An Ambient Network is multi-hop, enabling two nodes that are not in each others radio range to communicate with each other by relaying data through intermediate nodes. As a result, large areas can be covered by a single network.
Ad-hoc	The network is ad-hoc, meaning that the whole network set-up is automated. Nodes have the ability to discover and join the network automatically, without the need of manual configuration. Also, the network dynamically adapts to changes such as moving nodes or varying radio ranges due to environmental interference.
Self-Healing	The network is self-healing, which means that when a relaying node fails alternative paths are used to deliver data at the destination. The entire routing of messages throughout the network is adjusted automatically.

Energy-Efficient	The network is energy-efficient. Nodes maximize their sleep time - and therefore increase battery lifetime - by communicating only at certain tightly synchronized time intervals. An important reason for this energy-efficiency stems from the underlying network principles applied in Ambient networks. It is a combination of Time Division Multiple Access (TDMA) and Carrier Sense Multiple Access (CSMA) which enable the nodes to use their radios in the most energy-efficient manner.
Robust	As the network is multi-hop, it enables you to create redundancy in your networks by providing several paths between different nodes. Whenever a single MR fails, there are still other routes available towards the GW. This approach provides a high degree of robustness to the system.
Secure	Various security mechanisms are in place that protect sensitive information flowing through your networks. One of these mechanisms, for example, is the use of a network key; by setting such a key all communication is encrypted and only interpretable by trusted parties that have the appropriate security keys.
Localization	An Ambient network has integrated peripherals and network interactions that provide the means for a node to locate itself. As SPs do not need to register with the network, they can observe beacon messages that are being sent and derive a position estimate from the information gathered.

11.2.3 Network Size

Network size is an important aspect when planning a deployment for a certain application and considering the desired behaviour of the SmartPoints. Effectively, the size of the network is related to the two distinctive layers that exist in a network; on one hand there is the infrastructure which makes up the communication backbone and provides the appropriate coverage, on the other hand there are the SmartPoints whose number is only limited by the number of beacon messages they consume.

The size of the infrastructure is fixed and determined by the type of GW used.

The number of SPs is dependent on the reporting frequency of the SPs and the number of MRs. Each GW and MR transmit certain beacon messages. These beacon messages are used by SPs to communicate with the infrastructure and locate themselves. By default, a GW and MR transmit 2 of such beacons per second. They can be configured to transmit 4 of those, if deemed necessary, but the SP load needs to be taken into account.

Consider this example; there are 15 MRs in a network that is build up using a GW3000. The SP300T reports every 5 minutes by default. Then the absolute maximum number of SmartPoints is 5 x 60 x 2 x (15+1) = 9600. However; messages from SPs can collide and message loss will occur. Also, if all SPs are in range of just a few MRs, there will be a network unbalance and even more collisions will occur. The network architecture has various means to handle these unbalanced loads by various mechanisms and congestion control, ensuring maximum achievable performance in the worst of scenarios.

Adding more MRs to the nework will, in most cases' solve the aforementioned problem. Contact support@ambient-systems.net for more information on this topic.

A rule of thumb should be that each SmartPoint should be in reach of at least 3 MRs at any given time.

11.3 Appendix C: Technical Specifications

Please refer to the individual data sheets of the various products to obtain detailed technical specifications.

11.4 Appendix D: Technical Support

All customers can contact Ambient Systems technical support through our web site or by email. Before you contact technical support, please have the following ready:

- Model number of the product (e.g. MR3000, SP3000, etc.)
- Hardware Revision (located on the label of the device)
- Current firmware version (can be obtained using Ambient Studio)
- Serial ID (located on the label of the device)

Also, if you have encountered any problems visit the support section of our website where you can find software updates and user documentation as well as Frequently Asked Questions (FAQ) and answers to technical issues.

Website	www.ambient-systems.net Then browse to the support section
E-mail	support@ambient-systems.net

11.5 Appendix E: Warranty & Disclaimer

To all products and related documentation Ambient Systems B.V. Terms & Conditions (T&C) apply. The T&C can be found and downloaded from our website.

11.5.1 Trademarks

Ambient is a registered trademark of Ambient Systems B.V. Other trademarks or registered trademarks are the property of their respective owners.

11.5.2 Copyright Statement

No part of this publication or documentation accompanying this product may be reproduced in any form or by any means or used to make any derivative such as translation, transformation, or adaptation without permission from Ambient Systems B.V.

Contents are subject to change without prior notice.

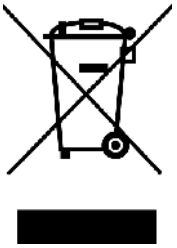
11.5.3 CE Mark Warning

In a domestic environment, this product may cause radio interference, in which case the user may be required to take adequate measures.

11.5.4 Manufacturer Declaration of Conformity

Hereby, Ambient Systems BV declares that the 3000 Series products are in compliance with the essential requirements and other relevant provisions of Directive 1999/5/ EC. A copy of the Declaration of Conformity can be obtained by sending a mail to support@ambient-systems.net

11.6 Appendix F: Recycling



a) General Information
Electric and electronic devices must not be disposed of in the domestic waste. Please dispose of the inoperative product in accordance with the current legal

regulations.

b) Batteries and Rechargeable Batteries
You, as the end user, are required by law (Battery Ordinance) to return all used batteries/rechargeable batteries. Disposal of them in the household waste is prohibited! Contaminated batteries/rechargeable batteries are labelled with these symbols to indicate that disposal in domestic waste is forbidden. The description of dangerous heavy metal constituents are: Cd=cadmium, Hg=mercury, Pb=lead (name on battery/rechargeable battery, e.g. under the trash icons on the left). You can return your exhausted batteries/rechargeable batteries free of charge to any authorized disposal station in your local authority, to our stores or to any other store where batteries/rechargeable batteries are sold. You thus fulfil your statutory obligations and contribute to the protection of the environment.

For more information contact support@ambient-systems.net

11.7 Appendix G: Registration

Please sent an email to support@ambient-systems.net to register the Ambient 3000 Series products.

11.8 Appendix H: Manual Revisions

Ambient Systems B.V. reserves the right to revise this publication and to make changes in the content hereof without obligation to notify any person or organization of such revisions or changes.

Revision	Date	Description
1.0	**02/04/09**	Release 1.0 documentation.