EnOcean Device Service Specification

Draft

30 Pages

Abstract

This specification defines the Java API to discover and control EnOcean devices on the OSGi platform and according to OSGi service design patterns. This API maps the representation of EnOcean entities defined by EnOcean Equipment Profiles standard into Java classes. OSGi service design patterns are used on the one hand for dynamic discovery, control and eventing of local and networked devices and on the other hand for dynamic network advertising and control of local OSGi services.

0 Document Information

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Feedback

This document can be downloaded from the OSGi Alliance design repository at https://github.com/osgi/design
The public can provide feedback about this document by opening a bug at https://www.osgi.org/bugzilla/.

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Terminology and Document Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY" and "OPTIONAL" in this document are to be interpreted as described in .

Source code is shown in this typeface.

Revision History

The last named individual in this history is currently responsible for this document.

Revision	Date	Comments
Initial	*February, 26th, 2013*	*Maïlys Robin, France Telecom Orange, mrobin.ext@orange.com* *Victor Perron, France Telecom Orange, victor.perron@orange.fr*
First draft	*April 4th, 2013*	*A.Bottaro, France Telecom Orange,* *M.Robin, France Telecom Orange,* *V.Perron, France Telecom Orange*
Revision 1	*April 18th, 2013*	*V.Perron, France Telecom Orange* • *Rename EO* concepts into EnOcean** • *Use a .learnedDevices property instead of getLearnedDevices()* • *Add a link between "Client Bundle" and "EnOceanDevice"*
Revision 2	*May 14th, 2013*	*V.Perron, France Telecom Orange* *A.Bottaro, France Telecom Orange* • *Addition of the EnOceanMessage, EnOceanChannel, EnOceanScaledChannel, EnOceanEnumChannel, EnOceanEnumChannelRange interfaces* • *Rewrite of the EnOceanProfile, EnOceanRPC, EnOceanRMCC specification* • *Revision of the main and EnOceanDevice diagrams* • *Addition of the known EnOcean Exceptions* • *Addition of the EnOcean EventAdmin section* • *EnOcean networking explanations*
Revision 3	*May 20th, 2013*	*V. Perron, France Telecom Orange* *A.Bottaro, France Telecom Orange* *N. Portinaro, Telecom Italia* *A. Kraft, Deutsche Telekom* • *Take N. Portinaro's and A. Kraft's remarks about send() standardization and level of detail* • *Remove EnOceanProfile notion in profit of EnOceanMessage.* • *Merged together RPC and RMCC notions.* • *The heavy changes to EnOceanMessage and EnOceanChannel types Introduced the EnOceanChannelDescription type that follows a more common design with UpnP and Zigbee device services.*

Revision	Date	Comments
Revision 4	*May 27th, 2013*	*V. Perron, France Telecom Orange* *A.Bottaro, France Telecom Orange* • *Add support for Security* • *Challenge Generic Profiles support* • *Convergence towards EnOcean Link notions of Channels* • *Improve EnOceanHost notion into EnOceanGatewayChip* • *EnOceanDevice EXPORT situation should work.*
Revision 5	*June 2nd, 2013*	*V. Perron, France Telecom Orange* *A.Bottaro, France Telecom Orange* *N. Portinaro, Telecom Italia* • *Discussion is ongoing within OSGi members about the use of EnOceanHost as a low-level notion or bundled inside of the base driver; for now, only chip configuration is available, not send methods.* • *Use protected getters and setters instead of plain properties for security objects.* • *Add the repeater notion to EnOcean device.* • *Move any non-filtering property to a method form.* • *Discussed setChannels() and getChannels() methods that would allow for a generic implementation of a Message, finally not integrated.*
Revision 6	*June 8th, 2013*	*V. Perron, France Telecom Orange* *A.Bottaro, France Telecom Orange* • *Remove the Repeater notion from EnOcean Device and keep it only at the EnOceanHost level.* • *Add the sendSecureTeachIn() method* • *Some overall cleanup; question to reintegrate SmartAck.*

Revision	Date	Comments
Revision 7	*June 19th, 2013*	*V. Perron, France Telecom Orange* *A. Bottaro, France Telecom Orange* *N. Portinaro, Telecom Italia* • *Overall cleeanups: the RFC's style has been rewritten in order to have less inclusions of Java-like text and be more descriptive. The Java specification, generated from the Javadocs, has been move to the end of the document, as what has been done with other service specifications.* • *EnOceanDevice: sendTeachIn, sendSecureTeachIn are removed in favor of a send(TeachInMessage). Provide setters for the dynamic, implementation-independant properties, like the senderId, security features, etc.* • *EnOceanMessage: the STATUS field is no more a filtering property, it carries not enough information and changes too often to be used as such. A getSubMessageCount() method has been added to help serializers in the case of multiple-frame messages. Those should be supported by the implementation transparently.* • *EnOceanChannel: Add the rawValue property that stores the value of the channel in bytes. Add setRawValue() and setValue() methods to enable for dynamic rewrite of the values.* • *EnOceanEnumChannelDescription / EnOceanScaledChannelDescription: define them as subinterfaces of the EnOceanChannelDescription interface. Make the serialization operations generic to the top-level EnOceanChannelDescription interface. Use doubles instead of floats in scaled channels.* • *Remove references to SmartAck and make it clearer that it will not be included for this iteration of the specification.* • *Still keep using only INTERFACES in this specification, but add methods to add/set properties. A bundle that would like to implement a "generic" Device/Message/etc class could then use those methods to do so.*

Revision	Date	Comments
Revision 8	*July 9th, 2013*	*V. Perron, France Telecom Orange* *A. Bottaro, France Telecom Orange* *N. Portinaro, Telecom Italia* *A. Kraft, Deutsche Telekom* *E. Grigorov, Prosyst* *K. Hackbarth, Deutsche Telekom* • *Rename EnOceanTelegram into EnOceanMessage. Fits better to EnOcean idea of a high-level, multipart message.* • *Add dBm and redundancy information to EnOceanMessage object. Every EnOceanMessage is sent by burst of three; knowing how many have been actually received, and at which average power level, can help giving an idea of the link quality.* • *Narrow EnOceanHost's calpabilities to "what should be awaited from a Gateway device" more than "what can ESP do"; we should, as it's done with Zigbee and the ZCL, not stick to ESP for Gateways, since some hardware vendors would not follow it anyway.* • *Datafields have been renamed to Channels, to stick better to EnOcean notions. Enumerated channels have been split into Enumerated as before, and a Flag type that describes boolean channels.*
Revision 9	*July 31st, 2013*	*V. Perron, France Telecom Orange* *A. Bottaro, France Telecom Orange* *M. Robin, France Telecom Orange* • *EXPORT scenario: BD chooses the appropriate dongle, associate service PID and sender ID propose an optional API to retrieve the sender ID or deassociate it.* • *EnOceanHost: remove ability to send messages (role of the BD) but add an API to retrieve the sender ID associated to a service PID, if allocated within that chip's ID pool.* • *Requirements: EnOceanDevice properties such as profile info, security info... MUST be persisted to survive a framework reset; those properties can only be retrieved during an (often manual) teach-in procedure.* • *EnOceanDevice: for imported devices, there is a CHIP_ID property that is set by the BD. For exported devices, there is no such property, but an ENOCEAN_EXPORT property is there. In both cases, a SERVICE_PID property is present and unique.*

Revision	Date	Comments
Revision 10	*Aug. 17th, 2013*	*V. Perron, France Telecom Orange* *A. Bottaro, France Telecom Orange* • *Every reference to RMCC has been removed, in favour of a united RPC notion.* • *Corrected main class diagram to make Set interfaces appear better, remove faulty <<Set>> notion.* • *Add the notion of EnOceanChannelDescriptionSet, EnOceanRPCSet, EnOceanMessageSet in Entities* • *Clarify the Operations Summary section: full update.* • *Clarify and rewrote EnOceanDevice section; move 'Export' section there and merge its information.* • *Rewrite EnOceanMessage section, cleanup artifacts from previous versions.* • *Reword the EnOceanChannel section; remove the notion of Shortcut and Friendly Name, those are not standard nor used;* • *Corrected the EnOceanChannelDescription part deeply; now more precise about description sets, new class diagram, introduced the Flag channel better, cleaned up outdated examples, introduce an unique identifier that is to be set for every Description class.* • *Rewrote the EnOcean Remote Management part; is clearer and standardized EnOceanRPCHandler into an EnOceanResponseHandler, with a notifyResponse() handler.* • *Confirm that there is no generic deserialization of the EnOceanRPC byte[] payload as of this specification, since EnOcean remote management is still extremely rare and there is no actual specification of it yet.* • *Moved EnOcean Networking and Security sections to a new "Annex" section at the end of the document.*

1 Introduction

EnOcean is a standard wireless communication protocol designed for low-cost and low-power devices by EnOcean GmBh.

EnOcean is widely supported by various types of devices such as smart meters, lights and many kinds of sensors in the residential area. OSGi applications need to communicate with those EnOcean devices. This specification defines how OSGi bundles can be developed to discover and control EnOcean devices on one hand, and act as EnOcean devices and interoperate with EnOcean clients on the other hand. In particular, a Java mapping is provided for the standard representation of EnOcean devices called EnOcean Equipment Profile.

The specification also describes the external API of an EnOcean Base Driver according to Device Access specification, the example made by ZigBee Device Service specification and spread OSGi practices on residential market.

Introduce the RFC. Discuss the origins and status of the RFC and list any open items to do.

2 Application Domain

System Architecture

When installing a new EnOcean network into a residential network with an OSGi home gateway, there are 2 options:

- Add EnOcean communication capability to your home gateway, with an additional hardware such as a USB device called "dongle" and then add the necessary software (bundles) to interpret the EnOcean messages.
- Replace the current home gateway with one featuring EnOcean communication.

In both cases OSGi applications call the EnOcean driver API to communicate with the EnOcean devices as shown in Figure 1.

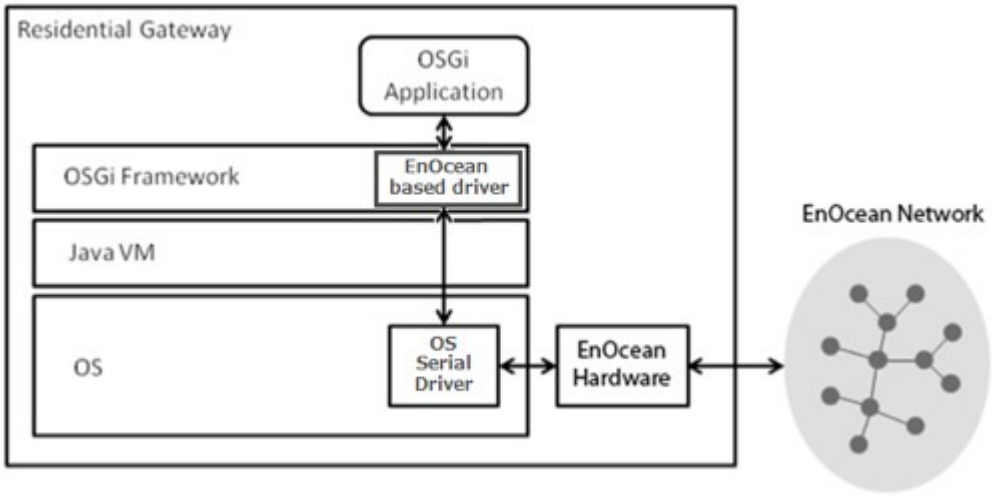


Figure 1: Communication with EnOcean devices through an EnOcean driver

The EnOcean specification defines two main types of devices: the transmitters and the receivers. Some receivers can be used as repeaters, and therefore are using bidirectional communication. The transmitters are using unidirectional communication only.

The very recent '*Smart Ack'* specification now enables transmitters to stay active for a few milliseconds after a transmission in order to receive messages from a remote device. For this to be possible, "mailboxes" have to be enabled on line-powered devices.

The EnOcean network is mainly composed of those transmitters paired to receivers through a “teach-in” procedure. It is a many-to-many model with no particular hierarchy, the opposite of a star network like Zigbee where every device relies on a single coordinator.

In this respect, the EnOcean gateway's hardware is no more and no less than an universal EnOcean transceiver, for which the “teach-in” and control procedures have to be software-defined.

EnOcean Stack

The EnOcean stack is shown in Figure 2. The three bottom layers, the **PHYSICAL** layer (not shown in the figure), the **DATALINK** layer and the **NETWORK** layer are defined by the ISO/IEC14543-3-10 standard, which is a new standard for the wireless application with ultra-low power consumption.

The EnOcean standard defines the **Application** and **Security** layers; it also defines:

1. The EnOcean Serial Protocol (ESP) for serial communication between a host and capable EnOcean modules;
2. The EnOcean Radio Protocol (ERP) defines packeted radio communication between EnOcean nodes;
3. Smart-Ack describes the use of “Mailboxes” on line-powered devices to send messages to energy-harvesting transmitters;
4. The EnOcean Equipment Profiles (EEP), described in detail in the next section, defines standard device profiles to be used by EnOcean devices.

The ISO standard enabled the physical, data link and network layers to be available for all, while the EnOcean application layers are available by joining the EnOcean Alliance.

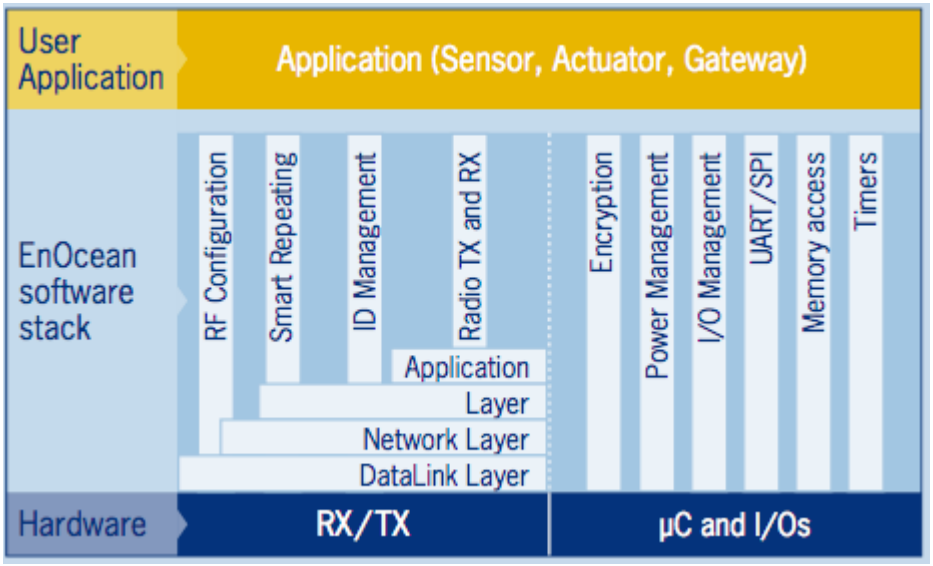


Figure 2: EnOcean Stack (source: EnOcean Website)

EnOcean Equipment Profiles (EEP)

The EnOcean Equipment Profiles enables interoperability between products developed by different vendors. For example, in a light control scenario, switches developed by a vendor can turn on and turn off lights developed by another vendor if both vendors are aware of each other's EEP Profiles. The EnOcean Alliance draws up the specifications for the applications based on the standard.

A device's EEP profile is fully defined by three combined elements:

- Its EnOcean Radio Protocol radio message type (**RORG, 8 bits**)
- Basic functionality of the data content (**FUNC, 6 bits**)
- Type of device; it refines the main functionality given by FUNC (**TYPE, 7 bits**)

There are currently around 100 profiles defined.

When the existing profiles are not adequate, it is possible to create a new profile. Once developed, it should be submitted to the technical working group of the EnOcean Alliance.

3 Problem Description

With the increasing number of EnOcean vendors, the number of manufacturer-specific APIs is also raising, causing the following problems:

- Application developers cannot rely on standard EnOcean hardware interoperability within the target residential gateway's environment.
- An application that was developed for a given environment may not work in other environments without significant changes.

Those problems make it difficult for third parties to develop portable OSGi applications communicating with EnOcean devices.

The standard Java API requested in this RFC for the access of EnOcean devices would give developers a unified way of communicating with EnOcean devices, allowing developers to rely on a single, vendor-agnostic API.

4 Requirements

R1: The solution **MUST** provide an API for controlling EnOcean devices.

R2: The solution **MUST** provide a base driver interface as an OSGi service for the following operations: device and service discovery, network management, binding management, device management.

R3: The solution **SHOULD** enable applications to trigger a re-scan of the network to refresh the registry with actual EnOcean device services.

R4: The solution **MUST** provide a mechanism which notifies OSGi applications of events occurred in the EnOcean network and devices.

R5: The solution **MUST** register a Device Service object representing each found EnOcean device into Service Registry and unregister the Device Service object when the EnOcean device is unavailable or has not sent updates since a very long time.

R6: The solution **MUST** associate an EEP profile for each found EnOcean device and update the EEP if it is changing.

R7: The solution **MUST** be able to add new profiles to the existing ones (in the case of a new profile is created by a member of the EnOcean Alliance).

R8: The solution **MAY** define the driver provisioning process in accordance with the OSGi Device Access specification.

R9: The solution **MUST** be independent from the physical interface used to control the EnOcean network. The solution **MUST** likewise work with network controllers based on EnOcean built-in chips, EnOcean USB dongles and high level protocols offered by EnOcean Gateway Devices compliant with the EnOcean Alliance specification.

R10: The solution **MUST** include device access control based on user and application permissions compliant with the OSGi security model.

5 Technical Solution

First give an architectural overview of the solution so the reader is gently introduced in the solution (Javadoc is not considered gently). What are the different modules? How do the modules relate? How do they interact? Where do they come from? This section should contain a class diagram. Then describe the different modules in detail. This should contain descriptions, Java code, UML class diagrams, state diagrams and interaction diagrams. This section should be sufficient to implement the solution assuming a skilled person.

Strictly use the terminology a defined in the Problem Context.

On each level, list the limitations of the solutions and any rationales for design decisions. Almost every decision is a trade off so explain what those trade offs are and why a specific trade off is made.

Address what security mechanisms are implemented and how they should be used.

6 Initial Spec Chapter

Provide a link to where the Initial Spec Chapter can be found. The Initial Spec Chapter is typically written by someone other than the author(s) of this RFC and represents a rewrite of this document as close as possible to what will ultimately appear in the OSGi Specifications. It will be used by the Specification Editor as the basis for the ultimate specification chapter.

The spec template and writing guidelines can be found here:

https://www.osgi.org/members/svn/documents/trunk/templates/specification-template-oo.ott

https://www.osgi.org/members/svn/documents/trunk/templates/specwriting.pdf

Essentials

- *Scope* – This specification is limited to general device discovery and control aspects of the standard EnOcean specifications. Aspects concerning the representation of specific or proprietary EnOcean profiles is not addressed.
- *Transparency* - EnOcean devices discovered on the network and devices locally implemented on the platform are represented in the OSGi service registry with the same API.
- *Lightweight implementation option* – The full description of EnOcean device services on the OSGi platform is optional. Some base driver implementations may implement all the classes including EnOcean device description classes while Implementations targeting constrained devices are able to implement only the part that is necessary for EnOcean device discovery and control.
- *Network Selection* – It must be possible to restrict the use of the EnOcean protocols to a selection of the connected devices.
- *Event handling* – Bundles are able to listen to EnOcean events.
- *Discover and control EnOcean devices as OSGi services* **–** Available learnt (via an EnOcean teach-in procedure) EnOcean external endpoints are dynamically reified as OSGi services on the service registry upon discovery.
- *OSGi services as exported EnOcean devices* **–** OSGi services implementing the API defined here and explicitly set to be exported should be made available to networks with EnOcean-enabled endpoints in a transparent way.

Entities

- *EnOcean Base Driver* – The bundle that implements the bridge between OSGi and EnOcean networks. It is responsible for accessing the various EnOcean gateway chips on the execution machine, and ensures reception and translation of EnOcean messages into proper objects. It is also used to send messages on the EnOcean network, using whatever chip it deems most appropriate.
- *EnOcean Host* – The **EnOceanHost** object is a link between the software and the EnOcean network. It represents the chip configuration (gateway capabilities) described in ESP3[9]. It is registered as an OSGi service.
- *EnOcean Device* – An EnOcean device. This entity is represented by a **EnOceanDevice** interface and registered as a service within the framework. It carries the unique chip ID of the device, and may represent either an imported or exported device, which may be a pure transmitter or a transceiver.

  It holds as well the available remote management commands, the profile identifiers and reference, and the latest received Message by this device.
- *EnOcean Messages* – Every EnOcean equipment is supposed to follow a "profile", which is essentially the way the emitted data is encoded. In order to reflect this standard as it is defined in the EEP[5]., we chose to give the possibility to manufacturers to register "Messages", the essence of a profile, along with their associated payload (as Channels). See "EnOcean Channels" below for more information.
- *EnOcean Channel* – EnOcean channels are available as an array inside EnOceanMessage objects. They are a useful way to define any kind of payload that would be put inside of an EnOcean Message.

  EnOcean Messages and their associated Channel descriptions should be registered as description sets within the framework, by a standard or vendor-specific bundle. This is enabled by the **EnOceanMessageSet** and **EnOceanChannelDescriptionSet** interfaces.

  The mechanism allows in particular a lightweight implementation of the EnOcean device service platform, by leaving the possibility not to implement the unnecessary profiles, messages or channels.
- *EnOcean RPC* – An interface that enables invocation of vendor-specific Remote Procedure Calls and Remote Management Commands. These are particular types of Messages and are not linked to any EnOcean Profile, so that their descriptions are defined and registered in another way. The RPCs are documented via the **EnOceanRPCSet** interface.
- *EnOcean Response Handler* – Enables clients to easily and asynchronously get answers to their Messages and RPCs.
- *EnOcean Client* – An application that is intended to control EnOcean device services.
- *EnOcean Exception* – Delivers errors during EnOceanMessage serialization/deserialization or during execution outside transmission.

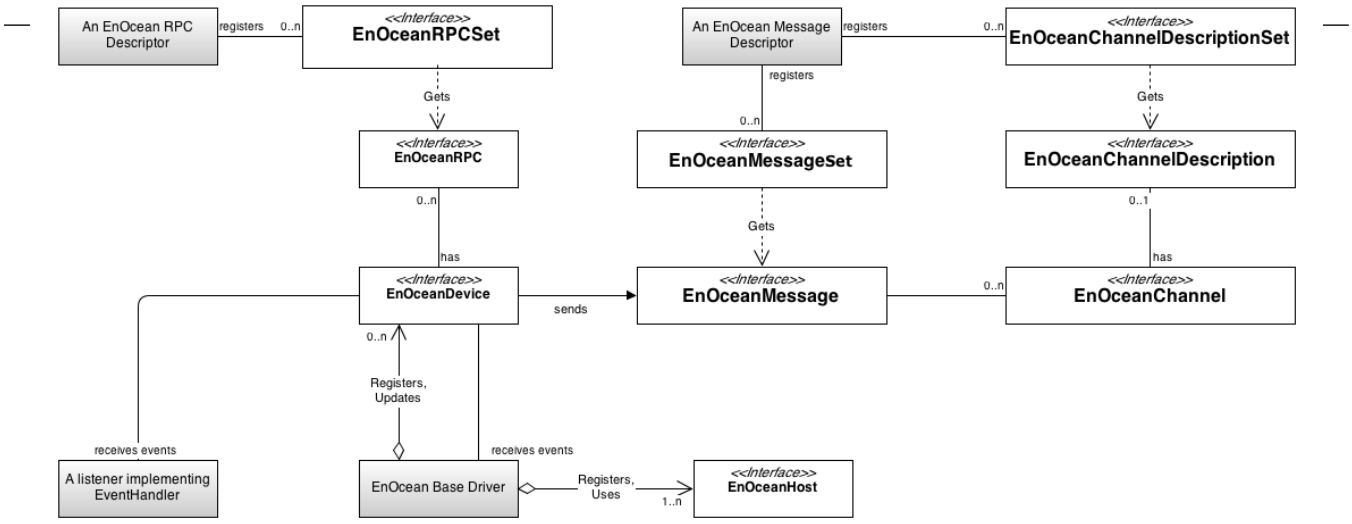


Figure 3: EnOcean Service Specification, Class Diagram

Operation Summary

To make an EnOcean device service available to EnOcean clients on the OSGi platform, it must be registered under the **EnOceanDevice** interface within the OSGi framework.

The EnOcean Base Driver is responsible for mapping external devices into **EnOceanDevice** objects, through the **EnOceanHost** interface to an EnOcean gateway. EnOcean "teach-in" messages will trigger this behaviour, this is called a **device import** situation.

Client bundles may also expose framework-internal (local) EnOceanDevice instances, registered within the framework. The Base Driver then should emulate those objects as EnOcean devices on the EnOcean network. This is a **device export** situation, made possible by the use of the 127 virtual base IDs available on an EnOcean gateway.

Updates concerning Messages emitted and received by the EnOcean devices are accessible through the proper **EventAdmin** subscription, described below.

EnOcean Base Driver

Most of the functionality described in the operation summary is implemented in an EnOcean *base driver*. This bundle implements the EnOcean protocols and handles the interaction with bundles that use the EnOcean devices. An EnOcean base driver is able to discover EnOcean devices on the network and map each discovered device into OSGi registered EnOceanDevice services.

It also is the receptor, through Event Admin service and OSGi service registry, of all the events related to local devices and enables bidirectional communication for RPC and Channel updates.

EnOcean Host

The EnOcean host represents an EnOcean gateway chip. Any EnOcean device service implementation should rely on at least one Gateway Chip in order to send and receive messages on the external EnOcean network.

This interface enables standard control over an EnOcean compatible chip. The chip itself will also be registered as an EnOceanDevice by the BaseDriver under its own CHIP_ID.

Every EnOceanHost object should at least be identified by its unique CHIP_ID.

The EnOceanHost interface enables OSGi applications to:

- Get or set gateway metadata (version, name, etc);
- Reset the gateway chip device;
- Retrieve a Sender ID (derived from EnOcean's BASE_ID) for the given Service PID of a device.
-

EnOcean Device

Generics

A physical EnOcean device is reified as an **EnOceanDevice** object within the framework. Any **EnOceanHost** is also an EnOceanDevice, but the to concepts are not linked by any inheritance.

An EnOcean device holds most of the natural properties for an EnOcean object: its unique ID, the profile, a friendly name, its security information, and its available RPCs – along with the associated getters (and setters when applicable). All those properties MUST be persistent across restart so that teach-in procedures are made only once.

It also holds methods that reflect the natural actions a user application may physically trigger on such a device: send a message to the device, send a teach-in message to the device, or switch the device to learning mode.

Every EnOcean Device bears a SERVICE_PID property that is assigned either by the base driver or by any service-exporting bundle. The property value format is free and the value must be unique on the framework.

The properties on which EnOceanDevice services can be filtered on are: the device's SERVICE_PID and CHIP_ID, the profile identifiers (RORG / FUNC / TYPE integers), its friendly name, and also its security mode.

The definition of the latter is motivated by the need for some bundles to select only security-enabled devices easily. The security level is an integer property value defined in the same way as the security level fomat in the EnOcean Security Draft[9].

Import & Export

In **import** situations, the device's CHIP_ID is uniquely set by the Base Driver, according to the one present in the teach-in message that originated the Device's creation. The SERVICE_PID (cf. Core Specification v4, section 5.2.6) should also be generated and derived from the CHIP_ID programmatically.

In **export** situations, the registering Client bundle should set the SERVICE_PID of the device service by itself, in a unique manner; the CHIP_ID (this device's EnOcean source ID when it issues messages) has to be allocated by the Base Driver, which keeps a dictionary of the currently allocated CHIP_IDs. The Client bundle should also set an ENOCEAN_EXPORT property in the registered device's Property Map.

The standard way to programmatically retrieve an exported CHIP_ID from a given SERVICE_PID is by using EnOceanHost's dedicated interface for this use.

Optionally, the Base Driver could provide an API to retrieve the CHIP_ID associated to a particular SERVICE_PID, or be instructed to erase such an association.

As an application developer, please refer to the documentation of your Base Driver to know its policies concerning exported CHIP_ID deletion, peremption and exhaustion.

Interface

The EnOceanDevice interface enables EnOcean clients to:

- Send messages, using raw bytes or fully-qualified EnOceanMessage objects. Most of the time, no answer is awaited from such a Message emission; yet the interfaces provide a way to specify an EnOceanResponseHandler upon sending a Message to retrieve the eventual answer.
- Get or set the security features of the Device in a protected way;
- Retrieve the currently paired devices in the case of a receiver, as a collection of device IDs;
- Get the currently available RPCs for the device;
- Optionally implemented, retrieve the latest issued Message.

EnOcean Messages

EnOceanMessages are at the core of the EnOcean application layer as a whole and the EnOcean Equipment Profile specification[5]. in particular. Every exchange of information within EnOcean networks is done with a dedicated message.

Any EnOceanMessage objet creation, modification or deletion must be mirrored to EventAdmin, with the following filters made available: the Message's RORG (radiotelegram basic type) , its SENDER_ID (which the CHIP_ID of the originating device), and optionally its DESTINATION_ID.

The RORG of a message defines grossly its shape and generic type; all the RORGs are defined in the EnOcean Radio Specification. When a Message becomes addressed, meaning it is directed to a particular destination device and not broadcasted, then it will be encapsulated into an Adressed Telegram (ADT) right before being sent; it will nevertheless keep the same RORG at the interface and EventAdmin levels.

Any EnOcean Message, in the case of an EnOcean Equipment Profile message, is uniquely identified by three numbers: its RORG type, and its FUNC and TYPE subtypes. Once uniquely identified, it is possible to retrieve an EnOceanMessage object within a registered EnOceanMessageSet; those identified Messages handle specialized serialization and deserialization of the Message's payload, among other things.

The method available to the interface are:

- Serialization and deserialization methods to and from plain byte arrays;
- A method to get the current ordered list of Channels in the message, letting out any “blank” space of the payload;
- Generic methods to get/set the message's status or other miscellaneous information.
- Contextual methods that give information about the current link quality and number of subtelegrams embedded into this Message. The link quality is evaluated out of the number of redundant messages received (out of three) and the average RSSI for each.

EnOcean Channel

The EnOceanChannel interface is an abstraction to generate or interpret EnOceanMessage channels with plain Java types instead of raw bytes.

The simple **EnOceanChannel** interface provides a way to separate the different fields in a message payload, knowing their offset and size in the byte array that constitutes the Message's payload.

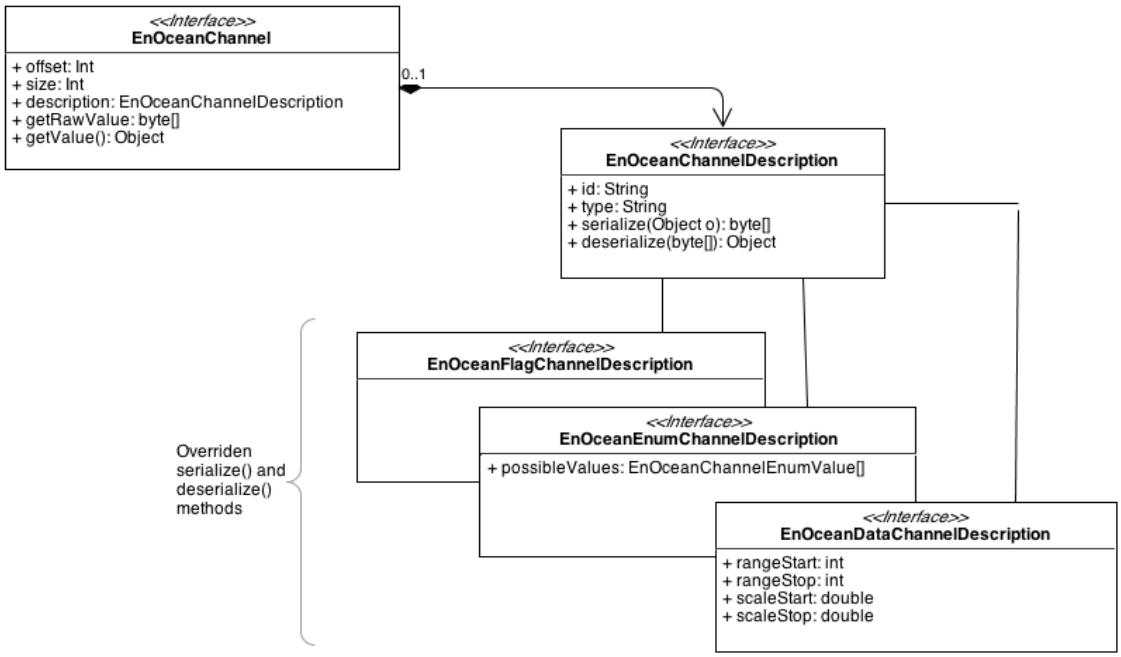
Any Channel can be linked to an **EnOceanChannelDescription** interface to provide more information, if available; see below for a description.

The value stored in an EnOceanChannel object, returned by the getValue() interface method, is a generic **Object** class. Only an EnOceanChannelDescription can help accessing this value's actual type.

Because in EnOcean, the value of a channel may possibly be many different objects, it will be up to the implementer to either get a proper Description object to decode the value, or in some cases rely on its knowledge of the incoming messages to decode it manually.

As an example, if the platform being developed is an electronic display that waits for Messages from a well-known temperature sensor, the Client bundle on the platform may interpret the Temperature Channels in every Temperature Message without needing an appropriate TemperatureChannelDescription object; it may directly cast the **Object** value of every message to a **Double** and display that.

In the same fashion, the setValue(Object obj) and getRawValue()/setRawValue(byte[] data) methods will help get/set the values, either as an object, or as plain raw bytes (left-truncated to the size, in bits, of that channel)



EnOcean Channel Description

The **EnOceanChannelDescription** interface enables the description of all the various channels as specified in the EnOcean specification, or be extensible to descriptions issued by 3rd – party actors.

Those Description objects are retrieved from the registered **EnOceanChannelDescriptionSet** interfaces.

Every Description object must bear an unique string identifier that links it to its usage. Furthermore, the description objects provide the high-level type of a channel (see below) and serialization/deserialization methods.

Here are the Channel types defined in this specification:

- *CHANNEL_TYPE_RAW*: A collection of bytes. This type is used when the description is not provided, and is thus the default. For this type, the EnOceanChannel's getValue() call actually returns a *byte[]* collection. The encryption key or a device ID on 4 bytes are examples of such raw types.

- *CHANNEL_TYPE_DATA*: A scaled physical value. Used when the data can be mapped to a physical value; for instance, the 'WND – Wind Speed' channel is a raw binary value, in a range from 0 to 255, that will be mapped as a wind speed between 0 and 70 m/s. For this type, the EnOceanChannel's getValue() call actually returns a **Double** value.

- *CHANNEL_TYPE_FLAG*: A boolean value. Used when the Channel can be either 1 or 0. The "*Teach-In*" Channel is a well-known example; this 1-bit field may either be 0 or 1, depending whether the Message is a teach-in one or not. For this type, the EnOceanChannel's getValue() call actually returns a **Boolean** value.

- *CHANNEL_TYPE_ENUM*: An enumeration of possible values. Used when the Channel can only take a discrete number of values. More complicated than the Flag type, Enumerated types may have thresholds: for instance, the A5-30 "*Digital Input- Input State (IPS)*" channel is a 8-bit value which means "Contact closed" between 0 and 195, and "Contact open" from 196 to 255. For this type, the EnOceanChannel's getValue() call actually returns an **EnOceanChannelEnum** object.

According to the channel type, the actual description object should implement one of the following specialized interfaces. This will ease the used of casting to the specialized interfaces on documented channels.

EnOcean Data Channel Description

The EnOceanDataChannelDescription interface inherits from EnOceanChannelDescription interface.

Two more methods give access to the integer input range of the data channel (such as 0-255) and to the floating-point output range of it (such as -30,0°C – 24,5°C). A method is also present to retrieve the physical unit of the channel. The serialize() and deserialize() methods are implemented to easily convert from the raw byte[] collection to a Double, and vice versa.

Here a a few samples of such Channels:

Short	Description	Possible implemented name	Range	Scale	Unit
TMP	Temperature (linear)	TemperatureScaledChannel_X	0..255	-10°..+30°	°C
HUM	Humidity (linear)	HumidityScaledChannel_X	0..250	0..100	%

EnOcean Flag Channel Description

The EnOceanFlagChannelDescription interface inherits from the EnOceanChannelDescription interface.

Those channels, typically are used for On/Off reporting values (like a switch) ; they have no additional methods, though the deserialize() method converts the input bit into a proper Boolean object.

EnOcean Enumerated Channel Description

The EnOceanEnumeratedChannelDescription interface inherits from the EnOceanChannelDescription interface.

The additional method provided to this interface is getPossibleValues(), which returns an array of the available **EnOceanChannelEnumValue** objects accessible to this channel. Every EnumValue object bears an integer input range and a String identifier to its meaning.

The serialize() and deserialize() methods of an EnOceanEnumeratedChannelDescription object thus convert an integer input value (say, 156) to an EnOceanChannelEnumValue, and vice versa.

Here is an example that shows the input range and the associated EnOceanChannelEnumValues.

Device profile	EnOceanChannelEnumValue	Start	Stop	Meaning
Fan speed stage switch	FanStageSwitch_Stage3	0	144	Fan speed: Stage 3
	FanStageSwitch_Stage2	145	164	Fan speed: Stage 2
	FanStageSwitch_Stage1	165	189	Fan speed: Stage 1
	FanStageSwitch_Stage0	190	209	Fan speed: Stage 0

EnOcean Remote Management.

Remote Management is a non-mandatory feature, which allows EnOcean devices to be configured and maintained over the air using radio messages.

The Remote Procedure Calls, or RPCs -as defined by the EnOcean Remote Management specification[6].- are not related to any EnOcean Equipment Profile.

EnOcean RPC

An EnOceanRPC object enables client bundles to remotely manage EnOcean devices using already defined behaviour.

RPCs are mandatorily defined by a Manufacturer code (11 bits, 0x7FF for the EnOcean alliance) and a unique Function code on 12 bits.

EnOceanRPC can be retrieved from an EnOceanRPCSet that had been previously registered within the OSGi framework by a documenting bundle, thanks to those unique Manufacturer and Function codes.

The EnOceanRPC objects also have methods to get or set a unique senderId, a destinationId (which is optional, many RPCs being broadcasted), get or set the inner payload as a byte[] collection, and invoke the RPC itself. As of this specification, there is no particular way to decode an RPC payload into Java high-level objects, since RPC still are rare in EnOcean networks and no actual specification is yet defined.

The invoke(EnOceanRPCHandler handler) method may accept an EnOceanResponseHandler reference that will be used to retrieve the results of the RPC.

EnOcean Response Handler

Responses to some Messages and RPCs are processed by the driver and sent back to handlers that were optionnaly passed into respectively send() or invoke() method calls.

The notifyResponse(EnOceanMessage original, byte[] data) or notifyResponse(EnOceanRPC original, byte[] data) callbacks of this object will be called when a response is issued.

The data that is returned may be deserialized into a Message or an RPC, depending on the origin of the call. This is left to the implementer's initiative.

Working With an EnOcean Device

Service Tracking

All discovered EnOcean devices in the local networks are registered under **EnOceanDevice** interface within the OSGi framework. Every time an EnOcean device appears or quits the network, the associated OSGi service is registered or unregistered in the OSGi service registry. Thanks to the EnOcean Base Driver, the OSGi service availability in the registry mirrors EnOcean device availability on EnOcean network.

Thanks to service events, a bundle can track the addition, modification and removal of an EnOceanDevice service.

Below stands an example showing how the tracking can be implemented. The sample Controller class extends the ServiceTracker class so that it can track all EnOceanDevice services.

```
public Class Controller extends ServiceTracker {
	public Object addingService(ServiceReference arg0) {
		Object service = context.getService(arg0);
		if (service != null && service instanceof EnOceanDevice) {
			eoDevice = (EnOceanDevice) service;
		}
		Logger.debug(service.getClass().getName() + " service found.", null);
		return service;
	}

	public void modifiedService(ServiceReference arg0, Object arg1) {
		/* Unimplemented */
	}

	public void removedService(ServiceReference arg0, Object service) {
		if (service instanceof EnOceanDevice) {
			eoDevice = null;
			Logger.debug("EnOceanDevice service was shut down.", null);
		}
	}
}
```

Event API

EnOcean events must be delivered to the Event Admin service by the EnOcean implementation, if present. EnOcean events have the following topic:

org/osgi/service/enocean/EnOceanEvent

The properties propagated when an EnOcean device service event occurs MAY comprise:

- enocean.chipId – (int) The identity as defined by EnOceanDevice.CHIP_ID of the device concerned by the event.
- enocean.rorg – (int)
- enocean.func – (int)
- enocean.type – (int)
- enocean.isTeachIn – (boolean) Helps detecting the arrival of new devices.
- enocean.senderId – (int)
- enocean.destinationId – (int)
- enocean.device – (EnOceanDevice) The associated EnOceanDevice object.
- enocean.message – (EnOceanMessage) The EnOceanMessage object associated with this event, or *null*.
- enocean.messageBytes – (byte[]) The serialized Message bytes in the case of the lightweight implementation option, or *null*.

In some cases, the EnOceanDevice event has no RORG, FUNC, nor TYPE yet. In that case the associated properties may be set to -1 or be absent.

EnOcean Exceptions

The **EnOceanException** can be thrown and holds information about the different EnOcean layers. Here below, ESP stands for "EnOcean Serial Protocol". The following errors are defined:

- FAILURE – (0x01) Operation was not successful.
- ESP_RET_NOT_SUPPORTED – (0x02) The ESP command was not supported by the driver.
- ESP_RET_WRONG_PARAM – (0x03) The ESP command was supplied wrong parameters.
- ESP_RET_OPERATION_DENIED – (0x04) The ESP command was denied authorization.
- INVALID_TELEGRAM – (0xF0) The message was invalid.

Java Interface Specification: org.osgi.service.enocean

EnOcean Package Version 1.0.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest.

For example: Import-Package: org.osgi.service.enocean; version="[1.0, 2.0)"

Summary

- Export the types discussed above.

Considered Alternatives

June 19, 2013:

The RFC's style has been changed to be more lightly descriptive on the actual Java types. The implementation efforts in parallel, on the opposite, are driving the actual interface specification that is now put and update in the "Java Interface Specification" paragraph above.

About the dynamic implementation of Messages, as proposed by N. Portinaro, it is decided to keep using interfaces only in the specification, and not define classes. Nevertheless, a sample of such a dynamic implementation using anonymous classes implementing those interfaces on-the-fly has been proposed as an example.

June 4, 2013:

It has been discussed whether or not to add a setChannels() or appendChannels() method to the EnOceanMessage interface. Unfortunately, trying to do so resulted in a cluttered and difficult to read interface for no clear benefits, so it has been decided not to add it yet.

The possibilty to send messages using the EnOceanHost interface has also been declined yet; this interface should be used for the configuration of the gateway chip only.

After an evaluation of the issues and rewards that would bring an implementation of the scarcely-used SmartAck protocol, it has been decided to set it aside for this iteration.

May 27, 2013:

The 'export' feature is not anymore set aside and should be challenged for consideration. The 'SmartAck' feature status is still under evaluation. The Security features of EnOcean have been integrated. Remote Management is integrated in a minimal fashion. Since there is no clear specification on the equivalent of the 'datatypes' for Remote Management, it has been decided yet (V.Perron) to set aside the development of abstractions for them and let the programmer implement extra methods above the specification when deemed useful.

April 03, 2013:

It has been decided (A.Bottaro, M.Robin, V.Perron) to set aside the 'export' feature of EnOcean device service for further reflexion, as well as 'SmartAck' feature from EnOcean, which will require extra effort. For this latter topic, one of the tracks worth exploring was the setup of Mailboxes at the EnOceanHost level (which sticks to the reality of the EnOcean gateway chips) and recommanding a dedicated 'real-time' channel to be implemented, so that SmartAck message frames could be carried synchronously.

7 Security Considerations

Description of all known vulnerabilities this may either introduce or address as well as scenarios of how the weaknesses could be circumvented.

8 Annex

EnOcean Networking

EnOcean networking is a quite particular wireless network in the sense that there is no actual “topology”. Every device emits messages on the same frequency band, which depends on the world region and local regulations.

In Europe, the 868 MHz frequency band is used; in Asia, the 315 MHz is adopted. The 902 MHz band is in the process of being used for North America. There is no notion of a “network identificator” in EnOcean.

The transmitting devices usually broadcasts all of their messages on this frequency, and most of the time do not wait for an answer. The transmitting devices being mostly energy-harvesting devices, they cannot easily wait for an answer.

The receiver modules listen to every message sent on the frequency band. They filter the messages of interest based on the Sender ID that is embedded within every message. They are supposed to listen only to Sender ID that have previously been “taught” to them, and discard the others.

The teach-in procedure is specific to EnOcean. The receiver module has to be manually (or remotely, but that is still very rare) switched to a “learning mode”. It will wait for a special kind of EnOcean messages, called “teach-in” messages. Those “teach-in” messages have to be sent by the emitting device that is targeted to be learnt by the receiver.

Once the receiver module has received this “teach-in” message, it should keep in non-volatile memory the sender ID of that message and such, be “paired” with it.

Because of this process, EnOcean networks are N-to-N: you may pair N emitters to 1 receiver, 1 emitter with N receivers, or even N emitters to M receivers.

In this respect, the EnOcean gateway is somewhat special; it is a device able to both send and receive messages, is line-powered, and listens to every message in the frequency band.

EnOcean Network Security

The security in EnOcean is mean exists in a point-to-point fashion. The emitting device will be responsible of transmitting the optional Key and/or Rolling Authentication Code (RLC) to the receiver device during a dedicated “Security-Teach-In” phase.

The security configuration, Key and RLC are transmitted using a special message. The receiver device then associates the given key and RLC to that device internally, and uses them to decode any further message coming from it.

As a result, the Key and RLC parameters, as well as the current security configuration, are properties tied to a sending EnOceanDevice object; furthermore, an arbitrary number of security configurations, keys and RLCs may coexist within the same EnOcean network.

It will be the responsibility of the receiver object to fetch the current security properties of the sending object and use them to decode further messages.

9 Document Support

References

[1]. Bradner, S., Key words for use in RFCs to Indicate Requirement Levels, RFC2119, March 1997.

[2]. Software Requirements & Specifications. Michael Jackson. ISBN 0-201-87712-0

[3]. André Bottaro, Anne Gérodolle, Philippe Lalanda, "Pervasive Service Composition in the Home Network", 21st IEEE International Conference on Advanced Information Networking and Applications (AINA-07), Niagara Falls, Canada, May 2007

[4]. Pavlin Dobrev, David Famolari, Christian Kurzke, Brent A. Miller, "Device and Service Discovery in Home Networks with OSGi", IEEE Communications magazine, Volume 40, Issue 8, pp. 86-92, August 2002ASHRAE 135-2004 standard, Data Communication Protocol for Building Automation and Control Networks

[5]. EnOcean Equipment Profiles v2.5, EnOcean Alliance, March 04, 2013

[6]. EnOcean System Specification – Remote Management v1.7, EnOcean Alliance, December 16, 2010

[7]. EnOcean System Specification – Smart Acknowledgment v1.4, EnOcean Alliance, September 15, 2010

[8]. EnOcean System Specification – EnOcean Serial Protocol v1.17, EnOcean Alliance, August 2, 2011

[9]. EnOcean System Specification – Security of EnOcean Radio Networks v1.3, EnOcean Alliance, July 31, 2012

Add references simply by adding new items. You can then cross-refer to them by chosing <Insert><Cross Reference><Numbered Item> and then selecting the paragraph. STATIC REFERENCES (I.E. BODGED) ARE NOT ACCEPTABLE, SOMEONE WILL HAVE TO UPDATE THEM LATER, SO DO IT PROPERLY NOW.

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Acronyms and Abbreviations

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