The need for ZigBee commissioning tools

Abstract

This paper provides an overview of ZigBee® and IEEE 802.15.4™ commissioning tools, describing what these tools do and why they are useful. It then looks at some of the key functionality available through commissioning tools, describing why and when you would use different features and what benefits they can provide.

Introduction

The benefits and capabilities of wireless sensor networking technologies such as ZigBee and 802.15.4 are well documented. These enabling technologies offer low-cost, low-power wireless communication for a wide range of applications using resilient, large-scale, multi-hop networks.

Most of the focus to date has been on features offered by these technologies and how to develop products with them. After those products are developed, the next step is to commission and deploy them.

This paper provides an overview of the ways in which commissioning tools can help with deployment and commissioning.

To find out more about commissioning in general, refer to Daintree's *"Understanding ZigBee Commissioning"* whitepaper, available from www.daintree.net/resources

About commissioning

In its broadest sense, commissioning covers a wide range of tasks including surveying the radio and physical environment, placement of devices, configuration of parameters, application binding, optimization of network and device parameters, and testing and verification of correct operation.

Often, non- and semi-technical issues need to be considered, including the skills and workflow practices of the installer, ease and identification and accessibility of devices, and interoperability and co-existence with other wireless or wired systems.

While consideration for commissioning is often focused on installation and deployment, the ability to easily configure and commission ZigBee systems during development, testing and manufacturing is equally important:

- During development and testing, the developer often has to set up a system of devices for testing. The ability to quickly commission devices or a network using standards-based over-the-air methods can significantly improve productivity.
- During manufacturing, it may be necessary to modify device parameters (perhaps for different groups of customers), to run basic manufacturing tests or even to actually specify the ZigBee settings of devices. The ability to modify these parameters without requiring a separate firmware download provides significant flexibility to the production process.

About commissioning tools

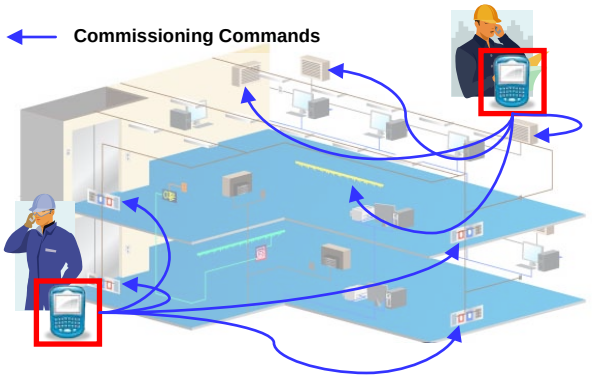
In a perfect world, devices would commission themselves. An installer would power them up, turn them on, and stand back and watch the devices work out which network they should join, how security worked in that network, which device (or devices) they should bind to, and which devices they should communicate with.

Maybe that perfect world will exist in the distant future, but as of today, it's up to the installer to perform all of these tasks.

When you look at the number of tasks involved in commissioning, and consider that many installers will have limited knowledge of the underlying technologies, it's easy to see the value of a commissioning tool.

Commissioning tools are designed to make life easier for installers. They typically run on a laptop or PDA, and provide an intuitive user interface that hides the complexity of the underlying technology. These tools offer flexibility in allowing the installer the means to visualize the network and devices, and options to configure, commission and manage the system.

In applications involving very large numbers of devices with many different types of devices and applications (such as lighting, heating, or security) several installers working in tandem can use multiple commissioning tools.



Commissioning tools can configure devices via a user interface. Multiple tools can be used by different installers for more rapid deployment.

Commissioning tools are generally not intended to be part of the network in its ongoing operational use, and simply facilitate commissioning or ongoing maintenance or management, without being part of the primary application.

Features and functionality

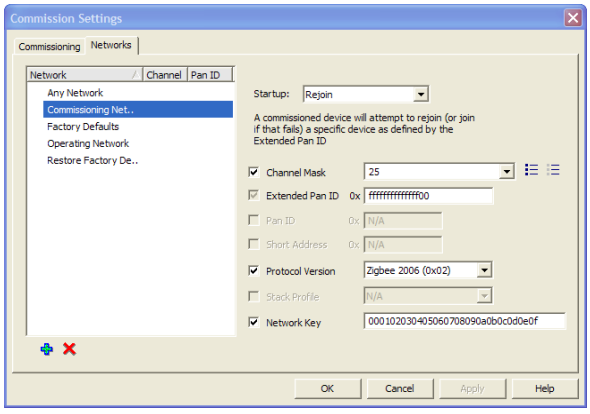
Exact requirements for a commissioning tool will vary depending on the type of device and application being commissioned, and the environment into which it is being deployed. In general, commissioning tools should provide the following functionality:

- Easy to use interface that hides the complexity of the underlying technology.
- Start-up commissioning to configure devices with the settings required to join (or start) their intended network.
- Membership commissioning to control which devices are permitted to join a specific network.
- Network and device discovery to provide information about the existing network, including locations of individual devices.
- Binding and group commissioning to establish the relationships between devices and their controlling applications.
- Over-the-air downloads to provide a fast and easy way to update device firmware.
- Up-to-date implementation of the latest standards, including the ZigBee Commissioning Cluster, to ensure platform independence.
- Flexibility to be able to work around situations that the designers of the commissioning tool haven't catered for.
- Portability to make it easy to take the tool wherever it is needed.
- Monitoring and analysis tools to help quickly identify and resolve any problems or errors that occur.

Easy to use

Commissioning tools should make it as easy as possible for installers who may have little or no knowledge of networking technologies.

Installers need a tool that ***hides the complexity*** of the underlying technology, and provides straight-forward configuration, testing, and troubleshooting capabilities. Ideally, it should provide graphical representations that make if fast and easy for installers to monitor network formation, measure key parameters such as link quality and bindings, and issue commissioning commands.



Commissioning tools allow installers to configure devices and networks without needing to understand the underlying technology.

Start-up commissioning

This is the ***initial configuration*** of a device that tells it which network to join and the way in which it should join that network.

It includes details such as

- Whether the device should join an existing network, or start a new network as the coordinator.
- The ID, channel and security details for the network being joined or started.

Start-up commissioning is typically done onsite by installers, with the device being commissioned over-the-air. It might also be done in the lab by developers, or perhaps as part of the manufacturing process, often with the device connected directly to the tool.

Membership commissioning

Whereas start-up commissioning addresses things from the device level, membership commissioning addresses them from the network level.

Membership determines which devices are (and aren't) allowed to join a specific network.

One network device operates as a ***trust center***, which manages (allocates and distributes) all of the network's ***security keys***. Only devices with valid keys are allowed to join or operate within the network. The trust center device can be a network coordinator, or even the commissioning tool itself.

Membership also provides the installer with the ability to force unwanted devices to leave a network, through the use of standards-based commands such as ***Permit Join*** and ***Leave***.

Network and device discovery

When adding devices to an existing installation, it's useful to know what is already out there: what is the existing coverage like in the area in which the new devices will be installed, and are there any problems with interference that need to be taken into consideration?

Commissioning tools should offer ***scanning*** functionality to allow discovery of network structure, devices and ambient energy levels. These can help the installers make decisions including:

- Is there adequate coverage in the area in which the new devices are being installed? Or are additional routers required?
- Which channels have lower levels of interference, and are therefore more suitable for starting new networks?

In addition to discovering the network as a whole, there are times when it is also useful to ***locate an individual device***.

One of the biggest issues installers face in commissioning is figuring out which device it is they're trying to commission. A commissioning tool typically shows the device wirelessly, but if there are dozens of identical device types, what is really needed is a tool that identifies which device is which.

Locationing can help to speed commissioning by quickly identifying individual devices.

Binding and group commissioning

Binding determines the relationships between devices, for example, which lights does a specific switch turn on and off.

Binding information can be stored either in individual devices or in a ***binding table*** (or cache). Storing binding information in a table is useful for some applications, for example in those where devices are replaced on a regular basis, binding details can be retained in a central table instead of needing to be reconfigured for each new device.

In addition to binding individual devices (for example one light to one switch), the commissioning tool

should also provide the ability to bind a group of devices to the same controller (for example all lights in a conference room, or all heating units on a specific floor). Again the tool should allow this information to be stored in individual devices or in a binding table.

Group bindings involve two main steps:

1. Define the group by identifying all devices that belong together and commissioning them with a ***group membership*** (for example, all lights in a room).
2. Assigning the binding to all devices in the group (for example, set the light switch to control the group of lights).

Commissioning tools can identify group memberships using ***service discovery***. This discovery queries devices and determines whether they have clusters that match a particular application that the source device needs to bind to.

The commissioning tool should also provide the ability to create a ***group table***, in which installers can add and remove devices. Storing the group details centrally in this way provides the same benefits as the binding table in the event that a device fails or needs to be replaced.

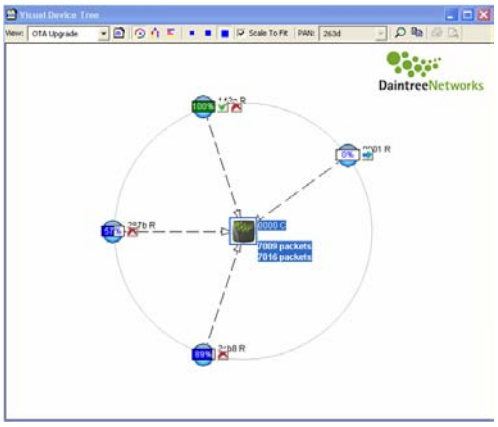
Over-the-air (OTA) upgrades

Over-the-air upgrades provide the ability to upgrade a device's firmware over a network. This feature removes a lot of the costs usually associated with upgrading nodes that have already been deployed. It can also reduce errors, in that it is an easier way to ensure that all required devices are upgraded with the same firmware.

Without OTA upgrades, devices typically need to be upgraded one at a time by physically attaching each device to a computer or PDA, upgrading the firmware, and then restarting the device.

With OTA upgrades, multiple devices can be upgraded and then restarted at the same time using over-the-air connectivity.

This feature is useful for developers for updating devices with new firmware during development and field trials. It is also useful during installation and maintenance, particularly if a large set of nodes has been installed an additional feature is added.



Upgrade multiple devices over-the-air in a single operation to save time and effort.

Up-to-date standards

A commissioning tool should use up-to-date specifications to help ensure interoperability between devices.

A standards-based protocol such as ZigBee offers obvious and significant benefits—interoperable building blocks, a wider range of options to application developers, and avoids the danger of obsolescence through the use of proprietary methods and solutions. In addition to a standards-based protocol, the ZigBee Alliance has and continues to deliver on standards-based commands and methodology for commissioning ZigBee systems. These will ensure that tools and devices can interoperate by using the same over-the-air commands.

The ZigBee Alliance has specified a new cluster called the ***ZigBee Commissioning Cluster (ZCC)***. This cluster delivers a standard set of over-the-air ZigBee commands for commissioning.

Flexibility

Commissioning tools are powerful and do a lot, but there will be times when developers or installers need them to do something that the tool's designers haven't catered for.

Therefore, any tool needs to provide enough flexibility to work around these situations. This is typically done through an ***API (Application Programming Interface)***,

which developers use to customize the tool's behavior. This customization may include things like issuing instructions directly to the network, or communicating and integrating with third-party systems, such as building management systems.

Installers can then use the customized version of the tool without ever needing to be aware of the underlying work-arounds.

Portability

One of the benefits of ZigBee and mesh networking is the ability to install devices in places or environments where it might be difficult (or at the very least, inconvenient) in which to use a laptop computer.

Therefore, a commissioning tool should ideally be portable, and able to go wherever it is needed.

Portable tools are easy to carry around, and have a compact and easy-to-read user interface

Monitoring and analysis

Monitoring and analysis tools provide the ability to validate correct operation and performance of deployed devices. This is particularly important for complex installations where human error or unexpected behavior could occur.

Ideally a commissioning tool should not only identify problems and unexpected behavior, it should also provide feedback about what is causing the problem and what possible actions can be taken to remedy it.

Both the error reporting and feedback need to be presented in a way in which installers can easily interpret and act on them.

Commissioning example

The steps required to commission networks and devices will change for almost every deployment. Therefore, the following example is provided as a general guide of how and where a commissioning tool (CT) could fit in:

1. Use the CT's network discovery capabilities to identify a quiet channel suitable for starting a new network.
2. Start a new network on that channel with the CT as the network coordinator.
3. Turn on all devices to be commissioned and deployed.
4. Use the CT's locationing capabilities to identify which device is which.
5. If required, use the CT's OTA upgrade capabilities to update device firmware.
6. Use the CT's start-up and membership configuration capabilities to commission each device ready to join its intended network (including security settings).
7. Use the CT to force the device to leave the commissioning network (with the CT as coordinator) and join its intended operating network.
8. Use the CT's binding and group commissioning capabilities to establish the device's relationships in the operating network.
9. Use the CT's network discovery and monitoring and analysis capabilities to check the newly deployed device and ensure all is well. Physically turn the new device off and on to ensure it restarts correctly.

Conclusion

Ideally, a commissioning tool should be simple enough that an installer with little or no knowledge of the underlying technology can perform all common commissioning and configuration tasks. The tool should also be powerful enough that a developer can customize it to meet the needs of a specific device or network.

Even though specific tool requirements may change for different deployment scenarios, some things will always remain the same. Any commissioning tool should provide the following benefits:

- simplify and speed-up commissioning and deployment
- provide feedback in a manner that makes it easy for installers to identify and remedy problems
- ensure interoperability through implementation of the latest standards

While we all look forward to a future where devices commission themselves, we can use commissioning tools today to make the job of deploying devices a lot easier!

About Daintree Networks

Based in Mountain View, California, Daintree Networks is a clean technology company that provides wireless control solutions for commercial buildings. Daintree has a strong background in wireless sensor and control mesh networking, with extensive knowledge and experience gained through its industry-standard design verification and operational support tool, the Sensor Network Analyzer (SNA). In addition to wireless embedded expertise, Daintree has put together a team of seasoned professionals from the lighting, telecommunications and networking worlds. Daintree's expertise and knowledge is now being focused on the development of cost-effective building automation systems. These provide benefits including reduced energy consumption, costs and carbon footprint, compliance with new "green" building regulations, and cost savings available through government rebates and the ability to take advantage of demand response programs.

Daintree's Wireless Lighting Control Solution (WLCS) allows lighting manufacturers to speed their time to market, and enables them to deliver powerful, comprehensive, flexible, and reliable wireless lighting control systems for commercial buildings. For more information, visit www.daintree.net or email sales@daintree.net

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