Zigbee Perspective on IoT

July 2017

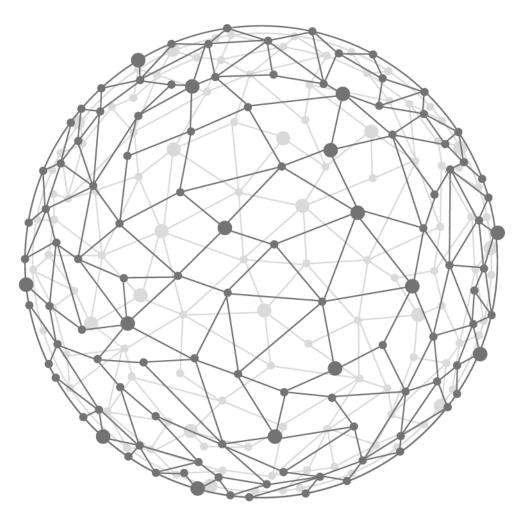**Tobin Richardson**

President & CEO, Zigbee Alliance

Zigbee Alliance

We're committed to standardizing across all IoT layers.
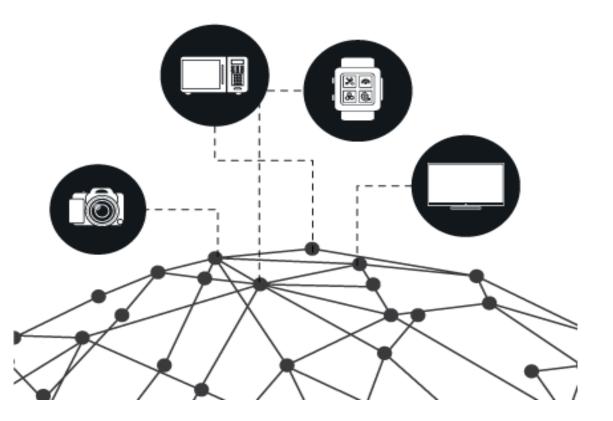
- From low-power mesh networking that connects products, to the unifying, universal language at the application layer that allows products to work together and transform the way we live, work and play.
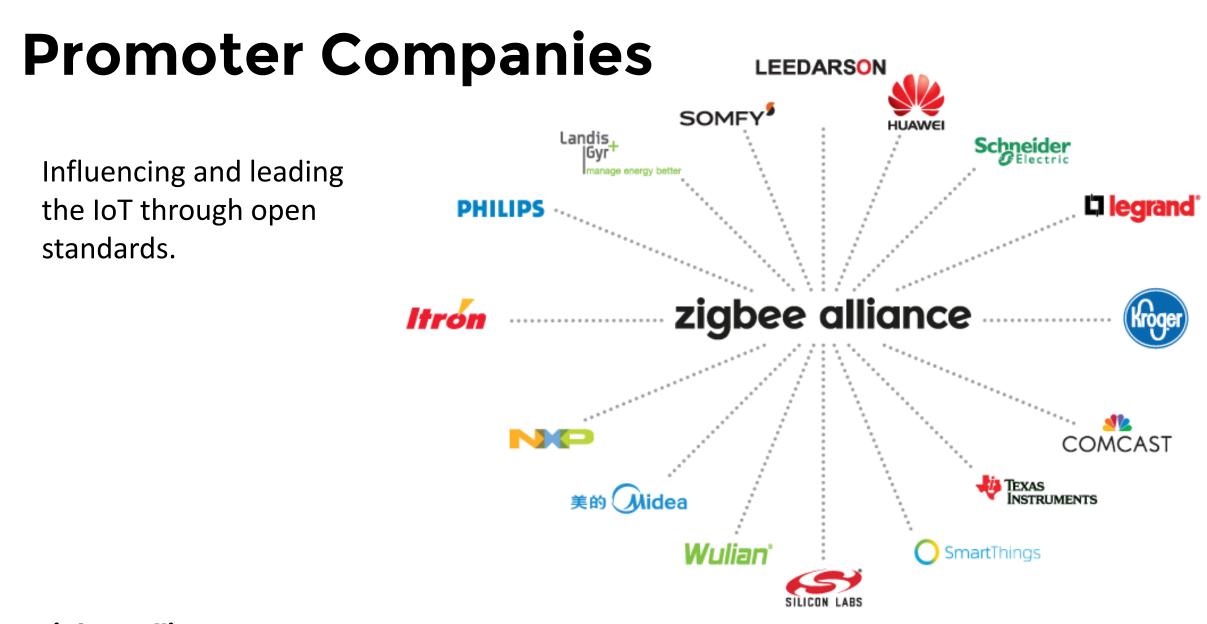
What We Do

- Develop open, global standards for wireless device-to-device communication (Internet of Things)
- Certify products to help ensure interoperability through the Zigbee Certified program
- Promote the use of Zigbee standards around the world

INTERNET
OF THINGS

Promoter Companies

Influencing and leading
the IoT through open
standards.

Major Initiatives (1)

- Wide adoption with 20 compliant platforms (silicon), modules and development support members to enable new products

- Now called "Zigbee" with updated brand and logo. "3.0" is for spec sheets.

- First open, full stack solution with mesh networking and interoperability language

Major Initiatives (2)

Meet Dotdot, our application layer and language for the IoT

- Extends the application layer at the heart of Zigbee to other networks
- Architecture currently under development by members
- First of major partnerships is with Thread — member demos already at member meetings and Consumer Electronics Show
- Market availability & timing coming soon; members get early access

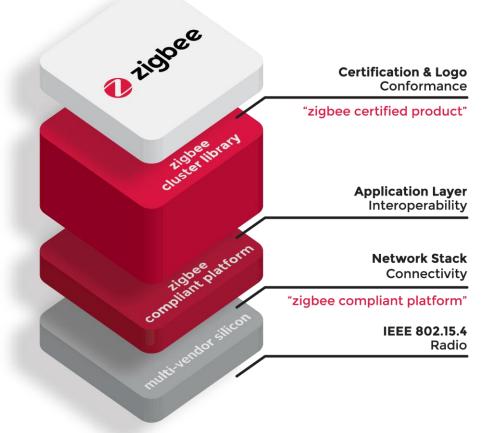**dotdot**

Evolution of our Application Layer

Consolidated App Layer

- With Zigbee, we've brought all our profiles under one technology.
- We've evolved the most mature, widely deployed, well-supported application layer.

Lessons

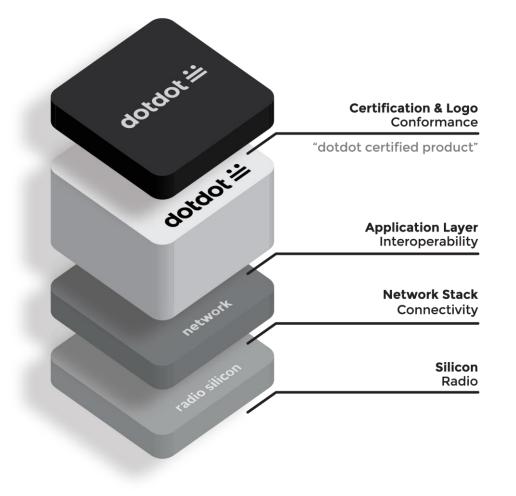- The IoT needs a universal language, and Zigbee's ZCL is the most robust.
- There is high demand to expand this across other networks.

Certification & Logo
Conformance
"zigbee certified product"

Application Layer
Interoperability

Network Stack
Connectivity
"zigbee compliant platform"

IEEE 802.15.4
Radio

zigbee cluster library
zigbee compliant platform
multi-vendor silicon

What is Dotdot?

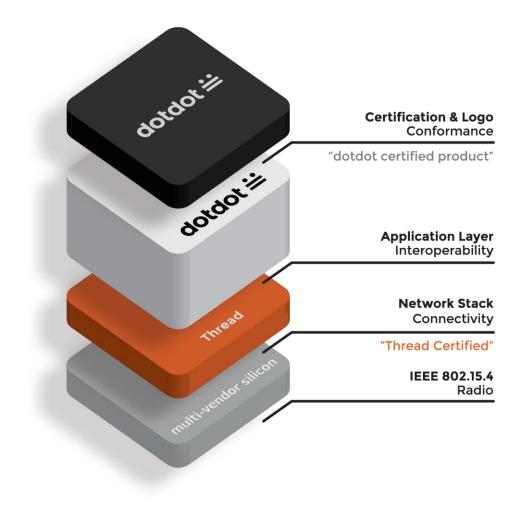- Dotdot is a generalization of all of the application layer functionality developed both in Zigbee PRO and the Zigbee Cluster Library for use over a variety of IP-based transports.

- The first transport to implement Dotdot outside of Zigbee PRO will be IP.

Certification & Logo
Conformance

"dotdot certified product"

Application Layer
Interoperability

Network Stack
Connectivity

Silicon
Radio

dotdot ⁞

Dotdot and **Thread**

- Will be first (non-Zigbee) qualified network for Dotdot certification

- Brings a universal application layer to IP mesh networking

- Result of successful liaison between both organizations

- Public spec, certification, and logo program in 2017

Certification & Logo
Conformance
"dotdot certified product"

Application Layer
Interoperability

Network Stack
Connectivity
"Thread Certified"

IEEE 802.15.4
Radio

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Zigbee Concepts

- **Endpoints: Logical representations of different applications on a physical device**
  - Example: A light strip could have multiple lights, each with their own endpoint.

- **Zigbee Device Profile (ZDP)**
  - In Zigbee, things like bindings and device discovery services are managed through the APS layer and its ZDP management commands.
  - In Zigbee the ZDP is accessible on a special endpoint, Endpoint 0, using ZDP commands.

- **Clusters (ZCL): Represent different aspects of a device's functionality on a given endpoint**
  - Example: The On/Off Cluster contains all the functionality related to turning a device on and off and saving its on/off state.

- **Commands: Used to take action on a device. Commands come in two flavors:**
  - General Commands: Take action on the resources on a device
  - Cluster Commands: Take action on a specific piece of functionality on a device

- **Attributes:**
  - Represent a stored value on a device. Attributes are contained within clusters and represent the state of a device on a specific endpoint, for a specific cluster.
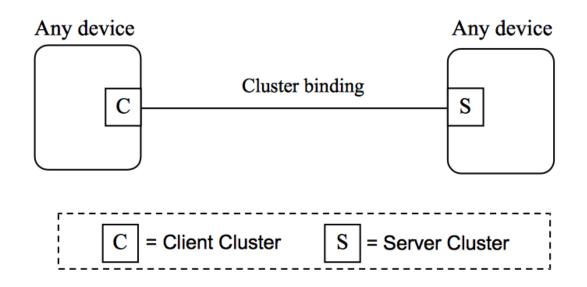
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Zigbee Cluster Library (ZCL)
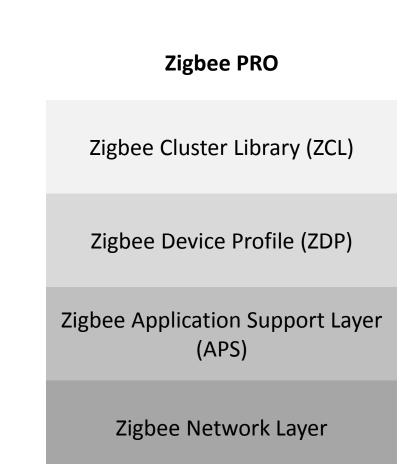
- **What is a "Cluster"?**
  - A related collection of attributes and commands, which together define a communications interface between two devices. The devices implement server and client sides of the interface respectively.
  - Cluster Client/Server model: This is where domain knowledge resides.
  - Major stakeholders have been involved since the beginning to develop this body of knowledge.
  - Clusters can be extended with manufacturer-specific functionality.
- The Zigbee Cluster Library (ZCL) is the repository for cluster functionality that has been developed by the Zigbee Alliance over the years. It is a working library with regular updates as new functionality is added.

Originally released in October, 2007

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What is in Zigbee PRO?

- **Zigbee Device Objects (ZDO):** Used to access general information about a device, how it is configured and what services it offers.

- **ZDP Commands:** Used to create and manage bindings on a device. Bindings determine how a device is provisioned on a network.

- **ZCL General Commands:** Used to access resources on a device including attribute and reporting configuration read and write.

- **Cluster functionality:** Used to take action on and store the specific state of a device.
  - Cluster commands: Expose functions on a device for a given cluster. (Example: On command in the On/Off cluster)
  - Cluster attributes: Expose state on a device for a given cluster. (Example: On/Off attribute in the On/Off cluster)
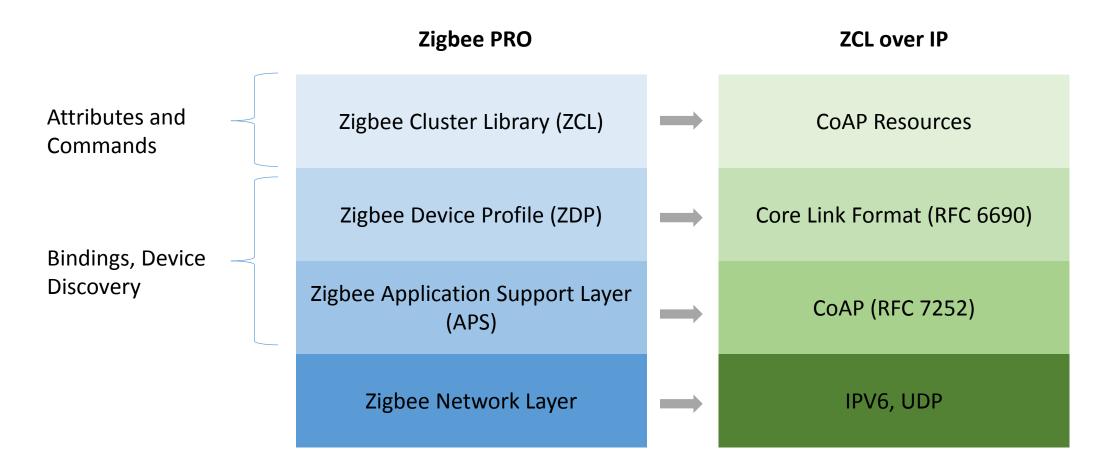
Zigbee PRO

Zigbee Cluster Library (ZCL)
Zigbee Device Profile (ZDP)
Zigbee Application Support Layer (APS)
Zigbee Network Layer

What is in ZCL/IP?

- **ZCL/IP uses several IETF documents to map Zigbee into the world of IP and a RESTful interface.**
  - Constrained RESTful Environments (CoRE) Link Format (RFC 6690)
  - Constrained Application Protocol (CoAP) (RFC 7252)
  - Concise Binary Object Representation (CBOR) (RFC 7049)
- **ZDO information is available through queries using the CoRE Link Format**
- **ZDP commands are available through CoAP methods GET, PUT, POST and DELETE**
- **ZCL General Commands and Cluster commands are accessible through CoAP methods GET, PUT, POST and DELETE**
- **ZCL General and Cluster response commands are returned in CoAP responses**
- **ZCL payloads are encoded in CBOR which makes them small and scalable**

ZCL over IP

CoAP Resources
Core Link Format (RFC 6690)
CoAP (RFC 7252)
IPV6, UDP

How does Zigbee Map to ZCL/IP?

Zigbee PRO

ZCL over IP

Attributes and Commands

Bindings, Device Discovery

Zigbee PRO		ZCL over IP
Zigbee Cluster Library (ZCL)	→	CoAP Resources
Zigbee Device Profile (ZDP)	→	Core Link Format (RFC 6690)
Zigbee Application Support Layer (APS)	→	CoAP (RFC 7252)
Zigbee Network Layer	→	IPV6, UDP

Zigbee vs. ZCL/IP Transactions

- In Zigbee, each transaction consists of two commands: an originating command and a corresponding response command.

- ZCL/IP follows a RESTful design in which each transaction consists of an originating CoAP Method (GET, PUT, POST, DELETE) and a corresponding CoAP response such as 2.05 Content or in an error case 4.05 method not allowed.

  - Zigbee Command IDs are sometimes included in the originating URI but are excluded from the CoAP response.

ZDP Commands and the CoRE Link Format

- **Discovery of a device's exposed functionality which is accessible in Zigbee through ZDP discovery commands are available through CoAP GET to .well-known/core**
  - Example: Multicast query used to discover Zigbee endpoints implementing the client side of the on/off cluster (ClusterID 0x0006).
    - `GET COAP://[FF03::FD]/.well-known/core?rt=urn:zcl:c:6.c`
  - **Returns a CoAP response code 2.05 (content) with the information about which endpoint implements this cluster**
    - `2.05 Content (Content-Format: application/link-format (40)) <coap://[2002:8290:4eed::8290:4eed]/zcl/e/1/c6>;rt=urn:zcl:c:6.c;ze =urn:z:cl:d.103.1`

ZDP Commands and CoAP

- **Zigbee Device Profile commands such as those involved in creating and managing bindings are available through CoAP methods such as GET, PUT, POST and DELETE to /b**
  - Example: To retrieve the binding located at index 0 the device would send
    - `GET  coap://[2002:8290:4eed::8290:4eed]/zcl/e/1/s6/b/0`

ZCL General Commands and CoAP

- **ZCL General Commands map to the CoAP RESTful interface using methods GET, PUT, POST and DELETE.**

- **ReadAttributes = GET to /a/<aid>**

- **WriteAttributes = PUT, POST to /a/<aid>**

- **DiscoverAttributes = GET to /a**

- **ConfigureReporting = PUT, POST, DELETE to /r/<rid>**

- **ReadReportingConfiguration = GET to /r/<rid>**

- **ReportAttributes = POST to /n**

- **DiscoverCommandsReceived = GET to /c**

- **For Example:**
  - **ReadAttribute on the OnOff attribute on the On/Off cluster (0x0006) on Endpoint 1 becomes:**
    - GET coap://[2002:8290:4eed::8290:4eed]/zcl/e/1/s6/a/0
  - **ReadAttributesResponse on the OnOff attribute on the On/Off cluster (0x0006) on endpoint 1 becomes:**
    - CoAP Response 2.05 Content with a CBOR map {0:0} indicating that the OnOff attribute is currently in the Off state.

ZCL Cluster Commands and CoAP

- ZCL Cluster Commands map to the CoAP RESTful interface using method POST to /c/<cid>

- ZCL Cluster Command responses map to the CoAP response of a given CoAP POST.

- For example: On Command sent to endpoint 1 becomes:
  - POST coap://[2002:8290:4eed::8290:4eed]/zcl/e/1/s6/c/1
  - CoAP response 2.04 Changed with a payload {0:0} indicating a Default Response with status SUCCESS

ZCL/IP Resource Table

Resource	Methods	URI
Resource discovery	GET	/zcl
Endpoints	GET	/e
Attributes	GET, PUT, POST	/a
Commands	GET, POST	/c
Bindings	GET, PUT, POST, DELETE	/b
Report Configuration	GET, PUT, POST, DELETE	/r
Report Notification	POST	/n
Group Notification	POST	/g
EZ-Mode Commissioning	GET, POST	/m

Application Layer Security

- **Unique ID:** All devices have a device certificate from the manufacturer to provide identity and a unique ID. Each device will either be provided at manufacture or self-generate a raw public private key pair.

- **Operational Certificates:** All devices must support handling of operational certificates if the network supports provisioning and usage of such certificates.

- **DTLS:** All devices must support application-level DTLS sessions for either device-to-device or device-to-cloud interactions. The DTLS session can be based on pre-shared key, raw public key or certificates.

- **Application Layer Security:** A device SHALL restrict access based on application level security. For example, a status may be accessible to all devices while a command may only be accepted with application level security included. The specification will detail what is required for each device and how the security session is initiated. Note this does not apply to group communications.

- **Service Discovery:** Service discovery on network does not require application level security.

- **Network Layer Security:** When network level security is available, it SHALL be used.

OTA Upgrade

- OTA Upgrade uses the OTA Cluster for transfer management and MAY use CoAP block transfer for the transfer of image information (this is still being developed).

- OTA Upgrade Security:
  - All devices have a certificate to support code signing for upgrade images from the manufacturer.
  - All devices support OTA software update and the update must be with signed images only to guarantee integrity and authenticity of the update.

CES 2017

- Product demonstration by Alliance members based on draft specification.

- Product demonstration included:
  - Security Control Panel
  - Lighting Control
  - Door Lock
  - Thermostat
  - Smart Plug
  - Variety of sensors

Next Steps / How to Get Involved

- **Effort Scope**
  - The Zigbee Alliance is currently focused on making the elements from Dotdot run over IPV6, hence the project name ZCL/IP.

- **Specification Status**
  - The ZCL/IP specification is currently at 0.7 and is being actively developed and tested within the Zigbee Alliance. As a result, the information in this document is subject to change.

- **Need More?**
  - For more documentation, to begin your implementation and participate in the specification testing process, please join the Zigbee Alliance.

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