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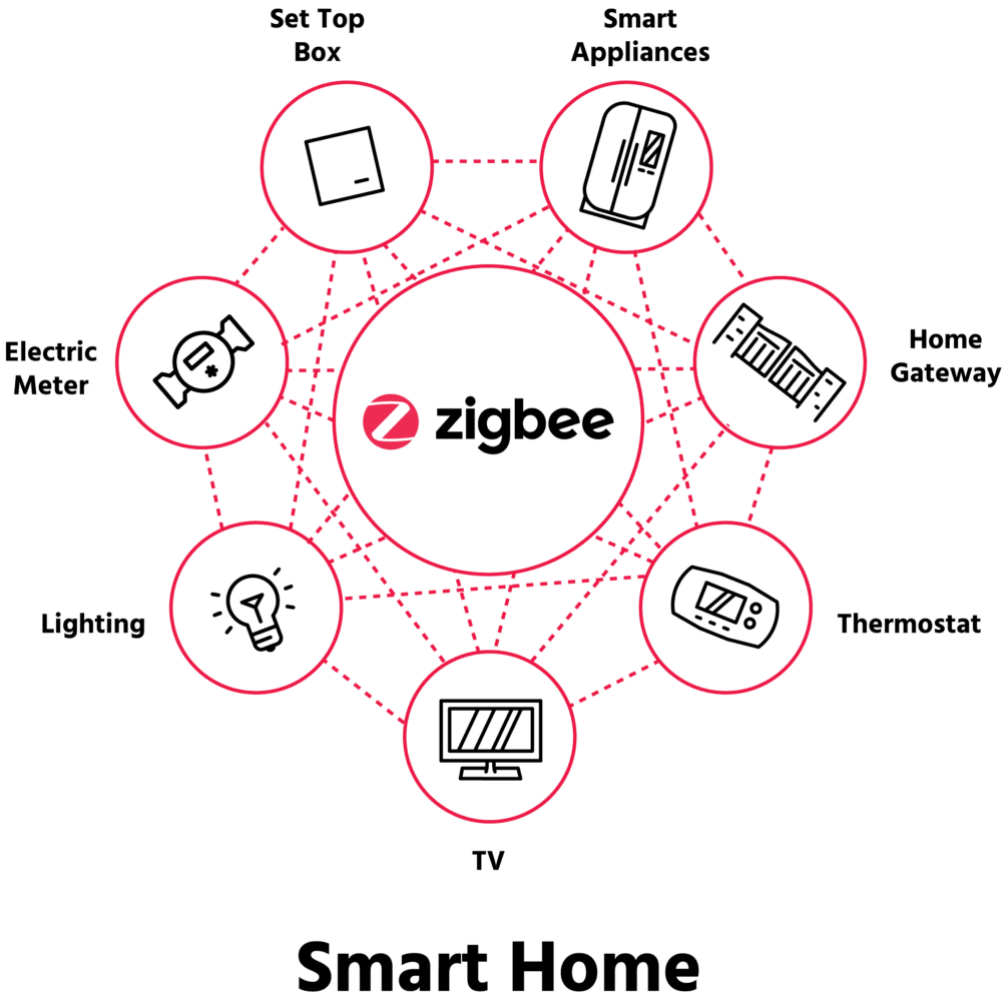
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Integrating ZigBee into RIOT OS



ZigBee

- First introduced in 2005 and used for connecting IoT devices
- Popular Home Brands: Phillips Hue, SmartThings, Aquara
- Appliances: Bulbs, Switches, Thermostats, various Sensors and more
- Recent competing standard: Matter over Thread
- ZigBee 4.0 released in 2025
- Builds upon IEEE 802.15.4



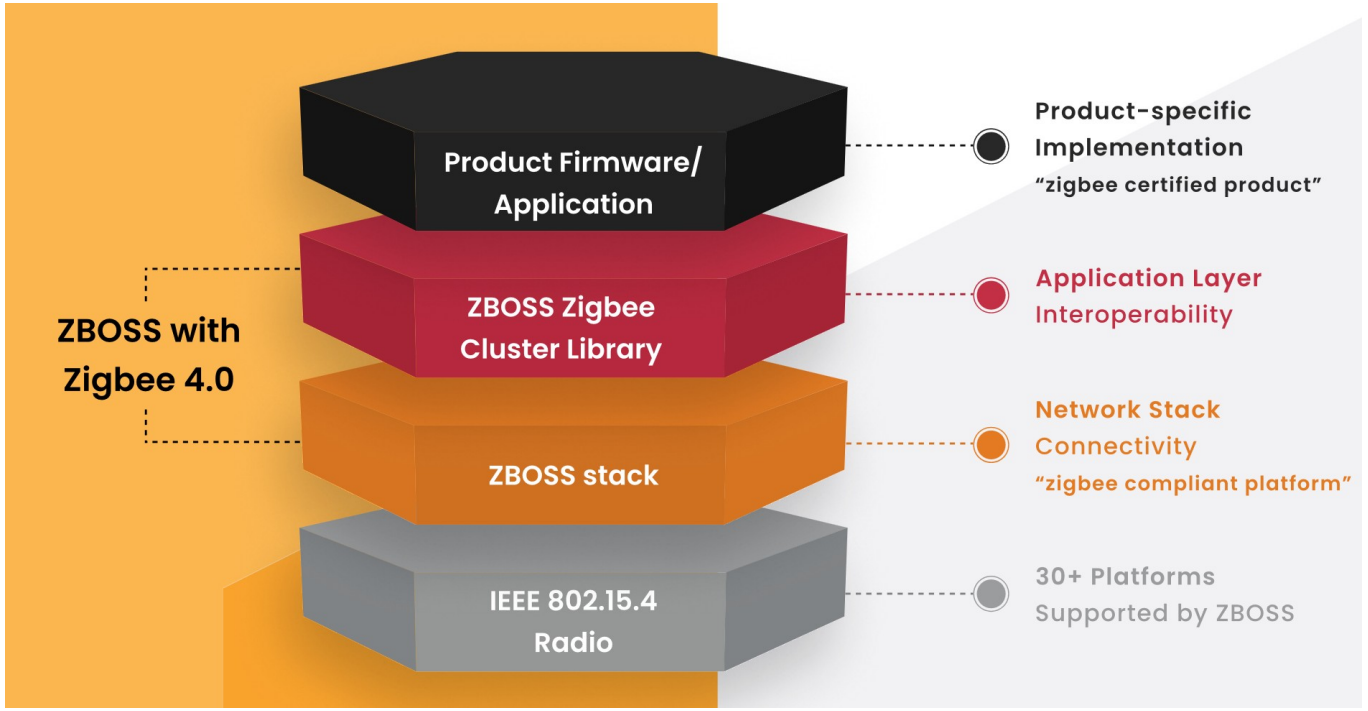
Contents

- About the ZBOSS ZigBee implementation
- Introduction to ZigBee
- Current State in RIOT OS
- Code example
- Live Demo

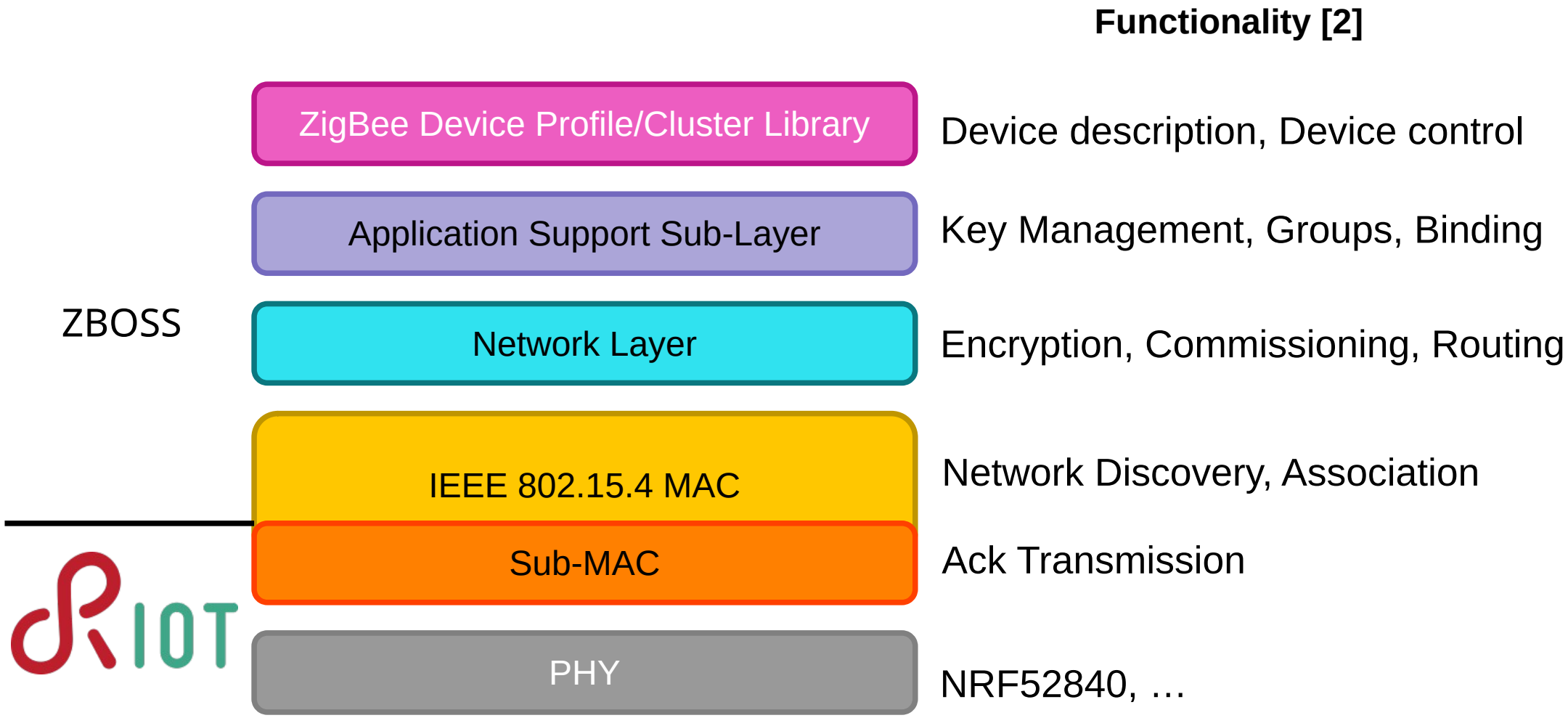


ZBOSS

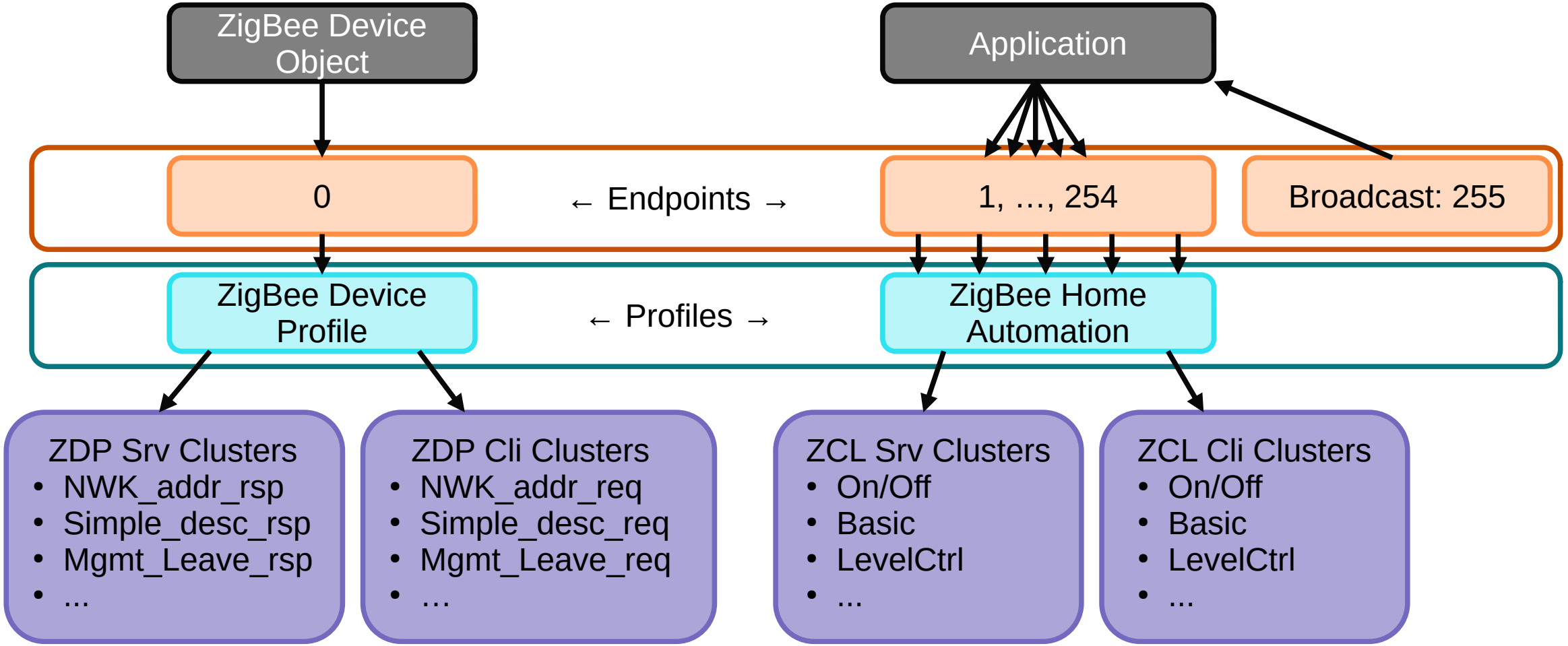
- Developed by DSR Corporation [3]
- Used in SDKs by Nordic, TI, NXP, ...
- Open Source until ~2014
  - Closed Source Version still developed to recent Standards



The ZigBee Stack



ZigBee Structure [2]



ZigBee Profiles

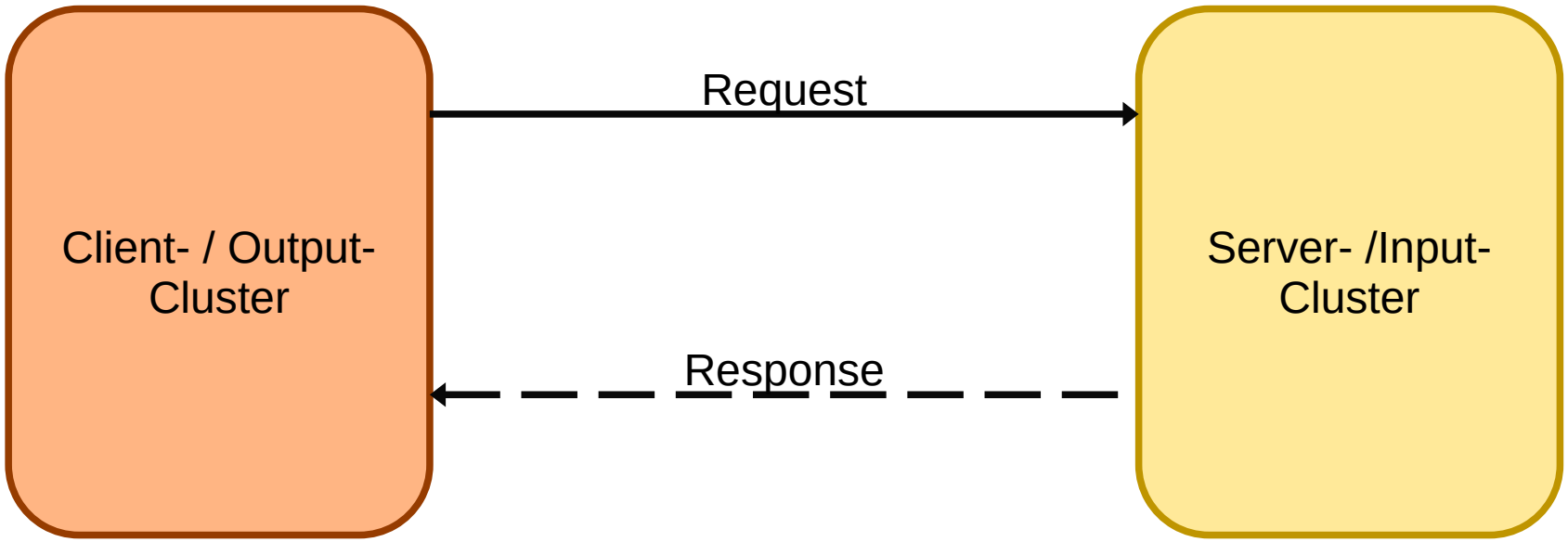
- Defines Application Messages for devices to agree upon [2]
- Common Profiles defined by Connectivity Standards Alliance (CSA):
  - Device Profile: 0x0000 (Discovery and Network Management)
  - Home Automation: 0x0104 (Control commands for appliances using Cluster Library)
- Each new Profile must be approved by CSA



ZigBee Cluster Library

- Specification defining Application messages
- Covers device specific functionalities like:
  - Sensors,
  - Thermostat,
  - Lighting,
  - Blinds/Shutters
  - Etc.

ZigBee Cluster Library



ZigBee Cluster Library

Every Cluster may contain ...

General Commands (always present) [1]

- Attribute-Related: Read, Write, Configure reporting, Discovery
- Others: Discover Commands generated/received
- Almost all Commands expect Responses or a default response

Specific Commands

- defined by each Cluster individually via ID and Format

Cluster Attributes

- unique to each Cluster, with ID, Access policy and data Type

Touchlink Commissioning

- Establishes Connection between two Devices
- Uses broadcast communication
- Cluster-Level Commissioning commands
- Predefined Key for encrypting the Network-Key
- Devices should be close to each other → TOUCHlink

ZigBee Cluster: On/Off

- Cluster ID: 0x0006 [1]
  - Server (Input) **Attributes**:

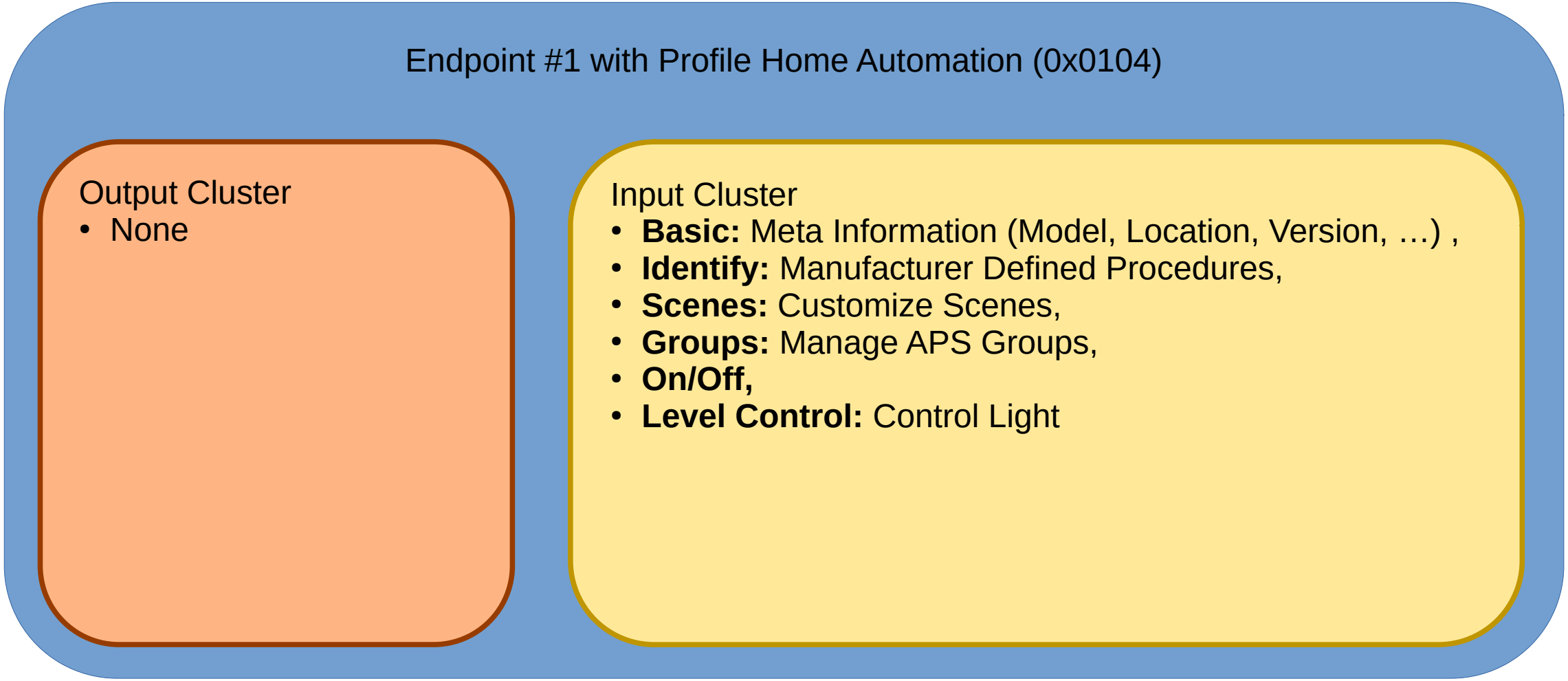
• OnOff	Bool	0x0000	Read, Report, Control via Scene
• GlobalSceneControl	Bool	0x4000	Read
• OnTime	uint16	0x4001	Read-Write
• OffWaitTime	uint16	0x4002	Read-Write
• StartUpOnOff	enum8	0x4003	Read-Write

  - Client Attributes: None

ZigBee Cluster: On/Off

- Cluster ID: 0x0006
  - Server (Input) **Commands**:
    - Off 0x00
    - On 0x01
    - Toggle 0x02
    - Off with Effect 0x40
    - On with recall global Scene 0x41
    - On with timed off 0x42
  - Client sends commands to server.

ZigBee Lightbulb Application Structure



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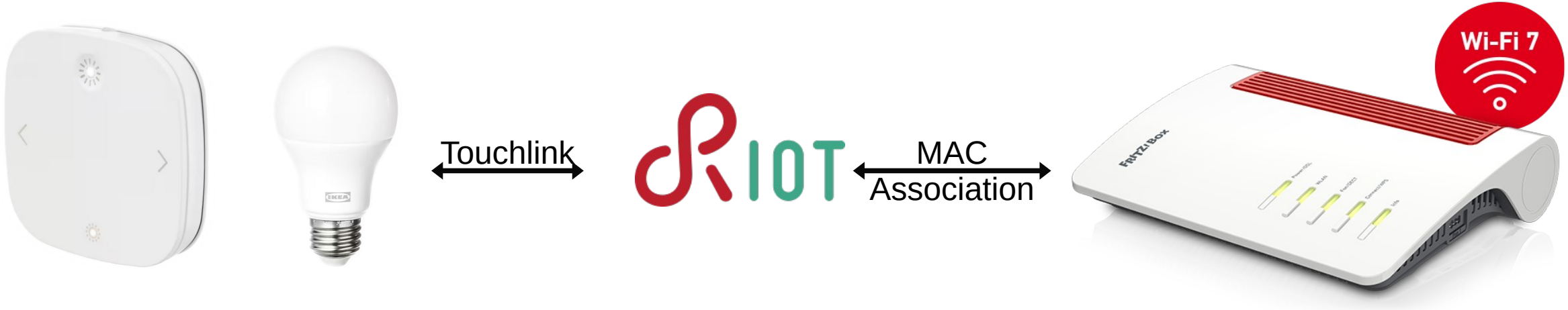
Current State of ZigBee in RIOT OS

State of ZigBee in RIOT

- Clusters implemented: On/Off, Groups, Basic, Touchlink
- Test-coverage must be increased (see WORKING.md)
- Lots of Bugfixes in RIOT and ZBOSS were necessary
  - SubMAC functionality is still incomplete
  - Stalling, assertion failures and hardfaults are still common
- Try ZigBee now with PR#21412

State of ZigBee in RIOT

- Working Commissioning Methods (only one device at a time):
  - Touchlink (both ways): RIOT device joins with Bulb or Remote Control
  - MAC Association (only Client Side): RIOT device joins with Hub (e.g. Fritz!Box 7690)



ZigBee Application in RIOT

```
static zb_zcl_groups_srv_attr_t group_attrs =
{ .name_support = 1 };

static zb_zcl_on_off_srv_attr_t on_off_attrs = {
    .on_off = ZB_FALSE,
    .global_scene_ctrl = ZB_TRUE,
    .on_time = 0x0000,
    .off_wait_time = 0x0000,
    .set_state = set_led, // function to set LED
};

....
```

```
/* This will declare a simple_desc_lightbulb */

ZB_DECLARE_SIMPLE_DESC(INPUT_CL_COUNT,
        OUTPUT_CL_COUNT);

ZB_SET_SIMPLE_DESC(lightbulb,
        APPLICATION_ENDPOINT,
        ZB_HA_PROFILE_ID,
        ZB_HA_ON_OFF_LIGHT_DEV_ID,
        APPLICATION_VERSION,
        INPUT_CL_COUNT, OUTPUT_CL_COUNT,
        /* input cl: */ZB_BASIC_CLUSTER_ID,
        ZB_ZLL_CLUSTER_ID,
        ZB_GROUPS_CLUSTER_ID,
        ZB_ON_OFF_CLUSTER_ID
        /* no output cl */);
```

ZigBee Application in RIOT

```
static zb_af_ep_desc_t lightbulb_ep = {
  APPLICATION_ENDPOINT,
  ZB_HA_PROFILE_ID,
  (INPUT_CL_COUNT + OUTPUT_CL_COUNT),
  (zb_af_simple_desc_1_1_t*)
    &simple_desc_lightbulb,
  {
    ZB_ZCL_CLUSTER_DESC(&basic_attrs,
       ZB_BASIC_CLUSTER_ID,
      _ZCL_SERVER_ROLE),
       ......

  }};
```

```
/* ZigBee Thread started via auto_init */

int main(void)

{

        zb_zcl_init_ep(&lightbulb_ep);

        return 0;

}
```

→ See PR#21412

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Live Demo

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Thank you!

References

[1] https://csa-iot.org/wp-content/uploads/2022/01/07-5123-08-Zigbee-Cluster-Library-1.pdf

[2] https://csa-iot.org/wp-content/uploads/2025/11/docs-06-3474-23-csg-zigbee-specificationR23.2_clean.pdf

[3] https://dsr-iot.com/static/0cd916f8081b0605288ba5c83c40a267/zboss-4.0-product-sheet.pdf