Welcome to

Hacking Bluetooth Low Energy for Internet of Things

About the Trainers

WHO IS THIS GUY?

+ Aditya Gupta (@adi1391)
+ Founder of Attify - specialized IoT security firm
+ Spoken at various cons earlier -BH, Defcon, OWASP AppSec, phdays and more.

WHO IS THIS GUY?

+ Dinesh Shetty (@din3zh)
+ Senior Security Manager @ Security Innovation
+ Author of iOS hacking guide
+ Spoken & trained all around the world – BH, Defcon, OWASP etc.

Since this is an extremely short workshop with limited time, we will focus on the basics. The entire workshop is **focused around exploiting the BLE devices** which we have. Due to limited time, we won't be able to go into topics such as BLE authentication, pairing, encryption details (but will cover them briefly). Please feel free to talk to us post-workshop if interested in these topics.

Outline

What do you know about BLE Security?

Have you hacked BLE devices earlier?

This is going to be a beginner-friendly class!

AGENDA?

+ Internals of BLE
+ BLE Security
+ Interacting with BLE devices
+ Sniffing BLE traffic
+ Controlling a device
+ BLE exploitation scripting

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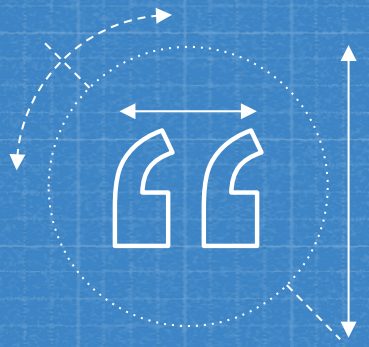
WHY BLE?

Why do we even care about Bluetooth Low Energy?



BLE is one of the **most common communication medium** used in IoT devices - especially **Smart homes, Fintech** and **medical devices.**

What is BLE?

- Bluetooth Low Energy, Bluetooth Smart, sub(Bluetooth 4.0 spec)
- Really, really different from the traditional Bluetooth
- Light weight, low power and resource consumption
- Battery can last for months to years
- Works on 2.4 GHz (ISM band) with a max range of around ~100m

Some devices using BLE?

- Smart home
- Smart mirrors
- Smart Coffee Machines
- Smart Plugs
- Smart enterprise devices
- Medical devices
- Payment systems
- And many more

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ATTACK SURFACE MAPPING

What are the various entry points?

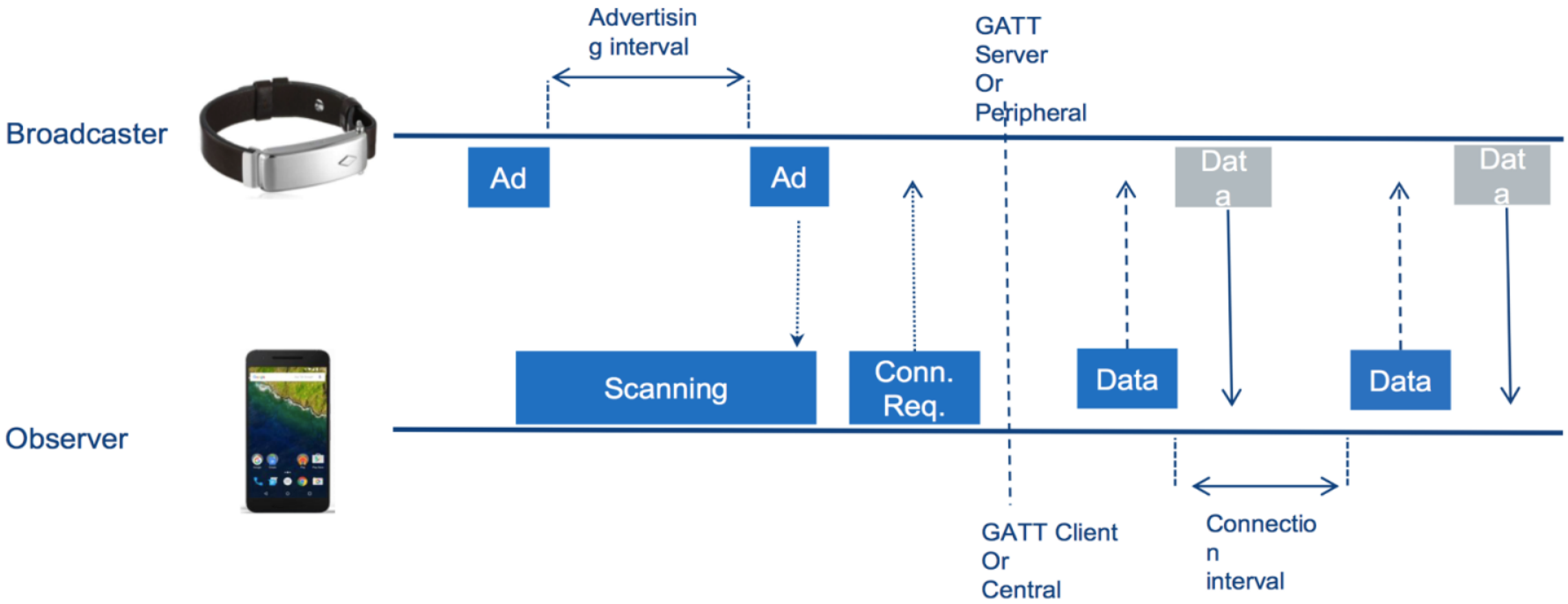
MAPPING BLE ATTACK SURFACE

- Understand the device and it’s functionality
- See how it communicates
- What are the various data components that it exchanges
- Sniff, Replay, MITM etc.

MAPPING BLE ATTACK SURFACE

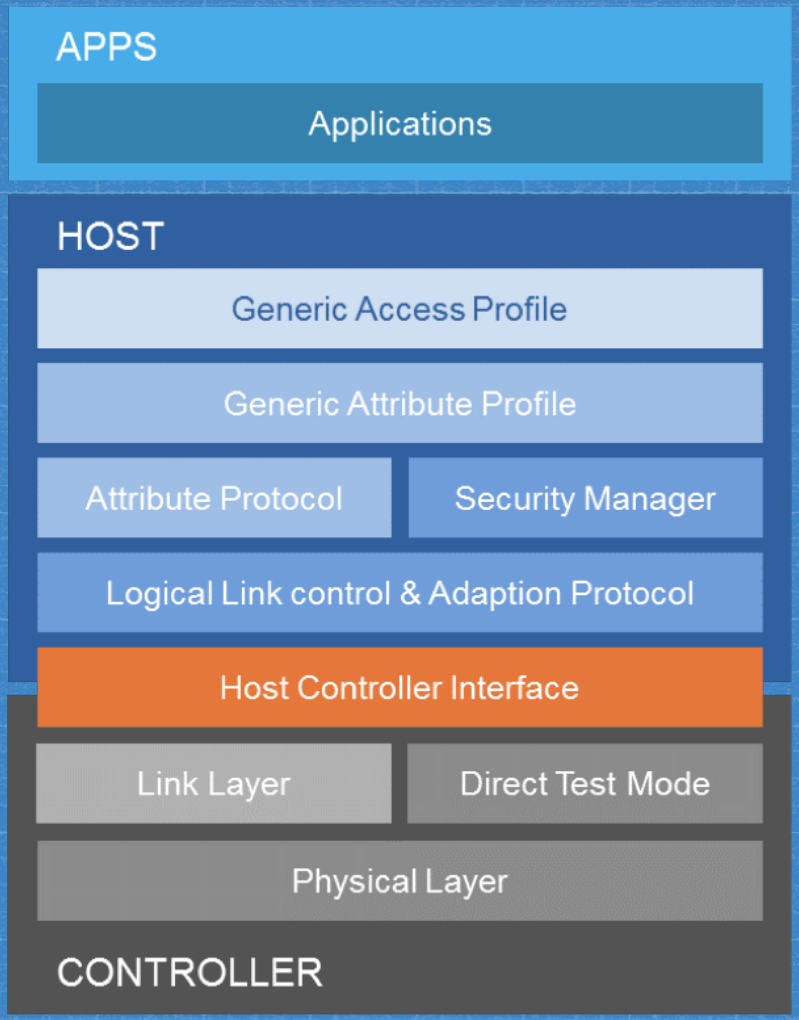
- In order to map the attack surface, we need more info
- How do BLE devices pair?
- How do BLE devices communicate?
- What does the architecture looks like?

HOW DO BLE DEVICES PAIR?



(Image source - When Encryption is Not Enough by Sumanth Naropanth, Chandra Prakash Gopalaiah & Kavya Racharla)

BLE STACK

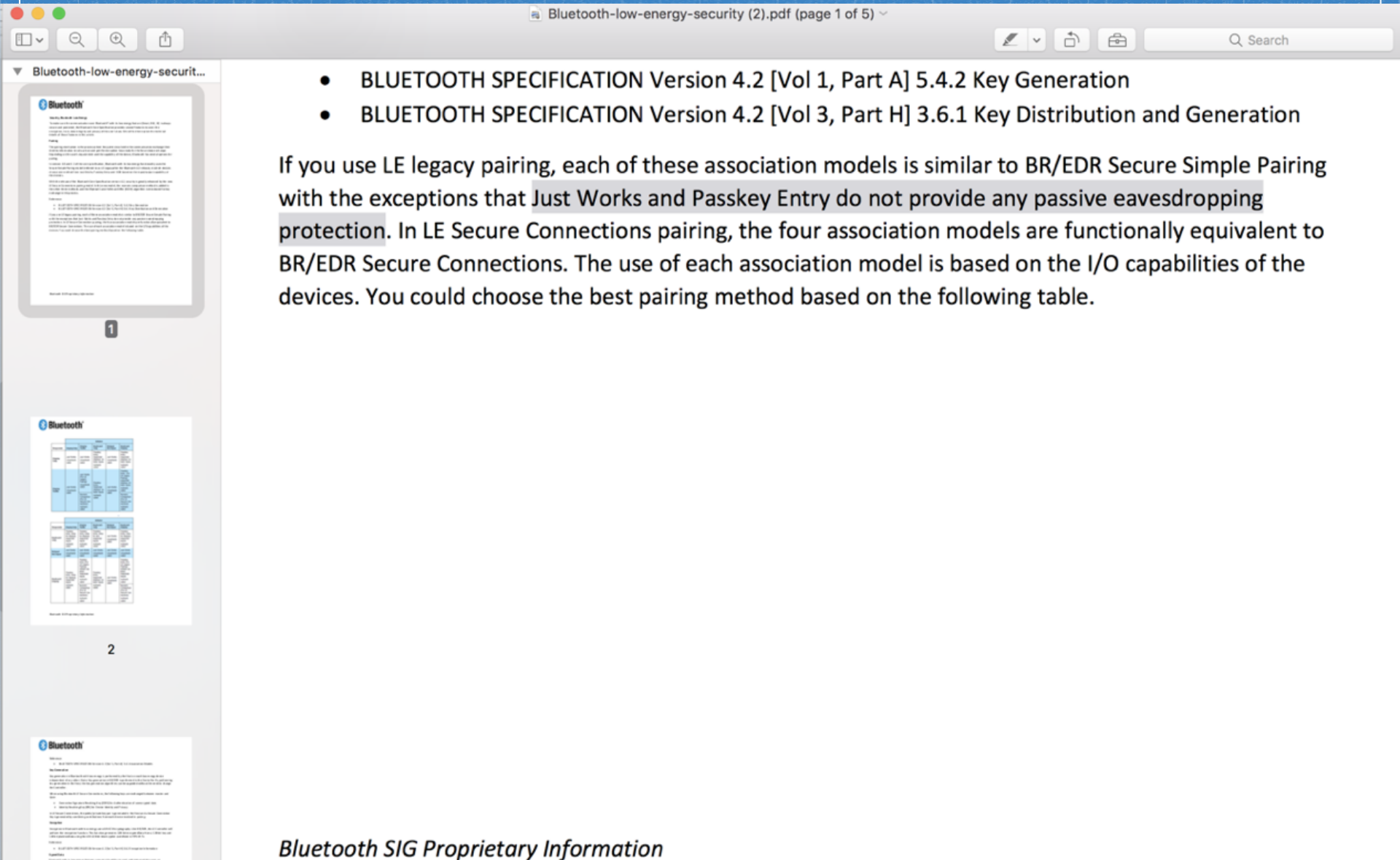


Source : https://www.bluetooth.com/specifications/bluetooth-core-specification

PAIRING MODES

- Just Works (000000)
- Numeric Comparison (Yes/No)
- Passkey (6-digit)
- Out-of-Band

As per the official docs.



- BLUETOOTH SPECIFICATION Version 4.2 [Vol 1, Part A] 5.4.2 Key Generation
- BLUETOOTH SPECIFICATION Version 4.2 [Vol 3, Part H] 3.6.1 Key Distribution and Generation

If you use LE legacy pairing, each of these association models is similar to BR/EDR Secure Simple Pairing with the exceptions that Just Works and Passkey Entry do not provide any passive eavesdropping protection. In LE Secure Connections pairing, the four association models are functionally equivalent to BR/EDR Secure Connections. The use of each association model is based on the I/O capabilities of the devices. You could choose the best pairing method based on the following table.

CRACKLE

- Tool by Mike Ryan to decrypt encrypted BLE communications
- You will need to capture the pairing packets
- If the devices have communicated in the past, on the next connection they will use the same known LTK

CRACKLE

- Let’s have a look at what can be done with Crackle
- Quickly look at the sample capture files
- Will first find out the TK and LTK, and then use the LTK to decrypt the packets

Installing CRACKLE

- git clone https://github.com/mikeryan/crackle.git
- cd crackle
- sudo apt-get install libpcap-dev
- sudo make && make install

Analyzing BLE packets

- From the 1st sample, we find the LTK
- Let’s decrypt the next one with the known LTK and see what has changed
- Open both the files in wireshark and save as text (export => plain text)

Analyzing BLE packets

- diff unc enc | colordiff
- Do you see differences in some packets
- Open up the unencrypted packets in wireshark and go to those packet numbers

Limitations

- Makes it a bit difficult to capture packets all the time
- Ubertooth also does not guarantee 100% of the packets to be captured
- Have to give it a couple of tries in order to make it work and get the TK and LTK

Limitations

- We get it working some times not always
- Not a lot of devices use Secure Connections
- Capturing packets is the biggest pain
- But yeah, works!

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LAB FOR BLE EXPLOITATION

What are the tools and h/w
you need to get started?

SETTING UP YOUR BLE LAB - S/W

- Wireshark
- Blue Hydra
- Ubertooth-utils
- hcitool
- Gatttool
- BTLEJuice
- Gattacker
- Usual utilities - hexdump, bless, strings etc.

SETTING UP YOUR BLE LAB - H/W

- **BLE DONGLE**
  - For sending BLE packets
  - Quick and handy to interact with BLE devices
- **Ubertooth One**
  - Works well for sniffing
  - Both for active and passive analysis
- **BLE SNIFFER (ADA)**
  - Inexpensive
  - Works (kinda) well
  - Integration with Wireshark
  - Cons - Windows
- **RPi 3**
  - Comes with a BLE interface
  - Provides portability for attacks
  - Automation?

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GETTING STARTED

Recon.

First step - RECONNAISSANCE

- Understand the device that you're going to attack
- Find out as much information as possible about the device
- BD_ADDR, RSSI, Device name etc.
- How are the devices communicating?

HCITOOL

```
HCITOOL(1)                    Linux System Administration                    HCITOOL(1)

NAME
       hcitool - configure Bluetooth connections

SYNOPSIS
       hcitool [-h]
       hcitool [-i <hciX>] [command [command parameters]]

DESCRIPTION
       hcitool  is  used to configure Bluetooth connections and send some special command to Bluetooth devices. If no command
       is given, or if the option -h is used, hcitool prints some usage information and exits.

OPTIONS
       -h     Gives a list of possible commands

       -i <hciX>
              The command is applied to device hciX , which must be the name of an installed Bluetooth device. If not  speci-
              fied, the command will be sent to the first available Bluetooth device.

COMMANDS
       dev    Display local devices

       inq    Inquire  remote  devices.  For  each  discovered  device,  Bluetooth device address, clock offset and class are
              printed.

       scan   Inquire remote devices. For each discovered device, device name are printed.

       name <bdaddr>
              Print device name of remote device with Bluetooth address bdaddr.

       info <bdaddr>
Manual page hcitool(1) line 1 (press h for help or q to quit)
```

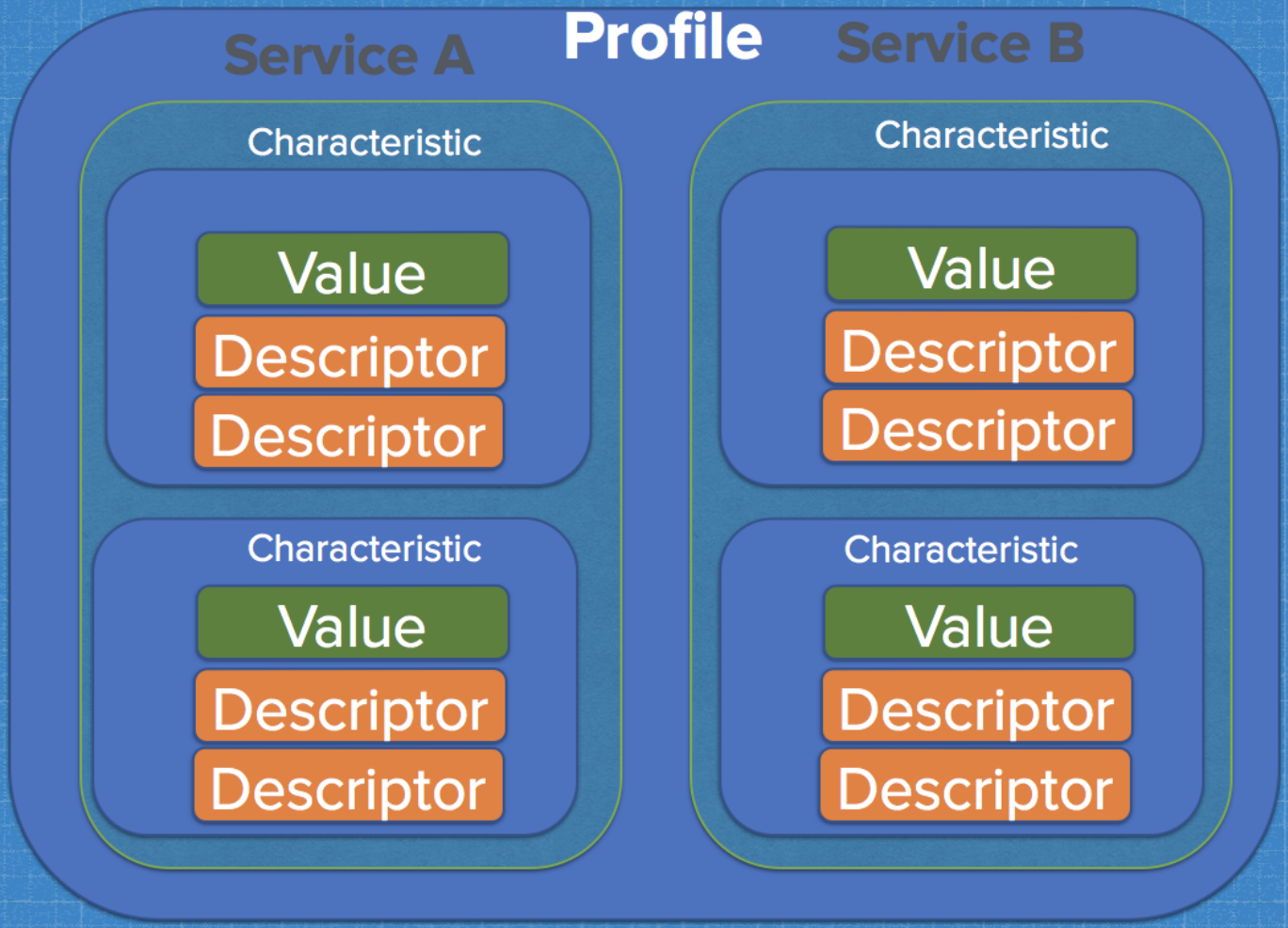
Understanding GATT and GAP

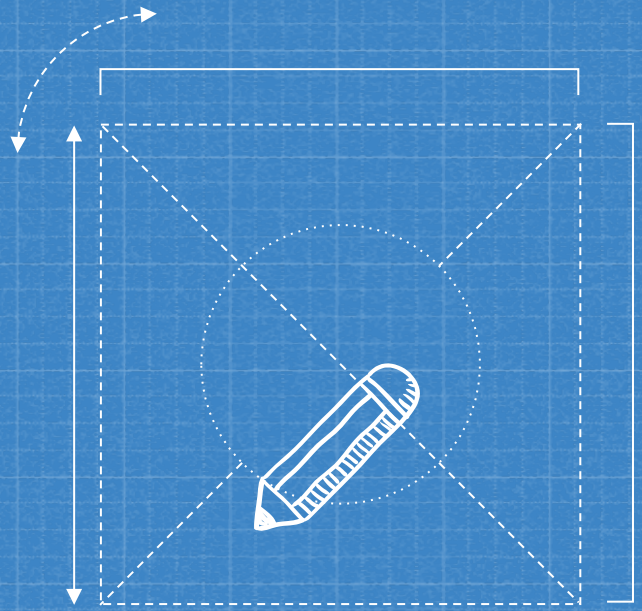
- **Generic Attribute Profile (GAP) -** responsible for discovery and basic setup
- **Attribute Protocol (ATT) –**
  - defines the client/server protocol for data exchange
  - Grouped together into meaningful services using the GATT
- Responsible for the exchange of all user data and profile information in a BLE connection
- GATT-based profiles as per the Bluetooth SIG ensuring device interoperability

Services and Characteristics

- Services can contain multiple characteristics
- Characteristics, services and descriptions are combined called Attributes
- Identified by associated UUID Depending on the properties, other devices could
  - Read
  - Write
  - Subscribe to notifications
- Services can be accessible with or without authentication

PROFILES


Profile
Service A
Characteristic
Value
Descriptor
Descriptor
Characteristic
Value
Descriptor
Descriptor
Service B
Characteristic
Value
Descriptor
Descriptor
Characteristic
Value
Descriptor
Descriptor



HANDS-ON

Use the [DEVICE 1] given to you and **connect to it using Gatttool**

Explore the **various services and characteristics** on that device

What we just did?

- hcitool lescan (or bluehydra scan)
- Identified the address
- gatttool -I -b [addr]
- **primary** (services) and then **characteristics**
- **char-read-hnd hnd-value**
- Look it up on the Bluetooth SIG website
- Does something stands out - custom value? Where does the name gets stored?

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EXPLOITING BLE

Now is the time when we start attacking devices.

TYPES OF ATTACKS IN BLE

Sniffing
Sniffing a given device to look at it’s entire data exchange that is happening - does it uses clear text data transmission? What kind of info is revealed?

Modifying attributes
Are you able to connect to the device? If yes, what if you can modify the values of various handles and make the device behaves otherwise.

MITM and Replay
Can you replay a given communication packet that you’ve captured? What are the consequences of the replay attack? Opening lock? Authentication?

Jamming
Can we jam the signal? If yes, what are the consequences of the signal being jammed? Think from a real-world attackers perspective.

Getting started with [Device 1]

- Connect to the Beacon using Gatttool
- Read all the various characteristics and handlers
- See which ones stand out (not defined in the Bluetooth SIG)
- Modify the values of that handler
- Poke until it hurts!
- What do you see/hear?

Getting started with [Device 1]

```
[FF:FF:E0:00:36:EB][LE]> characteristics
handle: 0x0002, char properties: 0x12, char value handle: 0x0003, uuid: 00002a00-0000-1000-8000-00805f9b34fb
handle: 0x0004, char properties: 0x02, char value handle: 0x0005, uuid: 00002a01-0000-1000-8000-00805f9b34fb
handle: 0x0007, char properties: 0x12, char value handle: 0x0008, uuid: 00002a19-0000-1000-8000-00805f9b34fb
handle: 0x000a, char properties: 0x1c, char value handle: 0x000b, uuid: 00002a06-0000-1000-8000-00805f9b34fb
handle: 0x000d, char properties: 0x12, char value handle: 0x000e, uuid: 0000ffe1-0000-1000-8000-00805f9b34fb
Notification handle = 0x000e value: 01
```

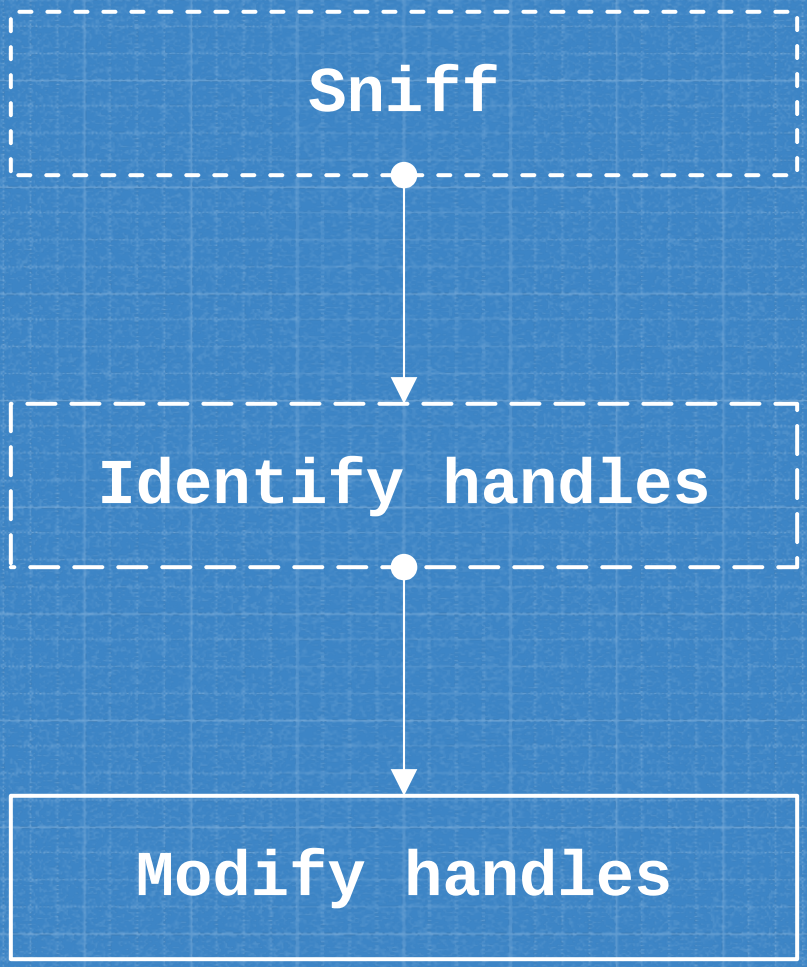
Getting started with [Device 1]

- `0x2a00` corresponds to device name
- `0x2a01` corresponds to Appearance
- `0x2a06` corresponds to **Alert level**
- `0x2a19` corresponds to Battery level

How do you know what to change?

- Yes we told you?
- But in real-life?
- Sniffing is the answer?
- We will all now sniff packets - let’s hope the hands-on exercise works - if not sample packet capture!

BLE hacking process



Ubertooth One

- Developed by Michael Ossmann
- CC2400 + NXP LPC1756 + USB 2.0
- Identify clear text data transmission
- Identify which handlers and being written and read
- Manually modify those handlers

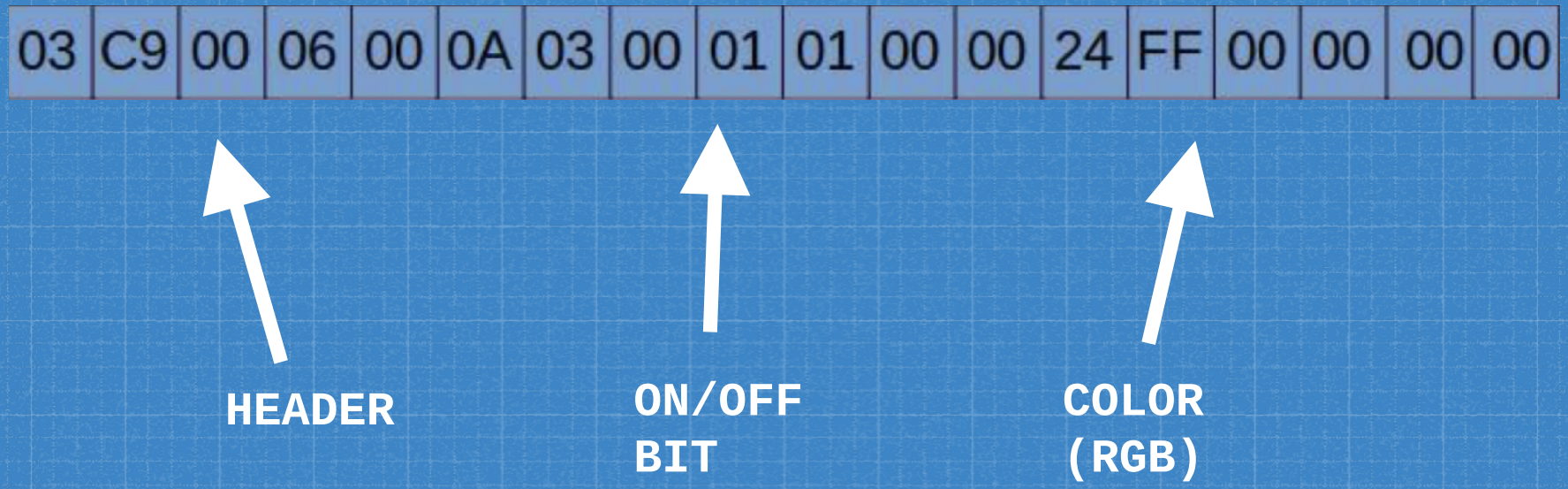
Ubertooth One

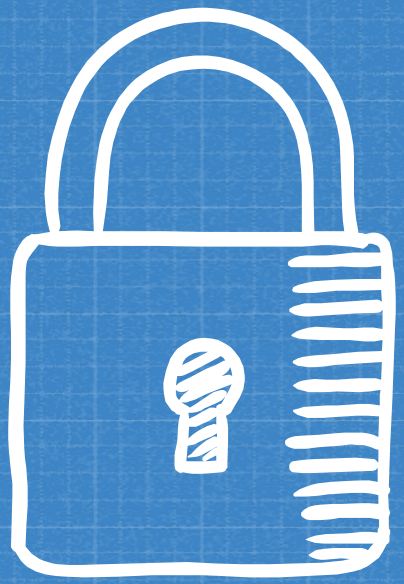
- Use **-f** for the follow mode
- **sudo ubertooth-btle -f -t [address] -c file.pcap**
- Analyze it in Wireshark
- use filter - btl2cap.cid==0x04
- Do you see any useful data?

Real-time sniffing

- Can also create a pipe and pass the data from ubertooth sniff to pipe
- Use the pipe as capture interface in Wireshark
- **sudo mkfifo /tmp/pipe**
- **sudo ubertooth-btle -f -t [address] -c /tmp/pipe**
- In wireshark - add this as a new interface and then sniff over this

Exploiting a LightBulb





HACKING A BLE SMART LOCK

Hacking a SmartLock

- Find the Bluetooth address using hcitool for the SmartLock
- Starts advertising once you hit the button
- Install [app-name] on your mobile phone
- Set up [device] to sniff packets for your target (Addr on back of your device)
- Is the **password in clear text**? How is it **unlocking the device**?
- Can you transmit those same packets by yourself (hcitool) or change the handlers (gatttool)?

Let’s automate?

- Introduction to PyGatt
- Connect to the adapter
- What action do you want to perform?
- Automate the process (send both the requests that is required to exploit the device)
- python exploit-lock.py

Thanks!

ANY QUESTIONS?

You can find me at:
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CREDITS

Special thanks to all the people who made and released these awesome tools:

- Ubertooth One - Michael Ossmann
- Blue Hydra - Pwnie Express
- Gattacker - Slawomir Jasek
- Manufacturers - for making vulnerable devices
- Defcon - for selecting this workshop
- Attify team members - for putting all the effort behind this workshop
- You - for attending the workshop and registering for it like a ninja

- Enjoy the rest of the event. Find us around. Tweet - #defconiot