Hacking Bluetooth enabled mobile phones and beyond – **Full Disclosure**

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21C3: The Usual Suspects

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Who we are

- Adam Laurie
  - CSO of The Bunker Secure Hosting Ltd.
  - Co-Maintainer of Apache-SSL
  - DEFCON Staff/Organiser
- Marcel Holtmann
  - Maintainer and core developer of the Linux Bluetooth Stack BlueZ
- Martin Herfurt
  - Security Researcher
  - Founder of trifinite.org

Outline (1)

- Bluetooth Introduction
- History
- Technology Overview
- The BlueSnarf Attack
- The HeloMoto Attack
- The BlueBug Attack
- Bluetooone
- Long-Distance Attacking

Outline (2)

- Blooover
- Blueprinting
- DOS Attacks
- Sniffing Bluetooth with hcidump
- Conclusions – Lessons tought
- Feedback / Discussion

Bluetooth Introduction (1)

- Wire replacement technology
- Low power
- Short range 10m - 100m
- 2.4 GHz
- 1 Mb/s data rate

Bluetooth Introduction (2)

- Bluetooth SIG
  - Trade Association
  - Founded 1998
  - Owns & Licenses IP
  - Individual membership free
  - Promoter members: Agere, Ericsson, IBM, Intel, Microsoft, Motorola, Nokia and Toshiba
  - Consumer http://www.bluetooth.com
  - Technical http://www.bluetooth.org

History (1)

- Bluejacking
  - Early adopters abuse 'Name' field to send message
  - Now more commonly send 'Business Card' with message via OBEX
  - 'Toothing' - Casual sexual liasons

History (2)

- Bluesnarfing
  - First publicised by Marcel Holtmann, October 2003
    - Wireless Technologies Congress, Sindelfingen, Germany
  - Adam Laurie, A L Digital, November 2003
    - Bugtraq, Full Disclosure
    - Houses of Parliament
    - London Underground
  - 'Snarf' - networking slang for 'unauthorised copy'

History (3)

- Bluesnarfing
  - Data Theft
  - Calendar
    - Appointments
    - Images
  - Phone Book
    - Names, Addresses, Numbers
    - PINs and other codes
    - Images

History (4)

- Bluebugging
  - First publicised by Martin Herfurt, March 2004
    - CeBIT Hanover
  - Create unauthorised connection to serial profile
  - Full access to AT command set
  - Read/Write access to SMS store
  - Read/Write access to Phone Book

History (5)

- Full Disclosure after 13 months
  - More time for manufacturers to fix
    - Embedded devices
    - New process for telecom industry
  - Nokia claims to have fixed all vulnerable devices
    - Firmware updates available
    - 6310i tested OK
  - Motorola committed to fix known vulnerabilities
  - Sony Ericsson publicly stated “all problems fixed”

Bluetooth Technology

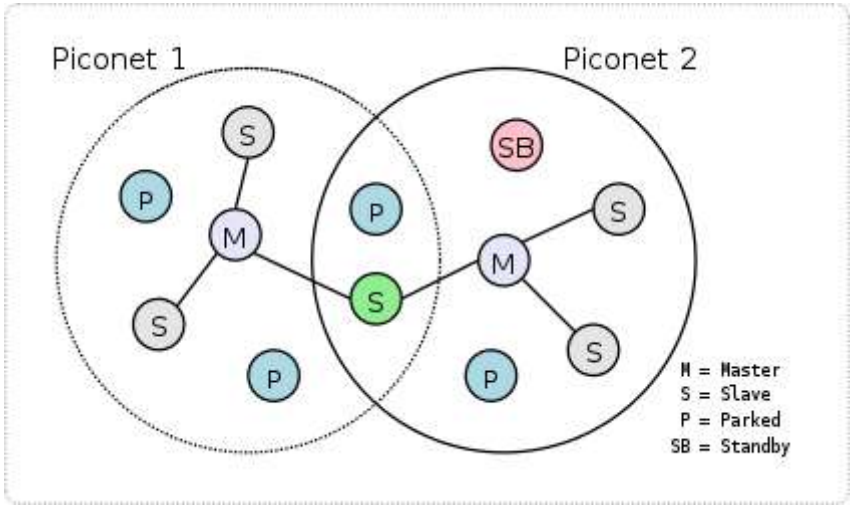
- Data and voice transmission
  - ACL data connections
  - SCO and eSCO voice channels
- Symmetric and asymmetric connections
- Frequency hopping
  - ISM band at 2.4 GHz
  - 79 channels
  - 1600 hops per second
  - Multi-Slot packets

Bluetooth Piconet

- Bluetooth devices create a piconet
  - One master per piconet
  - Up to seven active slaves
  - Over 200 passive members are possible
  - Master sets the hopping sequence
  - Transfer rates of 721 Kbit/sec
- Bluetooth 1.2 and EDR (aka 2.0)
  - Adaptive Frequency Hopping
  - Transfer rates up to 2.1 Mbit/sec

Bluetooth Scatternet

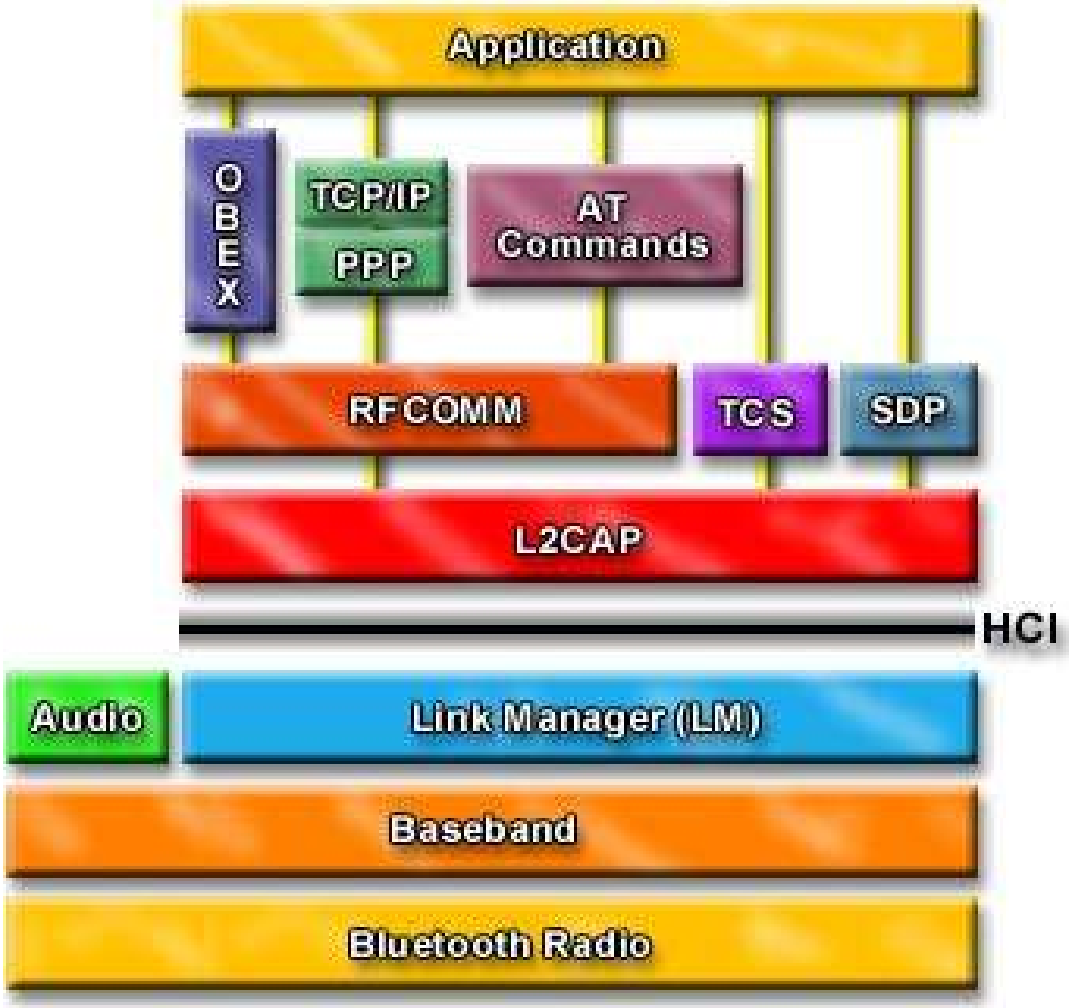
- Connected piconets create a scatternet
  - Master in one and slave in another piconet
  - Slave in two different piconets
  - Only master in one piconet
  - Scatternet support is optional



Bluetooth Architecture

- Hardware layer
  - Radio, Baseband and Link Manager
  - Access through Host Controller Interface
    - Hardware abstraction
    - Standards for USB and UART
- Host protocol stack
  - L2CAP, RFCOMM, BNEP, AVDTP etc.
- Profile implementations
  - Serial Port, Dialup, PAN, HID etc.

Bluetooth Stack



Application specific security mechanisms

Bluetooth host security mechanisms

Security mechanisms on the Bluetooth chip

Bluetooth Security

- Link manager security
  - All security routines are inside the Bluetooth chip
  - Nothing is transmitted in “plain text”
- Host stack security
  - Interface for link manager security routines
  - Part of the HCI specification
  - Easy interface
  - No further encryption of pin codes or keys

Security Modes

- Security mode 1
  - No active security enforcement
- Security mode 2
  - Service level security
  - On device level no difference to mode 1
- Security mode 3
  - Device level security
  - Enforce security for every low-level connection

Linux and Bluetooth

```
# hciconfig -a
hci0:   Type: USB
        BD Address: 00:02:5B:A1:88:52 ACL MTU: 384:8  SCO MTU: 64:8
        UP RUNNING PSCAN ISCAN
        RX bytes:9765 acl:321 sco:0 events:425 errors:0
        TX bytes:8518 acl:222 sco:0 commands:75 errors:0
        Features: 0xff 0xff 0x8b 0xfe 0x9b 0xf9 0x00 0x80
        Packet type: DM1 DM3 DM5 DH1 DH3 DH5 HV1 HV2 HV3
        Link policy: RSWITCH HOLD SNIFF PARK
        Link mode: SLAVE ACCEPT
        Name: 'Casira BC3-MM'
        Class: 0x1e0100
        Service Classes: Networking, Rendering, Capturing, Object Transfer
        Device Class: Computer, Uncategorized
        HCI Ver: 1.2 (0x2) HCI Rev: 0x529 LMP Ver: 1.2 (0x2) LMP Subver: 0x529
        Manufacturer: Cambridge Silicon Radio (10)

# hcitool scan
Scanning ...
        00:04:0E:21:06:FD       AVM BlueFRITZ! AP-DSL
        00:01:EC:3A:45:86       HBH-10
        00:04:76:63:72:4D       Aficio AP600N
        00:A0:57:AD:22:0F       ELSA Vianect Blue ISDN
        00:E0:03:04:6D:36       Nokia 6210
        00:80:37:06:78:92       Ericsson T39m
        00:06:C6:C4:08:27       Anycom LAN Access Point
```

Sniffing with hcidump

- Recording of HCI packets
  - Commands, events, ACL and SCO data packets
- Only for local connections
- Decoding of higher layer protocols
  - HCI and L2CAP
  - SDP, RFCOMM, BNEP, CMTP, HIDP, HCRP and AVDTP
  - OBEX and CAPI
- No sniffing of baseband or radio traffic

Security Commands

- HCI_Create_New_Unit_Key
- HCI_{Read|Write}_Pin_Type
- HCI_{Read|Write|Delete}_Stored_Link_Key
- HCI_{Read|Write}_Authentication_Enable
- HCI_{Read|Write}_Encryption_Mode

- HCI_Authentication_Requested
- HCI_Set_Connection_Encryption
- HCI_Change_Local_Link_Key
- HCI_Master_Link_Key

Pairing Functions

- Events
  - HCI_Link_Key_Notification
  - HCI_Link_Key_Request
  - HCI_Pin_Code_Request
- Commands
  - HCI_Link_Key_Request_Reply
  - HCI_Link_Key_Request_Negative_Reply
  - HCI_Pin_Code_Request_Reply
  - HCI_Pin_Code_Request_Negative_Reply

How Pairing Works

- First connection
  (1) HCI_Pin_Code_Request
  (2) HCI_Pin_Code_Request_Reply
  (3) HCI_Link_Key_Notification
- Further connections
  (1) HCI_Link_Key_Request
  (2) HCI_Link_Key_Request_Reply
  (3) HCI_Link_Key_Notification (optional)

BlueSnarf

- Trivial OBEX PUSH channel attack
  - obexapp (FreeBSD)
  - PULL known objects instead of PUSH
  - No authentication
- Infrared Data Association
  - IrMC (Specifications for Ir Mobile Communications)
    - e.g. telecom/pb.vcf
- Ericsson R520m, T39m, T68
- Sony Ericsson T68i, T610, Z1010
- Nokia 6310, 6310i, 8910, 8910i

HeloMoto

- Requires entry in 'Device History'
- OBEX PUSH to create entry
- Connect RFCOMM to Handsfree or Headset
  - No Authentication required
  - Full AT command set access
- Motorola V80, V5xx, V6xx and E398

BlueBug History (1)

- First presentation in February 2004
  - FH Salzburg 'Forum IKT 2004'
  - Spicing up a presentation about Wardriving
- Got inspired from Adam's BlueSnarf which has been written about on slashdot
- Tried to figure out how Adam did it (no purpose-built tools available)
- Found BlueBug
  - Based on AT Commands -> not OBEX

BlueBug History (2)

- Fieldtrial at CeBIT 2004
  - Booth close to the restrooms -> many people there
  - Even Policemen ;)
- Got on slashdot at the end of March 2004
- Teamed up with Adam in April 2004
- Various media citations
- Presentation at Blackhat and DEFCON in August 2004
- Full Disclosure at 21C3 in December 2004 (now!)

BlueBug Facts (1)

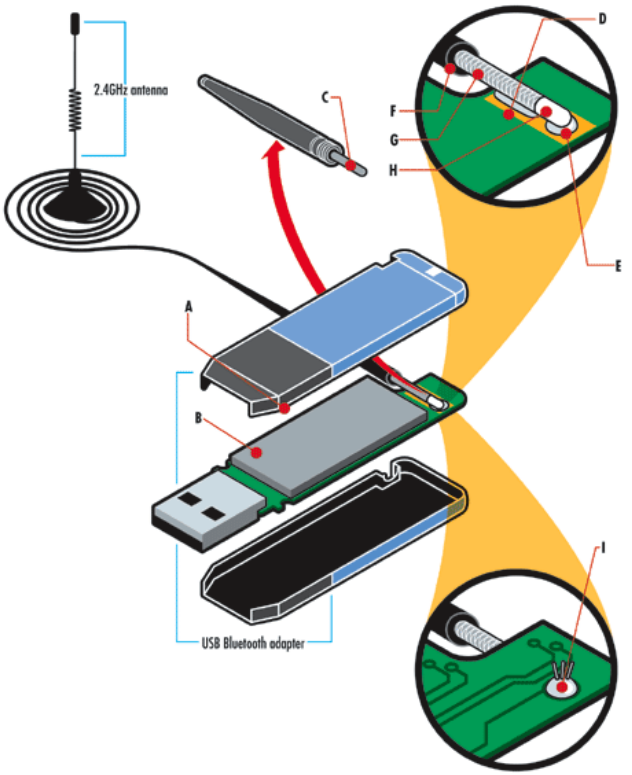
- As mentioned earlier...
  - BlueBug is based on AT Commands (ASCII Terminal)
  - Very common for the configuration and control of telecommunications devices
  - High level of control...
    - Call control (turning phone into a bug)
    - Sending/Reading/Deleting SMS
    - Reading/Writing Phonebook Entries
    - Setting Forwards
    - -> causing costs on the vulnerable phones!

BlueBug Facts (2)

- How come!?
  - Various Manufacturers poorly implemented the Bluetooth security mechanisms
  - Unpublished services on RFCOMM channels
    - Not announced via SDP
- Connecting to unpublished HS service without pairing!
  - Nokia has quite a lot of models (6310, 6310i, 8910, 8910i,...)
  - Sony Ericsson T86i, T610, ...
  - Motorola has similar problems (see HeloMoto)

Bluetooone

- Enhancing the range of a Bluetooth dongle by connecting a directional antenna -> as done in the Long Distance Attack
- Original idea from Mike Outmesguine (Author of Book: “Wi-Fi Toys”)
- Step by Step instruction on trifinite.org



Long-Distance Attacking (BlueSniper)

- Beginning of August 2004 (right after DEFCON 12)
- Experiment in Santa Monica California
- Modified Class-1 Dongle Snarfing/Bugging Class-2 device (Nokia 6310i) from a distance of 1,78 km (1.01 miles)

Blooover -What is it?

- Blooover - *Bluetooth* Wireless Technology Hoover
- Proof-of-Concept Application
- Educational Purposes only
- Phone Auditing Tool
- Running on Java
  - J2ME MIDP 2.0
  - Implemented JSR-82 (Bluetooth API)
  - Nokia 6600, Nokia 7610, Nokia 6670, ... Series 60
    Siemens S65
    SonyEricsson P900 ...

Blooover- What does it do?

- Blooover is performing the BlueBug attack
  - Reading phonebooks
  - Writing phonebook entries
  - Reading/decoding SMS stored on the device (buggy..)
  - Setting Call forward (predef. Number) +49 1337 7001
  - Initiating phone call (predef. Number) 0800 2848283
    - Not working well on Nokia phones :(but on some T610
- Please use this application responsibly!
  - For research purposes only!
  - With permission of owner

Blueprinting – What is it?

- Blueprinting is fingerprinting *Bluetooth* Wireless Technology interfaces of devices
- This work has been started by Collin R. Mulliner and Martin Herfurt
- Relevant to all kinds of applications
  - Security auditing
  - Device Statistics
  - Automated Application Distribution
- Released paper and tool at 21C3 in December 2004 in Berlin (again, now!)

Blueprinting - How

- Hashing Information from Profile Entries
  - RecordHandle
  - RFCOMM channel number
  - Adding it all up ($RecHandle_1$*$Channel_1$)+ ($RecHandle_2$*$Channel_2$)+...+($RecHandle_n$*$Channel_n$)
- Bluetooth Device Address
  - First three bytes refer to manufacturer (IEEE OUI)
- Example of Blueprint

00:60:57@2621543

BlueSmack

- Using L2CAP echo feature
  - Signal channel request/response
  - L2CAP signal MTU is unknown
  - No open L2CAP channel needed
- Buffer overflow
- Denial of service attack

BlueSmack


```
< HCI Command: Create Connection (0x01|0x0005) plen 13
  0000: b6 1e 33 6d 0e 00 18 cc  02 00 00 00 01           ..2m.........
> HCI Event: Command Status (0x0f) plen 4
  0000: 00 01 05 04                                       ....
> HCI Event: Connect Complete (0x03) plen 11
  0000: 00 29 00 b6 1d 32 6d 0e  00 01 00                 .)...2m....

< ACL data: handle 0x0029 flags 0x02 dlen 28
    L2CAP(s): Echo req: dlen 20
    0000: 45 46 47 48 49 4a 4b 4c  4d 4e 4f 50 51 52 53 54  EFGHIJKLMNOPQRST
    0010: 55 56 57 58                                       UVWX
> HCI Event: Number of Completed Packets (0x13) plen 5
  0000: 01 29 00 01 00                                    .)...
> ACL data: handle 0x0029 flags 0x02 dlen 28
    L2CAP(s): Echo rsp: dlen 20
    0000: 45 46 47 48 49 4a 4b 4c  4d 4e 4f 50 51 52 53 54  EFGHIJKLMNOPQRST
    0010: 55 56 57 58                                       UVWX

< HCI Command: Disconnect (0x01|0x0006) plen 3
  0000: 29 00 13                                          )..
> HCI Event: Command Status (0x0f) plen 4
  0000: 00 01 06 04                                       ....
> HCI Event: Disconn Complete (0x05) plen 4
  0000: 00 29 00 16                                       .)..
```

Conclusions

- Bluetooth is a secure standard (per se)
  - Problems at application level
- Cooperation with Bluetooth SIG
  - Pre-release testing at UPF (UnPlugFest)
    - Specifics under NDA
  - Better communication channels for external testers
    - Security Expert Group mailing list
    - bluetooth.org more open areas
  - Mandatory security at application level

trifinite.org

- http://trifinite.org/
- Loose association of BT security experts
- Features
  - **trifinite.**blog
  - **trifinite.**stuff
  - **trifinite.**album
  - **trifinite.**group

trifinite.group

- Adam Laurie (the Bunker Secure Hosting)
- Marcel Holtmann (BlueZ)
- Collin Mulliner (mulliner.org)
- Tim Hurman (Pentest)
- Mark Rowe (Pentest)
- Martin Herfurt (trifinite.org)
- Spot (Sony)

Questions / Feedback / Answers

- Contact us via 21c3@trifinite.org
  (group alias for Adam, Marcel and Martin)