Advanced Attacks Against PocketPC Phones

Collin Mulliner

collin[AT]trifinite.org

the trifinite group

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Advanced Attacks Against PocketPC Phones

0wnd by an MMS

About Myself

- Collin Mulliner

  - Handheld computing freak

  - Bluetooth hacker

  - Security researcher (mostly PDA/smart phone stuff)

  - Contact:

    - email: collin[AT]trifinite.org

    - web: http://www.mulliner.org/blog/

What this Talk is about

- Attacking and exploiting PocketPC smart phones

- Vulnerability analysis of smart phones

  - Apply fuzzing to mobile/smart phones

- The Multimedia Messaging Service (MMS)

  - The User Agent/client side of MMS

- **Analyzing and attacking the PocketPC MMS User Agent**

Agenda

- Mobile Phone Attacks State of the Art

- PocketPC Overview

- The Multimedia Messaging Service

- Mobile Phone Vulnerability Testing

- 0wnd by an MMS

- Conclusions

Mobile Phone Attacks
State of the Art

- Bluetooth-based attacks

  - Initiate calls and send SMS (text messages)

  - Steal phonebook and/or other files

  - Denial-of-service

- Third-party application vulnerabilities

  - Code injection/execution

  - Denial-of-service

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Mobile Phone Attacks
SMS/MMS

- Symbian MMS worms

  - Do not utilize vulnerabilities in applications or the OS

  - Require quite some amount of user interaction in order to infect a target

  - Examples: CommWarrior and Mabir

- SMS-based denial-of-service attacks

  - Nokia 6210: vCard format string vulnerability

  - Siemens 3568i: crash because of "unusual characters"

PocketPC Attacks

- Third-party applications vulnerabilities

  - For example: FTP servers

- Bluetooth stack remote code execution exploit

  - Non-public, because it will never be fixed (Tim Hurman)

- Bluetooth OBEX push attack (bypass authentication)

  - Full access to all files on the device

- ActiveSync denial-of-service

- Some "local" attacks

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PocketPC

- Is the WindowsCE version for PDAs and smart phones

  - WindowsCE: Windows for **C**onsumer **E**lectronics

- Supports many platforms (x86, SH, ARM)

  - Most PocketPC devices are ARM-based

- Current version of WinCE is 5.x, we are looking at **4.2x**

  - WinCE 4.2 and 5.0 share many similarities

  - Still many WinCE 4.2x devices out there

- Are there any Windows Mobile 6 devices yet?

PocketPC Phones

- i-mate PDA2k

  – PocketPC 2003 SE (WinCE 4.21)

  – GSM, WLAN, Bluetooth, IrDA

- HP iPAQ h6315

  – PocketPC 2003 (WinCE 4.2)

  – GSM, WLAN, Bluetooth, IrDA

- Many more...

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The WindowsCE 4.2x OS

- One single 4GB virtual address space

  - Divided into 32 so-called slots (each slot is 32MB/64MB)

  - All processes share the virtual address space

- Limited to 32 concurrent processes

  - Basically no thread limit

WindowsCE OS Security

- Single user OS

  - No real login, just an optional 'device lock'

- Any process can access everything

  - Once you are in ... you are in

- Full access to everything...

  - All files in file system

  - Bluetooth

  - Mobile phone interface (GSM/CDMA/UMTS/...)

WindowsCE Exploitation

- Buffer overflow/stack smashing

  - Overwrite return address, take control of program flow

- WindowsCE/ARM shellcode and exploit development

  - Covered quite well by now

    - 2004 Seth Fogie (at Defcon-12)

    - 2005 San (in Phrack #63)

    - 2005 Collin Mulliner (at WhatTheHack!)

    - 2005 Tim Hurman (pentest.co.uk)

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WindowsCE Exploit Issues

- No "command shell"

  - Need to hard code everything the exploit is supposed to do

- Return address depends on slot used by process

  - Slots are dynamically assigned

  - Need to "guess" slot part of return address

- WinCE 5.x is build with stack protection

  - ➜ Attack 3rd party applications

The Multimedia Messaging Service

- Messaging service for mobile phones
  - Commonly known as MMS and Picture Messaging

- Designed for multimedia content (pictures, audio, video,..)
  - But basically supports any kind of data

- Messages are sent in a store and forward manner
  - Service requires infrastructure to function
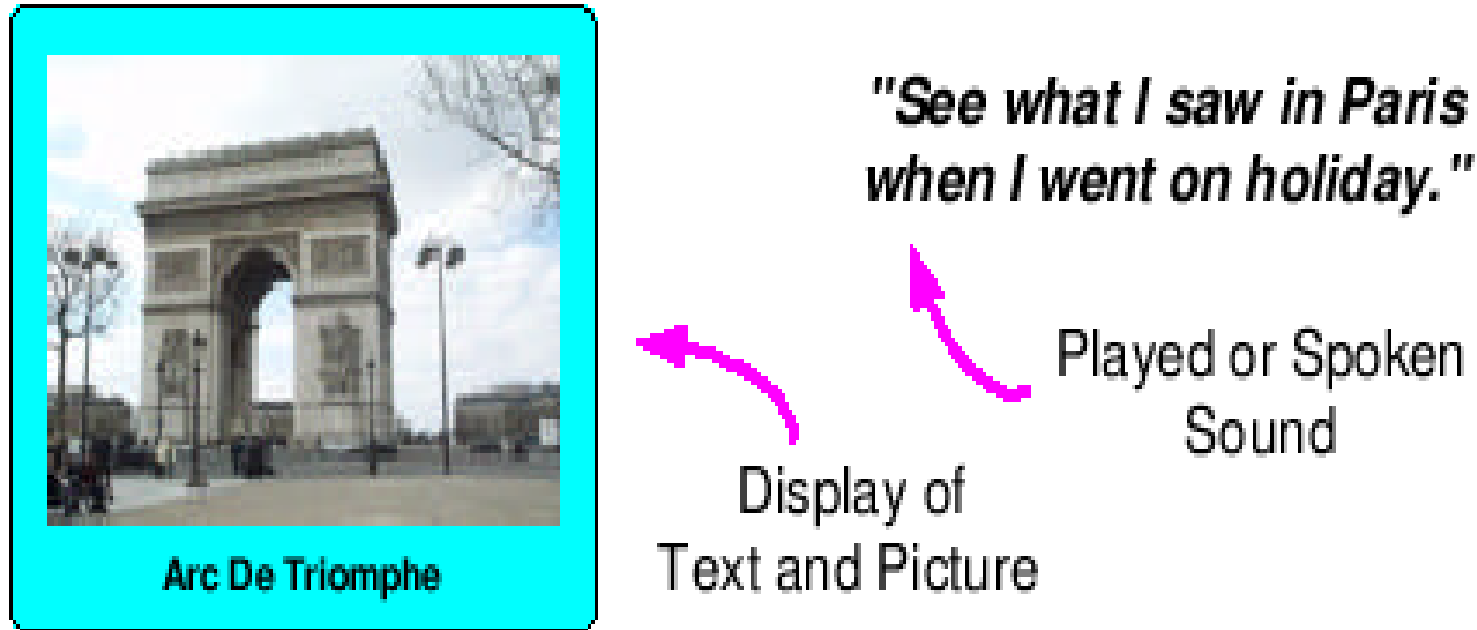
- Pay-per-use service
  - Per message fee

MMS

"See what I saw in Paris when I went on holiday."

Played or Spoken Sound

Display of Text and Picture

Arc De Triomphe

Figure 1 Example Message with Multimedia Content

From: WAP-205-MMSArchOverview

The MMS Architecture

- IP-based service

    - Utilizes HTTP and WAP (Wireless Application Protocol)

    - Transported by GPRS and friends

- Message delivery is carried out by four components

    - MMS Server

    - MMS Relay

    - WAP Gateway/PushProxy

    - SMSC (Short Message Service Center)

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MMS Message Delivery
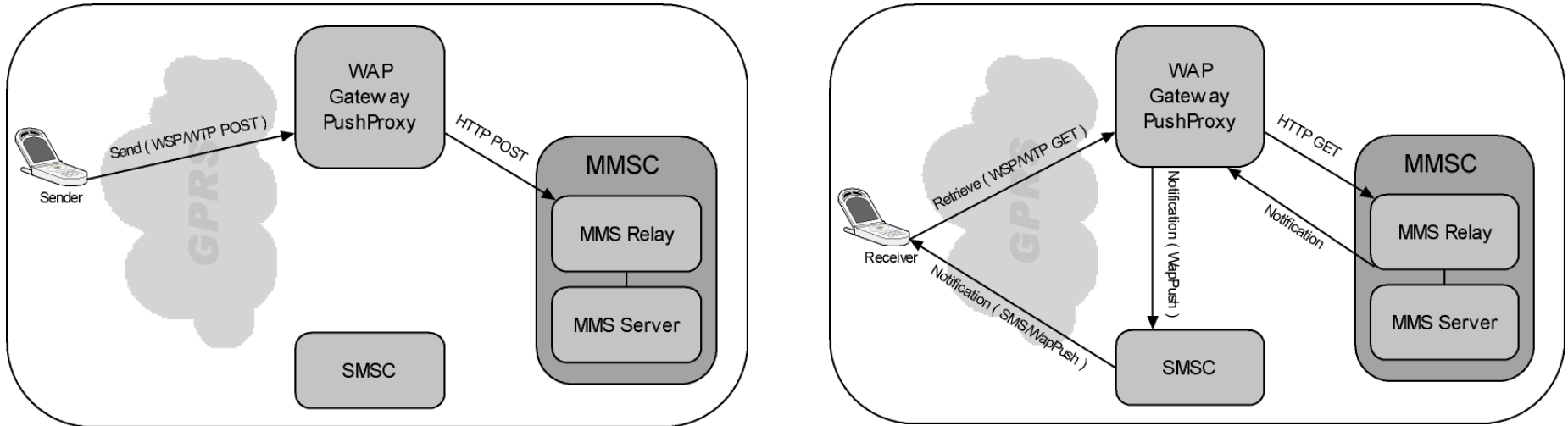
- Sender submits message to MMS Relay

    - Sender (WTP/WSP) → WAP Gateway (HTTP) → MMS Relay

- Recipient retrieves message after notification

    - MMS Relay → WAP PushProxy/SMSC (SMS) → Recipient

    - Recipient (WTP/WSP) → WAP Gateway (HTTP) → MMS Relay

MMS Messages

- ## Structured like Internet email messages

  - Messages are split into header and body

    - Header contains control information
    - Body contains message content (MIME multi-part)

- ## Messages are in binary form when transfered to and from mobile phone user agents

  - Reduce size for over-the-air transport

MMS Message Types

Transaction	Request Type	Result Type
Sending a message	`M-Send.req`	`M-Send.conf`
Receiving a message	`WTP/WSP/HTTP Get.req`	`M-Retrieve.conf`
New message notification	`M-Notification.ind`	`M-NotifyResp.ind`
Delivery Report	`M-Delivery.ind`	
Acknowledgment	`M-Acknowledge.ind`	

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The MMS User Agent

- Represents the sending and receiving end-point

- Handles multiple different network types and protocols

  - SMS-based WAPPush

  - IP-based WAP GET/POST

- Processes and displays multiple media types

  - SMIL and WML for the presentation part

    - SMIL (Synchronized Multimedia Integration Language)

  - GIF, JPEG, BMP, AMR, MV4, ... for the content part

- ➡ A lot of things to mess up

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The PocketPC MMS User Agent

- The **Inbox** application

  - Also handles SMS and email (POP3 and IMAP)

- ArcSoft MMS Composer

  - Version 1.5.5.6 (HP iPAQ h6315 WinCE4.2)

  - Version 2.0.0.13 (i-mate PDA2K WinCE 4.21)

- Application binary: tmail.exe

Analyzing the MMS User Agent

- Identify the inputs to the user agent

  - Possible attack vectors

- Determine message sanitization by the MMS infrastructure

  - Avoid testing sanitized parts of a message

- Implement a virtual MMS infrastructure

  - Testing is done using fuzzing

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MMS User Agent Inputs

- New message notification (*M-Notification.ind*)

  - Header fields

  - Delivered via WAPPush (SMS)

- Message header (*M-Retrieve.conf*)

  - Delivered via WAP/HTTP GET

- Message body (*M-Retrieve.conf*)

  - MIME multipart

  - Delivered via WAP/HTTP GET

Sanitization in the MMS Infrastructure

- MMS messages are sanitized by the MMS Relay

  - Sanitization is performed during message submission

  - Messages failing the checks are rejected

- Sanitization has to be avoided

  - Vulnerabilities may not be exploitable if the message part used to deliver the attack is sanitized

  - Need to determine sanitization rules of MMS Relay

Testing the Sanitization Rules

- Fuzzing-like testing procedure

  - Test each message part to determine if it is affected by the sanitization

- Findings:

  - Message header is heavily sanitized

    - Most header fields not usable for attacks

  - Message body is not sanitized

    - Body parts are suitable for attacks

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A Closer Look at MMS Delivery

- New Notification is sent to receiver as WAPPush via SMS

  - Binary SMS from port 9200 to port 2948 (SMS ports!)

- PushRouter forwards WAPPush to MMS User Agent

  - If content-type is: application/vnd.wap.mms-message

- MMS User Agent retrieves message via WAP/HTTP

  - The message URL is part of the notification message

- PocketPC also accepts WAPPush via UDP port 2948

  - Also on the wireless LAN interface!!!

MMS New Message Notification

- Encapsulated in a WAPPush message

```
pos     hex                                          ascii
0000    0006 2261 7070 6C69 6361 7469 6F6E 2F76     .."application/v
0010    6E64 2E77 6170 2E6D 6D73 2D6D 6573 7361     nd.wap.mms-messa
0020    6765 00AF 848C 8298 3233 3432 3235 3437     ge......23422547
0030    3839 3233 008D 9089 1080 0E83 2B31 3535     8923........+155
0040    3531 3233 3435 3637 0097 1083 2B31 3535     51234567....+155
0050    3534 3232 3334 3232 3335 0096 1E83 4772     5422342235....Gr
0060    6565 7469 6E67 7320 746F 2074 6865 2044     eetings to the D
0070    4546 434F 4E20 6372 6577 008E 0202 9A83     EFCON crew......
0080    6874 7470 3A2F 2F79 6F75 726D 6D73 7365     http://yourmmsse
0090    7276 6572 2E63 6F6D 2F6D 6D73 3F72 6566     rver.com/mms?ref
00A0    3D34 3232 3330 3831 3500                     =42230815.
```

wappush, transaction id, subject, message url

Notification Attack

- Flood phone with notifications via WLAN (UDP:2948)

  - Phone tries to dial-up GPRS to retrieve message

  - New message "sound" is very annoying

- Sending hundreds of messages DoSs the phone

  - Phone becomes slow (lots of memory is used)

- Messages fill up MMS inbox and filesystem

  - Messages have to be deleted one by one

    - It's not fun to delete +1000 messages

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Proof-of-Concept: NotiFlood

- PocketPC accepts notifications sent to **broadcast address**

  - We don't even need to scan for devices!

- Each notification needs to be unique

  - This means unique *Transaction ID* and *ContentLocation*

- NotiFlood Proof-of-Concept is available online at:

  - http://www.mulliner.org/pocketpc/feed/notiflood.tar.gz

You have 1000 New Messages
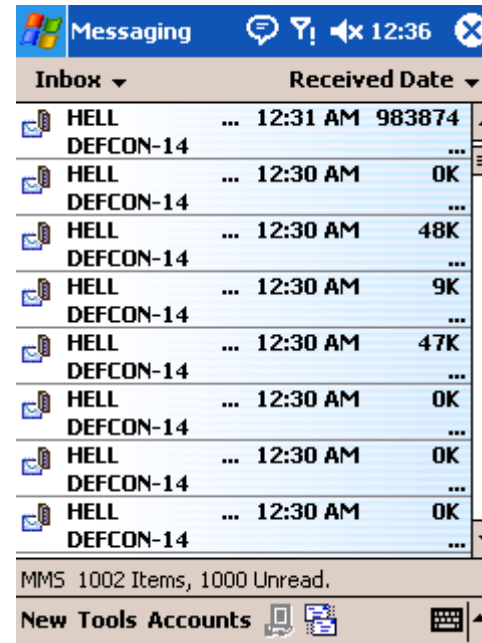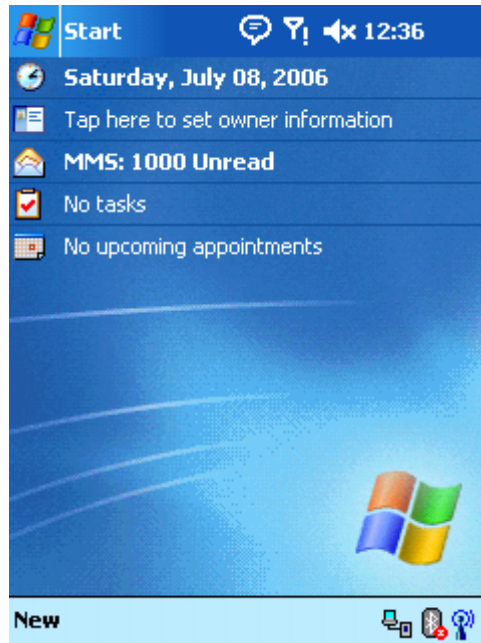
Fuzzing

- Feed target application half way valid input in order to find bugs and exploitable vulnerabilities

  - Fuzzing maybe is the best method for cases with only access to application binary

- Fuzzing requires sending a lot of messages

  - Sending thousands of messages is expensive

  - ➔ Use own MMS infrastructure for fuzzing

Virtual MMS System

- MMS infrastructure

  - MMS Relay/Server   (Apache Web server)

  - WAP Gateway   (Kannel WAP Gateway)

  - MMS Message Generator   (customized MMSLib)

- GSM infrastructure simulated using wireless LAN

  - New message notification sent via UDP (port 2948)

- Configure User Agent to use virtual infrastructure

  - WAP Gateway and MMS Relay and Server

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Fuzzing the User Agent

- Focused on triggering basic buffer overflows

  – Mainly modified string length or replaced variable size binary data with string

- The fuzzing process

  – Attach debugger to tmail.exe

  – Generate message and dump into directory accessible by web server

  – Send notification to phone

    - Phone retrives message from web server

  – Watch out for exceptions caught by the debugger

MMS Message

- Message type is: *M-Retrieve.conf*

```
pos    hex                                              ascii
000    8C84 9838 3135 3437 3131 3432 3335 008D         ...81547114235..
010    9089 1080 0E83 2B31 3830 3532 3539 3233         ......+180525923
020    3432 0097 0E83 2B31 3830 3532 3539 3432         42....+180525942
030    3233 0096 0783 4865 6C6C 6F00 8A80 841B         23....Hello.....
040    B38A 3C53 4D49 4C3E 0089 6170 706C 6963         ..<SMIL>..applic
050    6174 696F 6E2F 736D 696C 0002 1017 83C0         ation/smil......
060    223C 7465 7874 3E00 8E74 7874 3100 4869         "<text>..txt1.Hi
070    204A 6F68 6E2C 2068 6F77 2061 7265 2079          John, how are y
080    6F75 3F20 0A21 8267 6170 706C 6963 6174         ou? ....applicat
090    696F 6E2F 736D 696C 00C0 223C 534D 494C         ion/smil.."<SMIL
0A0    3E00 8E73 6D69 6C31 003C 736D 696C 3E0A         >..smil1.<smil>.
0B0    3C68 6561 643E 0A3C 6C61 796F 7574 3E3C         <head>.<layout><
0C0    726F 6F74 2D6C 6179 6F75 742F 3E3C 7265         root-layout/><re
...
200    3C2F 626F 6479 3E0A 3C2F 736D 696C 3E0A         </body>.</smil>.
```

subject, multi-part entry header, text file, SMIL file

Advantages of Simulated Testing

- Full control over all parts of the delivery process
  - Deterministic testing
  - More possibilities for testing
    - For example, message parts that would otherwise be sanitized
- Increased testing speed
  - Testing is much faster (about 10 times)
- Avoidance of usage fees (~0.49€ per message)
  - Extensive testing not possible otherwise

Bugs Found 1/3

- **M-Notification.ind**

  - Buffer overflows in parsers for:

    - Transaction ID (~264 bytes ☠ MMS Composer 2.0)

    - Subject

    - ContentLocation

      - ~267 bytes ☠ MMS Composer 1.5

      - ~406 bytes ☠ MMS Composer 2.0

  - Non of these are exploitable for code injection

  - NotiFlood can now also crash tmail.exe

    - **Actively prevent victim from using the Inbox application while using wireless LAN (prevents usage of email/SMS/MMS)**

Bugs Found 2/3

- **M-Retrieve.conf** (header)

    - Buffer overflows in parsers for:

        - Subject (crash only; non-exploitable)

        - Content-Type (overwrites return address; potentially exploitable)

        - Start-info parameter of Content-Type (non-exploitable)

Bugs Found 3/3

- **M-Retrieve.conf** (body - in the Multipart Entry Header)
    - Buffer overflows in parsers for:
        - Content-Type
        - Content-ID
        - ContentLocation
    - All are string length based bugs
    - All allow overwriting the return address (potentially exploitable)
- M-Retrieve.conf bugs are not exploitable in the real-world due to sanitization by MMS infrastructure ...or are they?
    - ➜ Avoid sanitization through running our own MMS Server

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Rogue MMS Server

- Use setup like the *Virtual MMS System*

- Send notification via SMS to target devices

  - ContentLocation in notification points to rogue MMS Server

- Unfortunately not possible with mobile phone service provider that operates closed WAP Gateway

  - Tested major U.S. and German mobile phone service providers, some seem to block this!

  - **Test your service provider!**

SMIL

- Synchronized Multimedia Integration Language

  - XML-based presentation language

  - Specifies how MMS content is displayed to user

  - Basically the HTML for MMS

- SMIL files are transported in the message body and therefore are not sanitized

  - ➔ Perfect attack vector!

SMIL File

```
<smil>
 <head>
  <meta name="title" content="mms"/>
  <layout>
   <root-layout width="229" height="226" />
   <region id="Image" left="4%" top="2%" width="92%" height="80%" fit="hidden" />
   <region id="Text" left="4%" top="81%" width="87%" height="16%" fit="hidden" />
  </layout>
 </head>
 <body>
  <par dur="5000ms" >
   <text src="1.txt" region="Text"/>
  </par>
 </body>
</smil>
```

id parameter of region tag, region parameter of text tag

SMIL Parser Vulnerabilities

- REGION tag, buffer overflow for ID parameter

  - Exploitable (can be used to overwrite return address)

- TEXT tag, buffer overflow for REGION parameter

  - Exploitable (can be used to overwrite return address)

- In both cases the content enclosed by double-quotes is just copied to a stack based variable

 - Probably the same parser code for both tags

Building an MMS User Agent

- We need our own User Agent in order to send the exploit to target device

- The User Agent basically is:

    - Message generator (based on MMSLib)

    - WAP Client to send message (based on jWAP)

- MMS Message type to send is: *M-Send.req*

- Use mobile phone for GPRS dial-up

    - MMS Relay is not reachable from the Internet or is on private IP-range

MMS / SMIL Exploit

- The first mobile phone remote code execution exploit

  – MMS as the attack vector

- Real code injection/execution

  – User only needs to view the message to trigger exploit

- WindowsCE exploit complications apply

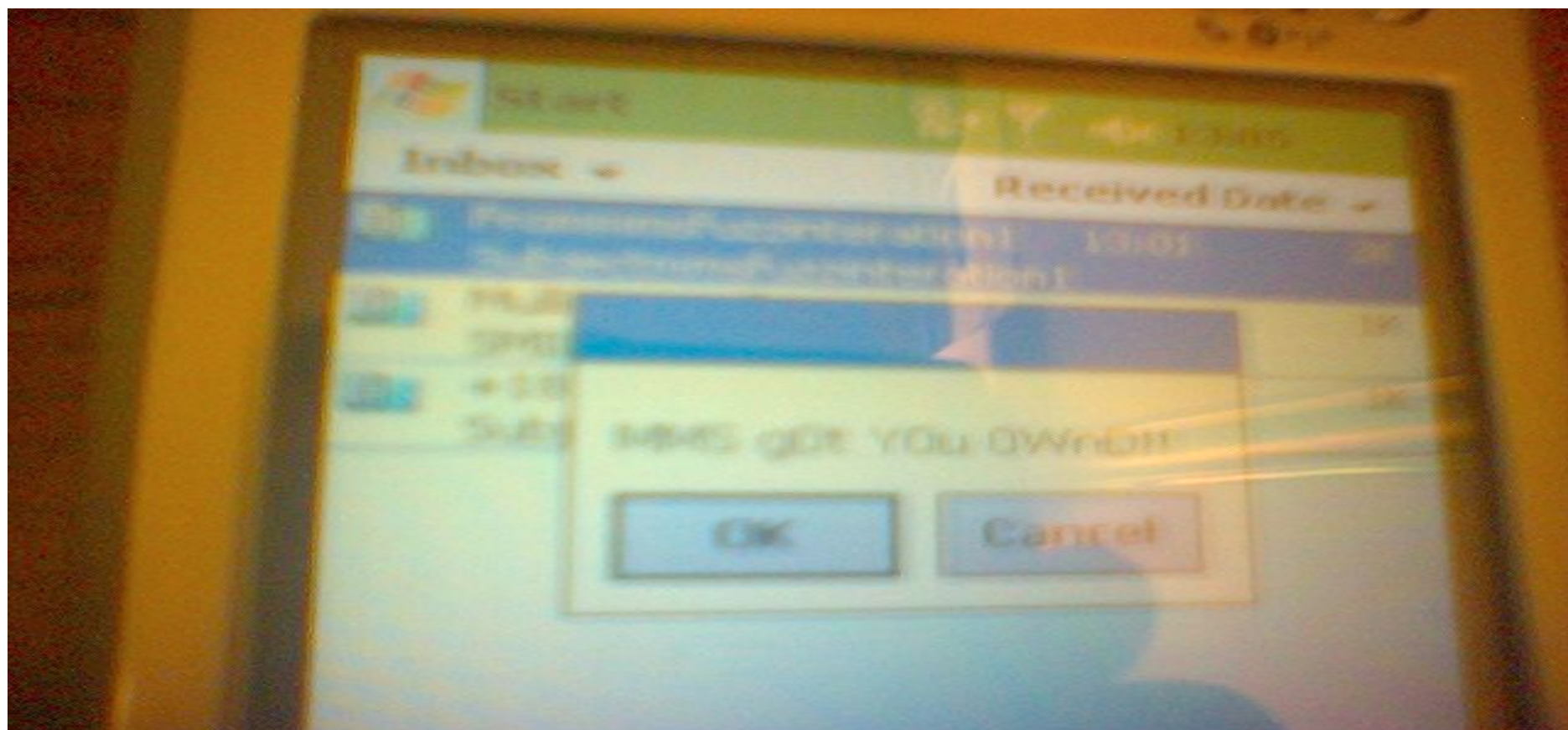 – Return address guessing is tricky ...but works!

MMS g0t Y0u 0wnd

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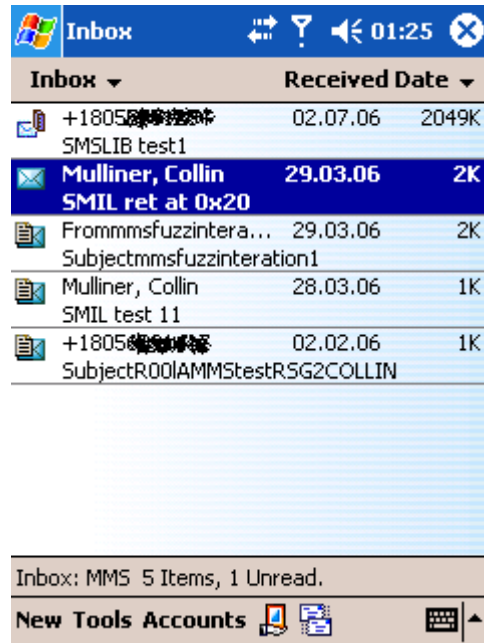
Exploit Details

- Return address and stack size

  - i-mate PDA2k

    - Return address 0x??05EE**40** (?? ⇨ slot address prefix)
    - Stack size 400 bytes

  - iPAQ h6315

    - Return address 0x??05EE**9C**
    - Stack size 300 bytes

- Common slots used by tmail.exe: 14, 16, 20, 24

The Exploit in Action ... 0WND

Vendors have been Notified

- Microsoft and ArcSoft have been notified in July 2006
  - Both companys told me that they take this seriously
- I was told that a security fix should be available within the next weeks
  - "The OEMs just need to test it before they can release it"
- Sofar I haven't seen a patch or firmware update for my devices. I guess they are considered OLD by now.

NotiFlood and WinCE 5.x

- People report that NotiFlood is 100% lethal to WinCE 5.x devices

  – NotiFlood's *crash* option (-c) doesn't only crash the Inbox application **but the whole device!**

  – Recovery using either soft-reset or battery removal

- WinCE 5.x should have become more secure but here we see the opposite :-(

- (DoS is lame, I know)

Defense

- WLAN notification flooding denial-of-service

  - Packet filter / firewall on phone

- MMS message based attacks (the SMIL exploit)

  - IDS / "Anti-Virus" on phone

  - Mobile phone service provider based IDS / "Anti-Virus"

- General SMS/MMS Service Provider Measures

  - Filter binary SMS that carry MMS M-Notification.ind

- *Install firmware updates when available!!!*

DIY Defense

- Prevent MMS-notification delivery by the PushRouter

  – Attacker can't reach MMS Composer anymore

- Change value of one registry key (any value will do)

  – Works on WinCE 4.x and 5.x

```
\HKEY_LOCAL_MACHINE\Security\PushRouter\Registrations\
ByCTAndAppId\application/vnd.wap.mms-message;
```

- This will prevent both the SMIL and NotiFlood attack

- WARNING: this will completely disable receiving MMS messages

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Conclusions

- Security analysis of smart phones is complicated

  - One has to deal with the service infrastructure

  - One application two attack vectors

    - WiFi ➜ MMS User Agent ⬅ SMS/MMS

- Found +10 bugs in the PocketPC MMS implementation

  - Full advisory was published in early August 2006

- First code injection against a mobile/smart phone

  - Stuff like this will become a major problem in the future!

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Future Work

- Look at other parts of MMS messages

  - Especially the multimedia content should be interesting

- Find bugs in other MMS User Agents

  - Symbian, PalmOS, or even Linux

- Abuse/attack the MMS Infrastructure

  - Highly complex system ...many different things to play with

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Questions

Thank you for your attation,
any questions?

References

- Microsoft PocketPC http://www.microsoft.com/pocketpc/

- MMS http://www.wapforum.com (Documents WAP-[205,206,209,210,230]-WSP)

- jWAP http://jwap.sourceforge.net (Java WAP Library)

- SMSLib http://smslib.sourcefore.net (Java SMS Library)

- MMS Lib http://www.hellkvist.org/software/ (PHP MMS Library)

- Kannel http://www.kannel.org (Free/OpenSource WAP Gateway)

- Reliable Software Group http://www.cs.ucsb.edu/~seclab/

- The trifinite group http://www.trifinite.org

- My PocketPC stuff http://www.mulliner.org/pocketpc/

- Mobile Security Information http://www.mulliner.org/mobilesecurity/

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