Program Analysis for Security

John Mitchell
Software bugs are serious problems

Thanks: Isil and Thomas Dillig
Facebook missed a single security check…

Man Finds Easy Hack to Delete Any Facebook Photo Album

Facebook awards him a $12,500 "bug bounty" for his discovery

[PopPhoto.com Feb 10]
App stores

Apps for whatever you’re up for.

Stay on top of the news. Stay on top of your finances. Or plan your dream vacation. No matter what you want to do with your iPhone, there’s probably an app to help you do it.

LinkedIn Business

iPhone is ready for work. Manage projects, track stocks, monitor finances, and more with these 9-to-5 apps.

View business apps in the App Store

Google Education

Keep up with your studies using intelligent education apps like King of Math and NatureTap.

View education apps in the App Store

HBO GO Entertainment

Kick back and enjoy the show. Or find countless other ways to entertain yourself. These apps offer hours of viewing pleasure.

View entertainment apps in the App Store

Family & Kids

Turn every night into family night with interactive apps that are fun for the whole house.

View family and kids apps in the App Store

Finance

Create budgets, pay bills, and more with financial apps that take everything into account.

View finance apps in the App Store

Food & Drink


View food and drink apps in the App Store
How can you tell whether software you
  – Develop
  – Buy
is safe to install and run?
Two options

• Static analysis
  – Inspect code or run automated method to find errors or gain confidence about their absence

• Dynamic analysis
  – Run code, possibly under instrumented conditions, to see if there are likely problems
Program Analyzers

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<td>info leak</td>
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</table>
Manual testing only examines a small subset of behaviors.
Static vs Dynamic Analysis

• Static
  – Can consider all possible inputs
  – Find bugs and vulnerabilities
  – Can prove absence of bugs, in some cases

• Dynamic
  – Need to choose sample test input
  – Can find bugs vulnerabilities
  – Cannot prove their absence
Cost of Fixing a Defect

Credit: Andy Chou, Coverity
Cost of security or data privacy vulnerability?
Dynamic analysis

• Instrument code for testing
  – Heap memory: Purify
  – Perl tainting (information flow)
  – Java race condition checking

• Black-box testing
  – Fuzzing and penetration testing
  – Black-box web application security analysis
Static Analysis

• Long research history
• Decade of commercial products
  – FindBugs, Fortify, Coverity, MS tools, ...
Static Analysis: Outline

• General discussion of static analysis tools
  – Goals and limitations
  – Approach based on abstract states
• More about one specific approach
  – Property checkers from Engler et al., Coverity
  – Sample security checkers results
• Static analysis for of Android apps

Slides from: S. Bugrahe, A. Chou, I&T Dillig, D. Engler, J. Franklin, A. Aiken, ...
Static analysis goals

• Bug finding
  – Identify code that the programmer wishes to modify or improve

• Correctness
  – Verify the absence of certain classes of errors
### Soundness, Completeness

<table>
<thead>
<tr>
<th>Property</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soundness</strong></td>
<td>“Sound for reporting correctness” Analysis says no bugs → No bugs or equivalently There is a bug → Analysis finds a bug</td>
</tr>
<tr>
<td><strong>Completeness</strong></td>
<td>“Complete for reporting correctness” No bugs → Analysis says no bugs</td>
</tr>
</tbody>
</table>

Recall: $A \rightarrow B$ is equivalent to $(\neg B) \rightarrow (\neg A)$
<table>
<thead>
<tr>
<th></th>
<th>Complete</th>
<th>Incomplete</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sound</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reports all errors</td>
<td></td>
<td>Reports all errors</td>
</tr>
<tr>
<td>Reports no false alarms</td>
<td></td>
<td>May report false alarms</td>
</tr>
<tr>
<td><strong>Undecidable</strong></td>
<td><strong>Decidable</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Unsound</strong></td>
<td><strong>Decidable</strong></td>
<td></td>
</tr>
<tr>
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Sound Program Analyzer

Spec

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Program Analyzer

Analyze large code bases

false alarm

false alarm

false alarm

Sound → may report many warnings

May emit false false alarms
So ware

Behaviors

Sound
Over-approximation of Behaviors

Repeated Error

False Alarm

approximation is too coarse...
yields too many false alarms

Modules
Outline

• General discussion of tools
  – Goals and limitations
  – Approach based on abstract states

• More about one specific approach
  – Property checkers from Engler et al., Coverity
  – Sample security-related results

• Static analysis for Android malware
  – ...

Slides from: S. Bugrahe, A. Chou, I&T Dillig, D. Engler, J. Franklin, A. Aiken, ...
Does this program ever crash?

```
entry
X ← 0
Is Y = 0 ?
  yes -> X ← X + 1
  no  -> X ← X - 1
  yes -> Is Y = 0 ?
  no  -> exit
Is X < 0 ?
  yes -> crash
  no  -> Is Y = 0 ?
```
Does this program ever crash?

infeasible path!
... program will never crash
Try analyzing without approximating...

non-termination!
... therefore, need to approximate
\[ d_{out} = f(d_{in}) \]
\[ X \leftarrow X + 1 \]

\[ X = 0 \]

\[ X = 1 \]

\[ \text{Is } Y = 0 ? \]

\[ d_{in1} \]

\[ f1 \]

\[ d_{out1} \]

\[ d_{in2} \]

\[ f2 \]

\[ d_{out2} \]

\[ d_{out1} = f_1(d_{in1}) \]

\[ d_{out1} = d_{in2} \]

\[ d_{out2} = f_2(d_{in2}) \]
What is the space of dataflow elements, $\Delta$?

What is the least upper bound operator, $\sqcup$?

$\text{d}_{\text{out}1} = f_1(d_{\text{in}1})$

$\text{d}_{\text{out}2} = f_2(d_{\text{in}2})$

$\text{d}_{\text{join}} = \text{d}_{\text{out}1} \sqcup \text{d}_{\text{out}2}$

$\text{d}_{\text{join}} = \text{d}_{\text{in}3}$

$\text{d}_{\text{out}3} = f_3(d_{\text{in}3})$

Least upper bound operator

Example: union of possible values
Try analyzing with “signs” approximation...

Is \( Y = 0 \) ?

Is \( X < 0 \) ?

terminates...
... but reports false alarm
... therefore, need more precision

lost precision
\[ X = T \]

\[ X \neq \text{neg} \]

\[ X = T \]

\[ X \neq \text{pos} \]

\[ X = \top \]

\[ X = \bot \]

\[ X = \top \]

\[ Y = 0 \]

\[ Y \neq 0 \]

\[ \text{true} \]

\[ \text{false} \]

refined signs lattice

Boolean formula lattice
Try analyzing with “path-sensitive signs” approximation...

entry

$X \leftarrow 0$

Is $Y = 0$?

$Y = 0$

$X = 0$

$X = pos$

$X = neg$

$X = 0$

$Y \neq 0$

Is $X < 0$?

$X = pos$

$X = neg$

$X = pos$

$X = neg$

$X = pos$

$Y = 0$

$Y \neq 0$

exit

crash

... terminates...
... no false alarm
... soundly proved never crashes

true

$X = 0$

false

refinement

no precision loss
Outline

• General discussion of tools
  – Goals and limitations
  – Approach based on abstract states

★ More about one specific approach
  – Property checkers from Engler et al., Coverity
  – Sample security-related results

• Static analysis for Android malware
  – ...

Slides from: S. Bugrahe, A. Chou, I&T Dillig, D. Engler, J. Franklin, A. Aiken, ...
Unsound Program Analyzer

- Code
- Spec
- Program Analyzer

Not sound → may miss some bugs

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analyze large code bases
false alarm
may emit false alarms
Demo

• Coverity video: [http://youtu.be/_Vt4niZfNeA](http://youtu.be/_Vt4niZfNeA)
• Observations
  – Code analysis integrated into development workflow
  – Program context important: analysis involves sequence of function calls, surrounding statements
  – This is a sales video: no discussion of false alarms
Bugs to Detect

Some examples

- Crash Causing Defects
- Null pointer dereference
- Use after free
- Double free
- Array indexing errors
- Mismatched array new/delete
- Potential stack overrun
- Potential heap overrun
- Return pointers to local variables
- Logically inconsistent code

- Uninitialized variables
- Invalid use of negative values
- Passing large parameters by value
- Underallocations of dynamic data
- Memory leaks
- File handle leaks
- Network resource leaks
- Unused values
- Unhandled return codes
- Use of invalid iterators

Slide credit: Andy Chou
Example: Check for missing optional args

- Prototype for open() syscall:
  ```c
  int open(const char *path, int oflag, /* mode_t mode */...);
  ```

- Typical mistake:
  ```c
  fd = open("file", O_CREAT);
  ```

- Result: file has random permissions

- Check: Look for oflags == O_CREAT without mode argument
Example: Chroot protocol checker

- **Goal:** confine process to a “jail” on the filesystem
  - chroot() changes filesystem root for a process
- **Problem**
  - chroot() itself does not change current working directory

```
chroot()
chdir("/")
open("../file", ...)
```

Error if open before chdir
• Race condition between time of check and use

• Not applicable to all programs
Tainting checkers

Tainted data accepted from source

Unvetted data taints other data transitively

Tainted data is used in an operator or function

Example Sinks:  system()  printf()  malloc()  strcpy()  Sent to RDBMS  Included in HTML

Resultant Vulnerability:  command injection  format string manip.  integer/ buffer overflow  buffer overflow  SQL injection  cross site scripting
Example code with function def, calls

```c
#include <stdlib.h>
#include <stdio.h>

void say_hello(char * name, int size) {
    printf("Enter your name: ");
    fgets(name, size, stdin);
    printf("Hello %s.\n", name);
}

int main(int argc, char *argv[]) {
    if (argc != 2) {
        printf("Error, must provide an input buffer size.\n");
        exit(-1);
    }
    int size = atoi(argv[1]);
    char * name = (char*)malloc(size);
    if (name) {
        say_hello(name, size);
        free(name);
    } else {
        printf("Failed to allocate %d bytes.\n", size);
    }
}
```
Reverse Topological Sort

Idea: analyze function before you analyze caller
Apply Library Models

Tool has built-in summaries of library function behavior
Bottom Up Analysis

Analyze function using known properties of functions it calls
Bottom Up Analysis

Analyze function using known properties of functions it calls
Finish analysis by analyzing all functions in the program.
#define SIZE 8

void set_a_b(char * a, char * b) {
    char * buf[SIZE];
    if (a) {
        b = new char[5];
    } else {
        if (a && b) {
            buf[SIZE] = a;
            return;
        } else {
            delete [] b;
        }
    }
    *b = 'x';

    *a = *b;
}
Control Flow Graph

Char * buf[8];

if (a)
  b = new char [5];

if (a && b)
  buf[8] = a;

delete [] b;

*b = 'x';

*a = *b;

END

Represent logical structure of code in graph form
Path Traversal

Conceptually: Analyze each path through control graph separately

Actually: Perform some checking computation once per node; combine paths at merge nodes

```
char * buf[8];
if (a)
    b = new char [5];
if (a && b)
    buf[8] = a;
delete [] b;
*b = 'x';
*a = *b;
END
```
char * buf[8];
if (a)
!a
if (a && b)
!(a && b)
delete [] b;
*b = 'x';
*a = *b;
END

Apply Checking

Null pointers Use after free Array overrun

See how three checkers are run for this path

Checker
- Defined by a state diagram, with state transitions and error states

Run Checker
- Assign initial state to each program var
- State at program point depends on state at previous point, program actions
- Emit error if error state reached
Apply Checking

Null pointers Use after free Array overrun

```
char * buf[8];

if (a)
    !a
    if (a && b)
        !(a && b)
        delete [] b;
        *
        *b = 'x';
        *a = *b;

END
```

“buf is 8 bytes”
char * buf[8];
if (a)
!a
if (a && b)
!(a && b)
delete [] b;
*b = 'x';
*a = *b;
END

Apply Checking

Null pointers Use after free Array overrun

“buf is 8 bytes”

“a is null”
Apply Checking

char * buf[8];

if (a)

!a

if (a && b)

!(a && b)

delete [] b;

*b = 'x';

*a = *b;

END

Null pointers Use after free Array overrun

“buf is 8 bytes”

“a is null”

Already knew a was null
char * buf[8];

if (a)

!a

if (a && b)

!(a && b)

delete [] b;

*b = 'x';

*a = *b;

END

Null pointers  Use after free  Array overrun

“buf is 8 bytes”

“a is null”

“b is deleted”
Apply Checking

Null pointers
Use after free
Array overrun

char * buf[8];

if (a)

!a

if (a && b)

!(a && b)

delete[] b;

*b = 'x';

*a = *b;

END

“buf is 8 bytes”

“a is null”

“b is deleted”

“b dereferenced!”
Apply Checking

Null pointers Use after free Array overrun

char * buf[8];
if (a)
!a
if (a && b)
!(a && b)
delete [] b;
*b = 'x';
*a = *b;
END

“buf is 8 bytes”

“a is null”

“b is deleted”

“b dereferenced!”

No more errors reported for b
False Positives

• **What is a bug?** Something the user will fix.

• **Many sources of false positives**
  – False paths
  – Idioms
  – Execution environment assumptions
  – Killpaths
  – Conditional compilation
  – “third party code”
  – Analysis imprecision
  – …
A False Path

```c
char * buf[8];
if (a)
    b = new char [5];
if (a && b)
    buf[8] = a;
delete [] b;
*b = 'x';
*a = *b;
END
```
char * buf[8];

if (a)

!a

if (a && b)

buf[8] = a;

END
```c
char * buf[8];

if (a)
  if (a && b)
    buf[8] = a;

END
```

**False Path Pruning**

- Integer Range
- Disequality
- Branch

- "a in [0,0]"
- "a == 0 is true"
False Path Pruning

```
char * buf[8];
if (a)
    if (a && b)
        buf[8] = a;
!a
```

- "a in [0,0]"
- "a == 0 is true"
- "a != 0"

```
END
```
char * buf[8];
if (a)
  if (a && b)
    buf[8] = a;
END

Impossible

“a in [0,0]”
“a == 0 is true”

“a != 0”

“a in [0,0]”
“a == 0 is true”

“a != 0”

“a == 0 is true”

“a != 0”

Integer Range  Disequality  Branch
Environment Assumptions

• Should the return value of malloc() be checked?

  ```c
  int *p = malloc(sizeof(int));
  *p = 42;
  ```

<table>
<thead>
<tr>
<th>OS Kernel: Crash machine.</th>
<th>File server: Pause filesystem.</th>
<th>Web application: 200ms downtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spreadsheet: Lose unsaved changes.</td>
<td>Game: Annoy user.</td>
<td>IP Phone: Annoy user.</td>
</tr>
<tr>
<td>Library: ?</td>
<td>Medical device: malloc?!</td>
<td></td>
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</tbody>
</table>
Statistical Analysis

• Assume the code is usually right

\[
\begin{align*}
\text{3/4 deref} & \quad \begin{array}{l}
\text{int } *p = \text{malloc}(&\text{sizeof(int)}); \\
*_{p} = 42; \\
*_{p} = \text{malloc}(&\text{sizeof(int)}); \\
*_{p} = 42; \\
\text{int } *p = \text{malloc}(&\text{sizeof(int)}); \\
\text{if}(p) \quad *_{p} = 42; \\
*_{p} = \text{malloc}(&\text{sizeof(int)}); \\
*_{p} = 42; \\
\end{array} \\
\text{1/4 deref} & \quad \begin{array}{l}
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*_{p} = 42; \\
\end{array}
\end{align*}
\]
Application to Security Bugs

• Stanford research project
  – Used modified compiler to find over 100 security holes in Linux and BSD
  – http://www.stanford.edu/~engler/

• Benefit
  – Capture recommended practices, known to experts, in tool available to all
Sanitize integers before use

Warn when unchecked integers from untrusted sources reach trusting sinks

Linux: 125 errors, 24 false; BSD: 12 errors, 4 false

SYS
- Syscall param
- Network packet
- copyin(&v, p, len)

v.tainted
- any <= v <= any
- memcpy(p, q, v)
- copyin(p, q, v)
- copyout(p, q, v)

ERROR

v.clean

Use(v)
Example security holes

• Remote exploit, no checks

    /* 2.4.9/drivers/isdn/act2000/capi.c:actcapi_dispatch */
    isdn_ctrl cmd;
    ...
    while ((skb = skb_dequeue(&card->rcvq))) {
        msg = skb->data;
        ...
        memcpy(cmd.parm.setup.phone,
               msg->msg.connect_ind.addr.num,
               msg->msg.connect_ind.addr.len - 1);
Example security holes

- Missed lower-bound check:

```c
/* 2.4.5/drivers/char/drm/i810_dma.c */

if(copy_from_user(&d, arg, sizeof(arg)))
    return -EFAULT;
if(d.idx > dma->buf_count)
    return -EINVAL;
buf = dma->buflist[d.idx];
Copy_from_user(buf_priv->virtual, d.address, d.used);
```
User-pointer inference

• **Problem: which are the user pointers?**
  - Hard to determine by dataflow analysis
  - Easy to tell if kernel *believes* pointer is from user!

• **Belief inference**
  - “\( *p \)” implies safe kernel pointer
  - “copyin\((p)\)/copyout\((p)\)” implies dangerous user ptr
  - Error: pointer \( p \) has both beliefs.

• **Implementation: 2 pass checker**
  - inter-procedural: compute all tainted pointers
  - local pass to check that they are not dereferenced
Results for BSD and Linux

- All bugs released to implementers; most serious fixed

<table>
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<tr>
<th>Violation</th>
<th>Linux Bug Fixed</th>
<th>BSD Bug Fixed</th>
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<tbody>
<tr>
<td>Gain control of system</td>
<td>18 15</td>
<td>3 3</td>
</tr>
<tr>
<td>Corrupt memory</td>
<td>43 17</td>
<td>2 2</td>
</tr>
<tr>
<td>Read arbitrary memory</td>
<td>19 14</td>
<td>7 7</td>
</tr>
<tr>
<td>Denial of service</td>
<td>17 5</td>
<td>0 0</td>
</tr>
<tr>
<td>Minor</td>
<td>28 1</td>
<td>0 0</td>
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<td>Total</td>
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• General discussion of tools
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  – Approach based on abstract states

• More about one specific approach
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  – Sample security-related results

Static analysis for Android malware
  – ...

Slides from: S. Bugrahe, A. Chou, I&T Dillig, D. Engler, J. Franklin, A. Aiken, ...
STAMP Admission System

Static Analysis
More behaviors, fewer details

Dynamic Analysis
Fewer behaviors, more details

Alex Aiken, John Mitchell, Saswat Anand, Jason Franklin Osbert Bastani, Lazaro Clapp, Patrick Mutchler, Manolis Papadakis
Data Flow Analysis

- **getLoc()**
  - Source: Location
  - sendSMS()
    - Sink: SMS
  - sendInet()
    - Sink: Internet

- **Location** ➔ **SMS** ➔ **Location** ➔ **Internet**

- **Source-to-sink flows**
  - Sources: Location, Calendar, Contacts, Device ID etc.
  - Sinks: Internet, SMS, Disk, etc.
Applications of Data Flow Analysis

- **Malware/Greyware Analysis**
  - Data flow summaries enable enterprise-specific policies

- **API Misuse and Data Theft Detection**
  - Source: FB_Data
  - Send Internet
  - Sink: Internet

- **Automatic Generation of App Privacy Policies**
  - Source: Untrusted_Data
  - SQL Stmt
  - Sink: SQL

- **Vulnerability Discovery**

Privacy Policy
This app collects your:
- Contacts
- Phone Number
- Address
Challenges

• Android is 3.4M+ lines of complex code
  o Uses reflection, callbacks, native code

• **Scalability**: Whole system analysis impractical

• **Soundness**: Avoid missing flows

• **Precision**: Minimize false positives
STAMP Approach

- Model Android/Java
  - Sources and sinks
  - Data structures
  - Callbacks
  - 500+ models

- Whole-program analysis
  - Context sensitive

Too expensive!
Building Models

• 30k+ methods in Java/Android API
  o 5 mins x 30k = 2500 hours

• Follow the permissions
  o 20 permissions for sensitive sources
    ▪ ACCESS_FINE_LOCATION (8 methods with source annotations)
    ▪ READ_PHONE_STATE - (9 methods)
  o 4 permissions for sensitive sinks
    ▪ INTERNET, SEND_SMS, etc.
Identifying Sensitive Data

- Returns device IMEI in String
- Requires permission GET_PHONE_STATE

```java
android.Telephony.TelephonyManager: String getDeviceId()
```

```java
@STAMP(
    SRC ="$GET_PHONE_STATE.deviceid",
    SINK ="@return"
)
```
Data We Track (Sources)

- Account data
- Audio
- Calendar
- Call log
- Camera
- Contacts
- Device Id
- Location
- Photos (Geotags)
- SD card data
- SMS

30+ types of sensitive data
Data Destinations (Sinks)

- Internet (socket)
- SMS
- Email
- System Logs
- Webview/Browser
- File System
- Broadcast Message

10+ types of exit points
Currently Detectable Flow Types

396 Flow Types

Unique Flow Types = Sources x Sink
Contact Sync for Facebook (unofficial)

This application allows you to synchronize your Facebook contacts on Android.

To configure, go to “Settings => Accounts & Sync => Add Account”. Depending on how many friends you have, the first import might take a while, so be patient.

IMPORTANT:
* Facebook does not allow to export phone numbers or emails. Only names, pictures and statuses are synced.
* Facebook users have the option to block one or all apps. If they opt for that, they will be EXCLUDED from your friends list.

Please send bug reports or any kind of feedback.

https://www.facebook.com/ContactSync
https://plus.google.com/ud/1002866051202961737
https://github.com/roadrunner/Contact-Sync

Visit Developer’s Website  Email Developer  Privacy Policy

App Screenshots
# Contact Sync Permissions

<table>
<thead>
<tr>
<th>Category</th>
<th>Permission</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your Accounts</td>
<td>AUTHENTICATE_ACCOUNTS</td>
<td>Act as an account authenticator</td>
</tr>
<tr>
<td></td>
<td>MANAGE_ACCOUNTS</td>
<td>Manage accounts list</td>
</tr>
<tr>
<td></td>
<td>USE_CREDENTIALS</td>
<td>Use authentication credentials</td>
</tr>
<tr>
<td>Network Communication</td>
<td>INTERNET</td>
<td>Full Internet access</td>
</tr>
<tr>
<td></td>
<td>ACCESS_NETWORK_STATE</td>
<td>View network state</td>
</tr>
<tr>
<td>Your Personal Information</td>
<td>READ_CONTACTS</td>
<td>Read contact data</td>
</tr>
<tr>
<td></td>
<td>WRITE_CONTACTS</td>
<td>Write contact data</td>
</tr>
<tr>
<td>System Tools</td>
<td>WRITE_SETTINGS</td>
<td>Modify global system settings</td>
</tr>
<tr>
<td></td>
<td>WRITE_SYNC_SETTINGS</td>
<td>Write sync settings (e.g. Contact sync)</td>
</tr>
<tr>
<td></td>
<td>READ_SYNC_SETTINGS</td>
<td>Read whether sync is enabled</td>
</tr>
<tr>
<td></td>
<td>READ_SYNC_STATS</td>
<td>Read history of syncs</td>
</tr>
<tr>
<td>Your Accounts</td>
<td>GET_ACCOUNTS</td>
<td>Discover known accounts</td>
</tr>
<tr>
<td>Extra/Custom</td>
<td>WRITE_SECURE_SETTINGS</td>
<td>Modify secure system settings</td>
</tr>
</tbody>
</table>
Possible Flows from Permissions

Sources

- READ_CONTACTS
- READ_SYNC_SETTINGS
- READ_SYNC_STATS
- GET_ACCOUNTS
- INTERNET

Sinks

- INTERNET
- WRITE_SETTINGS
- WRITE_CONTACTS
- WRITE_SECURE_SETTINGS
- WRITE_SETTINGS
Expected Flows

Sources

- READ_CONTACTS
- READ_SYNC_SETTINGS
- READ_SYNC_STATS
- GET_ACCOUNTS
- INTERNET

Sinks

- INTERNET
- WRITE_SETTINGS
- WRITE_CONTACTS
- WRITE_SECURE_SETTINGS
- WRITE_SETTINGS
Observed Flows

FB API → Source: FB_Data → Write Contacts → Sink: Contact_Book

Read Contacts → Source: Contacts → Send Internet → Sink: Internet

Write Contacts → Source: FB_Data

Send Internet → Sink: Internet
Example Study: Mobile Web Apps

• Goal
  Identify security concerns and vulnerabilities specific to mobile apps that access the web using an embedded browser

• Technical summary
  • WebView object renders web content
  • methods loadUrl, loadData, loadDataWithBaseUrl, postUrl
  • addJavascriptInterface(obj, name) allows JavaScript code in the web content to call Java object method name.foo()
Sample results

Analyze 998,286 free web apps from June 2014

<table>
<thead>
<tr>
<th>Mobile Web App Feature</th>
<th>% Apps</th>
</tr>
</thead>
<tbody>
<tr>
<td>JavaScript Enabled</td>
<td>97</td>
</tr>
<tr>
<td>JavaScript Bridge</td>
<td>36</td>
</tr>
<tr>
<td>shouldOverrideUrlLoading</td>
<td>94</td>
</tr>
<tr>
<td>shouldInterceptRequest</td>
<td>47</td>
</tr>
<tr>
<td>onReceivedSslError</td>
<td>27</td>
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<tr>
<td>postUrl</td>
<td>2</td>
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<tr>
<td>Custom URL Patterns</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vuln</th>
<th>% Relevant</th>
<th>% Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsafe Navigation</td>
<td>15</td>
<td>34</td>
</tr>
<tr>
<td>Unsafe Retrieval</td>
<td>40</td>
<td>56</td>
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<tr>
<td>Unsafe SSL</td>
<td>27</td>
<td>29</td>
</tr>
<tr>
<td>Exposed POST</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Leaky URL</td>
<td>10</td>
<td>16</td>
</tr>
</tbody>
</table>
Summary

• Static vs dynamic analyzers
• General properties of static analyzers
  – Fundamental limitations
  – Basic method based on abstract states
• More details on one specific method
  – Property checkers from Engler et al., Coverity
  – Sample security-related results
• Static analysis for Android malware
  – STAMP method, sample studies

Slides from: S. Bugrahe, A. Chou, I&T Dillig, D. Engler, J. Franklin, A. Aiken, ...