Security when applications become web sites

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Web and apps perceived differently

- Users know software can do bad things.
- Conservative: only install “trusted” software.

- Users believe web sites cannot do “bad” things to system.
- Liberal about visiting dubious web sites.
The Web’s evolution: rich apps (e.g., Gmail, games)
- Ever increasing functionality and performance demand.
- Security problems will only get worse.

Browser becoming platform for running applications
Google Native Client—run x86 code in browser:
- High performance.
- Easy porting of legacy code.

Quake
91,582 LoC
Problem: how to sandbox x86 code?

```
mov $0, %ecx      # O_RDONLY
mov "/etc/passwd", %ebx
mov $5, %eax      # open
int $0x80         # syscall
```

Solution:

1. Compile code to verifiable form.
2. Verify code prior to launch.
Our work: add syscalls, securely

Problem: how to securely allow syscalls?

game1.sav → X → quake.nexe

Quake server
Our work: add syscalls, securely

Problem: how to securely allow syscalls?

game1.sav → quake.nexe

Quake server

quake.nexe
Our work: add syscalls, securely

Problem: how to securely allow syscalls?

Challenge: figure out policy and enforce it
Motivating examples

- **Quake**
  - Online gaming.

- **VOIP client**
  - Live support while shopping online.

- **Peer-to-peer streaming video player**
  - No need for server bandwidth.

- **Photo editor and publisher**
  - No need for server CPU expense.
Example: Hypothetical Flickr

1. Visit Flickr’s NaCl web site

2. Choose file to upload

3. Edit picture

4. Upload!
User actions specify user’s intent

Security: carry out user intentions and nothing more.

- User wants to open pic.jpg
- User expects app will read pic.jpg

User action: select pic.jpg via file chooser.
User actions grant privileges

Give applications privileges based on user actions [Karp06]

- **File chooser**: Read file
- **Textbox**: Allow connection to host
- **Link text**: Allow connection to peers specified in torrent file obtained from link
- **Button**: Allow microphone access

Policy modules: generic and small (e.g., bittorrent 100 LoC)
Trusted UI gives user action proof

Code

```python
add_trusted(TEXTBOX, "SMTP server");
```

User interface displayed

```
SMTP server      smtp.com
```

Endorsements (→ privileges)

```
```
**Trusted UI gives user action proof**

**Code**

```python
add_trusted(TEXTBOX, "SMTP server");
add_trusted(TEXTBOX, "Type warez.com to continue");
```

**User interface displayed**

<table>
<thead>
<tr>
<th>SMTP server</th>
<th>smtp.com</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type warez.com to continue</td>
<td>warez.com</td>
</tr>
</tbody>
</table>

**Endorsements (→ privileges)**

- `textbox://Type warez.com to continue/warez.com`
Allow controlled sharing using IFC

- flickr.com
- flickr.nexe
- pass.txt
- pic.jpg

Need Information Flow Control (IFC).
How to allow sharing data, and avoid exfiltration?

- flickr.com
  - flickr.nexe
    - pass.txt
    - pic.jpg
  - stats.com
    - desksearch.nexe
      - index.db
How to allow sharing data, and avoid exfiltration?

Allow controlled sharing using IFC
How to allow sharing data, and avoid exfiltration?

- flickr.com
  - flickr.nexe
  - pass.txt
  - pic.jpg

- stats.com
  - desksearch.nexe
  - index.db

- search.com
  - websearch.nexe

Need Information Flow Control (IFC).
Allow controlled sharing using IFC

How to allow sharing data, and avoid exfiltration?

Need Information Flow Control (IFC).
Track data and control export

To prevent data disclosure:

1. Label data.
2. Taint processes that hold labeled data.
3. Deny tainted processes from talking to network.
Track data and control export

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Labels control information flow

- Red on previous slide represents a category of taint.

  **Category**  An arbitrary string, *e.g.*, “secret”.
  **Label**    A set of integrity and secrecy categories.

Information can flow from $x$ to $y$ if:
- Secrecy categories of $x \subset y$.
- Integrity categories of $y \subset x$.
Category owners can export data.

- They can remove owned categories from their label.

### NaCl applications own the following categories:

<table>
<thead>
<tr>
<th>Category</th>
<th>Allows sharing between</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTTP origin</td>
<td>Applications in same page</td>
</tr>
<tr>
<td>Hash of app binary</td>
<td>Instances of same application</td>
</tr>
<tr>
<td>Certificate that signed app</td>
<td>Applications from same vendor</td>
</tr>
</tbody>
</table>
Telephoning from your browser

Make and receive calls from your browser:
- Live phone support while shopping online.
- Sales callbacks.

NaCl benefits:
- Can reuse SIP libraries: 347,501 LoC.
- Need performance for audio codecs.
Client-based video streaming

Watch and stream videos using bittorrent.

- No need for server bandwidth.
- High performance for video codecs.

Security requirements:

- Restrict network traffic to bittorrent peers.
- Restrict disk access to bittorrent files.

movie.torrent: http://tracker.com

tracker.com: 1.2.3.4 2.2.2.2 8.8.8.8
NaCl bittaurent player

Policy module tracker.nexe (100 LoC; cf. 327,000 untrusted):
- Connects only to trackers authorized by user.
- Grants privileges only for IPs returned by tracker.

Select film:
- [http://www.tracker.com/rocky.torrent](http://www.tracker.com/rocky.torrent)
- [http://www.tracker.com/caligari.torrent](http://www.tracker.com/caligari.torrent)
- [http://www.tracker.com/nosferatu.torrent](http://www.tracker.com/nosferatu.torrent)
NaCl bittaurent player

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Policy module tracker.nex (100 LoC; cf. 327,000 untrusted):
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Select film:
- http://www.tracker.com/rocky.torrent
- http://www.tracker.com/coligard.torrent
- http://www.tracker.com/nosferatu.torrent

get rocky

bitplayer.nex
S [], I [[click://rocky],
tcp://1.2.3.4), [tcp://2.2.2.2],
tcp://8.8.8.8]]

OK

tracker.com:
1.2.3.4
2.2.2.2
8.8.8.8

X

6.6.6.6
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Convergence of applications and web sites is inevitable.
- Web apps need more performance and functionality.
- Threatens to undermine already tenuous browser security.

Information flow control transcends complex module interactions.

Infer user’s intent from actions.
1. User action generates endorsement.
2. Policy modules translate endorsements to privileges.