Towards a security and privacy model for the IoT

Saša Radomirović
University of Luxembourg
Motivation

Model security and privacy in the IoT.
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What are the dangers to look out for in the IoT?
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What are the dangers to look out for in the IoT?

How do we recognize early signs of something that might go wrong?
Approach

1. Look at past developments.
2. Study current situation.
3. Extrapolate.
Internet of Things (IoT)

- communication network
- extends the present Internet
- includes everyday items and sensors
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Technologies used:
- *Radio Frequency Identification* (RFID) tags attached to cheap and disposable objects
- more powerful radio signal transmitters/receivers integrated into large and valuable objects
## Simplistic Timeline of the Internet

<table>
<thead>
<tr>
<th>Time</th>
<th>Network</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980s</td>
<td>PCs are widespread</td>
<td></td>
</tr>
<tr>
<td>early 90s</td>
<td>dial-up connections</td>
<td>BBSs are popular</td>
</tr>
<tr>
<td>mid 90s</td>
<td>Internet is popular</td>
<td>BBSs reachable from Internet</td>
</tr>
<tr>
<td></td>
<td>(0.4% of world pop.)</td>
<td>E-commerce starts</td>
</tr>
<tr>
<td>early 00s</td>
<td>broadband</td>
<td>E-commerce takes off</td>
</tr>
<tr>
<td></td>
<td>(4.1% of world pop.)</td>
<td>Amazon makes profit</td>
</tr>
<tr>
<td>late 00s</td>
<td>wireless</td>
<td>cloud applications</td>
</tr>
</tbody>
</table>
Phase transitions

- significant size of Internet $\rightarrow$ E-commerce becoming possible
- switch to broadband $\rightarrow$ Cloud apps, social networking, TV
# Simplistic Timeline of the Internet and Malware

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</thead>
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<tr>
<td>1980s</td>
<td>Trojans and viruses on floppy discs</td>
<td></td>
</tr>
<tr>
<td>early 90s</td>
<td>dial-up connections</td>
<td>Malware spreading through BBSs</td>
</tr>
<tr>
<td>mid 90s</td>
<td>Internet is popular (0.4% of world pop.)</td>
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</tr>
<tr>
<td>early 00s</td>
<td>broadband (4.1% of world pop.)</td>
<td>Website defacement</td>
</tr>
<tr>
<td>late 00s</td>
<td>wireless (26% of world pop.)</td>
<td>Internet black market</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E-commerce takes off</td>
</tr>
<tr>
<td></td>
<td></td>
<td>XP SP2 with software firewall</td>
</tr>
<tr>
<td></td>
<td></td>
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Phase transitions

- Significant size of Internet → E-commerce becoming possible
- Switch to broadband → Cloud apps, social networking, TV

But also:

- Before E-commerce: viruses, worms as pranks
- After E-commerce: malware for profit
Phase transitions in malware

Transitions caused by combination of honeymoon effect and low-hanging fruit.
Phase transitions in malware

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Example of a phase transition:

- Exploits before XP SP2: trivial (open ports).
- Exploits after XP SP2: client-side exploits, larger effort required.
Phase transitions in malware

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Note: Large number of identically vulnerable devices.
Internet story so far

- Several vulnerable objects (home PCs) exist.
- Exploits don’t seem interesting, are only created for amusement.
- Context change (e-commerce).
- Exploits blow up.
Present developments

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   Examples:
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   - Firmware of Network cards can be “easily” changed, could thus be infected by malware.
   - Printers can be “easily” hacked, fuser temperature can be increased.
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2. Loss of privacy.
   - Long list of fingerprinting and profiling techniques.
     Short story: Everything is “fingerprintable” (typing cadence, browser configuration, sensor noise patterns, ...)
   - Data collection sites are mushrooming.
     Examples: cvgadget.com, dirtsearch.com, mylife.com, pipl.com, rapleaf.com, spokeo.com, wink.com, ...
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Other developments?
Outlook for IoT: Infrastructure

Today: VANets (car-to-car networks), wireless road pricing, sensor networks, RFID tickets, biometric scanners, ...
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(Distant?) future: phase transition, context change.
Outlook for IoT: Security and Privacy

- IoT technologies fall into hardware exploits category.
- Cheap mass production implies shoddy security design. There will be a plethora of vulnerable devices.
- Wireless communication is cheap and ubiquitous. → Advertising pamphlets, gifts, purchased equipment may contain Trojan devices. (Trust issues...)

Saša Radomirović

SecIoT 2010
Mitigation

- Defense against discovered vulnerabilities in devices:
  Proactive mitigation (cf. Firefox’ plugin check). Compare own devices with list of known vulnerabilities.
Mitigation


- Defense against Trojan devices: Scan every incoming and outgoing item.
Mitigation


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Note: OS security analogy.
Towards Modeling: Formal aspects

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Specific Privacy issue: Digital Crumbs

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Privacy property requirement: Two digital crumbs created by the same entity should not be linkable.
Conclusion

- Technological advancement gives rise to profound socio-economical changes.
- A consequence for the IoT is that legacy devices may become a security and privacy liability. Security vulnerabilities of devices should therefore be proactively monitored.
- It might be useful to consider a set of devices in the IoT as a fusion of an OS and a communication network.
Future Work

- Develop phase transition theory.
- Complete the formal model.
- Work out unlinkability of digital crumbs and other privacy properties.
Thank you!