

Practical Keystroke Timing Attacks in Sandboxed JavaScript

M. Lipp, D. Gruss, M. Schwarz, D. Bidner, C. Maurice, S. Mangard

Sep 11, 2017—ESORICS'17

Graz University of Technology

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- First JavaScript-based keystroke timing attack
- Build classifiers to detect visited websites or to identify users and a covert channel
- Runs in the background and can monitor on other tabs and applications

Background

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- Exploit timing characteristics to learn information about the user or the input
 - Infer typed sentences
 - Recover passphrases

- Many ways to obtain keystroke timings have been presented:
 - SSH leaks inter-keystroke timings in interactive mode [Son+01]
 - Network latency with significant traffic [Hog+01]
 - Instruction and stack pointer, interrupt, network packet statistics [Zha+09]
 - CPU usage [Jan+12]
 - Wi-Fi Signals [Ali+15]
 - /proc/interrupts [Dia+16]
 - JavaScript Sensor API [Meh+16]

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- Requires unprivileged code execution and an accurate timing source (e.g., `rdtsc`)

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1  int now = rdtsc();
2  while (true) {
3      int last = now;
4      now = rdtsc();
5      if ((now - last) > threshold) {
6          reportEvent(now, now - last);
7      }
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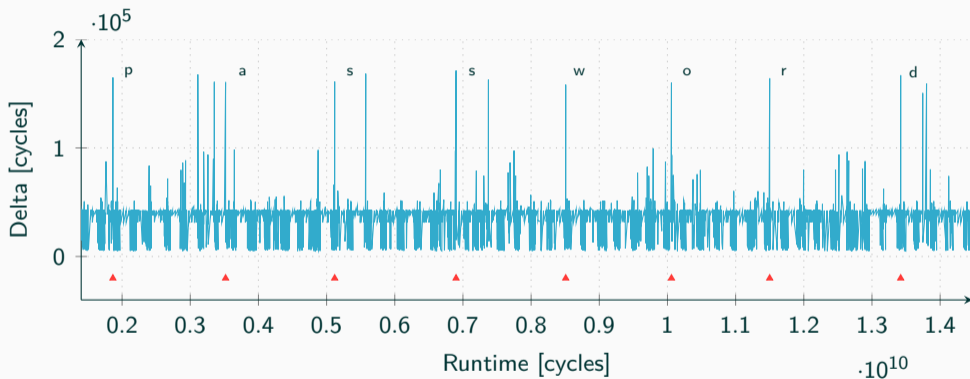
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 - More time the operating system consumes to handle the interrupt
→ higher timing difference



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- W3C standard now recommends a resolution of 5 μ s

Sandboxed Keystroke Timing Attacks without High-Resolution Timers

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 - *Offline phase*: Post-processing and evaluation

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 - Constantly increment a value
 - Number of increments is proportional to the time the function is scheduled
 - Interrupt → lower increments

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 - `setTimeout/setInterval` **enforce a minimum pause** of 4 ms

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 - Utilize Web Worker API to execute code in background

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1  function measure_time(id) {
2      setTimeout(measure_time, 0, id + 1);
3      counter = 0;
4      begin = window.performance.now();
5      while ((window.performance.now() - begin) < 5) {
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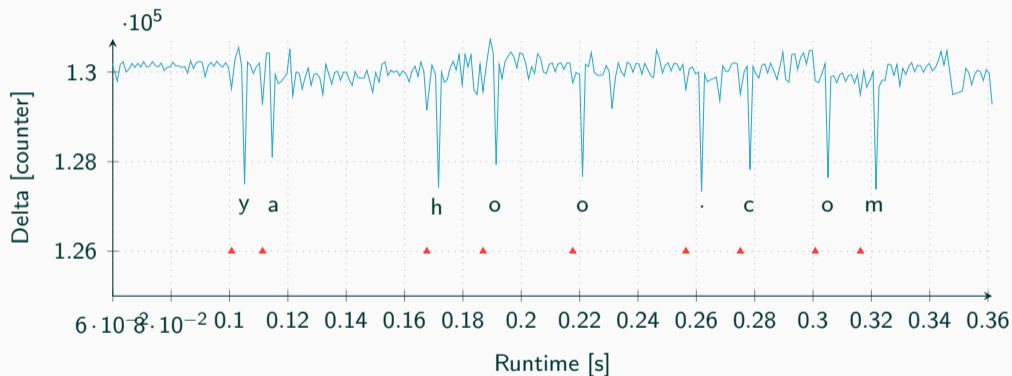
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- Less than 256 bytes of code
- Can be hidden in modern JavaScript frameworks or online advertisements



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- **Features** of recorded measurements **are strong enough** that simple techniques (k-nearest neighbours (KNN)) allow to build an **efficient and accurate classifier**

Practical Attacks and Evaluation

- Infer URLs a user enters into the browsers address bar
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- Train a classifier with the input sequences of the top 10 most visited websites

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- Compute the correlation for different alignments
- Evaluate classifier using k-fold cross-validation

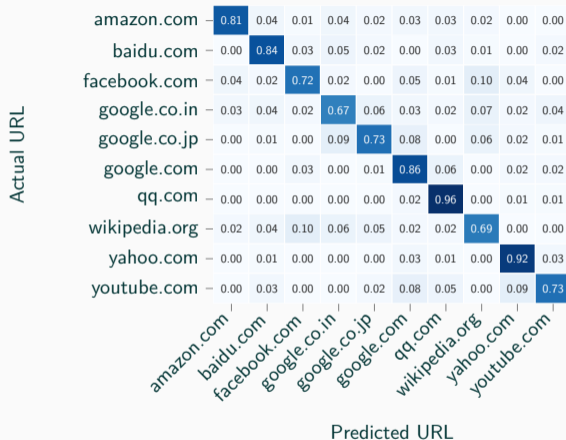


Figure 1: Confusion matrix for URL input.

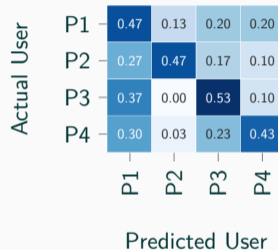


Figure 2: Confusion matrix for input by different users.

- Evaluate attack on mobile devices

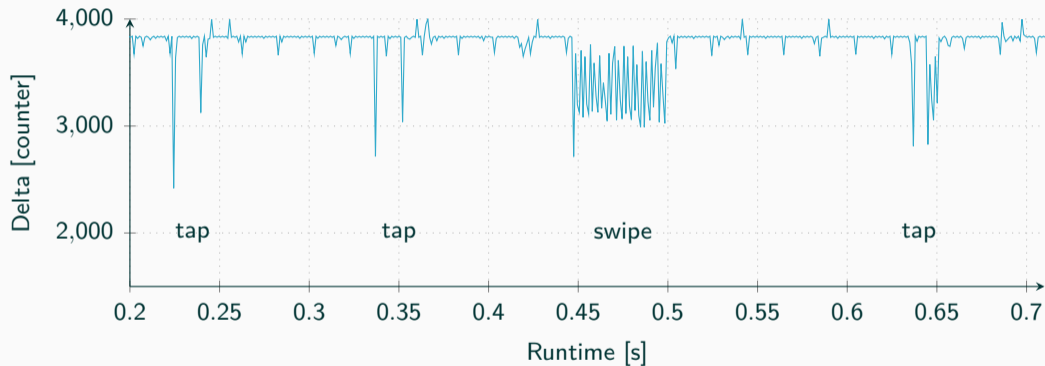


Figure 3: Keystroke timing attack running in a native app on the Google Nexus 5.

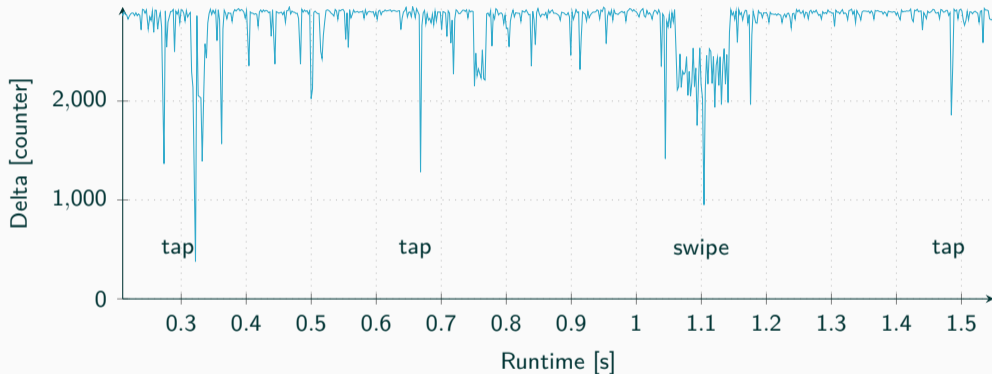


Figure 4: Keystroke timing attack running in JavaScript on the Google Nexus 5.

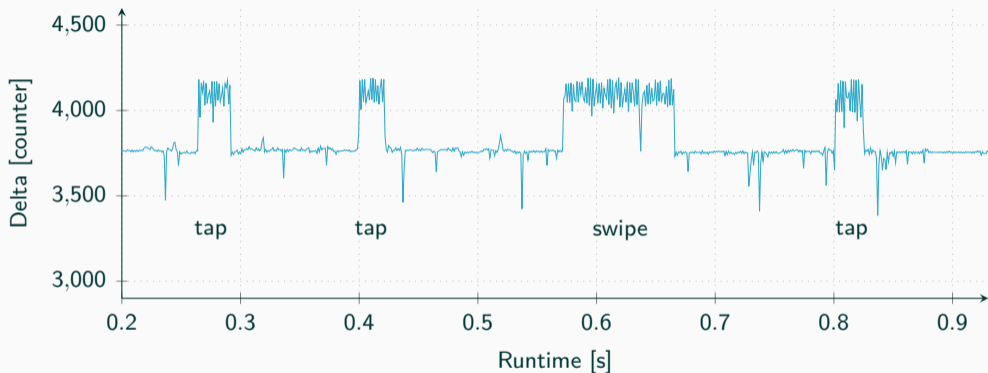


Figure 5: Keystroke timing attack running in JavaScript on the Xiaomi Redmi Note 3.

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- Allows to monitor keystrokes in different tabs and other applications

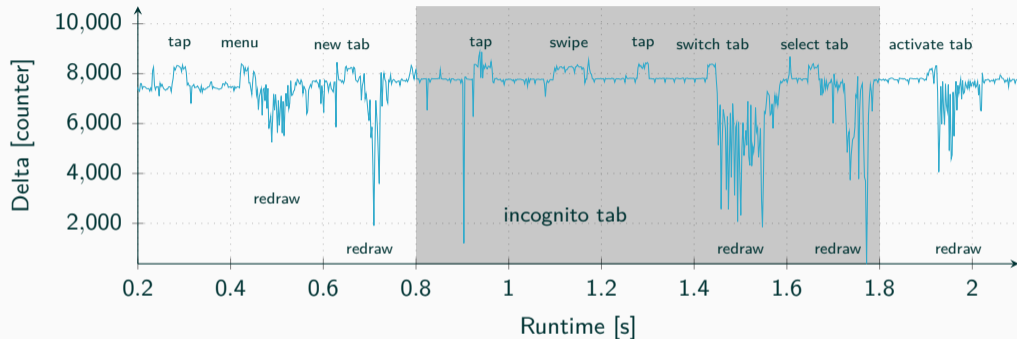


Figure 6: Keystroke timing attack running while switching to a different tab in the Chrome browser on the Xiaomi Redmi Note 3.

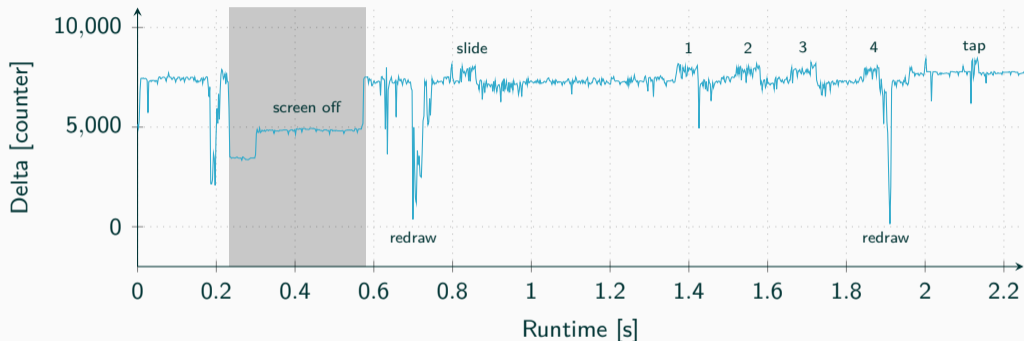


Figure 7: Keystroke timing attack running in the Firefox browser on the Xiaomi Redmi Note 3. While the user locked the screen, the application still detects keystrokes as long as it is executed on the last used tab.

Device	SoC	Keystrokes	Screen lock
Google Nexus 5	Qualcomm MSM8974 Snapdragon 800	✓	-
Xiaomi Redmi Note 3	Mediatek MT6795 Helio X10	✓	✓
Homtom HT3	MediaTek MTK6580	✓	✓
Samsung Galaxy S6	Samsung Exynos 7420	-	✓
OnePlus One	Qualcomm MSM8974AC Snapdragon 801	✓	✓
OnePlus 3T	Qualcomm MSM8996 Snapdragon 821	-	-

Table 1: Mobile test devices.

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- Utilize `XMLHttpRequest` to fetch a network resource from an invalid URL to implicitly issue an interrupt

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- Transmission rate
 - Raw transmission rate of 25 bps using a sample interval of 40 ms

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 - Per-page level access control to APIs, e.g., web workers

Conclusion

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- Highly practical, as it runs in background to spy on other tabs and applications

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