WebSec: Securing Web-driven Systems

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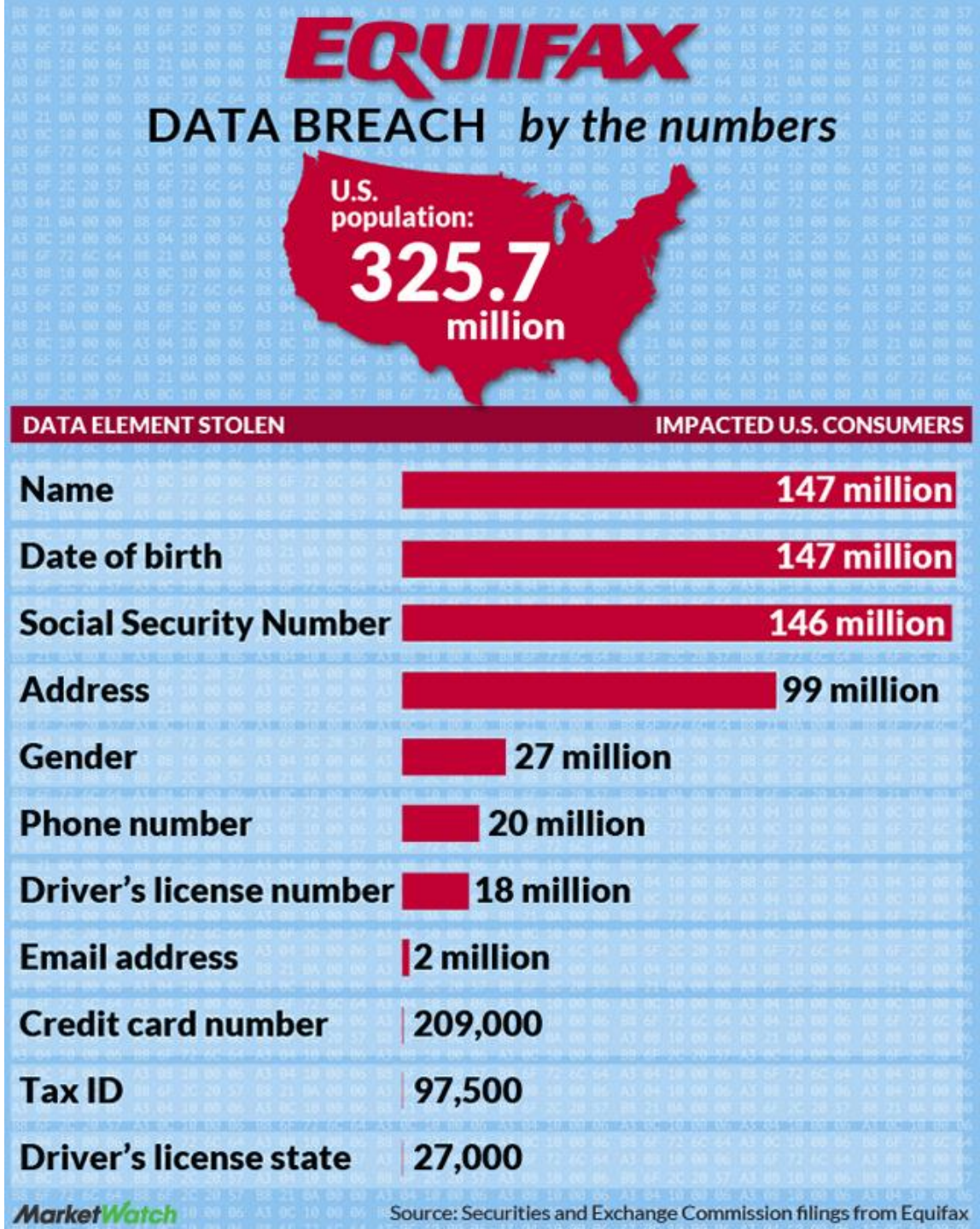
2017 Equifax data breach

- Web code injection attack
- Open-source web framework Apache Struts

Web vulnerabilities and attacks like cross-site scripting (XSS) are the lion's share for companies like Google



JavaScript at the heart of the web

- JavaScript at the heart of the modern web
  - Client-side, server-side, browser extensions
  - Third-party code everywhere
  - Typical news web site: scripts from ~100 sources
    - Libraries, gadgets, ads, analytics, tracking, fingerprinting,..
- Malicious/buggy JavaScript
  - Exfiltrating private information
  - Malwartising
  - Defacing web sites
  - Phishing attacks

Securing JavaScript essential

Mixpanel analytics accidentally slurped up passwords

Posted Feb 5, 2018 by Josh Constine (@joshconstine)

The passwords of some people using sites monitored by popular analytics provider Mixpanel were mistakenly pulled into its software.

Goals

- Developing a comprehensive solution for XSS
- Tackling the challenge of JavaScript security
- Building a principled framework for system-wide security
- Demonstrating practical impact in collaboration with industry

Project highlights

- World-leading publication record
  - Published 6 papers in all "Big Four" security conferences, all A*
    - USENIX Security Symposium (USENIX Sec) 2022, among 256 papers out of 1423 (18%)
    - IEEE Security & Privacy Symposium (S&P) 2021 (two papers), among 115 papers out of 952 (12.1%).
    - USENIX Security Symposium (USENIX Sec) 2021, among 248 papers out of 1319 (18.8%)
    - ACM Conference on Computer and Communications Security (CCS) 2018, among 134 papers out of 809 (16.6%)
    - Network and Distributed System Security Symposium (NDSS) 2019, among 149 papers out of 933 (16%)
  - Other A* publications, top in Web, Programming Languages, and Verification
    - Web Conference (WWW) 2020
    - ACM Symposium on Principles of Programming Languages (POPL) 2019, 2022
    - Computer-Aided Verification (CAV) 2019
- Putting theory to work for practice: WebSec tools
  - AutoNav https://www.cse.chalmers.se/research/group/security/autonav
  - Black Widow https://github.com/SecuringWeb/BlackWidow
  - JSFlow https://jsflow.net
  - OSTRICH https://github.com/uuverifiers/ostrich
  - SandTrap https://github.com/sandtrap-monitor/sandtrap
- Educational tool: Information Flow Challenge: https://ifc-challenge.appspot.com
- Passed the mid-term project evaluation with the top grade ☺

Malicious Browser Extensions

ars TECHNICA

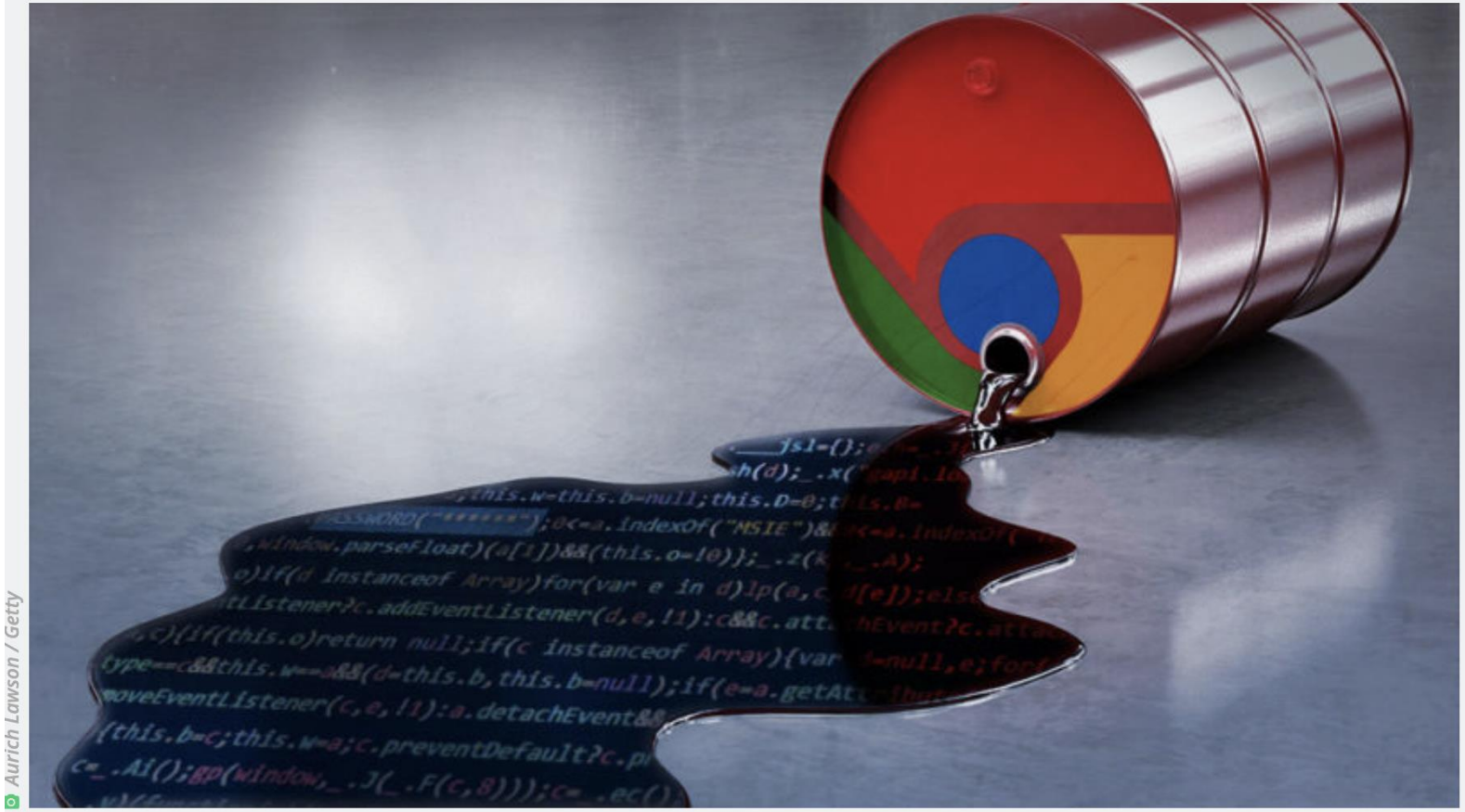
BIZ & IT TECH SCIENCE POLICY CARS GAMING & CULTURE STORE

DON'T TRUST EXTENSIONS —

My browser, the spy: How extensions slurped up browsing histories from 4M users

Have your tax returns, Nest videos, and medical info been made public?

DAN GOODIN - 7/18/2019, 2:00 PM

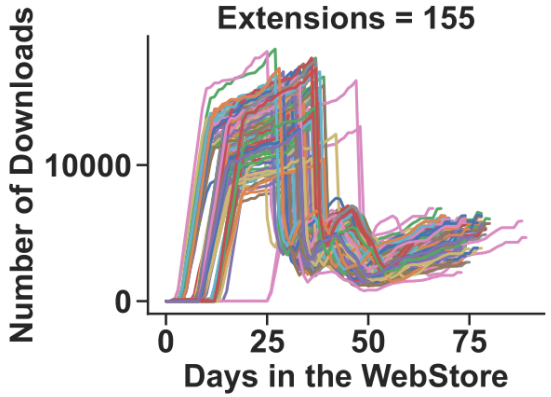


Aurich Lawson / Getty

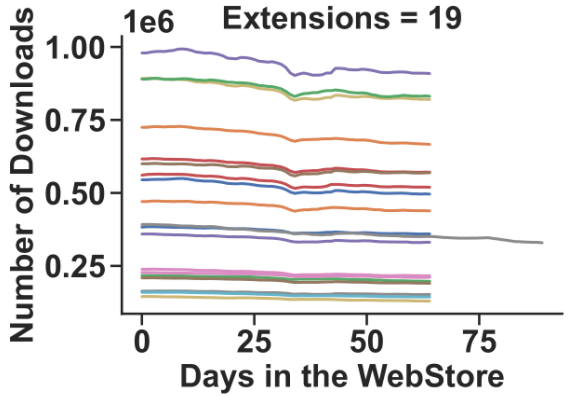
No Signal Left to Chance: Driving Browser Extension Analysis by Download Patterns

Joint work with Pablo Picazo and Benjamin Eriksson

- Train machine learning algorithm on deleted extensions
- Use alive ones for validation
- Found 326 malicious extensions by the download signal alone
- Additional 6,579 when combining with static analysis
- 4,858 have been removed so far

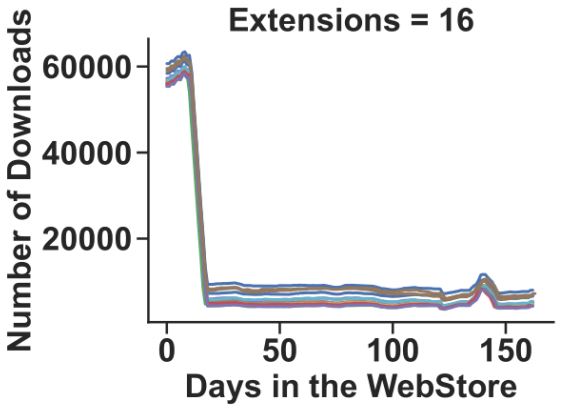


(a) TabHD extensions

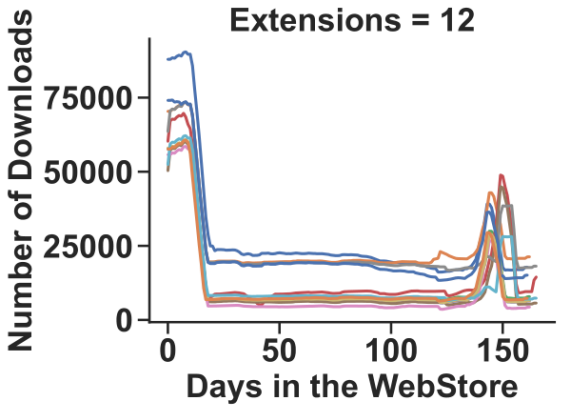


(b) MyWay extensions

Malicious



(a) FreeAddon extensions



(b) FreeAddon extensions

Benign

Utilization and dissemination

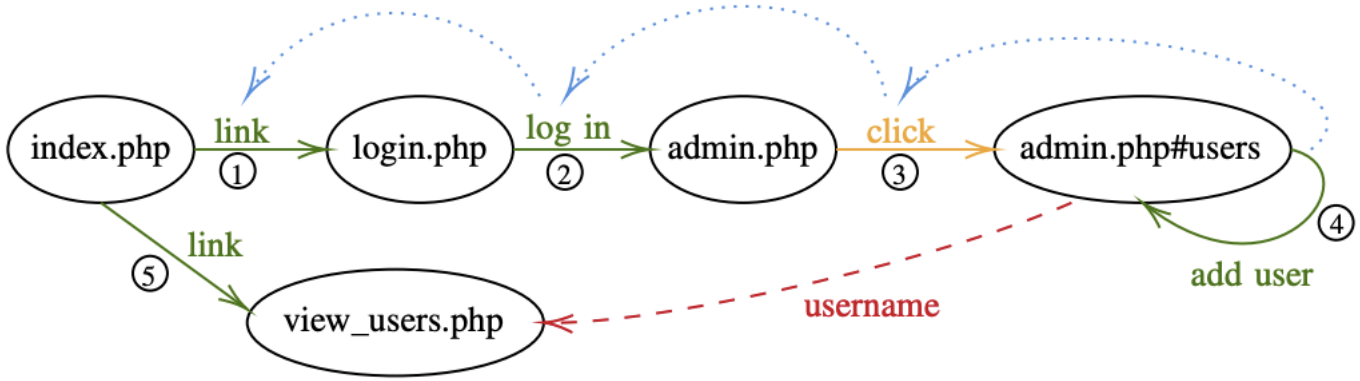
- Patent granted on securing web-driven trigger-action systems
- Acknowledged vulnerability discovery in industrial software
  - IFTTT, Zapier, Node-RED, CIVS, EasyChair, WordPress, osCommerce, HotCRP,…
- Collaboration with Chalmers Innovation System
- Utilization
  - Boost adoption potential of BlackWidow and JSFlow
  - BlackWidow and JSFlow prototypes for security testing
- Educational tool: Information Flow Challenge https://ifc-challenge.appspot.com

WebSec: Securing Web-driven Systems

https://www.cse.chalmers.se/research/group/security/websec

Extra slides

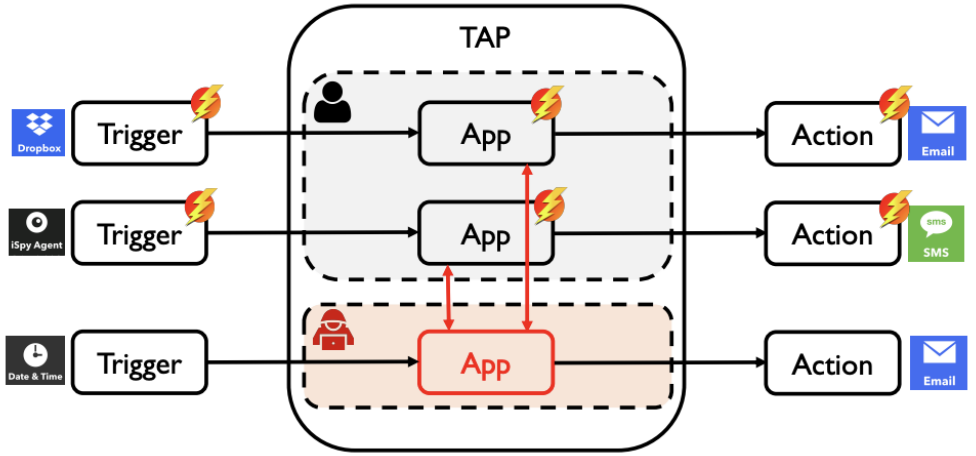
Crawling 2.0



- Black Widow https://github.com/SecuringWeb/BlackWidow
- Navigation modeling, including clicks and form submissions
- Traversing, with global workflows
- Tracking inter-state dependencies
- Code coverage improvement: up to 280% wrt other crawlers
- Found new XSS vulnerabilities in production software
  - HotCRP, osCommerce, PrestaShop, and WordPress

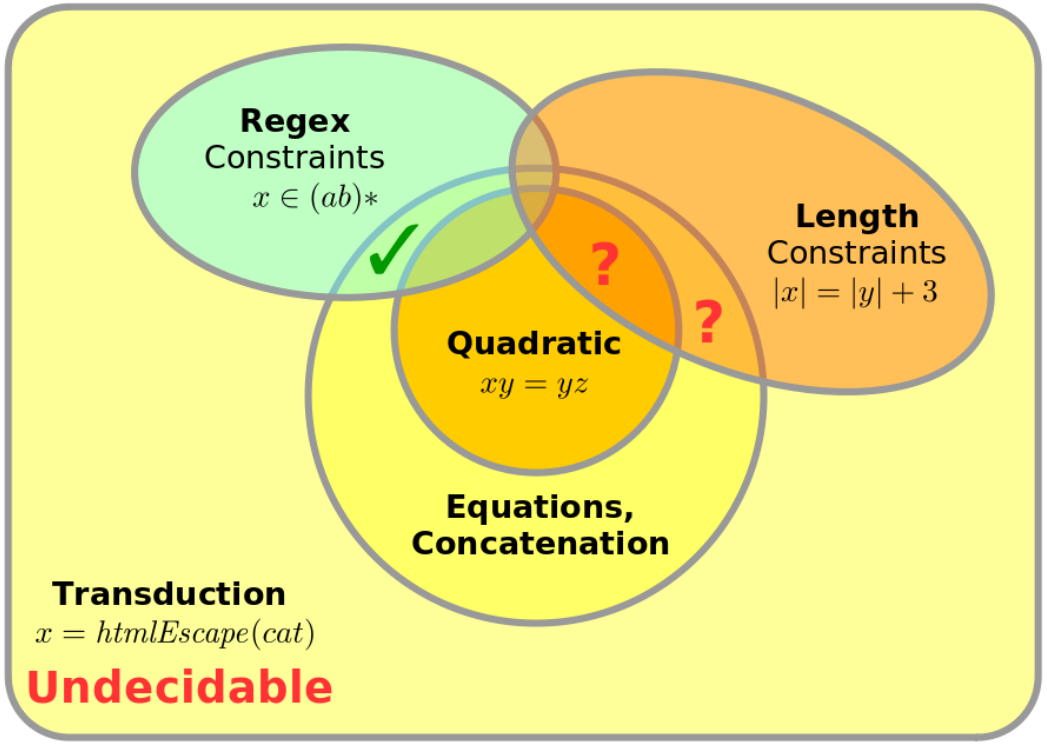
Securing JavaScript

- SandTrap https://github.com/sandtrap-monitor/sandtrap
- JavaScript sandbox breakouts
  - IFTTT, Zapier, Node-RED
  - Coordinated disclosure
- SandTrap monitor to enforce policies
  - Baseline and advanced
  - Module-, API-, value-, and context-level
- Benchmarking on IFTTT, Zapier, Node-RED



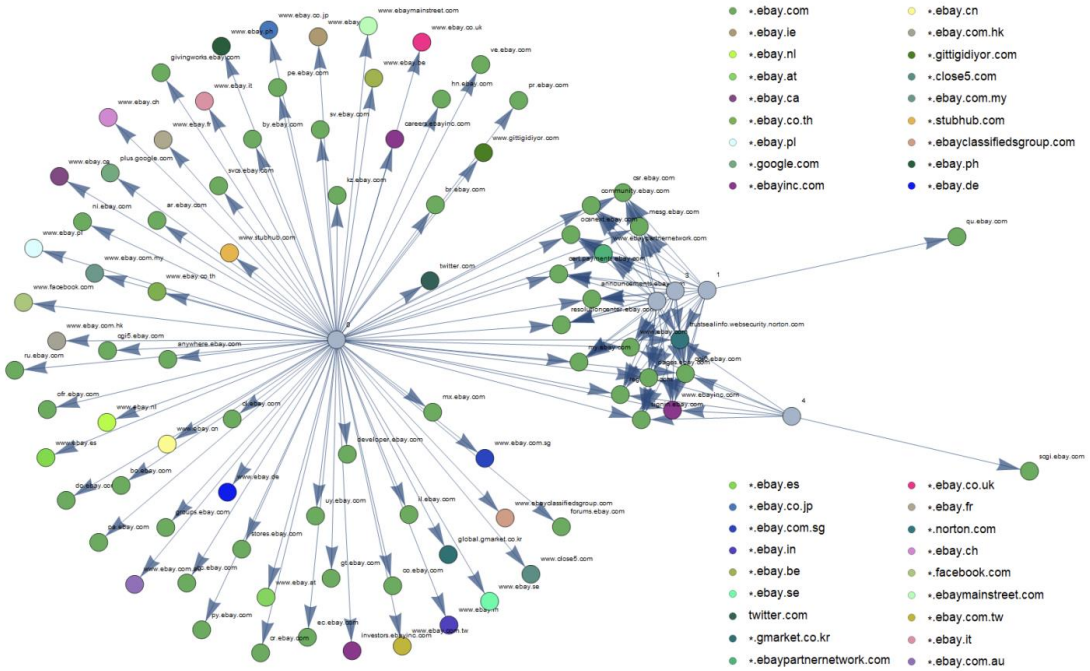
SMT Methods for Strings

- OSTRICH https://github.com/uuverifiers/ostrich
- Solver for expressive combination of string constraints:
  - Word equations
  - Regular expressions
  - Transformations (e.g., escaping)
  - Length constraints
- Wide range of applications:
  - Symbolic execution, verification
  - Web crawling, scanning
  - Testing, white-box fuzzing, etc.



Web Navigation Policies

- AutoNav
  https://www.cse.chalmers.se/research/group/security/autonav
- New `navigate-to` directive proposed by W3C
- Opening for privacy attacks
  - Login detection
  - Shopping card exfiltration
- Specification- and implementation-level
- AutoNav to infer navigation policies
- Input to W3C standardization and vendors
  (Firefox and Chrome)



Browser Fingerprinting

- JSFlow https://jsflow.net
- Gather browser-specific info from sources
  - Fonts, canvas, screen resolution,…
- Combine and sent to network sink
- JSFlow to track the trackers!
- Analysis of categories
  - Analytics
  - Authentication (Banks)
  - Bot detection
  - Tracking by fingerprinting