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Behind the Scenes of Online Attacks: an Analysis of Exploitation Behaviors on the Web

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Motivations

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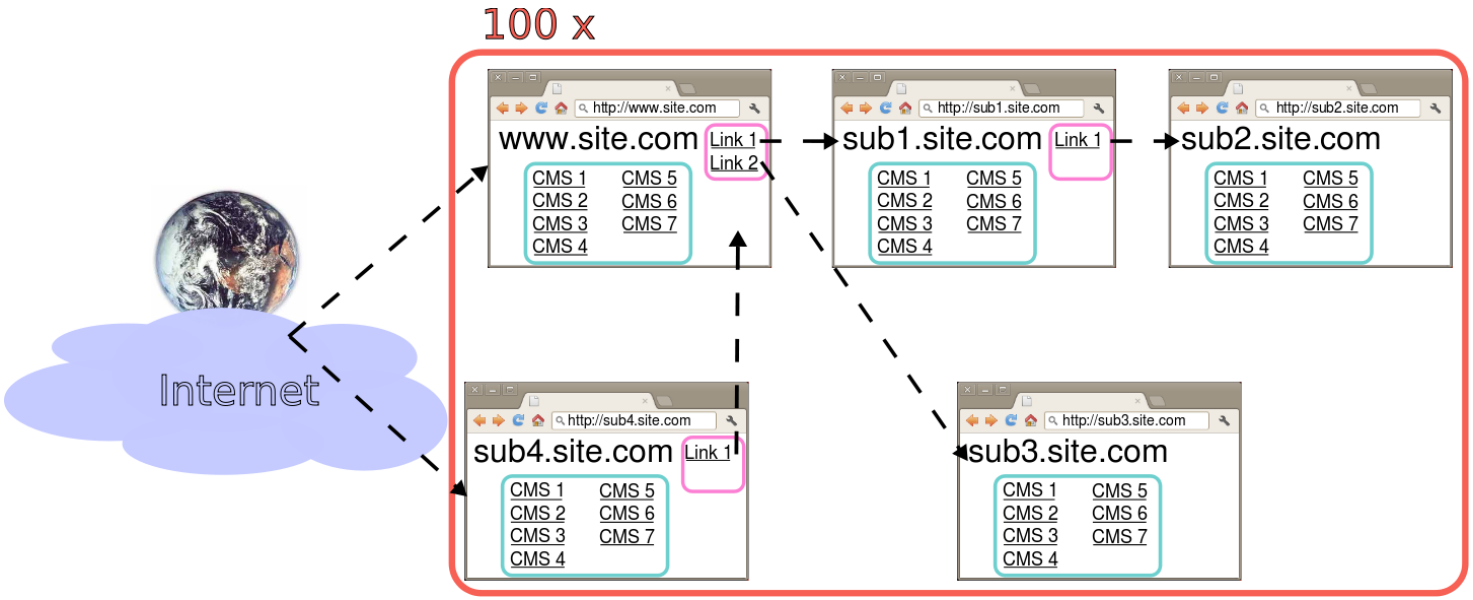
- Studying the internals of web attacks
  - What attackers do while and after they exploit a vulnerability on a website
  - Understand why attacks are carried out (fun, profit, damaging others, etc.)

- Previous studies
  - how attacks against web sites are carried out
  - how criminals find their victims on the Internet
  - Lack of studies on the behavior of attackers (what they do during and after a typical attack)
    - » Previous works used static, non functional honeypots (not exploitable)

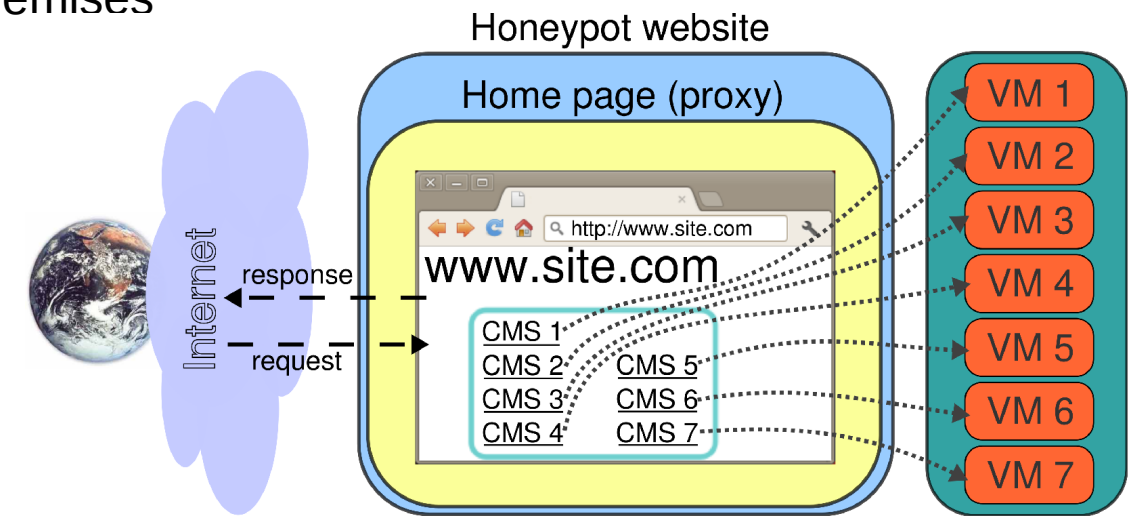
How



- 2500 vulnerable applications deployed on 500 websites on 100 domain hosted on 9 popular hosting providers
  - 5 common CMSs (blog, forum, e-commerce web app, generic portal, SQL manager), 1 static website and 17 PHP web shells

Data collection

- 100 days of operation
- Centralized data collection for simple and effective management
- Each deployed website acts as a proxy
  - Redirects traffic to the real web applications installed on VMs in our premises



Collected data

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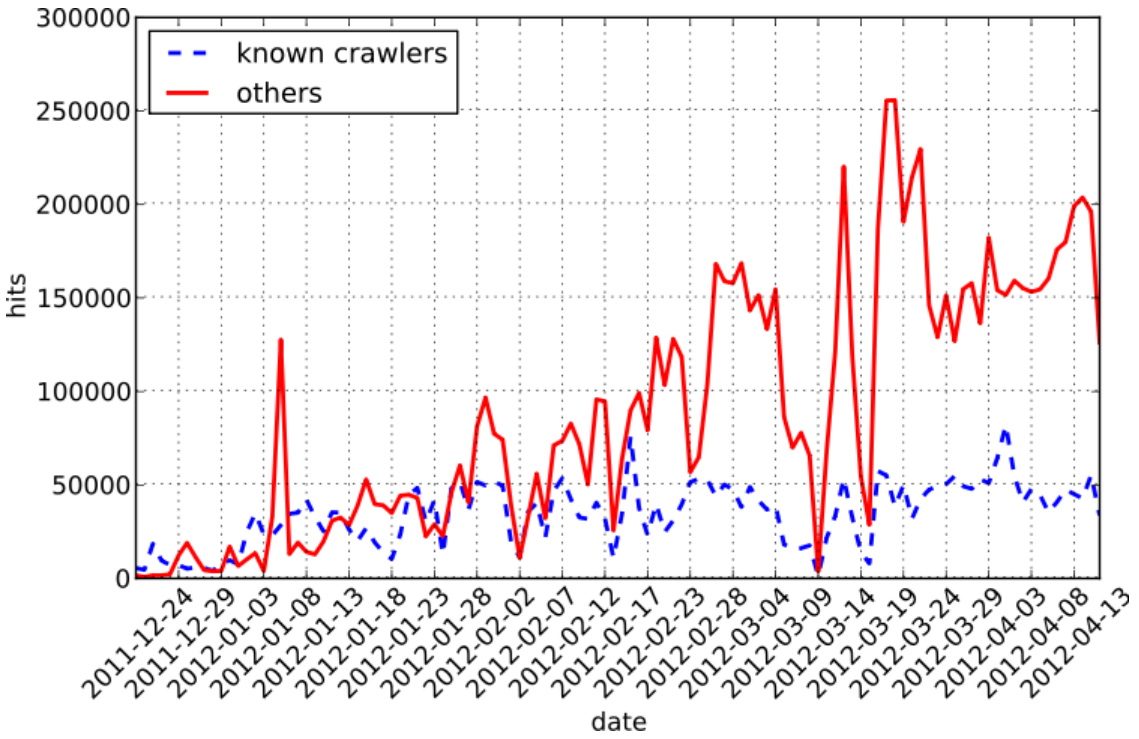
- ~10 GB of raw HTTP requests
- In average:
  - 1-10K uploaded files every day
  - 100-200K HTTP requests/day
- First suspicious activities:
  - automated: 2h 10' after deployment
  - manual: after 4h 30'

Requests volume



Requests by country
(excluding known crawlers)

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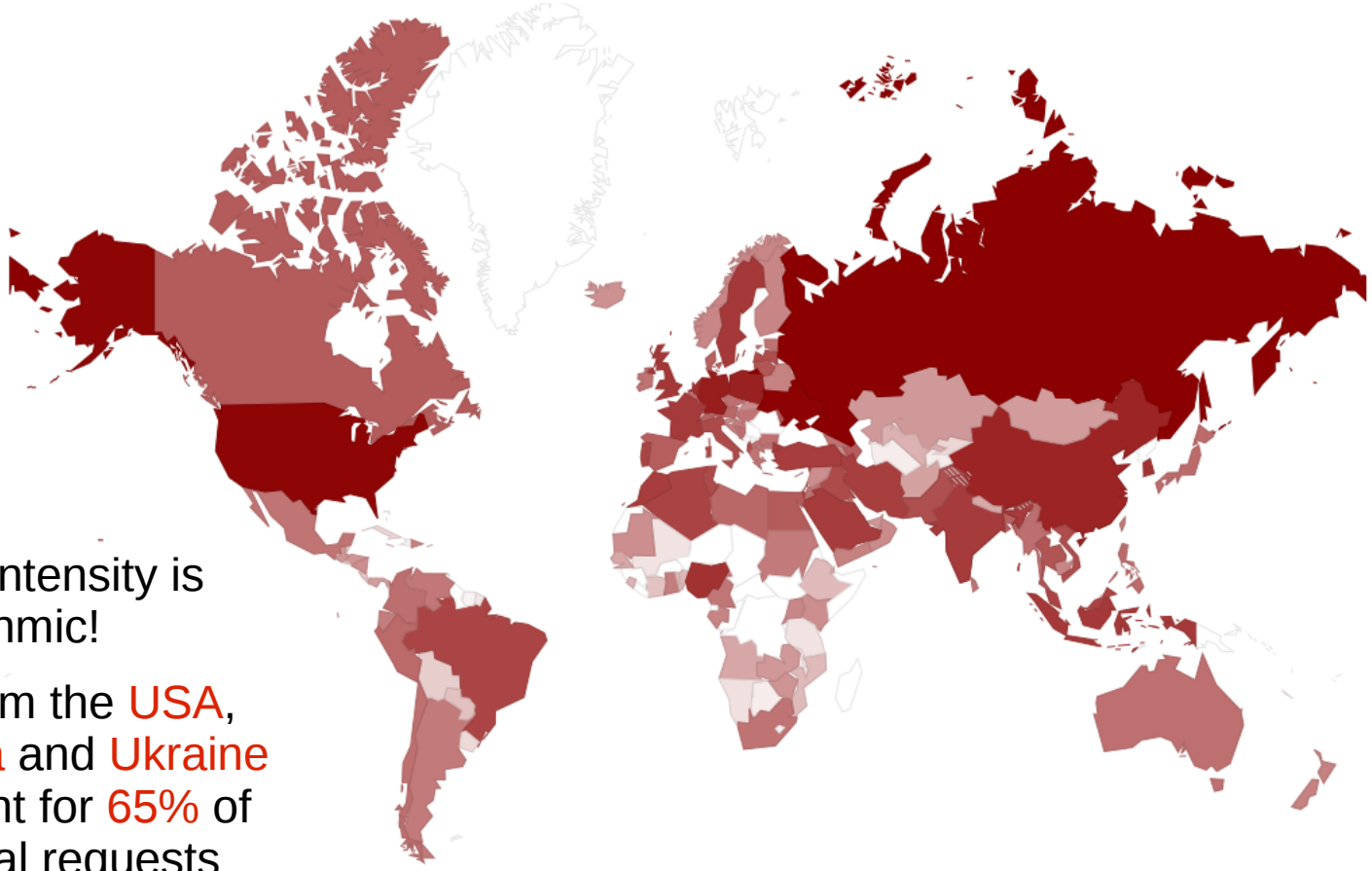

- Color intensity is logarithmic!
- IPs from the USA, Russia and Ukraine account for 65% of the total requests

Attack analysis

The four different phases

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1. Discovery: how attackers find their targets
   - Referer analysis, dorks used to reach our websites, first suspicious activities

69.8% of the attacks start with a scout bot visiting the pages often disguising its User-Agent

Attack analysis

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In 84% of the cases, the attack is launched by a 2nd automated system, not disguising its User-Agent (exploitation bot)

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   - Exploits detection and analysis, exploitation sessions, uploaded files categorization, and attack time/location normalization
   - Analysis of forum activities: registrations, posts and URLs, geolocation, message categories

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4. Post-Exploitation: second stage of the attack, usually carried out manually (optional)
   - Session identification, analysis of shell commands

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3.5 hours after a successful exploit, the typical attacker reaches the uploaded shell and performs a second attack stage for an average duration of 5' 37”

Attack analysis

phases #1-2: discovery - reconnaissance

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- Discovery: referer shows where visitors are coming from
  - Set in 50% of the cases
  - Attackers find our honeypots mostly from search engine queries (in the order: Google, Yandex, Bing, Yahoo)
  - Some visits from web mail services (spam or phishing victims) and social networks

Attack analysis

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- Reconnaissance: how were pages visited?
  - 84% of the malicious traffic was from automated systems
    - No images or style-sheets requested
    - Low inter-arrival time
    - Multiple subdomains visited within a short time frame
  - 6.8% of the requests mimicked the User-Agent string of known search engines

Attack analysis

phase #3: exploitation

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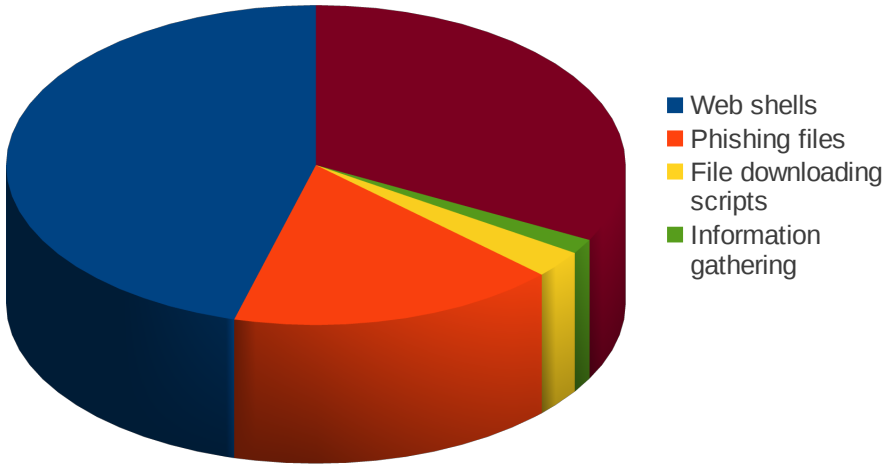
- 444 distinct exploitation sessions
  - Session = a set of requests that can be linked to the same origin, arriving within 5' from each other
  - 75% of the sessions used at least once '`libwww/perl`' as User-Agent string → scout bots and automatic attacks

- Almost one exploitation out of two uploaded a web shell, to continue the attack at a later stage (post-exploitation)



Attack analysis

phase #3: Forum activity

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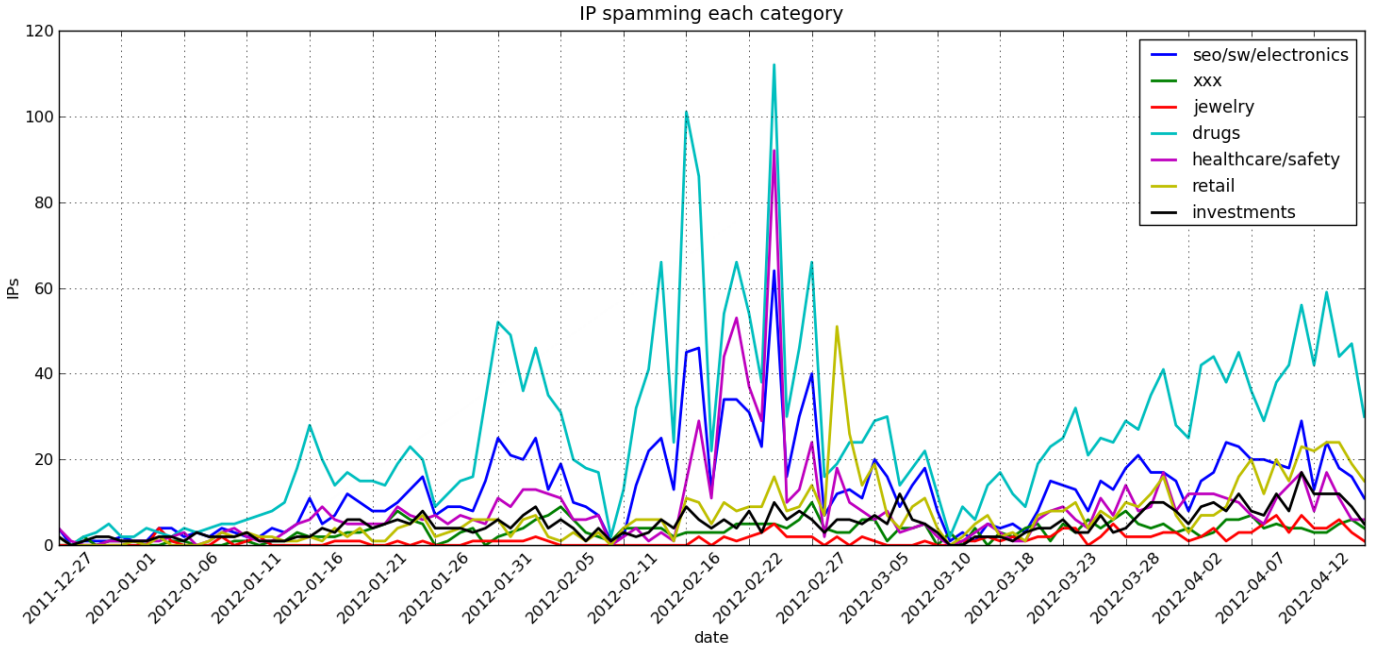
- Daily averages: 604 posts, 1907 registrations, 232 online users
  - One third of the IPs acting on the forum registered at least one account, but never posted any message → any business related to selling forum accounts?
- ~1% of the links posted to the forum led to malicious content†



† According to Google SafeBrowsing and Wepawet

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phases #3-4

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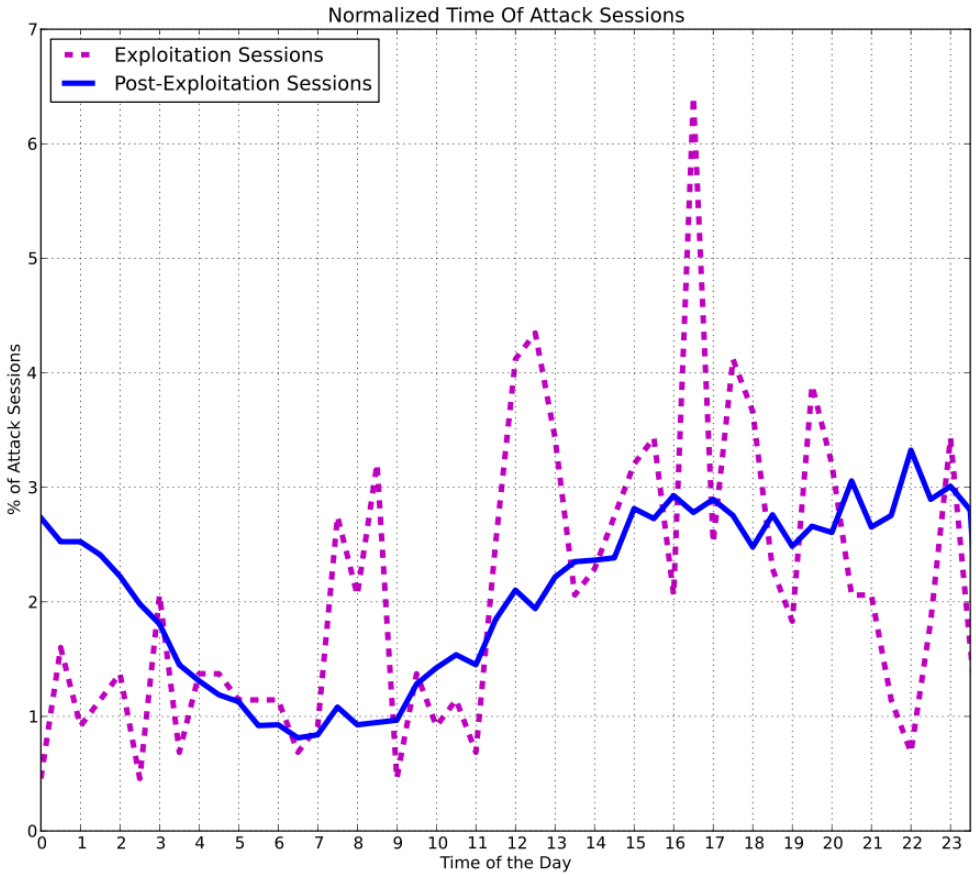
- Clear hourly trends for post-exploitation (manual) sessions



Attack analysis

phase #4: post-exploitation

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- Almost 8500 interactive sessions collected
  - Known and unknown web shells
  - Average session duration: 5' 37”
    - 9 sessions lasting more than one hour
  - Parsed commands from the logs
    - 61% of the sessions upload a file to the system
    - 50% of the sessions (try to) modify existing files
      - Defacement in 13% of the cases

Attacker goals

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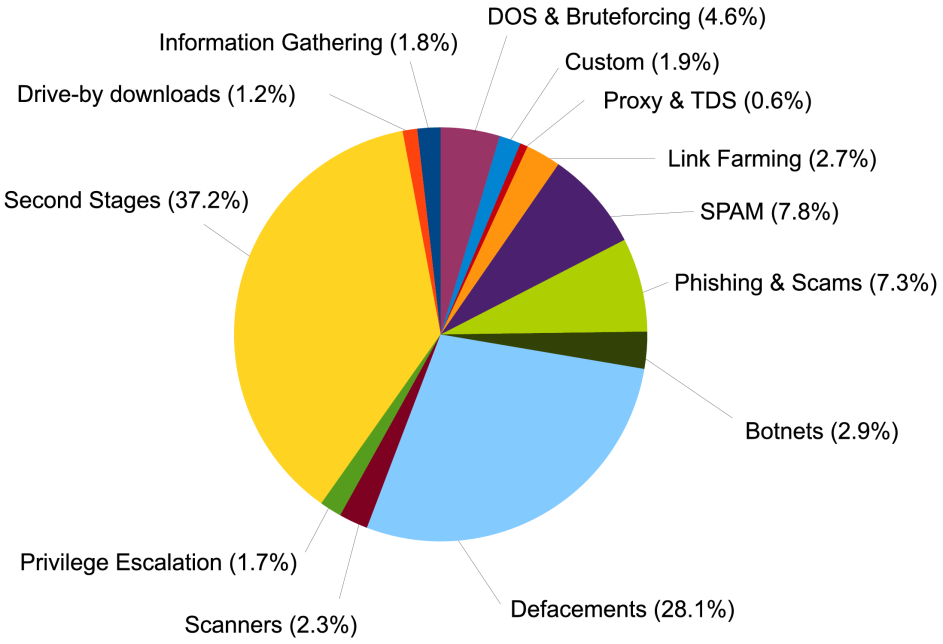
- The analysis of collected files allows to understand the attackers' goals
  - » File normalization and similarity-based clustering
  - » Manual labeling of clusters



Clustering example

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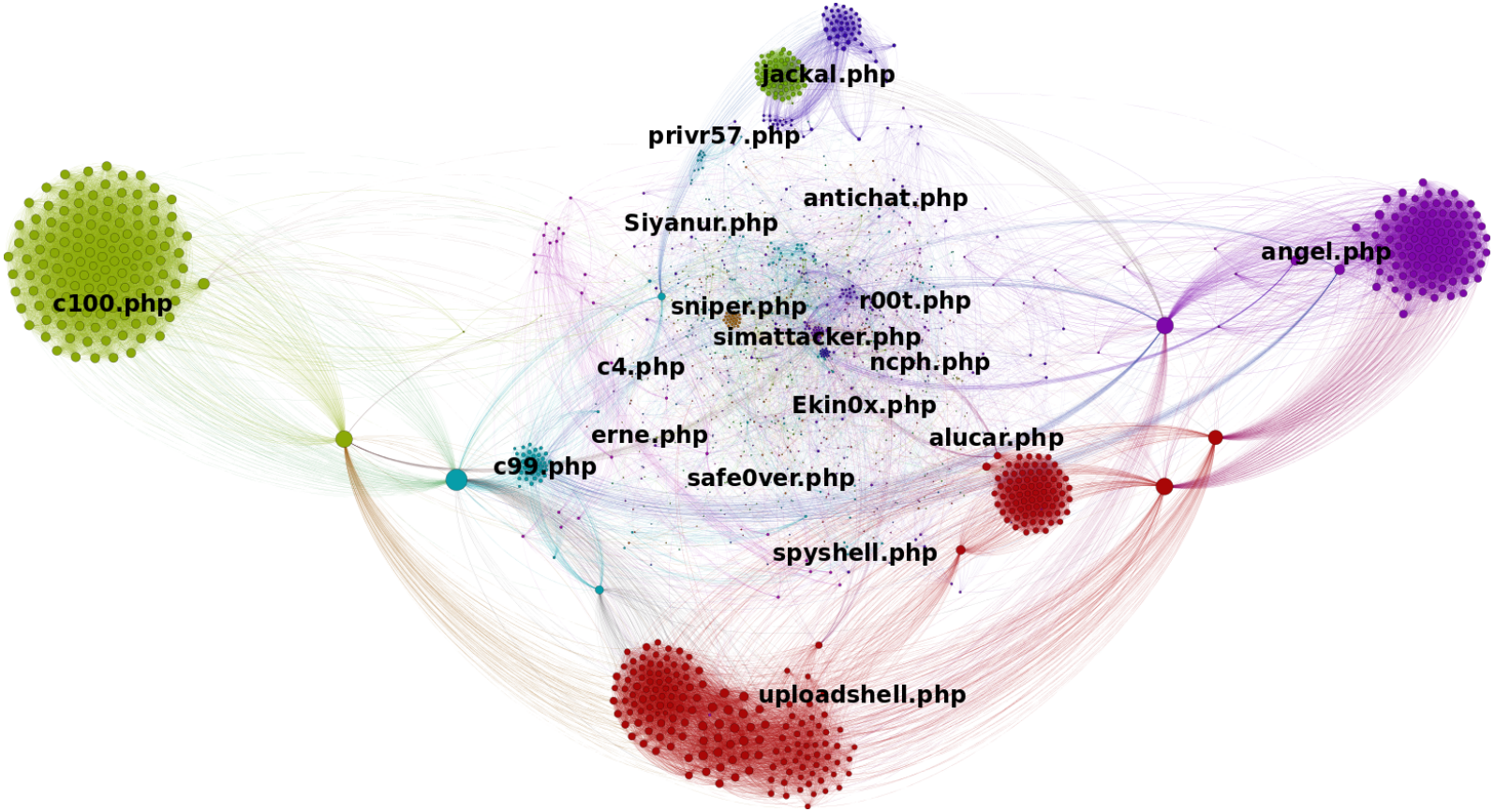
- Similarity clustering on web shells (ours are labeled)



Conclusions

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- The study confirmed some known trends
  - Strong presence of Eastern European countries in spamming activities
  - Scam and phishing campaigns often run from African countries
  - Most common spam topic: pharmaceutical ads
- Unexpected results
  - Most of the attacks involve some manual activity
  - Many IRC botnets still around
  - Despite their low sophistication, these represent a large fraction of the attacks to which vulnerable websites are exposed every day

Thank you

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For further questions, suggestions, comments:

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