Big Data and Computer Security

DNS & botnets

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Introduction

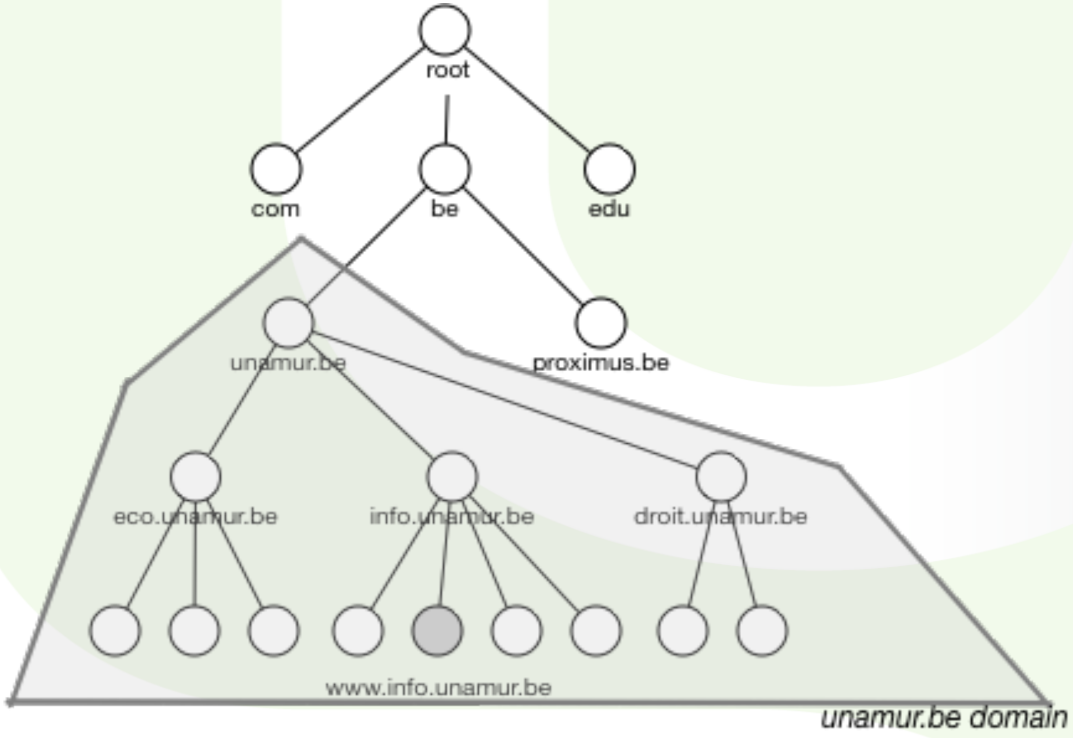
- Objectives
  - define and structure a global approach solve the problem
  - identify useful features
  - apply visualization techniques
  - analyse data
- The important thing to demonstrate is your ability to analyze a problem in depth, and identify the elements and methods that can help you solving it

Domain Name System – DNS

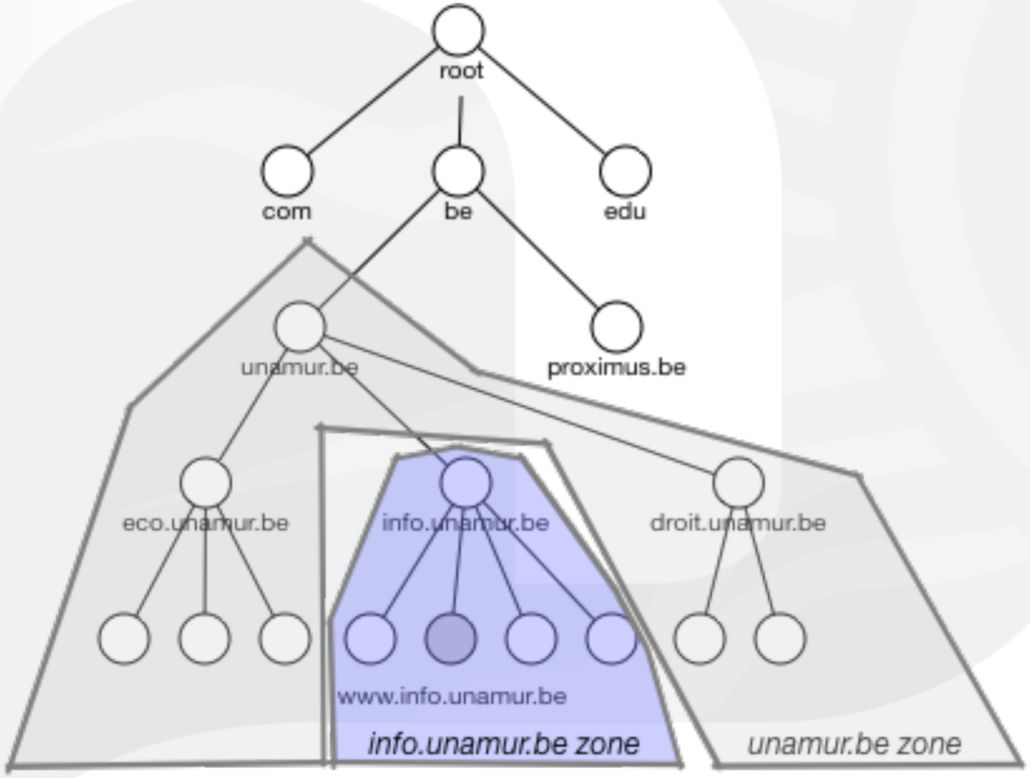
- Originally defined in RFC1034 & RFC1035, further developed and extended in many other RFCs
- Usually transported over UDP, but also over TCP, on port 53
- Client/server protocol
- Actors
  - [Client] needs to resolve a name
  - [Resolver] builds and sends the queries to the nameserver and processes the response
  - [NameServer] handles queries and produces responses

DNS Protocol: domain vs zone

DNS Domain



DNS Zone



DNS Protocol: recursive vs iterative query

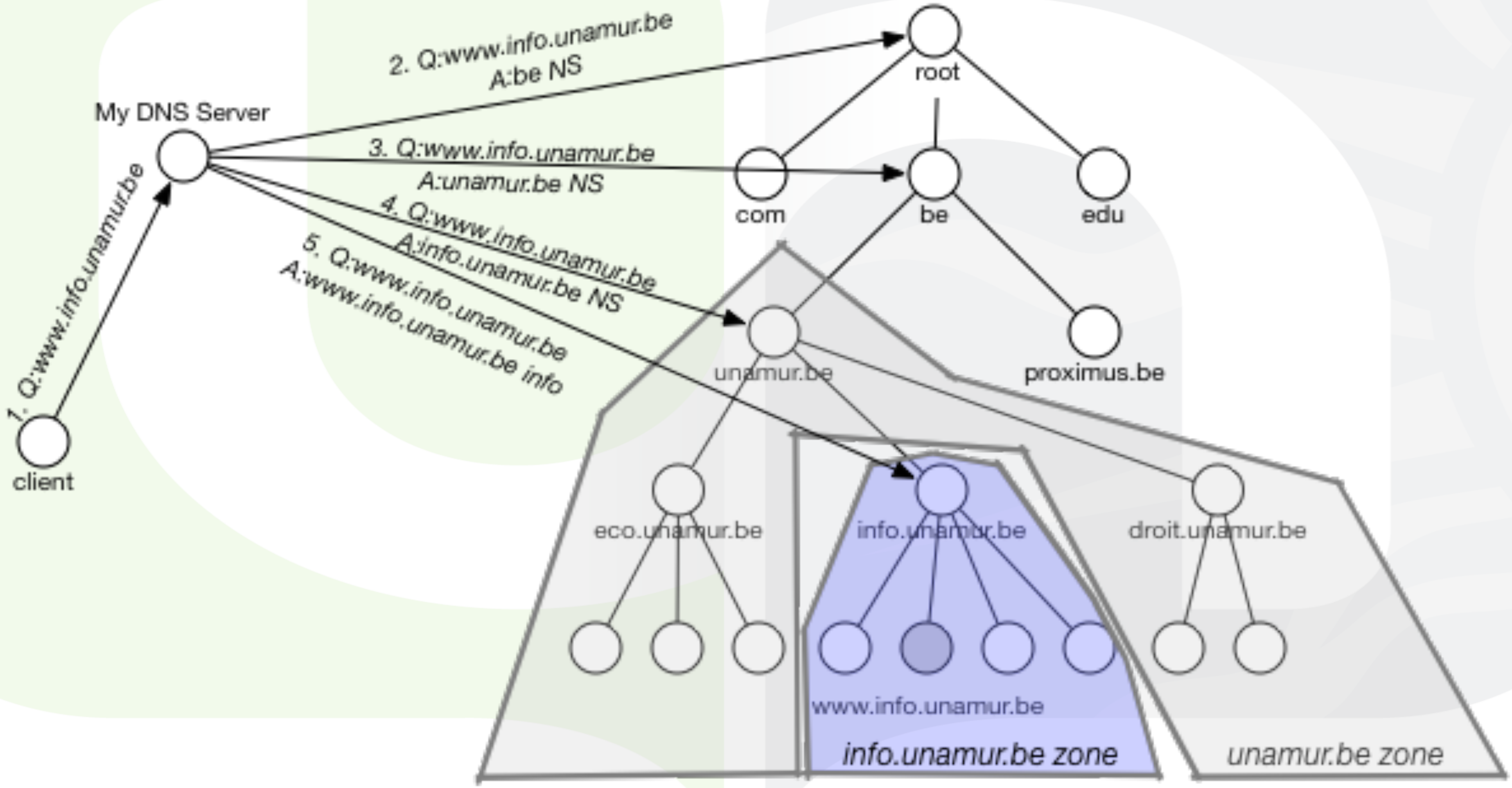
Recursive

- queried nameserver has to reply with the requested information if it exists, with an error otherwise. It can't refer to another authority

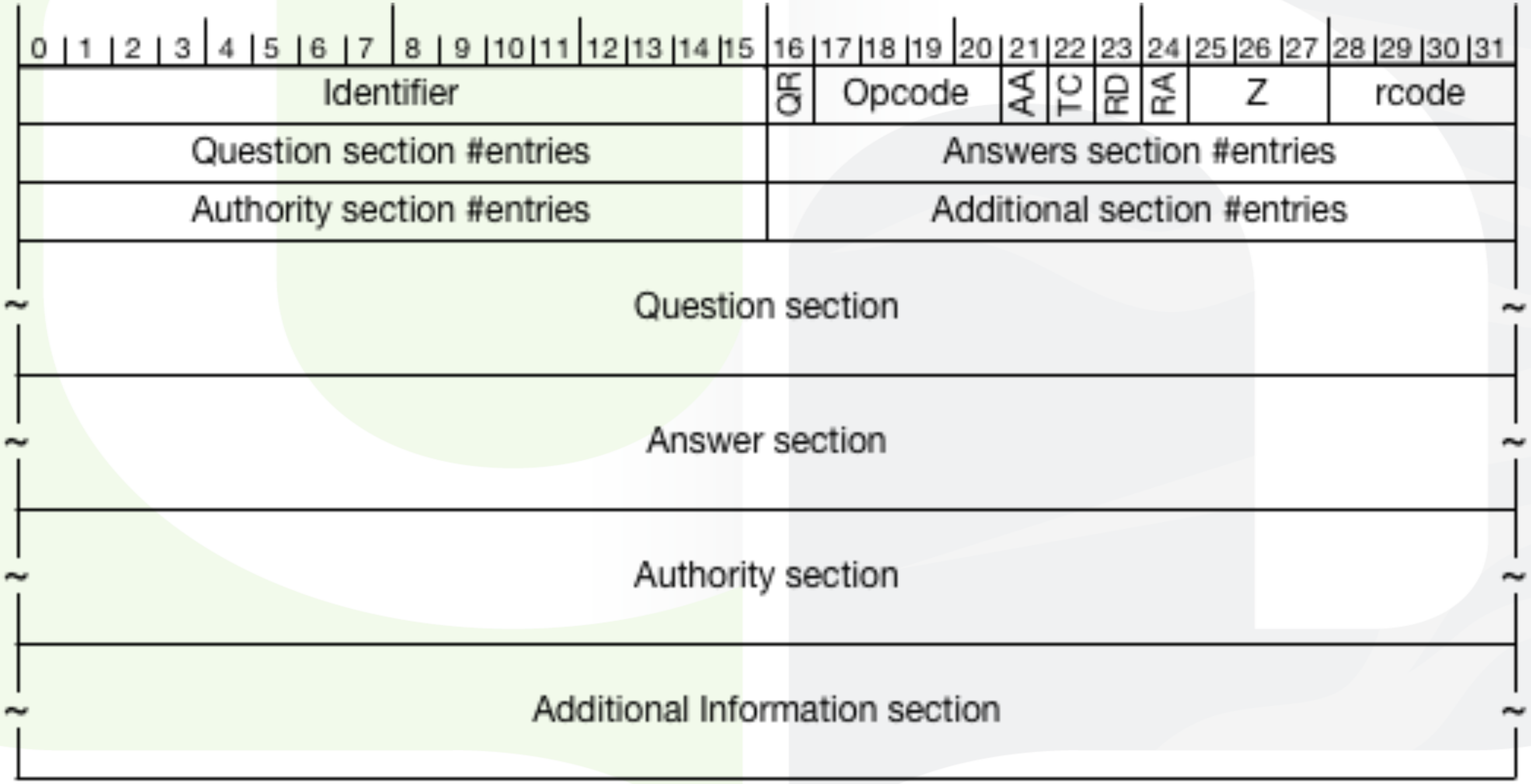
Iterative (non-recursive)

- queried nameserver replies with the best answer *it already knows*; if it doesn't know the answer to the query, it returns data about the nameservers closest to the domain name in the query *in its local data*

DNS Protocol: DNS query



DNS Protocol: message (query & response)



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<tr><td colspan="16">Identifier</td><td>QR</td><td colspan="4">Opcode</td><td>AA</td><td>TC</td><td>RD</td><td>RA</td><td colspan="3">Z</td><td colspan="4">rcode</td></tr>
<tr><td colspan="16">Question section #entries</td><td colspan="16">Answers section #entries</td></tr>
<tr><td colspan="16">Authority section #entries</td><td colspan="16">Additional section #entries</td></tr>
<tr><td colspan="32">Question section</td></tr>
<tr><td colspan="32">Answer section</td></tr>
<tr><td colspan="32">Authority section</td></tr>
<tr><td colspan="32">Additional Information section</td></tr>
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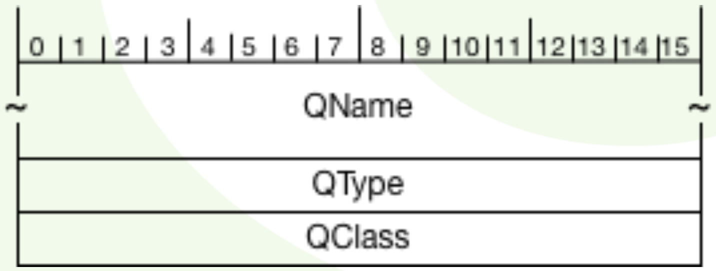
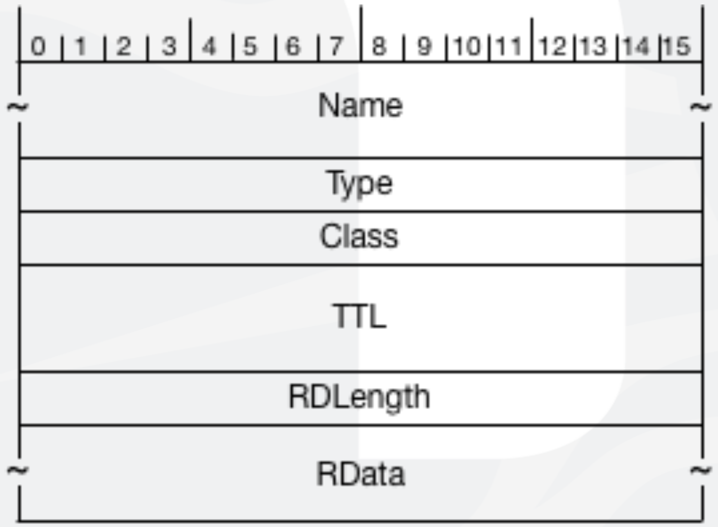
DNS Protocol: message (query & response)

DNS Question



DNS Resource Record (RR)



DNS Protocol: RR types

- IP addresses and names: A, AAAA, PTR, CNAME
- NS authority: NS, SOA
- Mail information: MX
- DNSSEC Info and keys
- Additional information: TXT, HINFO, MINFO
- See http://www.iana.org/assignments/dns-parameters/dns-parameters.xhtml

DNS uses and abuses

- Some for good
  - [RFC5782] management of domains blacklists
  - [RFCs 4034,4025,2535,2930,2230,4255…] management of cryptographic materials (RRSIG, DNSKEY, NSEC RRs..)
  - [RFC4408,6376] email validation (SPF – Sender Policy Framework, DKIM – Domain Keys Identified Mail signatures)
- Some for bad
  - [DNS signaling] use DNS queries to exfiltrate stolen data; use DNS responses to send commands from C&C to bots
  - [DNS tunneling] use DNS message to tunnel protocols like http, ftp…

Botnets

- What is a botnet?
  - a system of computers that are under the control of a criminal (the botmaster), after having been infected by a piece of malware that took advantage of a vulnerability or exploit to provide remote access and control of the machine
- What is it used for?
  - sending spam
  - carry out DDoS attacks
  - data and identity theft
  - illegal file storage and sharing
  - spread of malicious pieces of payload
  - proxy malicious communications (to hide mothership)
  - manipulation of polls, cracking of passwords…

Botnet topologies

- Star topology
  - not very resilient or resistant to detection
- Multi-server topology, with interconnected servers
  - a bit better
- Tree (hierarchical) topology
  - not the full tree is visible to everyone
  - resilient to the take down of a subtree
  - possible to rent part of the botnet
- Random topology
  - no central C&C
  - P2P communications

Botnet communications

- Why?
  - send commands (C&C → bots)
  - send code updates (C&C → bots)
  - send collected data (bots → C&C)
- Channels
  - IRC
  - HTTP
  - P2P
  - DNS
  - pop3, SMS…
- Most require the IP of the C&C node

Botnet & DNS

- How does a bot reach C&C?
  - knowing its IP address (easy to trace)
  - knowing its domain name and using DNS to lookup IP (single IP: easy to trace)
  - knowing its domain name and using DNS to lookup IP (multiple rotating IPs : difficult to trace)
  - knowing its domain nameS and using DNS to lookup IP (multiple names, rotating IPs: difficult to trace)
  - use multiple NameServers
  - use proxy bots to proxy between bots and C&C and hide actual C&C identity

Fast Flux services – domain flux

- A single IP address is mapped to multiple domains, either known by bots or dynamically generated (DGA)
- Detection more difficult due to domain diversity (incl. TLD)
- Wildcarding subdomains: define a RR *.mydomain.com with 1 IP, and have bots query for <anything>.mydomain.com; botmaster knows which bots are active
- Domain Generation Algorithms (DGA): botmaster regularly generates a set of domain names and registers/unregisters them quickly; only one is used as C&C; bots have to look up names until the find the right one
  - Ex. Conficker-C generated 50.000 domains per day, distributed across 110 TLDs

Fast Flux services – IP Flux

- A single domain is mapped to multiple IP addresses; using multiple addresses decreases the probability of detection
    - [single flux] relies on `honest' DNS servers; bots send DNS queries and NS responds with rotating addresses for C&C
    - [double flux] introduces an extra level of indirection; relies on `honest' and `fake' DNS servers; bots send queries to honest NS, which refers to `fake' or compromised NS with rotating addresses; here it is the addresses of NS that rotate

Botnet & DNS

- What could reveal the presence of a bot on your network?
    - query name
        - dictionary words?
        - # different characters? # digits? special characters?
        - name length? # domain components?
        - suspicious names (ex. -Yahoo or Microsoft as 3LD)
    - multiple machines looking for similar names may reveal infected machines using DGA

Botnet & DNS

- What could reveal the presence of a bot on your network?
  - returned IP:
    - IP belongs to DSL lines
    - number of returned IP outside of common range (1-3)
    - multiple IP in different AS may reveal fastflux
  - use silent IP for communication between C&C and agents
    - use private IP (127.0.0.1, 192.168/16…) in response when C&C does not need to be contacted, to hide real C&C address

Botnet & DNS

- What could reveal the presence of a bot on your network?
  - TTL: a short TTL may indicate fastflux
  - packet length: long packets may indicate tunneling
  - #IP/domain over time: changing IPs for a domain may indicate fastflux
  - window (first seen-last seen): legitimate domains should resolve to consistent set, while malicious names should appear during limited windows of time

The project

- Objective
  - identify DNS queries that are likely to originate from a bot trying to reach its C&C center
- Practicalities
  - report file to be submitted on WebCampus
  - Deadline: June 15th, 2020 18:00CET

The project

- Some hints
  - define your goal
  - describe what you want to achieve, and how
  - implement several approaches, measure and compare them
  - re. visualization, scatter plots (Lecture 1. slide 37) and internal/external monitoring (Lecture 2. slides 12-16) may help

Resources

- https://cloud.info.unamur.be/index.php/s/KgLeRNkpXPDnZnq a set of pcap files captured on the university network, containing DNS packets only, unfiltered
- https://github.com/jncolin/dns_pcap_extractor a python script that parses a pcap file and extracts the DNS information; adapt to create a csv file with the information you need from header fields, questions and answers
- https://www.alexa.com/topsites probably contains valid URL
- http://www.malwaredomainlist.com/, http://www.malwaredomains.com/ or https://isc.sans.edu/suspicious_domains.html hopefully contain illegal domain names
- http://www.secrepo.com/misc/zeus_dga_domains.txt.zip contains 31000 DGA domains from Dec 2014
- http://www.secrepo.com/ contains pointers to numerous datasets of various kind

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