Now with more spiders!

PATHspider II: The Tutorial

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mami
measurement and architecture for a middleboxed internet

PATHspider

measurement | architecture | experimentation

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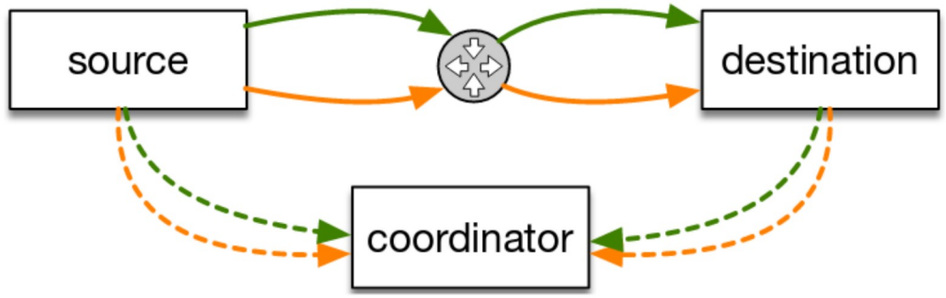
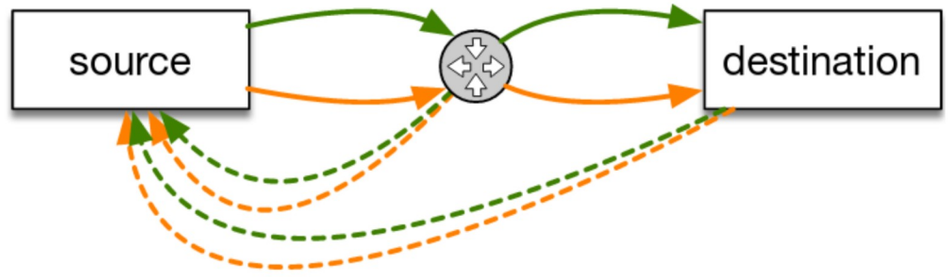
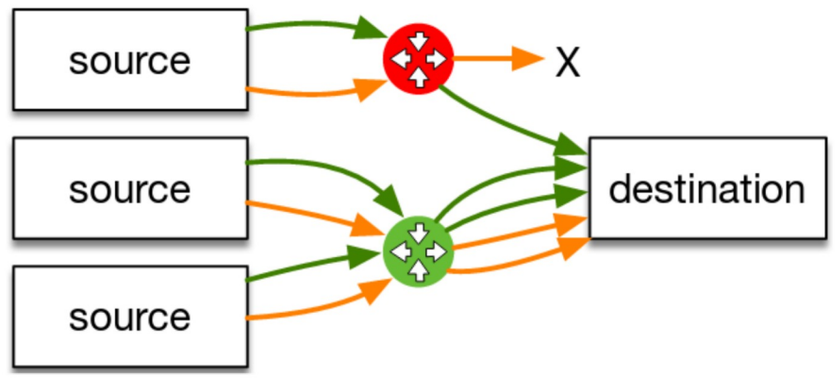
Active Measurement of Path Transparency

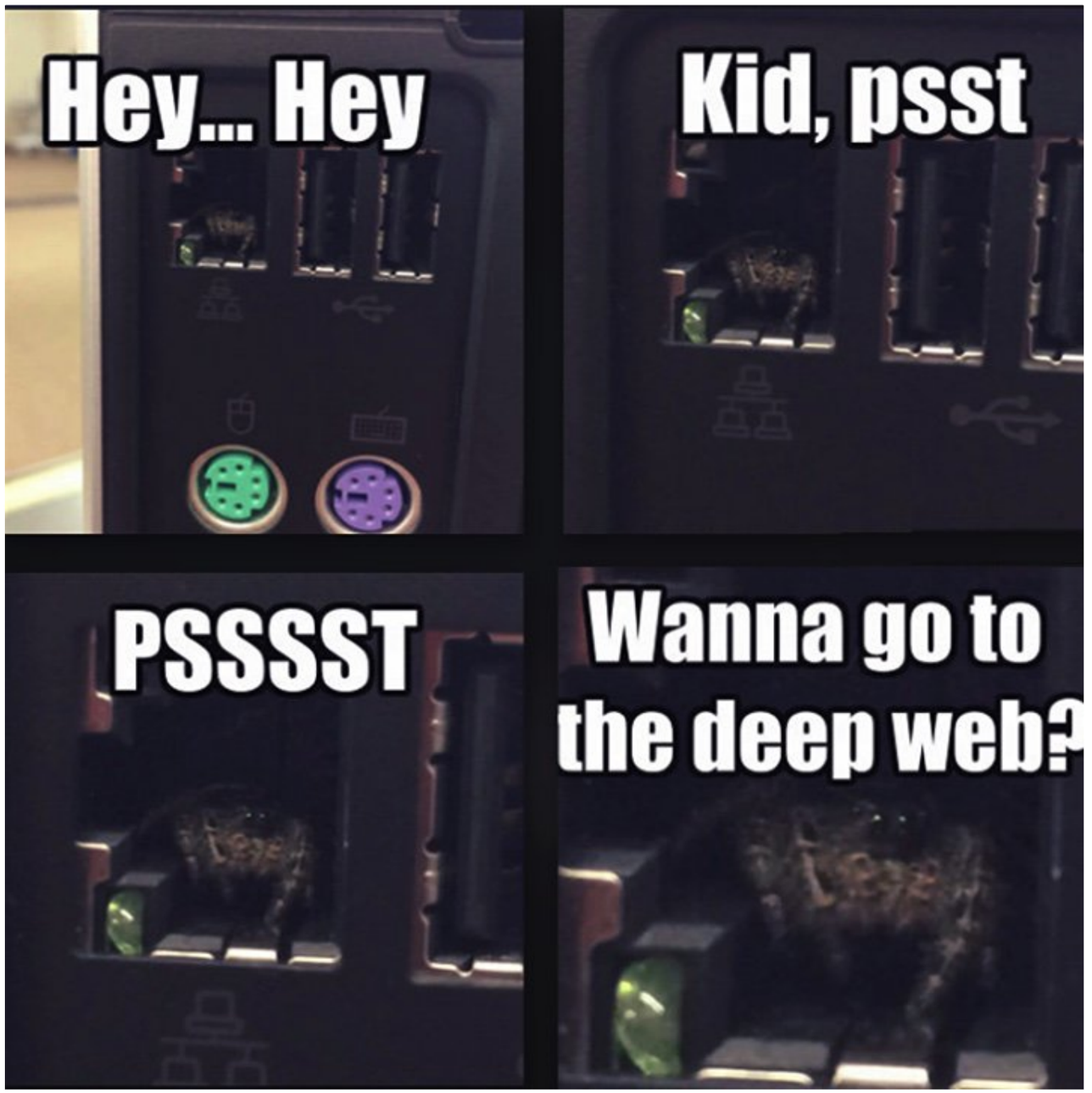
- Methodology:
  1. Throw packets at the Internet
  2. See what happens
- Ideal: two-ended A/B testing
- Scalable: one-ended A/B testing
- Multiple sources: **isolate** on-path from near-target impairment







Spiders in the network



ecnspider

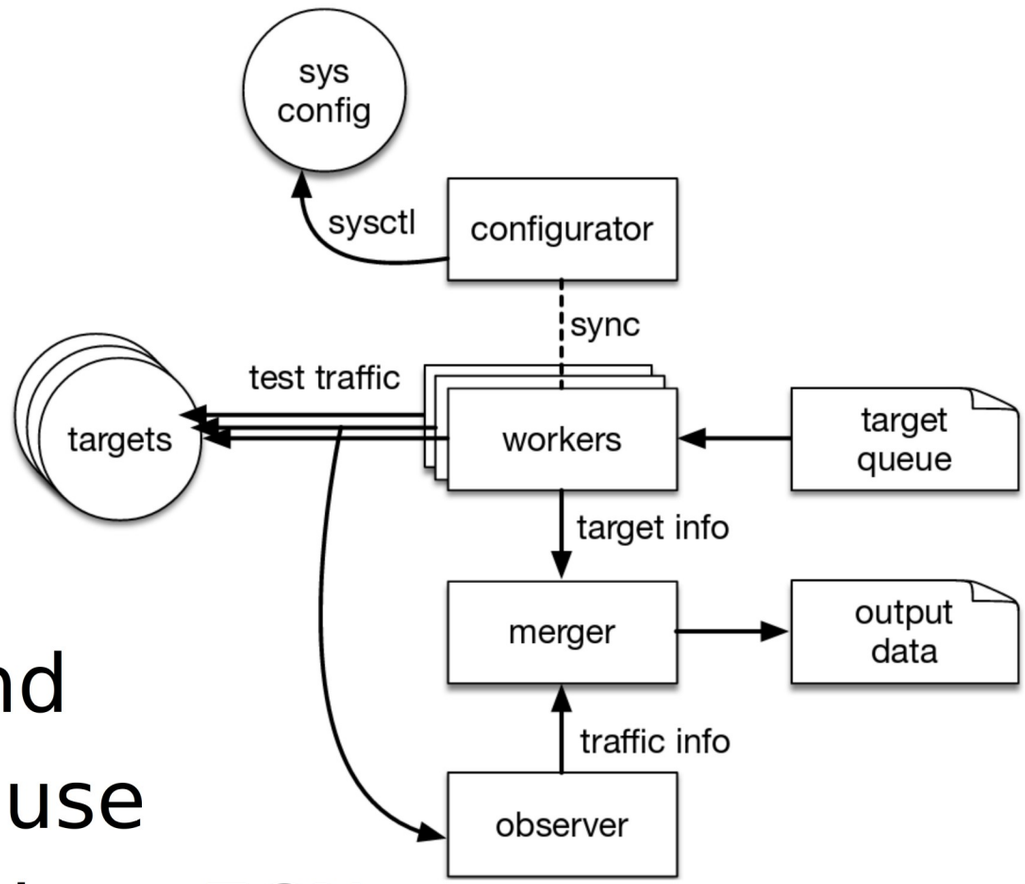
PATHspider before PATHspider

mami measurement

ecnspider

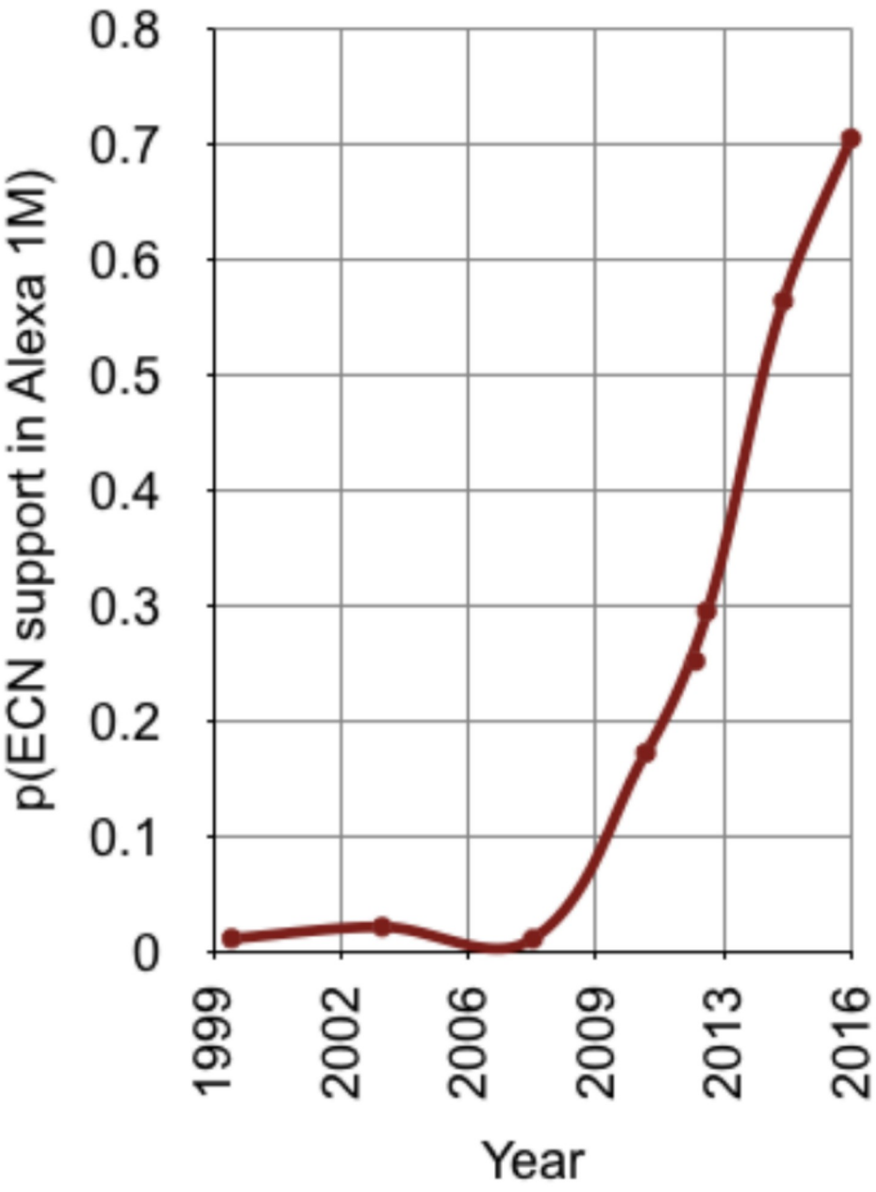
https://github.com/britram/ecnspider/

- The original implementation supported by mPlane/RITE
- Three distinct components:
  - DNS List Resolver
  - QoF Flow Meter
  - Active Traffic Generator
- Used hardcoded `sysctl(1)` and `iptables(1)` commands to cause packets to be emitted with various ECN-related flags



ecnspider Results

- **A measurement run in June 2016 from a single vantage point, a DigitalOcean server in Amsterdam, to the set of unique IPv4 and IPv6 addresses serving the top million websites, and found that 432544 of 617873 (70.005%) of IPv4 addresses and 20262 of 24472 (82.797%) IPv6 addresses will negotiate ECN**
- **This continues a trend ETH started observing in 2013**



PATHspider 1.0

More than just ECN

mami measurement

PATHspider 1.0

https://github.com/mami-project/pathspider/tree/1.0.1

- Architecture based closely on the original ecnspider
- Generalised to support more than just ECN
  - Added TCP Fast Open and DiffServ Codepoints
- Still performing A/B testing, but with more A/B tests
- Replaced QoF with a Python flowmeter implementation using *python-libtrace*
- Began to develop a generalised measurement methodology for path transparency testing
- Published at ANRW ‘16

Plugin Architecture

```
@implementer(ISpider, IPlugin)
class ExampleSpider(Spider):
    def config_zero(self):
        […] # Prepare the system for the A test (sysctl, etc.)
    def config_one(self):
        […] # Prepare the system for the B test (sysctl, etc.)
    def connect(self, job, pcs, config):
        […] # Perform the connection, open a socket
    def post_connect(self, job, conn, pcs, config):
        […] # Perform a post-connection operation, e.g a HTTP
GET
    def create_observer(self):
        […] # Create the observer, with the observer functions
    def merge(self, flow, res):
        […] # Merge connection results with flow results
```

Built-in Flowmeter

- PATHspider’s built-in flow meter is extensible via the plugin architecture
- Using *python-libtrace* to dissect packets, any flow property imaginable can be reported back based on the raw packets:
  - ECN negotiation (IP/TCP headers)
  - Bleaching of bits, dropping of options
  - Checksum recalculations
  - Number of packets containing a prime number of octets

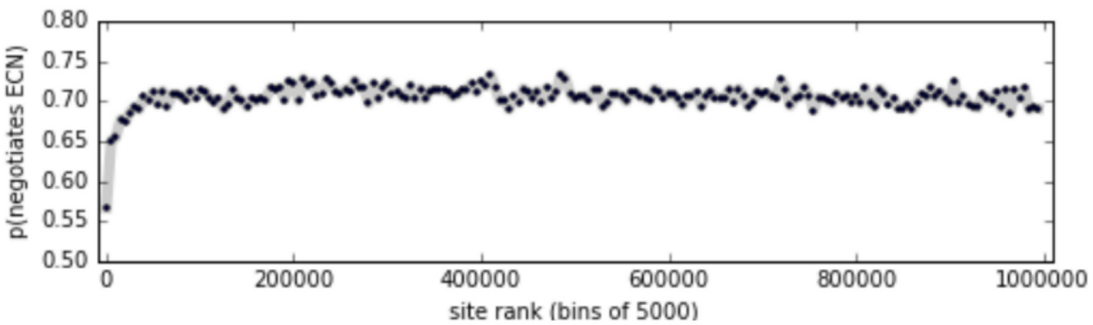
PATHspider 1.0 Results

Explicit Congestion Notification (ECN)

State of ECN server-side deployment, as measured from a Digital Ocean vantage point in Amsterdam on 13 June 2016:

	IPv4	IPv6	all
No ECN connectivity issues	**99.5%**	**99.9%**	**99.5%**
ECN successfully negotiated	**70.0%**	**82.8%**	**70.5%**

ECN negotiation by Alexa rank bin: note this is nearly uniform, but higher-ranked servers tend to disable ECN:



DiffServ Code Points (DSCP)

Initial study: 10006 out of 96978 **(10.31%)** of Alexa Top 100k websites had unexpected, non-zero DSCP values. More measurement is necessary to better characterize these anomalies.

TCP Fast Open (TFO)

Initial study: **330 IPv4 and 32 IPv6** addresses in Alexa Top 1M are TFO-capable (of which 278 and 28 are Google properties). DDoS prevention services, enterprise firewalls, and CPE tend to interfere with TFO. More measurement is necessary to analyze impairments.

PATHspider 2.0

n-dimensional hyperspider

mami measurement

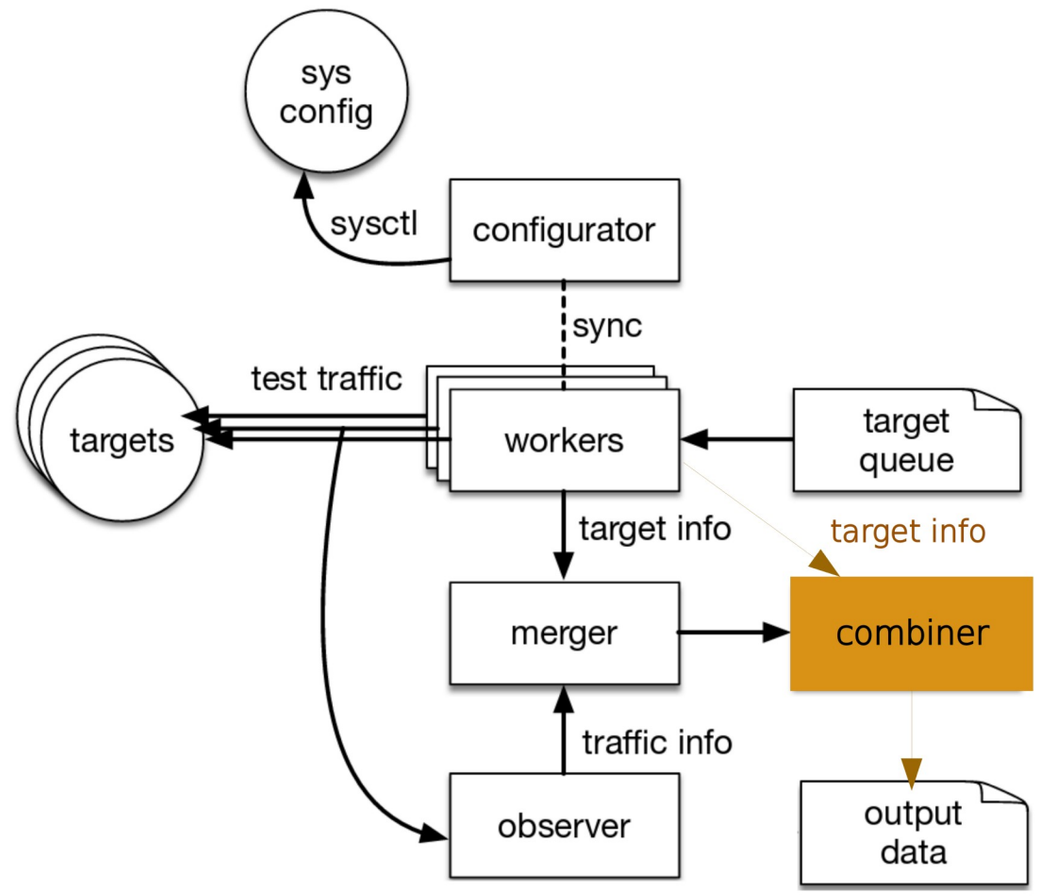
PATHspider 2.0

https://github.com/mami-project/pathspider/tree/master/

- Architecture changed to add a flow combiner
- Generalised to support more than just A/B testing
  - Any permutation of any number of tests
- Replaced PATHspider's HTTP code with *cURL*
- Added framework for packet forging based plugins using *Scapy*
- Completely rewritten (in Go) target list resolver
- Observer modules usable for standalone passive observation or analysis

A/B/.../n Testing

- Combiner thread holds a table of merged flows and waits for $|flows| == |tests|$
- Conditions generated based on the combined flows



Plugin Types

- Synchronised (traditional ecnspider)
  - ECN, DSCP
- Desynchronised (ecnspider with configurator disabled)
  - TFO, H2, TLS NPN/ALPN
- Forge (new in PATHspider 2.0!)
  - Evil Bit, UDP Zero Checksum, UDP Options

Connection helpers

- Instead of writing client code, use the code that already exists
- In the `pathspider.helpers` module:
  - DNS (dnslib)
  - HTTP/HTTPS (pycURL)
  - TCP (Python socket)
  - Tor HTTP/HTTPS (pycURL)
- For synchronised plugins, just use the helper
- For desynchronised plugins, the helpers are customisable, e.g. cURL helpers accept arbitrary CURLOPTs

Synchronised Plugin

```
class ExamplePlugin(SynchronizedSpider, PluggableSpider):
    name = "..."
    description = "..."
    version = "..."
    chains = [BasicChain, ...]
    connect_supported = ["http", "https", "tcp", "dnstcp"]

    def config_zero(self): # e.g. sysctl
        ...
    def config_one(self): # e.g. sysctl
        ...
    configurations = [config_zero, config_one, ...]
    def combine_flows(self, flows): # generate conditions
        ...
        return conditions
```

Desynchronised Plugin

```
class ExamplePlugin(DesynchronizedSpider, PluggableSpider):
    name = "..."
    description = "..."
    version = "..."
    chains = [BasicChain, …]
    connect_supported = [“tcp”, ...]

    def connect_zero(self): # e.g. call http helper
        ...
    def connect_one(self): # e.g. call http helper
        ...
    connections = [connect_zero, connect_one, ...]
    def combine_flows(self, flows): # generate conditions
        ...
        return conditions
```

Forge Plugin

```
class ExamplePlugin(ForgeSpider, PluggableSpider):
    name = "..."
    description = "..."
    version = "..."
    chains = [BasicChain, …]
    connect_supported = [“tcp”, ...]

    def forge(self, job, seq): # e.g. make a tcp syn
        ...

    def combine_flows(self, flows): # generate conditions
        ...
        return conditions
```

Observer modules

- While these used to be part of plugins in PATHspider 1.0, they are now independent and so can be reused
  - BasicChain, DNSChain, DSCPChain, ECNChain, EvilChain, ICMPChain, TCPChain, TFOChain
- These can also be used together, limiting each chain to just a single layer and letting the combiner produce conditions.
- Chains can produce information to be consumed by other chains later in the list.
- These can now be run independently of a PATHspider measurement:
- e.g. > `pspdr observe tcp ecn`

Target List Resolution

https://pathspider.net/hellfire

- Hellfire is a parallelised DNS resolver. It is written in Go and for the purpose of generating input lists to PATHspider, though may be useful for other applications.
- Can use many sources for input:
  - Alexa Top 1 Million Global Sites
  - Cisco Umbrella 1 Million
  - Citizen Lab Test Lists
  - OpenDNS Public Domain Lists
  - Comma-Seperated Values Files
  - Plain Text Domain Lists

Hands-on Time!

Emit some packets

mami measurement