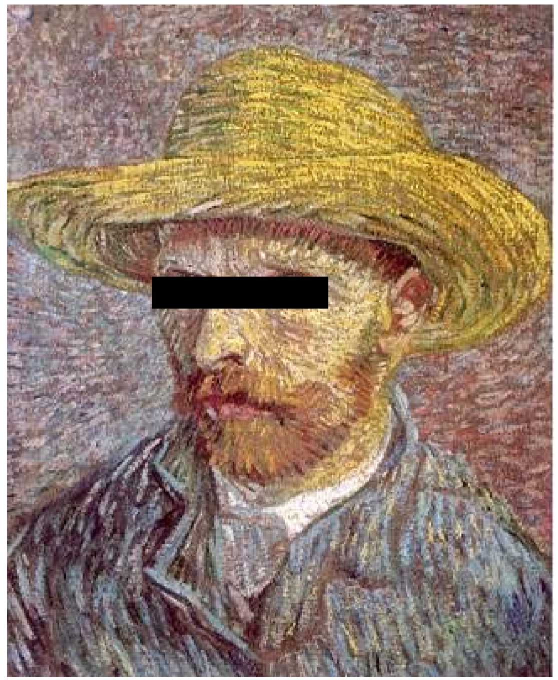
Monitoring and Privacy



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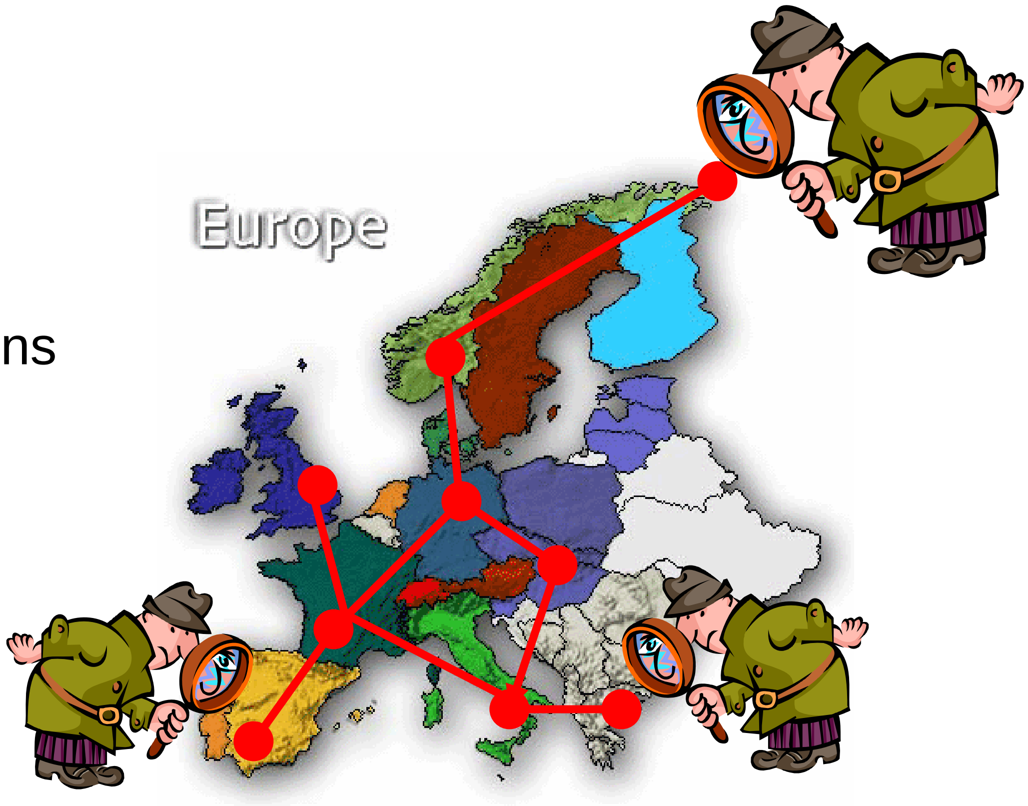
Lobster infrastructure

- idea:
  - distributed monitoring
  - convenient access to network data
  - share data
    - within organisations
    - between organisations



MAPI – The Monitoring API

- core concept: *flow*
  subset of network traffic corresponding to arbitrary user criteria
  - desired subset is expressed *functionally*
    - start with all incoming traffic
    - successively apply *functions* to it (filters, samplers, hashing, transcoding, etc.)

```
int fd = mapi_create_flow (“host1:/dev/eth0”, “host2:/dev/eth1”);
int funcid = mapi_apply_function (fd, “PKT_COUNTER”);
mapi_connect (fd);
while (1) {
    resptr = mapi_read_results (fd, funcid, 0);
    sleep(1);
}
mapi_close (fd);
```

Worm detection:

```
fd=mapi_create_flow("/dev/dag0");
mapi_apply_function(fd,"BPF_FILTER","src port 1234");
ctr_id1=mapi_apply_function(fd,"PKT_COUNTER");
mapi_apply_function(fd,"STR_SEARCH","pattern",100,300);
ctr_id2=mapi_apply_function(fd,"PKT_COUNTER");
mapi_apply_function(fd,"TO_FILE",MFF_PCAP,"worm.trace",0);
mapi_connect(fd);

while(1) {
    ctr_val1=mapi_read_results(fd,ctr_id1);
    ctr_val2=mapi_read_results(fd,ctr_id2);

    printf("BPF match: %llu String match: %llu\n",
              *ctr_val1,*ctr_val2);
    sleep(10);
}
```

Privacy

- a shared monitoring infrastructure?
  ➔ what about **privacy**?!

Before talking about privacy ask the following: would ***you*** *share information?*

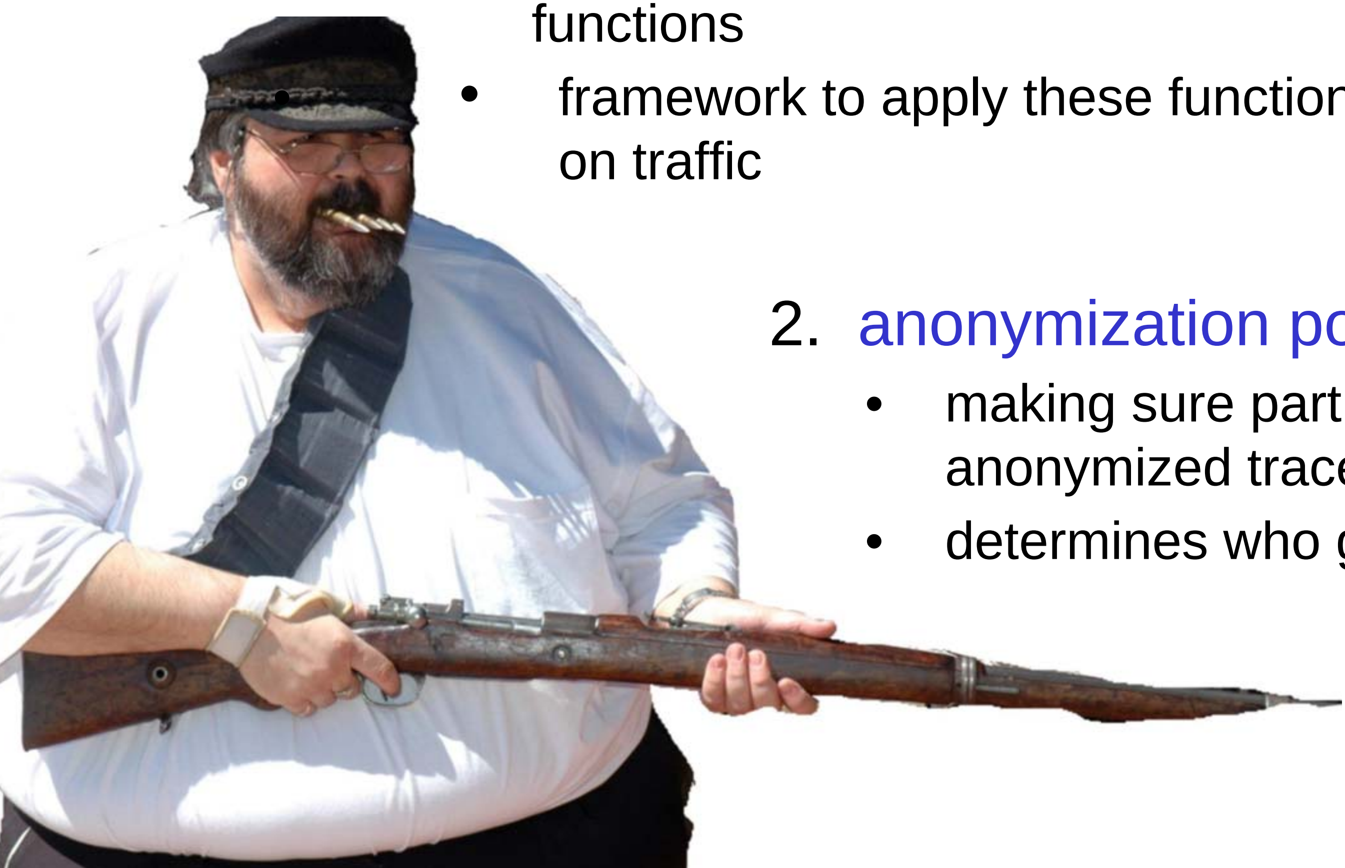
Responses vary…

– No, **absolutely not**. I will not reveal any information
  • I will not reveal even the load of my networ
– Maybe I can share **some general**
  • what traffic goes in and out of m
– I am willing to share the **h** packets
  • IP addresses anony tripped
  • just like NLANR
– I would lik
  • **all i** my local administrators
  • **tion** with associated researchers
  • **ed information** with the rest of the world
– Yes share **everything**!
  • information wants to be free!

Lobster can provide all of the above

How does it work?

1. applying anonymisation functions
   - functionality to strip/hash payloads, zero addresses, etc.
     ➔ library of possible anonymisation functions
   - framework to apply these functions on traffic



2. anonymization policy enforcement
   - making sure parties only get properly anonymized traces
   - determines who gets access to what

How does it work?

1. applying anonymisation functions

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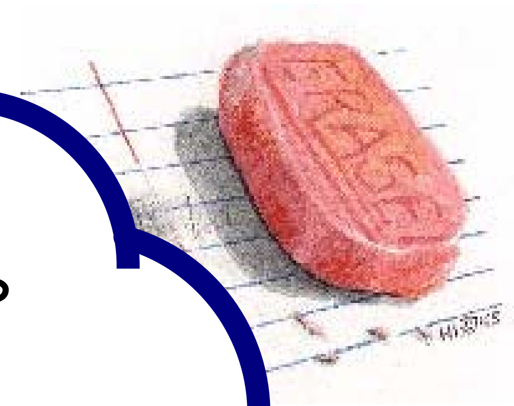
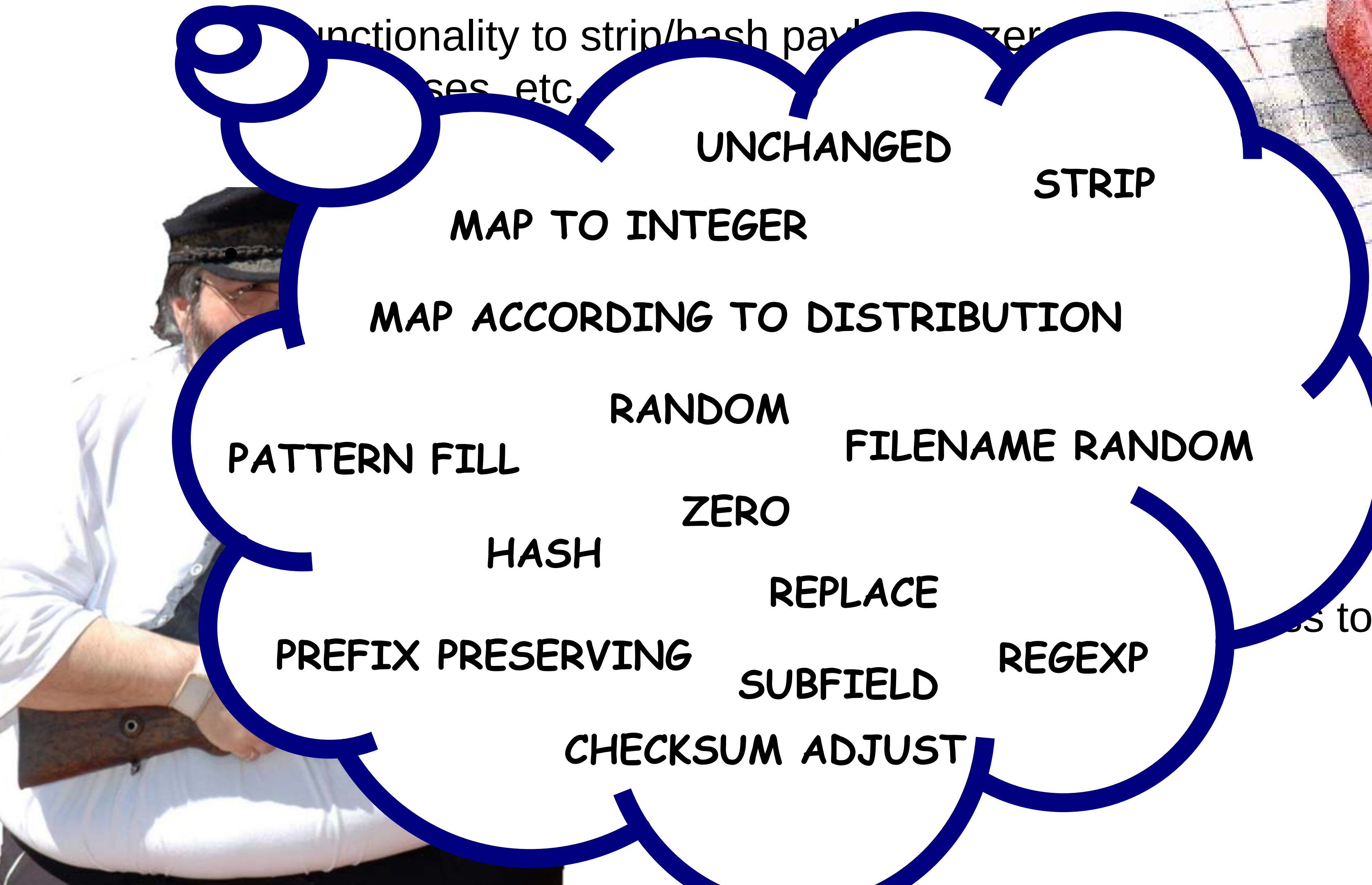
ses, etc.





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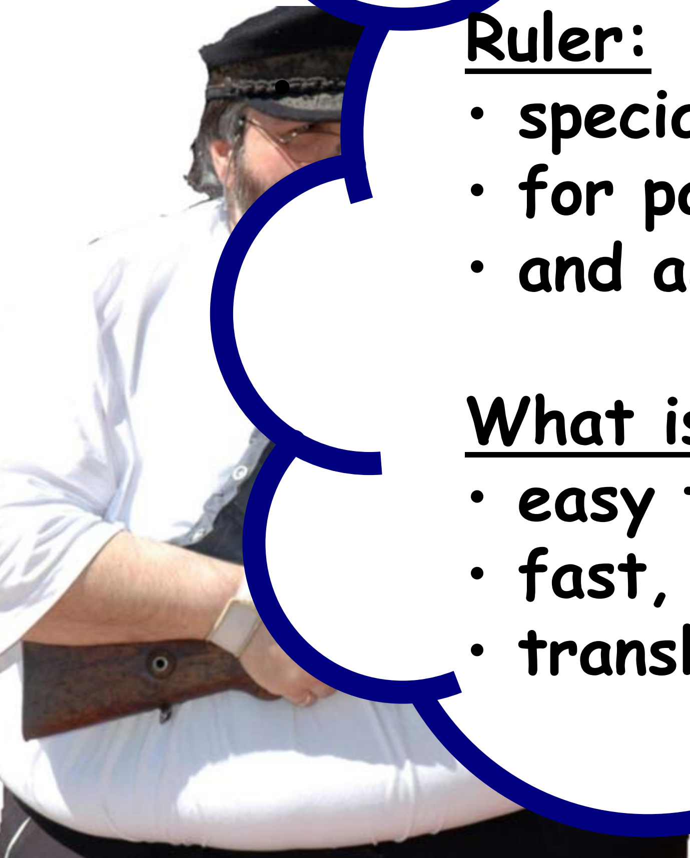

Ruler:
- special-purpose, high-level language
- for packet rewriting in general
- and anonymization in particular

What is so nice about it?
- easy to specify needs
- fast, efficient
- translates to low-level HW

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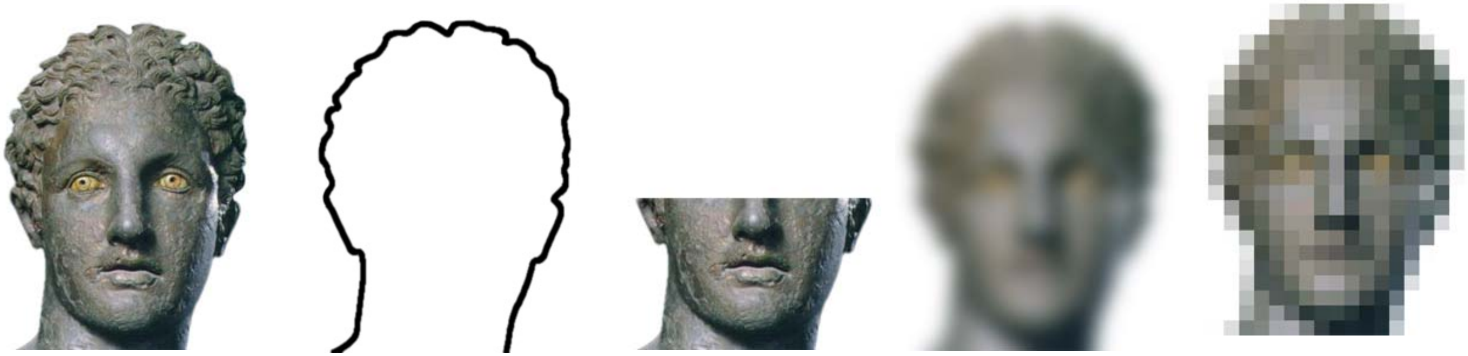
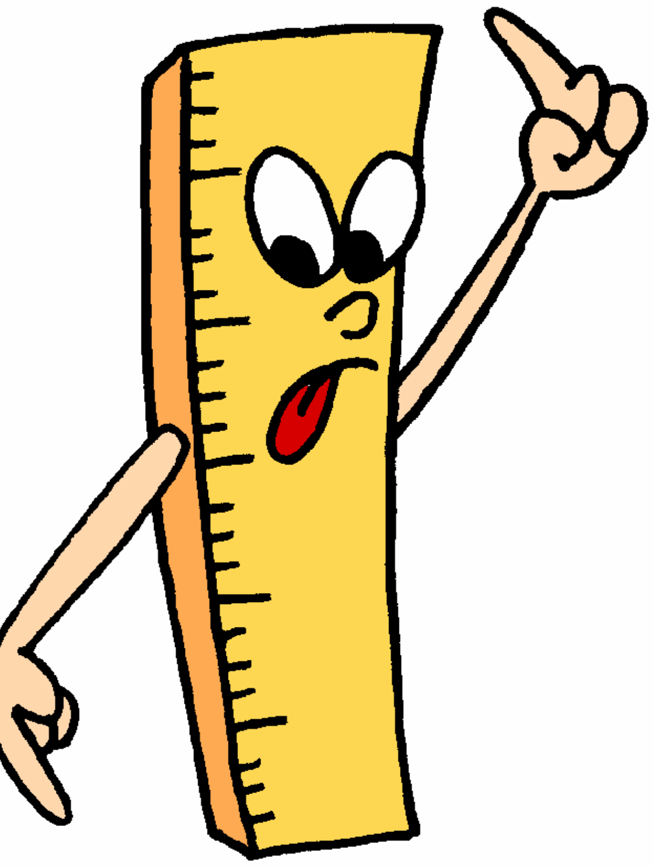
Authorisation

different policies

- different anonymization rules for different users
- credentials determine what sort of access is allowed



Ruler



a simple rule-based language

- Generic sanitization
- Efficient (DFA-based) implementation
- Design to allow for (future) formal reasoning
- Understands common network protocols
- Extensible
- Implemented on CPU, NPU, HW

Ruler

- Patterns and filters consisting of rules

pattern:

```
pattern udpHeader: (
        source: byte #2
        dest: byte #2
        len: byte #2
        checksum: byte #2)
```

filter:

```
include layouts.rli
filter simple
    eh:Ethernet_header iph:IPv4_header *
    => eh iph with [src=0, dest=0];
```

Matching language

- Fixed number of bytes, fixed value

```
42#1
5
0x800#2
“url”
```

- Fixed number of bytes, arbitrary value

```
byte#2
byte#1
byte
```

- Arbitrary number of bytes and value

```
*
```

Matching language: bit patterns

- Surrounded by {}
- Fixed number of bits, fixed value

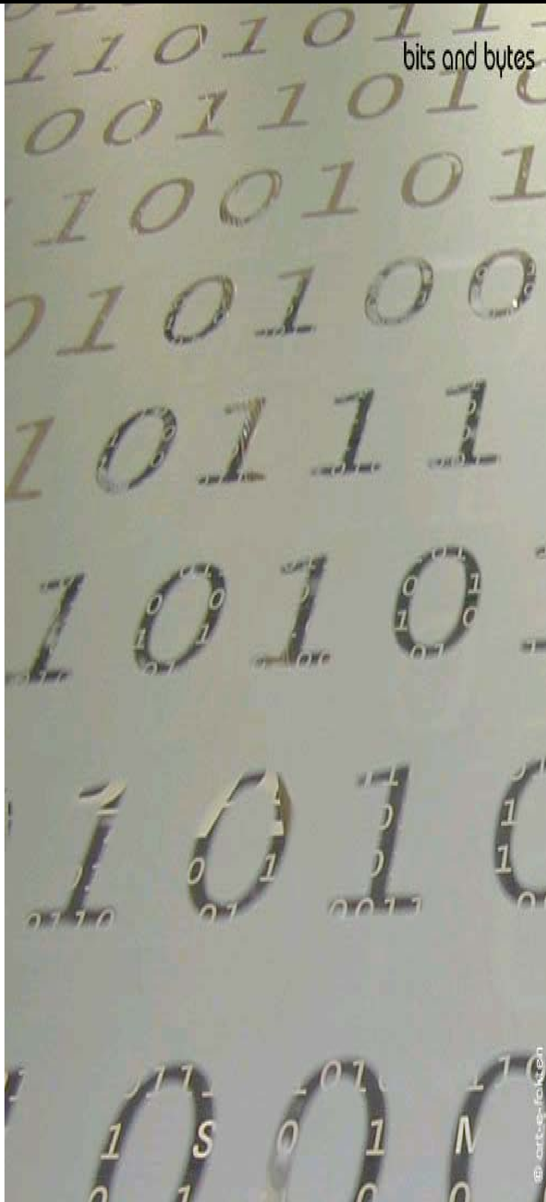
```
{42#7}
{0}
{0x800#16}
```

- Fixed number of bits,
  arbitrary value

```
{bit#2}
{bit#1}
{bit}
```

- Combination

```
{bit#1 42#7}
```



Matching language: labels

- Patterns can be labeled

```
source: byte #6
dest: byte #6
payload: *
```

- Patterns can be grouped with brackets

```
ether:(s:byte#6 d:byte#6 p:byte#2)
```

- Note the nested labels: **`ether`** refers to 14 bytes, **`ether.s`** refers to 6 bytes

Matching language: patterns

- Patterns can be defined and named separately

```
pattern ether: (
   s:byte#6 d:byte#6 p:byte#2
)
```

- Allows re-use of common patterns

include files

- Definitions can be included from another file
  `include “layouts.rli”`
- Normally used for pattern definitions
  (but can be used for filters too)
- `layouts.rli` defines many common header layouts:
  ethernet, IP, TCP, UDP, etc.

use of labels

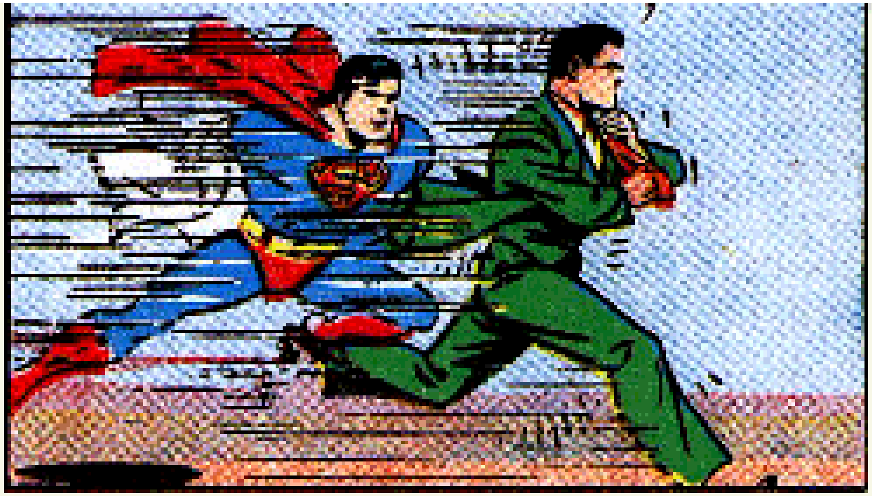
- Pattern names can now be used instead of the pattern they stand for

```
ether * "warez" *
```

- Labels can be used in rewrite actions:

```
a:byte#2 b:* => b a
```

- The trick is to do it fast



The *with* construct

- The `with` construct replaces named parts of a pattern with other patterns

```
ether with [p=0x0806#2]
```

- Restrictions: replacement pattern may not be longer or shorter than the original.

```
ether with [p=42]  // WRONG (1 byte)
```

Rule actions

- Action is one of:
  - `reject`
  - `accept, accept 5`
  - **result pattern**

Tagged Deterministic Finite Automata

- We compile to a **Tagged** Deterministic Finite Automaton (TDFA)
- Tagged because we need the position of sub-patterns.
- States:
  - **stop** (we know what action to take)
  - **inspect** (look at a byte, branch)
  - **tag** (register positions in the input)
  - **jump** (skip irrelevant input bytes)
  - **memory inspect** (look at previous input)

extensibility

- Ruler is extensible: it may call external functions

```
filter zap_url
        head:(Ethernet_header IPv4_header * "GET ") url:* tail: (0x0D 0x0A *)
   => head @hash(url) tail ;
```

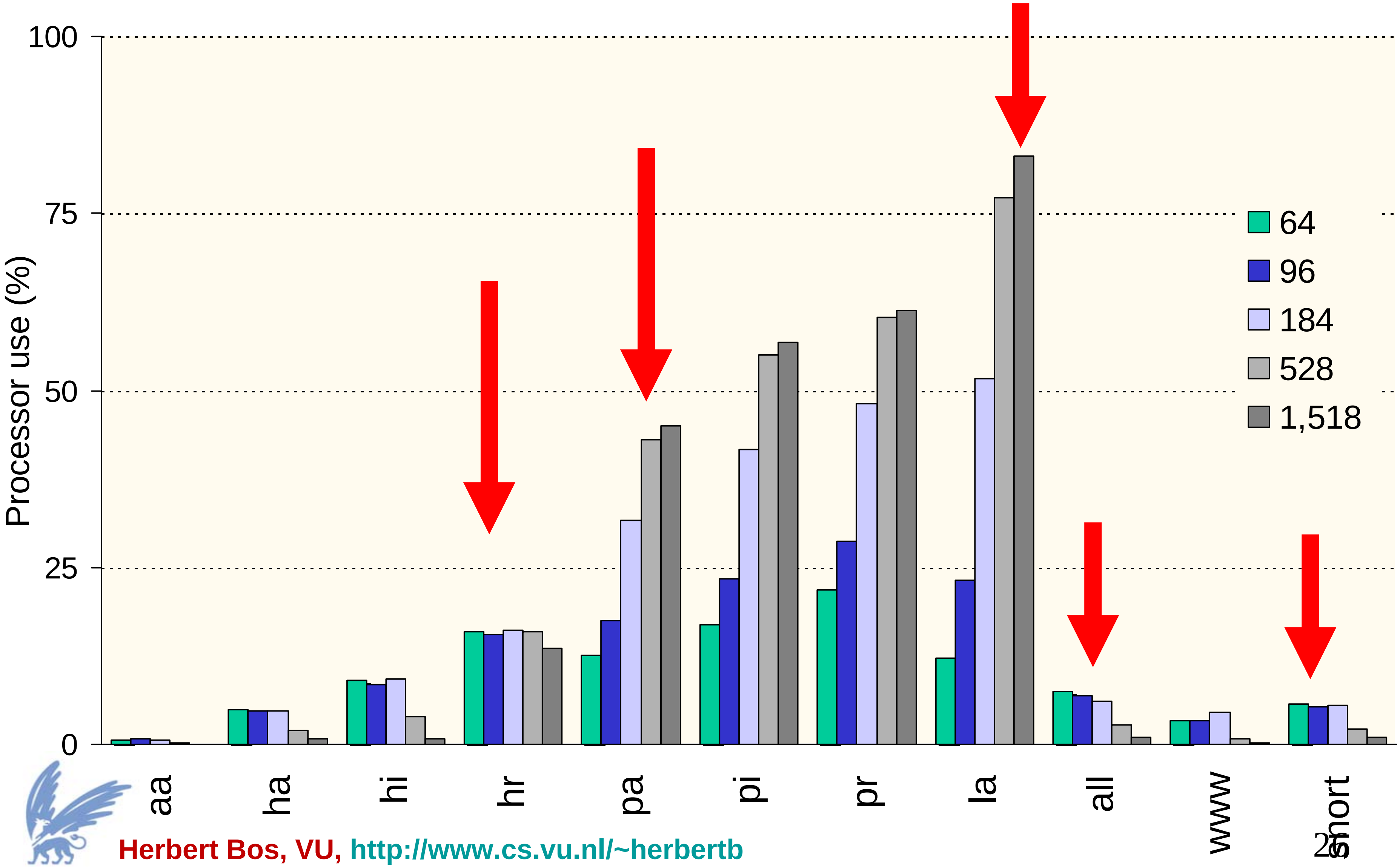
  - allows us to use libraries of previously developed anonymisation functions
- in Lobster we have integrated Ruler with MAPI
  - a Ruler program can be applied to packets of arbitrary flows
  - Ruler may use MAPI's default anonymisation functions
- also: implementations directly on
  - pcap
  - DAG API

Performance

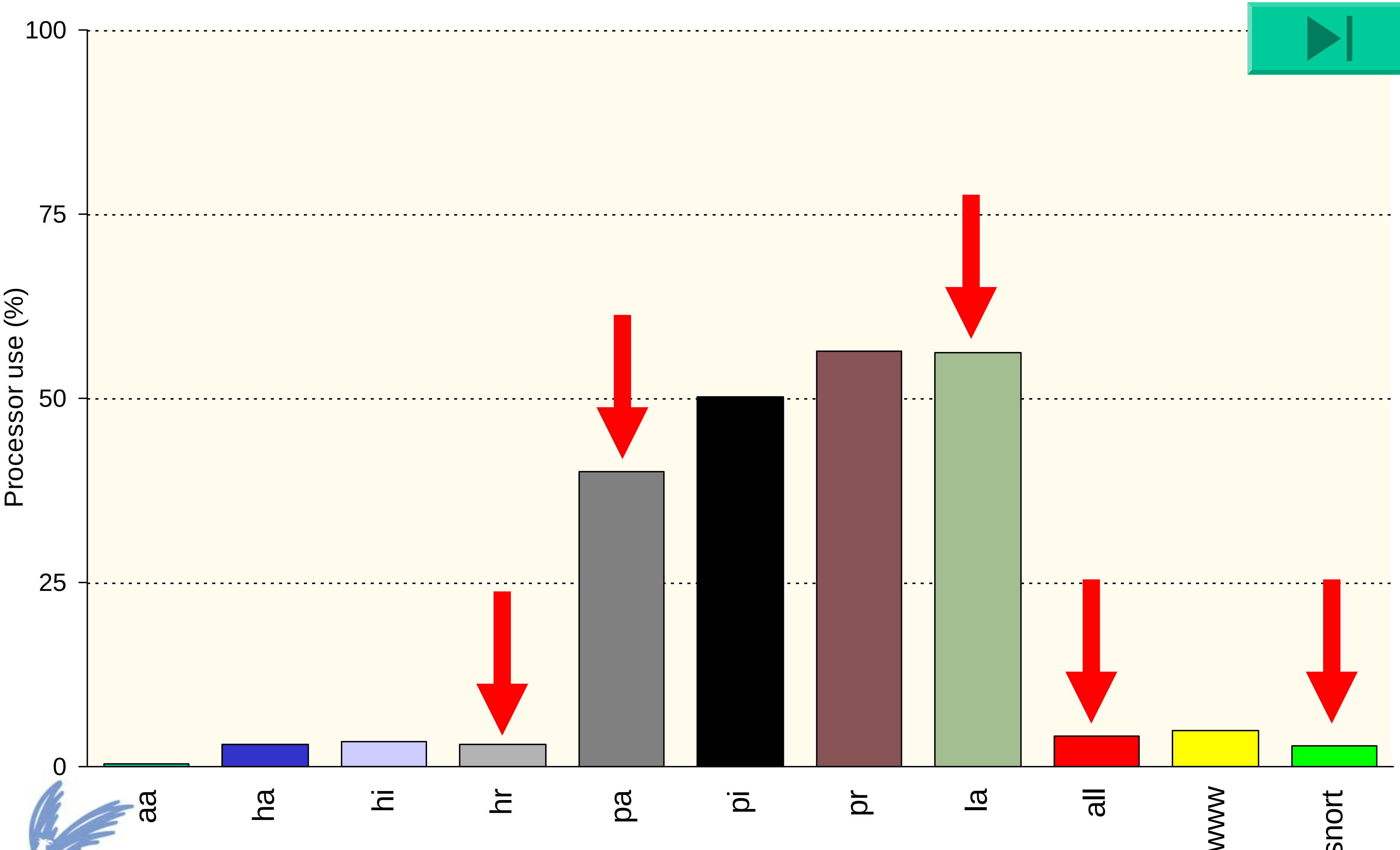
Used filters

name	action	description
aa	accept/reject	match anything
ha	accept/reject	match on header
hi	in-place	match on header
hr	rewrite	match on header
pa	accept/reject	match on entire packet
pi	in-place	match on entire packet
pr	rewrite	match on entire packet
la	accept/reject	large FSM, match on entire packet
all	in-place	Select IP, ARP traffic, zero addr., drop payload
www	in-place	Select & anonymise TCP traffic to port 80
snort	accept/reject	Select packets matching Snort `backdoor' rules

Synthetic traffic



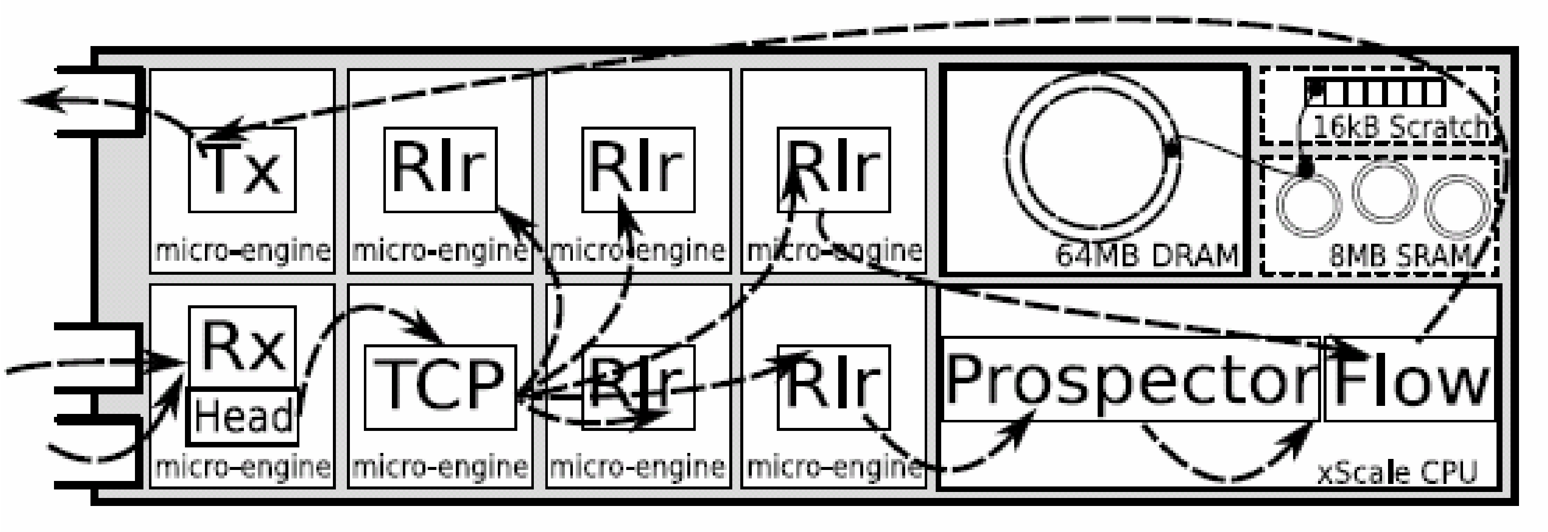
Real traffic



applications

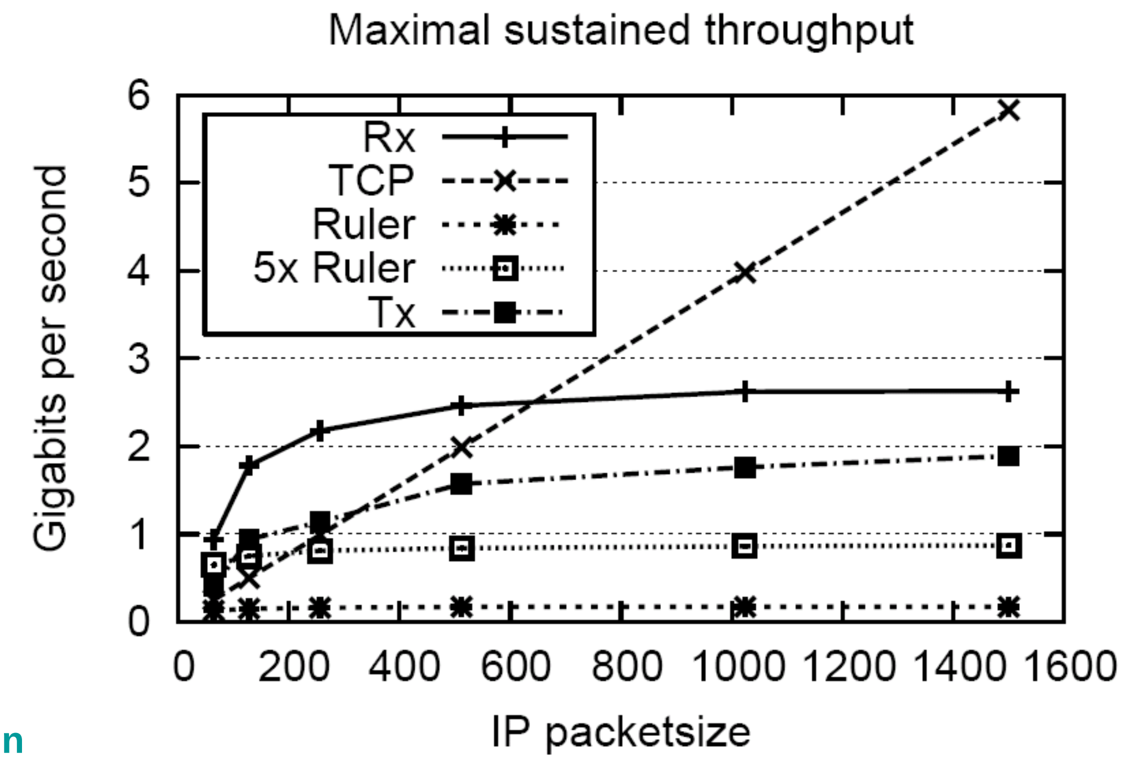
- besides anonymisation we also applied Ruler to intrusion detection
- developed a snort2ruler compiler
  - translates majority of Snort rules automatically
  - some rules need manual help
  - some rules cannot be translated *as is*
  - implemented in parallel on an Intel IXP2400 network processor

SafeCard: Ruler for IDS/IPS



Preliminary results

- able to keep up with gigabit scanning (only small number of rules tested)
- large number of rules:
  - large number of states
  - *long* compilation
- Gigabit rates: even on IXP with real traffic



conclusions

- useful
- efficient
- multiple application domains
- state space may be the limiting factor
- fits in FFPF/Streamline and Lobster

availability

http://www.ist-lobster.org/downloads/

filters

The **hr** filter reverses the order of the packet headers and payload. This requires all bytes in the packet to be copied to an output buffer.

```
filter hr
  eh: Ethernet_IPv4 ih: IPv4
  uh: UDP with [dest=0x7AAA˜2]
  d: *
    =>
  d uh ih eh ;
```

filters

```
filter pa [accept_reject]
  eh:Ethernet_IPv4 ih:IPv4 uh:UDP
  * "REJECT" *
    =>
  reject;
  * => accept;
```

```
filter la [accept_reject]
  eh:Ethernet_IPv4 ih:IPv4 uh:UDP
  * (0x00 byte#8 "z") *
    =>
  reject;
  eh:Ethernet_IPv4 ih:IPv4 uh:UDP
  * (0xff byte#8 0x11) *
    =>
  reject;
  eh:Ethernet_IPv4 ih:IPv4 uh:UDP
  * ("R" byte#4 "T") *
    =>
  reject;
  * => accept;
```

```
filter all [in_place]
  eh: Ethernet_IPv4 ih: IPv4 d: *
   =>
  eh with [e_dest=0#6,e_src=0#6]
  ih with [src=0~4,dest=0~4];

  eh: Ethernet_ARP ah: ARP d: *
    =>
  eh with [e_dest=0#6,e_src=0#6]
  ah with [sender_ha=0#6,sender_ip=0#4,
           target_ha=0#6,target_ip=0#4];
```

EXAMPLES

Ruler

1

```
include layouts.rli
filter two_rules
        eh: Ethernet_header iph: IPv4_header payload:(* “/bin/sh” *)
        => reject ;
        eh: Ethernet_header iph: IPv4_header payload:*
        => eh iph with [src=0, dest=0] ;
```

2

```
include layouts.rli
filter rewrite
      eh:Ethernet_header iph:IPv4_header with [ proto=17] udph:udpHeader *
        => iph.src iph.dest udph.source udph.dest udph.len ;
```

Ruler

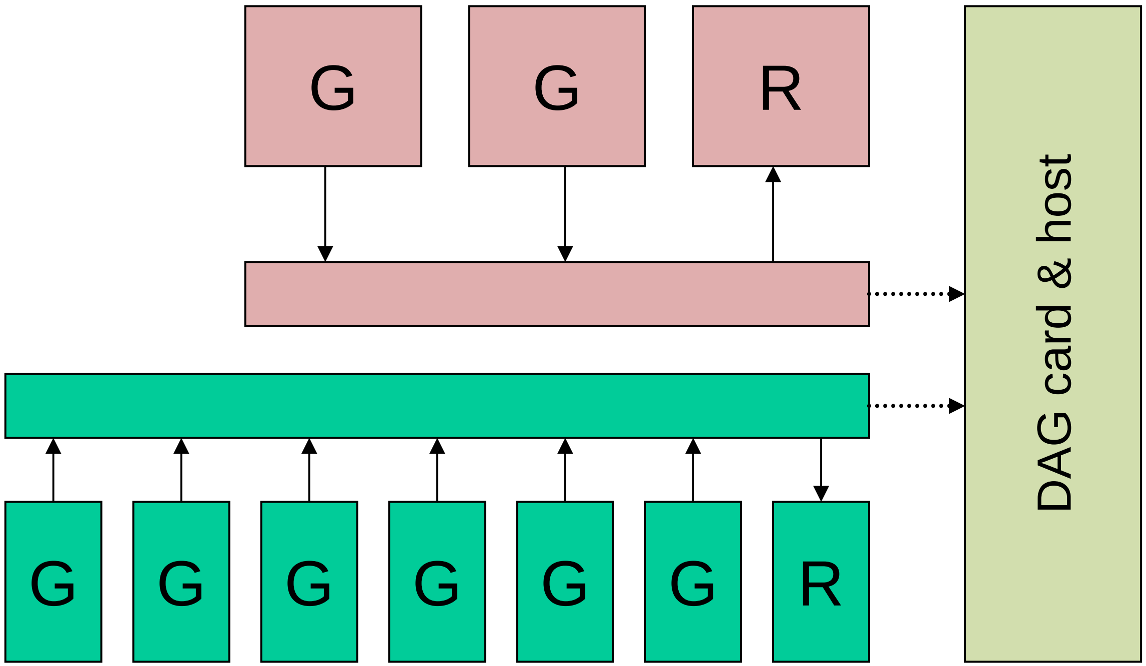
3

```
include layouts.rli
filter zap_url
      head:(Ethernet_header IPv4_header * "GET ") url:* tail: (0x0D 0x0A *)
 => head "XXX" tail;
```

4

```
include layouts.rli
filter zap_url
      head:(Ethernet_header IPv4_header * "GET ") url:* tail: (0x0D 0x0A *)
   => head @hash(url) tail ;
```

Measurement setup



- 2 times 1Gb link
- Port mirroring

G = generator

R = receiver