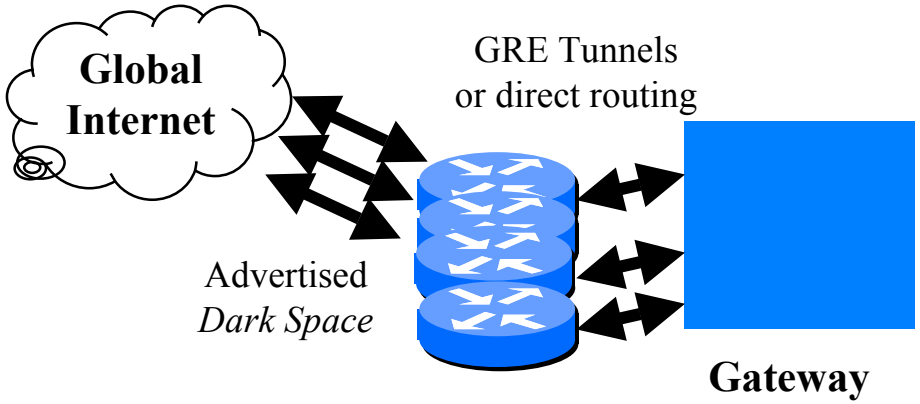
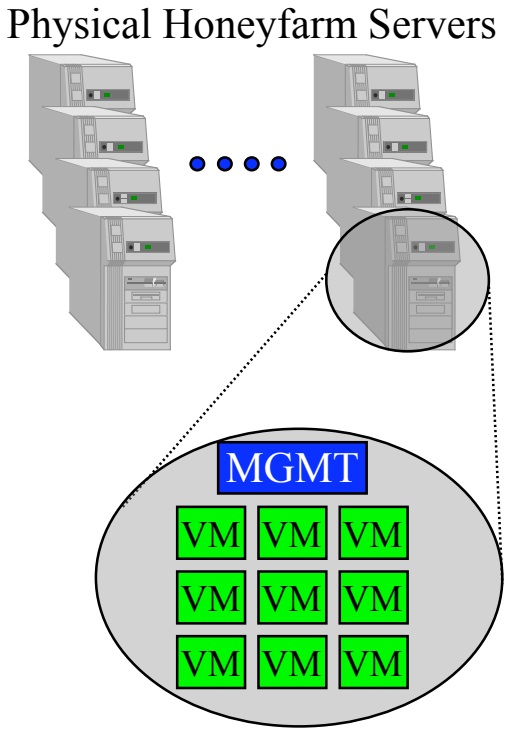
```
#!/usr/bin/perl
while (<>) {
  chomp;
  if ( /^(get|post|options|head|...)(.*)/i ) {
    # Do not respond if it looks like an exploit
    last if length > 1000;

    my $date = gmtime;
    if ( $1 =~ /get|head/i )
      print "HTTP/1.1 200 OK\r\n";
    elsif ( $1 =~ /search/i )
      print "HTTP/1.1 411 Length Required\r\n";
    elsif ( $1 =~ /options/i ) {
      print "HTTP/1.1 200 OK\r\n";
      print "DASL: \r\nDAV: 1, 2\r\n";
      print "Public: OPTIONS, TRACE, GET, HEAD, DELETE, ...\r\n";
      print "Allow: OPTIONS, TRACE, GET, HEAD, DELETE, ...\r\n";
    }
    elsif ( $1 =~ /propfind/i )
      print "HTTP/1.1 207 Multi-Status\r\n";
    else
      print "HTTP/1.1 405 Method Not Allowed\r\n";
  }
  print <<EOF;
Server: Microsoft-IIS/5.0
Date: $date GMT
Content-Length: 0
Content-Type: text/html
Set-Cookie: ASPSESSIONIDACBAABCQ=BHAMAEHAOAIHMOMGJCPFLBGO; path=/
Cache-control: private

EOF
```

GQ: Building a Large-Scale *Honeyfarm*

- *Honeyfarm*: use a network telescope to route scan traffic to a set of honeypots
- Goal: scale to 100,000s of monitored addresses …
- … at high fidelity





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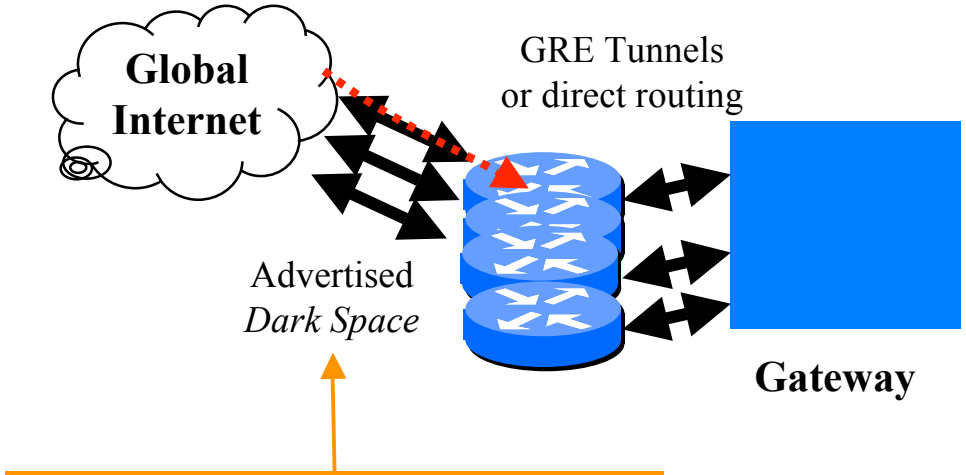
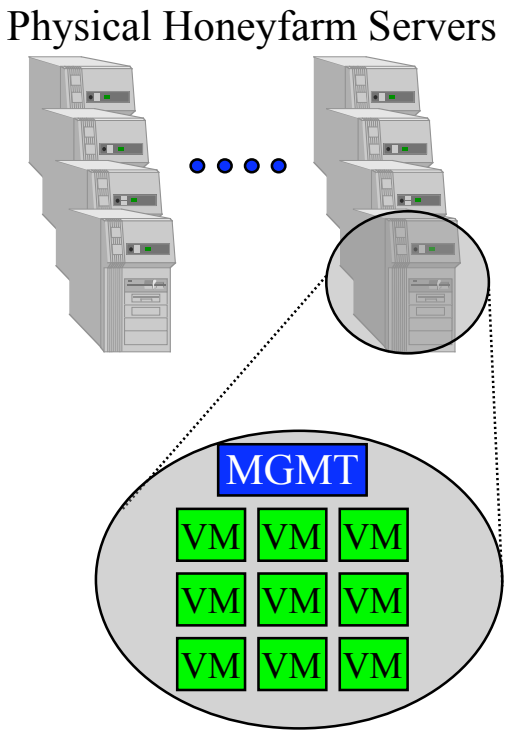


Dark space: blocks of otherwise unallocated addresses



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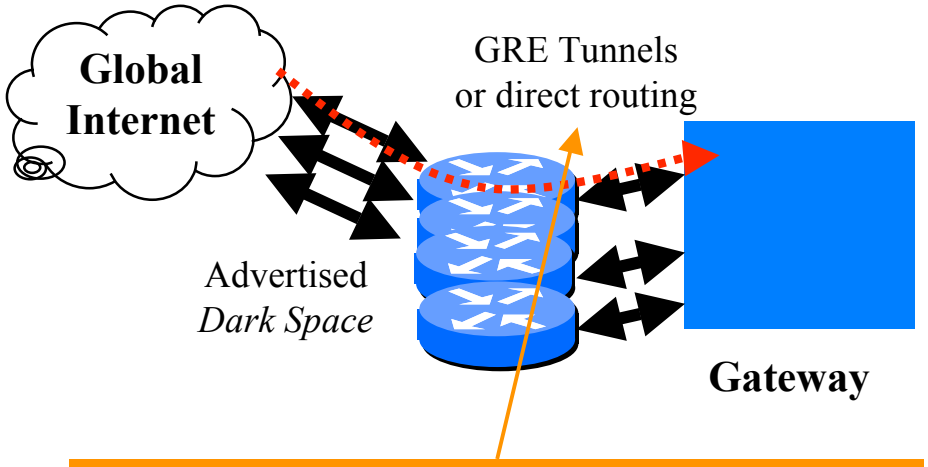
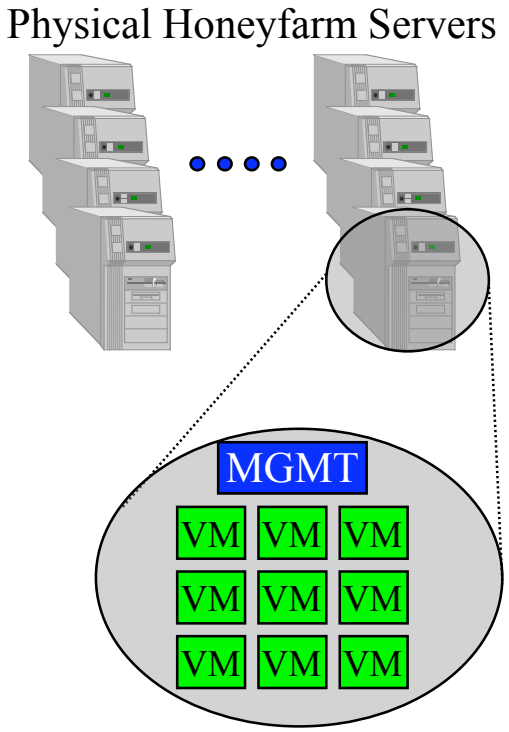


Routers send dark space traffic either via tunnels or direct attachment



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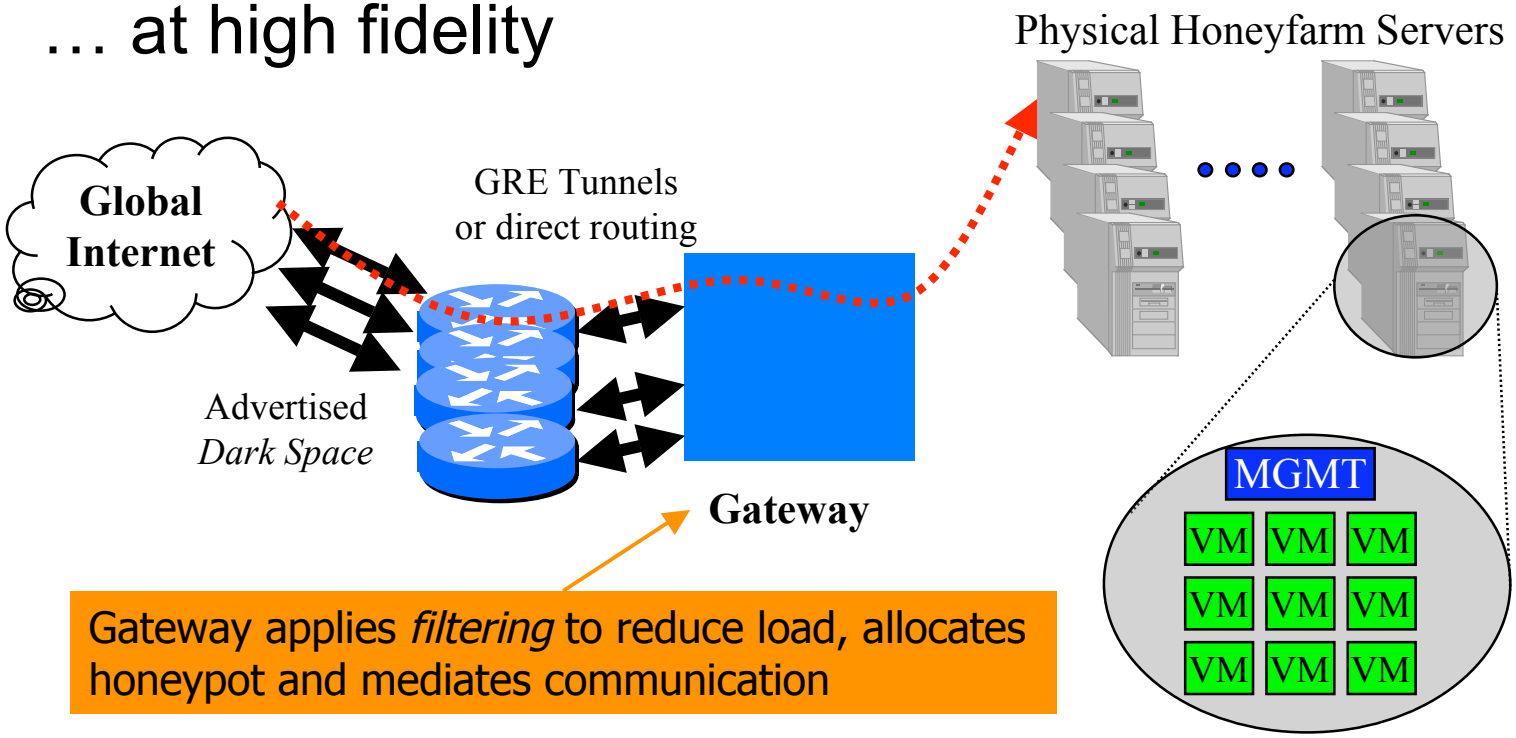
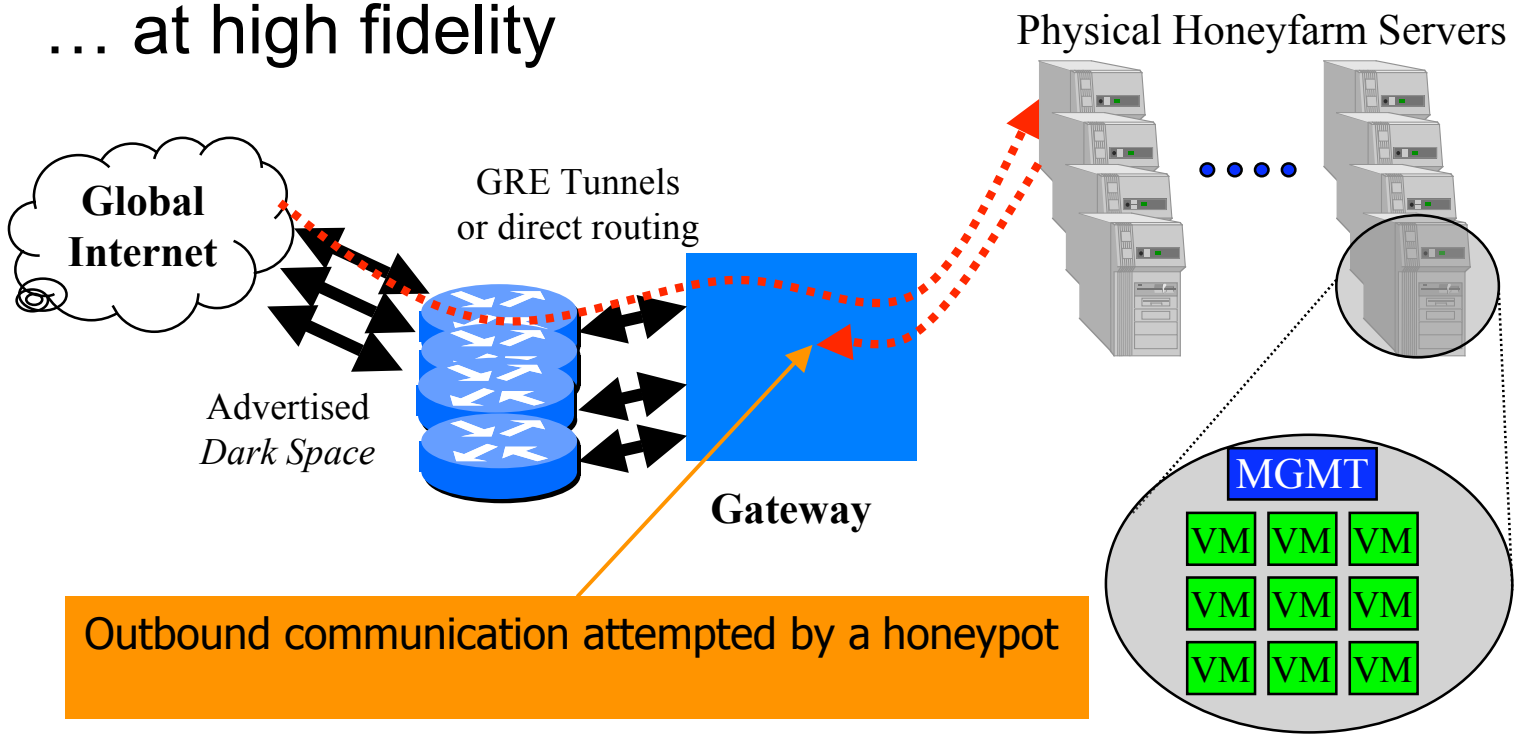


Gateway applies *filtering* to reduce load, allocates honeypot and mediates communication

GQ: Building a Large-Scale *Honeyfarm*

- *Honeyfarm*: use a network telescope to route scan traffic to a set of honeypots
- Goal: scale to 100,000s of monitored addresses …
- … at high fidelity



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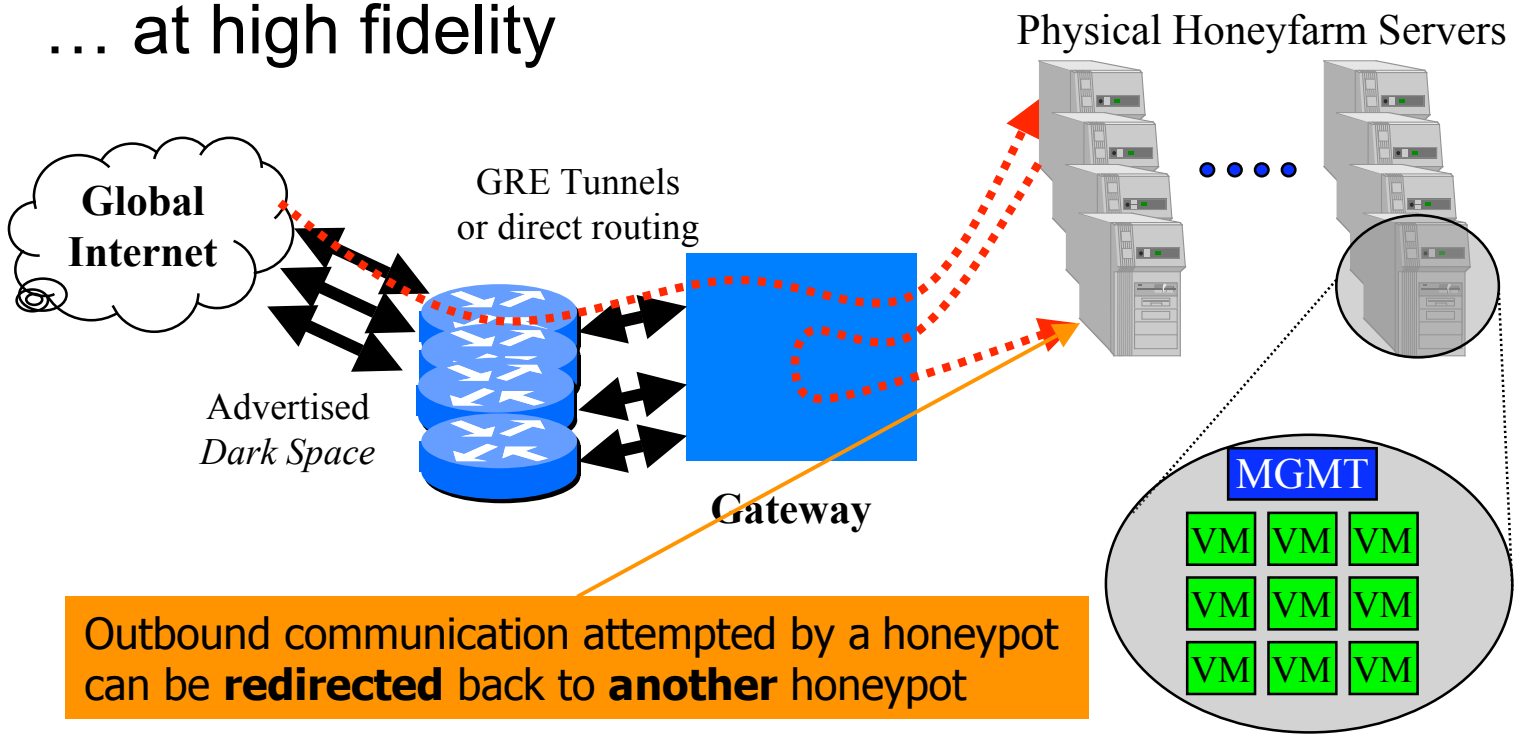

Outbound communication attempted by a honeypot can be **redirected** back to **another** honeypot

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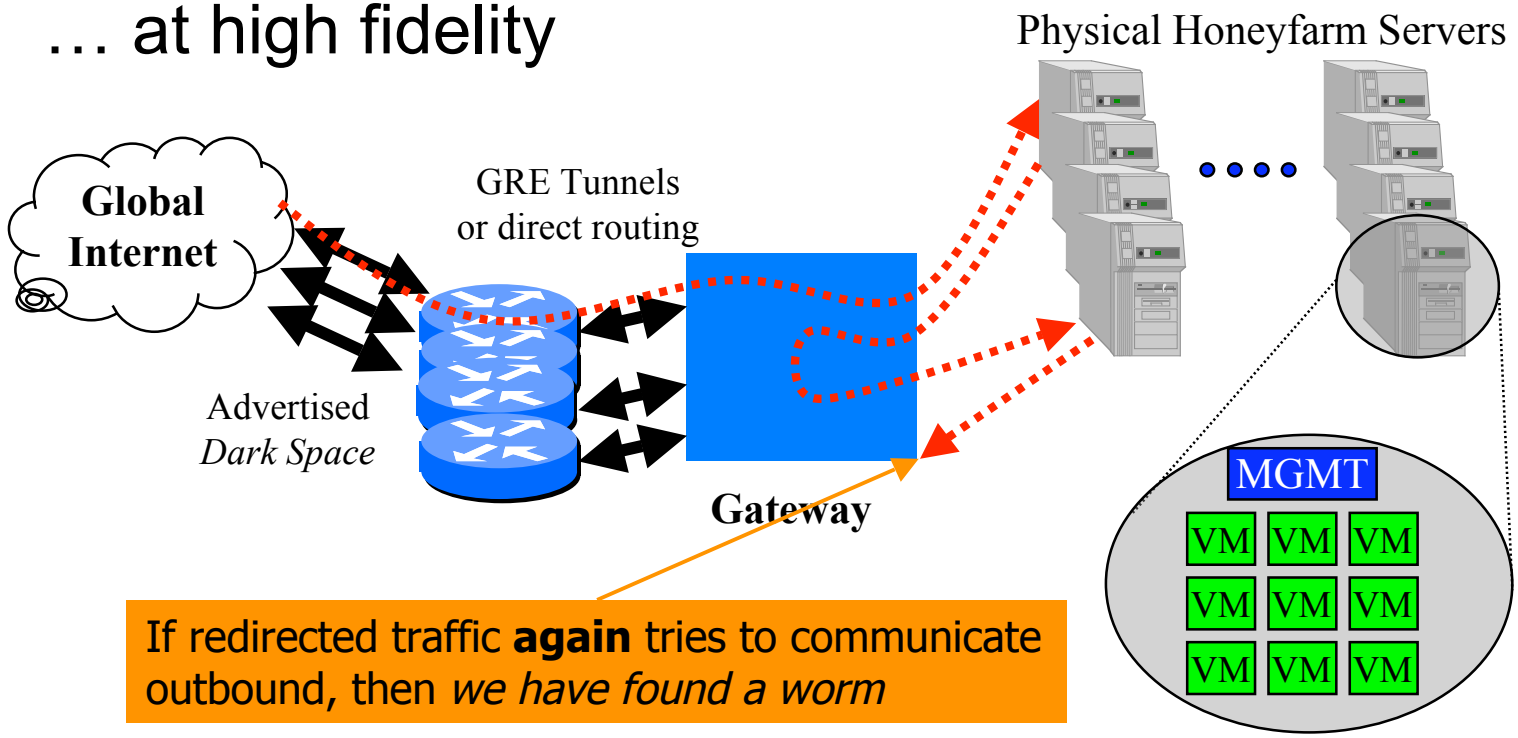
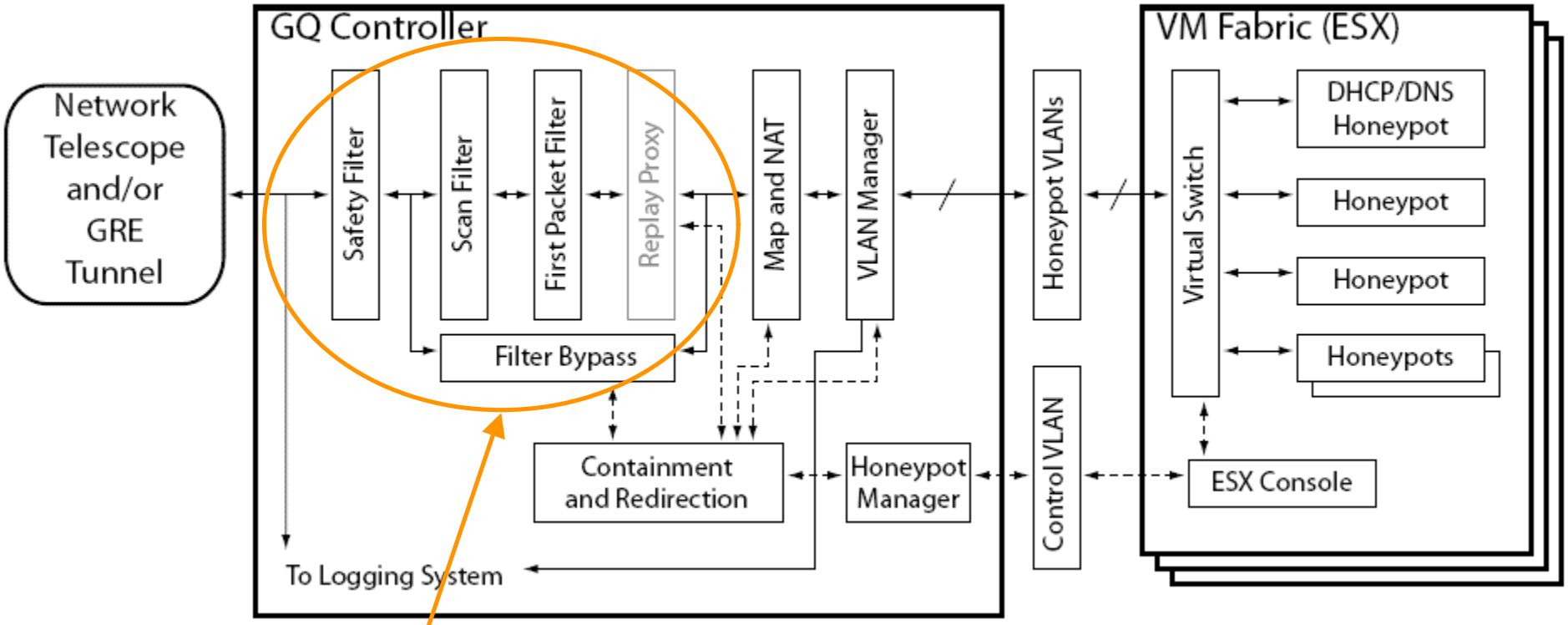
- *Honeyfarm*: use a network telescope to route scan traffic to a set of honeypots
- Goal: scale to 100,000s of monitored addresses …
- … at high fidelity



If redirected traffic **again** tries to communicate outbound, then *we have found a worm*

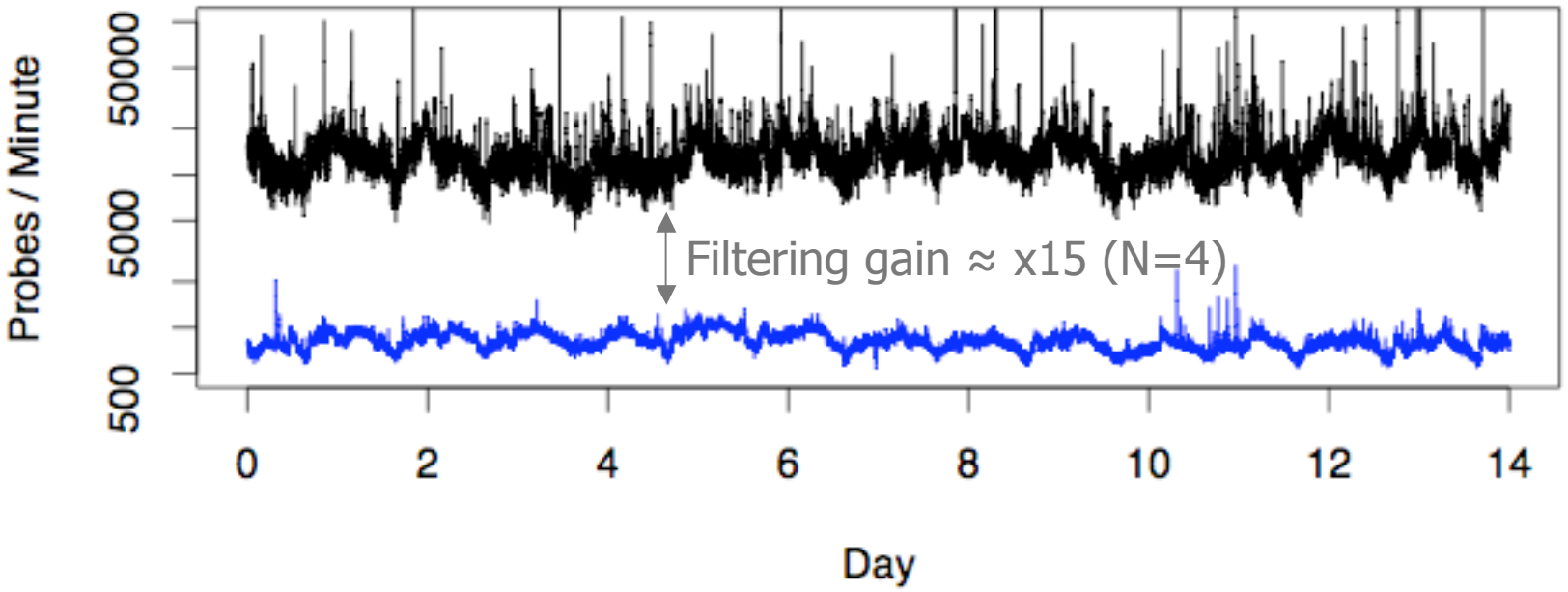
GQ Architecture



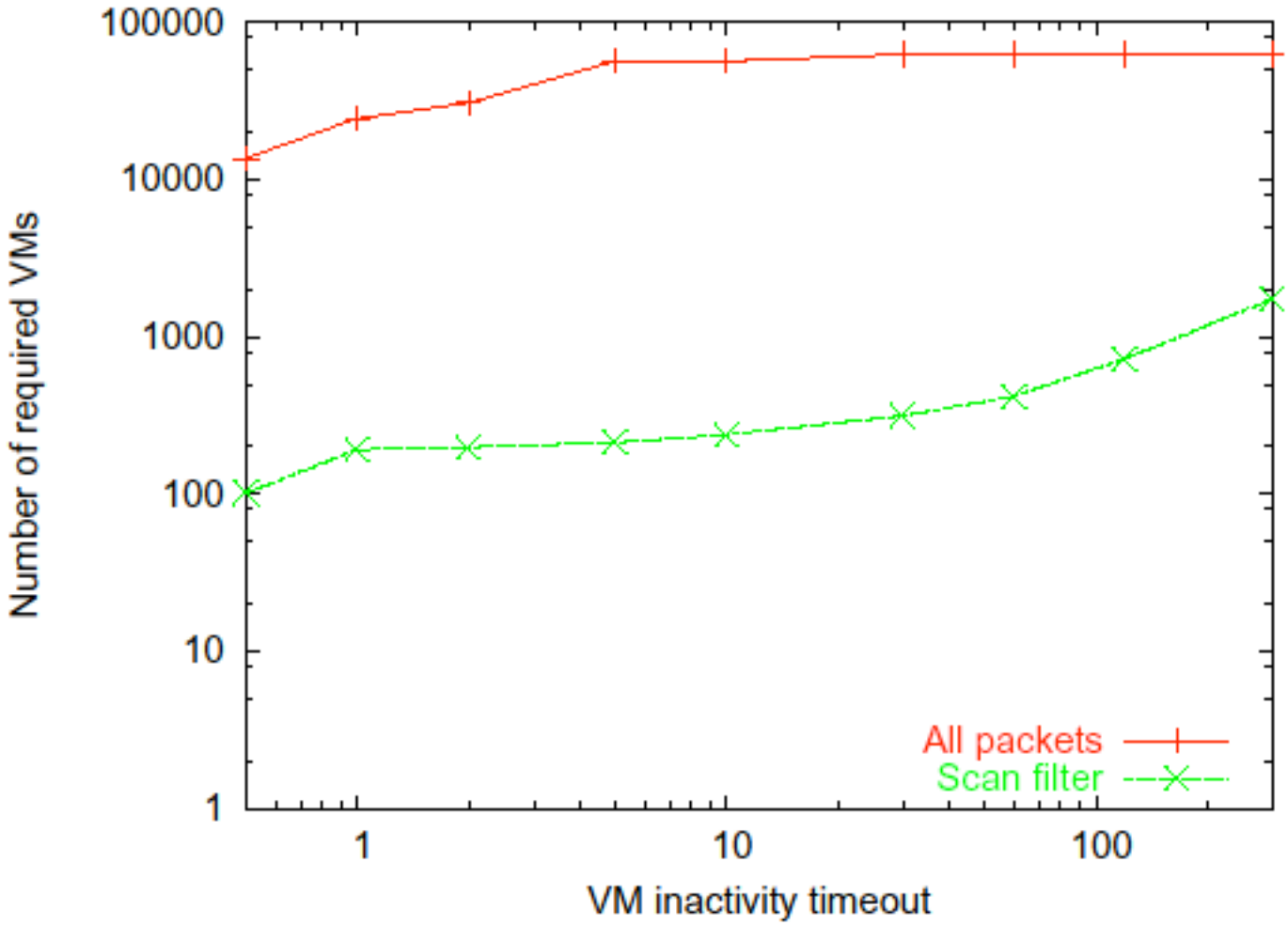
- Controller: VM independent
  - Aggressive filtering
  - *Containment* and *redirection*
  - Mapping and NAT: link incoming traffic to selected VM
- Honeypot Manager: VM dependent

Scan Filtering

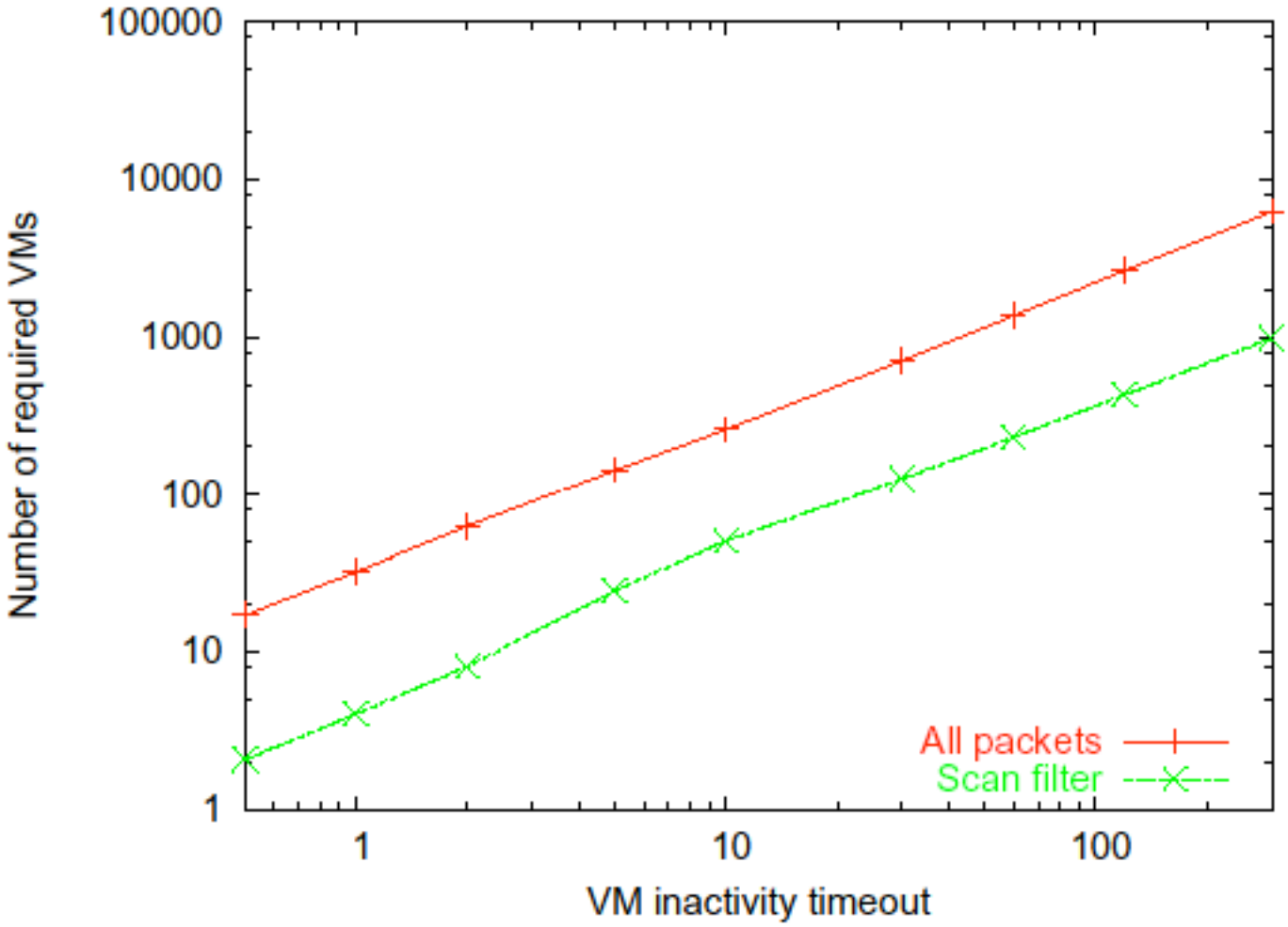
- GQ telescope: 250,000+ Internet addresses



- 10-20K probes/min: can't answer each with a VM!
- Simple filter: each origin gets N probes answered
- Major gain, but still need ~ dozen VM's/sec

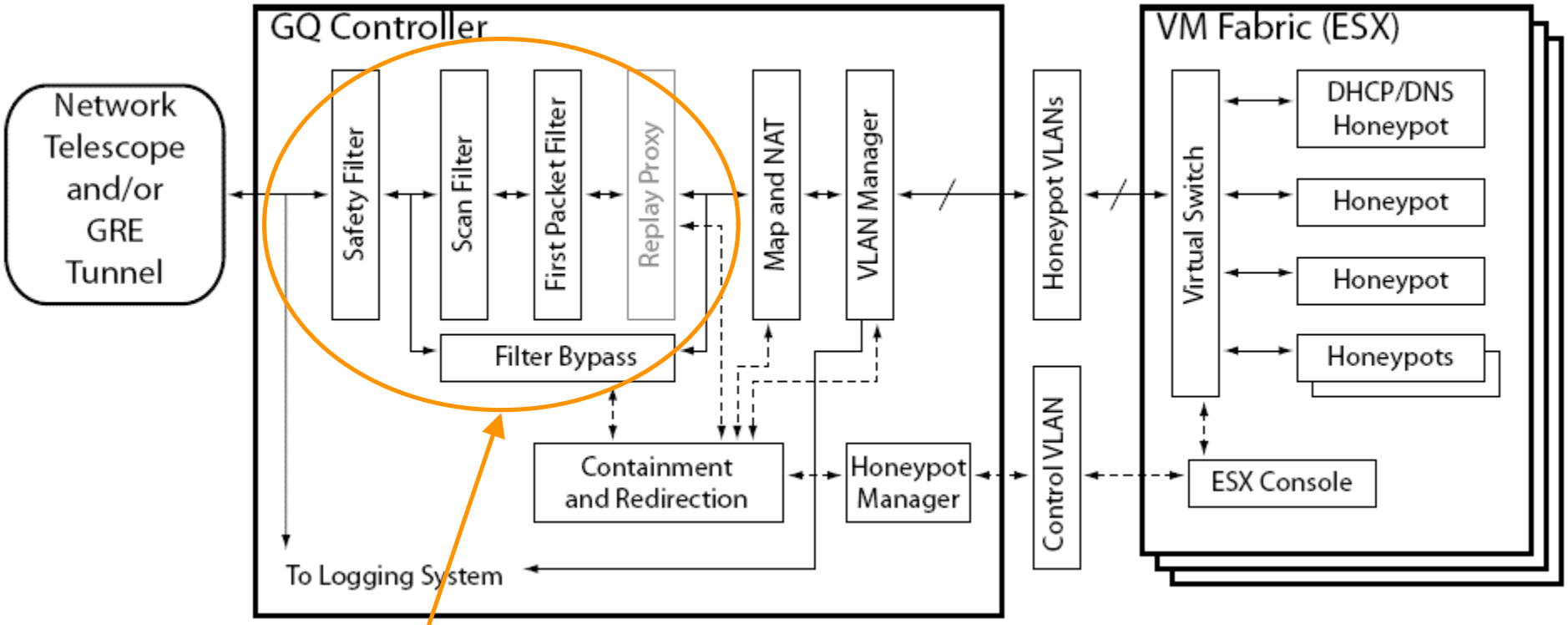


(a) Maximum number of simultaneous VMs



(b) Average number of simultaneous VMs

GQ Architecture



- Controller: VM independent
  - Aggressive filtering
  - *Containment* and *redirection*
  - Mapping and NAT: link incoming traffic to selected VM
- Honeypot Manager: VM dependent

⇒ SMB Negotiate Protocol Request
⇐ SMB Negotiate Protocol Response
⇒ SMB Session Setup AndX Request
⇐ SMB Session Setup AndX Response
⇒ SMB Tree Connect AndX Request
Path: \\XX.128.18.16\IPC$
⇐ SMB Tree Connect AndX Response
⇒ SMB NT Create AndX Req, Path: \samr
⇐ SMB NT Create AndX Response
⇒ DCERPC Bind: call_id: 1 UUID: SAMR
⇐ DCERPC Bind_ack:
⇒ SAMR Connect4 Request
⇐ SAMR Connect4 Reply
⇒ SAMR EnumDomains Request
⇐ SAMR EnumDomains Reply
⇒ SAMR LookupDomain Request
⇐ SAMR LookupDomain Reply
⇒ SAMR OpenDomain Request
⇐ SAMR OpenDomain Reply
⇒ SAMR EnumDomainUsers Request

Now start another session, connect to SRVSVC pipe and issue Remote-Time-of-Day Request

(that stuff again)

⇒ SMB NT Create AndX Request,
Path: \srvsvc
⇐ SMB NT Create AndX Response
⇒ DCERPC Bind: call_id: 1 UUID: SRVSVC
⇐ DCERPC Bind_ack: call_id: 1
⇒ SRVSVC NetrRemoteTOD Request
⇐ SRVSVC NetrRemoteTOD Reply
⇒ SMB Close Request
⇐ SMB Close Response
⇒ SMB Tree Connect AndX Request,
Path: \\XX.128.18.16\ADMIN$
⇐ SMB Tree Connect AndX Response
⇒ SMB NT Create AndX Request,
Path:\system32\msmsgri32.exe

Only **here** do we find what file they're modifying

⇐ SMB NT Create AndX Response,
FID: 0x74ca
⇒ SMB Trans2Req SET_FILE_INFORMATION
⇐ SMB Trans2Resp SET_FILE_INFORMATION
⇒ SMB Trans2Req QUERY_FS_INFORMATION
⇐ SMB Trans2Resp QUERY_FS_INFORMATION
⇒ SMB Write Request

And only **here** do we find what code they're injecting into it!

⇒ SMB Negotiate Protocol Request
⇐ SMB Negotiate Protocol Response
⇒ SMB Session Setup AndX Request
⇐ SMB Session Setup AndX Response
⇒ SMB Tree Connect AndX Request
Path: \\XX.128.18.16\IPC$
⇐ SMB Tree Connect AndX Response
⇒ SMB NT Create AndX Req, Path: \samr
⇐ SMB NT Create AndX Response
⇒ DCERPC Bind: call_id: 1 UUID: SAMR
⇐ DCERPC Bind_ack:
⇒ SAMR Connect4 Request
⇐ SAMR Connect4 Reply
⇒ SAMR EnumDomains Request
⇐ SAMR EnumDomains Reply
⇒ SAMR LookupDomain Request
⇐ SAMR LookupDomain Reply
⇒ SAMR OpenDomain Request
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⇐ SMB NT Create AndX Response
⇒ DCERPC Bind: call_id: 1 UUID: SRVSVC
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⇒ SRVSVC NetrRemoteTOD Request
⇐ SRVSVC NetrRemoteTOD Reply
⇒ SMB Close Request
⇐ SMB Close Response
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Path: \\XX.128.18.16\ADMIN$
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And only **here** do we find what code they're injecting into it!

Matching Protocol Dialog In A New Setting

```
A->V  N1|180|S26|0388|S7|96|S20|96|S8|113|S16|R8|96|R6|72|R4|0014CCB8|18|M4|18|M4
      |144.165.114.119|M20
A<-V  N4|S26|0388|S28|R24|M16|0000000092F3E82470FDD91195F8000C295763F7|M4
A->V  N4|S26|0388|S56|R24|0000000092F3E82470FDD91195F8000C295763F7|M8
A<-V  N1|180|S26|0388|S7|124|S8|124|S6|125|S1|R8|124|DECRPC-6|100|R4|M4|000B0BB0
      |M4|000B27A0|M8|8|10|000B8D18|M8|000BC610|5|M4|4|hone|M36
A->V  N1|156|S26|0388|S7|72|S20|72|S8|89|S16|R8|72|R6|48|R4|M4
      |0000000092F3E82470FDD91195F8000C295763F7|8|10|001503F8|5|M4|4|hone
A<-V  N4|S26|0388|S28|R24|000B27A0|M32
```

N4 = 4 bytes of NetBIOS

S26 = 26 bytes of SMB (Server Message Block)

R24 = 24 bytes of DCE-RPC

M32 = Security Account Manager

Matching Protocol Dialog In A New Setting

```
A->V  N1|180|S26|0388|S7|96|S20|96|S8|113|S16|R8|96|R6|72|R4|0014CCB8|18|M4|18|M4
          |144.165.114.119|M20
A<-V  N4|S26|0388|S28|R24|M16|00000000|92F3E82470|FDD91195F8000C295763F7|M4
A->V  N4|S26|0388|S56|R24|00000000|92F3E82470|FDD91195F8000C295763F7|M8
A<-V  N1|180|S26|0388|S7|124|S8|124|S6|125|S1|R8|124|DECRPC-6|100|R4|M4|000B0BB0
          |M4|000B27A0|M8|8|10|000B8D18|M8|000BC610|5|M4|4|hone|M36
A->V  N1|156|S26|0388|S7|72|S20|72|S8|89|S16|R8|72|R6|48|R4|M4
          |00000000|92F3E82470|FDD91195F8000C295763F7|8|10|001503F8|5|M4|4|hone
A<-V  N4|S26|0388|S28|R24|000B27A0|M32
```

Grey = embedded length field

Bold = transaction ID / "cookie" field

Bold Italic = embedded IP address or hostname

- How can we accurately identify & adjust all of these?

Two Dialogs for Matching Randex

A->V N1|180|S26|**0388**|S7|96|S20|96|S8|113|S16|R8|96|R6|72|R4|0014CCB8|18|M4|18|M4
|*144.165.114.119*|M20

A<-V N4|S26|**0388**|S28|R24|M16|0000000**92F3E82470**FDD91195F8000C29**5763F7**|M4

A->V N4|S26|**0388**|S56|R24|00000000**92F3E82470**FDD91195F8000C29**5763F7**|M8

A<-V N1|180|S26|**0388**|S7|124|S8|124|S6|125|S1|R8|124|DECRPC-6|100|R4|M4|000B0BB0
|M4|000B27A0|M8|8|10|000B8D18|M8|000BC610|5|M4|4|*hone*|M36

A->V N1|156|S26|**0388**|S7|72|S20|72|S8|89|S16|R8|72|R6|48|R4|M4
|00000000**92F3E82470**FDD91195F8000C29**5763F7**|8|10|001503F8|5|M4|4|*hone*

A<-V N4|S26|**0388**|S28|R24|000B27A0|M32

A->V N1|172|S26|**0474**|S7|88|S20|88|S8|105|S16|R8|88|R6|64|R4|0014CCB8|14|M4|14|M4
|*48.196.8.48*|M20

A<-V N4|S26|**0474**|S28|R24|M16|0000000**6093917586**FDD91195F8000C29**4A478F**|M4

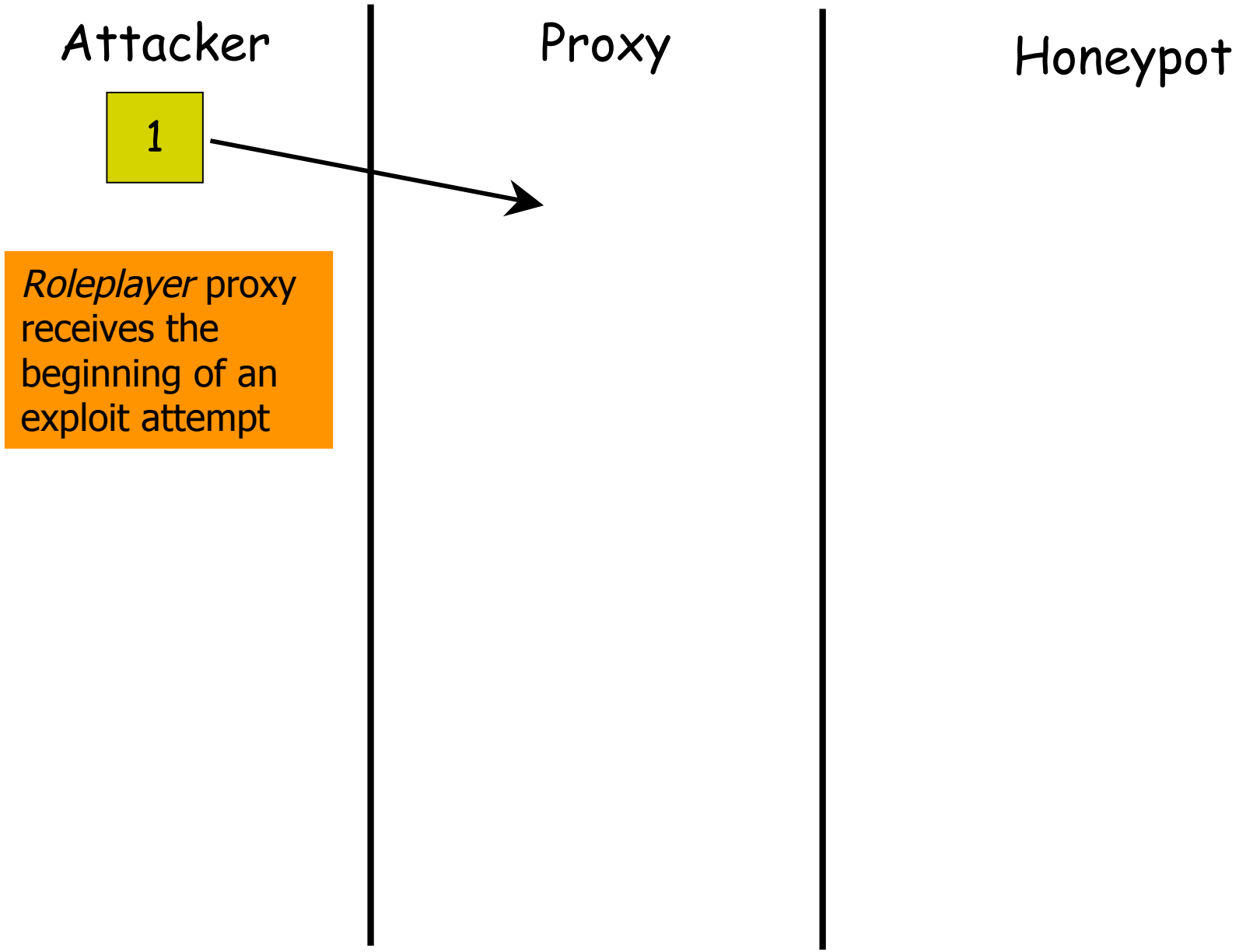
A->V N4|S26|**0474**|S56|R24|00000000**6093917586**FDD91195F8000C29**4A478F**|M8

A<-V N1|184|S26|**0474**|S7|128|S8|128|S6|129|S1|R8|128|DECRPC-6|104|R4|M4|000B0BB0
|M4|000B6380|M8|12|14|000B76C0|M8|000C9FA8|7|M4|6|*host02*|M36

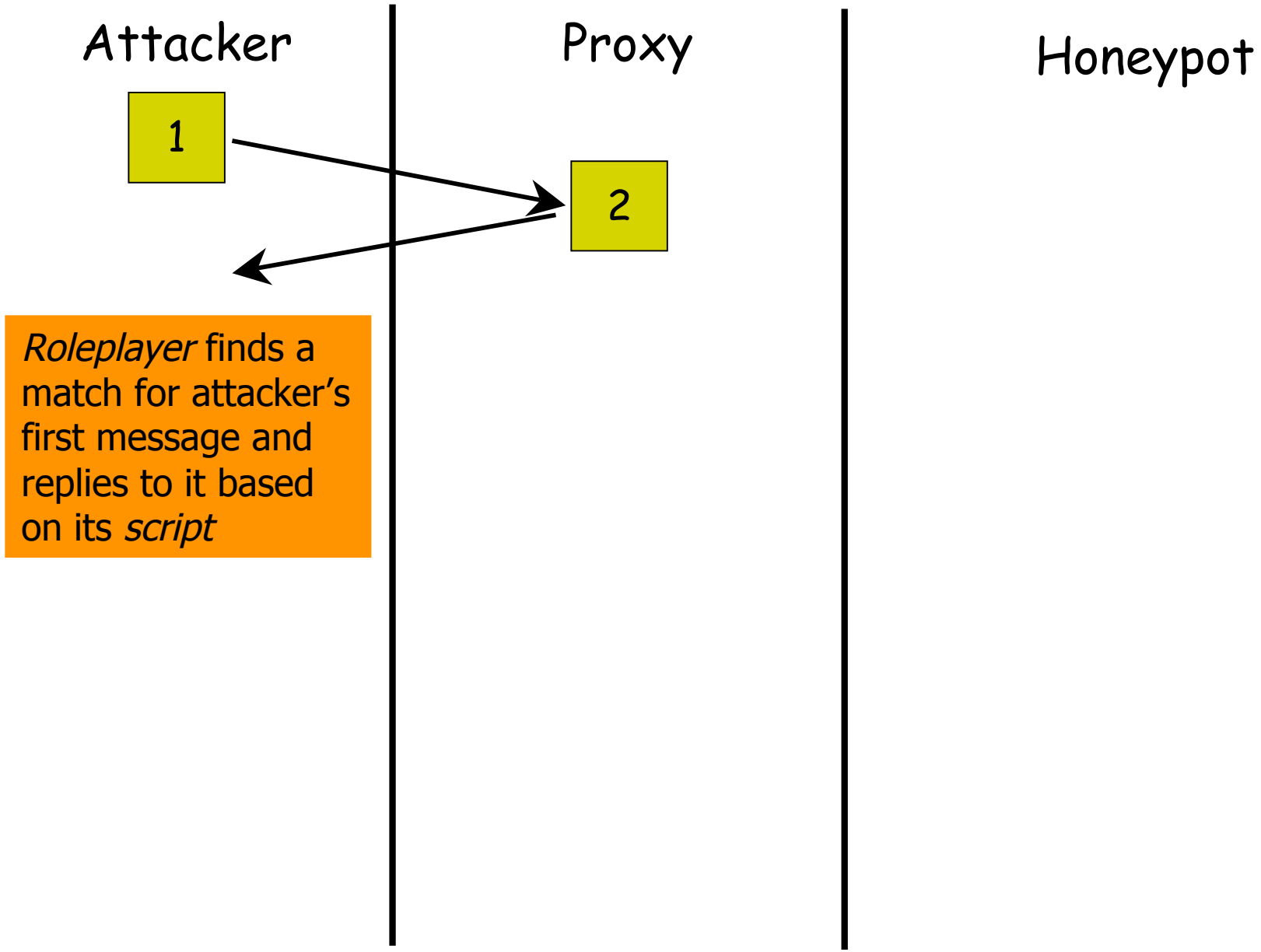
A->V N1|160|S26|**0474**|S7|76|S20|76|S8|89|S16|R8|76|R6|52|R4|M4
|00000000**6093917586**FDD91195F8000C29**4A478F**|12|14|001503F8|7|M4|6|*host02*

A<-V N4|S26|**0474**|S28|R24|000B27A0|M32

Replay Proxy



Replay Proxy



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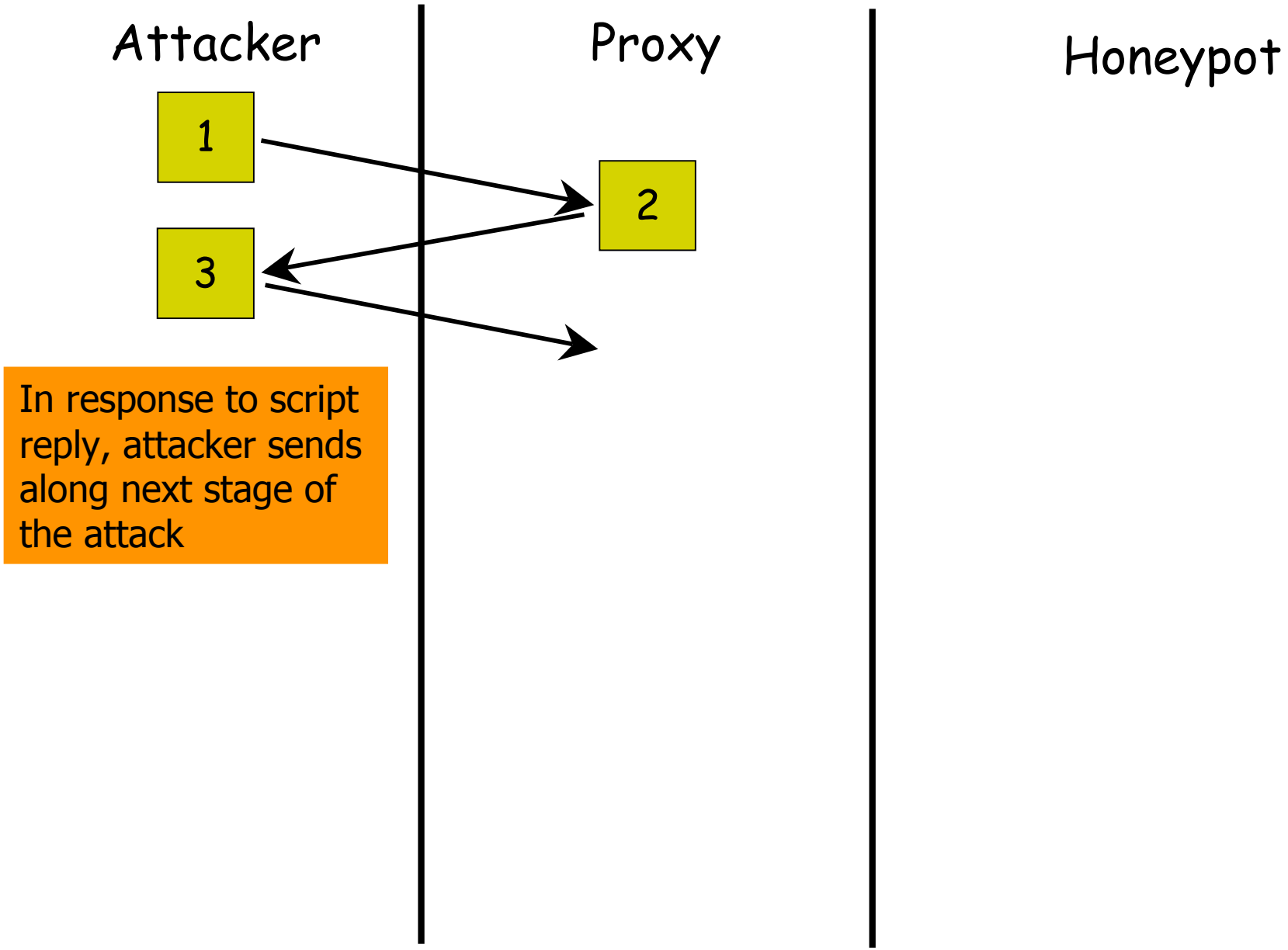

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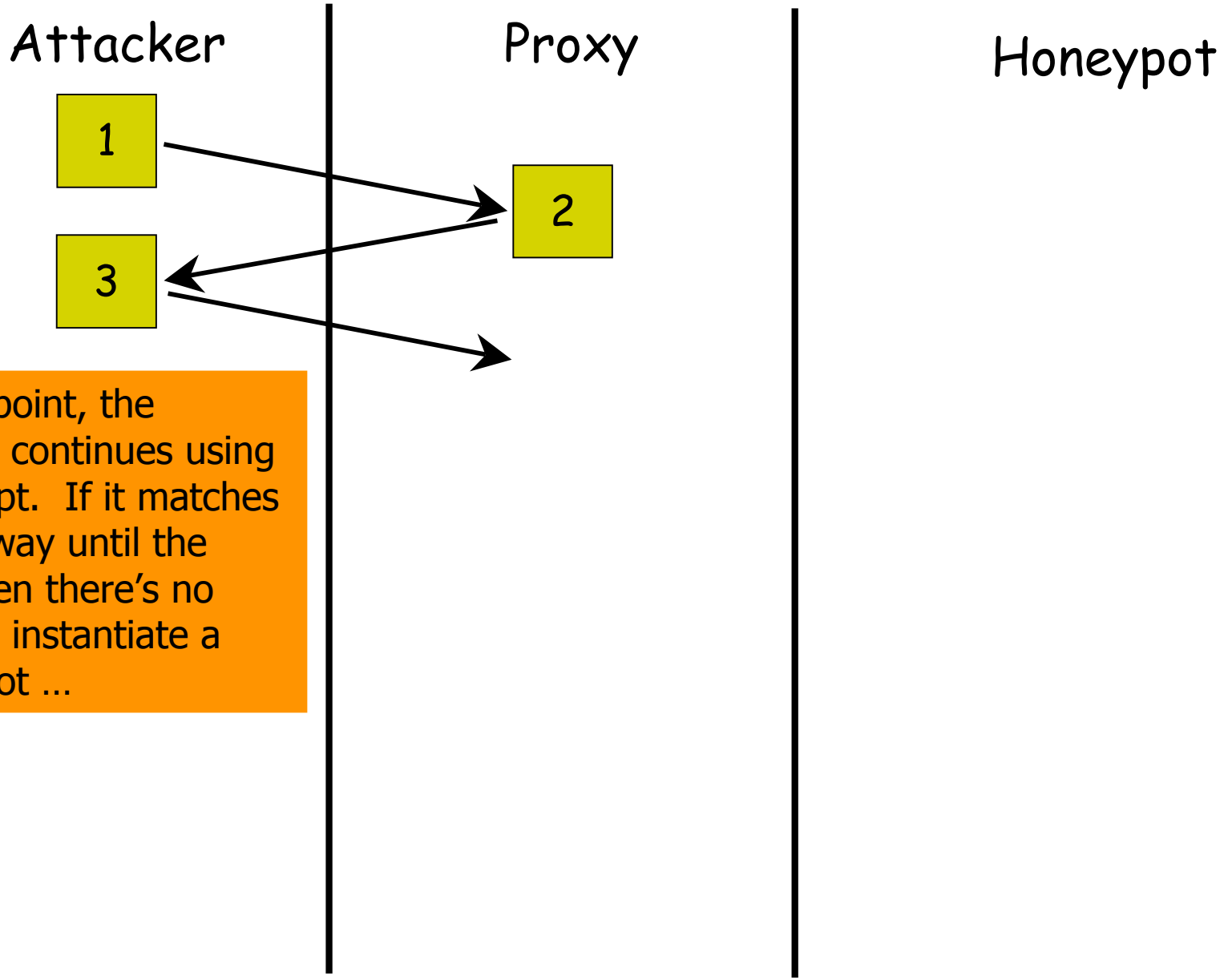
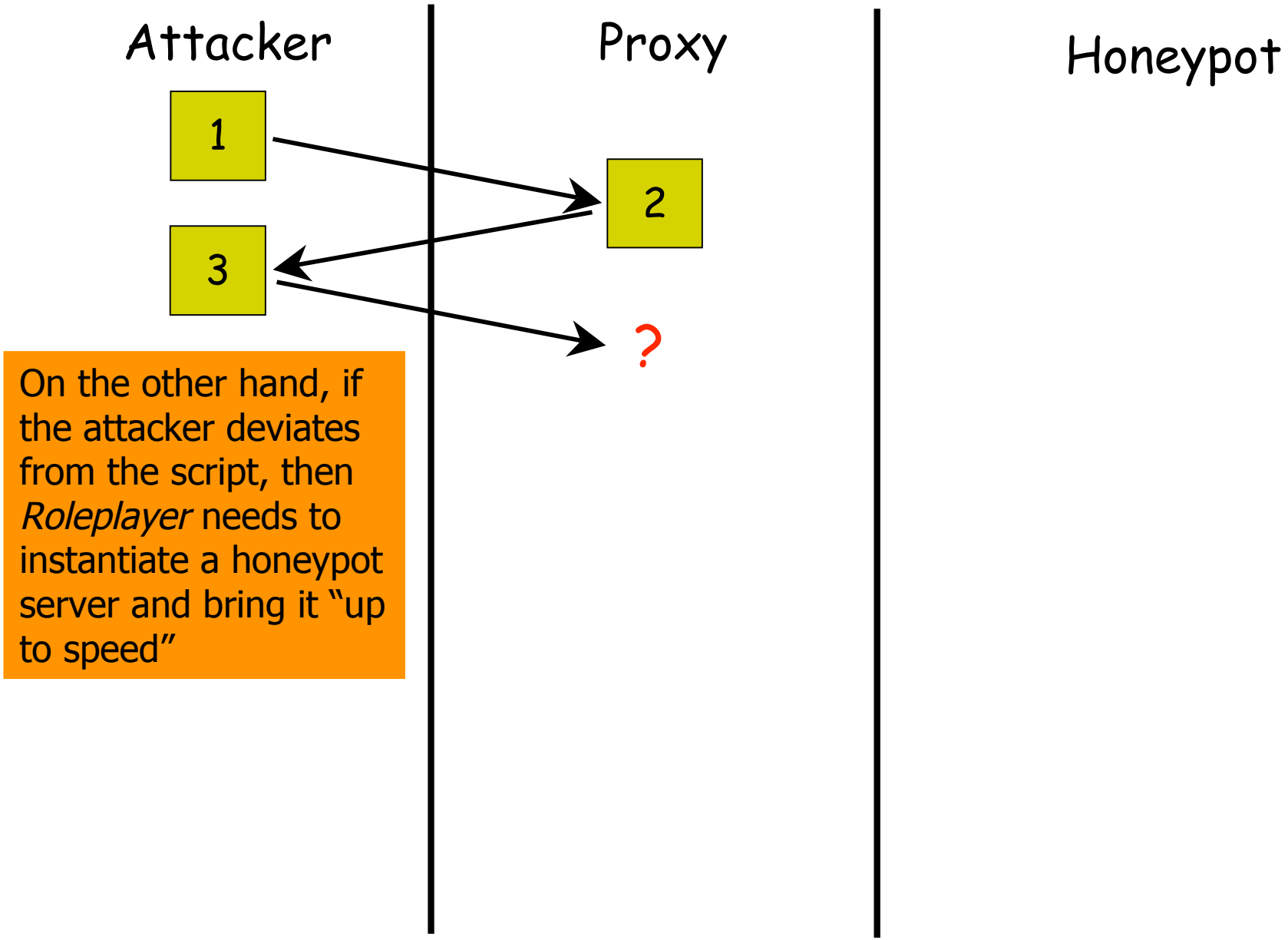


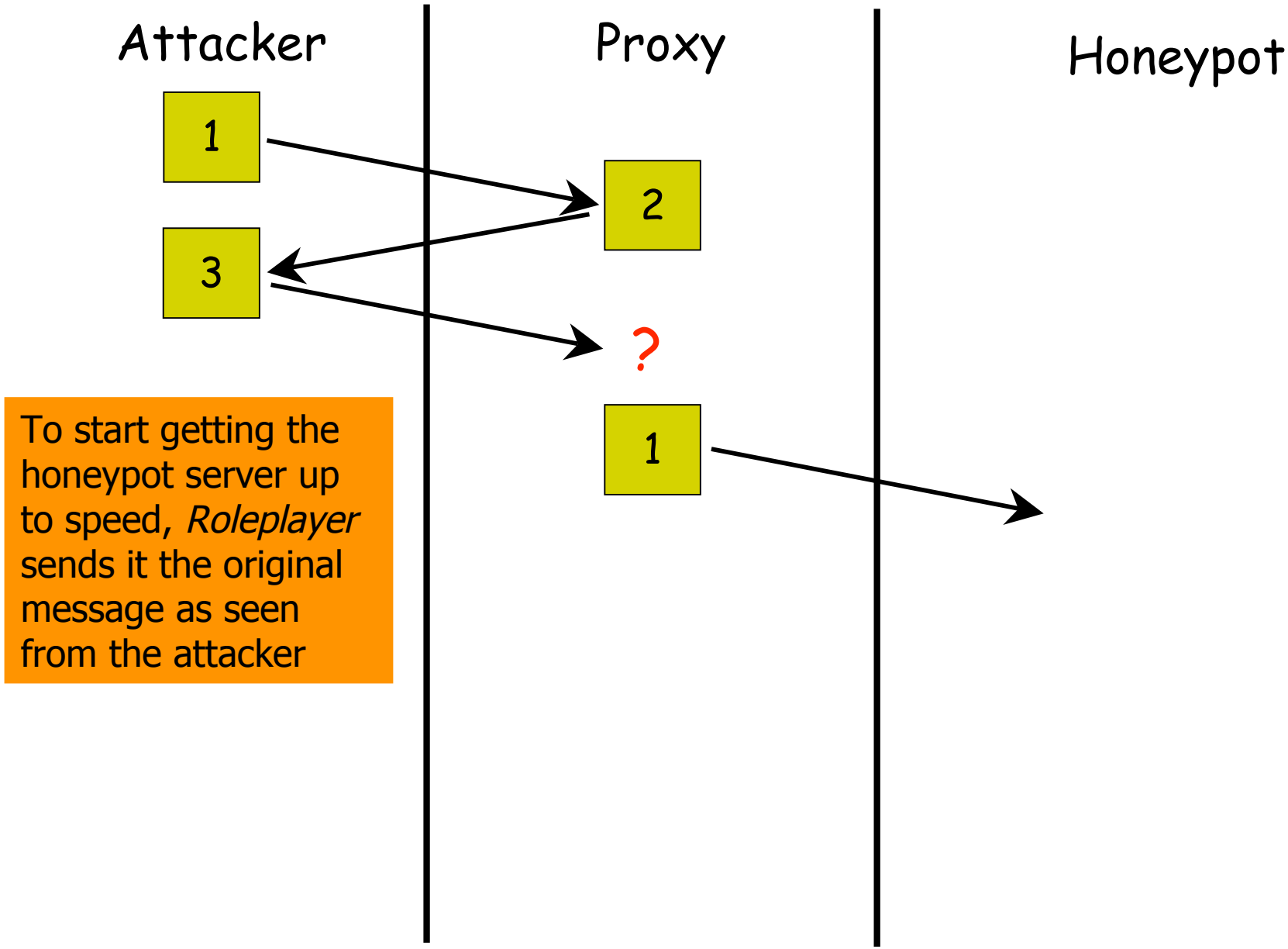
At this point, the process continues using the script. If it matches all the way until the end, then there's no need to instantiate a honeypot …

Replay Proxy



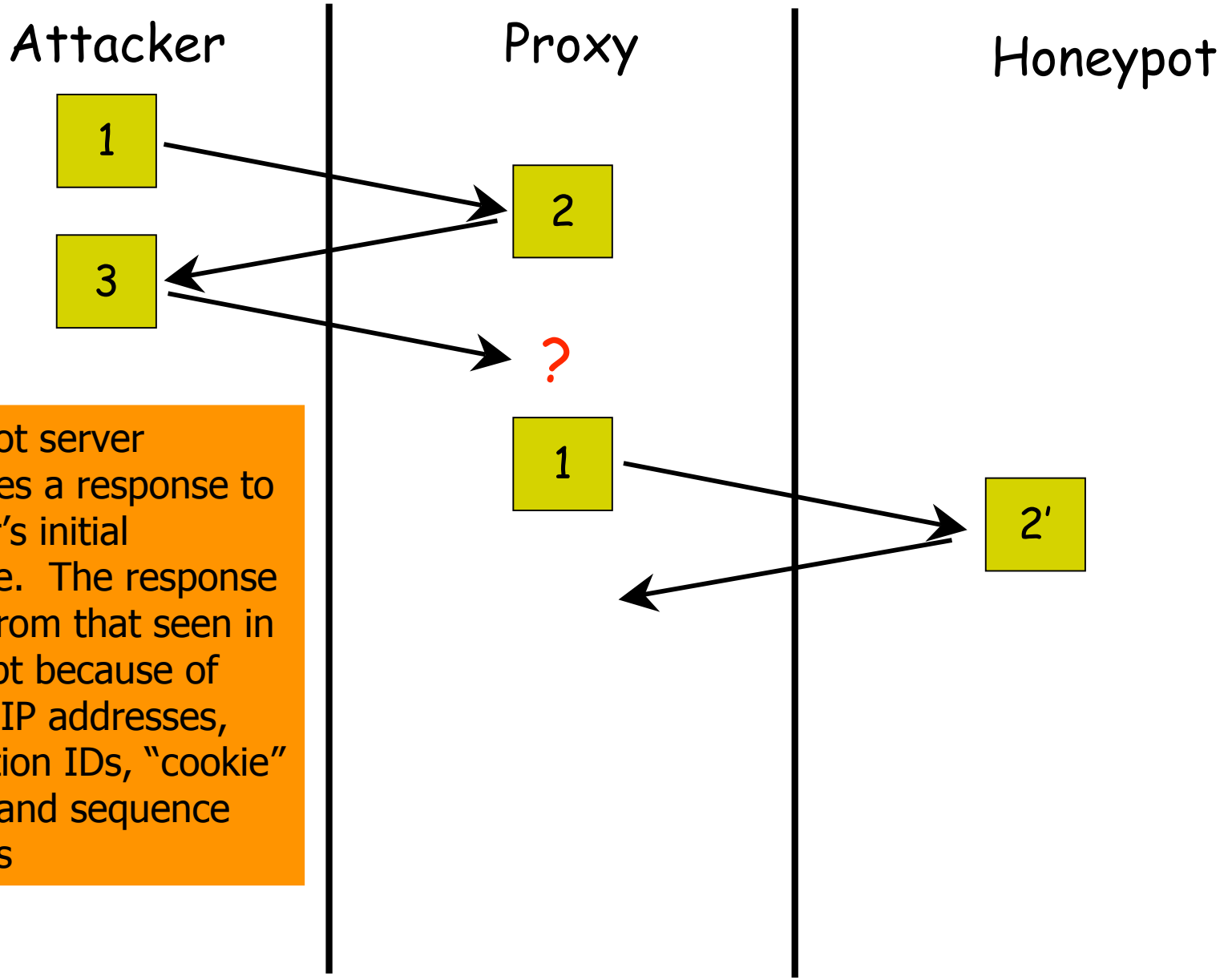
On the other hand, if the attacker deviates from the script, then *Roleplayer* needs to instantiate a honeypot server and bring it "up to speed"

Replay Proxy



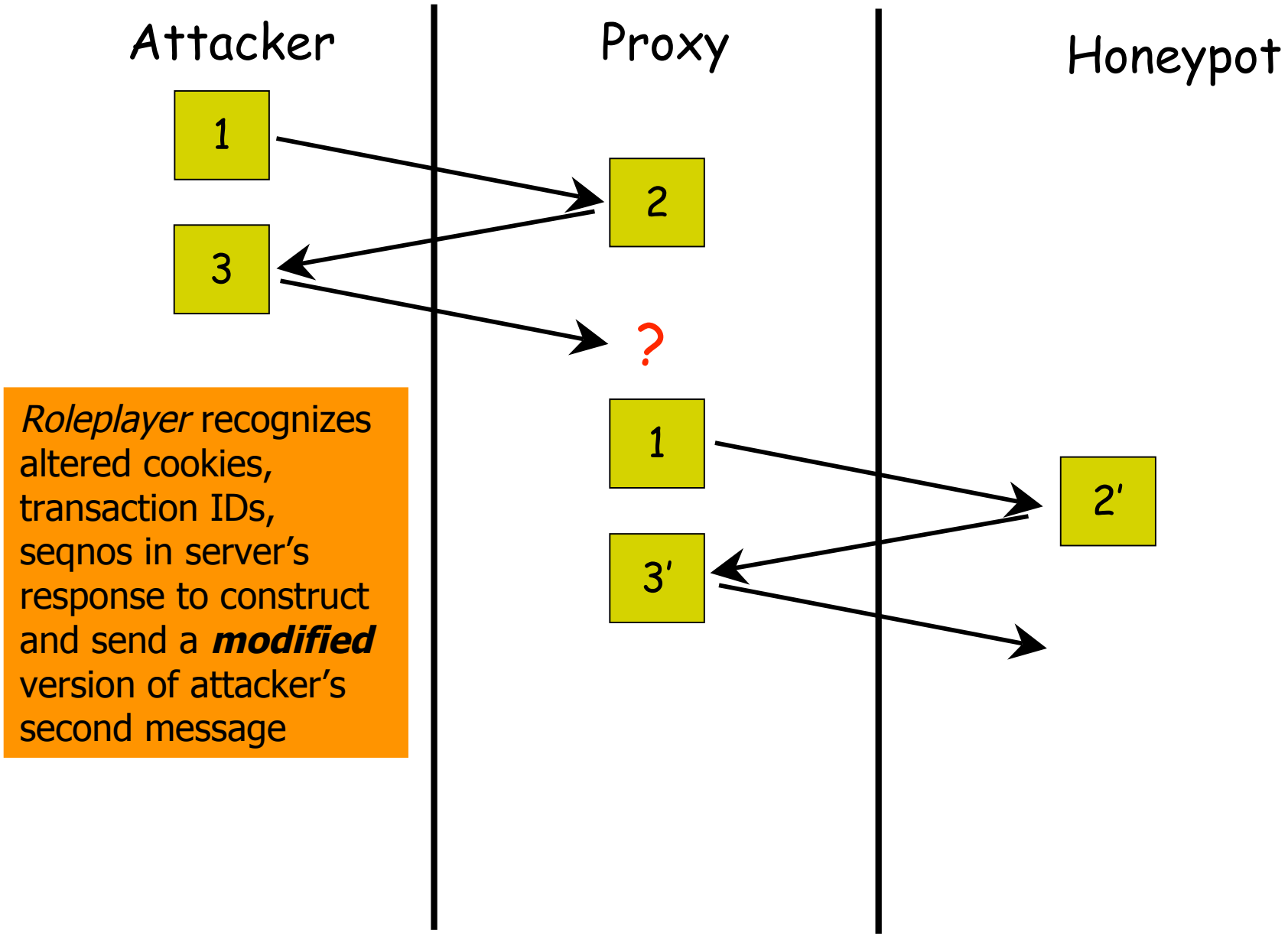
To start getting the honeypot server up to speed, *Roleplayer* sends it the original message as seen from the attacker

Replay Proxy



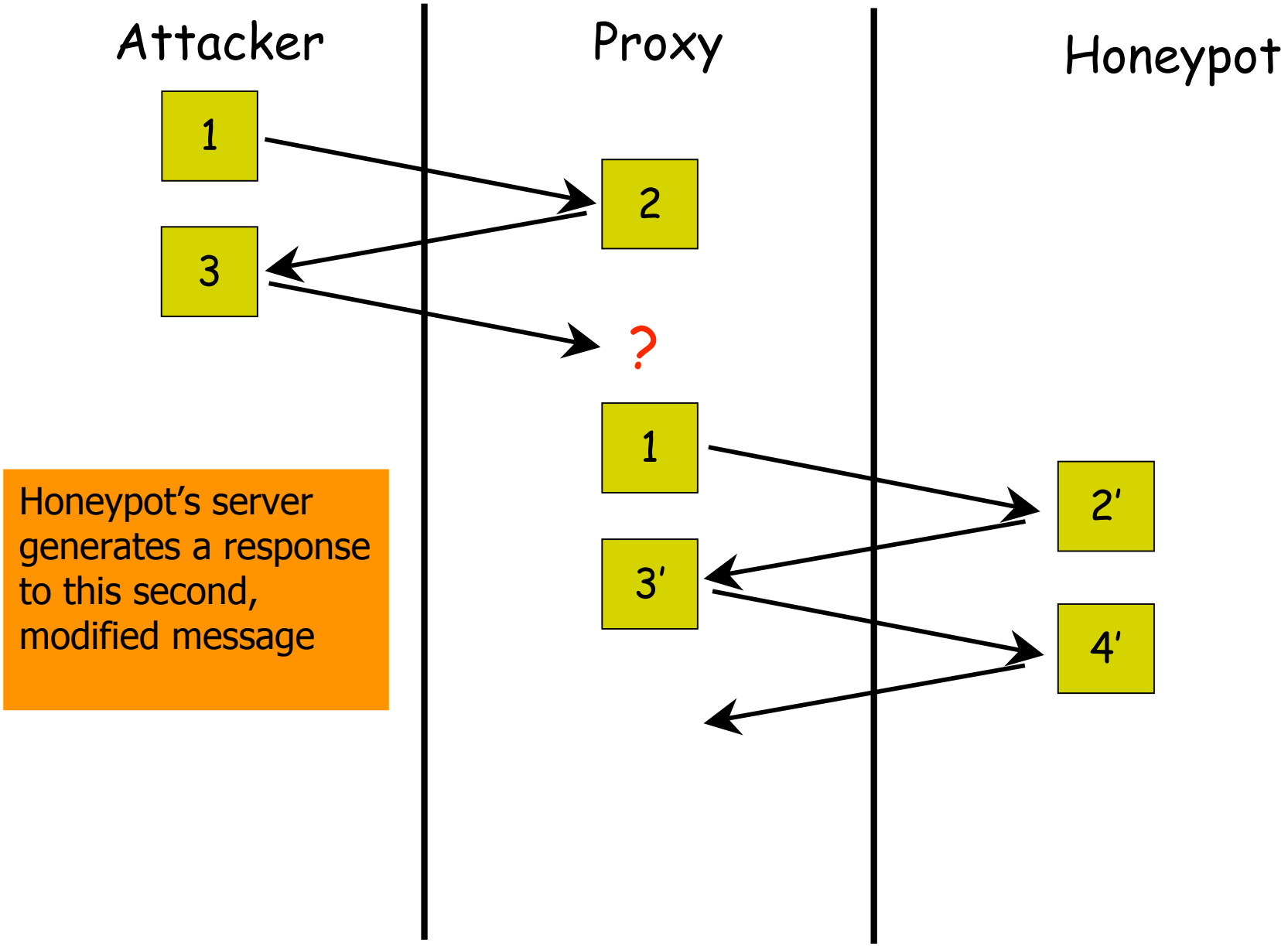
Honeypot server generates a response to attacker's initial message. The response *differs* from that seen in the script because of varying IP addresses, transaction IDs, "cookie" values, and sequence numbers

Replay Proxy

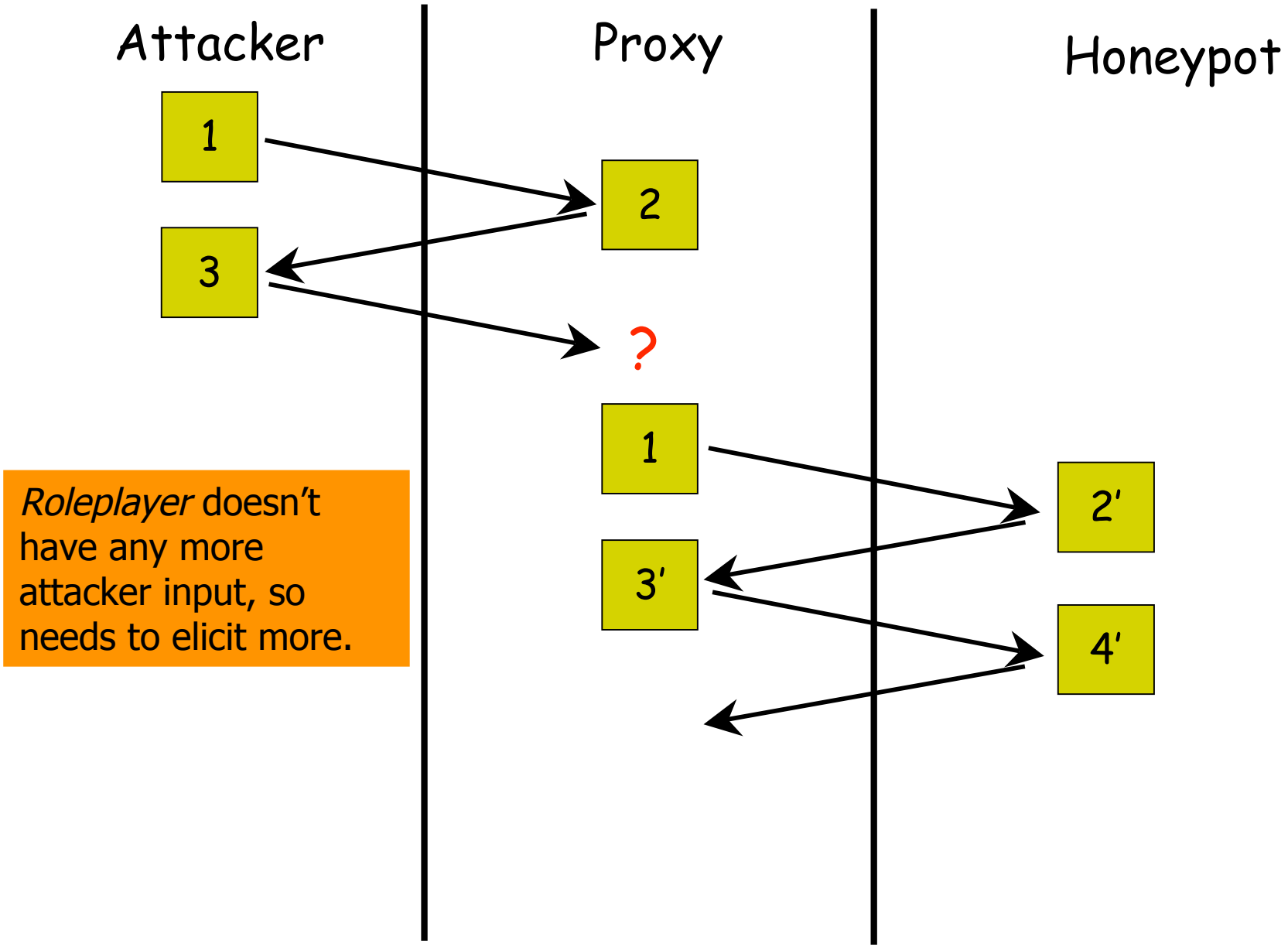


Roleplayer recognizes altered cookies, transaction IDs, seqnos in server's response to construct and send a ***modified*** version of attacker's second message

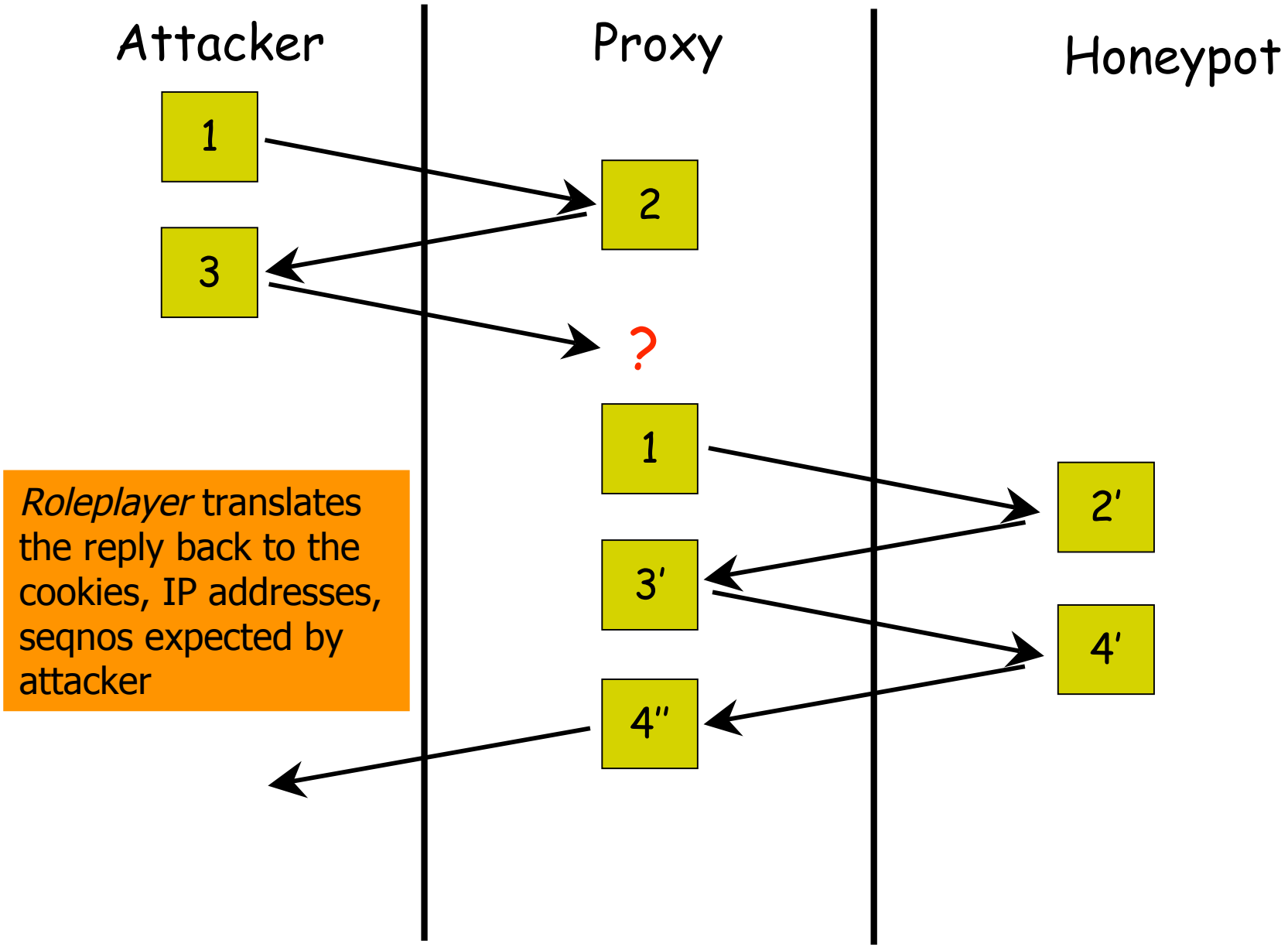
Replay Proxy



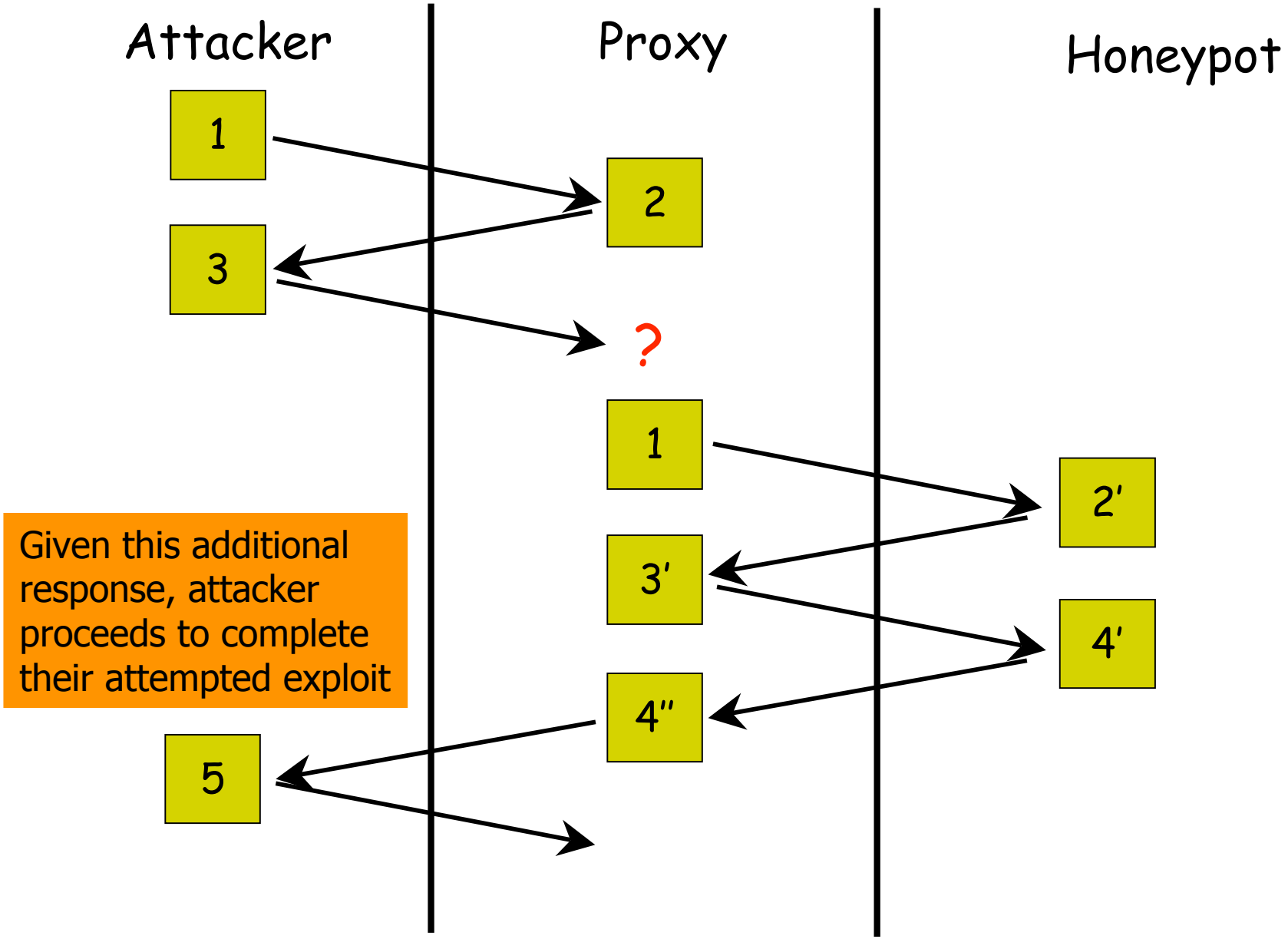
Replay Proxy



Replay Proxy



Replay Proxy



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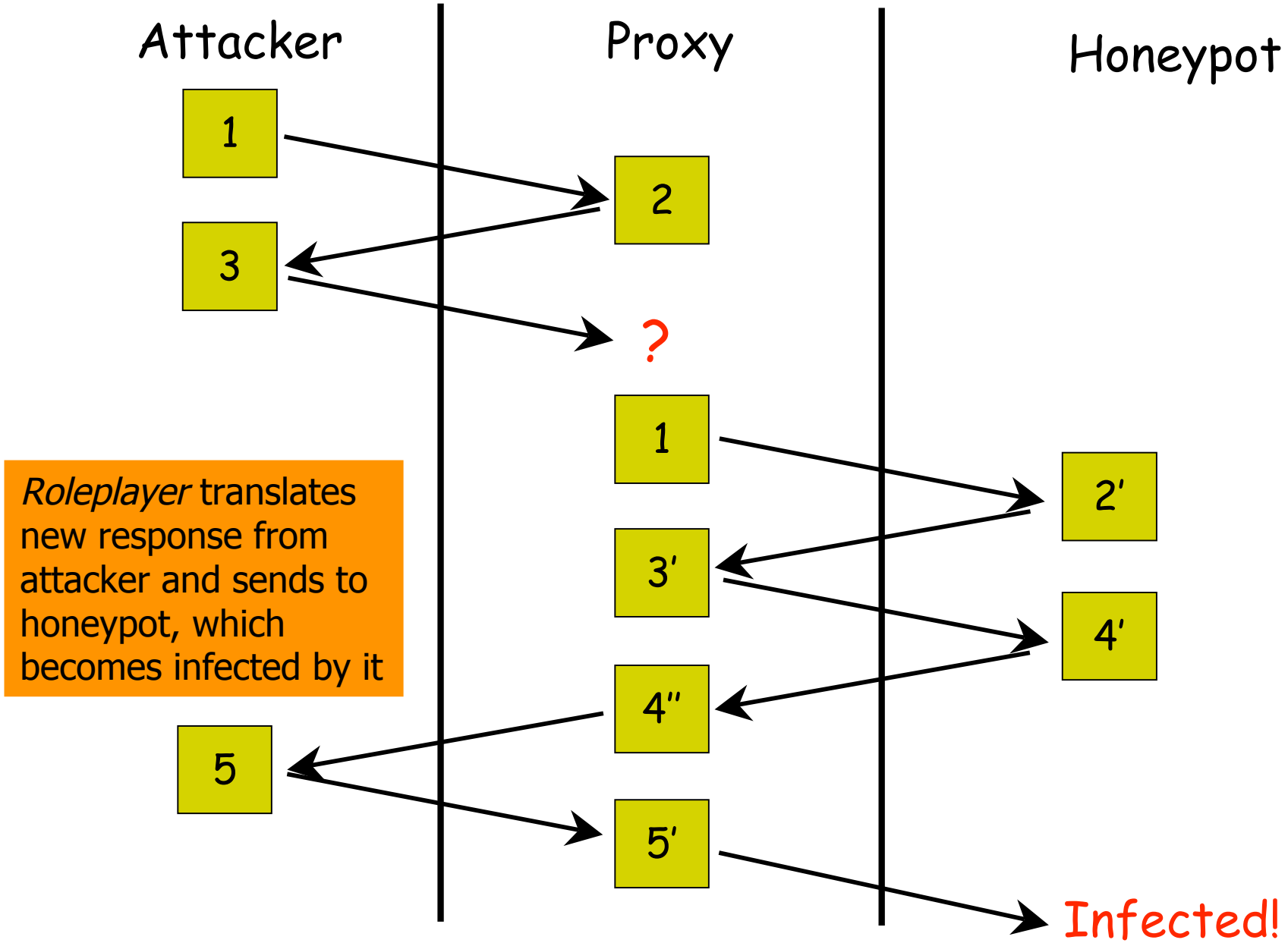
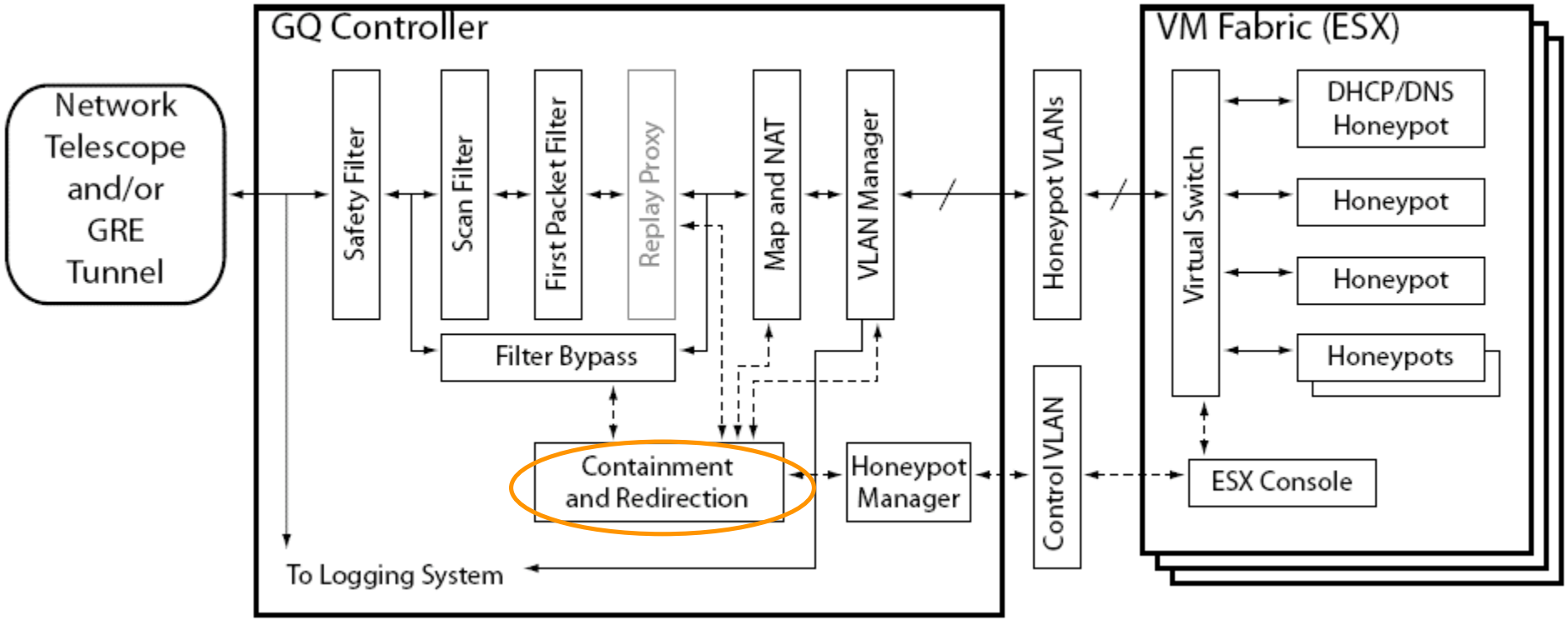


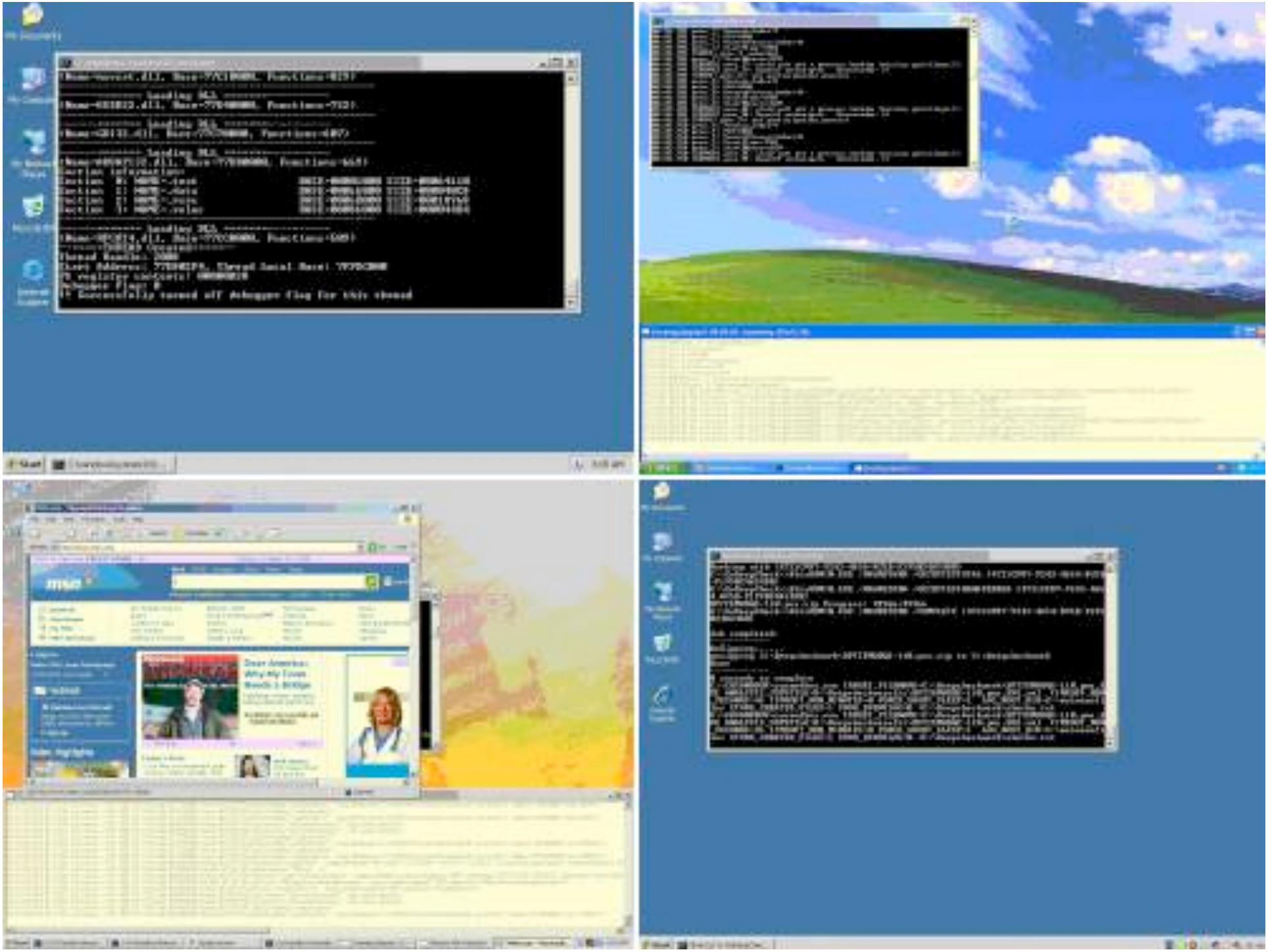
Executable Name	Size (B)	MD5Sum	Worm Name	# Events	# Conns	Time (s)
a####.exe	10366	7a67f7c8...	W32.Zotob.E	4	3	29.0
a####.exe	10878	bf47cfe2...	W32.Zotob.H	9	3	25.2
a####.exe	25726	62697686...	Quarantined but no name	1	3	223.2
cpufanctrl.exe	191150	1737ec9a...	Backdoor.Sdbot	1	4	111.2
chkdisk32.exe	73728	27764a5d...	Quarantined but no name	1	4	134.7
dllhost.exe	10240	53bfe15e...	W32.Welchia.Worm	297	4 or 6	24.5
enbiei.exe	11808	d1ee9d2e...	W32.Blaster.F.Worm	1	3	28.9
msblast.exe	6176	5ae700c1...	W32.Balster.Worm	1	3	43.8
lsd	18432	17028f1e...	W32.Poxdar	11	8	32.4
NeroFil.EXE	78480	5ca9a953...	W32.Spybot.Worm	1	5	237.5
sysmsn.exe	93184	5f6c8c40...	W32.Spybot.Worm	3	3	79.6
MsUpdaters.exe	107008	aa0ee4b0...	W32.Spybot.Worm	1	5	57.0
RealPlayer.exe	120320	4995eb34...	W32.Spybot.Worm	2	5	95.4
WinTemp.exe	209920	9e74a7b4...	W32.Spybot.Worm	1	5	178.4
wins.exe	214528	7a9aee7b...	W32.Spybot.Worm	1	5	118.2
msnet.exe	238592	6355d4d5...	W32.Spybot.Worm	1	7	189.4
MSGUPDATES.EXE	241152	65b401eb...	W32.Spybot.Worm	2	5	125.3
ntsf.exe	211968	5ac5998e...	Qurantined but no name	1	5	459.4
scardsvr32.exe	33169	1a570b48...	W32.Femot.Worm	4	3	46.2
scardsvr32.exe	34304	b10069a8...	W32.Femot.Worm	1	3	66.5
scardsvr32.exe	34816	ba599948...	W32.Femot.Worm	55	3	96.6
scardsvr32.exe	35328	617b4056...	W32.Femot.Worm	2	3	179.6
scardsvr32.exe	36864	0372809c...	W32.Femot.Worm	1	5	49.3
scardsvr32.exe	39689	470de280...	W32.Femot.Worm	4	3	41.4
scardsvr32.exe	40504	23055595...	W32.Femot.Worm	1	3	41.1
scardsvr32.exe	43008	ff20f56b...	W32.Valla.2048	1	5	32.2
scardsvr32.exe	66374	f7a00ef5...	Quarantined but no name	1	7	54.8

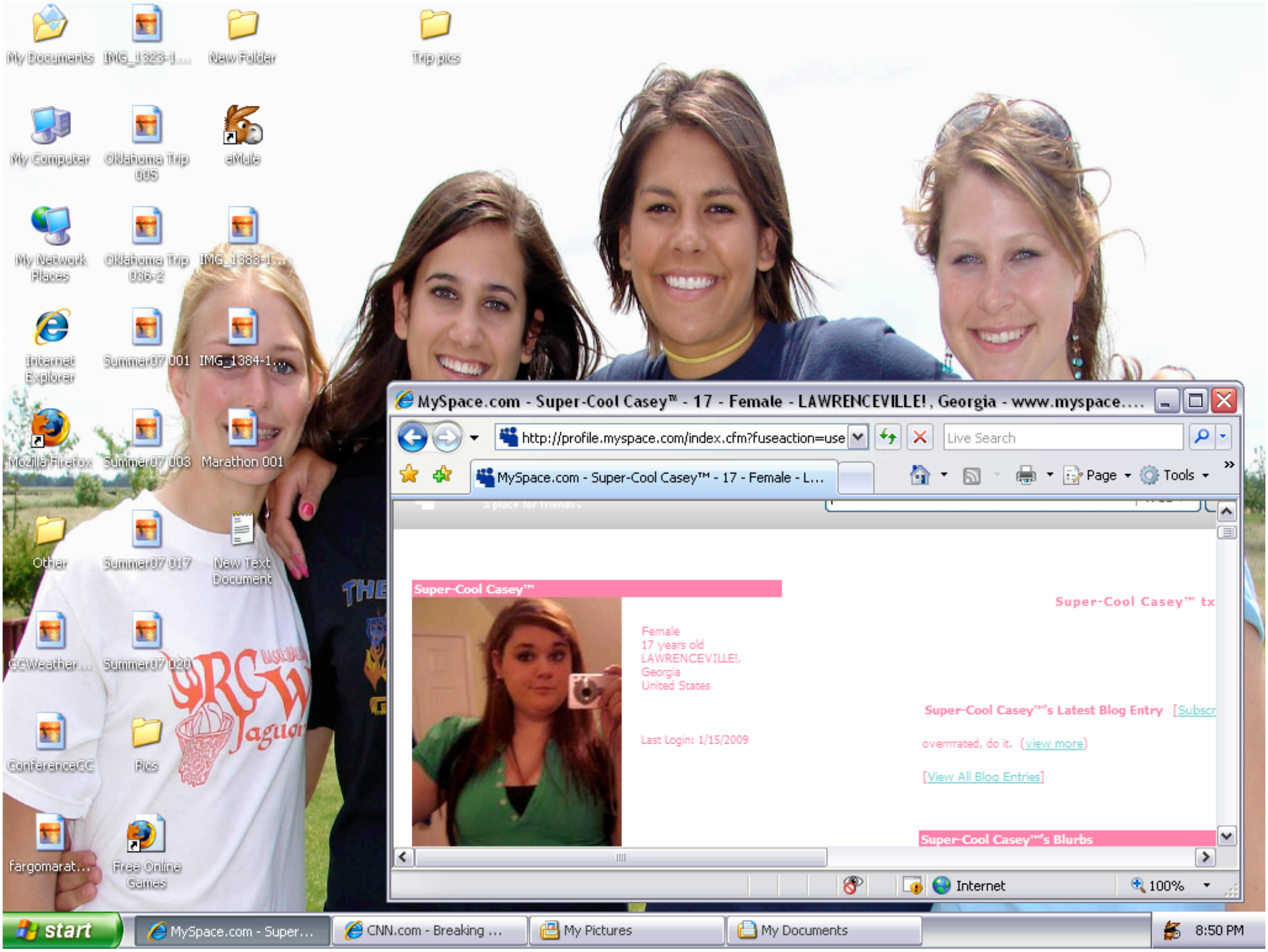
x.exe	9343	986b5970...	W32.Korgo.Q	17	2	6.6
x.exe	9344	d6df3972...	W32.Korgo.T	7	2	9.5
x.exe	9353	7d99b0e9...	W32.Korgo.V	102	2	6.0
x.exe	9359	a0139d7a...	W32.Korgo.W	31	2	5.9
x.exe	9728	c05385e6...	W32.Korgo.Z	20	2	6.6
x.exe	11391	7f60162c...	W32.Korgo.S	169	2	6.6
x.exe	11776	c0610a0d...	W32.Korgo.S	15	2	8.6
x.exe	13825	0b80b637...	W32.Korgo.V	2	2	24.4
x.exe	20992	31385818...	W32.Licum	2	2	7.9
x.exe	23040	e0989c83...	W32.Korgo.S	3	2	10.4
x.exe	187348	384c6289...	W32.Pinfi	1	2	329.7
x.exe	187350	a4410431...	W32.Korgo.V	6	2	11.3
x.exe	187352	b3673398...	W32.Pinfi	5	2	20.1
x.exe	187354	c132582a...	W32.Pinfi	5	2	24.9
x.exe	187356	d586e6c2...	W32.Pinfi	2	2	27.5
x.exe	187358	2430c64c...	W32.Korgo.V	1	2	27.5
x.exe	187360	eb1d07c1...	W32.Pinfi	1	2	63.1
x.exe	187392	2d9951ca...	W32.Korgo.W	1	2	76.1
x.exe	189400	7d195c0a...	W32.Korgo.S	1	2	18.0
x.exe	189402	c03b5262...	W32.Pinfi	1	2	58.2
x.exe	189406	4957f2e3...	W32.Korgo.S	1	2	210.9
xxxx...x	46592	a12cab51...	Backdoor.Berbew.N	844	2	9.4
xxxx...x	56832	b783511e...	W32.Info.A	34	2	7.2
xxxx...x	57856	ab5e47bf...	Trojan.Dropper	685	3	10.0
xxxx...x	224218	d009d6e5...	W32.Pinfi	1	3	32.5
xxxx...x	224220	af79e0c6...	W32.Pinfi	3	2	34.2
n/a	10240	7623c942...	W32.Korgo.C	3	2	4.8
n/a	10752	1b90cc9f...	W32.Korgo.L	1	2	7.0
n/a	10752	32a0d7d0...	W32.Korgo.G	8	2	4.1
n/a	10752	ab7ecc7a...	W32.Korgo.N	2	2	5.3
n/a	10752	d175bad0...	W32.Korgo.G	3	2	5.4
n/a	10752	d85bf0c5...	W32.Korgo.E	1	2	5.6
n/a	10752	b1e7d9ba...	W32.Korgo.gen	1	2	5.0
n/a	10879	042774a2...	W32.Korgo.I	15	2	4.3
n/a	11264	a36ba4a2...	W32.Korgo.I	1	2	5.4
multiple	n/a	n/a	W32.Muma.A	2	7	186.7
multiple	n/a	n/a	W32.Muma.B	2	7	208.9
multiple	n/a	n/a	BAT.Boohoo.Worm	1	72	384.9

GQ Architecture



- Controller: VM independent
  - Aggressive filtering
  - *Containment* and *redirection*
  - Mapping and NAT: link incoming traffic to selected VM
- Honeypot Manager: VM dependent

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My Network Places
Oklahoma Trip 006-2
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IMG_1384-1...
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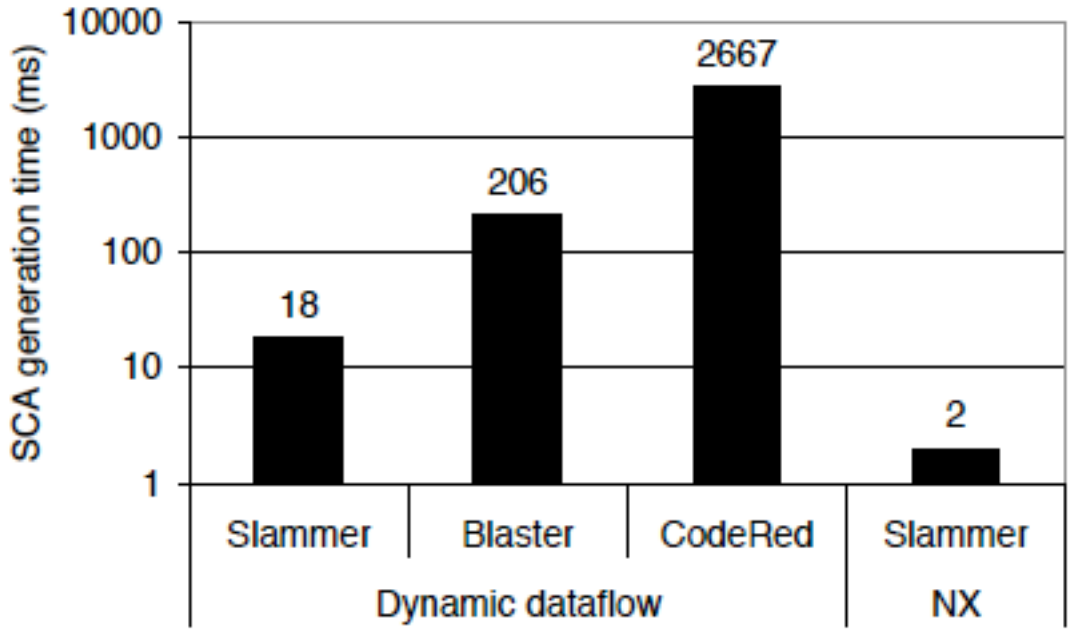

Figure 8: SCA generation time in milliseconds for real worms using two detectors.

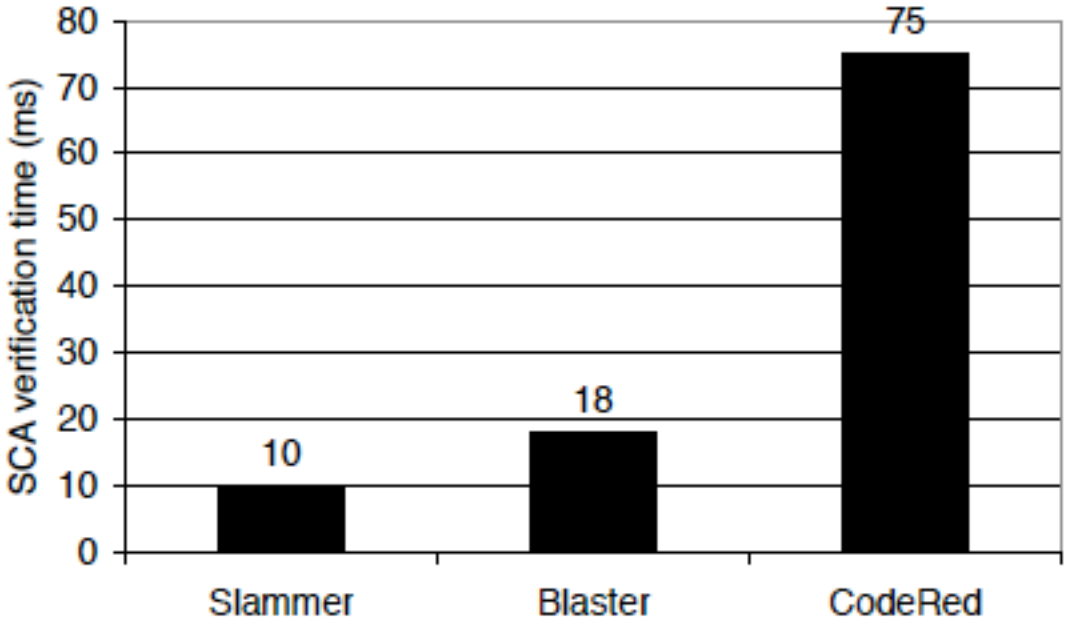

Figure 10: SCA verification time in milliseconds for real worms.