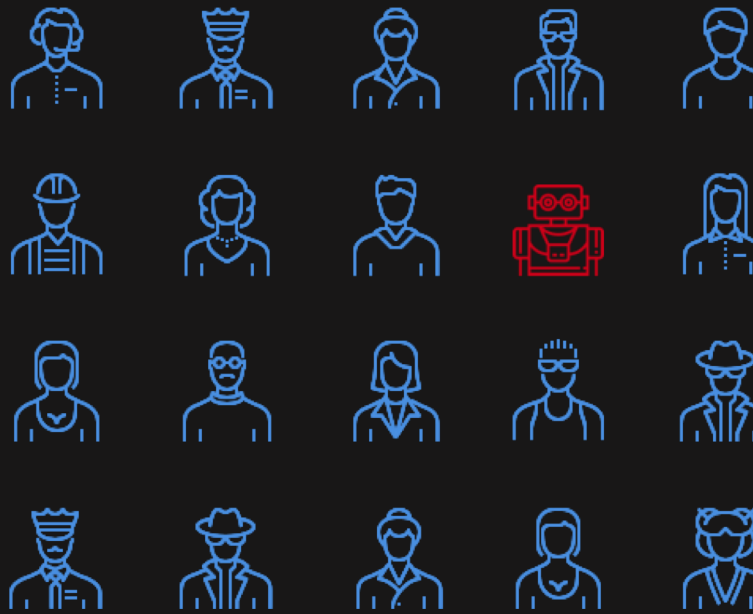
White Ops

A penny per visit adds up real fast:
Designing effective defenses against an adversary that makes more money than you do



Michael Tiffany

Platform Security Summit , May, 2018

Ad fraud pays astonishing well and consequences have been low

It makes the most money with the least risk:

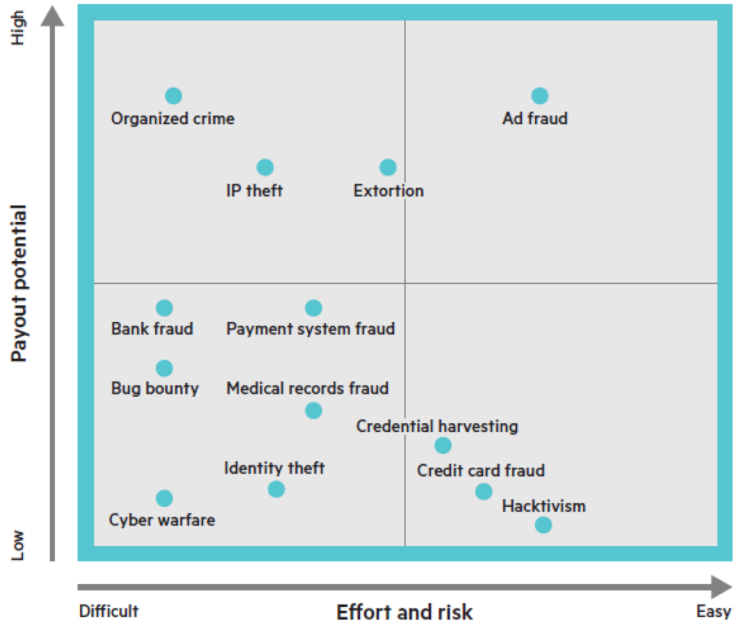


Figure 1: Attractiveness of hacking based on financial gain and effort

Source: HP Enterprise Solutions. The Business of Hacking, May 2016

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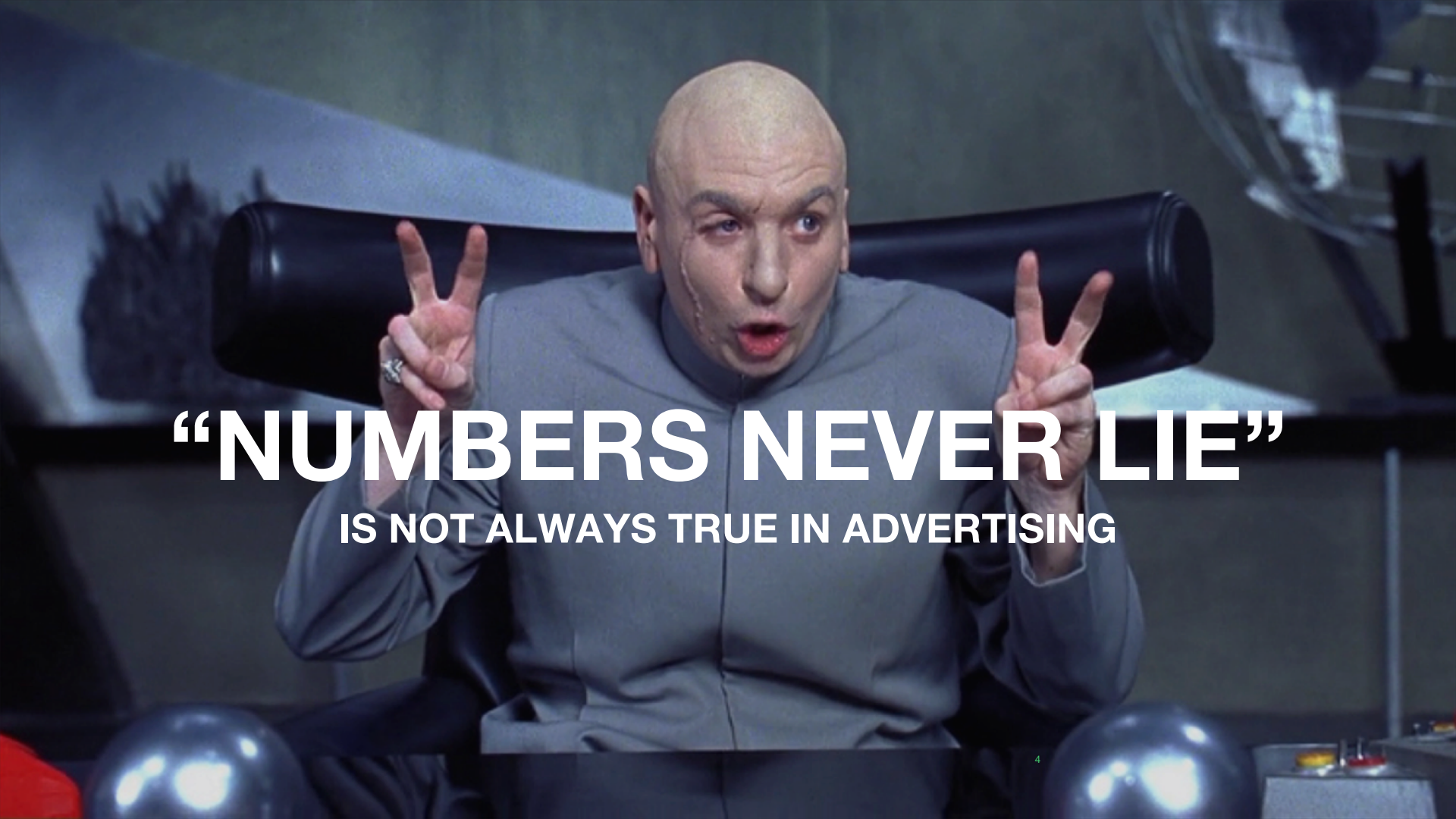
But:

Almost all digital advertising is targeted.

And bots don’t buy anything.

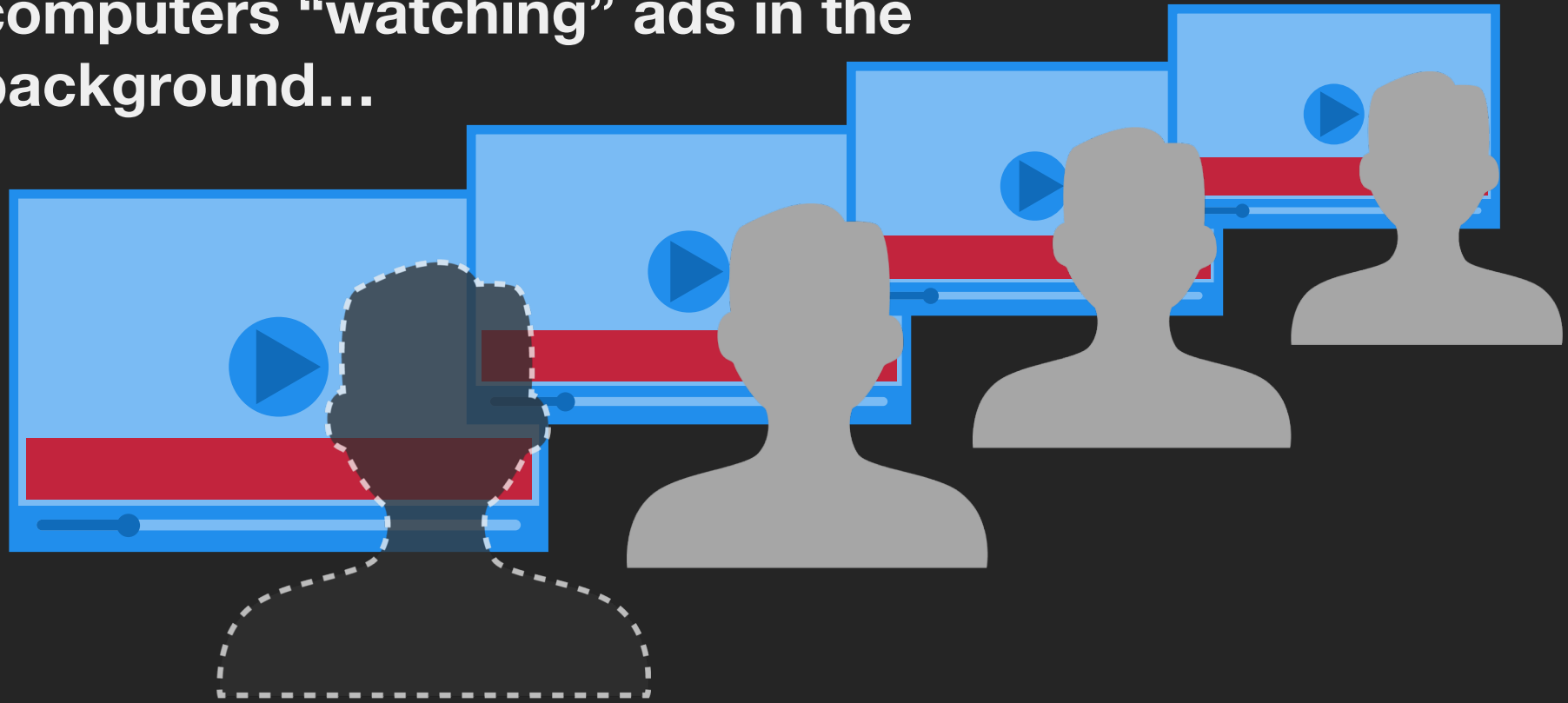
So why doesn’t this problem solve itself?


“NUMBERS NEVER LIE”
IS NOT ALWAYS TRUE IN ADVERTISING

A bot on Grandma's computer looks as real as she does

If Grandma is:
logged into a social network, checking her email, buying things on the web… and there is **a bot** on her computer… **the bot** looks like it's doing those things, too.

With bots on millions of infected computers “watching” ads in the background…



Bots can inflate the size of any audience

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Need to serve more ads? The market price for bot traffic that passes as human is $0.01 or $0.02 per visit

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A 50,000 node botnet is big enough to pull in $150,000/mo.

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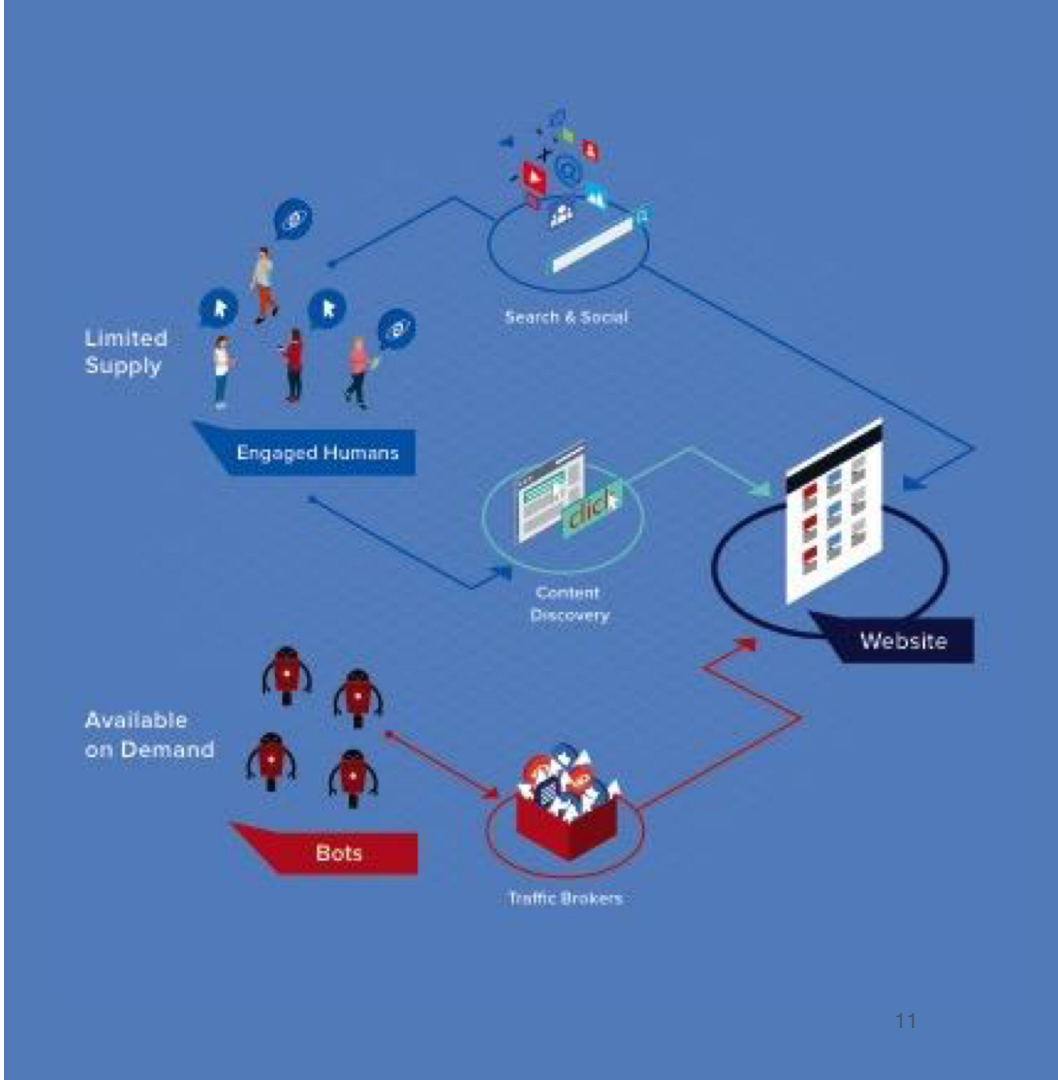
Botnets sell their traffic to an enabling layer of CPC traffic brokers, who use cover stories about placing affiliate links and pay-per-click text ads for their customers' websites to drive traffic to them

Traffic acquisition programs provide visitors on demand

Publishers paying handsomely for legitimate search traffic are competing against publishers paying much less for bot traffic, and the tools used by most marketers cannot tell the difference.



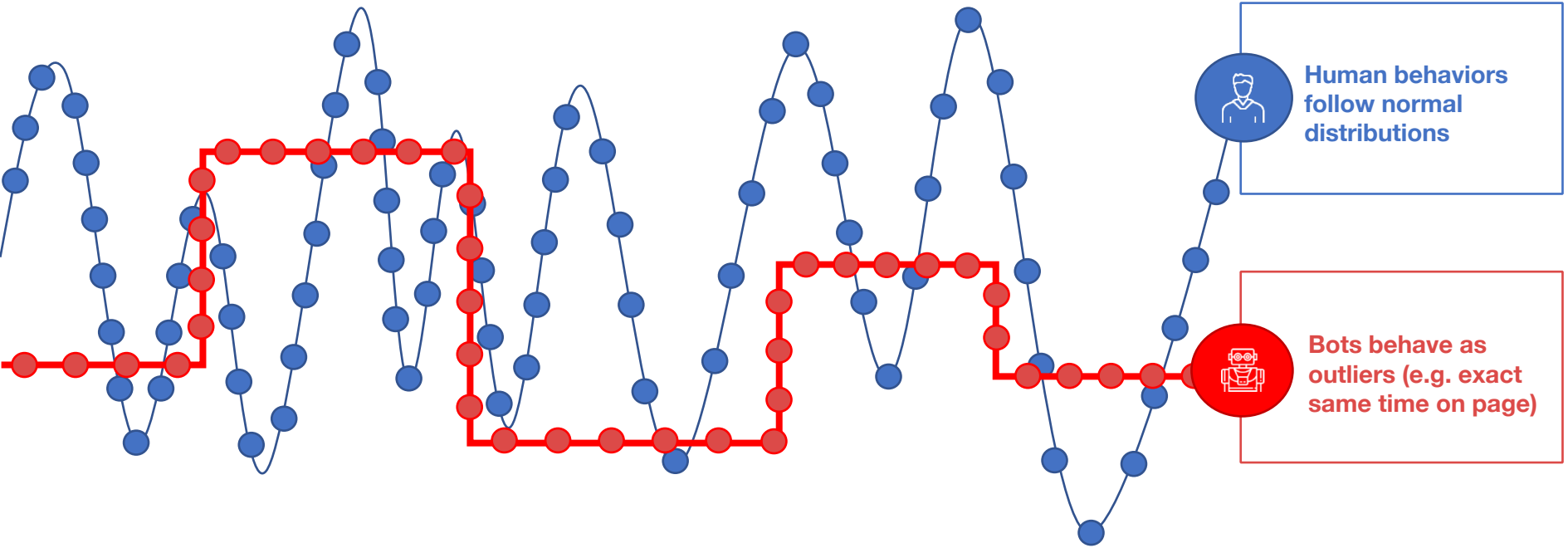
The result on the market:

Infinite reach seems possible against even the most niche audiences

The price of advertising stays the same or even goes down during peak demand

In a market with the biggest of Big Data, how does this happen?

Past bot defense relied on the idea of finding anomalous behaviors: patterns that simply look “non-human”



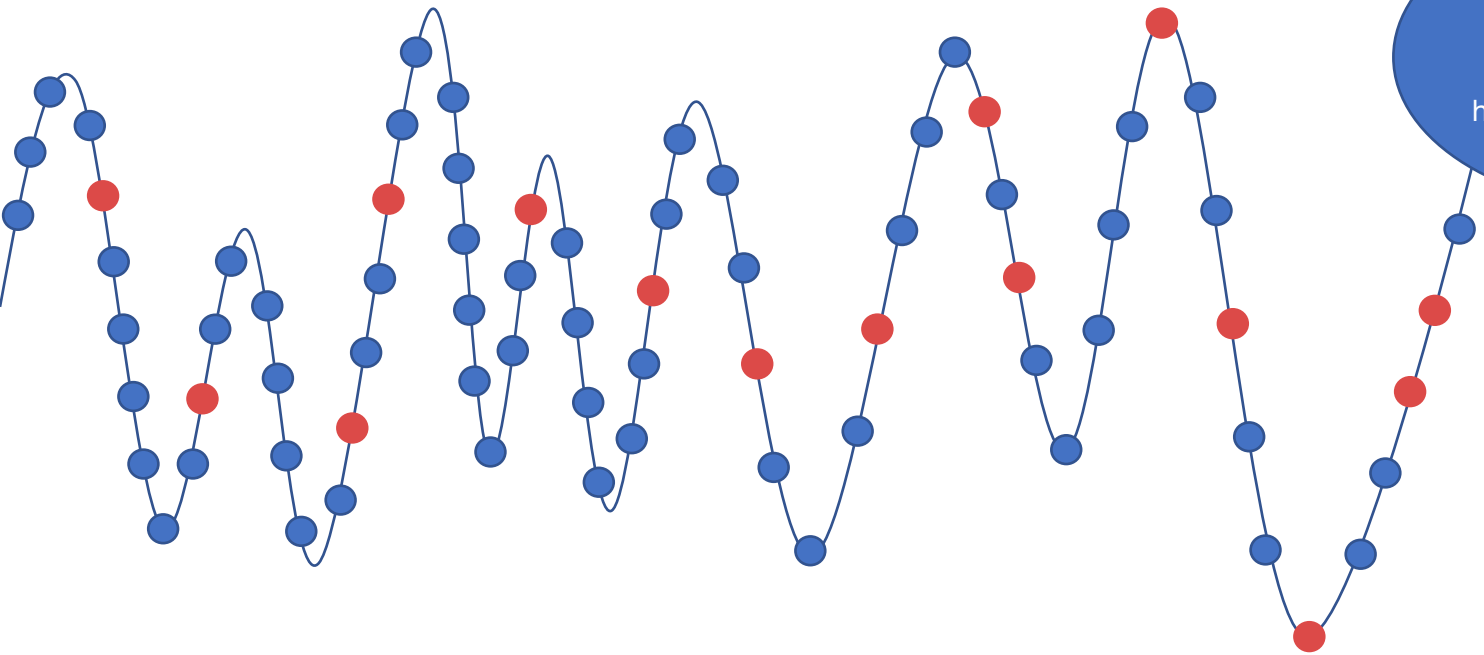
Human behaviors follow normal distributions

Bots behave as outliers (e.g. exact same time on page)

The challenge is that bots have evolved and can now perfectly imitate human behaviors.

Yesterday's Bots		Today's Bots
Lived in data centers	→	76% live on residential machines
Lacked cookies, etc.	→	Have cookies, browser history
Behaved "like bots"	→	Behave like humans
Never bought things	→	Get credit for what their pet humans buy

So now instead of being clear outliers, the bots simply blend right in with the humans *and get credit for their conversions*



If bots can now impersonate human behaviors, how effective can looking for non-human behaviors possibly be?

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Just how sophisticated are we talking?

All the fraud models

- Be a “Content Creator”, hire “traffic”, get paid by publisher
- Be a “Publisher”, hire “traffic”, get paid by SSPs
  - “cashout sites” or “ghost sites”
- Be an “SSP”, create “inventory”, get paid by DSPs
  - Ad injection (malware, evil proxies/vpns, dnschanger, etc)
  - Vertically integrated bots that create “traffic” and “inventory” (Methbot)
- Have bots, sell “traffic”
  - 0wn end users
  - Run a “bot farm”
- Have shady site, disguising source of traffic (“traffic laundering”)
- Have site, push affiliate cookies (“cookie stuffing”)
- Have site, run lots of invisible ads (“ad stacking”)

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Fraud detection forms the selection pressure for the ecosystem. Let's look at the past several generations of evolution.

Bot Designs: curl/wget

- A very small shell script
- Figure out the URL that triggers a billing event, hit it
- Great for your IoT botnet
- Very easy to catch by anyone who cares

Bot Designs: Scripts

- Basic web scraper/crawler type code
- Usually written in something like python, node, perl, php, ruby, etc

- Can parse HTML
- Doesn’t execute JavaScript
- Fairly easy to catch by anyone who cares

Bot Designs: Embedded

- A rendering engine is embedded in another application
- Internet Explorer, Chromium, and Webkit all have supported embedding tools
  - IE WebBrowser control, MSHTML
  - Chromium Embedded Framework
  - WebKit
  - Official support for embedding Gecko was dropped in 2011. Can still be done.

- Usually intended for rendering trusted content
- May have security controls disabled
- Range widely in detection difficulty

Bot Designs: Off-the-shelf headless browsers

- Repurposed tools designed for scraping or QA
- Runs without displaying anything
- PhantomJS, SlimerJS, Zombie.js, HtmlUnit, etc.
- Headless Chrome

- Not usually suitable for compromised end user systems
- Large payloads, requiring frequent updates
- Unmodified, detectable with a little effort
- Minor modifications for stealth make detection tricky

Bot Designs: Off-the-shelf automation tools

- Repurposed tools designed for scraping or QA
- Hooks into a real web browser and automates it
- Selenium, Webdriver, and their various wrappers
    - There’s currently a draft W3C spec for webdriver, supposed to set navigator.webdriver = true

- Not usually suitable for compromised end user systems
- Large payloads, requiring frequent updates
- Can be difficult to detect

Bot Designs: System Emulators

- Primarily done for bots wanting to run mobile traffic
- Usually combined with off-the-shelf automation tools
- Also done to run “bot farms”
- Tricky to detect

Bot Designs: Custom Browser

- Implement enough of a browser to make verification vendors happy
- Large development effort
- High maintenance
- Deep control of behaviour
- Didn’t expect anyone to actually do this, but in Methbot, we found one

Bot Designs: Hybrid

- Browser farm in the cloud with SOCKS through infected residential machines
- An improvement on the Methbot model:
  - Enabling programmatic spoofing
  - Real residential IPs
- No suspicious CPU load on the infected endpoints to spin up the fans and attract attention
- Dramatically simpler management and update deployment
- Hides infrastructure from researchers

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Just how good can custom browsers get?

Methbot, a custom browser with modular monkeypatching

- At peak, 300M video ad impressions per day, for millions of dollars
- Hundreds of thousands of IPs falsely registered as US ISPs
  - No, not BGP hijacks, large block allocations and small leased blocks
- Custom HTTP library (buggy)
- DOM support via Cheerio
- CSS support (library unknown)
- Fully custom implementations of many browser APIs
- Flash support via custom NPAPI implementation and Fresh Player
- NodeJS runtime
- A “bot farm” running on dedicated servers
- Extensive fraud detection countermeasures

HOWTO: Live remote malware inspection

```
var ary = Object.keys(window), dumpf, dumpt, dumpc;
// grab a random object from the global namespace
var rndObj = window[ary[(Math.random()*ary.length)|0]];
// wrap a hopefully untampered toString function
var str = function(o){return function(){}.toString.apply(o)};
// try to dump some code
try{ dumpf = str(rndObj)              }catch(e){}
try{ dumpt = str(rndObj.toString)     }catch(e){}
try{ dumpc = str(rndObj.constructor) }catch(e){}
```

And their response in the arms race:

```
text = text.split('function() {}.toString.apply(')
           .join('window.__MethFakedFuncToString(');
text = text.split('function(){}.toString.apply(')
           .join('window.__MethFakedFuncToString(');
text = text.split('{}.toString.apply(')
           .join('window.__MethFakedToString(');
```

Methbot - __MethFakedFuncToString

```
__MethFakedFuncToString = function(el){
    try {
        if (el.hasOwnProperty('toString'))
            return el.toString()
    } catch (e) {}
    var t = null;
    t = function() {}.toString.apply(el)
    return t;
}
```

Other JavaScript Dumping Countermeasures

```
function toString() {
  // An if-else chain is used here because a "switch" block or an Object lookup
  // would coerce these functions into strings.
  if (this === _functionToStringShim) {
    var target = _functionToStringOrig;
  } else if (this === _alertShim) {
    target = _alertOrig;
  } else if (this === _confirmShim) {
    target = _confirmOrig;
  /* This code has been modified from its original version. It has been formatted to fit this slide. */
  } else if (this == _getCurrentPositionShim) {
    target = _getCurrentPositionOrig;
  } else if (this === _onmessageDelegate && _onmessageFormatted != null) {
    return _onmessageFormatted;
  } else {
    target = this;
  }
  return sandbox('Function', 'toString')(target);
}
```

Escalation: Very specific countermeasures

```
// return loadLocalFile(this.link, this.callback,
// '../for_whiteops/load.src.4.16.6.js')
//}
// wo flash
if (this.link.indexOf('viz11.swf') !== -1) {
var res = {
  url: this.link, statusCode: 200, status: '200 OK',
  rawHeaders:'HTTP/1.1 200 OK\nServer: nginx/1.4.6 (Ubuntu)\n',
  headers: {}, $:cheerio.load(''), body:new Buffer('')
};
return this.callback(false, res)
}
```

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Now let’s talk IP address diversity

Methbot’s approach: IP Registration Forgery

```
inetnum:        196.62.0.0 - 196.62.31.255
netname:        COMCAST-CABLE
descr:          Comcast Cable Communications, Inc
country:        US
admin-c:        IP9-AFRINIC
tech-c:         IP9-AFRINIC
status:         ASSIGNED PA
mnt-by:         IP-ADMIN
mnt-lower:      IP-ADMIN
mnt-domains:    IP-ADMIN
mnt-routes:     IP-ADMIN
changed:        adw0rd.yandex.ru@gmail.com 20151014
source:         AFRINIC
parent:         196.62.0.0 - 196.62.255.255
```

```
person:         IP Admin
address:        IP Admin
phone:          +2482534202
e-mail:         adw0rd.yandex.ru@gmail.com
nic-hdl:        IP9-AFRINIC
changed:        adw0rd.yandex.ru@gmail.com 20151014
source:         AFRINIC
```

Methbot - IP Registration Forgery

```
inetnum:        196.62.32.0 - 196.62.63.255
netname:        TIME-WARNER
descr:          Time Warner Cable Inc.
country:        US
admin-c:        IP9-AFRINIC
tech-c:         IP9-AFRINIC
status:         ASSIGNED PA
mnt-by:         IP-ADMIN
mnt-lower:      IP-ADMIN
mnt-domains:    IP-ADMIN
mnt-routes:     IP-ADMIN
source:         AFRINIC # Filtered
parent:         196.62.0.0 - 196.62.255.255
```

Methbot - IP Registration Forgery

```
inetnum:        196.62.64.0 - 196.62.95.255
netname:        VERIZON
descr:          Verizon Trademark Services LLC
country:        US
admin-c:        IP9-AFRINIC
tech-c:         IP9-AFRINIC
status:         ASSIGNED PA
mnt-by:         IP-ADMIN
mnt-lower:      IP-ADMIN
mnt-domains:    IP-ADMIN
mnt-routes:     IP-ADMIN
source:         AFRINIC # Filtered
parent:         196.62.0.0 - 196.62.255.255
```

Methbot - IP Registration Forgery

```
inetnum:        196.62.96.0 - 196.62.127.255
netname:        ATT
descr:          AT&T Services, Inc.
country:        US
admin-c:        IP9-AFRINIC
tech-c:         IP9-AFRINIC
status:         ASSIGNED PA
mnt-by:         IP-ADMIN
mnt-lower:      IP-ADMIN
mnt-domains:    IP-ADMIN
mnt-routes:     IP-ADMIN
source:         AFRINIC # Filtered
parent:         196.62.0.0 - 196.62.255.255
```

Methbot - IP Registration Forgery

```
inetnum:        196.62.128.0 - 196.62.159.255
netname:        COX
descr:          Cox Communications Inc
country:        US
admin-c:        IP9-AFRINIC
tech-c:         IP9-AFRINIC
status:         ASSIGNED PA
mnt-by:         IP-ADMIN
mnt-lower:      IP-ADMIN
mnt-domains:    IP-ADMIN
mnt-routes:     IP-ADMIN
source:         AFRINIC # Filtered
parent:         196.62.0.0 - 196.62.255.255
```

Methbot - IP Registration Forgery

```
inetnum:        196.62.160.0 - 196.62.191.255
netname:        CHARTER
descr:          Charter Communications Operating, LLC
country:        US
admin-c:        IP9-AFRINIC
tech-c:         IP9-AFRINIC
status:         ASSIGNED PA
mnt-by:         IP-ADMIN
mnt-lower:      IP-ADMIN
mnt-domains:    IP-ADMIN
mnt-routes:     IP-ADMIN
source:         AFRINIC # Filtered
parent:         196.62.0.0 - 196.62.255.255
```

Methbot - IP Registration Forgery

```
inetnum:        196.62.192.0 - 196.62.223.255
netname:        Cequel
descr:          Cequel Communications Holdings
country:        US
admin-c:        IP9-AFRINIC
tech-c:         IP9-AFRINIC
status:         ASSIGNED PA
mnt-by:         IP-ADMIN
mnt-lower:      IP-ADMIN
mnt-domains:    IP-ADMIN
mnt-routes:     IP-ADMIN
source:         AFRINIC # Filtered
parent:         196.62.0.0 - 196.62.255.255
```

Methbot - IP Registration Forgery

```
inetnum:        196.62.224.0 - 196.62.255.255
netname:        CenturyLink
descr:          CenturyLink, Inc.
country:        US
admin-c:        IP9-AFRINIC
tech-c:         IP9-AFRINIC
status:         ASSIGNED PA
mnt-by:         IP-ADMIN
mnt-lower:      IP-ADMIN
mnt-domains:    IP-ADMIN
mnt-routes:     IP-ADMIN
source:         AFRINIC # Filtered
parent:         196.62.0.0 - 196.62.255.255
```

Methbot - IP Registration Forgery

```
% Abuse contact for '161.8.192.0 - 161.8.223.255' is 'stepanenko.aa@mmk.ru'

inetnum:        161.8.192.0 - 161.8.223.255
netname:        Verizon_Trademark_Services_LLC-19
descr:          Verizon Trademark Services LLC
country:        US
admin-c:        SOV68-RIPE
tech-c:         SOV68-RIPE
status:         LEGACY
mnt-by:         MMKMGN-MNT
mnt-by:         NetBC
created:        2015-10-13T14:47:56Z
last-modified:  2015-10-13T14:47:56Z
source:         RIPE

person:         NetBComm LLC
address:        USA, Texas, Dallas , Verizon
Trademark Services LLC
phone:          +12191278854
nic-hdl:        SOV68-RIPE
mnt-by:         NetBC
created:        2015-07-20T07:15:59Z
last-modified:  2015-12-25T08:57:55Z
source:         RIPE # Filtered
```

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The ultimate option (for now)

Today’s hybrid approach

- Use real browsers!
- Completely control the operating environment of your real browsers for performance, management, scalability… in server farms under your control
- Then use a residential botnet *just to proxy your traffic*

Today's botnets simply blend in

- They have real cookies, Device IDs, and history
- They can mimic humans
- Their potential ML training set is as big as the botnet, and unfettered by privacy considerations

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The lesson:

It doesn’t matter what fraud detection technique you have today.

What matters is how you run the arms race.

All arms races are resource depletion games

- The side that wins is the side that can run the arms race longer.
- There are only two winning patterns:

1. Start richer and stay richer
2. Tilt the arms race so that your side can keep up at a much lower cost than the other side

What to do when your enemy is smarter, richer, and better-looking?

We must model our adversaries as:

- at least as smart as us
- quite possibly better resourced than us

Each day they win, they get fraud profits; each day we win, we get to keep our stressful infosec jobs

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Looking human is easier than you think

The game we play is out in the open

The adversary:

- has access to our payload
- can monkey-patch our payload to selectively execute it or not execute it at all
- can monitor and manipulate what is sent back to our servers
- can analyze how normal browsers execute our payload, and what data is sent back to our servers
- can operate their fraud operations off of real computers using real identity tokens (e.g. cookies) and real behavior patterns (real mouse movements, matching the times of day of real visitors, visiting the same sites as real people as well as the sites that earn them money)

But they have to play it

They adversary:

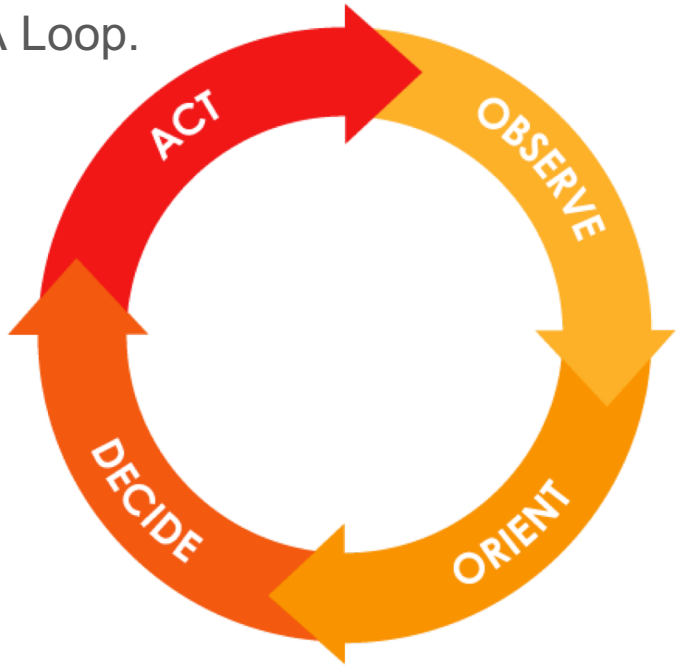
- *must* accept our payload
- they *must* download it from us
- they *must* send data back to us

because all real browsers and apps do.

Our adversaries can try to beat our game, but they can’t refuse to play our game.

The OODA Loop

There's already a formal framework for heads-up competition between equally capable adaptive adversaries: it's called the OODA Loop.



The trick here is to get inside the adversary's OODA loop by:

- presenting a dynamic challenge
- denying the adversary immediate success/fail feedback
- changing the challenge on a periodicity slighter shorter than the feedback loop to the adversary

Result:

The adversary is forced to play the next round of the game before they can tell if they won the last round or not.

To win like this:
You need a sufficiently large parameter space of possible fresh dynamic challenges to last until [victory, the life of your project, the heat death of the universe… choose what fits your threat model]

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Can you use these principles in your own arms races?

Yes, if:

- You can trigger a silent alarm
- You can stop the adversary from benefitting from her action without interrupting that action

Denying immediate success/fail feedback is key.

Harder locks add only time to the lockpicker’s attack. The silent alarm completely changes his risk:reward calculation.

Thank you!