ARBOR NETWORKS

Breaking the Bank

An Analysis of the 2012 – 2013 'Operation Ababil' Financial Industry DDoS Attack Campaign

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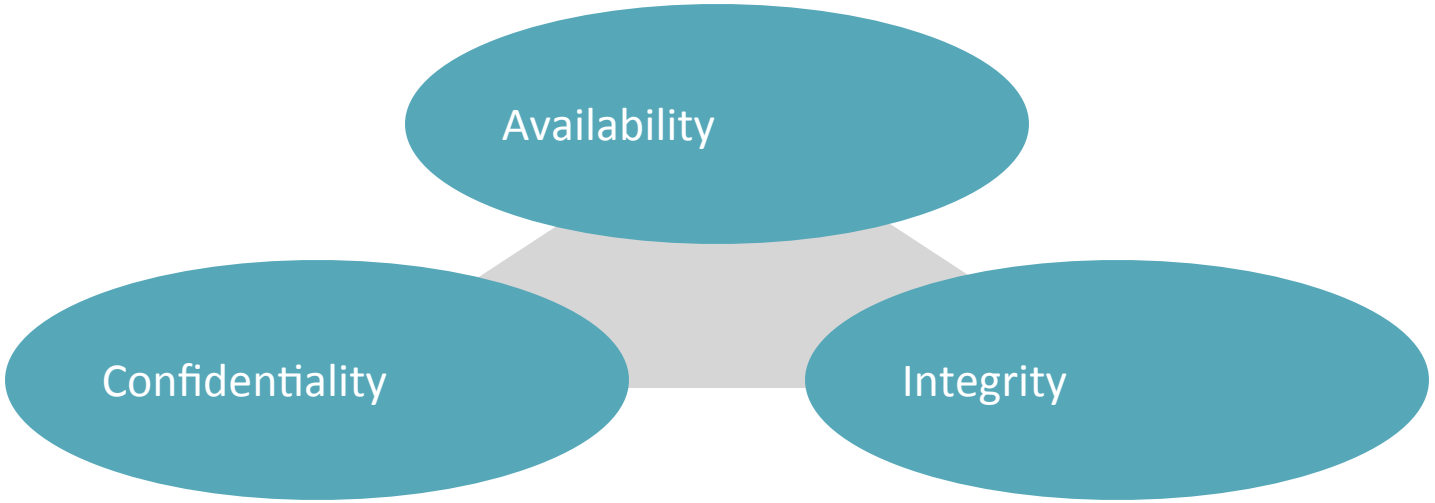
DDoS Background

What is a Distributed Denial of Service (DDoS) attack?

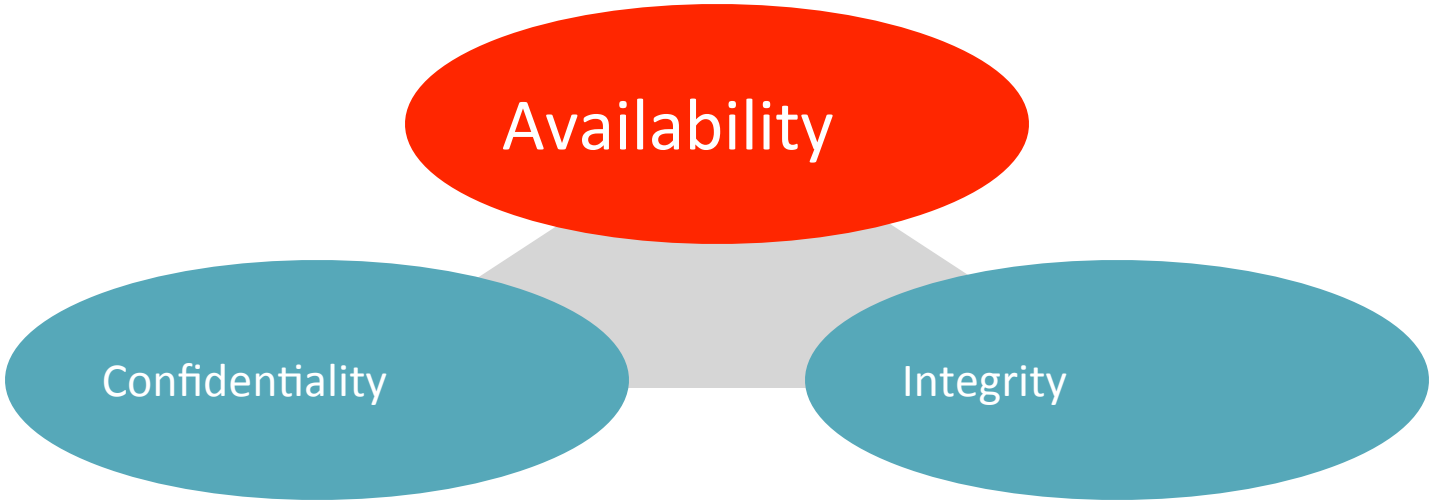
- An attempt to consume finite resources, exploit weaknesses in software design or implementation, or exploit lack of infrastructure capacity
- Targets the availability and utility of computing and network resources
- Attacks are almost always distributed for even more significant effect – i.e., DDoS
- The collateral damage caused by an attack can be as bad, if not worse, than the attack itself
- DDoS attacks affect availability! No availability, no applications/ services/data/Internet! No revenue!
- DDoS attacks are attacks against capacity and/or state!

Three Security Characteristics



- The goal of security is to maintain these three characteristics

Three Security Characteristics



- The primary goal of DDoS defense is maintaining availability in the face of attack

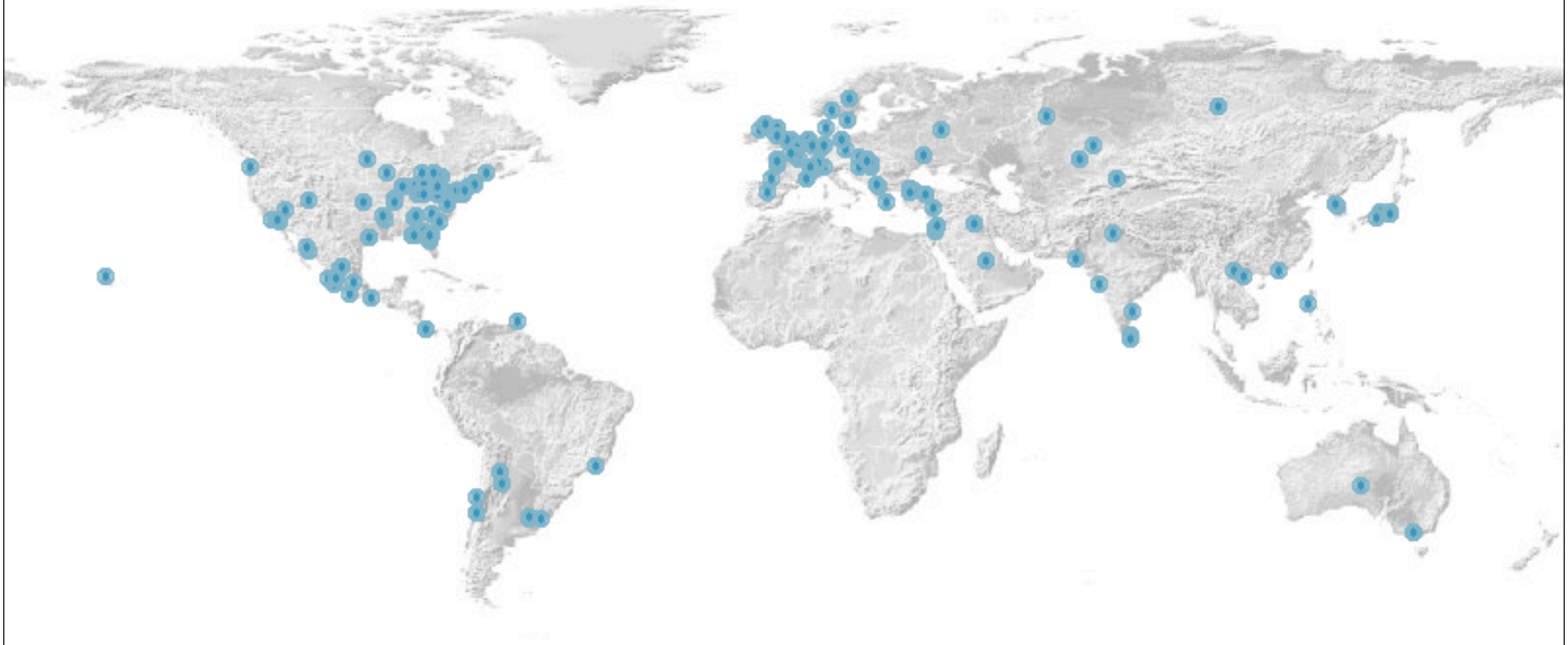
‘Operation Ababil’ DDoS Attacks, AKA ‘Triple Crown’

- On 18Sep2012, a purported organization calling itself ‘Cyber Fighters of Izz ad-din Al Qassam” posted on Pastebin calling for attacks against Bank of America and the New York Stock Exchange, supposedly in response to a video video posted on YouTube offensive to Muslims
- Attack campaign originally christened ‘Triple Crown’ because three distinct attack tools/methodologies were being used. Industry eventually switched over to attacker sobriquet of ‘Operation Ababil’.
- Fifth Week of attack campaign announced via Pastebin on 16Oct2012 - no longer naming targets
- Phase 2 of attack campaign announced via Pastebin on 10Dec2012
- Pastebin post on 8Jan2013 indicates the attacks will be waged for 56 additional weeks
- Pastebin post on 6May2013 indicated pause for supposed Anonymous #OpUSA, which never materialized
- An abortive Phase 4 kicked off unannounced on 23Jul13 – a few hours of attacks that week; a few hours the next week; one attack in mid-August; and then nothing more, so far . . .

Evolution of Attack Campaign

- **Phase 1 (Sep 2012)**
  - 1-2 banks concurrently attacked, mainly HTTP & HTTP/S combined with malformed DNS flooding attacks
  - Targeting only the largest institutions
- **Phase 2 (Dec 2012)**
  - 3-5 banks concurrently attacked – some HTTP, but more SSL combined with malformed DNS flooding attacks
  - Targeting regional and mid-size institutions
- **Phase 3 (Feb 2013)**
  - 6+ organizations attacked simultaneously, different characteristics for each target, application attacks mostly HTTP/S & malformed DNS
  - Targeting additional institutions such as credit unions and non-customer facing financial services
  - Expanded target base to Europe
- **Phase 4 (Jul/Aug 2013)**
  - A few hours of attacks targeting 2-3 institutions simultaneously, then nothing until mid-August; 1 institution targeted the week of 11Aug13.
  - Somewhat improved attack methodology, UDP/53 traffic directed towards authoritative DNS servers for targeted organizations

About the Botnet



- Started small, with only a few hundred compromised servers
- Maximum number of hosts ~20,000
- Blacklist currently includes ~3,000 hosts
- Attackers continue adding bots to stay ahead of blacklists, compensate for bots identified and shut down by ISPs, tinkering with bot code

Focused Multi-Stage & Multi-Vector DDoS

- Compromised PHP, WordPress, & Joomla servers
- Multiple concurrent attack vectors
  - GET and POST app layer attacks on HTTP and HTTP/S
  - DNS query app-layer attack, mainly against ISP authoritative DNS servers
  - Floods on UDP, TCP SYN floods on TCP/53 against ISP authoritative DNS servers & target organization Web properties
- Characteristics of this attack campaign
  - Relatively high bps/pps/cps/tps rates per individual attack source
  - Attacks on multiple targeted organizations in same vertical
  - Real-time monitoring of effectiveness
  - Some agility in modifying attack vectors when mitigated
  - Revert to using conventional botnet for SYN-floods, etc. when main attack methodologies are successfully mitigated

Why a Server-Based Botnet?

- Generally more powerful machines
- Much higher Internet transit bandwidth
- Hosts not shut down outside of business hours
- Less chance that administrators will notice performance issue and investigate
- Many IDC operators don't have basic visibility into their network traffic
- Easy to identify new hosts to compromise
- This is nothing new – the first botnets in the late 1980s/early 1990s were comprised of servers. It's 'Back to the Future'!

Primary Attack Tools/Methodologies

- Brobot
  - PHP attack kit, first seen Jan2012. Implements TCP, UDP (malformed DNS query) and ICMP flooding attacks, plus HTTP & HTTP/S GET and POST
  - New variant in Dec2012 implemented the creation of crafted, well-formed DNS queries
- Kamikaze
  - HTTP & HTTP/S DDoS PHP script first used in Sep2012
  - Multi-tier C&C commands sent to ‘runners' which pass attack commands to other compromised systems.
- Amos
  - Related to Kamikaze but uses different request template, slightly different User-Agents, and does not implement the cURL functions.
- Additional tools and variants of the above continue to evolve, conventional botnets used on occasion

Multi-vector DDoS, High-PPS/BPS

- Multiple concurrent attack vectors
  - GET and POST application- layer attacks over HTTP and HTTP/S
  - DNS query app-layer attack
  - Floods on UDP, TCP SYN-floods, ICMP and other IP protocols (mainly grossly-malformed DNS packets used as a blunt instrument against Web servers, not DNS servers, until Phase 4, when authoritative DNS servers for targeted organizations were packeted with this traffic)
- Unique characteristics of the attacks
  - Relatively high packet-per-second (pps) and bits-per-second (bps) rates per individual source, relatively low number of sources (not unheard-of, just not the norm)
  - Preannounced attack windows at first, until the defenders were consistently & succesfully mitigating the attacks (went longer)
  - Attack volumes were overkill – the targeted sites would've been knocked offline by a tiny fraction of the pps/bps utilized in these attacks, as they were so brittle, fragile, non-scalable, and unprepared. Overkill is quite common in DDoS attacks, but this was an extreme example.

Evidence of Some Sophistication

- Reconnaissance
  - Attackers probing banks and then customizing attacks to the target
- Targeting multiple customer servers
  - HTTP, HTTP/S, authentication subsytems, CGIs, etc.
  - Repeated download of previously-identified large binary files via HTTP/S (.pdf files, .jpgs, et. al.)
  - Repeated GETs/POSTs against non-existent URIs
- Multiple concurrent targets = more stress on upstream mitigation
- Increasing turnover of bots used in attacks
- More frequent/earlier attacks against ISP authoritative DNS servers (not the authoritative DNS servers of the targeted organizations) in earlier phases; attacks against authoritative DNS servers of targeted organizations began in Phase 4
- Began attacking ISP/MSSP network infrastructure directly in Phase 3 – network infrastructure BCPs a must!

Different MO from Most Other DDoS Attacks

Typical DDoS Attacks

- Generally hit-and-run tactics
- Little to no warning
- Attacks peter out as money/interest/attention span runs out
- Use available attack tools

'Operation Ababil' Financial Attack Campaign

- Sustained attacks over a long period of time
- Telegraph every move via Pastebin during initial phases
- Substantial & sustained funding
- Continuously evolving attack tools/methods

ISP/MSSP Lessons Learned

- As is quite common, these DDoS attacks succeeded initially mainly due to the unpreparedness of the defenders.
- Some ISPs/MSSPs exhibited organizational rigidity; excessive bureaucracy, lack of operational agility; lack of detailed understanding of targeted end-systems characteristics in order to perform optimal countermeasure selection; lack of cross-functional collaboration; all these inhibited initial defense efforts.
- Some ISPs/MSSPs exhibited an incomplete understanding of all available mitigation options, including full spectrum of countermeasures. Lack of S/RTBH deployment also inhibited initial defense efforts for some ISPs/MSSPs.
- Capacity models should be re-evaluated as larger multi-vector, multi-end-customer attacks are more common– initially, a significant proportion of total mitigation capacity lay fallow for some ISPs/MSSPs during these attacks, nor was it dynamically deployed as the attack campaign continued.

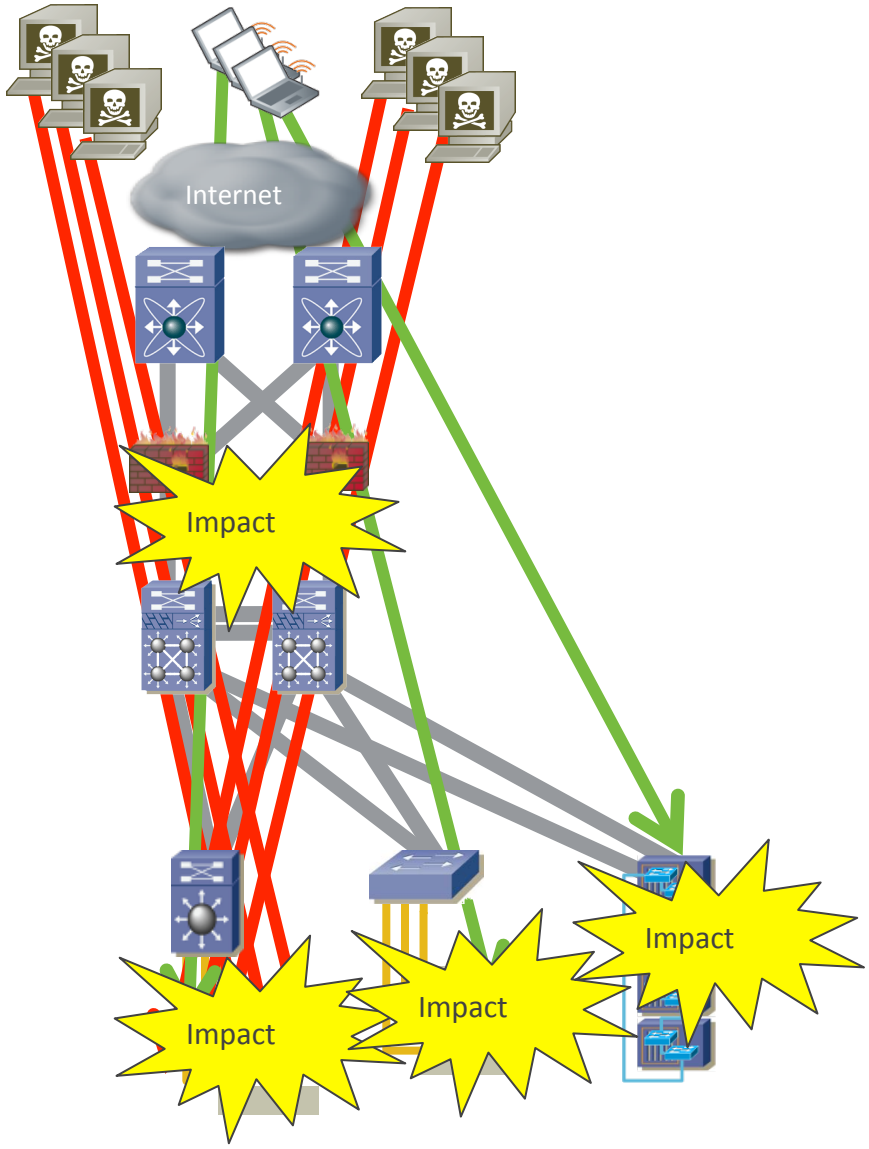
ISP/MSSP Lessons Learned (cont.)

- Some ISPs/MSSPs should work to increase speed of new technology adoption, broaden/deepen mitigation education & training, increase inter- and intra-organizational cooperation, fully leverage existing investments in mitigation capabilities
- Some ISPs/MSSPs should work to customize mitigation tool/ countermeasure selection & configuration based upon specifics of end-customer systems under protection, in response to changing attack methodologies.
- Operationalize and practice with all mitigation tools/countermeasures ahead of time, be aware of all mitigation options and utilize as appropriate.
- Exhibit creative thinking during attacks, quickly effectively leverage mitigation vendor recommendations and advice, remove bureaucratic barriers to operational agility.
- Implement anycast diversion to divert attack traffic into multiple mitigation centers simultaneously, if this hasn't already been accomplished.

Enterprise Lessons Learned

- Firewalls/IPS/Load-balancers don't offer any protection against DDoS attacks
  - All targeted organizations have these devices, they are part of the problem!
- ISP/MSSP coverage constraints
  - Resource strain (human, technical) when multiple customers attacked simultaneously
  - Can be slow to upgrade to the latest releases/protections
  - Need to have detailed knowledge of end-customer systems under protection
- Enterprises need DDoS mitigation capabilities both upstream and on-premise
  - On-premise for direct control and rapid response
  - In-cloud for scale and broad topological coverage of end-customer edge, as well as ISP/MSSP public-facing properties (DNS, etc.)

Targeted Organizations All Had FW/'IPS'/WAF/LB



Enterprise Lessons Learned (cont)

- Attackers were changing their tactics in real time as they noticed ISPs/MSSPs effectively mitigating the attacks
- Particular focus on taking down poorly-written, non-scalable, brittle, fragile banking applications, mainly utilizing brute-force layer-4/-7 attacks against SSL login subsystems
- Exhaustion of login subsystem resources appeared to cause database and middleware failures – session state appeared to overwhelm middle tier, leading to apparent middle-/back-tier failures leading to database corruption, etc.
- We observed this phenomenon in at least two of the attacks against separate banks, during which the MSSP was highly effective at mitigating the DDoS attack traffic, but the banking site still went down due to apparent disruption and corruption of underlying application/ data per the above scenario
- Appropriate network access policy enforcement via stateless ACLs a must – why allow UDP/53 to Web servers?!

Enterprise Lessons Learned (cont)

- Very obvious that only a few of the targeted organizations had given much thought/invested many resources in DDoS defense, had rarely (if ever) rehearsed DDoS defense, had little or no focus on maintaining availability in the face of attack, had little clue as to how effectively collaborate with ISPs/MSSPs
- This is a gigantic problem across all industry verticals – most enterprises are simply unaware of/unconcerned with availability, focus all their 'security' resources on mandated compliance measures, none of which include an availability component
- DDoS is essentially a man-made disaster affecting business continuity – why is DDoS defense not included in disaster preparedness/business continuity planning efforts, resourcing?
- Why is there no PCI/DSS availability component?!

Almost All Security Spending/Effort is Focused on Confidentiality & Integrity

- Confidentiality and integrity are relatively simple concepts, easy for non-specialists to understand
- In practice, confidentiality and integrity pretty much equate to encryption - again, easy for non-specialists to understand
- The reality is that there's more to them than encryption, but it's easy to proclaim victory - "We have anti-virus, we have disk encryption, we're PCI-compliant, woo-hoo!"
- And yet, hundreds of millions of botted hosts; enterprise networks of all sizes in all verticals completely penetrated, intellectual property stolen, defense secrets leaked, et. al.
- Availability can't be finessed - the Web server/DNS server/VoIP PBX is either up or it's down. No way to obfuscate/overstate/prevaricate with regards to actual, real-world security posture.
- Availability requires operational security (opsec) practitioners who understand TCP/IP and routing/switching; who understand Web servers; who understand DNS servers; who understand security; who understand layer-7.
- These people are rare, and they don't come cheaply. Most organizations don't even understand the required skillsets and experiential scope to look for in order to identify and hire the right folks

Availability is Hard!

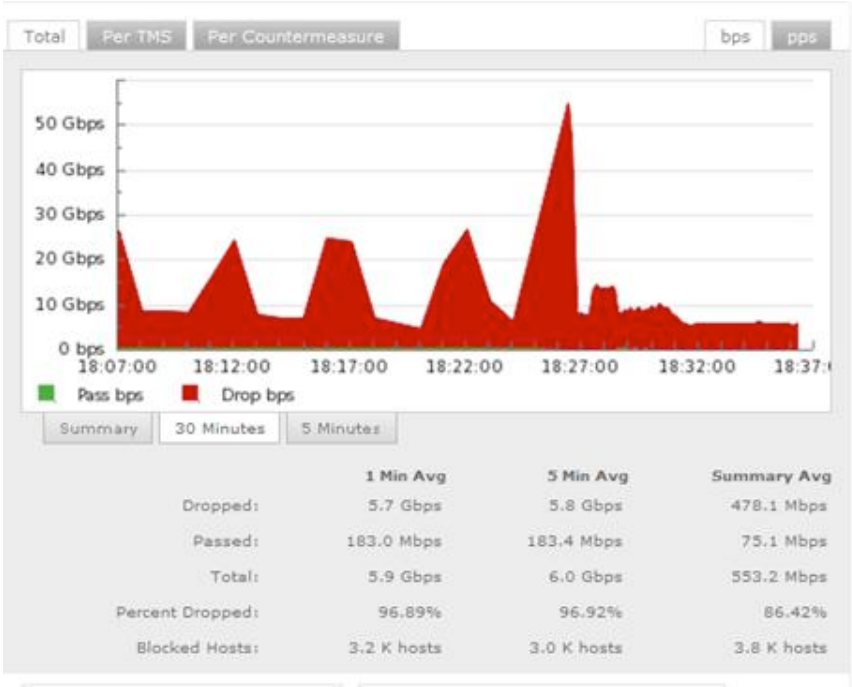
- Maintaining availability in the face of attack requires a combination of skills, architecture, operational agility, analytical capabilities, and mitigation capabilities which most organizations simply do not possess
- In practice, most organizations never take availability into account when designing/speccing/building/deploying/testing online apps/services/properties
- In practice, most organizations never make the logical connection between maintaining availability and business continuity
- In practice, most organizations never stress-test their apps/services stacks in order to determine scalability/resiliency shortcomings and proceed to fix them
- In practice, most organizations do not have plans for DDoS mitigation - or if they have a plan, they never rehearse it!

Are We Doomed?

- No! Deploying the existing, well-known tools/techniques/BCPs results in a vastly improved security posture with measurable results.
- The evolution of this attack campaign clearly demonstrates that positive change is possible – targeted organizations & defending ISPs/MSSPs altered architectures, mitigation techniques, processes, and procedures in order to successfully mitigate these attacks.
- ISPs/MSSPs & enterprises defending against these attacks have learned optimizing for specific attack vectors/methodologies isn't a viable strategy – rather, optimizing for the servers/applications/services being protected is the way to go.
- It's important to keep in mind that IPv6 has all the same issues as IPv,4, plus new ones all its own – and all in hexadecimal! Feature parity, architectural parity, & operational parity are a must!
- Automation is a Good Thing, but it's no substitute for resilient architecture, insightful planning, and plain old elbow-grease – top-notch opsec personnel are more important now than ever before!

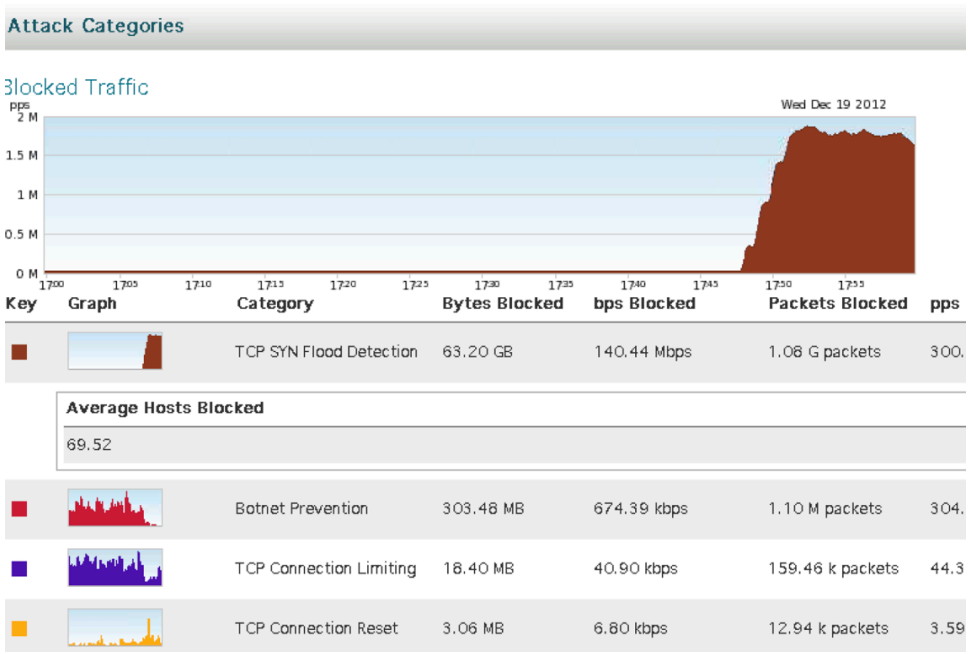
Successful 'Operation Ababil' Attack Mitigation - Coordinated In-Cloud (ISP/MSSP) & On-Premise (End-Customer) Defense

In-cloud mitigation
IDMS



~67Gbps of attack traffic mitigated
in upstream ISP/MSSP mitigation center

On-Premise mitigation
IDMS



~2mpps of attack traffic mitigated
on-premise by enterprise

References

This presentation:

http://bit.ly/16DiOuO - https://www.box.com/s/ko8lk4vlh1835p36na3u

Presentations on related topics:

https://www.box.com/s/4h2l6f4m8is6jnwk28cg

2009/2010/2011 Arbor Worldwide Infrastructure Security Reports:

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2012 Arbor Worldwide Infrastructure Security Report:

http://www.arbornetworks.com/research/infrastructure-security-report

RFC5635 - S/RTBH

http://tools.ietf.org/html/rfc5635

Q&A

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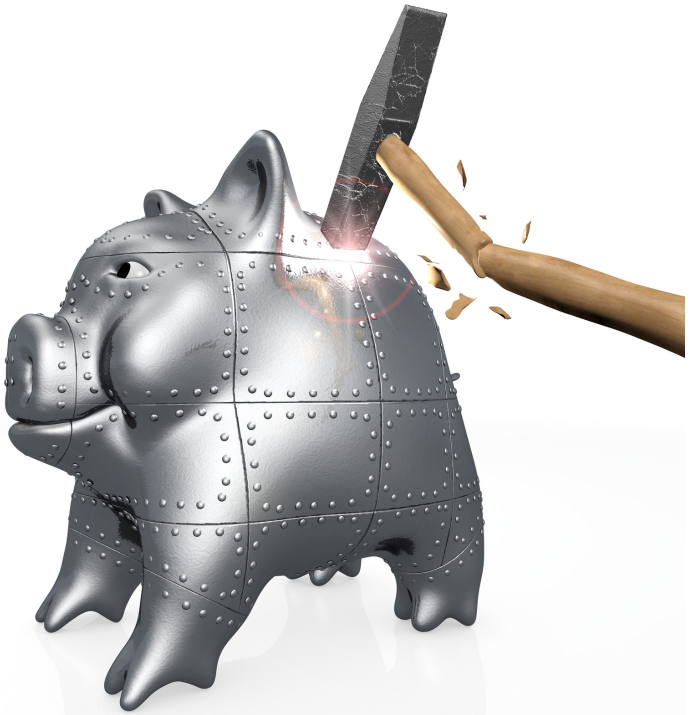
Thank You!



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