Slowloris HTTP DoS

Slowloris HTTP DoS - Author not stated, ha.ckers.org.

- Published: date not stated
- Original: <http://ha.ckers.org/blog/20090617/slowloris-http-dos/>
- Preserved from: http://ha.ckers.org/blog/20090617/slowloris-http-dos/ (manual-import) on 2026-09-10
- Licence: unknown

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Content

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UPDATE: Amit Klein pointed me to a post written by Adrian Ilarion Ciobanu written in early 2007 that perfectly describes this denial of service attack. So although there was no tool released at that time he still technically deserves all the credit for this. I apologize for having missed this post.

As you may recall at one point a few weeks back I talked about how denial of service can be used f or hacking and not just yet another script kiddy tool. Well I wasn't speaking totally hypothetically. A month ago, or so, I was pondering Jack Louis (RIP) and Robert E Lee's Sockstress, and I got the feeling that other unrelated low bandwidth attacks were possible. Then I randomly started thinking about the way Apache works and figured out that it may be possible to create something similar to a SYN flood, but in HTTP.

Slowloris was born. It basically uses a concept of keeping an HTTP session alive indefinitely (or as long as possible) and repeating that process a few hundred times. So in my testing, against an unprotected and lone Apache server, you can expect to be able to take it offline in a few thousand packets or less on average, and then you can let the server come back again as soon as you kill the process. It also has some stealth features, including a method of bypassing HTTPReady protection. Why is this noteworthy?

Typical flooding attacks require tons and tons of packets and end up denying service to other applications as a result. By creating a flood of TCP requests, sure you can take down an upstream router, or a web server, but it's overkill if you really just want to take down a single website. Slowloris does this without sending an overabundance of TCP or HTTP traffic, and it does so without increasing the load significantly, or in any other way hurting the box (assuming other things aren't tied to the HTTP processes - like a database for instance). This appears to only affect certain types of webservers (generally those that thread processes, like Apache, but not like IIS).

So I contacted Apache a week ago, because I was a little concerned that I hadn't heard much about this, other than one conversation with HD Moore about a similar attack he encountered using a

different payload. I expected a well thought through response, given their dominance in the server market and the fact that I gave them an early copy of the code. Alas:

> DoS attacks by tying up TCP connections are expected. Please see:

http://httpd.apache.org/docs/trunk/misc/security_tips.html#dos

Regards, Joe

Yes, that was the entire response. So, while RTFM is a perfectly valid response on the Internet, it's also extremely short sighted, because *almost* no servers are configured properly - or if they are, it's as a side effect of needing load balancing or something upstream that happens to protect them. Also, if you actually read that Apache.org page, it really doesn't cover this attack at all. And Joe sorta totally missed the boat or at least mis-typed in his brevity, because this isn't a TCP DoS, it's an HTTP DoS. If your server used UDP and I re-wrote Slowloris to speak UDP it would work too. The best example of how this differs from a TCP DoS is the fact that other unrelated services are unaffected, and you can still connect to them like you normally would.

The reason this works is because **the web server will patiently wait well beyond what is reasonable, allowing an attacker to consume all of the available threads of which there are a finite amount**. That makes it a web server problem, not a OS or networking problem, although there may be OS or network solutions to Apache's default configuration issues. This is further evidenced by the fact that IIS isn't vulnerable to Slowloris in it's current incarnation. Even if Apache and IIS are on the same physical box, Apache will be affected but IIS will not. That would lead me to believe it's a architectural flaw in Apache's default web server's design. Though this isn't just Apache's problem, to be fair. Other web servers are vulnerable as well, although none come close to the size of Apache in terms of market share. You can find more information on the Slowloris page.

Anyway, I hope this gets people thinking about better web server architecture. That's especially true if this is "expected" behavior of their web server, and at least offer a default configuration that can protect from this sort of attack, instead of having to jump through a bunch of convoluted hoops. I thought it would be better to open this up for discussion, so I encourage you to try out the tool in QA or staging and see how your web server handles it. The software is very beta though, so do not use this against anything in production - I make no warranties about its ability to do anything outside of a lab environment!

Technical comments

Comments below are quoted from the archived source and retain the commenters' claims and qualifications.

Comment 1

sirdarckcat Says:

June 17th, 2009 at 8:58 am

I understand why Joe sent you that message, and I think that after reading this post he would send it again.

Apache Max Clients DoS abusing the keep alive of content-length/keep-alive header/send a lot of small headers with a timer/etc.. are well known attacks for quite some time.

Maybe I missed something, is there anything I missed?

Comment 2

RSnake Says:

June 17th, 2009 at 9:11 am

@sirdarckcat - Slowloris can defeat all of those protections, with the possible exception of the experimental modules (if you want to take the risk of installing something that isn't production ready). Well known or not, default Apache and even tuning each of those items doesn't do much to stop Slowloris if you tune it to compensate.

The point is even if it was fixable, it's not default and few webmasters if any will change it. Also, by increasing max clients you are only delaying the inevitable. Slowloris will still win eventually. It may take 1000 threads instead of 200, but whatever.

If you can point me to the "well known" attack code, I'd love to see it.

Comment 4

sirdarckcat Says:

June 17th, 2009 at 9:30 am

Which protections?

What I said are names of attacks.. inorder to exhaust the apache's max clients, by delaying the timeout you can do several things:

1.- send a content-length header without sending enough data

2.- use the keep-alive header and an incomplete request

3.- send a lot of small headers very slow

Greetz!!

Comment 5

RSnake Says:

June 17th, 2009 at 9:37 am

@sirdarckcat - the ones listed on the page Joe sent. You're right, all three will do the job. Content-length has been seen in the wild. I haven't seen the headers version though. But all three would work, and I may eventually add all three in, although I think Keep-Alive is an easy one to fix compared to the other two.

Comment 9

RSnake Says:

June 17th, 2009 at 11:04 am

@Ryan - ApacheBench does not send partial requests, unless you are talking about Keep alives, which Slowloris has nothing to do with.

MaxClients and MaxRequestsPerChild don't fix the problem, they just make Slowloris work a little harder to have the same effect. Read the comments above.

Comment 12

BillB Says:

June 17th, 2009 at 11:36 am

What would help is a max connections per IP. MaxClients doesn't help because they will be consumed. Same with MaxRequestsPerChild and any thread settings. Seems a little strange to me that apache doesn't have a max connections per IP, certainly an attack with a bunch of slow connections isn't a new one.

Comment 13

RSnake Says:

June 17th, 2009 at 11:58 am

@All, we have now gone through and tested every single recommendation Apache has made on that page - even the scary experimental one that says it may take down your server in the process of it's use, and none of them stopped Slowloris. I think we can finally move on from that part of the discussion.

@Acidus - Agree with most of what you're saying with a few exceptions. The Keep-Alive DoS isn't really relevant except that it too is a DoS which has the same effect. I also never claimed the house was on fire. In fact, most big websites that really would need to worry about this are going to be more secure inherently because they use load balancers which are far less vulnerable from what I've seen so far. As far as arming script kiddies, if it's not a problem/big deal then why should anyone worry about script kiddies having it? Right? However, whether it is or isn't a big deal I do think it's worth talking about since Apache's recommendations are crapola. And yes, I do think there are ways to make Apache work and still have high performance - IIS has managed to do a pretty good job.

@BillB - that's not a bad idea. You could probably invent something like that on your own. I haven't heard of anything quite like that though. Perhaps mod_security could use a tweak to add something like this in?

Comment 14

gat3way Says:

June 17th, 2009 at 12:18 pm

Yeah, but that's nothing new really. You can achieve the very same result (with Apache) without even sending anything on the socket. Since the MaxClients limit is hardcoded to be 256, all you need is to open and connect 256 sockets to the webserver and since there is a request timeout, you need eventually to reopen and reconnect them again depending on the server's timeout value.

Besides, Apache by default does not log anything in that case since there is no request at all (this usually makes server administrators angry :)

I agree Apache could provide a limit of connections from a given IP but sometimes that could become kind of a bad problem (imagine your webserver is accessed through a reverse proxy and all requests come from the proxy's address).

Besides, Apache by default (mpm_prefork) does not spawn new threads, it forks new processes instead. This is a lot more CPU consuming (because of context switching) and memory-consuming as well. Thus, raising the MaxClients can be devastating, it could trigger oom kills and/or make the system unresponsible.

Finally, what I believe is a neat solution to the problem is introducing a web caching tier in front of the apache servers and carefully setting timeout values and connection limits on the web caches. This should eliminate or at least decrease the impact of the problems you've described.

Comment 16

RSnake Says:

June 17th, 2009 at 1:15 pm

@gat3way - yes, but if you just open a socket and they have HTTPReady, you can't DoS the server, in my experience. That was a specific requirement given that HTTPReady is touted as a solution to this exact problem - it's not. But I agree with everything else you've said.

@Daniel Boteanu - I've heard about the plane seat lockout concept before (I think Jeremiah G told me about it at one point). Very cool concept, and I can see a lot of applications for it. I like the concept of dynamic timeouts in general, because that really can be applied to every part of the OSI model.

Comment 19

RSnake Says:

June 17th, 2009 at 1:26 pm

@Acidus ! Whoops, sorry, that's right. I knew it was a while ago, and Jeremiah was with me in the audience when you were talking about it. My brain works in strange ways, but yes, I think that was the first time I had heard about it.

@Matt Presson - Unfortunately that would only work remotely if you could guess the ISNs involved because you need the full TCP handshake for that to work for the HTTP headers to be accepted by the socket. But if you were on the same switch and could ARP spoof and sniff the traffic, sure.

Comment 21

RSnake Says:

June 17th, 2009 at 3:22 pm

@phoenix

mod_bandwidth only works with Apache 1.3.

mod_evasive does nothing to stop this unless it tells something else to firewall the user off. I didn't try every configuration but it doesn't appear to do much against Slowloris unless it communicates it's problems to something that has a chance of dealing with it on Apache's behalf.

Comment 25

sirdarckcat Says:

June 17th, 2009 at 8:48 pm

mod_evasive sucks, and mod_bandwidth is broken.

your best bet is iptables and limit max simultaneous connections / ip.

anyway.. I think it's important to state clear that what you are exhausting is apache's maxclients directive (I know that you cannot fix this just increasing the number, but what your attacks is exhausting is that).

A friend showed this to me a couple of mins ago:

http://seclists.org/fulldisclosure/2009/Jun/0188.html

Just plain stupid, haha

Greetz!!

Comment 27

Wireghoul Says:

June 17th, 2009 at 9:13 pm

I'm surprised mod_choke hasn't been mentioned. Is it considered to "unstable" ?

Also, spotted this typo on the slowloris page;

In considering the ramifcations of a slow denial of service attack against

Comment 28

Christian Folini Says:

June 17th, 2009 at 11:08 pm

Very nice to see somebody write about this topic. The question has been raised on the apache users list in 2007. All we got from apache was the same stupid tips page, which ignores this particular problem completely. See the thread at http://tinyurl.com/mbkhr9

I did some research on this, but never actually released it. If somebody is interested in it, then get in touch with me at netnea.com.

Actually RSnake, you are going in the right direction with slowloris. However, there is a lot of room for additional nastiness. I.e. working with file uploads instead of http headers (http-headers limit you to a max connection duration of LimitRequestFields * Timeout), file uploads do not really have a connection duration limit. And from the way Apache works, just about anybody is allowed to *send* in a file. Apache won't necessarily accept it, but as a start, it will try and swallow it completely. ModSecurity could help you a bit though.

What I have not tried out is hacking the ssl handshake. I am confident you would be able to get the same DoS effect and hide from the access log that way.

I am happy somebody with some leverage finally made this public. I've been sitting on my research on the topic for too long.

Comment 29

aykay Says:

June 18th, 2009 at 12:21 am

There is already a way to define a maximum number of connections per source IP address. You even don't have to "tweak" mod_security to achieve that.

Alternative to limit max simultaneous connections with iptables you could use the apache module: mod_qos (http://mod-qos.sourceforge.net/).

It can limit the number of concurrent connections for a singe IP source address by defining the configuration option QS_SrvMaxConnPerIP.

mod_qos could also be configured to allow a server to support keep-alive as long as sufficient connections are free, but to disable the keep-alive support when a defined connection threshold (QS_SrvMaxConnClose) is reached.

Comment 30

phoenix Says:

June 18th, 2009 at 12:46 am

@Rsnake > I did compile mod_bandwidth on Apache 2.2 with no problem

Comment 32

Wladimir Palant Says:

June 18th, 2009 at 5:59 am

> Anyway, I hope this gets people thinking about better web server architecture.

Definitely. I used to run Apache - until a year ago my server simply went down due to memory exhaustion. Took me some time to figure out what was going on and that it wasn't a DoS attack. It was simply due to keep-alive being enabled on a directory where many clients downloaded a small file from. That resulted in tons of open connections (keep alive timeout was 150 seconds which used to be the default I guess) that weren't doing anything but just sitting there and wasting lots of memory. This finally made me install nginx and I still cannot believe how much difference that made. nginx uses a single-threaded approach which is both less wasteful and apparently allows for a far better performance if done correctly.

Comment 34

kmike Says:

June 18th, 2009 at 6:59 am

Yes, it's interesting if this type of attack is effective against the state machine-based web servers such as nginx or lighttpd.

Also, Nginx can limit the number of connections per IP (don't know if lighttpd has a similar feature), thus more attacking IPs are needed to achieve the same result.

Comment 38

GeorgZ Says:

June 18th, 2009 at 11:02 am

I guess the actual "idea" is *really* old (> 5 years). It reminds me to Lutz Donnerhackes "Teergrube" (SMTP) for slowing down spammers.

I agree that something like MaxClientsPerIp should be present in Apache, but unless you figure out why IIS behaves more "intelligent", I would just say that Apache is more tolerant for slow clients.

Comment 39

rvdh Says:

June 18th, 2009 at 6:52 pm

There are more roads that lead to rome:

http://httpd.apache.org/docs/1.3/misc/fin_wait_2.html

Comment 40

id Says:

June 18th, 2009 at 9:23 pm

Couple more suggestions of "solutions" that I tested today.

cband - nope

MPM worker - nope

dosevasive - couldn't find the source, if anyone has a pointer I'll try it.

Also, there's been large percentage of posters on this, and various other forums, saying it's a very old/well known/easily defended against issue. However no one has posted a link to any code that does the slow and low bandwidth approach. I'd be interested to see the code, and compare the various suggested protections.

I am also very curious to know why, if this is so well know, it isn't commonly used in attacks (this site has had quite a few DoSings, none similar). Maybe it's because everyone else (except every site we've tried) is implementing their super secret protections they aren't sharing?

Comment 41

Roland Dobbins Says:

June 18th, 2009 at 10:50 pm

I've read through all of this, and through the TCP vectors discussed in the latest Phrack, and I see absolutely *nothing* new here from either a conceptual or an actualization standpoint. All these things and more have been seen in the wild for a decade or more (by me personally, I'm not reporting second- or third-hand).

It's good to see that folks in the security research/infosec communities are finally starting to think about DDoS and all its implications, but the concept of prior art is still apparently something few security researchers (and academics, for that matter) seem to grasp. Before investing the time and effort to write a tool which duplicates attacks seen over and over again in the wild by operational security (opsec) folks, and before making an announcement that something is new and different which in actuality has been seen and dealt with by others over and over again, a bit of due diligence ought to be undertaken, IMHO.

Also, note that there are in fact quite a few countermeasures for dealing with such attacks, including architecture, configuration, and even dedicated DDoS mitigation devices [full disclosure; I work for a company which makes such devices]. It's also important to note that, far from providing any materially useful security benefit, load-balancers actually tend to increase vulnerability to DDoS due to all the state they instantiate, and so it's important to ensure that one's various reaction mechanisms (S/RTBH, dedicated DDoS mitigation devices, et. al.) are located northbound of the load-balancers so as to protect them as well as the load-balanced instances southbound of them.

This in no way diminishes the value of discussion

Comment 49

RSnake Says:

June 19th, 2009 at 10:49 am

Apache's take on this issue (part two) - still not worth thinking about. They closed the bug that this guy opened: https://issues.apache.org/bugzilla/show_bug.cgi?id=47386

Comment 51

RSnake Says:

June 19th, 2009 at 11:32 am

Incidentally we have a new working theory. Our theory is that no Apache module as it stands right now can fix this. We tried mod_security's "drop" on a single IP address, which should send a FIN immediately upon seeing that IP address. Unfortunately it too was unable to stop this. I think possibly the Apache modules are just called too late. We tried the same thing with .htaccess denys but that only denies once the connection is complete, and mod_security runs after .htaccess. I can't confirm this theory but maybe someone who is more familiar with Apache internals can.

Comment 52

RSnake Says:

June 19th, 2009 at 11:36 am

Ivan Ristic confirmed that mod_security runs too late, although it still might be possible to write a module that can defend against this. He also confirmed that there are no good workarounds built into any existing modules that he is aware of - or even to simpler DoS scenarios as well. It's been something he's wanted to write, but it doesn't currently exist.

Comment 53

RSnake Says:

June 19th, 2009 at 11:37 am

@karavelov - can you tell us what configuration of Slowloris you used? Perhaps my defaults weren't well suited for attacking those...?

Comment 54

Joe Says:

June 19th, 2009 at 11:41 am

Why can't setting keep alives to a lower number not help here?

Comment 55

Wireghoul Says:

June 19th, 2009 at 12:46 pm

@RSnake @id

Did you try mod_choke? If your distro doesn't already have it, consult http://modules.apache.org/ for source

Comment 56

RSnake Says:

June 19th, 2009 at 1:05 pm

@Wireghoul - nope but we can try it out.

For those if you who are following this we've looked at pretty much everything you can possibly do with your Apache config and we've been trying all of your suggestions. One guy on slashdot mentioned this configuration so we tried it out and it looks like it solves the *default* Slowloris attack:

Timeout 5

KeepAliveTimeout 0

The problem is if you set -timeout to 4 Slowloris wins again (assuming fairly low latency). It's all about how long you allow the socket to stay open. This will break all kinds of stuff by doing this though, as Acidus mentioned above.

Comment 57

Tim McGuire Says:

June 19th, 2009 at 2:31 pm

I tested this against tomcat and as expected it works great (from vmware).

Comment 58

Ed Says:

June 19th, 2009 at 2:51 pm

How is this possible ?

“If your server used UDP and I re-wrote Slowloris to speak UDP it would work too.”

http://gaia.cs.umass.edu/kurose/transport/UDP.html

Comment 59

RSnake Says:

June 19th, 2009 at 2:54 pm

@Ed MINA is just one example - http://www.ashishpaliwal.com/blog/2008/10/what-is-apache-mina/ Most of the UDP web servers I’ve seen are experimental. I was only speaking hypothetically.

Comment 60

Ed Says:

June 19th, 2009 at 2:58 pm

@RSnake, hypothetically how would you hold a connectionless protocols connection open ? DNS uses udp/tcp, lets say your requests are

Comment 61

Ed Says:

June 19th, 2009 at 2:58 pm

oops less than 512K

Comment 62

RSnake Says:

June 19th, 2009 at 3:00 pm

@Ed - I’d hold them open in the same way however that UDP service naturally held them open. UDP is stateless but that doesn’t mean whatever is supervising it has to be stateless. In the same way that HTTP is stateless - we’ve invented cookies that the browser and the server use between them to create state over a stateless protocol.

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