SHARKFEST 2015

WIRESHARK DEVELOPER AND USER CONFERENCE

SSL DOES NOT MEAN SOL

What if you don't have the server keys?

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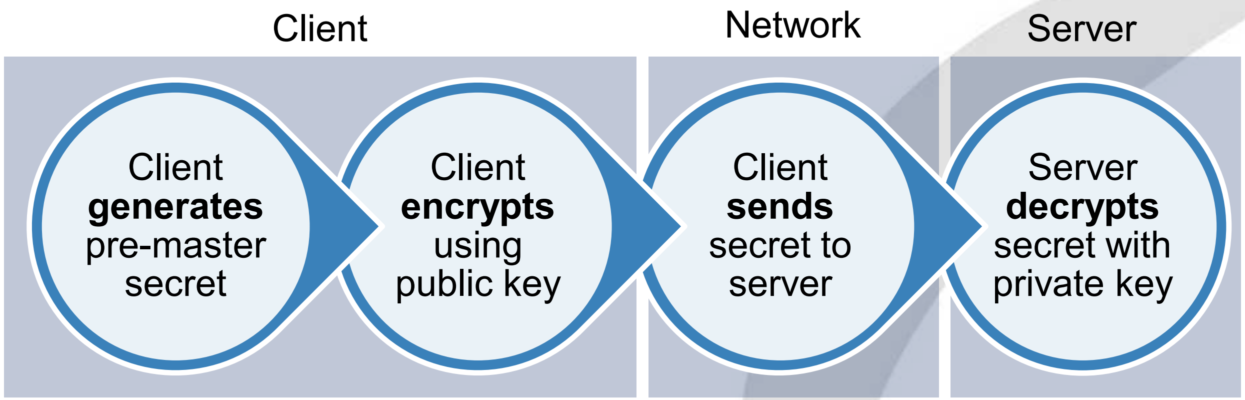
Setting Expectations

- This session is not about..
  - An introduction to SSL encryption
  - How to set up SSL decryption in Wireshark
  - A detailed walk through of the SSL handshake and all the variants
- This session is about…
  - What you can do when you *do not have access to server keys*
    - Calculating server command response time from SSL, even in the cloud
    - Using encrypted data to your advantage
    - Identifying application layer behavior based on SSL patterns
  - Walking through real world examples using Wireshark
  - Focus will be on helping you to analyze application performance more so than security breaches, suspicious activity, etc.

A (very) Brief History of Secure Sockets Layer (SSL)

- Used to encrypt + protect integrity of network data
  - SSL 2.0 was first “public release” in 1995
  - SSL 3.0 released in 1996 forming the foundation for Transport Layer Security (TLS) 1.0 (RFC 2246, 1999)
  - TLS 1.0 is not backward compatible with SSL 3.0!
  - Upgraded to TLS 1.1 (RFC 4346, 2006) and TLS 1.2 (RFC 5346, 2008)
- Supports a wide variety of encryption algorithms
  - RSA and DSA are *asymmetric* (public key encrypts; private key decrypts) – used to <u>exchange and generate key information</u> during the SSL handshake
  - AES and 3DES are *symmetric* algorithms (one key encrypts and decrypts) – used to <u>transfer data</u> (much faster to compute) after the SSL handshake
- TLS 1.0 or higher is recommended practice
  - Many clients & systems now support TLS 1.2 which addresses some vulnerabilities

What’s so Special About the Client Key Exchange?



Both Client and Server generate the master secret from the pre-master to generate the session key.

Therefore, Wireshark needs the server’s private key to decrypt the client pre-master secret to order to generate the master secret to generate the session key to decrypt the SSL packet data!

A Tale of Two Connections

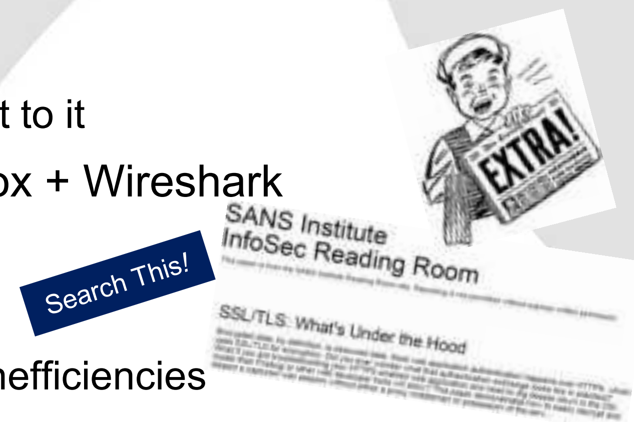
Good, we will get the client key exchange!

No.	Length	Source	Destination	Protocol	Stream index	Sess ID Len	Info
155	62	BCBSMN911 [illegible]	proxy-mb. [illegible]	TCP	9		54785□9119 [SYN] Seq=312491139 Win=8192 Len=0 MSS=1460 SACK_PERM=1
156	62	proxy-mb. [illegible]	BCBSMN911 [illegible]	TCP	9		9119□54785 [SYN, ACK] Seq=523685150 Ack=312491140 Win=14600 Len=0 MS
157	54	BCBSMN911 [illegible]	proxy-mb. [illegible]	TCP	9		54785□9119 [ACK] Seq=312491140 Ack=523685151 Win=64240 Len=0
159	62	BCBSMN911 [illegible]	proxy-mb. [illegible]	TCP	10		54789□9119 [SYN] Seq=2035020690 Win=8192 Len=0 MSS=1460 SACK_PERM=1
161	62	proxy-mb. [illegible]	BCBSMN911 [illegible]	TCP	10		9119□54789 [SYN, ACK] Seq=3851424993 Ack=2035020691 Win=14600 Len=0
162	54	BCBSMN911 [illegible]	proxy-mb. [illegible]	TCP	10		54789□9119 [ACK] Seq=2035020691 Ack=3851424994 Win=64240 Len=0
170	292	BCBSMN911 [illegible]	proxy-mb. [illegible]	HTTP	9		CONNECT encrypted-tbn3.gstatic.com:443 HTTP/1.1
171	270	BCBSMN911 [illegible]	proxy-mb. [illegible]	HTTP	10		CONNECT ssl.gstatic.com:443 HTTP/1.1
172	60	proxy-mb. [illegible]	BCBSMN911 [illegible]	TCP	9		9119□54785 [ACK] Seq=523685151 Ack=312491378 Win=15544 Len=0
174	60	proxy-mb. [illegible]	BCBSMN911 [illegible]	TCP	10		9119□54789 [ACK] Seq=3851424994 Ack=2035020907 Win=15544 Len=0
194	192	proxy-mb. [illegible]	BCBSMN911 [illegible]	HTTP	10		HTTP/1.1 200 Connection established
195	268	BCBSMN911 [illegible]	proxy-mb. [illegible]	TLSv1.2	10	0	Client Hello
196	192	proxy-mb. [illegible]	BCBSMN911 [illegible]	HTTP	9		HTTP/1.1 200 Connection established
197	571	BCBSMN911 [illegible]	proxy-mb. [illegible]	TLSv1.2	9	32	Client Hello
210	1514	proxy-mb. [illegible]	BCBSMN911 [illegible]	TLSv1.2	10		Server Hello
211	504	proxy-mb. [illegible]	BCBSMN911 [illegible]	TCP	10		[TCP segment of a reassembled PDU]
212	54	BCBSMN911 [illegible]	proxy-mb. [illegible]	TCP	10		54789□9119 [ACK] Seq=2035021121 Ack=3851427042 Win=64240 Len=0
215	1514	proxy-mb. [illegible]	BCBSMN911 [illegible]	TCP	10		[TCP segment of a reassembled PDU]
216	598	proxy-mb. [illegible]	BCBSMN911 [illegible]	TLSv1.2	10		Certificate
217	54	BCBSMN911 [illegible]	proxy-mb. [illegible]	TCP	10		54789□9119 [ACK] Seq=2035021121 Ack=3851429046 Win=64240 Len=0
219	60	proxy-mb. [illegible]	BCBSMN911 [illegible]	TCP	9		9119□54785 [ACK] Seq=523685289 Ack=312491895 Win=16616 Len=0
222	207	proxy-mb. [illegible]	BCBSMN911 [illegible]	TLSv1.2	9	32	Server Hello, Change Cipher Spec, Hello Request, Hello Request
224	316	BCBSMN911 [illegible]	proxy-mb. [illegible]	TLSv1.2	10		Client Key Exchange, Change Cipher Spec, Hello Request, Hello Request
226	241	BCBSMN911 [illegible]	proxy-mb. [illegible]	TLSv1.2	9		Change Cipher Spec, Hello Request, Hello Request
227	60	proxy-mb. [illegible]	BCBSMN911 [illegible]	TCP	9		9119□54785 [ACK] Seq=523685442 Ack=312492082 Win=17688 Len=0
238	60	proxy-mb. [illegible]	BCBSMN911 [illegible]	TCP	10		9119□54789 [ACK] Seq=3851429046 Ack=2035021383 Win=17688 Len=0
241	98	proxy-mb. [illegible]	BCBSMN911 [illegible]	TCP	10		[TCP segment of a reassembled PDU]
242	152	proxy-mb. [illegible]	BCBSMN911 [illegible]	TLSv1.2	9		Application Data, Application Data
243	288	proxy-mb. [illegible]	BCBSMN911 [illegible]	TLSv1.2	10		New Session Ticket
244	54	BCBSMN911 [illegible]	proxy-mb. [illegible]	TCP	10		54789□9119 [ACK] Seq=2035021383 Ack=3851429422 Win=63864 Len=0
252	54	BCBSMN911 [illegible]	proxy-mb. [illegible]	TCP	9		54785□9119 [ACK] Seq=312492082 Ack=523685540 Win=63851 Len=0

Rats, the client is reusing a previous session ID and the server accepts.

What if we don’t have the client key exchange*?

- If your SSL session reused the Session ID…
  - Try to find a trace containing the original handshake containing the key exchange and pre-pend it
- Use Fiddler or similar
  - As a proxy that runs on the client
  - As a proxy on another workstation & point the remote client to it
- Use client pre-master secret logged by Chrome or Firefox + Wireshark
  - This is cool ‘cuz we don’t need the server key to decrypt it
- When all else fails…
  - Use knowledge of TCP & SSL segmentation to watch for inefficiencies
    - SSL payload size (small is probably ok for SSH but not FTP)!
  - Identify unlike flows across firewalls using encrypted data pattern matching
  - Look for other factors that throttle throughput in other sessions



*Or the client key exchange uses Diffie-Hellman in which we are  even if we posses the server key.

Diffie-Hellman

- Described in a 1976 White Paper by Whitfield Diffie and Martin Hellman
- Protects against long-term key compromise (i.e. server keys!)
- Is not SSL specific, can be used for any secret information exchange
- Client generates a random number, as does server
  - Thus forms a way for the client to encrypt the pre-master (already encrypted with the server’s public key) back to the server

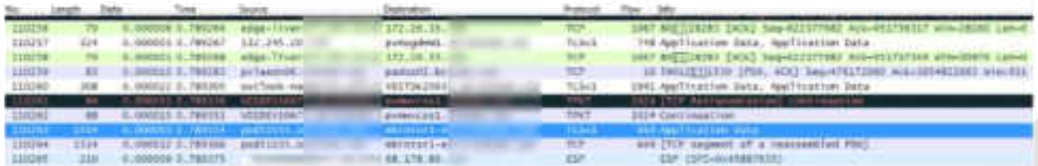
Diffie-Hellman

Use Case: Firewall Pattern Matching

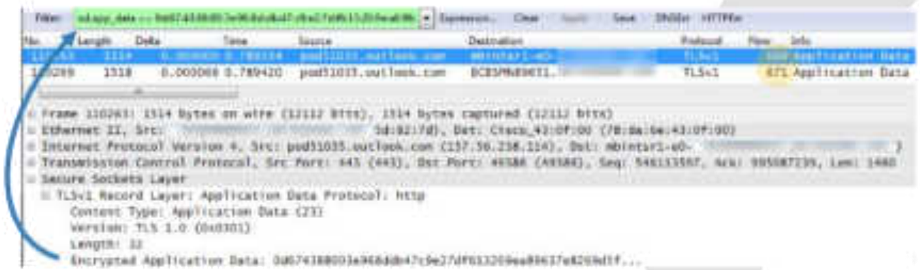
- Perimeter firewalls NAT from private to public IP
  - Terminates TCP but maintain SSL session data
  - Unfortunately, we cannot say the same for proxy servers, load balancers, or anything else that terminates SSL connections
- Simply grab some binary data (i.e. encrypted) from SSL on one side of the firewall and filter on it to find the other side
- Once you have a match, you can then filter on the TCP streams and determine the firewall delay and other characteristics
  - Do not use SPANs nor multiple sniffers due to delays and timestamp synchronization
  - Best practice is to use taps above and below the firewall that feed a common sniffer or are combined via a visibility fabric (Apcon, Big Switch, Gigamon, Ixia, VSS, etc.)
- Also works great for following encrypted VMWare VDI streams (filter on UDP payload) across multiple tiers

Using Wireshark to Find NATed SSL Flows

❶ Start with a pool of packets captures inside and outside of the firewall…

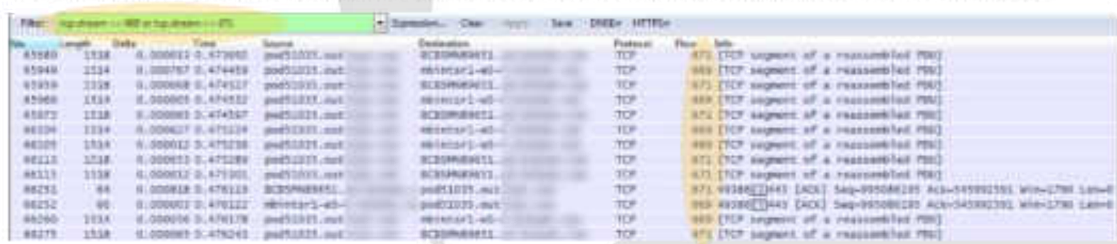


❷ Filter on some SSL data from the flow of interest into the firewall…



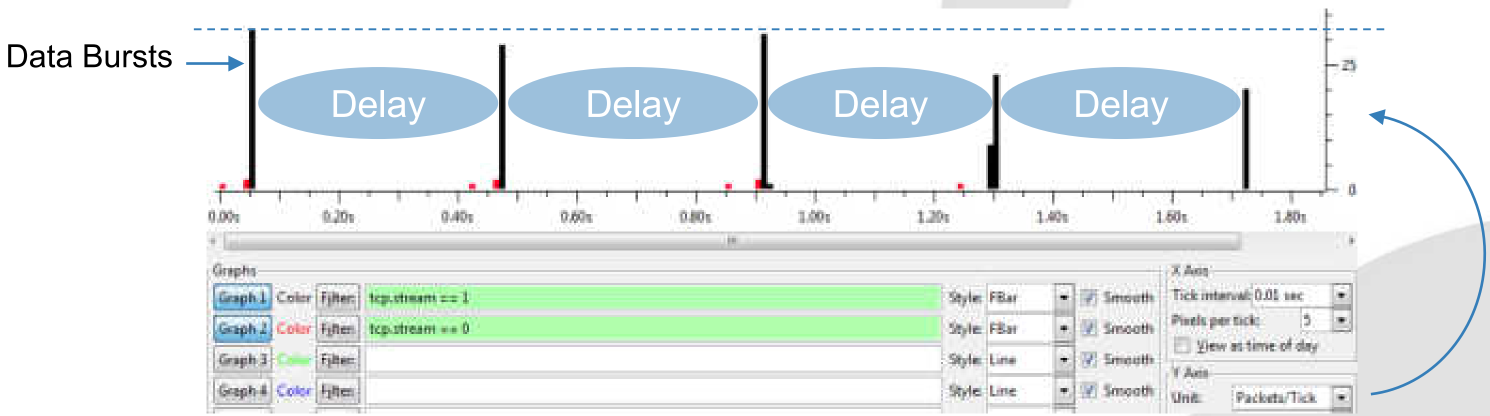
Which picks up the matching flow on the other side of the firewall.

❸ We now have our two flows either side of the firewall for focused analysis



Use Case: Slow eMail Migration

- Migrating user’s mailboxes from internal Lotus Notes servers to Microsoft Office 365 in the Cloud
  - Typical mailbox size was 50 GB
  - Throughput varied from 200-500 kbps over a 1 gig Internet pipe
  - 4k users @ 1 hour per user = 166 days!
- Subsequent web proxy bypass did not help nor did moving to DMZ
- Graphing the I/O revealed a potential problem area



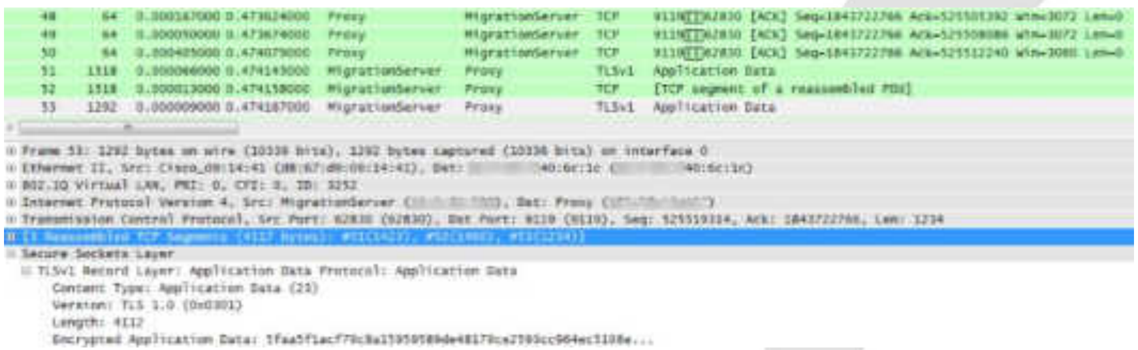
Use Case: Slow eMail Migration

- A pattern emerged when walking through the SSL & checking neighboring flows
  - *A **second flow** (in red below) running was clearly controlling the throughput*
  - The throttling was set to approximate three bursts or blocks of data per second
  - Properties could not be changed, i.e. they are controlled by the (MS) cloud server

	No.	Length	Delta	Time	Source	Destination	Protocol	Info
	27	64	0.000033000	0.054483000	Proxy	MigrationServer	TCP	9119□□62830 [ACK] Seq=1843722766 Ack=525495198 Win=3006 Len=0
	28	1518	0.000078000	0.054561000	MigrationServer	Proxy	TLSv1	Application Data
	29	1518	0.000013000	0.054574000	MigrationServer	Proxy	TCP	[TCP segment of a reassembled PDU]
	30	1292	0.000009000	0.054583000	MigrationServer	Proxy	TLSv1	Application Data
	31	64	0.000159000	0.054742000	Proxy	MigrationServer	TCP	9119□□62830 [ACK] Seq=1843722766 Ack=525499352 Win=2987 Len=0
	32	484	0.000070000	0.054812000	MigrationServer	Proxy	TLSv1	Application Data, Application Data
	33	64	0.000630000	0.055442000	Proxy	MigrationServer	TCP	9119□□62830 [ACK] Seq=1843722766 Ack=525500812 Win=2979 Len=0
	34	64	0.000046000	0.055488000	Proxy	MigrationServer	TCP	9119□□62830 [ACK] Seq=1843722766 Ack=525503506 Win=2967 Len=0
Stop →	35	64	0.000193000	0.055681000	Proxy	MigrationServer	TCP	9119□□62830 [ACK] Seq=1843722766 Ack=525503832 Win=2964 Len=0
	36	196	0.368240000	0.423921000	Proxy	MigrationServer	TLSv1	Application Data, Application Data
Wait	37	292	0.045276000	0.469167000	Proxy	MigrationServer	TLSv1	Application Data, Application Data
	38	64	0.000134000	0.469531000	MigrationServer	Proxy	TCP	62831□□9119 [ACK] Seq=653341697 Ack=3420581597 Win=511 Len=0
Start →	39	1518	0.003211000	0.472742000	MigrationServer	Proxy	TLSv1	Application Data
	40	1518	0.000011000	0.472753000	MigrationServer	Proxy	TCP	[TCP segment of a reassembled PDU]
	41	1292	0.000009000	0.472762000	MigrationServer	Proxy	TLSv1	Application Data
	42	1518	0.000394000	0.473156000	MigrationServer	Proxy	TLSv1	Application Data
	⋮							
Stop →	67	64	0.000183000	0.478359000	Proxy	MigrationServer	TCP	9119□□62830 [ACK] Seq=1843722766 Ack=525529250 Win=2980 Len=0
	68	356	0.380602000	0.858961000	Proxy	MigrationServer	TLSv1	Application Data, Application Data, Application Data
Wait	69	132	0.052061000	0.909022000	Proxy	MigrationServer	TLSv1	Application Data
	70	64	0.000460000	0.909482000	MigrationServer	Proxy	TCP	62831□□9119 [ACK] Seq=653341697 Ack=3420581909 Win=510 Len=0
Start →	71	1518	0.006197000	0.915679000	MigrationServer	Proxy	TLSv1	Application Data

Use Case: Slow eMail Migration

- Each data stream was equated to one piece of mail
  - Due to control channel, conversion rate was approximately three emails per second(!)
  - Another potential optimization was to increase the application layer block size to greater than 12k (which we derived from the SSL segment size of 4112 bytes x 3 per turn)



- Solution was to run multiple severs simultaneously with multiple mailbox migrations per server to the cloud, which is per MS recommendation
  - We were running up to 40 migrations in parallel at the peak
  - All mailboxes were migrated in under 30 days

Wrapping it Up

- First gain a solid understanding of the general application layer command-response characteristics in the unencrypted world (HTTP, SQL, mail, etc.)
  - Pretend that the SSL layer *is* the application layer and apply those characteristics
- Figure out who is the client and who provides the data
  - Usually the client opens the connection, but not always!
- Breakdown the TCP segmentation and the SSL segmentation
  - Ensure that the SSL segment size makes sense for the application (SSH vs. HTTPS for instance)
- Identifying network from back-end response time is easier but must use patterns and neighboring flows for more complex cases

Thank You!

Contact us!

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