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HTTPS Event-Flow Correlation: Improving Situational Awareness in Encrypted Web Traffic

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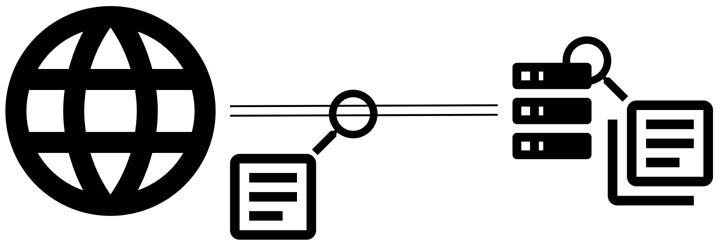
Motivation

- Web traffic is currently mostly encrypted
- Analysis of encrypted traffic is inaccurate and costly
  - Unecrypted handshakes
  - Statistical features
  - Reencryption proxies
- Enrich network monitoring by data from host-based monitoring

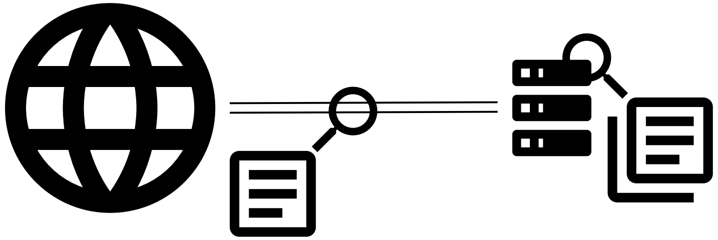
Host-Based and Network Monitoring I



Flows						
start_t	end_t	src	dst	bytes	proto	application data
10:21:00	10:21:25	10.0.0.5	10.0.0.1	1643	TLS	
10:21:19	10:24:03	10.0.0.2	10.0.0.1	1554	TLS	

Events		
timestamp	server	message
10:21:01.154	10.0.0.1	GET example.com 200 Mozilla/5.0+iPhone+OS
10:21:13.278	10.0.0.1	GET edu.example.com 200 Mozilla/5.0+iPhone
10:21:21.004	10.0.0.1	POST example.com 200 Mozilla/5.0+iPhone+O
10:21:22.152	10.0.0.2	GET example.com 200 Chromium/64.2+Windo

Host-Based and Network Monitoring II



	Flows						
	start_t	end_t	src	dst	bytes	proto	application data
1	10:21:00	10:21:25	10.0.0.5	10.0.0.1	1643	TLS	
2	10:21:19	10:24:03	10.0.0.2	10.0.0.1	1554	TLS	

Events			
timestamp	server	message	
10:21:01.154	10.0.0.1	GET example.com 200 Mozilla/5.0+iPhone+OS	A
10:21:13.278	10.0.0.1	GET edu.example.com 200 Mozilla/5.0+iPhone	B
10:21:21.004	10.0.0.1	POST example.com 200 Mozilla/5.0+iPhone+O	C
10:21:22.152	10.0.0.2	GET example.com 200 Chromium/64.2+Windo	D

Event-Flow Correlation: 1ABC, 2D

Benefits and Restrictions

- Benefits of event-flow correlation
  - Enrichment of encrypted network traffic monitoring
  - Consistency check for event logs
  - Improvement of situational awareness for incident handlers
- Restrictions of event-flow correlation
  - Time synchronization of monitoring infrastructure
  - Monitoring of custom features necessary
  - Usable only for „internal“ web services

Research Topic

- Correlation of the HTTPS events and network flows
- Research questions
  - *How accurately can be events recorded on a web server correlated to the network flows that caused them?*
  - *What impact will future web traffic encryption technologies have on the accuracy of the correlation process?*

Common Features

Feature		HTTP			
Event	Flow	Plain	TLS 1.2	TLS 1.3	QUIC
time-generated	[START_NSEC, END_NSEC]	✓	✓	✓	✓
s-ip	L3_IPV4_DST	✓	✓	✓	✓
s-port	L4_PORT_DST	✓	✓	✓	✓
c-ip	L3_IPV4_SRC	✓	✓	✓	✓
c-port	L4_PORT_SRC	✓	✓	✓	✓
cs-host	HTTP_REQUEST_HOST	✓	✓	✗	✗
cs-uri-stem	HTTP_REQUETS_URL	✓	✗	✗	✗
cs-user-agent	HTTP_USER_AGENT	✓	✗	✗	✗

Correlation Methods

- Four methods based on different sets of common features:
  - All-params – for TLS 1.2 encrypted flows
  - No-sni – TLS 1.3 and QUIC encrypted flows
  - No-port – environment does not allow custom features monitoring
  - No-port-sni – scenario with the least available data

Dataset

- Seven days of web traffic from a large campus network
- Approximately 3 000 000 flows and 6 000 000 events
- TLS 1.2 network flows and Windows Server events
- All devices time-synchronized with millisecond precision
- Webservers unable to log client port disqualified
- Dataset and all tools are public

Evaluation

	All-params	No-sni	No-port	No-port-sni
Accuracy	1,0000	0,9999	0,9999	0,9999
Precision	1,0000	0,9999	0,4055	0,3555
Recall	1,0000	1,0000	1,0000	1,0000
F1-Score	1,0000	0,9999	0,5770	0,5245

Conclusion

- Event-flow correlation may enrich encrypted web traffic monitoring with content and client data
- *How accurately can be events recorded on a web server correlated to the network flows that caused them?*
  - Event-flow correlation is suitable if client port can be monitored
- *What impact will future web traffic encryption technologies have on the accuracy of the correlation process?*
  - Lack of SNI in TLS 1.3 and QUIC has only marginal effect on correlation accuracy

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