inovex

building IoT

MQTT in the Enterprise

How to successfully run an MQTT Message Broker

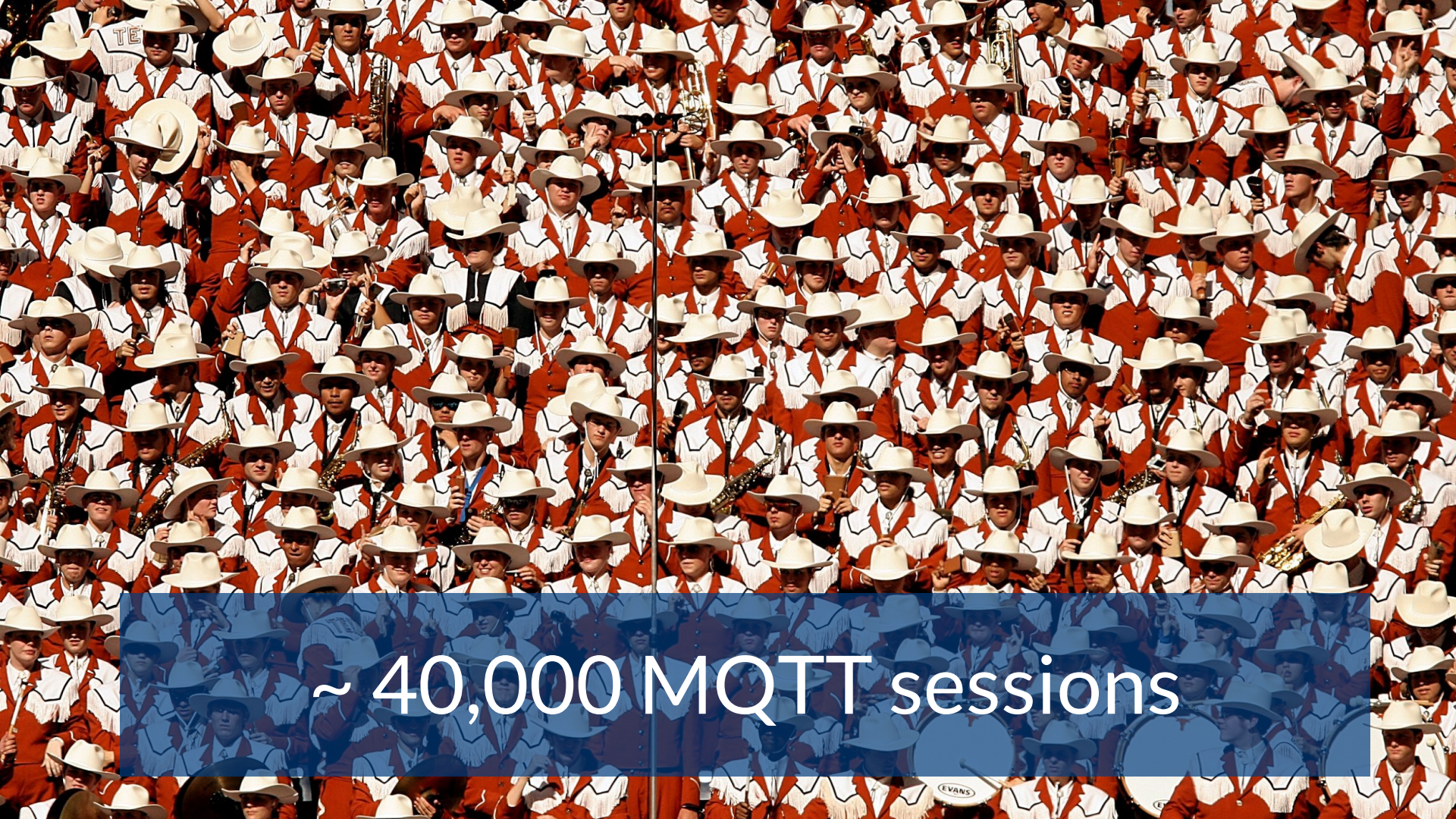
Arnold Bechtoldt
(Senior Systems Engineer)

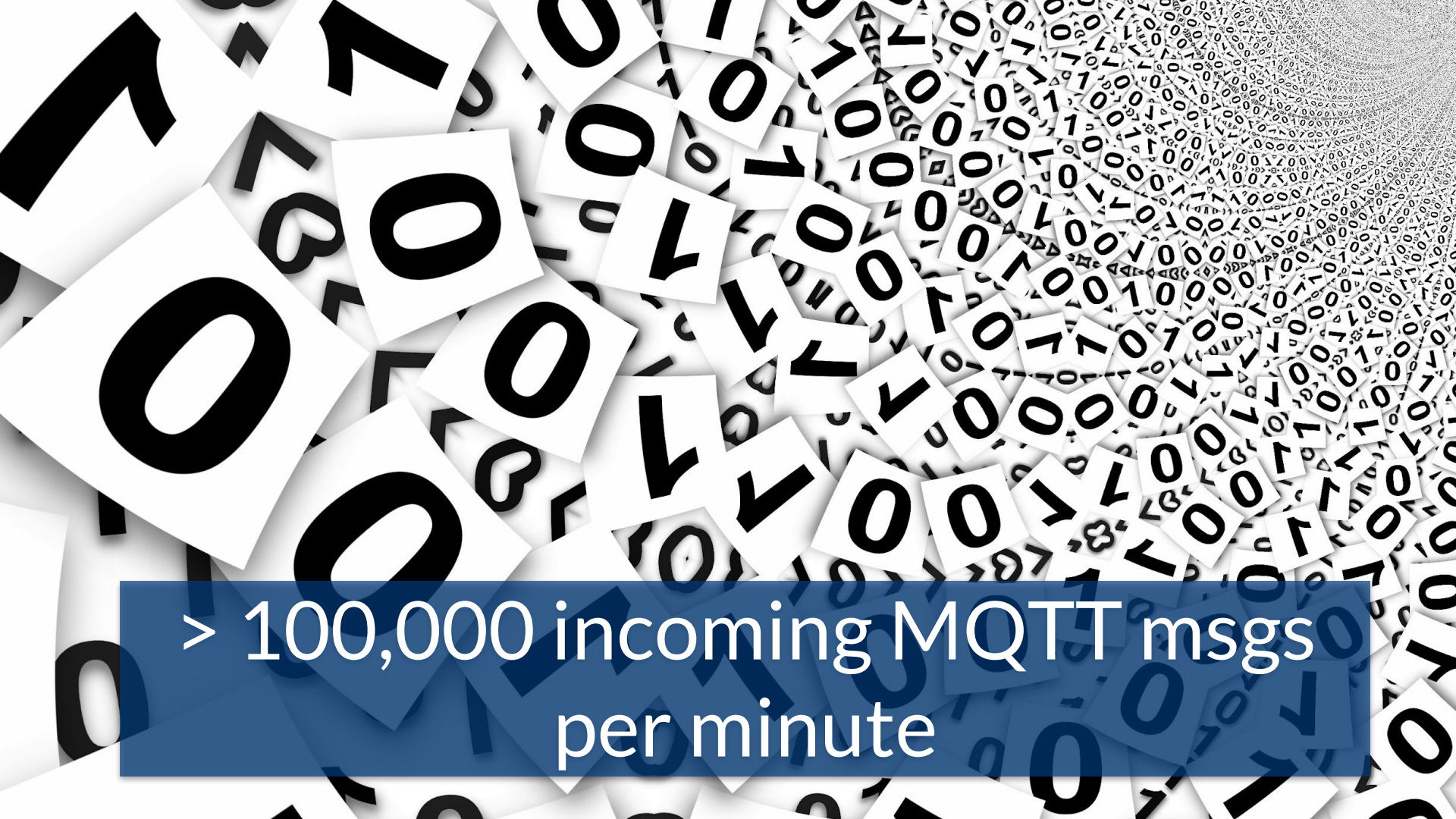
5 learnings from two years of ~~suffering~~ challenges!

Background


Thousands of cars (MQTT clients)


Dozens of backend services
(MQTT clients)

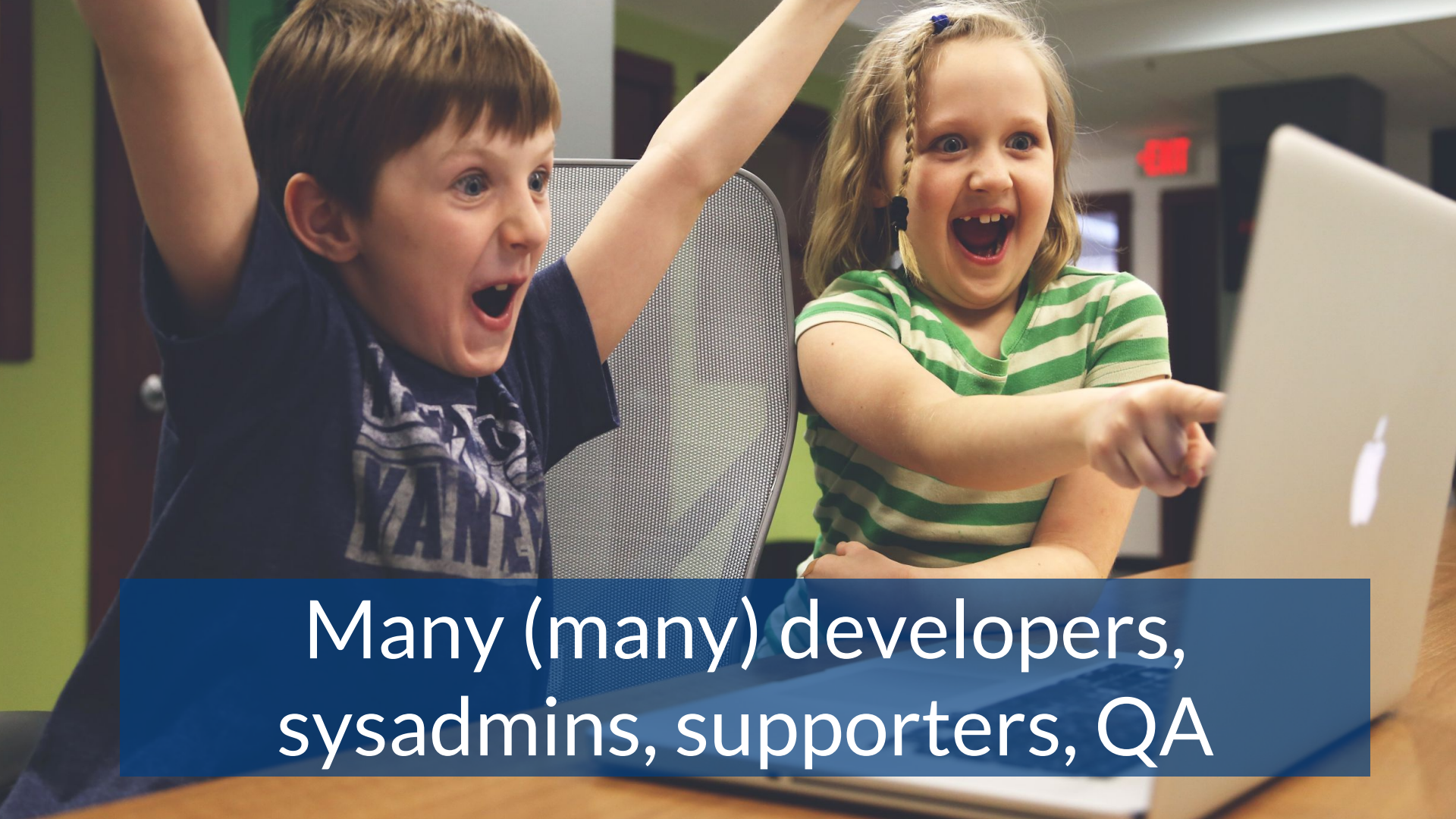

~ 40,000 MQTT sessions


> 100,000 incoming MQTT msgs
per minute


> 1,000,000 customers

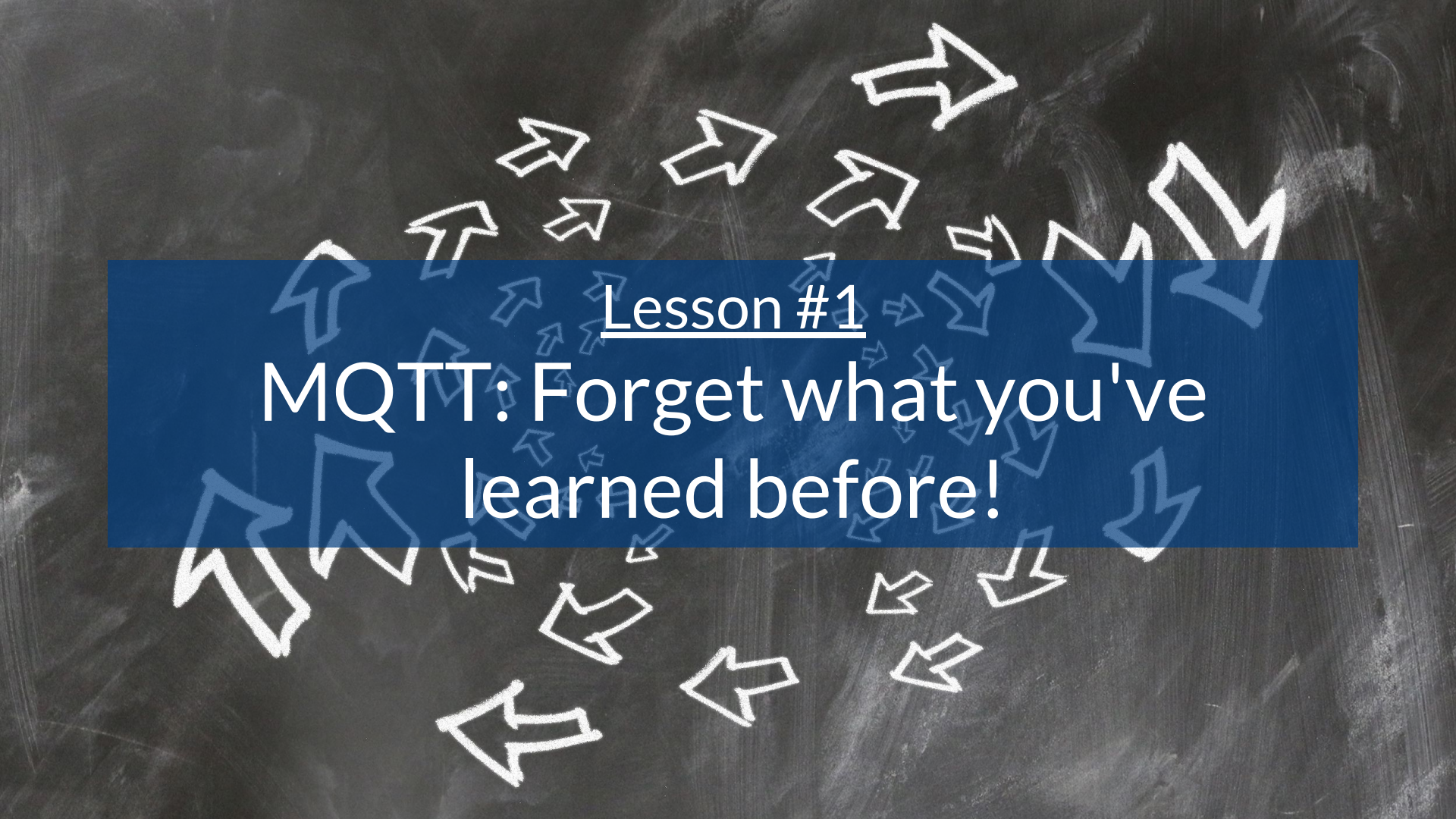
Today's Learning Goal:

How not to kill customers with IoT!


Many (many) developers,
sysadmins, supporters, QA


inovex to the rescue!

Message Broker in the Middle (MITM)


Lesson #1
MQTT: Forget what you've learned before!

MQTT is different

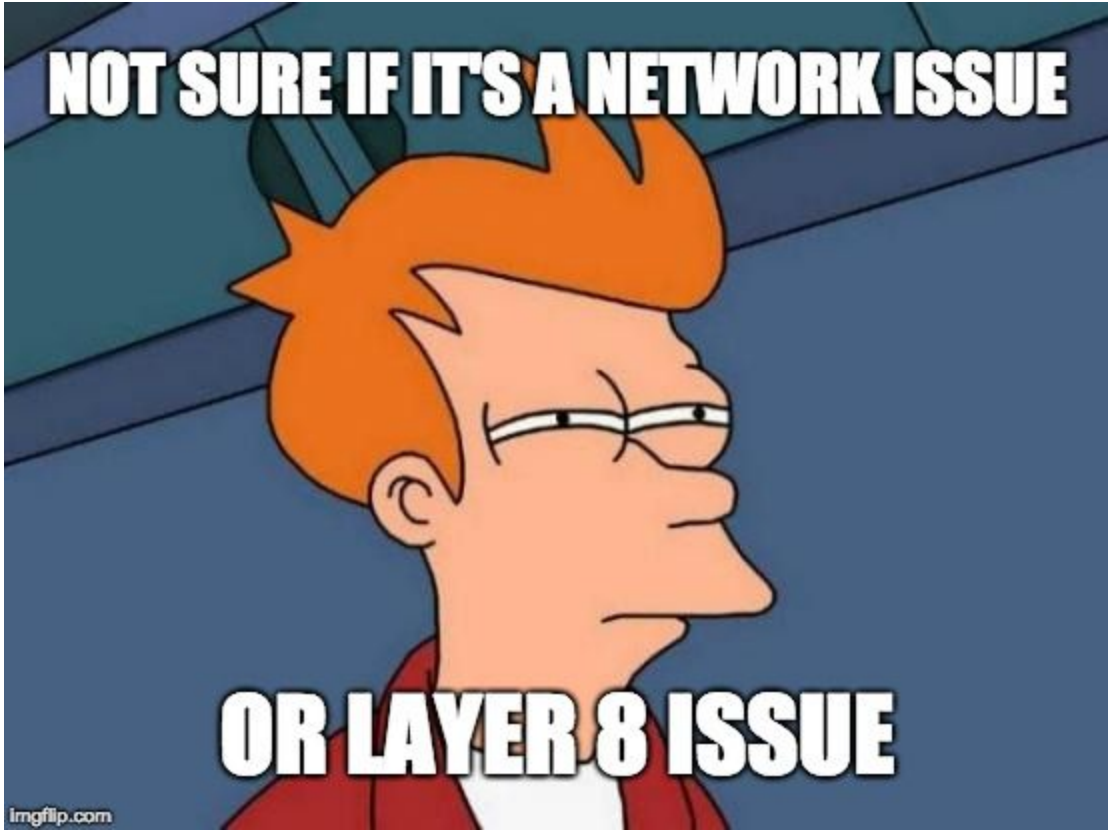
- Rules from HTTP world won’t apply
- “MQTT is simple.” vs. “MQTT is hard.”
- MQTT tooling support (was) missing
- HiveMQ is a rather stateful application

Lesson #2

The(re is no) “I” in IoT!

IoT networking

- Most MQTT clients connected via GSM/UMTS
- Miserable internet connection
- Almost all support tickets caused by network issues
- Embedded hardware lacks network fault tolerance
- Comparing (MQTT) monitoring metrics helps


NOT SURE IF IT'S A NETWORK ISSUE
OR LAYER 8 ISSUE
imgflip.com

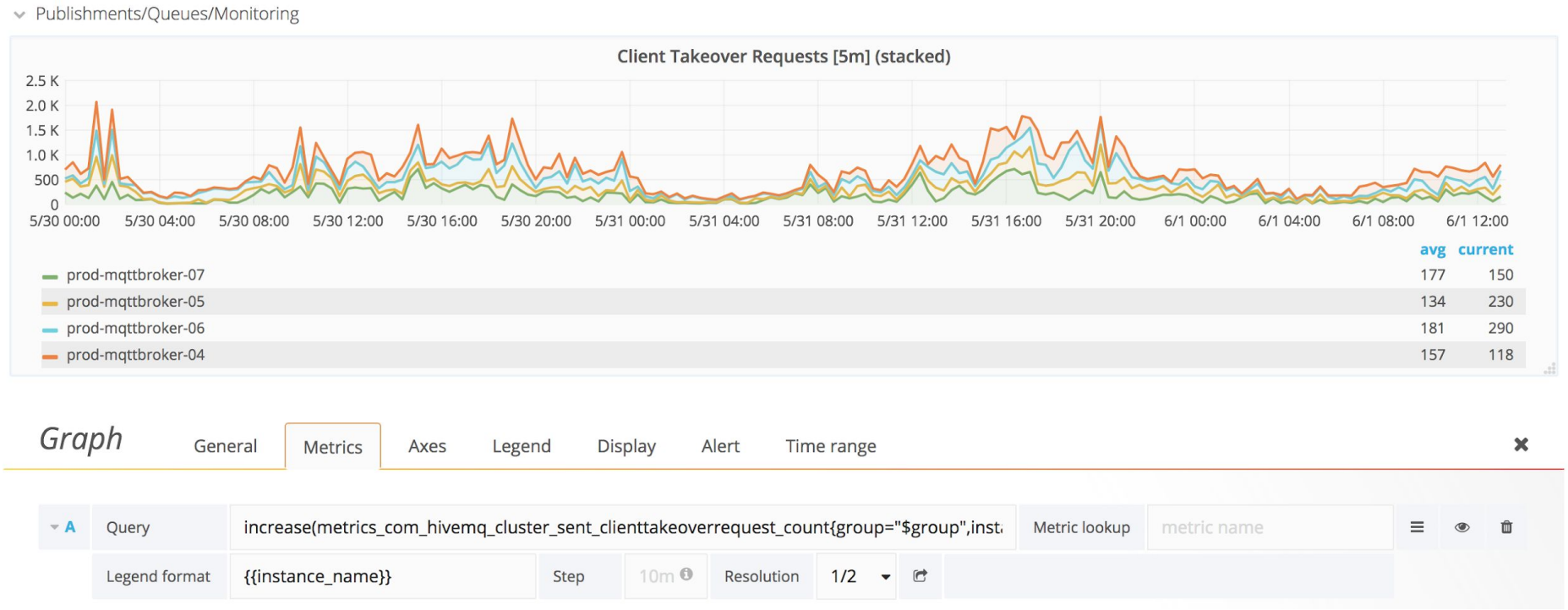
Lesson #3

Monitor your (MQTT) clients to understand their behaviour!

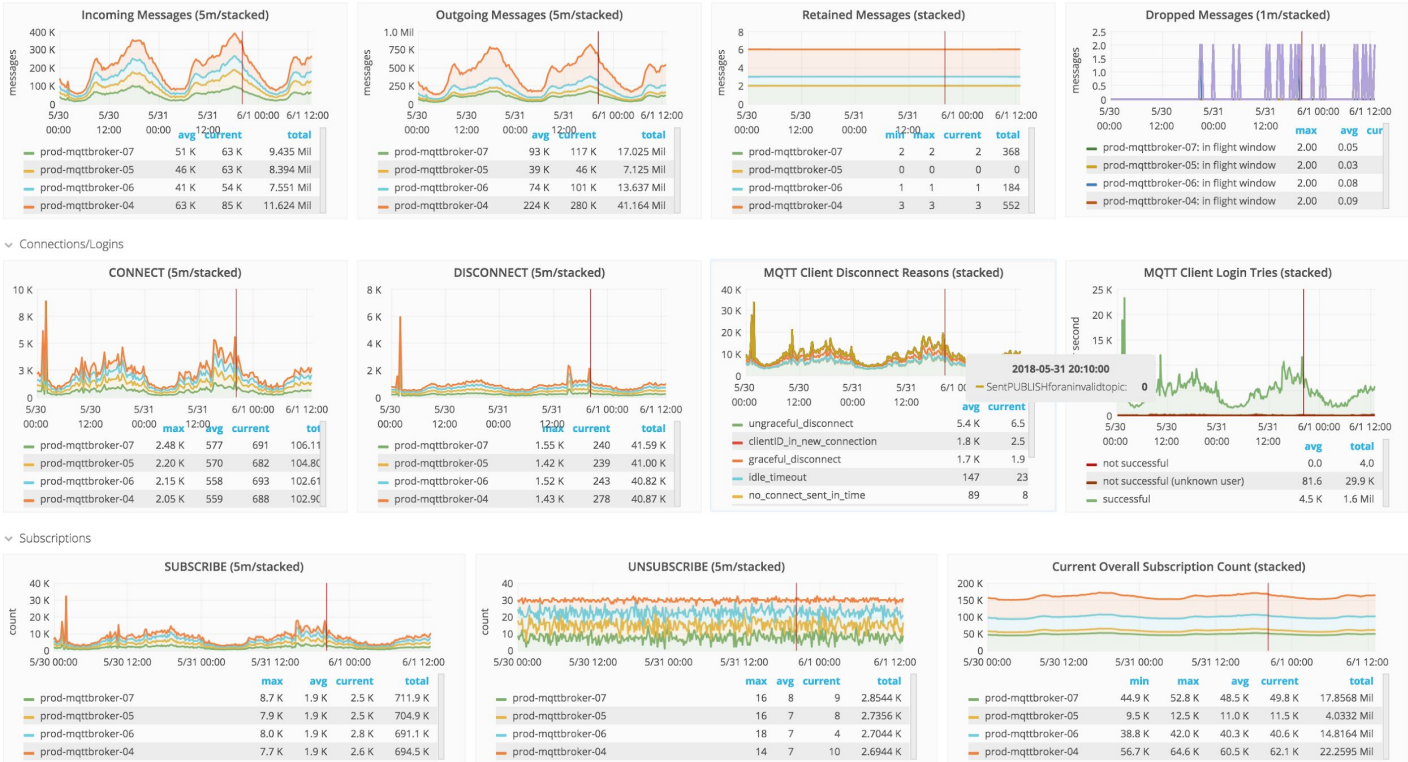
HiveMQ Prometheus Metrics (> 1800)

```
metrics_com_hivemq_messages_dropped_before_publish_send_count_count 0.0
metrics_com_hivemq_messages_dropped_count_count 6092213.0
metrics_com_hivemq_messages_dropped_in_flight_window_count_count 835421.0
metrics_com_hivemq_messages_dropped_internal_error_count_count 0.0
metrics_com_hivemq_messages_dropped_not_connected_count_count 1238.0
metrics_com_hivemq_messages_dropped_not_writable_count_count 4775796.0
metrics_com_hivemq_messages_dropped_qos_0_queue_not_empty_count_count 479758.0
metrics_com_hivemq_messages_dropped_queue_full_count_count 0.0
metrics_com_hivemq_messages_dropped_rate_count 6092213.0
metrics_com_hivemq_messages_dropped_rate_fifteenminuterate 0.0026798488064779242
metrics_com_hivemq_messages_dropped_rate_fiveminuterate 0.003673811334623905
metrics_com_hivemq_messages_dropped_rate_meanrate 1.1690383860629943
metrics_com_hivemq_messages_dropped_rate_oneminuterate 0.0024693484286362477
metrics_com_hivemq_messages_incoming_connect_count_count 1.0997633E7
metrics_com_hivemq_messages_incoming_connect_rate_count 1.0997633E7
metrics_com_hivemq_messages_incoming_connect_rate_fifteenminuterate 2.695426446661923
metrics_com_hivemq_messages_incoming_connect_rate_fiveminuterate 2.846849980596273
metrics_com_hivemq_messages_incoming_connect_rate_meanrate 2.110342385291968
metrics_com_hivemq_messages_incoming_connect_rate_oneminuterate 2.890580707427736
metrics_com_hivemq_messages_incoming_disconnect_count_count 3926444.0
metrics_com_hivemq_messages_incoming_disconnect_rate_count 3926444.0
metrics_com_hivemq_messages_incoming_disconnect_rate_fifteenminuterate 0.8603151573544764
metrics_com_hivemq_messages_incoming_disconnect_rate_fiveminuterate 0.8937906297328476
metrics_com_hivemq_messages_incoming_disconnect_rate_meanrate 0.7534476952336496
metrics_com_hivemq_messages_incoming_disconnect_rate_oneminuterate 0.848894289974284
metrics_com_hivemq_messages_incoming_pingreq_count_count 1.6680187E8
```

Visualizing Metrics



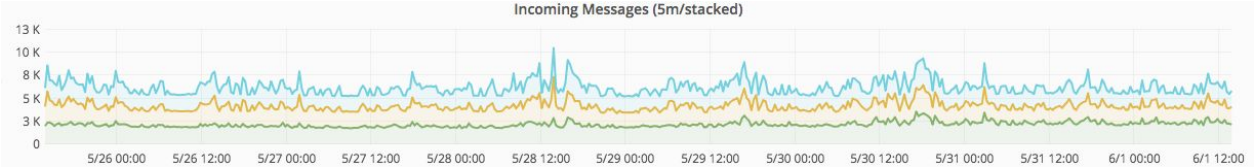
MQTT Broker Dashboard (Grafana)



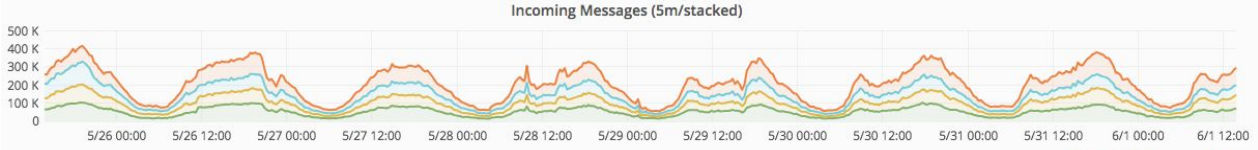
(Bad) Dev/Prod Parity

Testing

Integration



Production




Lesson #4
Log all* MQTT events and people will start loving you!

Notice: Don’t break data privacy law!

Prepared for general use

Quick Links

The following links help you to find some query examples. Open an example and modify to your own needs:

Use Case	Index	TEST	INT	PROD	Comment
Login details (after connect)	*-mqttbroker-authplugin-*	Kibana	Kibana	Kibana	(user abc)
Login details by VIN (after connect)	*-mqttbroker-authplugin-*	Kibana	Kibana	Kibana	(vehicle XYZ)
Connects/Disconnects by VIN	*-mqttbroker-events-*	Kibana	Kibana	Kibana	(vehicle XYZ)
Non-graceful disconnects	*-mqttbroker-events-*	Kibana	Kibana	Kibana	
MQTT Message Drops	*-mqttbroker-events-*		Kibana	Kibana	
HTTP IP Triggers	*-mqttbroker-restplugin-*	Kibana	Kibana	Kibana	
MQTT actions by VIN	*-mqttbroker-logs-*	Kibana	Kibana	Kibana	(vehicle XYZ)

Unstructured logs as base ...

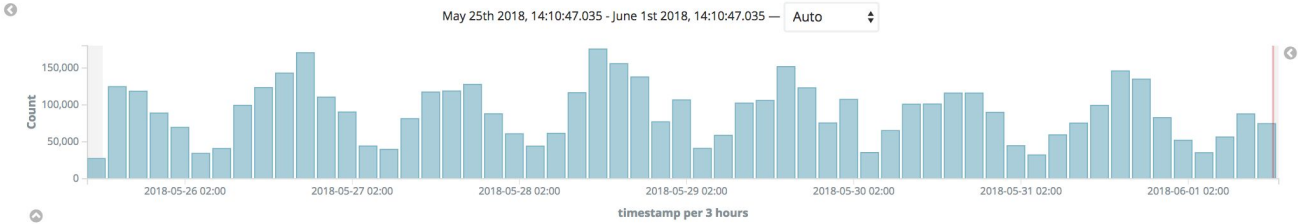
```
2018-06-01T18:25:30,737Z [hivemq-native-eventloop-child-15] DEBUG event.client-connected - Client ID: mqttlinkstatusaggregator, IP:             , Clean
2018-06-01T18:25:31,452Z [hivemq-native-eventloop-child-3] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.25 disconnected ungracefull
2018-06-01T18:25:31,788Z [hivemq-native-eventloop-child-5] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.31 disconnected ungracefull
2018-06-01T18:25:31,829Z [single-writer-9] DEBUG event.client-disconnected - Client ID: mqttlinkstatusaggregator, IP:             was disconnected. re
2018-06-01T18:25:31,830Z [hivemq-native-eventloop-child-15] DEBUG event.client-disconnected - Client ID: mqttlinkstatusaggregator, IP:            l dis
2018-06-01T18:25:33,453Z [hivemq-native-eventloop-child-7] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.25 disconnected ungracefull
2018-06-01T18:25:33,790Z [hivemq-native-eventloop-child-9] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.31 disconnected ungracefull
2018-06-01T18:25:34,016Z [hivemq-native-eventloop-child-10] DEBUG event.client-connected - Client ID: mqttlinkstatusaggregator, IP:           ', Clean
2018-06-01T18:25:35,124Z [single-writer-9] DEBUG event.client-disconnected - Client ID: mqttlinkstatusaggregator, IP:            was disconnected. re
2018-06-01T18:25:35,125Z [hivemq-native-eventloop-child-10] DEBUG event.client-disconnected - Client ID: mqttlinkstatusaggregator, IP:             dis
2018-06-01T18:25:35,455Z [hivemq-native-eventloop-child-15] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.25 disconnected ungraceful
2018-06-01T18:25:35,791Z [hivemq-native-eventloop-child-1] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.31 disconnected ungracefull
2018-06-01T18:25:36,218Z [hivemq-native-eventloop-child-2] DEBUG event.client-connected - Client ID: mqttlinkstatusaggregator, IP:             , Clean
2018-06-01T18:25:37,347Z [single-writer-14] DEBUG event.client-disconnected - Client ID: mqttlinkstatusaggregator, IP:            ' was disconnected. r
2018-06-01T18:25:37,348Z [hivemq-native-eventloop-child-2] DEBUG event.client-disconnected - Client ID: mqttlinkstatusaggregator, IP:             disc
2018-06-01T18:25:37,457Z [hivemq-native-eventloop-child-7] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.25 disconnected ungracefull
2018-06-01T18:25:37,795Z [hivemq-native-eventloop-child-9] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.31 disconnected ungracefull
2018-06-01T18:25:38,700Z [hivemq-native-eventloop-child-11] DEBUG event.client-connected - Client ID: test-mqttbrokerlb-03-haproxy-healthchecker, IP:10
2018-06-01T18:25:38,706Z [hivemq-native-eventloop-child-11] DEBUG event.client-disconnected - Client ID: test-mqttbrokerlb-03-haproxy-healthchecker, IP
2018-06-01T18:25:39,459Z [hivemq-native-eventloop-child-15] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.25 disconnected ungraceful
2018-06-01T18:25:39,797Z [hivemq-native-eventloop-child-1] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.31 disconnected ungracefull
2018-06-01T18:25:40,221Z [hivemq-native-eventloop-child-2] DEBUG event.client-disconnected - Client ID: vehicl eMockListener1521022427024, IP          }
2018-06-01T18:25:41,460Z [hivemq-native-eventloop-child-5] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.25 disconnected ungracefull
2018-06-01T18:25:41,798Z [hivemq-native-eventloop-child-7] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.31 disconnected ungracefull
2018-06-01T18:25:43,462Z [hivemq-native-eventloop-child-9] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.25 disconnected ungracefull
2018-06-01T18:25:43,807Z [hivemq-native-eventloop-child-11] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.31 disconnected ungraceful
2018-06-01T18:25:44,521Z [hivemq-native-eventloop-child-13] DEBUG event.client-connected - Client ID: test-mqttbrokerlb-04-haproxy-healthchecker, IP:10
2018-06-01T18:25:44,529Z [hivemq-native-eventloop-child-13] DEBUG event.client-disconnected - Client ID: test-mqttbrokerlb-04-haproxy-healthchecker, IP
2018-06-01T18:25:44,978Z [hivemq-native-eventloop-child-1] DEBUG event.client-connected - Client ID: mqttlinkstatusaggregator, IP:           ', Clean
2018-06-01T18:25:45,464Z [hivemq-native-eventloop-child-5] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.25 disconnected ungracefull
2018-06-01T18:25:45,808Z [hivemq-native-eventloop-child-7] DEBUG event.client-disconnected - Client ID: UNKNOWN, IP:10.9.54.31 disconnected ungracefull
```

… manipulated with Logstash

```
# fix a few inconsistencies in the original log format before offering the log line to kv for parsing
mutate {
  gsub => [
  "LOGMESSAGE", "connected\.?$", "",
  "LOGMESSAGE", "\swas disconnected\.", ",",
  "LOGMESSAGE", "disconnected gracefully\.?", ", reason: graceful_disconnect",
  "LOGMESSAGE", "disconnected ungracefully\.?", ", reason: ungraceful_disconnect",
  "LOGMESSAGE", "An other client connected with the same client id.$", "clientID_in_new_connection",
  "LOGMESSAGE", "Another client connected with the same clientId.$", "clientID_in_new_connection",
  "LOGMESSAGE", "Client was idle for too long.$", "idle_timeout",
  "LOGMESSAGE", "Outgoing publish message was dropped\.", "",
  "LOGMESSAGE", "reason: Internal error\.$", "reason: internal_error",
  "LOGMESSAGE", "reason: No CONNECT sent in time.$", "reason: no_connect_sent_in_time",
  "LOGMESSAGE", "reason:", "event_reason:",
  "LOGMESSAGE", "\.$", ""
  ]
}

kv {
  source => "LOGMESSAGE"
  prefix => "mqtt_"
  field_split => ","
  value_split => ":"
  remove_char_value => " "
  remove_char_key => " "
  transform_key => "lowercase"
}
```

… to show MQTT client login



Time	mqtt_ip	mqtt_username	mqtt_clientid	mqtt_auth_result
June 1st 2018, 14:10:41.312			PERSIST	successful
June 1st 2018, 14:10:40.975			PERSIST	successful
June 1st 2018, 14:10:40.657			PERSIST	successful
June 1st 2018, 14:10:40.485			CLEAN_V	successful
June 1st 2018, 14:10:40.457			PERSIST	successful
June 1st 2018, 14:10:40.083			PERSIST	successful
June 1st 2018, 14:10:39.992			CLEAN_V	successful
June 1st 2018, 14:10:39.812			CLEAN_V	successful
June 1st 2018, 14:10:39.779			PERSIST	successful
June 1st 2018, 14:10:39.745	10.14.72.32	internal.healthcheck.user	prod-mc	successful
June 1st 2018, 14:10:39.728			CLEAN_V	successful
June 1st 2018, 14:10:39.606			CLEAN_V	successful
June 1st 2018, 14:10:39.597	10.14.72.14	internal.healthcheck.user	prod-mc	successful
June 1st 2018, 14:10:39.584			PERSIST	successful

… or dropped messages!

Time	mqtt_receivingclient	mqtt_event_reason	mqtt_topic	
June 1st 2018, 14:08:09.684	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/ambienttemperature
June 1st 2018, 14:06:38.149	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/batterysts
June 1st 2018, 14:05:11.696	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/screen_change_event
June 1st 2018, 14:03:47.629	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/engine_event
June 1st 2018, 14:02:20.945	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/ambienttemperature
June 1st 2018, 14:00:47.381	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/batterysts
June 1st 2018, 13:59:21.353	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/seat_belt_buckle_event
June 1st 2018, 13:57:57.848	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/door_event
June 1st 2018, 13:56:31.252	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/seat_belt_buckle_event
June 1st 2018, 13:55:00.604	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/ambienttemperature
June 1st 2018, 13:53:37.168	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/seat_belt_buckle_event
June 1st 2018, 13:52:12.377	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/screen_change_event
June 1st 2018, 13:50:48.468	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/ambienttemperature
June 1st 2018, 13:49:24.761	cs-spark-stream-prod-vehiclebusinessstate	Theinflightwindowisfull		/client/batterysts


Lesson #5
“S” in IoT stands for security!

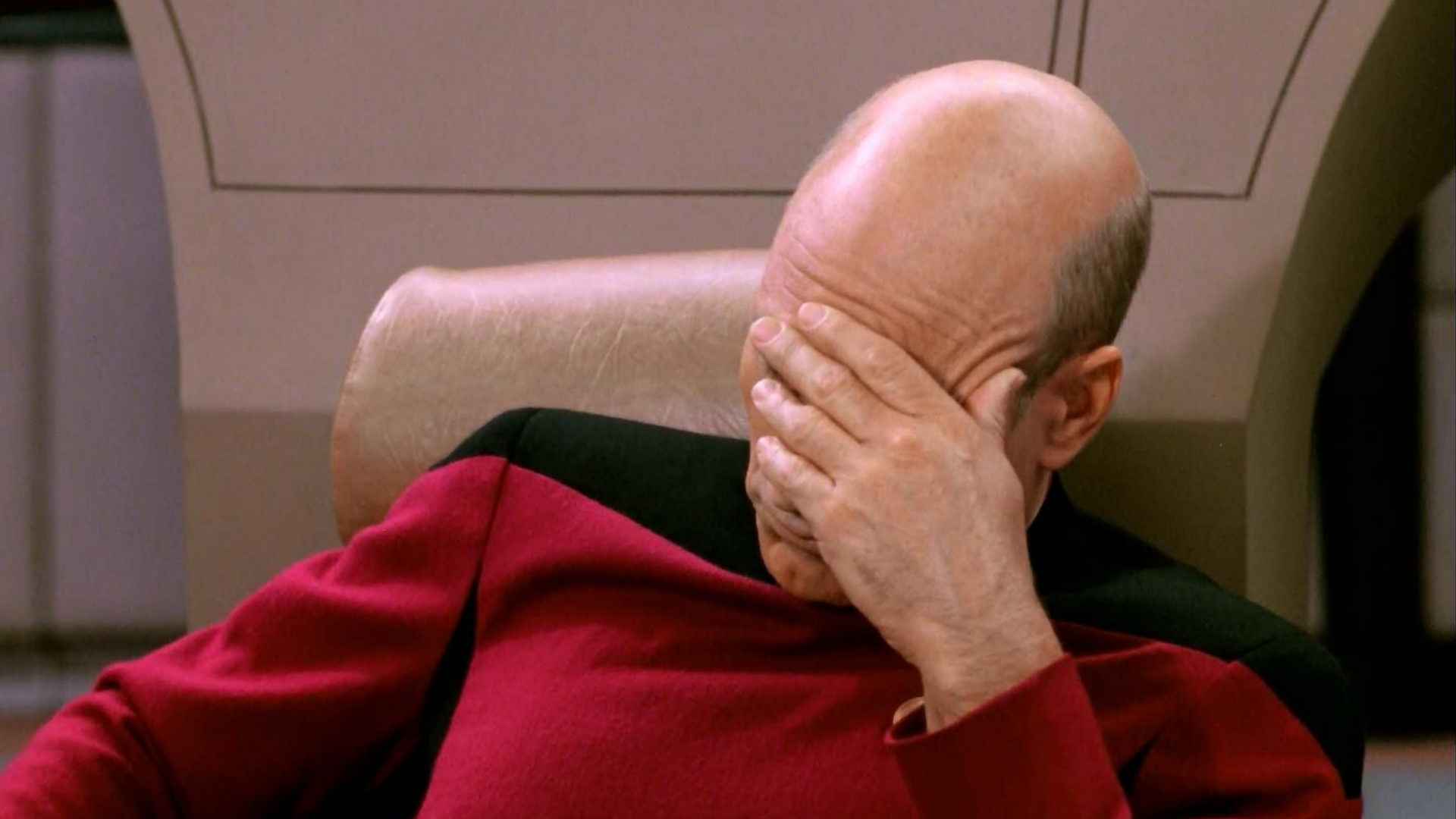
Security in the Enterprise

- MQTT security mechanisms are *okay*
- IoT security is possible
- *Problem Exists Between Chair And Keyboard* (PEBCAK)
- Fight for security!

Ultimative list of *recommendations*

Don’t ...

- force passwords with length of 8 chars.
- log passwords in plaintext.
- forget authorization after implementing authentication.
- use credentials across ten thousands of clients.
- publish passwords on Github!!!



Mission accomplished!

[...] die pragmatische, unkomplizierte und produktive Zusammenarbeit mit inovex positiv hervorzuheben, da [...] komplexe Problemstellungen [...] gemeinsam gelöst wurden [...].

Generell finde ich die Zusammenarbeit [...] schon ziemlich gut und v. a. auch pragmatisch. Auch dass sich alle [...] verantwortlich fühlen, dass die Dinge laufen/funktionieren.

Thank you to all [...] and giving us the chance to provide such a solution, from monitoring point of view it seems that we have the best MQTT connection ever.

Open Source now ...

GitHub

- github.com/inovex/mqtt-stresser
- github.com/inovex/mqtt_blackbox_exporter
- inovex.de/blog (HAProxy MQTT Health Check)
- ...

Arnold Bechtoldt

inovex

arnold.bechtoldt@inovex.de

sayat.me/arbe

---

github.com/bechtoldt

youtube.com/inovexGmbH

arbe.io

inovex.de

inovex.de/blog