Secure logging with `syslog-ng`

Forward integrity and confidentiality of system logs

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Security Devroom

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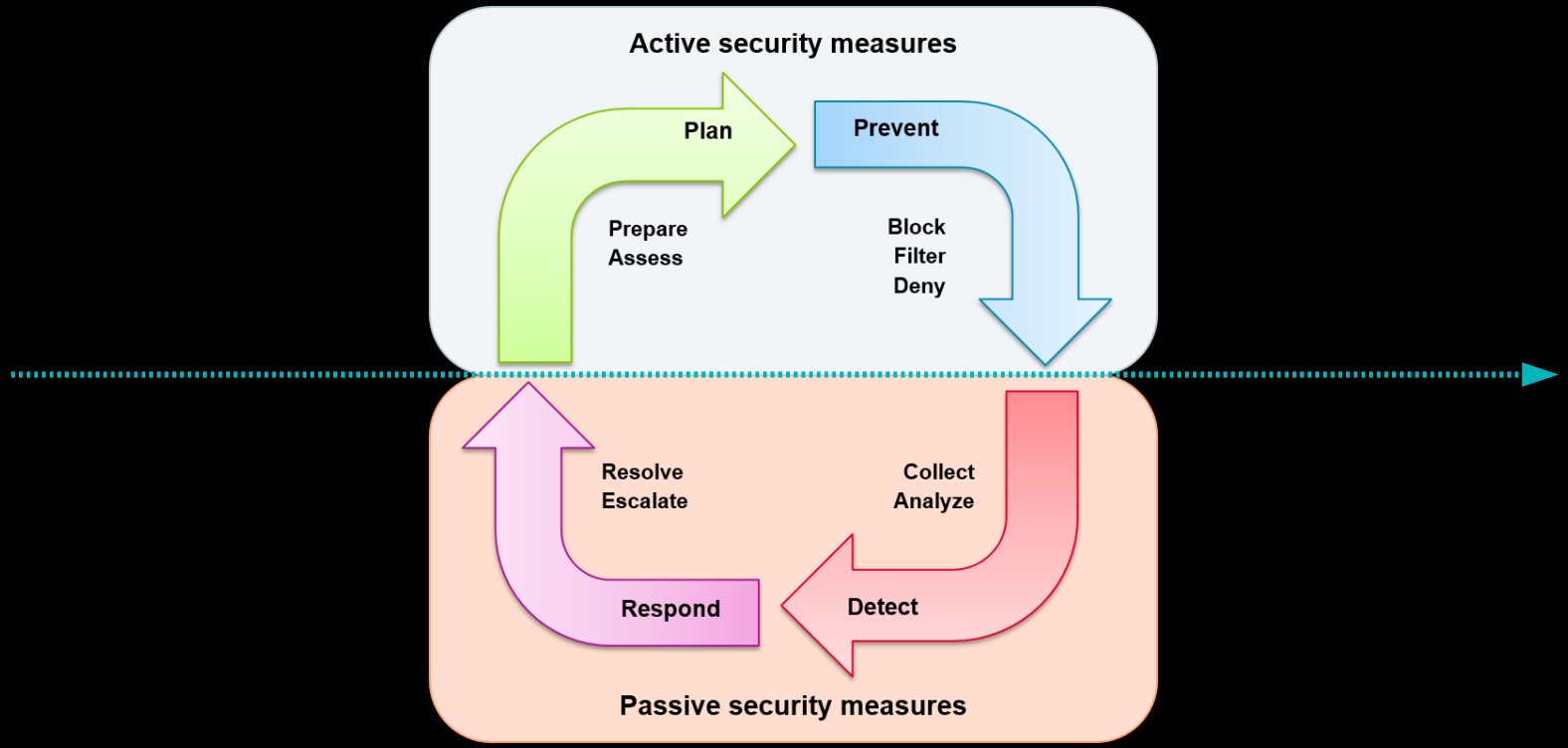
The security cycle

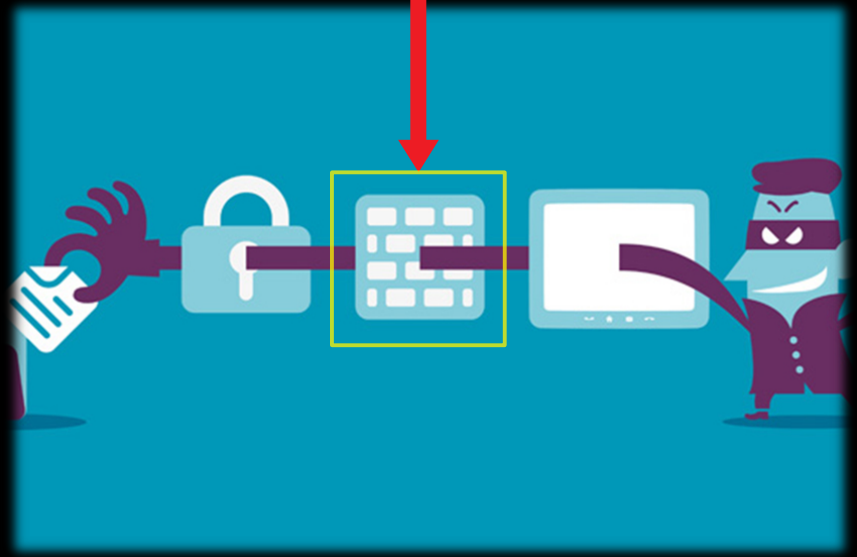


Security monitoring objective

Make the attacker visible

Instrument the system

Perform continuous log analysis

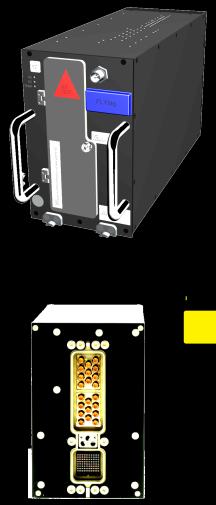


Secure logging threat model

- Successful compromise of log host
- Full control over log device
- Hide traces
  - Add log entries
  - Remove log entries
  - Edit log entries

System log integrity principle

System log host



System log file

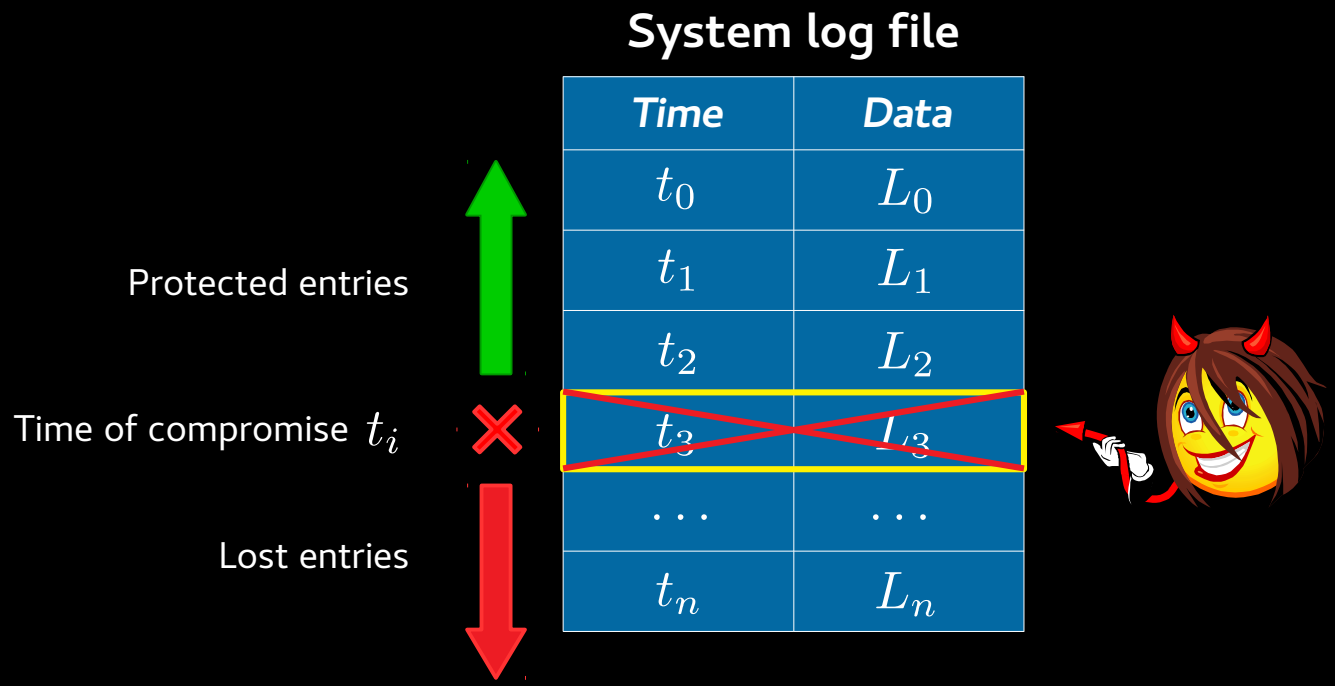
Time	*Data*
t_0	L_0
t_1	L_1
t_2	L_2
~~t_3~~	~~L_3~~
$\dots$	$\dots$
t_n	L_n

System log file

Time	*Data*
t_0	L_0
t_1	L_1
t_2	L_2
t_3	L'_3
$\dots$	$\dots$
t_n	L_n

A verifier will detect that L'_3 has been tampered with

Forward integrity principle



- Compromise at t_i means no integrity guarantee for $t_n \geq t_i$ with $n \geq i$
- Log entries are still integrity protected for $t_n < t_i$ with $n < i$

Forward integrity algorithm

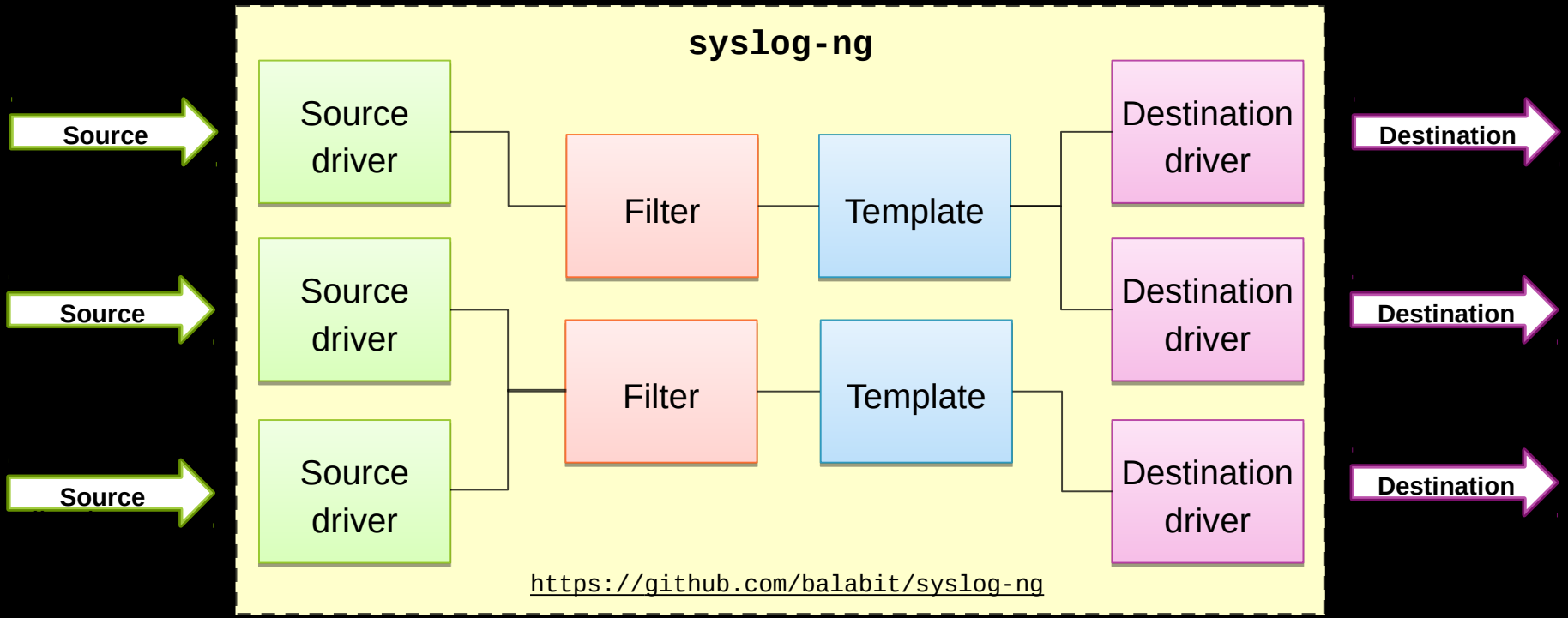
- Share key K_0 and compute $K_i := evolve(K_{i-1})$
- Compute individual integrity tags per log entry
- Compute aggregated integrity tag for the whole log file:
  $AggMAC_i := HMAC_{K_i}(AggMAC_{i-1}, HMAC_{K_i}(L_i))$
- Delete previous K_{i-1} and $AggMAC_{i-1}$
- At time of compromise t_i the attacker has access to K_i but not to K_{i-1}
- The integrity tag $AggMAC$ protects the whole log file

Integrity protected system log file

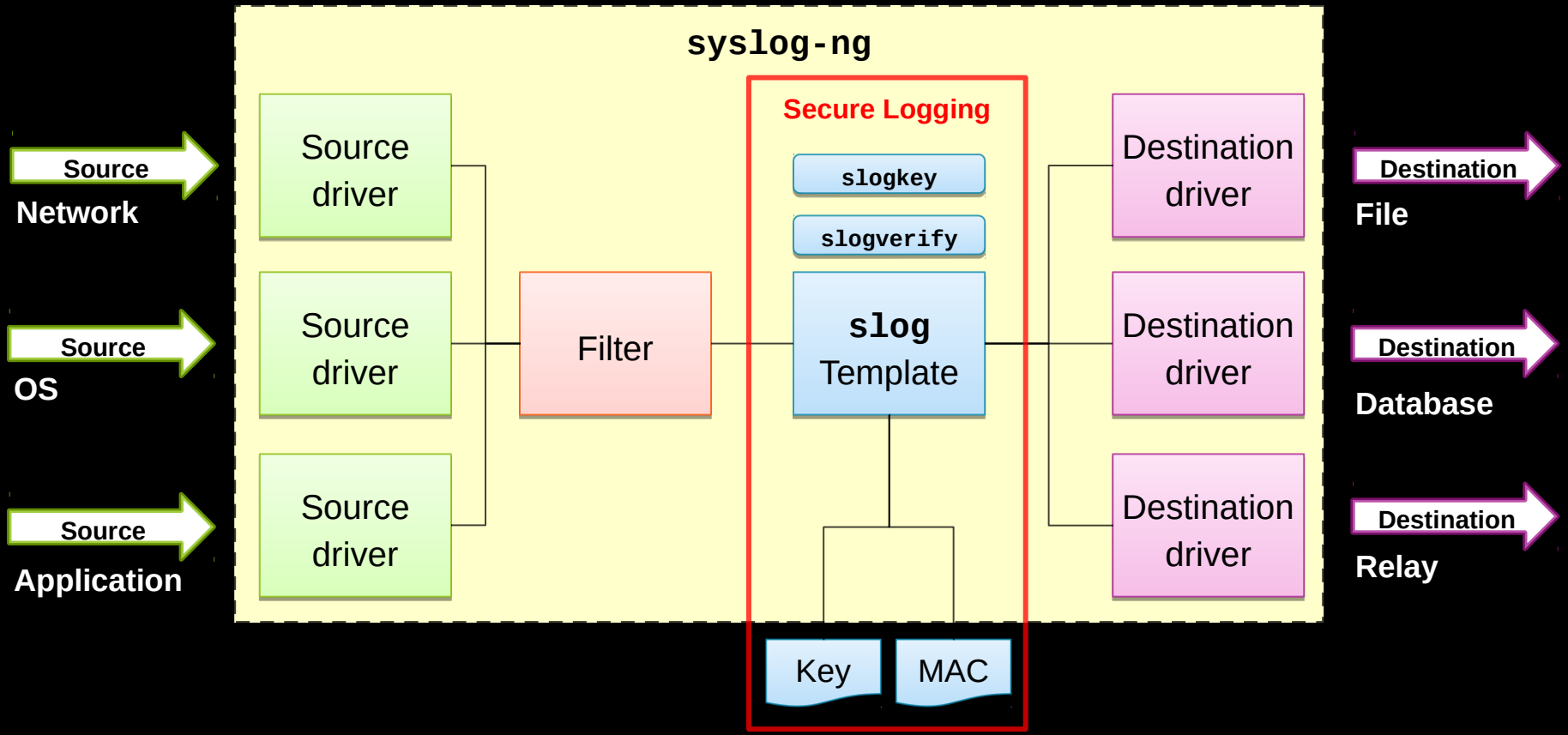
Time	*Data*	*Integrity tag*
t_0	L_0	$HMAC_{K_0}(L_0)$
t_1	L_1	$HMAC_{K_1}(L_1)$
t_2	L_2	$HMAC_{K_2}(L_2)$
t_3	L_3	$HMAC_{K_3}(L_3)$
$\dots$	$\dots$	$\dots$
t_n	L_n	$HMAC_{K_n}(L_n)$

$AggMAC_i := HMAC_{K_i}(AggMAC_{i-1}, HMAC_{K_i}(L_i))$

syslog-ng overview



Secure logging implementation



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Secure logging example

Original input at source

```
Dies ist eine Log Nachricht
Und dies auch
Hier kommt mal eine laengere Nachricht
```

Log messages

```
OFMBAAAAAAA=:LouI2vSfIJAuq17CjQdBeqh1YdgvwqFY9RyxTcQk2u0yc+Tqfm14OmOdU+LpC+alJMnPn3aT/A==
OVMBAAAAAAA=:UWEhUdN2d+iADsPtBFKVGBNB+nGRnm/D03m23/OMJ/jpdpXd6SQ5cb4=
OlMBAAAAAAA=:4r5Hw8kyXytlkF5z/nIWwdm8J4XOylKxBY572tlqOINg0vjAVDbOoo1mjsh4LHswEqW/xCJSbiu96QFFXqFyqaxc
```

Output of successful log verification

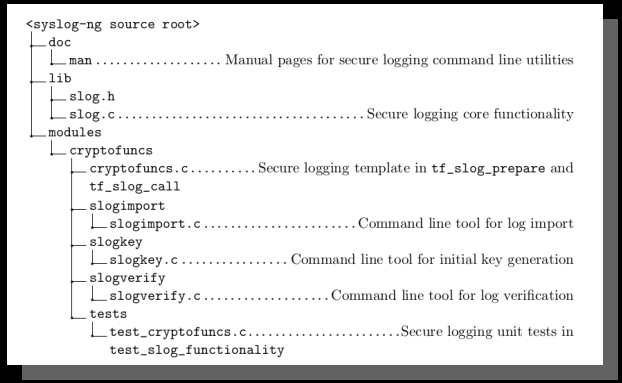
```
0000000000000000: Dies ist eine Log Nachricht
0000000000000001: Und dies auch
0000000000000002: Hier kommt mal eine laengere Nachricht
```

Example `syslog-ng.conf`

```
source s_network {
  network(
    transport ("udp")
    port(514)

    # NOTE : Secure logging requires this flag to be set
    flags(store-raw-message)
  );
);


# Secure logging template with key and MAC file locations
template t_slog {
  template("$(slog -k /var/slog/host.key -m /var/slog/mac.dat $RAWMSG)\n");
};

# Destination that uses the secure logging template
destination d_local {
  file("/var/log/messages.slog" template(t_slog));
};

log {
  source(s_network);
  destination(d_local);
};
```

Implementation and performance

- 6 new source files to `syslog-ng`
- No new dependencies were introduced
- All cryptographic operations rely on OpenSSL
- Excellent performance when using AES-NI
  - Intel Core i7 6th Gen @ 2.2GHz 9000 log entries/s
  - Typical log host with $2 \cdot 10^5$ entries in 24 hours
  - $7.3 \cdot 10^7$ log entries during 1 year of operation
  - Key derivation in < 1s



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Challenges

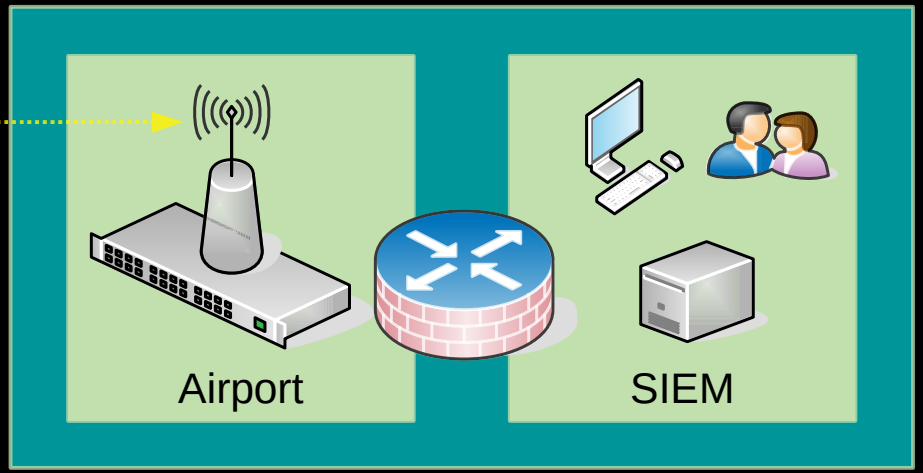
- Log system behavior under load
- `syslog-ng` internal API poorly documented
- No `syslog-ng` developers guide available
- Complex build system
- Packaging for target platform must be performed manually
- No log rotation

Example scenario

Airborne segment

- Key derivation
- Log record creation

Ground segment



- Log record relay
- Log record analysis

Summary

Achievements

- Tamper evident secure log system with easy integration into existing `syslog-ng` installations
- Performance on log host superior to `systemd` forward secure sealing
- Efficient offline log file verification
- Log verification can be integrated into existing SIEM solution
- Industrial readiness

Future work

- Crash recovery: Restore log entries that might have been lost during a system crash

Fragen?
Questions?
Perguntas?
Frågor?
שאלות?

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