



High quality VoIP platforms with Kamailio

Test driven development and debugging

Agenda

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- ▶ New in development
- ▶ Testing and debugging
- ▶ Integration testing
- ▶ Code quality
- ▶ Contribution & Community
- ▶ Contact

About me

- ▶ Henning Westerholt
- ▶ Involved in Kamailio project since 2007
- ▶ Core developer of the Kamailio project, member of management board
 - ▶ Core, database work and different other modules
 - ▶ Administration, code quality, quality assurance
- ▶ Senior IT Manager with a broad experience in product IT and internal IT
- ▶ Consulting for Kamailio and Voice over IP services

About Kamailio

- ▶ Kamailio®
 - ▶ Carrier grade SIP Server released under GPL, in development since 2001
 - ▶ Building large platforms for VoIP and real-time communications
 - ▶ Useful for scaling up gateways, PBXs or servers like Asterisk or FreeSWITCH
- ▶ Large, active and diverse development community
- ▶ Statistics
 - ▶ 345 authors with over 30.000 commits to git repository since 2001
 - ▶ Almost one million lines of code, appr. 270 man-years effort invested
 - ▶ Two maintenance versions released recently (5.3.2 and 5.2.6)
- ▶ Extensive core functionality and over 200 extension modules

New in development

- ▶ Current stable version released October 2019 with many new modules, features and extensions (prometheus support, rtp media engine, secfilter, kemix, lost etc..)
- ▶ Features currently new in the development version
 - ▶ New module pv_headers - flexible header management with pseudo-variables
 - ▶ New module MQTT - connect Kamailio to a MQTT broker
 - ▶ New module seccsipip - STIR/SHAKEN security support
 - ▶ Many extensions in existing modules and core (e.g. cft, registrar, structured json logging, core etc..)

Testing and debugging

- ▶ Kamailio execute its configuration language (or the embedded KEMI script) for each SIP message its processes
- ▶ Debugging of cfg can be done with the „debugger“ module
- ▶ The “cfgt” module helps to integrate it in a unit test development process
- ▶ Load module and enable in cfg
 - ▶ `modparam("debugger", "cfgtrace", 1)`
 - ▶ `modparam("debugger", "breakpoint", 1)`
 - ▶ `children=1`
- ▶ Observe cfg tracing in log file to see flow of the execution
- ▶ Step through the cfg execution like in other debugger

Tracing cfg file execution (1/2)

Options request

- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[DEFAULT_ROUTE] c=[/etc/kamailio/kamailio.cfg] l=510 a=16 n=if
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[DEFAULT_ROUTE] c=[/etc/kamailio/kamailio.cfg] l=505 a=25
n=is_method
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[DEFAULT_ROUTE] c=[/etc/kamailio/kamailio.cfg] l=510 a=5 n=route
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[REQINIT] c=[/etc/kamailio/kamailio.cfg] l=623 a=16 n=if
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[REQINIT] c=[/etc/kamailio/kamailio.cfg] l=616 a=16 n=if
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[REQINIT] c=[/etc/kamailio/kamailio.cfg] l=621 a=16 n=if
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[REQINIT] c=[/etc/kamailio/kamailio.cfg] l=616 a=24 n=pike_check_req

Tracing cfg file execution (2/2)

Options request

- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[REQINIT] c=[/etc/kamailio/kamailio.cfg] l=629 a=16 n=if
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[REQINIT] c=[/etc/kamailio/kamailio.cfg] l=634 a=16 n=if
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[REQINIT] c=[/etc/kamailio/kamailio.cfg] l=629 a=25
n=mf_process_maxfwd_header
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[REQINIT] c=[/etc/kamailio/kamailio.cfg] l=639 a=16 n=if
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[REQINIT] c=[/etc/kamailio/kamailio.cfg] l=634 a=25 n=is_method
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[REQINIT] c=[/etc/kamailio/kamailio.cfg] l=635 a=26 n=sl_send_reply
- ▶ Feb 1 09:26:30 proxy-2 kamailio[25588]: 2(25592) ERROR: {1 1 OPTIONS 1423580698@116.203.64.8}
*** cfgtrace:request_route=[REQINIT] c=[/etc/kamailio/kamailio.cfg] l=636 a=2 n=exit

Debugger module

- ▶ The debugger module provides more functions
 - ▶ Print also assignments in cfgtrace
 - ▶ Print filtered module debugging messages
 - ▶ Print current message status in log file
 - ▶ Set breakpoints conditionally in the cfg
 - ▶ etc..
- ▶ <https://kamailio.org/docs/modules/stable/modules/debugger.html>

Looking for UDP children

- ▶ root@proxy:~# kamcmd ps
- ▶ 19521 main process - attendant
- ▶ 19522 udp receiver child=0 sock=127.0.0.1:5060
- ▶ 19523 udp receiver child=0 sock=proxy.\$domain.net:5060
- ▶ 19524 slow timer
- ▶ 19525 timer
- ▶ 19526 secondary timer
- ▶ 19527 JSONRPCS FIFO
- ▶ 19528 JSONRPCS DATAGRAM
- ▶ 19529 ctl handler
- ▶ 19543 tcp receiver (generic) child=0
- ▶ 19545 tcp main process

Test request with sipsak - Kamailio stops at breakpoint

- ▶ request:
- ▶ OPTIONS sip:proxy.\$domain.net SIP/2.0
- ▶ Via: SIP/2.0/UDP XXX.XXX.64.8:59332;branch=z9hG4bK.0d4f8ba3;rport;alias
- ▶ [...]

- ▶ send to: UDP:XXX.XXX.180.151:5060
- ▶ ** timeout after 4000 ms**

Debugging with breakpoints (1/2)

- ▶ kamcmd> dbg.bp on 19523
- ▶ 200 ok
- ▶ kamcmd> dbg.bp next 19523
- ▶ exec [/etc/kamailio/kamailio.cfg:512] a=16 n=if
- ▶ kamcmd> dbg.bp next 19523
- ▶ exec [/etc/kamailio/kamailio.cfg:505] a=25 n=is_method
- ▶ kamcmd> dbg.bp next 19523
- ▶ exec [/etc/kamailio/kamailio.cfg:512] a=5 n=route
- ▶ kamcmd> dbg.bp next 19523
- ▶ exec [/etc/kamailio/kamailio.cfg:625] a=16 n=if
- ▶ kamcmd> dbg.bp next 19523
- ▶ exec [/etc/kamailio/kamailio.cfg:618] a=16 n=if
- ▶ kamcmd> dbg.bp next 19523

Debugging with breakpoints (2/2)

- ▶ `exec [/etc/kamailio/kamailio.cfg:623] a=16 n=if`
- ▶ `kamcmd> dbg.bp next 19523`
- ▶ `exec [/etc/kamailio/kamailio.cfg:618] a=24 n=pike_check_req`
- ▶ `kamcmd> dbg.bp next 19523`
- ▶ `exec [/etc/kamailio/kamailio.cfg:631] a=16 n=if`
- ▶ `kamcmd> dbg.bp next 19523`
- ▶ `exec [/etc/kamailio/kamailio.cfg:636] a=16 n=if`
- ▶ `kamcmd> dbg.bp next 19523`
- ▶ `exec [/etc/kamailio/kamailio.cfg:631] a=25 n=mf_process_maxfwd_header`
- ▶ `kamcmd> dbg.bp eval 19523 $fU`
- ▶ `$fU : t=str v=sipsak`
- ▶ `kamcmd> dbg.bp move 19523`
- ▶ `200 ok`

Test request blocked - received after releasing breakpoint

- ▶ message received
- ▶ received from: UDP: XXX.XXX.180.151:5060
- ▶ SIP/2.0 200 Keepalive
- ▶ [...]

- ▶ ** reply received 13330.225 ms after first send
- ▶ and 1766.365 ms after last send **
- ▶ SIP/2.0 200 Keepalive
- ▶ final received

Integration tests

- ▶ Testing a large infrastructure is a lot of work, especially if you do it manually
- ▶ The compilation of Kamailio core does not need many dependencies, some modules need them, though
- ▶ Installing these libraries in your development system is not enough, you need also setup test databases etc..
- ▶ Kamailio provides a unit test infrastructure to help to test individual modules and their interactions together
- ▶ It is available as dedicated project in github
- ▶ <https://github.com/kamailio/kamailio-tests>

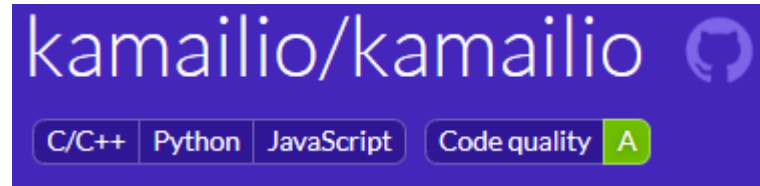
Integration tests

- ▶ Based on docker container infrastructure
- ▶ Available currently for Debian 9, Debian 10 and CentOS 7
- ▶ Quick start
 - ▶ clone kamilio and kamilio-test repository
 - ▶ Copy desired docker file in current (sub directory)
 - ▶ `/home/user/repositories/test/docker build -t kamilio-tests-deb9x .`
 - ▶ `/home/user/repositories/test# docker run kamilio-tests-deb9x`
- ▶ Explanation, how to add new tests:
<https://www.giacomovacca.com/2019/11/kamilio-tests-testing-framework-for.html>

Available unit tests, test output

- ▶ * test unit tasync0001: async routing - cfg variables tests - ok
- ▶ * test unit tauthx0001: user authentication - basic tests - ok
- ▶ * test unit tcfgxx0001: default config file - basic load tests - ok
- ▶ * test unit tcfgxx0002: default config file - basic sip signaling tests - ok
- ▶ * test unit tgeoip0001: geoip2 module - basic tests - ok
- ▶ * test unit tgroup0001: group module - group membership tests - ok
- ▶ * test unit tlcust0001: log_custom - basic tests - ok
- ▶ * test unit tmodxx0001: load all modules - detect undefined symbols - ok
- ▶ * test unit tmtree0001: mtree - basic tests - ok
- ▶ * test unit tphonu0001: phonenum module - basic tests - ok
- ▶ * test unit tsiput0001: siputils - basic tests - ok
- ▶ * test unit tsjlua0001: sipjson - tests with Lua scripts - ok
- ▶ * test unit tsjson0001: sipjson - basic tests - ok
- ▶ * test unit tuacxx0001: uac module - uac_req_send() tests - ok
- ▶ * test unit tulocx0001: user location - basic tests - ok

Code quality



- ▶ Ensuring a good code quality is especially important for a stable and secure VoIP server
- ▶ Kamailio is using different static code analyser to improve code quality
- ▶ Kamailio has about half of the average defects (per line of code) as comparable sized projects
- ▶ These tools are commercial, but provide their service for free to OSS projects
- ▶ Be aware that a fair amount of reported issues are false positives
- ▶ If you want to use them on your private code, you need to get a license or subscription
- ▶ We use mostly Coverity, LGTM was evaluated so far

Version: 5.4-dev

Jan 04, 2020

Last Analyzed

1,319,337

Lines of Code Analyzed

0.30

Defect Density

Defect changes since previous build dated Jan 03, 2020

0

Newly detected

0

Eliminated

Defects by status for current build

3,675

Total defects

397

Outstanding

33

Dismissed

3,245

Fixed

S kamilio-kamilio Help ▾

Issues: By Snapshot | Outstanding Issues i ⚙️ Filters: Issue Kind, Classification

CID	Type	Impact	Status	First Detected	Owner	Classification	Severity	Action	Component	Category	File
278937	Resource leak	High	New	01/03/20	Unassigned	Unclassified	Unspecified	Undecided	modules	Resource leaks	/sr
278936	Out-of-bounds read	High	New	01/03/20	Unassigned	Unclassified	Unspecified	Undecided	modules	Memory - illegal access	/sr
278935	Dereference before null	Medium	New	01/03/20	Unassigned	Unclassified	Unspecified	Undecided	modules	Null pointer dereference	/sr
278934	Copy into fixed size buffer	Low	New	01/03/20	Unassigned	Unclassified	Unspecified	Undecided	modules	Security best practices	/sr
278933	Dereference before null	Medium	New	01/03/20	Unassigned	Unclassified	Unspecified	Undecided	modules	Null pointer dereference	/sr
278932	String not null terminated	High	New	01/03/20	Unassigned	Unclassified	Unspecified	Undecided	modules	Memory - illegal access	/sr

1 of 397 issues selected Page 1 of 2

pvh_hash.c

```

72     PKG_MEM_ERROR;
73     return -1;
74 }
75     memset(e, 0, e_size);
76
77     if(pvh_str_new(&e->key, key->len + 1) < 0)
78         goto err;
79     pvh_str_copy(&e->key, key, key->len + 1);
80
81     str_hash_add(ht, e);
82     return 1;
83
84 err:
85     pvh_str_free(&e->key);

```

7. **noescape**: Resource e is not freed or pointed-to in memset.

8. **noescape**: Resource &e->key is not freed or pointed-to in pvh_str_new. [\[show details\]](#)

9. Condition pvh_str_new(&e->key, key->len + 1) < 0, taking true branch.

10. Jumping to label err.

11. **noescape**: Resource &e->key is not freed or pointed-to in pvh_str_free. [\[show details\]](#)

278937 Resource leak

The system resource will not be rec availability of the resource.

In pvh_str_hash_add_key: Leak of (CWE-404)

▼ Triage

Classification:

Severity:

Action:

Ext. Reference:

Owner:

Enter comments (See the Triage comments)

► Projects & Streams

► Detection History

► Triage History

▼ Occurrences

1: kamilio-kamilio

Events contributing to issue:

4 alloc fr

Missing header guard ▾

efficiency

maintainability

modularity

external/jsf

Source root/src/.../isaac/rand.h

1

```
/*
```

This header file should contain a header guard to prevent multiple inclusion (`#endif` matching `#ifndef STANDARD` occurs before the end of the file).



2

```
-----
```

3

```
rand.h: definitions for a random number generator
```

↓

4-56

Use of goto ▾

maintainability

readability

language-features

Source root/src/core/tcp_read.c

↑

1-1739

1740

```
 *           queued -- the receive buffer might still be non-empty)
```

1741

```
 */
```

1742

```
inline static int handle_io(struct fd_map* fm, short events, int idx)
```

Multiple forward and backward goto statements may make function `handle_io` hard to understand.



1743

```
{
```

1744

```
    int ret;
```

↓

1745-2028

How to get access to these tools

- ▶ <https://scan.coverity.com/projects/kamailio-kamailio?tab=overview>
- ▶ <https://lgtm.com/projects/g/kamailio/kamailio/?mode=list>
- ▶ Coverity recommended over LGTM
- ▶ For coverity access signup with Github or other authentication provider on their site
- ▶ Request access to the Kamailio repository through their workflow
- ▶ Developers will review and grant you access

Contribution & Community

- ▶ Contributions to this (and other parts) are welcome!
- ▶ Follow our contributing guide
 - ▶ <https://github.com/kamailio/kamailio/blob/master/.github/CONTRIBUTING.md>
- ▶ Use github pull requests for changes, issues for bugs
- ▶ If you need help in your approach or having questions, ask on sr-dev list first
- ▶ For non-trivial changes (e.g. new modules, core changes) ask for review of a (core) developer
- ▶ If you contributing regularly or contributing a completely new module, you will get commit access soon

- ▶ Related work: “Fuzzing Kamailio”, presented on Kamailio World 2019

Thank you for your attention

- ▶ Contact:
 - ▶ <https://kamilio.org/>
 - ▶ Henning Westerholt, hw@skalatan.de
 - ▶ Blog: <https://skalatan.de/>
 - ▶ Commercial service: <https://gilawa.com>
- ▶ Meet the world-wide community at the Kamilio World Conference
 - ▶ April 27 - 29.2020 in Berlin
 - ▶ <http://kamilio.world.com/>