Modular And Test Driven SIP Routing With Lua

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Who we are, what we do

- Düsseldorf based VoIP service provider (since 2004)
- Active in Germany and UK
- Full MVNO in the Telefónica network
- Private and Business customers
- VoIP and Mobile products
- Some 100k active customers
- Almost 100 million minutes each month

Of course, we use Kamailio

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All over our network.

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But we have a huge problem!

What problem?

at sipgate

- methods of software development have changed:
  - Agile, fast cycles, many releases
  - small modules
  - unit tests, continuous deployment
  - permanent refactoring of functions

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at sipgate

- methods of software development have changed:
  - Agile, fast cycles, many releases
  - small modules
  - unit tests, continuous deployment
  - permanent refactoring of functions
- telephony side:
  - "organically grown" routing logic (since 2004)
  - 40 developers, but only 4 people can read/write it
  - learnings from software development haven't made it to this part

What problem?

Nobody wants to touch it!

What problem?

1. Readability

What problem?

2. damm@mindel: /etc/kamailio (ssh)

```
else if( uri =~ "^sip:[1-9]{1}[0-9]{6}[pgy][0-9]+@(.*)" ) {
        # Mark Call as LI needed
        setsflag(0);

        route(34);
        route(13);
        route(12);
        route(10);
        route(blockNonVerifiedOutgoing);
        route(checkBlockedIn);
        route(23);
        route(24);
        route(handleNAT);

        route(checkDebugGroupOnFromUser);
        route(checkDebugOnIncomingCalls);

        if (!isflagset(15)) {
                append_hf("X-CONF: transfer-in\r\n");
        }
        route(careAboutXCID);
        $(avp(s:calltype)) = $(avp(s:calltype)) + ',group';

        $ru = $(avp(s:mastersipid-in));
        route(sendToTransferOrForward);
        $rU = $oU;

        xlog("L_NOTICE", "main_route: Some log line here. F=$fu T=$tu R=$ru\n");
}
                                                        1206,0-1      33%
```

sipgate

What problem?

1. Readability

What problem?

2. Config file size

What problem?

What problem?

2. Config file size

What problem?

3. Testability

What problem?

What problem?

It's a mess!

But how do we fix that?

But how do we fix that?

- app_*:
  - app_lua
  - app_python
  - app_jsdt
  - app_java, app_mono, app_perl
  - missing: app_ruby ;)

But how do we fix that?

- app_*:
  - app_lua
  - app_python
  - app_jsdt
  - app_java, app_mono, app_perl
  - missing: app_ruby ;)

- KEMI
  - lua
  - python
  - jsdt
  - sqlang

Why Lua?

1. Speed

Interpreter	Average	Min	Max
Native	302.28	6	3824
Lua	308.32	6	3596
Python	393.71	23	3266

All times in Microseconds.
Source: https://www.kamailio.org/wiki/devel/config-engines#interpreters_performances

Why Lua?

2. Easy to learn

- None of us had written Lua (production) code before.
- If you've written code before, you'll be able to start right away.
- Less fear of changing something within Kamailio.

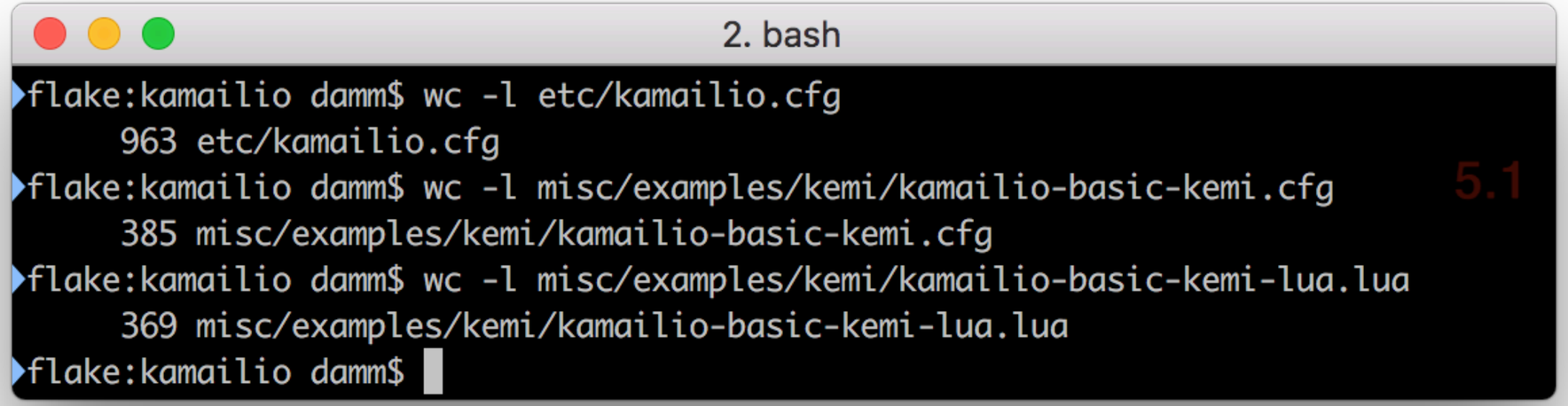
Why Lua?

3. You can work test-driven

- Impossible with native Kamailio language
- Know if you broke something before you deploy it!

Standard way: one big Lua file

Still many lines of code



Standard way: one big Lua file

Still have to know Kamailio syntax all the time

```
function ksr_request_route()

   -- per request initial checks
   ksr_route_reqinit();

   -- NAT detection
   ksr_route_natdetect();

   -- CANCEL processing
   if KSR.pv.get("$rm") == "CANCEL" then
      if KSR.tm.t_check_trans()>0 then
         ksr_route_relay();
      end
      return 1;
   end

   -- handle requests within SIP dialogs
   ksr_route_withindlg();

   -- -- only initial requests (no To tag)

   -- handle retransmissions
   if KSR.tmx.t_precheck_trans()>0 then
      KSR.tm.t_check_trans();
      return 1;
   end
   if KSR.tm.t_check_trans()==0 then return 1 end

   -- authentication
   ksr_route_auth();

   -- remove preloaded route headers
   KSR.hdr.remove("Route");
   if string.find("INVITE|SUBSCRIBE", KSR.pv.get("$rm")) then
      KSR.rr.record_route();
   end

   -- account only INVITEs
   if KSR.pv.get("$rm")=="INVITE" then
      KSR.setflag(FLT_ACC); -- do accounting
   end

   -- dispatch requests to foreign domains
   ksr_route_sipout();

   -- -- requests for my local domains

   -- handle registrations
   ksr_route_registrar();

   if KSR.pv.is_null("$rU") then
      -- request with no Username in RURI
      KSR.sl.sl_send_reply(484,"Address Incomplete");
      return 1;
   end

   -- user location service
   ksr_route_location();

   return 1;
end
```

Standard way: one big Lua file

Still not testable

```
function ksr_request_route()

   -- per request initial checks
   ksr_route_reqinit();

   -- NAT detection
   ksr_route_natdetect();

   -- CANCEL processing
   if KSR.pv.get("$rm") == "CANCEL" then
      if KSR.tm.t_check_trans()>0 then
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      end
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   -- handle requests within SIP dialogs
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   -- handle retransmissions
   if KSR.tmx.t_precheck_trans()>0 then
      KSR.tm.t_check_trans();
      return 1;
   end
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   -- authentication
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      return 1;
   end

   -- user location service
   ksr_route_location();

   return 1;
end
```

How about a library?

- Encapsulate Kamailio functions in easy-to-use native functions

```
if KSR.pv.get("$rm") == "INVITE" then
  [..]
end

if kamailio.is_invite() then
  [..]
end
```

- Re-use often used calls
- Testable
- Fix logic errors before deploying them into production

How about a library?

Reduce the main script to a minimum

```
kamailio = require("kamailio")

function ksr_request_route()
  kamailio.process_request()
end
```

So how do we get there?

- Install dependencies
  - Interpreter: lua, version 5.1 (apt-get install lua-5.1)
  - Testing framework: busted (apt-get install lua-busted)
- Create your library.
- Define your function.
- Write tests.
- Make the function work.

Create your library

- Can be just one file containing all your methods
  `/etc/kamailio/kamailio-functions.lua`
  `/usr/local/share/lua/5.1/kamailio-functions.lua`

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- Can be a directory containing multiple files

```
/usr/local/share/lua/5.1/kamailio/
├── actions.lua
├── init.lua
├── message.lua
├── message_state.lua
├── nathandling.lua
├── security.lua
└── traffic.lua
```

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  /usr/local/share/lua/5.1/kama

- Can be a directory containing multipl
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  ├── actions.lua
  ├── init.lua
  ├── message.lua
  ├── message_state.lua
  ├── nathandling.lua
  ├── security.lua
  └── traffic.lua

```
damm@stretch:~$ lua
Lua 5.1.5  Copyright (C) 1994-2012 Lua.org, PUC-Rio
> foo = require "foo"
stdin:1: module 'foo' not found:
    no field package.preload['foo']
    no file './foo.lua'
    no file '/usr/local/share/lua/5.1/foo.lua'
    no file '/usr/local/share/lua/5.1/foo/init.lua'
    no file '/usr/local/lib/lua/5.1/foo.lua'
    no file '/usr/local/lib/lua/5.1/foo/init.lua'
    no file '/usr/share/lua/5.1/foo.lua'
    no file '/usr/share/lua/5.1/foo/init.lua'
    no file './foo.so'
    no file '/usr/local/lib/lua/5.1/foo.so'
    no file '/usr/lib/x86_64-linux-gnu/lua/5.1/foo.so'
    no file '/usr/lib/lua/5.1/foo.so'
    no file '/usr/local/lib/lua/5.1/loadall.so'
stack traceback:
    [C]: in function 'require'
    stdin:1: in main chunk
    [C]: ?
>
```

Create your library

```
traffic = require "kamailio.traffic"
message = require "kamailio.message"
security = require "kamailio.security"
rex = require "rex_pcre"

local kamailio = {}

function kamailio:process_request()
  [..]
end

function kamailio:process_reply()
  [..]
end

return kamailio
```

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```

Write your function

kamailio.cfg

```
route["clir"] {
  if ($rU =~ "^\*31[0-9]+$") {
    strip(3);
    setflag(21);
  } else if ($rU =~ "^\*31[*#][0-9]+$") {
    strip(4);
    setflag(21);
  } else if ($rU =~ "^\*31\%23[0-9]+$") {
    strip(6);
    setflag(21);
  }
  if (isflagset(21) && method=="INVITE") {
    xlog("L_NOTICE", "User wants to suppress his number for this call. F=$fU T=$tU
D=$fn\n");
    append_hf("Privacy: id\r\n");
  }
}
```

Write your function

kamailio/headers.lua

```
rex = require "rex_pcre"
message = require "kamailio.message"

local headers = {}

function headers.get_request_user()
  return KSR.pv.get("$rU")
end

function headers.set_request_user(value)
  KSR.pv.sets("$rU", value)
end

function headers.set_privacy_header()
  KSR.hdr.append("Privacy: id")
end

function headers.suppress_cid_if_needed()
  request_user = headers.get_request_user()
  if rex.find(request_user, "^\\*31([#]|%23)?") then
    headers.set_request_user(rex.gsub(request_user, "^\\*31([#]|%23)?", ""))
    if message.is_invite() then headers.set_privacy_header() end
  end
end

return headers
```

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    if message.is_invite() then headers.set_privacy_header() end
  end
end

return headers
```

Test it

spec/headers_spec.lua

```
require 'busted.runner'()

local headers = require "../kamailio/headers"

describe("Check and enable CLIR ->", function()
  it("Caller dials *31021112345", function()
    -- Call the function
    headers.suppress_cid_if_needed()
    -- Now check if everything is as expected
    assert.spy(KSR.pv.sets).was.called_with( "$rU", "021112345" )
    assert.spy(KSR.hdr.append).was.called_with("Privacy: id")
 end)
end)
```

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    -- Call the function
    headers.suppress_cid_if_needed()
    -- Now check if everything is as expected
    assert.spy(KSR.pv.sets).was.
    assert.spy(KSR.hdr.append).w
 end)
end)
```

```
2. damm@stretch: ~/kamailioworld (ssh)
damm@stretch:~/kamailioworld$ busted tests/test_headers.lua
*
0 successes / 0 failures / 1 error / 0 pending : 0.00134 seconds

Error → tests/test_headers.lua @ 22
Check and enable CLIR Caller dials *31021112345
./src////kamailio/headers.lua:7: attempt to index global 'KSR' (a nil value)
damm@stretch:~/kamailioworld$
```

Fix your tests

```
require 'busted.runner'()

local function init_mock(options)
  -- mock global variable 'KSR'
  local ksr_mock = {
    pv = {
      get = function(key)
        if key == "$rU" then
          if options.rU ~= nil then return options.rU else return "01234567" end
        end
      end,
      sets = function(k, v) end,
    },
    hdr = {
      append = function(header) end,
    }
  }
  _G["KSR"] = mock(ksr_mock)

  local message_mock = {
    is_invite = function() return options.is_invite end
  }
  _G["message"] = mock(message_mock)
end

local headers = require "kamailio/headers"
[..]
```

Fix your tests

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require 'busted.runner'()

local function init mock(options)
  -- mock global variable 'KSR'
  local ksr_mock = {
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        end
      end,
      sets = function(k, v) end,
    },
    hdr = {
      append = function(header) end,
    }
  }
  _G["KSR"] = mock(ksr_mock)

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        end
      end,
      sets = function(k, v) end,
    },
    hdr = {
      append = function(header) end,
    }
  }
  _G["KSR"] = mock(ksr_mock)

  local message_mock = {
    is_invite = function() return options.is_invite end
  }
  _G["message"] = mock(message_mock)
end

local headers = require "kamailio/headers"
[..]
```

Fix your tests

```
require 'busted.runner'()

local function init_mock(options) [..] end

describe("Check and enable CLIR ->", function()
  it("Caller dials *31021112345", function()
    -- Initialize the mock
    init_mock{ rU = "*31021112345", is_invite = true }
    -- Call the function
    headers.suppress_cid_if_needed()
    -- Now check if everything is as expected
    assert.spy(KSR.pv.sets).was.called_with("$rU", "021112345")
    assert.spy(KSR.hdr.append).was.called_with("Privacy: id")
  end)
end)
```

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require 'busted.runner'()

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describe("Check and enable CLIR ->", function()
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    init_mock{ rU = "*31021112345", is_invite = true }
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    assert.spy(KSR.pv.sets).was.called_with("$rU", "021112345")
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    -- Call the function
    headers.suppress_cid_if_needed()
    -- Now check if everything is as expected
    assert.spy(KSR.pv.sets).was.called_with("$rU", "021112345")
    assert.spy(KSR.hdr.append).w
  end)
end)
```

```
2. damm@stretch: ~/kamailioworld (ssh)
damm@stretch:~/kamailioworld$ busted tests/test_headers.lua
●
1 success / 0 failures / 0 errors / 0 pending : 0.00123 seconds
damm@stretch:~/kamailioworld$
```

Add more tests

```
require 'busted.runner'()

local function init_mock(options) [..] end

describe("Check and enable CLIR ->", function()
  it("Caller dials *31021112345", function() .. end)
  it("Caller dials *31*021112345", function() .. end)
  it("Caller dials *31#021112345", function() .. end)
  it("Caller dials *31%23021112345", function() .. end)
  it("Caller dials +4921112345", function() .. end)
  it("Caller dials *31+4921112345, non-INVITE", function() .. end)
end)
```

Add more tests

```
require 'busted.runner'()

local function init_mock(options) [..] end

describe("Check and enable CLIR ->", function()
  it("Caller dials *31021112345", function() .. end)
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  it("Caller dials *31#021112345", function() .. end)
  it("Caller dials *31%23021112345", function() .. end)
  it("Caller dials +4921112345", function()
    init_mock{ rU = "+4921112345", is_invite = true }
    headers.suppress_cid_if_needed()
    assert.spy(KSR.pv.sets).was.called(0)
    assert.spy(KSR.hdr.append).was.called(0)
  end)
  it("Caller dials *31+4921112345, non-INVITE", function()
    init_mock{ rU = "*31+4921112345" }
    headers.suppress_cid_if_needed()
    assert.spy(KSR.pv.sets).was.called_with("$rU", "+4921112345")
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  end)
end)
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  it("Caller dials *31#021112345", function() .. end)
  it("Caller dials *31%23021112345", function() .. end)
  it("Caller dials +4921112345", function()
    init_mock{ rU = "+4921112345", is_invite = true }
    headers.suppress_cid_if_needed()
    assert.spy(KSR.pv.sets).was.called(0)
    assert.spy(KSR.hdr.append).was.called(0)
  end)
  it("Caller dials *31+4921112345, non-INVITE", function()
    init_mock{ rU = "*31+4921112345" }
    headers.suppress_cid_if_needed()
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  it("Caller dials *31021112345", function() .. end)
  it("Caller dials *31*021112345", function() .. end)
  it("Caller dials *31#021112345", function() .. end)
  it("Caller dials *31%23021112345", function() .. end)
  it("Caller dials +4921112345", function()
    init_mock{ rU = "+4921112345", is_invite = true }
    headers.suppress_cid_if_needed()
    assert.spy(KSR.pv.sets).was.called(0)
    assert.spy(KSR.hdr.append).was.called(0)
  end)
  it("Caller dials *31+4921112345, non-INVITE", function()
    init_mock{ rU = "*31+4921112345" }
    headers.suppress_cid_if_needed()
    assert.spy(KSR.pv.sets).was.called_with("$rU", "+4921112345")
    assert.spy(KSR.hdr.append).was.called(0)
  end)
end)
```

Add more tests

```
require 'busted.runner'()

local function init_mock(options) [..] end

describe("Check and enable CLIR ->", function()
  it("Caller dials *31021112345", function() .. end)
  it("Caller dials *31*021112345", function() .. end)
  it("Caller dials *31#021112345", function() .. end)
  it("Caller dials *31%230211123
  it("Caller dials +4921112345",
    init_mock{ rU = "+4921112345
    headers.suppress_cid_if_need
    assert.spy(KSR.pv.sets).was.
    assert.spy(KSR.hdr.append).w
  end)
  it("Caller dials *31+492111234
    init_mock{ rU = "*31+4921112
    headers.suppress_cid_if_need
    assert.spy(KSR.pv.sets).was.
    assert.spy(KSR.hdr.append).w
  end)
end)
```

```
2. damm@stretch: ~/kamailioworld (ssh)
damm@stretch:~/kamailioworld$ busted -l spec/headers_spec.lua
spec/headers_spec.lua:29: Check and enable CLIR -> Caller dials *31021112345
spec/headers_spec.lua:38: Check and enable CLIR -> Caller dials *31*021112345
spec/headers_spec.lua:47: Check and enable CLIR -> Caller dials *31#021112345
spec/headers_spec.lua:56: Check and enable CLIR -> Caller dials *31%23021112345
spec/headers_spec.lua:65: Check and enable CLIR -> Caller dials +4921112345
spec/headers_spec.lua:74: Check and enable CLIR -> Caller dials *31+4921112345, non-INVITE
damm@stretch:~/kamailioworld$ busted spec/headers_spec.lua
•■••••
5 successes / 1 failure / 0 errors / 0 pending : 0.008387 seconds

Failure → spec/headers_spec.lua @ 38
Check and enable CLIR -> Caller dials *31*021112345
spec/headers_spec.lua:44: Function was not called with the arguments
damm@stretch:~/kamailioworld$
```

Fix your code

kamailio/headers.lua

```
rex = require "rex_pcre"
message = require "kamailio.message"

local headers = {}

function headers.get_request_user()
  return KSR.pv.get("$rU")
end

function headers.set_request_user(value)
  KSR.pv.sets("$rU", value)
end

function headers.set_privacy_header()
  KSR.hdr.append("Privacy: id")
end

function headers.suppress_cid_if_needed()
  request_user = headers.get_request_user()
  if rex.find(request_user, "^\\*31([#]|%23)?") then
    headers.set_request_user(rex.gsub(request_user, "^\\*31([#]|%23)?", ""))
    if message.is_invite() then headers.set_privacy_header() end
  end
end

return headers
```

Fix your code

kamailio/headers.lua

```
rex = require "rex_pcre"
message = require "kamailio.message"

local headers = {}

function headers.get_request_user()
  return KSR.pv.get("$rU")
end

function headers.set_request_user(value)
  KSR.pv.sets("$rU", value)
end

function headers.set_privacy_header()
  KSR.hdr.append("Privacy: id")
end

function headers.suppress_cid_if_needed()
  request_user = headers.get_request_user()
  if rex.find(request_user, "^\*31([#]|%23)?") then
    headers.set_request_user(rex.gsub(request_user, "^\*31([#]|%23)?", ""))
    if message.is_invite() then headers.set_privacy_header() end
  end
end

return headers
```

Fix your code

kamailio/headers.lua

```
rex = require "rex_pcre"
message = require "kamailio.message"

local headers = {}

function headers.get_request_user()
  return KSR.pv.get("$rU")
end

function headers.set_request_user(value)
  KSR.pv.sets("$rU", value)
end

function headers.set_privacy_header()
  KSR.hdr.append("Privacy: id")
end

function headers.suppress_cid_if_needed()
  request_user = headers.get_request_user()
  if rex.find(request_user, "^\\*31([*#]|%23)?") then
    headers.set_request_user(rex.gsub(request_user, "^\\*31([*#]|%23)?", ""))
    if message.is_invite() then headers.set_privacy_header() end
  end
end

return headers
```

Fix your code

kamailio/headers.lua

```
rex = require "rex_pcre"
message = require "kamailio.message"

local headers = {}

function headers.get_request_user()
  return KSR.pv.get("$rU")
end

function headers.set_request_user(value)
  KSR.pv.sets("$rU", value)
end

function headers.set_privacy_header()
  KSR.hdr.append("Privacy: id")
end

function headers.suppress_cid_if_needed()
  request_user = headers.get_request_user()
  if rex.find(request_user, "^\*31([*#]|%23)?") then
    headers.set_request_user(rex.gsub(request_user, "^\*31([*#]|%23)?", ""))
    if message.is_invite() then headers.set_privacy_header() end
  end
end

return headers
```

Rerun your tests

```
require 'busted.runner'()

local function init_mock(options) [..] end

describe("Check and enable CLIR ->", function()
  it("Caller dials *31021112345", function() .. end)
  it("Caller dials *31*021112345", function() .. end)
  it("Caller dials *31#021112345", function() .. end)
  it("Caller dials *31%23021112345", function() .. end)
  it("Caller dials +4921112345", function() .. end)
  it("Caller dials *31+4921112345, non-INVITE", function() .. end)
end)
```

Rerun your tests

```lua
require 'busted.runner'()

local function init_mock(options) [..] end

describe("Check and enable CLIR ->", function()
  it("Caller dials *31021112345", function() .. end)
  it("Caller dials *31*021112345", function() .. end)
  it("Caller dials *31#021112345", function() .. end)
  it("Caller dials *31%23021112345", function() .. end)
  it("Caller dials +4921112345", function() .. end)
  it("Caller dials *31+492111234
end)
```

2. damm@stretch: ~/kamailioworld (ssh)

```
damm@stretch:~/kamailioworld$ busted -l spec/headers_spec.lua
spec/headers_spec.lua:29: Check and enable CLIR -> Caller dials *31021112345
spec/headers_spec.lua:38: Check and enable CLIR -> Caller dials *31*021112345
spec/headers_spec.lua:47: Check and enable CLIR -> Caller dials *31#021112345
spec/headers_spec.lua:56: Check and enable CLIR -> Caller dials *31%23021112345
spec/headers_spec.lua:65: Check and enable CLIR -> Caller dials +4921112345
spec/headers_spec.lua:74: Check and enable CLIR -> Caller dials *31+4921112345, non-INVITE
damm@stretch:~/kamailioworld$ busted spec/headers_spec.lua
●●●●●●
6 successes / 0 failures / 0 errors / 0 pending : 0.006695 seconds
damm@stretch:~/kamailioworld$
```

Too dry?

Try it yourself:
https://github.com/sipgate/lua-kamailio

That's it

Questions?

Want to chat? Stop by!