OPTIMIZATIONS FOR KEMI SIP ROUTING

Flexibility

KAMAILIO

Extensibility

Performance

Highlights 2017 - 2018

kemi framework

- introduced in Kamailio v5.0.0
  - use other scripting languages for writing SIP routing logic (route blocks)
  - exports a function one time and becomes available in embedded interpreters
  - ***allows reloading routing script without restart***

KEMI Framework
kamailio embedded (interpreter) interface

- Kamailio Configuration File - Two Main Roles
  - Kamailio application initialization
    - Done once at startup (passive scope)
    - Global parameters, loading modules and modules'parameters
    - Many values can be changed at runtime via RPC (no restart)
  - Rules for handling SIP traffic
    - Done during runtime to decide the routing of SIP messages
    - No reload without restart for native kamailio.cfg scripting language
    - KEMI routing scripts can be reloaded without restart (v5.0+)
- Scripting languages
  - Native scripting language
    - built from scratch, routing blocks with set of actions
  - Kamailio Embedded Interface (KEMI) languages
    - reuse existing (popular) scripting languages
    - replace the routing blocks from native scripting language
    - allow reloading of scripts without restart and more features
  - Inline execution of scripting languages
    - can be executed inside native scripting language
    - support for Lua, JavaScript, Python, Perl, .Net (C#, …), Squirrel, Java, Ruby

```
298  # Routing to foreign domains
299  route[SIPOUT] {
300          if (uri==myself) return;
301
302          append_hf("P-hint: outbound\r\n");
303          route(RELAY);
304          exit;
305  }
```

KEMI Framework
kamailio embedded (interpreter) interface

Native (Custom) Routing Language Since 2001

Kamailio Embedded Interpreter Interface - K E M I

- introduced in Kamailio v5.0.0
  - split parts: **passive** (global and module params) and **active** (routing blocks)
  - live reload of active part
- working for next scripting languages (embedded interpreters)
  - Lua
  - JavaScript
  - Python - Python3
  - Squirrel
  - Ruby
- not yet updated for next existing embedded interpreters
  - can be used with inline execution
  - Perl
  - Mono (.NET, C#, …)
  - Java (?)
- *native language still available*
  - *the old kamailio.cfg scripting language is still there, maintained and developed*

```
298  # Routing to foreign domains
299  route[SIPOUT] {
300          if (uri==myself) return;
301
302          append_hf("P-hint: outbound\r\n");
303          route(RELAY);
304          exit;
305  }
```

KEMI Framework
sip routing logic in lua

- app_lua
  - existing since 2010 offering inline execution of Lua scripts
  - https://www.kamailio.org/docs/modules/stable/modules/app_lua.html
- highlights
  - very small interpreter, fast
  - decent number of extensions (native lua libraries)
  - popular in gaming space, also in RTC (Asterisk, Freeswitch)

https://github.com/kamailio/kamailio/blob/master/misc/examples/kemi/kamailio-basic-kemi-lua.lua

```
324  -- Routing to foreign domains
325  function ksr_route_sipout()
326          if KSR.is_myself(KSR.pv.get("$ru")) then return 1; end
327
328          KSR.hdr.append_hf("P-Hint: outbound\r\n");
329          ksr_route_relay();
330          KSR.x.exit();
331  end
```

KEMI Framework
sip routing logic in python

- app_python - app_python3
  - introduced in 2010 for inline execution of Python scripts
  - https://www.kamailio.org/docs/modules/stable/modules/app_python.html
  - https://www.kamailio.org/docs/modules/devel/modules/app_python3.html
- highlights
  - popular scripting language with extensive number of extensions
  - object oriented, perceived as slower than other scripting languages
  - reloading of the routing script not implemented yet

https://github.com/kamailio/kamailio/blob/master/misc/examples/kemi/kamailio-basic-kemi-python.py

```
332     # Routing to foreign domains
333     def ksr_route_sipout(self, msg):
334         if KSR.is_myself(KSR.pv.get("$ru")) :
335             return 1;
336
337         KSR.hdr.append("P-Hint: outbound\r\n");
338         self.ksr_route_relay(msg);
339         return -255;
```

KEMI Framework
Kamailio API Exports

- index of exported functions
  - KSR static or dynamic object
  - function names and parameters map (pretty well) over the ones for native kamailio.cfg scripting

http://kamailio.org/docs/tutorials/devel/kamailio-kemi-framework


RUN
MONITOR
OPTIMIZE
DESIGN

KEMI Performances For v5.2

- **Done in November 2018, just before the release of Kamailo v5.0**
  - The focus was to compare the execution time of request_route {} from native kamailio.cfg with the equivalent KEMI callback functions for processing SIP REGISTER requests with user authetication
    - Done for Lua and Python
- **Testing Environment**
  - Server: Intel NUC 7i7DNHE; CPU: I7-8650U @ 1.90GHz; CPU Cores: 4; CPU Threads: 8; Memory: 16GB
  - Operating system: Debian Testing
  - SIP traffic tool: sipp
- **Testing metrics**
  - Each iteration was done with sending 20 000 requests
  - For each iteration was collected
    - cnt - number of SIP messages processed (counter)
    - sum - the sum of execution times for request_route or ksr_request_route() (microseconds)
    - min - the minimum execution time for request_route or ksr_request_route() (microseconds)
    - max - the maximum execution time for request_route or ksr_request_route() (microseconds)
    - avg - the average execution time for request_route or ksr_request_route() (microseconds)

https://www.kamailio.org/wiki/kemi/performance-tests/5.2.x

KEMI Performances For v5.2

Lua

cnt: 61197
sum: 3844555
min: 22
max: 1852
avg: 62.8226

Native

cnt: 62752
sum: 4184315
min: 17
max: 1948
avg: 66.6802

Python

cnt: 60785
sum: 4400362
min: 20
max: 2093
avg: 72.3922

https://www.kamailio.org/wiki/kemi/performance-tests/5.2.x

KEMI Performances For v5.2

- **Remarks**
  - the execution of **native scripting** routing blocks and **Lua scripting** functions **takes more or less same time**
  - sometimes is native scripting slightly faster, other times is Lua scripting slightly faster
  - the **average** (for both native and Lua scripts) is in the range of **60** to **80 microseconds** (1 / 1 000 000 of a second)
  - the minimum reflects more what it takes for the first REGISTER request without authorization header
    - which is **quickly challenged** with 401 response
  - the maximum reflect the processing of the REGISTER request **with valid authorization** header
    - which does **a query to database** to fetch the password
    - as well as **store/update the record** in the location hash table (writing to database on timer - usrloc db_mode 2).
  - there are variable number of **retransmissions**, being the reason for having cnt higher than 60000
    - a matter of sipp being able to match the response with the request at this high pace of stress testing
    - **4 000 registrations per second**, with a limit of **10 000 transactions at the same time**
    - stopping after **20 000 sent messages**
  - note that each registration is **challenged for authentication**, so it is resent with authorization header
  - the execution times for the **Python script** were in the **same range** as for native and Lua routing scripts

https://www.kamailio.org/wiki/kemi/performance-tests/5.2.x

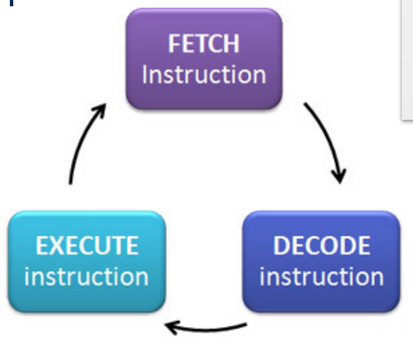
KAMAILIO

Optimize For Performance

Executing Module Functions

- No penalty for looking up what function to execute
  - Mapping the functions exports via a static array
  - Exported function to KEMI script has the index in the array of the functions to execute, which was set when loading the modules
- No performance difference for vast majority of them
  - Native execution process
    - Evaluate the parameters via fixup callbacks to int or string (replace variables with their value)
    - Execute the function exported to KEMI
  - KEMI execution process
    - Evaluation of parameters is done in KEMI script
    - Execute the function exported to KEMI

To Be Exported To Lua	Mapped When Loading Modules
sr_kemi_lua_exec_func_0	sr_kemi_lua_export_t(t_relay)
…	…
sr_kemi_lua_exec_func_100	sr_kemi_lua_export_t(sl_send_reply)
…	…
null	null
…	…

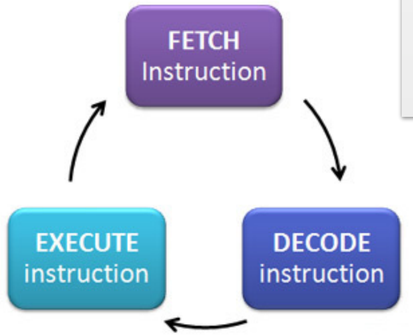


Executing Module Functions

- What is different
  - Parameters that are regular expressions are parsed every time
    - Done also for native scripting when they contain variables
    - Applies to matching or substitution functions
    - Solutions:
      - Use regexp matching functions from that scripting language
      - Use dialplan module that loads regexp matching and substitution rules from database and caches them in memory
      - Use string based replacement functions
      - *Future plan:* analyze if some sort of caching can help

Note: it is not a big difference in execution time, all the operations are done in memory, so this is not a big concern in terms of performanc

To Be Exported To Lua	Mapped When Loading Modules
sr_kemi_lua_exec_func_0	sr_kemi_lua_export_t(t_relay)
...	...
sr_kemi_lua_exec_func_100	sr_kemi_lua_export_t(sl_send_reply)
...	...
null	null
...	...



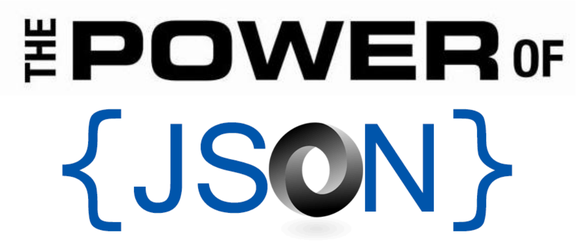
Variables

- Store value in a local KEMI script variable
  - Get the value of Kamailio's (pseudo-)variable and store it locally
    - The scripting languages highly optimize the lookup of their native variables
    - Local variables in KEMI scripts are found faster even than pseudo-variables in native kamailio.cfg routing blocks
      - Lua precompiles in memory to native object code
    - Solutions:
      - Use regexp matching functions from that scripting language
- Be careful with:
  - Pseudo-variables that can change their value after executing some function. For example: $ru changes after a successful lookup("location")
  - Do not define many (pseudo-)variable names (more to follow)

```
if KSR.corex.has_user_agent() then
  local K_ua = KSR.pv.gete("$ua");
  if string.find(K_ua, "friendly-scanner")
      or string.find(K_ua, "sipcli") then
    KSR.sl.sl_send_reply(200, "OK");
    KSR.x.exit();
  end
end
```

SIPJSON Module

- Creates a JSON document with attributes from SIP message
  - Some KEMI scripting languages converts easily JSON to object or hash table
    - e.g., JavaScript, Lua, Python
  - Attribute names try to follow the pseudo-variable names




```
OPTIONS sip:alice@127.0.0.1 SIP/2.0
Via: SIP/2.0/UDP 127.0.0.1:65502;branch=z9hG4bK.79e78613;rport;alias
From: sip:sipsak@172.17.0.2;tag=74806173
To: sip:alice@127.0.0.1
Call-ID: 482215126@172.17.0.2
CSeq: 1 OPTIONS
Contact: sip:sipsak@127.0.0.1:65502
Content-Length: 0
Max-Forwards: 70
User-Agent: sipsak 0.9.7pre
Accept: text/plain
```

sj_serialize("0B", "$var(json)");

```
{
  "mt":2,
  "rm":"OPTIONS",
  "pr":"udp",
  "si":"127.0.0.1",
  "sp":36747,
  "Ri":"127.0.0.1",
  "Rp":5060,
  "ru":"sip:alice@127.0.0.1",
  "rU":"alice",
  "rd":"127.0.0.1",
  "rp":0,
  "fU":"sipsak",
  "fd":"172.17.0.2",
  "ua":"sipsak 0.9.7pre",
  "ci":"482215126@172.17.0.2",
  "rb":""
  ...
}
```

SIPJSON Module

$ sudo luarocks install lua-cjson


```
local json = require("cjson")
KSR.sipjson.sj_serialize(“0B”, “$var(json)")
local KV = json.decode(KSR.pv.gete(“$var(json)"))
if KV[“rm”] == “INVITE" then
    …
end
```

Variables

- Have preference for dedicated functions with specific variables
  - htable module offers functions to:
    - set values and expire interval
    - remove items by name, with regexp or other matching rules
    - check if an item exists
  - pv module offers functions to:
    - do some XAVP operations (new - to be extended)
    - evaluate a string with pseudo-variables
  - corex module offers functions to:
    - test R-URI username and User-Agent header
    - set send socket
  - …

```
KSR.pv.sets("$sht(t=>x)", "kamailio");
KSR.pv.seti("$shtex(t=>x)", 300);

— is equivalent with:

KSR.htable.sht_setxs("t", "x", "kamailio", 300);
```

http://kamailio.org/docs/tutorials/devel/kamailio-kemi-framework

Variables

- Avoid declaring many (pseudo-)variables with dynamic name
  - When a set or get operation is done over a pseudo-variable, it is automatically declared in Kamailio code — a structure is created for it
  - If the same name is used, same associate structure is used
    - example: $sht(t=>a), $sht(t=>b) and $sht(t=>c) are three variables, each with its own structure
    - example: $var(x) = “a”; $sht(t=>$var(x)); $var(x) = “b”; $sht(t=>$var(x)); $var(x) = “c”; $sht(t=>$var(x)); — in this case only two variables are declared, respectively: $var(x) and $sht(t=>$var(x))

```
// do not use
KSR.pv.seti(“$sht(ipban=>” + KSR.pv.gete(“$si”) + ”)”, 1);

// use instead
KSR.pv.seti(“$sht(ipban=>$si)”, 1);
```

- core parameters to control the pv cache size

-***pv_cache_limit*** - the limit how many pv declarations in the cache after which an action is taken. Default value is 2048

- ***pv_cache_action*** - specify what action to be done when the size of pv cache is exceeded. If 0, print an warning log message when the limit is exceeded. If 1, warning log messages is printed and the cache systems tries to drop a $sht(...) declaration. Default is 0

Core Keywords

- Those special tokens in kamailio.cfg routing blocks
  - uri, from_uri, to_uri, method, myself, af, UDP, TCP, TLS, src_ip, …
    - The usual conditions can be done with functions
    - Variants to match methods and myself conditions

```
KSR.is_myself_ruri()
KSR.is_myself_furi()
KSR.is_myself_turi()
KSR.is_myself_srcip()

– better than

KSR.is_myself(KSR.pv.get("$ru"))
```

```
if KSR.pv.get("$rm") == "CANCEL" then

– is equivalent with:

if KSR.is_CANCEL() then
```


```
if string.find("INVITE,BYE,SUBSCRIBE,UPDATE", KSR.pv.get("$rm")) then

– is equivalent with:

if KSR.is_method_in("IBSU") then
```

Concerned About Performances?

https://en.wikipedia.org/wiki/List_of_applications_using_Lua

It Is Not Only About Performances

- Plenty of additional benefits
  - Documentation of the scripting language
  - More data types and operations, coherence in behaviour
  - Knowledge base and examples to learn the scripting language
  - Extensive testing of the scripting language
  - Development of the scripting language
  - Large set of extensions
  - Debugging tools
  - Specialized editors
  - Additional scalability mechanisms (threads, coroutines, …)
  - **Reloading without restart**

THANK YOU!

Daniel-Constantin Mierla
Co-Founder Kamailio Project
@miconda
asipto.com