SOURCEFORGE

virgo64

64 bit VIRGO linux kernel - derived from virgo-linux-github-code

Brought to you by: ka_shrinivaasan

[af4f20]: / virgo-docs / VirgoDesign.txt

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History

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1680 lines (1402 with data), 146.7 kB

```
1  /*****************************************************************************
2  #-----------------------------------------------------------------------------------------------
3  #NEURONRAIN VIRGO - Cloud, Machine Learning and Queue augmented Linux Kernel Fork-off
4  #This program is free software: you can redistribute it and/or modify
5  #it under the terms of the GNU General Public License as published by
6  #the Free Software Foundation, either version 3 of the License, or
7  #(at your option) any later version.
8  #This program is distributed in the hope that it will be useful,
9  #but WITHOUT ANY WARRANTY; without even the implied warranty of
10 #MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
11 #GNU General Public License for more details.
12 #You should have received a copy of the GNU General Public License
13 #along with this program.  If not, see <http://www.gnu.org/licenses/>.
14 #-----------------------------------------------------------------------------------------------
15 #K.Srinivasan
16 #NeuronRain Documentation and Licensing: http://neuronrain-documentation.readthedocs.io/en/latest/
17 #Personal website(research): https://sites.google.com/site/kuja27/
```

```
18  #-------------------------------------------------------------------------------------------
19  ******************************************************************************/
20
21
22  885. VIRGO is an operating system kernel forked off from Linux kernel mainline to add cloud functionalities (sys
23
24  886. Remote Device Invocation , which is an old terminlogy for Internet-Of-Things has already been experimented
25
26  887. Memory pooling:
27  ---------------
28  Memory pooling is proposed to be implemented by a new virgo_malloc() system call that transparently allocates a
29
30  888. CPU pooling or cloud ability in a system call:
31  ----------------------------------------------
32  Clone() system call is linux specific and internally it invokes sys_clone(). All fork(),vfork() and clone() syst
33
34  virgo_clone() is a wrapper over clone() that looks up a map of machines-to-loadfactor and get the host with leas
35
36  Kernel has support for kernel space sockets with kernel_accept(), kernel_bind(), kernel_connect(), kernel_sendms
37
38  Experimental Prototype
39  ----------------------
40  virgo_clone() system call and a kernel module virgocloudexec which implements Sun RPC interface have been implem
41
42  VIRGO - loadbalancer to get the host:ip of the least loaded node
43  ----------------------------------------------------------------
44  889. Loadbalancer option 1 - Centralized loadbalancer registry that tracks load:
45  ------------------------------------------------------------------------------
46
47  Virgo_clone() system call needs to lookup a registry or map of host-to-load and get the least loaded host:ip fro
48
49  Many application level userspace load monitoring tools are available but as virgo_clone() is in kernel space, it
50
51  (Design notes for LB option 1 handwritten by myself are at :http://sourceforge.net/p/virgo-linux/code-0/HEAD/tre
52
53  890. Loadbalancer option 2 - Linux Psuedorandom number generator based load balancer(experimental) instead of ce
54  ---------------------------------------------------------------------------------------------------------------
55
56  Each virgo_clone() client has a PRG which is queried (/dev/random or /dev/urandom) to get the id of the host to
57  Expected number of requests per node is derived as:
```

```
58
59  expected number of requests per node = summation(each_value_for_the_random_variable_for_number_of_requests * prol
60
61  =expected number of requests per node = (math.pow(N, k+2) - k*math.pow(N,2) + k*math.pow(N,1) - 1) / (math.pow(N
62
63  This loadbalancer is dependent on efficacy of the PRG and since each request is uniformly, identically, independe
64  would distribute requests evenly. This obviates the need for loadtracking and coherency of the load-to-host table
65
66  (Design notes for LB option 2 handwritten by myself at :http://sourceforge.net/p/virgo-linux/code-0/HEAD/tree/tru
67
68
69  (python script in virgo-python-src/)
70
71  ********************************************************************************************
72  891. Implemented VIRGO Linux components (as on 7 March 2016)
73  ********************************************************************************************
74  1. cpupooling virtualization - VIRGO_clone() system call and VIRGO cpupooling driver by which a remote procedure
75  2. memorypooling virtualization - VIRGO_malloc(), VIRGO_get(), VIRGO_set(), VIRGO_free() system calls and VIRGO r
76  3. filesystem virtualization - VIRGO_open(), VIRGO_read(), VIRGO_write(), VIRGO_close() system calls and VIRGO cl
77  4. config - VIRGO config driver for configuration symbols export.
78  5. queueing - VIRGO Queuing driver kernel service for queuing incoming requests, handle them with workqueue and s
79  6. cloudsync - kernel module for synchronization primitives (Bakery algorithm etc.,) with exported symbols that c
80  7. utils - utility driver that exports miscellaneous kernel functions that can be used across VIRGO Linux kernel
81  8. EventNet - eventnet kernel driver to vfs_read()/vfs_write() text files for EventNet vertex and edge messages
82  9. Kernel_Analytics - kernel module that reads machine-learnt config key-value pairs set in /etc/virgo_kernel_ana
83  10. Testcases and kern.log testlogs for the above
84  11. SATURN program analysis wrapper driver.
85
86  Thus VIRGO Linux at present implements a minimum cloud OS (with cloud-wide cpu, memory and file system managemen
87
88  ********************************************************************************************
89  VIRGO Features (list is quite dynamic and might be rewritten depending on feasibility - longterm with no deadline
90  ********************************************************************************************
91  892. (FEATURE - DONE-minimum separate config file support in client and kernel service )1. More Sophisticated VIR
92
93
94  893. (FEATURE - Special case implementation DONE) 2. Object Marshalling and Unmarshalling (Serialization) Feature
95
96  894. (FEATURE - DONE) Virgo_malloc(), virgo_set(), virgo_get() and virgo_free() syscalls that virtualize the phys
97  Initial Design Handwritten notes committed at: http://sourceforge.net/p/virgo-linux/code-0/210/tree/trunk/virgo-c
```

```
 98
 99  895. (FEATURE - DONE) Integrated testing of AsFer-VIRGO Linux Kernel request roundtrip - invocation of VIRGO lin
100
101  895.1 Schematic Diagram:
102  -----------------------
103         AsFer Python -----> Boost::Python C++ Extension ------> VIRGO memory system calls --------> VIRGO Linux K
104         /\                                                                                          V
105          |                                                                                          |
106          ---------------------------------------------<-----------------------------------------------
107
108         AsFer Python -----> CPython Extensions ------> VIRGO memory system calls --------> VIRGO Linux Kernel Me
109          /\                                                                                         V
110          |                                                                                          |
111          ---------------------------------------------<-----------------------------------------------
112
113  896. (FEATURE - DONE) Multithreading of VIRGO cloudexec kernel module (if not already done by kernel module subs
114
115  897. (FEATURE - DONE) Sophisticated queuing and persistence of CPU and Memory pooling requests in Kernel Side (b
116
117  898. (FEATURE - DONE-Minimum Functionality - this section is an extended draft on respective topics in NeuronRai
118
119  ----------------------------------------
120  Example scenario 898.1 without implementation:
121  ----------------------------------------
122  - Philips Hue IoT mobile app controlled bulb - http://www2.meethue.com/en-xx/
123  - kernel_analytics module learns key-value pairs from the AsFer code and exports it VIRGO kernel wide
124  - A driver function with in bulb embedded device driver can be invoked through VIRGO cpupooling (invoked from re
125  based on if-else clause of the kernel_analytics variable i.e remote_client invokes virgo_clone() with function a
126  ----------------------------------------
127  Example scenario 898.2 without implementation:
128  ----------------------------------------
129  - A swivel security camera driver is remotely invoked via virgo_clone() in the VIRGO cloud.
130  - The camera driver uses a machine learnt variable exported by kernel_analytics-and-AsFer to pan the camera by h
131  ------------------------------------------------------------------------------------------------
132  Example scenario 898.3 without implementation - probably one of the best applications of NeuronRain IoT OS:
133  ------------------------------------------------------------------------------------------------
134  - Autonomous Driverless Automobiles - a VIRGO driver for a vehicle which learns kernel analytics variables (driv
135         - AsFer analytics receives obstacle distance data 360+360 degrees (vertical and horizontal) around the v
136         - VIRGO Linux kernel on vehicle has two special drivers for Gear-Clutch-Break-Accelerator-Fuel(GCBAF) an
137         - AsFer analytics with high frequency computes threshold variables for applying break, clutch, gear, vel
```

```
138         - These analytics variables are continuously read by GCBAF and Steering drivers which autopilot the vehi
139         - Above applies to Fly-by-wire aeronautics too with appropriate changes in analytics variables computed.
140         - The crucial parameter is the response time in variable computation and table updates which requires a l
141
142 E.g. Autopilot in Tesla Cars processes Petabytes of information (Smooth-as-Silk algorithm) from sensors which ar
143
144 ---------------------------------------------
145 References for Machine Learning + Linux Kernel
146 ---------------------------------------------
147 898.4 KernTune - http://repository.uwc.ac.za/xmlui/bitstream/handle/10566/53/Yi_KernTune(2007).pdf?sequence=3
148 898.5 Self-learning, Predictive Systems - https://icri-ci.technion.ac.il/projects/past-projects/machine-learning
149 898.6 Linux Process Scheduling and Machine Learning - http://www.cs.ucr.edu/~kishore/papers/tencon.pdf
150 898.7 Network Latency and Machine Learning - https://users.soe.ucsc.edu/~slukin/rtt_paper.pdf
151 898.8 Machine Learning based Meta-Scheduler for Multicore processors - https://books.google.co.in/books?id=1GWcHr
152
153 899. A Symmetric Multi Processing subsystem Scheduler that virtualizes all nodes in cloud (probably this would ir
154
155 900. (FEATURE - ONGOING) Virgo is an effort to virtualize the cloud as a single machine - Here cloud is not limi
156
157 901. (FEATURE - DONE) Memory Pooling Subsystem Driver - Virgo_malloc(), Virgo_set(), Virgo_get() and Virgo_free(
158
159 902. (FEATURE - DONE) Virgo Cloud File System with virgo_cloud_open(), virgo_cloud_read() , virgo_cloud_write() a
160
161 903. (FEATURE - DONE) VIRGO Cloud File System commands through syscall paths - virgo_open(),virgo_close(),virgo_
162
163 904. (FEATURE - DONE) VIRGO memory pooling feature is also a distributed key-value store similar to other promine
164
165 905. VIRGO memory pooling can be improved with disk persistence for in-memory key-value store using virgo_malloc
166
167 906. (FEATURE-DONE) Socket Debugging, Program Analysis and Verification features for user code that can find bugs
168
169 907. (FEATURE - DONE-Minimum Functionality) Operating System Logfile analysis using Machine Learning code in Ast
170
171 908. (USERSPACE C++ usecase implemented in GRAFIT course material - https://gitlab.com/shrinivaasanka/Grafit) Imp
172
173 909. Scalability features for Multicore machines - references:
174 (http://halobates.de/lk09-scalability.pdf, http://pdos.csail.mit.edu/papers/linux:osdi10.pdf)
175
176 910. (USERSPACE C++ usecase implemented in GRAFIT course material - https://gitlab.com/shrinivaasanka/Grafit) Rea
177
```

```
911. (FEATURE - SATURN integration - minimum functionality DONE) Program Comprehension features as an add-on des

912. (FEATURE - DONE) Bakery Algorithm implementation - cloudsync kernel module

913. (FEATURE - minimal EventNet Logical Clock primitive implemented in AstroInfer and this section is an extend

914. (FEATURE - minimum functionality DONE - this section is an extended draft on respective packing/filling/til

Kernel Malloc syscall kmalloc() internally works as follows:
        - kmem_cache_t object has pointers to 3 lists
        - These 3 lists are full objects SLAB list, partial objects SLAB list and free objects SLAB list - all a
 and cache_cache is the global list of all caches created thus far.
        - Any kmalloc() allocation searches partial objects SLAB list and allocates a memory block with kmem_cac
        - Any kfree() returns an object to a free SLAB list
        - Full SLABs are removed from partial SLAB list and appended to full SLAB list
        - SLABs are virtual memory pages created with kmem_cache_create
        - Each SLAB in SLABs list has blocks of similar sized objects (e.g. multiples of two). Closest matching

KERNELSPACE:
VIRGO address translation table already implements a tree registry of vtables each of capacity 3000 that keep tra
USERSPACE: sbrk() and brk() are no longer used internally in malloc() library routines. Instead mmap() has repla

915. (FEATURE - ONGOING) Cleanup the code and remove unnecessary comments.

916. (FEATURE - DONE) Documentation - This design document is also a documentation for commit notes and other bu

917. (FEATURE - DONE) Telnet path to virgo_cloud_malloc,virgo_cloud_set and virgo_cloud_get has been tested and

918. Augment the Linux kernel workqueue implementation (http://lxr.free-electrons.com/source/kernel/workqueue.c)

919. (FEATURE - DONE) VIRGO queue driver with native userspace queue and kernel workqueue-handler framework that

920. (FEATURE - DONE) KERNELSPACE EXECUTION ACROSS CLOUD NODES which geographically distribute userspace and ker
a logical abstraction for a cloudwide virtualized kernel:

        Remote Cloud Node Client
        (cpupooling, eventnet, memorypooling, cloudfs, queueing - telnet and syscalls clients)
                |
                |
 (Userspace)    |
```

```
                |-----------------------------------Kernel Sockets-----------------------------------> Remote
                                                                                  (VIRGO cpupooling, memorypooling, cloudfs
                                                                                                                          \
                <-----------------------------------Kernel Sockets-------------------------------------------
                |
                |
                |
 (Userspace)    |
```

921. (FEATURE - DONE) VIRGO platform as on 5 May 2014 implements a minimum set of features and kernelsocket comma

922. (FEATURE - DONE) VIRGO Queue standalone kernel service has been implemented in addition to paths in schemati

```
VIRGO Queue client(e.g telnet) ------> VIRGO Queue kernel service ---> Linux Workqueue handler ------> KingCobra
```

923. (FEATURE - DONE) EventNet kernel module service:
VIRGO eventnet client (telnet) -------> VIRGO EventNet kernel service -----> EventNet graph text files

924. (FEATURE - DONE) Related to point 22 - Reuse EventNet cloudwide logical time infinite graph in AsFer in pla

925. (FEATURE - OPTIONAL) The kernel modules services listening on ports could return a JSON response when conne

926. (FEATURE-Minimum Functionality DONE) Pointer Swizzling and Unswizzling of VIRGO addressspace pointers to/fr

```
*********************************************************************************************
                                        CODE COMMIT RELATED NOTES
*********************************************************************************************
```

927. VIRGO code commits as on 16/05/2013
---
1. VIRGO cloudexec driver with a listener kernel thread service has been implemented and it listens on port 1000
through /etc/modules load-on-bootup facility

2. VIRGO cloudexec virgo_clone() system call has been implemented that would kernel_connect() to the VIRGO cloud

```
port 10000

3. VIRGO cloudexec driver has been split into virgo.h (VIRGO typedefs), virgocloudexecsvc.h(VIRGO cloudexec servi
module_init() of VIRGO cloudexec driver) and virgo_cloudexec.c (with module ops definitions)

4. VIRGO does not implement SUN RPC interface anymore and now has its own virgo ops.

5. Lot of Kbuild related commits with commented lines for future use have been done viz., to integrate VIRGO to k

928. VIRGO code commits as on 20/05/2013
---------------------------------
1. test_virgo_clone.c testcase for sys_virgo_clone() system call works and connections are established to VIRGO c

2. Makefile for test_virgo_clone.c and updated buildscript.sh for headers_install for custom-built linux.

929. VIRGO code commits as on 6/6/2013
---------------------------------
1. Message header related bug fixes

930. VIRGO code commits as on 25/6/2013
---------------------------------
1.telnet to kernel service was tested and found working
2.GFP_KERNEL changed to GFP_ATOMIC in VIRGO cloudexec kernel service

931. VIRGO code commits as on 1/7/2013
---------------------------------
1. Instead of printing iovec, printing buffer correctly prints the messages
2. wake_up_process() added and function received from virgo_clone() syscall is executed with kernel_thread and re
virgo_clone() syscall client.


932. commit as on 03/07/2013
-----------------------
PRG loadbalancer preliminary code implemented. More work to be done

933. commit as on 10/07/2013
-----------------------
Tested PRG loadbalancer read config code through telnet and virgo_clone. VFS code to read from virgo_cloud.conf c

934. commits as on 12/07/2013
```

```
298 ------------------------
299 PRG loadbalancer prototype has been completed and tested with test_virgo_clone and telnet and symbol export erro
300
301 935. commits as on 16/07/2013
302 ------------------------
303 read_virgo_config() and read_virgo_clone_config()(replica of read_virgo_config()) have been implemented and teste
304 all nodes). Thus minimal cloud functionality with config file  support is in place. Todo things include function
305
306 936. commits as on 17/07/2013
307 ------------------------
308 moved read_virgo_config() to VIRGOcloudexec's module_init so that config is read at boot time and exported symbo
309 Also commented read_virgo_clone_config() as it is redundant
310
311 937. commits as on 23/07/2013
312 ------------------------
313
314 Lack of reflection kind of facilities requires map of function_names to pointers_to_functions to be executed
315 on cloud has to be lookedup in the map to get pointer to function. This map is not scalable if number of functio
316 in millions and size of the map increases linearly. Also having it in memory is both CPU and memory intensive.
317 Moreover this map has to be synchronized in all nodes for coherency and consistency which is another intensive ta
318 Thus name to pointer function table is at present not implemented. Suitable way to call a function by name of the
319 is yet to be found out and references in this topic are scarce.
320
321 If parameterIsExecutable is set to 1 the data received from virgo_clone() is not a function but name of executab
322 This executable is then run on usermode using call_usermodehelper() which internally takes care of queueing the w
323 and executes the binary as child of keventd and reaps silently. Thus workqueue component of kernel is indirectly
324 This is sometimes more flexible alternative that executes a binary itself on cloud and
325 is preferable to clone()ing a function on cloud. Virgo_clone() syscall client or telnet needs to send the message
326
327 If parameterIsExecutable is set to 0 then data received from virgo_clone() is name of a function and is executed
328 using dlsym() lookup and pthread_create() in user space. This unifies both call_usermodehelper() and creating a u
329 with a fixed binary which is same for any function. The dlsym lookup requires mangled function names which need t
330 virgo_clone or telnet. This is far more efficient than a function pointer table.
331
332 call_usermodehelper() Kernel upcall to usermode to exec a fixed binary that would inturn execute the cloneFunctio
333 by spawning a pthread. cloneFunction is name of the function and not binary. This clone function will be dlsym()e
334 and a pthread will be created by the fixed binary. Name of the fixed binary is hardcoded herein as
335 "virgo_kernelupcall_plugin". This fixed binary takes clone function as argument. For testing libvirgo.so has been
336 virgo_cloud_test.c and separate build script to build the cloud function binaries has been added.
337
```

```
 - Ka.Shrinivaasan (alias) Shrinivas Kannan (alias) Srinivasan Kannan
   (https://sites.google.com/site/kuja27)

938. commits as on 24/07/2013
-----------------------

test_virgo_clone unit test case updated with mangled function name to be sent to remote cloud node. Tested with
end-to-end and all features are working. But sometimes kernel_connect hangs randomly (this was observed only toda
to blocking vs non-blocking problem. Origin unknown).

- Ka.Shrinivaasan (alias) Shrinivas Kannan (alias) Srinivasan Kannan
  (https://sites.google.com/site/kuja27)

939. commits as on 29/07/2013
-----------------------

Added kernel mode execution in the clone_func and created a sample kernel_thread for a cloud function. Some File
binaries and parameterIsExecutable has been moved to virgo.h

940. commits as on 30/07/2013
-----------------------
New usecase virgo_cloud_test_kernelspace.ko kernel module has been added. This exports a function virgo_cloud_te
accessed by virgo_cloudexec kernel service to spawn a kernel thread that is executed in kernel addresspace. This
on cloud adds a unique ability to VIRGO cloud platform to seamlessly integrate hardware devices on to cloud and
to them from a remote cloud node through virgo_clone().

Thus above feature adds power to VIRGO cloud to make it act as a single "logical device driver" though devices a

941. commits as on 01/08/2013 and 02/08/2013
---------------------------------------
Added Bash shell commandline with -c option for call_usermodehelper upcall clauses to pass in remote virgo_clone
arguments to it. Also tried output redirection but it works some times that too with a fatal kernel panic.

Ideal solutions are :
1. either to do a copy_from_user() for message buffer from user address space (or)
2. somehow rebuild the kernel with fd_install() pointing stdout to a VFS file* struct. In older kernels like 2.6
with in kmod.c (___call_usermodehelper()) which has been redesigned in kernel 3.x versions and fd_install has be
3. Create a Netlink socket listener in userspace and send message up from kernel Netlink socket.

All the above are quite intensive and time consuming to implement.Moreover doing FileIO in usermode helper is st
```

```
378
379 Since Objective of VIRGO is to virtualize the cloud as single execution "machine", doing an upcall (which would
380 redundant often and kernel mode execution is sufficient. Kernel mode execution with intermodule function invocat
381 the entire board in remote machine (since it can access PCI bus, RAM and all other device cards)
382
383 As a longterm design goal, VIRGO can be implemented as a separate protocol itself and sk_buff packet payload fro
384 can be parsed by kernel service and kernel_thread can be created for the message.
385
386 942. commits as on 05/08/2013:
387 -------------------------
388 Major commits done for kernel upcall usermode output logging with fd_install redirection to a VFS file. With thi
389
390 943. 11 August 2013:
391 ---------------
392 Open Source Design and Academic Research Notes uploaded to http://sourceforge.net/projects/acadpdrafts/files/Mis
393
394
395 944. commits as on 23 August 2013
396 ----------------------------
397 New Multithreading Feature added for VIRGO Kernel Service - action item 5 in ToDo list above (virgo_cloudexec dr
398
399 945. commits as on 1 September 2013
400 ------------------------------
401 GNU Copyright license and Product Owner Profile (for identity of license issuer) have been committed. Also Virgo
402
403 946. commits as on 14 September 2013
404 ------------------------------
405 Updated virgo malloc design handwritten nodes on kmalloc() and malloc() usage in kernelspace and userspace execu
406
407 ---------------------------------------
408 947. VIRGO virtual addressing
409 ---------------------------------------
410 VIRGO virtual address is defined with the following datatype:
411
412 struct virgo_address
413 {
414         int node_id;
415         void* addr;
416 };
417
```

```
418 VIRGO address translation table is defined with following datatype:
419
420 struct virgo_addr_transtable
421 {
422         int node_id;
423         void* addr;
424 };
425
426 -----------------------------------------------
427 948. VIRGO memory pooling prototypical implementation
428 -----------------------------------------------
429 VIRGO memory pooling implementation as per the design notes committed as above is to be implemented as a prototy
430 under drivers/virgo/memorypooling and $LINUX_SRC_ROOT/virgo_malloc. But the underlying code is more or less simi
431
432 virgo_malloc() and related syscalls and virgo mempool driver connect to and listen on port different from cpupoo
433
434 949. Commits as on 17 September 2013
435 ------------------------------
436 Initial untested prototype code - virgo_malloc and virgo mempool driver - for VIRGO Memory Pooling has been comm
437
438 950. Commits as on 19 September 2013
439 ------------------------------
440 3.7.8 Kernel full build done and compilation errors in VIRGO malloc and mempool driver code and more functions c
441
442 951. Commits as on 23 September 2013
443 ------------------------------
444 Updated virgo_malloc.c with two functions, int_to_str() and addr_to_str(), using kmalloc() with full kernel re-b
445 (Rather a re-re-build because some source file updates in previous build got deleted somehow mysteriously. This
446
447 952. Commits as on 24 September 2013
448 ------------------------------
449 Updated syscall*.tbl files, staging.sh, Makefiles for virgo_malloc(),virgo_set(),virgo_get() and virgo_free() me
450
451 953. Commits as on 25 September 2013
452 ------------------------------
453 All build related errors fixed after kernel rebuild some changes made to function names to reflect their
454 names specific to memory pooling. Updated /etc/modules also has been committed to repository.
455
456 954. Commits as on 26 September 2013
457 ------------------------------
```

```
458 Circular dependency error in standalone build of cpu pooling and memory pooling drivers fixed and
459 datatypes and declarations for CPU pooling and Memory Pooling drivers have been segregated into respective heade
460 virgo_mempool.h with corresponding service header files) to avoid any dependency error.
461
462 955. Commits as on 27 September 2013
463 ------------------------------
464 Major commits for Memory Pooling Driver listen port change and parsing VIRGO memory pooling commands have been d
465
466 956. Commits as on 30 September 2013
467 ------------------------------
468 New parser functions added for parameter parsing and initial testing on virgo_malloc() works with telnet client
469
470 957. Commits as on 1 October 2013
471 ----------------------------
472 Removed strcpy in virgo_malloc as ongoing bugfix for buffer truncation in syscall path.
473
474 958. Commits as on 7 October 2013
475 ----------------------------
476 Fixed the buffer truncation error from virgo_malloc syscall to mempool driver service which was caused by
477 sizeof() for a char*. BUF_SIZE is now used for size in both syscall client and mempool kernel service.
478
479 959. Commits as on 9 October 2013 and 10 October 2013
480 ------------------------------------------------
481 Mempool driver kernelspace virgo mempool ops have been rewritten due to lack of facilities to return a
482 value from kernel thread function. Since mempool service already spawns a kthread, this seems to be sufficient.
483 causes the kernel socket to block as it waits for more data to be sent.
484
485 960. Commits as on 11 October 2013
486 ----------------------------
487 sscanf format error for virgo_cloud_malloc() return pointer address and sock_release() null pointer exception ha
488 Added str_to_addr() utility function.
489
490 961. Commits as on 14 October 2013 and 15 October 2013
491 ------------------------------------------------
492 Updated todo list.
493
494 Rewritten virgo_cloud_malloc() syscall with:
495 - mutexed virgo_cloud_malloc() loop
496 - redefined virgo address translation table in virgo_mempool.h
497 - str_to_addr(): removed (void**) cast due to null sscanf though it should have worked
```

```
- str_to_addr(): removed (void *) cast due to null sscanf though it should have worked

962. Commits as on 18 October 2013
------------------------------
Continued debugging of null sscanf - added str_to_addr2() which uses simple_strtoll() kernel function
for scanning pointer as long long from string and casting it to void*. Also more %p qualifiers where
added in str_to_addr() for debugging.

Based on latest test_virgo_malloc run, simple_strtoll() correctly parses the address string into a long long base

963. Commits as on 21 October 2013
------------------------------
Kern.log for testing after vtranstable addr fix with simple_strtoll() added to repository and still the other %p

964. Commits as on 24 October 2013
------------------------------
Lot of bugfixes made to virgo_malloc.c for scanning address into VIRGO transtable and size computation. Testcase

Though the above sys_virgo_malloc() works, the return value is a kernel pointer if the virgo_malloc executes in t

965. Commits as on 25 October 2013
------------------------------
virgo_malloc.c has been rewritten by adding a userspace __user pointer to virgo_get() and virgo_set() syscalls wh

966. Commits as on 29 October 2013
------------------------------
Miscellaneous ongoing bugfixes for virgo_set() syscall error in copy_from_user().

967. Commits as on 2 November 2013
------------------------------
Due to an issue which corrupts the kernel memory, presently telnet path to VIRGO mempool driver has been
tested after commits on 31 October 2013 and 1 November 2013 and is working but again there is an issue in kstrtou
data to set.

968. Commits as on 6 November 2013
------------------------------
New parser function virgo_parse_integer() has been added to virgo_cloud_mempool_kernelspace driver module which i
lib/kstrtox.c and modified locally to add an if clause to discard quotes and unquotes. With this the telnet path
and virgo_set() are working. Today's kern.log has been added to repository in test_logs/.

969. Commits as on 7 November 2013
```

969. Commits as on 7 November 2013

In addition to virgo_malloc and virgo_set, virgo_get is also working through telnet path after today's commit fo

970. Commits as on 11 November 2013

More testing done on telnet path for virgo_malloc, virgo_set and virgo_get commands which work correctly. But th
kmem_cache_trace_alloc panics that follow each successful virgo command execution. kern.log for this has been ad

971. Commits as on 22 November 2013

More testing done on telnet path for virgo_malloc,virgo_set and virgo_set after commenting kernel socket shutdow
mempool sendto code. Kernel panics do not occur after commenting kernel socket shutdown.

972. Commits as on 2 December 2013

Lots of testing were done on telnet path and syscall path connection to VIRGO mempool driver and screenshots for

973. Commits as on 5 December 2013

More testing on system call path done for virgo_malloc(), virgo_set() and virgo_get() system calls with test_vir

VIRGO version 12.0 tagged.

974. Commits as on 12 March 2014

Initial VIRGO queueing driver implemented that flips between two internal queues: 1) a native queue implemented
structure virgo_workqueue_request.

975. Commits as on 20 March 2014

- VIRGO queue with additional boolean flags for its use as KingCobra queue
- KingCobra kernel space driver that is invoked by the VIRGO workqueue handler

976. Commits as on 30 March 2014

- VIRGO mempool driver has been augmented with use_as_kingcobra_service flags in CPU pooling and Memory pooling

977. Commits as on 6 April 2014

```
--------------------------
- VIRGO mempool driver recvfrom() function's if clause for KingCobra has been updated for REQUEST header formatt

978. Commits as on 7 April 2014
--------------------------
- generate_logical_timestamp() function has been implemented in VIRGO mempool driver that generates timestamps ba

979. Commits as on 25 April 2014
--------------------------
- client ip address in VIRGO mempool recvfrom KingCobra if clause is converted to host byte order from network by

980. Commits as on 5 May 2014
-------------------------
- Telnet path commands for VIRGO cloud file system - virgo_cloud_open(), virgo_cloud_read(), virgo_cloud_write()

981. Commits as on 7 May 2014
-------------------------
- Bugfixes to tokenization in kernel upcall plugin with strsep() for args passed on to the userspace

982. Commits as on 8 May 2014
-------------------------
- Bugfixes to virgo_cloud_fs.c for kernel upcall (parameterIsExecutable=0) and with these the kernel to userspace

983. Commits as on 6 June 2014
-------------------------
- VIRGO File System Calls Path implementation has been committed. Lots of Linux Full Build compilation errors fix

984. Commits as on 3 July 2014
--------------------------
- More testing and bugfixes for VIRGO File System syscalls have been done. virgo_write() causes kernel panic.

985. 7 July 2014 - virgo_write() kernel panic notes:
-----------------------------------------------
warning within http://lxr.free-electrons.com/source/arch/x86/kernel/smp.c#L121:

static void native_smp_send_reschedule(int cpu)
{
        if (unlikely(cpu_is_offline(cpu))) {
                WARN_ON(1);
                return;
        }
```

```
        }
        apic->send_IPI_mask(cpumask_of(cpu), RESCHEDULE_VECTOR);
}

This is probably a fixed kernel bug in <3.7.8 but recurring in 3.7.8:
- http://lkml.iu.edu/hypermail/linux/kernel/1205.3/00653.html
- http://www.kernelhub.org/?p=3&msg=74473&body_id=72338
- http://lists.openwall.net/linux-kernel/2012/09/07/22
- https://bugzilla.kernel.org/show_bug.cgi?id=54331
- https://bbs.archlinux.org/viewtopic.php?id=156276


986. Commits as on 29 July 2014
---------------------------
All VIRGO drivers(cloudfs, queuing, cpupooling and memorypooling) have been built on 3.15.5 kernel with some Mak

--------------------------------------------------------------------------------
Commits as on 17 August 2014
--------------------------------------------------------------------------------
987. (FEATURE - DONE) VIRGO Kernel Modules and System Calls major rewrite for 3.15.5 kernel - 17 August 2014
--------------------------------------------------------------------------------
1. VIRGO config files have been split into /etc/virgo_client.conf and /etc/virgo_cloud.conf to delink the cloud
config parameters reading and to do away with oft occurring symbol lookup errors and multiple definition errors
node_ip_addrs_in_cloud - these errors are frequent in 3.15.5 kernel than 3.7.8 kernel.

2. Each VIRGO module and system call now reads the config file independent of others - there is a read_virgo_con

3. New kernel module config has been added in drivers/virgo. This is for future prospective use as a config expo
be looked up by any other VIRGO module for config parameters.

4. include/linux/virgo_config.h has the declarations for all the config variables declared within each of the VI

5. Config variables in each driver and system call have been named with prefix and suffix to differentiate the m

6. In geographically distributed cloud virgo_client.conf has to be in client nodes and virgo_cloud.conf has to b

7. Above segregation largely simplifies the build process as each module and system call is independently built

8. VIRGO File system driver and system calls have been tested with above changes and the virgo_open(),virgo_read

-----------------------------------------------
```

```
---------------------------------------------
988. Committed as on 23 August 2014
---------------------------------------------
Commenting use_as_kingcobra_service if clauses temporarily as disabling also doesnot work and only commenting the
works for VIRGO syscall path. Quite weird as to how this relates to the problem. As this is a heisenbug further
difficult and sufficient testing has been done with logs committed to repository. Probably a runtime symbol looku
causes the freeze.
For forwarding messages to KingCobra and VIRGO queues, cpupooling driver is sufficient which also has the use_as_

---------------------------------------------
989. Committed as on 23 August 2014 and 24 August 2014
---------------------------------------------
As cpupooling driver has the same crash problem with kernel_accept() when KingCobra has benn enabled, KingCobra c

        VIRGO cpupooling or memorypooling ====> VIRGO Queue =====> KingCobra

                                        (or)
        VIRGO Queue kernel service ============================> KingCobra

-------------------------------------------------
990. Committed as on 26 August 2014
-------------------------------------------------
- all kmallocs have been made into GFP_ATOMIC instead of GFP_KERNEL
- moved some kingcobra related header code before kernel_recvmsg()
- some header file changes for set_fs()

This code has been tested with modified code for KingCobra and the standalone
kernel service that accepts requests from telnet directly at port 60000, pushes to virgo_queue
and is handled to invoke KingCobra servicerequest kernelspace function, works
(the kernel_recvmsg() crash was most probably due to Read-Only filesystem -errno printed is -30)

-----------------------------------------------------------------
VIRGO version 14.9.9 has been release tagged on 9 September 2014
-----------------------------------------------------------------

-----------------------------------------------------------
991. Committed as on 26 November 2014
-----------------------------------------------------------
New kernel module cloudsync has been added to repository under drivers/virgo that can be used for synchronizatio

-----------------------------------------------------------
```

```
------------------------------------------------------------
992. Committed as on 27 November 2014
------------------------------------------------------------
virgo_bakery.h bakery_lock() has been modified to take 2 parameters - thread_id and number of for loops (1 or 2)

------------------------------------------------------------
993. Committed as on 2 December 2014
------------------------------------------------------------
VIRGO bakery algorithm implementation has been rewritten with some bugfixes. Sometimes there are soft lockup err

------------------------------------------------------------------------
994. Committed as on 17 December 2014
------------------------------------------------------------------------
Initial code commits for VIRGO EventNet kernel module service:
------------------------------------------------------------
1.EventNet Kernel Service listens on port 20000

2.It receives eventnet log messages from VIRGO cloud nodes and writes the log messages
after parsing into two text files /var/log/eventnet/EventNetEdges.txt and
/var/log/eventnet/EventNetVertices.txt by VFS calls

3.These text files can then be processed by the EventNet implementations in AsFer (python pygraph and
C++ boost::graph based)

4.Two new directories virgo/utils and virgo/eventnet have been added.

5.virgo/eventnet has the new VIRGO EventNet kernel module service implementation that listens on
port 20000.

6.virgo/utils is the new generic utilities driver that has a virgo_eventnet_log()
exported function which connects to EventNet kernel service and sends the vertex and edge eventnet
log messages which are parsed by kernel service and written to the two text files above.

7.EventNet log messages have two formats:
   - Edge message - "eventnet_edgemsg#<id>#<from_event>#<to_event>"
   - Vertex message - "eventnet_vertextmsg#<id>-<partakers csv>-<partaker conversations csv>"

8.The utilities driver Module.symvers have to be copied to any driver which are
then merged with the symbol files of the corresponding driver. Target clean has to be commented while
building the unified Module.symvers because it erases symvers carried over earlier.
```

```
738 9.virgo/utils driver can be populated with all necessary utility exported functions that might be needed
739 in other VIRGO drivers.
740
741 10.Calls to virgo_eventnet_log() have to be #ifdef guarded as this is quite network intensive.
742
743 ----------------------------------------------------------------
744 995. Commits as on 18 December 2014
745 ----------------------------------------------------------------
746 Miscellaneous bugfixes,logs and screenshot
747
748 - virgo_cloudexec_eventnet.c - eventnet messages parser errors and eventnet_func bugs fixed
749 - virgo_cloud_eventnet_kernelspace.c - filp_open() args updated due to vfs_write() kernel panics. The vertexmessa
750 - VIRGO EventNet build script updated for copying Module.symvers from utils driver for merging with eventnet Modu
751 - Other build generated sources and kernel objects
752 - new testlogs directory with screenshot for edgemsg sent to EventNet kernel service and kern.log with previous l
753 - vertex message update
754
755 ----------------------------------------------------------------
756 996. Commits as on 2,3,4 January 2015
757 ----------------------------------------------------------------
758 - fixes for virgo eventnet vertex and edge message text file vfs_write() errors
759 - kern.logs and screenshots
760
761 ----------------------------------------------------------------
762 VIRGO version 15.1.8 release tagged on 8 January 2015
763 ----------------------------------------------------------------
764
765 ------------------------------------------------------------------------------------------------
766 772. (FEATURE) Commits as on 3 March 2015 - Initial commits for Kernel Analytics Module which reads the /etc/virg
767 ------------------------------------------------------------------------------------------
768 - Architecture of Key-Value Store in memorypooling (virgo_malloc,virgo_get,virgo_set,virgo_free) has been
769 uploaded as a diagram at http://sourceforge.net/p/virgo-linux/code-0/HEAD/tree/trunk/virgo-docs/VIRGOLinuxKernel_
770
771 - new kernel_analytics driver for AsFer <=> VIRGO+USBmd+KingCobra interface has been added.
772 - virgo_kernel_analytics.conf having csv(s) of key-value pairs of analytics variables is set by AsFer or any othe
773 - kernel_analytics Driver build script has been added
774
775 ------------------------------------------------------------------------
776 997. Commits as on 6 March 2015
777 ------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
- code has been added in VIRGO config module to import EXPORTed kernel_analytics config key-pair array
set by Apache Spark (mined from Uncomplicated Fire Wall logs) and manually and write to kern.log.

--------------------------------------------------------------------------
NeuronRain version 15.6.15 release tagged
--------------------------------------------------------------------------

--------------------------------------------------------------------------
998. Portability to linux kernel 4.0.5
--------------------------------------------------------------------------
The VIRGO kernel module drivers are based on kernel 3.15.5. With kernel 4.0.5 kernel which is the latest followi
compilation and LD errors occur - this is on cloudfs VIRGO File System driver :
- msghdr has to be user_msghdr for iov and iov_len as there is a segregation of msghdr
- modules_install throws an error in scripts/Makefile.modinst while overwriting already installed module

--------------------------------------------------------------------------
999. Commits as on 9 July 2015
--------------------------------------------------------------------------
VIRGO cpupooling driver has been ported to linux kernel 4.0.5 with msghdr changes as mentioned previously
with kern.log for VIRGO cpupooling driver invoked in parameterIsExecutable=2 (kernel module invocation)
added in testlogs

--------------------------------------------------------------------------
1000. Commits as on 10,11 July 2015
--------------------------------------------------------------------------
VIRGO Kernel Modules:
- memorypooling
- cloudfs
- utils
- config
- kernel_analytics
- cloudsync
- eventnet
- queuing
along with cpupooling have been ported to Linux Kernel 4.0.5 - Makefile and header files have been
updated wherever required.

--------------------------------------------------------------------------
1001. Commits as on 20,21,22 July 2015
--------------------------------------------------------------------------
```

```
817 ----------------------------------------------------------------------
818 Due to SourceForge Storage Disaster(http://sourceforge.net/blog/sourceforge-infrastructure-and-service-restorati
819 the github replica of VIRGO is urgently updated with some important changes for msg_iter,iovec
820 etc., in 4.0.5 kernel port specifically for KingCobra and VIRGO Queueing. These have to be committed to SourceFo
821 repository at http://sourceforge.net/users/ka_shrinivaasan once SourceForge repos are restored.
822 Time to move on to the manufacturing hub? GitHub ;-)
823 ------------------------------
824 1002. VIRGO Queueing Kernel Module Linux Kernel 4.0.5 port:
825 ------------------------------------------------------
826 - msg_iter is used instead of user_msghdr
827 - kvec changed to iovec
828 - Miscellaneous BUF_SIZE related changes
829 - kern.logs for these have been added to testlogs
830 - Module.symvers has been recreated with KingCobra Module.symvers from 4.0.5 KingCobra build
831 - clean target commented in build script as it wipes out Module.symvers
832 - updated .ko and .mod.c
833 ------------------------------
834 1003. KingCobra Module Linux Kernel 4.0.5 port
835 ------------------------------------------------------
836 - vfs_write() has a problem in 4.0.5
837 - the filp_open() args and flags which were working in 3.15.5 cause a
838 kernel panic implicitly and nothing was written to logs
839 - It took a very long time to figure out the reason to be vfs_write and filp_open
840 - O_CREAT, O_RDWR and O_LARGEFILE cause the panic and only O_APPEND is working, but
841 does not do vfs_write(). All other VIRGO Queue + KingCobra functionalities work viz.,
842 enqueueing, workqueue handler invocation, dequeueing, invoking kingcobra kernelspace service
843 request function from VIRGO queue handler, timestamp, timestamp and IP parser, reply_to_publisher etc.,
844 - As mentioned in Greg Kroah Hartman's "Driving me nuts", persistence in Kernel space is
845 a bad idea but still seems to be a necessary stuff - yet only vfs calls are used which have to be safe
846 - Thus KingCobra has to be in-memory only in 4.0.5 if vfs_write() doesn't work
847 - Intriguingly cloudfs filesystems primitives - virgo_cloud_open, virgo_cloud_read, virgo_cloud_write etc.,
848 work perfectly and append to a file.
849 - kern.logs for these have been added to testlogs
850 - Module.symvers has been recreated for 4.0.5
851 - updated .ko and .mod.c
852
853 ----------------------------------------------------------------
854 Due to SourceForge outage and for a future code diversification
855 NeuronRain codebases (AsFer, USBmd, VIRGO, KingCobra)
856 in http://sourceforge.net/u/userid-769929/profile/ have been
857 replicated in GitHub also - https://github.com/shrinivaasanka
```

```
replicated in GitHub also - https://github.com/shrinivaasanka
excluding some huge logs due to Large File Errors in GitHub.
-----------------------------------------------------------------


-----------------------------------------------------------------------
1004. Commits as on 30 July 2015
-----------------------------------------------------------------------
VIRGO system calls have been ported to Linux Kernel 4.0.5 with commented gcc option -Wimplicit-function-declarat
msghdr and iovec changes similar to drivers mentioned in previous commit notes above. But Kernel 4.1.3 has some M

The NeuronRain codebases in SourceForge and GitHub would henceforth be mostly and always out-of-sync and not gua


-----------------------------------------------------------------------
1005. Commits as on 2,3 August 2015
-----------------------------------------------------------------------
- new .config file added which is created from menuconfig
- drivers/Kconfig has been updated with 4.0.5 drivers/Kconfig for trace event linker errors
Linux Kernel 4.0.5 - KConfig is drivers/ has been updated to resolve RAS driver trace event linker error. RAS was
- link-vmlinux.sh has been replaced with 4.0.5 kernel version


-----------------------------------------------------------------------
1006. Commits as on 12 August 2015
-----------------------------------------------------------------------
VIRGO Linux Kernel 4.1.5 port - related code changes - some important notes:
-----------------------------------------------------------------------
- Linux Kernel 4.0.5 build suddenly had a serious root shell drop error in initramfs which was not resolved by:
        - adding rootdelay in grub
        - disabling uuid for block devices in grub config
        - mounting in read/write mode in recovery mode
        - no /dev/mapper related errors
        - repeated exits in root shell
        - delay before mount of root device in initrd scripts
- mysteriously there were some firmware microcode bundle executions in ieucodetool
- Above showed a serious grub corruption or /boot MBR bug or 4.0.5 VIRGO kernel build problem
- Linux 4.0.x kernels are EOL-ed
- Hence VIRGO is ported to 4.1.5 kernel released few days ago
- Only minimum files have been changed as in commit log for Makefiles and syscall table and headers and a build s
for 4.1.5:
    Changed paths:
    A buildscript_4.1.5.sh
    M linux-kernel-extensions/Makefile
    M linux-kernel-extensions/arch/x86/syscalls/Makefile
```

```
    M linux-kernel-extensions/arch/x86/syscalls/Makefile
    M linux-kernel-extensions/arch/x86/syscalls/syscall_32.tbl
    M linux-kernel-extensions/drivers/Makefile
    M linux-kernel-extensions/include/linux/syscalls.h

- Above minimum changes were enough to build an overlay-ed Linux Kernel with VIRGO codebase

------------------------------------------------------------------------
1007. Commits as on 14,15,16 August 2015
------------------------------------------------------------------------
Executed the minimum end-end telnet path primitives in Linux kernel 4.1.5 VIRGO code:
- cpu virtualization
- memory virtualization
- filesystem virtualization (updated filp_open flags)
and committed logs and screenshots for the above.

------------------------------------------------------------------------
1008. Commits as on 17 August 2015
------------------------------------------------------------------------
VIRGO queue driver:
- Rebuilt Module.symvers
- kern.log for telnet request to VIRGO Queue + KingCobra queueing system in kernelspace

------------------------------------------------------------------------
1009. Commits as on 25,26 September 2015
------------------------------------------------------------------------
VIRGO Linux Kernel 4.1.5 - memory system calls:
-----------------------------------------------
- updated testcases and added logs for syscalls invoked separately(malloc,set,get,free)
- The often observed unpredictable heisen kernel panics occur with 4.1.5 kernel too. The logs are 2.3G and
only grepped output is committed to repository.
- virgo_malloc.c has been updated with kstrdup() to copy the buf to iov.iov_base which was earlier
crashing in copy_from_iter() within tcp code. This problem did not happen in 3.15.5 kernel.
- But virgo_clone syscall code works without any changes to iov_base as above which does a strcpy()
 which is an internal memcpy() though. So what causes this crash in memory system calls alone
is a mystery.
- new insmod script has been added to load the VIRGO memory modules as necessary instead of at boot time.
- test_virgo_malloc.c and its Makefile has been updated.

VIRGO Linux Kernel 4.1.5 - filesystem calls- testcases and logs:
----------------------------------------------------------------
```

```
937 ----------------------------------------------------------------
938   - added insmod script for VIRGO filesystem drivers
939   - test_virgo_filesystem.c has been updated for syscall numbers in 4.1.5 VIRGO kernel
940   - virgo_fs.c syscalls code has been updated for iov.iov_base kstrdup() - without this there are kernel panics :
941 testlogs have been added, but there are heisen kernel panics. The virgo syscalls are executed but not written to
942 Thus execution logs are missing for VIRGO filesystem syscalls.
943
944 ----------------------------------------------------------------------
945 1010. Commits as on 28,29 September 2015
946 ----------------------------------------------------------------------
947
948 VIRGO Linux Kernel 4.1.5 filesystem syscalls:
949 ----------------------------------------
950 - Rewrote iov_base code with a separate iovbuf set to iov_base and strcpy()-ing the syscall command to iov_base :
951 memory syscalls
952 - Pleasantly the same iovbuf code that crashes in memory syscalls works for VIRGO FS without crash.Thus both virg
953 syscalls work without issues in 4.1.5 and virgo_malloc() works erratically in 4.1.5 which remains as issue.
954 - kern.log for VIRGO FS syscalls and virgofstest text file written by virgo_write() have been added to repository
955
956
957 VIRGO Linux 4.1.5 kernel memory syscalls:
958 ----------------------------------
959 - rewrote the iov_base buffer code for all VIRGO memory syscalls by allocating separate iovbuf and copying the me
960 - did extensive repetitive tests that were frequented by numerous kernel panics and crashes
961 - The stability of syscalls code with 3.15.5 kernel appears to be completely absent in 4.1.5
962 - The telnet path works relatively better though
963 - Difference between virgo_clone and virgo_malloc syscalls despite having same kernel sockets code looks like a r
964 - kernel OOPS traces are quite erratic.
965 - Makefile path in testcase has been updated
966
967 ----------------------------------------------------------------------
968 1011. Commits as on 4 October 2015
969 ----------------------------------------------------------------------
970 VIRGO Linux Kernel 4.1.5 - Memory System Calls:
971 ----------------------------------------------
972 - replaced copy_to_user() with a memcpy()
973 - updated the testcase with an example VUID hardcoded.
974 - str_to_addr2() is done on iov_base instead of buf which was causing NULL parsing
975 - kern.log with above resolutions and multiple VIRGO memory syscalls tests - malloc,get,set
976 - With above VIRGO malloc and set syscalls work relatively causing less number of random kernel panics
```

```
977  - return values of memory calls set to 0
978  - in virgo_get() syscall, memcpy() of iov_base is done to data_out userspace pointer
979  - kern.log with working logs for syscalls - virgo_malloc(), virgo_set(), virgo_get() but still there are random l
980  - Abridged kern.log for VIRGO Memory System Calls with 4.1.5 Kernel - shows example logs for virgo_malloc(), virg
981
982  ----------------------------------------------------------------
983  1012. Commits as on 14 October 2015
984  ----------------------------------------------------------------
985  VIRGO Queue Workqueue handler usermode clause has been updated with 4.1.5 kernel paths and kingcobra in user mode
986
987  ----------------------------------------------------------------
988  1013. Commits as on 15 October 2015
989  ----------------------------------------------------------------
990  - Updated VIRGO Queue kernel binaries and build generated sources
991  - virgo_queue.h has been modified for call_usermodehelper() - set_ds() and fd_install() have been uncommented fo
992
993  ----------------------------------------------------------------
994  1014. Commits as on 3 November 2015
995  ----------------------------------------------------------------
996  - kern.log for VIRGO kernel_analytics+config drivers which export the analytics variables from /etc/virgo_kernel_
997
998  ----------------------------------------------------------------
999  1015. Commits as on 10 January 2016
1000 ----------------------------------------------------------------
1001 NeuronRain VIRGO enterprise version 2016.1.10 released.
1002
1003 ------------------------------------------------------------------------------
1004 NeuronRain - AsFer commits for VIRGO - C++ and C Python extensions
1005 - Commits as on 29 January 2016
1006 ------------------------------------------------------------------------------
1007 ------------------------------------------------------------------------------------------------------------
1008 1016. (FEATURE - DONE)  Python-C++-VIRGOKernel and Python-C-VIRGOKernel boost::python and cpython implementations
1009 ------------------------------------------------------------------------------------------------------------
1010 - It is a known idiom that Linux Kernel and C++ are not compatible.
1011 - In this commit an important feature to invoke VIRGO Linux Kernel from userspace python libraries via two alter
1012 - In one alternative, C++ boost::python extensions have been added to encapsulate access to VIRGO memory system c
1013 - In the other alternative, C Python extensions have been added that replicate boost::python extensions above in
1014 works exceedingly well compared to boost::python.
1015 - This functionality is required when there is a need to set kernel analytics configuration variables learnt by A
1016 dynamically without re-reading /etc/virgo_kernel_analytics.conf.
```

```
1017  - This completes a major integration step of NeuronRain suite - request travel roundtrip to-and-fro top level ma
1018  code and rock-bottom C linux kernel - bull tamed ;-).
1019  - This kind of python access to device drivers is available for Graphics Drivers already on linux (GPIO - for ac
1020  - logs for both C++ and C paths have been added in cpp_boost_python_extensions/ and cpython_extensions.
1021  - top level python scripts to access VIRGO kernel system calls have been added in both directories:
1022          CPython - python cpython_extensions/asferpythonextensions.py
1023          C++ Boost::Python - python cpp_boost_python_extensions/asferpythonextensions.py
1024  - .so, .o files with build commandlines(asferpythonextensions.build.out) for "python setup.py build" have been a
1025  in build lib and temp directories.
1026  - main implementations for C++ and C are in cpp_boost_python_extensions/asferpythonextensions.cpp and cpython_ex
1027
1028  ------------------------------------------------------------------------------------------
1029  Commits as on 12 February 2016
1030  ------------------------------------------------------------------------------------------
1031  1017. Commits for Telnet/System Call Interface to VIRGO CPUPooling -> VIRGO Queue -> KingCobra
1032  ------------------------------------------------------------------------------------------
1033  *) This was commented earlier for the past few years due to a serious kernel panic in previous kernel versions -
1034  *) In 4.1.5 a deadlock between VIRGO CPUPooling and VIRGO queue driver init was causing following error in "use_a
1035          - "gave up waiting for virgo_queue init, unknown symbol push_request()"
1036  *) To address this a new boolean flag to selectively enable and disable VIRGO Queue kernel service mode "virgo_qu
1037  *) With this flag VIRGO Queue is both a kernel service driver and a standalone exporter of function symbols - pus
1038  *) Incoming request data from telnet/virgo_clone() system call into cpupooling kernel service reactor pattern (vi
1039  *) This resolves a long standing deadlock above between VIRGO cpupooling "use_as_kingcobra_service" clause and VI
1040  *) This makes virgo_clone() systemcall/telnet both synchronous and asynchronous - requests from telnet client/vi
1041  *) Above saves an additional code implementation for virgo_queue syscall paths - virgo_clone() handles, based on
1042  ------------------------------------------------------------------------------------------
1043  Prerequisites:
1044  --------------
1045  - insmod kingcobra_main_kernelspace.ko
1046  - insmod virgo_queue.ko compiled with flag virgo_queue_reactor_service_mode=1
1047          (when virgo_queue_reactor_service_mode=0, listens on port 60000 for direct telnet requests)
1048  - insmod virgo_cloud_test_kernelspace.ko
1049  - insmod virgo_cloudexec.ko (listens on port 10000)
1050
1051  ------------------------------------------------------------------------------------------
1052  Schematic Diagram
1053  ------------------------------------------------------------------------------------------
1054  VIRGO clone system call/telnet client ---> VIRGO cpupooling(compiled with use_as_kingcobra_service=1) ------> VI
1055
1056  ------------------------------------------------------------------------------------------
```

```
1018. Commits as on 15 February 2016 - Kernel Analytics - VIRGO Linux Kernelwide imports
-------------------------------------------------------------------------------
- Imported Kernel Analytics variables into CloudFS kernel module - printed in driver init()
- Module.symvers from kernel_analytics has been merged with CloudFS Module.symvers
- Logs for above has been added in cloudfs/test_logs/
- Makefile updated with correct fs path
- Copyleft notices updated

-------------------------------------------------------------------------------
1019. Commits as on 15 February 2016 - Kernel Analytics - VIRGO Linux Kernelwide imports
-------------------------------------------------------------------------------
- Kernel Analytics driver exported variables have been imported in CPU virtualization driver
- Module.symvers from kernel_analytics has been merged with Module.symvers in cpupooling
- kern.log for this import added to cpupooling/virgocloudexec/test_logs/

-------------------------------------------------------------------------------
1020. Commits as on 15 February 2016 - Kernel Analytics - VIRGO Linux Kernelwide imports
-------------------------------------------------------------------------------
- Imported kernel analytics variables into memory virtualization driver init() , exported from kernel_analytics (
- build shell script updated
- logs added to test_logs/
- Module.symvers from kernel_analytics has been merged with memory driver Module.symvers
- Makefile updated

-------------------------------------------------------------------------------
1021. Commits as on 15 February 2016 - Kernel Analytics - VIRGO Linux Kernelwide imports
-------------------------------------------------------------------------------
- Imported kernel analytics variables into VIRGO Queueing Driver
- logs for this added in test_logs/
- Makefile updated
- Module.symvers from kernel_analytics has been merged with Queueing driver's Module.symvers
- .ko, .o and build generated sources

-------------------------------------------------------------------------
Commits as on 16,17 February 2016
-------------------------------------------------------------------------
1022. (FEATURE-DONE) Socket Buffer Debug Utility Function - uses linux skbuff facility
-------------------------------------------------------------------------
- In this commit a multipurpose socket buffer debug utility function has been added in utils driver and exported
- It takes a socket as function argument does the following:
```

```
1097          - dereference the socket buffer head of skbuff per-socket transmit data queue
1098          - allocate skbuff with alloc_skb()
1099          - reserve head room with skb_reserve()
1100          - get a pointer to data payload with skb_put()
1101          - memcpy() an example const char* to skbuff data
1102          - Iterate through the linked list of skbuff queue in socket and print headroom and data pointers
1103          - This can be used as a packet sniffer anywhere within VIRGO linux network stack
1104  - Any skb_*() functions can be plugged-in here as deemed necessary.
1105  - kern.log(s) which print the socket internal skbuff data have been added to a new testlogs/ directory
1106  - .cmd files generated by kbuild
1107
1108  ------------------------------------------------------------------------------
1109  1023. (FEATURE-DONE) Commits as on 24 February 2016
1110  ------------------------------------------------------------------------------
1111  skbuff debug function in utils/ driver:
1112  (*) Added an if clause to check NULLity of skbuff headroom before doing skb_alloc()
1113  (*) kern.log for this commit has been added testlogs/
1114  (*) Rebuilt kernel objects and sources
1115
1116  ------------------------------------------------------------------------------
1117  Commits as on 29 February 2016
1118  ------------------------------------------------------------------------------
1119  ------------------------------------------------------------------------------
1120  771. (FEATURE-DONE) Software Analytics - SATURN Program Analysis added to VIRGO Linux kernel drivers - this sect
1121  ------------------------------------------------------------------------------
1122  - SATURN (saturn.stanford.edu) Program Analysis and Verification software has been
1123  integrated into VIRGO Kernel as a Verification+SoftwareAnalytics subsystem
1124  - A sample driver that can invoke an exported function has been added in drivers - saturn_program_analysis
1125  - Detailed document for an example null pointer analysis usecase has been created in virgo-docs/VIRGO_SATURN_Prog
1126  - linux-kernel-extensions/drivers/virgo/saturn_program_analysis/saturn_program_analysis_trees/error.txt is the e
1127  - SATURN generated preproc and trees are in linux-kernel-extensions/drivers/virgo/saturn_program_analysis/prepro
1128  linux-kernel-extensions/drivers/virgo/saturn_program_analysis/saturn_program_analysis_trees/
1129
1130  ------------------------------------------------------------------------------
1131  1024. Commits as on 10 March 2016
1132  ------------------------------------------------------------------------------
1133  - SATURN analysis databases (.db) for locking, memory and CFG analysis.
1134  - DOT and PNG files for locking, memory and CFG analysis.
1135  - new folder saturn_calypso_files/ has been added in saturn_program_analysis/ with new .clp files virgosaturncfg
1136  - SATURN alias analysis .db files
```

```
1137
1138  ------------------------------------------------------------------------------------------------------------
1139  1025.(FEATURE-DONE) NEURONRAIN - ASFER Commits for VIRGO - CloudFS systems calls integrated into Boost::Python C-
1140  ------------------------------------------------------------------------------------------------------------
1141  ------------------------------------------------------------------------------------------------------------
1142  AsFer Commits as on 30 May 2016
1143  ------------------------------------------------------------------------------------------------------------
1144  VIRGO CloudFS system calls have been added (invoked by unique number from syscall_32.tbl) for C++ Boost::Python :
1145  VIRGO Linux System Calls. Switch clause with a boolean flag has been introduced to select either VIRGO memory or
1146  kern.log and CloudFS textfile Logs for VIRGO memory and filesystem invocations from AsFer python have been commi
1147
1148  ------------------------------------------------------------------------------------------------------------
1149  1026. AsFer Commits as on 31 May 2016
1150  ------------------------------------------------------------------------------------------------------------
1151  Python CAPI interface to NEURONRAIN VIRGO Linux System Calls has been updated to include File System open, read,
1152  Rebuilt extension binaries, kern.logs and example appended text file have been committed to testlogs/. This is e
1153  commits done for Boost::Python C++ interface. Switch clause has been added to select memory or filesystem VIRGO s
1154
1155  ------------------------------------------------------------------------------------------------------------
1156  (BUG - STABILITY ISSUES) Commits - 25 July 2016 - Static Analysis of VIRGO Linux kernel for investigating heisen
1157  ------------------------------------------------------------------------------------------------------------
1158  Initial Documentation for Smatch and Coccinelle kernel static analyzers executed on VIRGO Linux kernel - to be u
1159  periodically with further analysis.
1160
1161  ------------------------------------------------------------------------------------------------------------
1162  (BUG - STABILITY ISSUES) Commits - 1 August 2016 - VIRGO Linux Stability Issues - Ongoing Random oops and panics
1163  ------------------------------------------------------------------------------------------------------------
1164  1. GFP_KERNEL has been replaced with GFP_ATOMIC flags in kmem allocations.
1165  2. NULL checks have been introduced in lot of places involving strcpy, strcat, strcmp etc., to circumvent
1166  buffer overflows.
1167  3. Though this has stabilized the driver to some extent, still there are OOPS in unrelated places deep
1168  with in kernel where paging datastructures are accessed - kmalloc somehow corrupts paging
1169  4. OOPS are debugged via gdb as:
1170          4.1 gdb ./vmlinux /proc/kcore
1171          or
1172          4.2 gdb <loadable_kernel_module>.o
1173     followed by
1174          4.3 l *(address+offset in OOPS dump)
1175  5. kern.log(s) for the above have been committed in tar.gz format and have numerous OOPS occurred during repetit
1176  invocation(boost::python C++) invocations of virgo memory system calls.
```

```
6. Paging related OOPS look like an offshoot of set_fs() encompassing the filp_open VFS calls.

-------------------------------------------------------------------------------------------
(BUG-STABILITY ISSUES) Commits - 26 September 2016 - Ongoing Random Panic investigation
-------------------------------------------------------------------------------------------
Further analysis on direct VIRGO memory cache primitives telnet invocation - problems are similar
to Boost::Python AsFer VIRGO system calls invocations.

-------------------------------------------------------------------------------------------
(BUG-STABILITY ISSUES) Commits - 27 September 2016 - Ongoing Random Panic investigation
-------------------------------------------------------------------------------------------
Analysis of VIRGO memory cache primitives reveal more inconsistencies in cacheline flushes between CPU and GPU.

-------------------------------------------------------------------------------------------
1027. Commits - 20 March 2017 and 21 March 2017 - VIRGO Linux 64-bit build based on 4.10.3 kernel
-------------------------------------------------------------------------------------------
*) moved virgoeventnetclient_driver_build.sh to virgoutils_driver_build.sh in utils/ driver
*) Updated VIRGO Linux Build Steps for 4.10.3
*) New repository has been created for 64-bit VIRGO Linux kernel based on 4.10.3 mainline kernel in GitHub and i
        https://github.com/shrinivaasanka/virgo64-linux-github-code
        https://sourceforge.net/p/virgo64-linux/
*) Though it could have been branched off from existing VIRGO repository (32-bit) which is based on 4.1.5 mainli
separate repository for 64-bit 4.10.3 VIRGO kernel code was simpler because:
        - there have been directory path changes for syscall entries in 4.10.3 and some other KBuild entities
        - Some script changes done for 4.1.5 in modpost and vmlinux phases are not required
        - having two VIRGO branches one with 4.1.5 code and 32-bit driver .ko binaries and other with 4.10.3 cod
binaries could be unmanageable and commits could go into wrong branch
        - 4.10.3 64-bit VIRGO kernel build is still in experimental phase and it is not known if 64-bit 4.10.3 b
problems in 4.1.5
        - If necessary one of these two repositories could be made branch of the other later

-------------------------------------------------------------------------------------------
1028. Commits - 27 March 2017 Ongoing analysis of VIRGO 64 bit linux kernel based on 4.10.3 kernel mainline
-------------------------------------------------------------------------------------------
*) Prima facie, 64 bit kernel is quite finicky and importunate compared to 32 bit and 64 bit specific idiosyncra
*) During the past 1 week, quite a few variants of kernel and drivers builds were tried with KASAN enabled and w
*) KASAN shows quite huge number of user memory accesses which later translate to panics.
*) Most nagging of these was kernel_recvmsg() panic.
*) Added and updated skbuff socket debug utility driver with a new debug function and to print more fields of skb
*) KASAN was complaining about _asan_load8 (loading 8 userspace bytes)
```

*) All erroneous return data types in VIRGO mempool ops structure have been corrected in VIRGO headers
*) all type casts have been sanitized
*) Changed all kernel stack allocations to kernel heap kzallocs
*) This later caused a crash in inet_sendmsg in kernel_sendmsg()
*) gdb64 disassemble showed a trapping instruction:
testb $0x6,0x91(%14) with corresponding source line:
sg = !!(sk->sk_route_caps & NETIF_F_SG)
in tcp_sendmsg() (net/ipv4/tcp.c)
*) changed kernel_sendmsg() to sock->ops->sendmsg()
*) These commits are still ongoing analysis only.
*) Screenshots for these have been added to debug-info/

1029. Continued analysis of VIRGO 64-bit linux kernel built on 4.10.3 mainline - Commits - 30 March 2017
---
*) Previous commit was crashing inside tcp_sendmsg()
*) GDB64 disassembly shows NULL values for register R12 which is added with an offset 91 and is an operand in tes
*) Protected all kernel_sendmsg() and kernel_recvmsg() in both system calls side and drivers side with
        oldfs=get_fs(), set_ds(KERNEL_DS) and set_fs(oldfs)
blocks without which there are random kernel_sendmsg and kernel_recvmsg hangs
*) Removed init_net and sock_create_kern usage everywhere and replaced them with sock_create calls
*) Tried MSG_FASTOPEN flags but it does not help much in resolving tcp_sendmsg() NULL pointer dereference issue.
speedsup the message delivery by piggybacking the message payload before complete handshake is established(SYN, S
SYN-ACK itself. But eventually it has to be enabled as fast open is becoming a standard.
*) Kasan reports have been enabled.
*) Added more debug code in skbuff debug utility functions in utils driver to check if sk->prot is a problem.
*) Replaced kernel_sendmsg with a sock->ops->sendmsg() in mempool sendto function which otherwise crashes in tcp_
*) With sock->ops->sendmsg() systemcalls <-----> drivers two-way request-reply works but still there are random
(Connection Reset by Peer) errors
*) Logs for working sys_virgo_malloc() call with correctly returned VIRGO Unique ID for memory allocated has beer
virgocloudexecmempool
*) sock->ops->sendmsg() in mempool driver sendto function requires a MSG_NOSIGNAL flag which prevents SIGPIPE sig
*) Reason for random broken pipe and connection reset by peer errors in mempool sendto is unknown. Both sides hav
there is no noticeable traffic.
*) While socket communications in 32 bit VIRGO kernel syscalls and drivers work with no issues, why 64-bit has so
Reasons could be 64 bit address alignment issues, 64 bit specific #ifdefs in kernel code flow, major changes fror
*) NULL values for register R12 indicate already freed skbuff data which are accessed/double-freed. Kernel TCP er
*) TCP engine clones the head data of skbuff queue, transmits it and waits for an ACK or timeout. Data is freed c
And head of the queue is advanced to next element in write queue and this continues till write queue is empty wa:
*) If ACK is not received, head data is cloned again and retransmitted by sequence number flow control.

```
1257
1258  ----------------------------------------------------------------------------------------------------
1259  1030. Continued Analysis of VIRGO 64 bit based on 4.10.3 linux kernel - Commits - 1 April 2017, 3 April 2017
1260  ----------------------------------------------------------------------------------------------------
1261  *) kernel_sendmsg() has been replaced with sock->ops->sendmsg() because
1262  kernel_sendmsg() is quite erratic in 4.10.3 64 bit
1263  *) There were connection reset errors in system calls side for virgo_malloc/. This was probably because
1264  sock->ops->sendmsg() requires MSG_DONTWAIT and MSG_NOSIGNAL flags and sendmsg does not block.
1265  *) sock release happens and virgo_malloc syscalls receives -104 error
1266  *) Temporarily sock_release has been commented. Rather socket timeout should be relied upon which should
1267  do automatic release of socket resources
1268  *) Similar flags have been applied in virgo_malloc syscalls too.
1269  *) Logs with above changes do not have reset errors as earlier.
1270  *) virgo set/get still crashes because 64 bit id is truncated which would require data type changes for
1271  64 bit
1272  *) test_virgo_malloc test case has been rebuilt with -m64 flag for invocation of 64 bit syscalls by
1273  numeric ids
1274
1275  ----------------------------------------------------------------------------------------------------
1276  1031. Continued Analysis of VIRGO 64 bit 4.10.3 kernel - commits - 10 April 2017
1277  ----------------------------------------------------------------------------------------------------
1278  *) There is something seriously wrong with 4.10.3 kernel sockets in 64 bit build VIRGO send/recv messages and eve
1279  *) All kernel socket functionalities which work well in 4.1.5 32 bit VIRGO , have random hangs, panics in 4.10.3
1280  in inet_recvmsg/sendmsg code path
1281  *) KASAN shows attempts to access user address which occurs despite set_fs(KERNEL_DS)
1282  *) Crash stack is similar to previous crashes in tcp_sendmsg()
1283  *) Tried different address and protocol families for kernel socket accept (TCP,UDP,RAW sockets)
1284  *) With Datagram sockets, kernel_listen() mysteriously fails with -95 error in kernel_bind(operation not supporte
1285  *) With RAW sockets, kernel_listen() fails with -93 error for AF_PACKET (protocol not supported)
1286  *) tcpdump pcap sniffer doesn't show anything unruly.
1287  *) This could either be a problem with kernel build (unlikely), Kbuild .config or could have extraneous reasons.
1288  4.1.5 and 4.10.3 are similar.
1289  *) Only major difference between 4.10.3 and 4.1.5 is init_net added in sock_create_kern() internally
1290  *) datatype of VIRGO Unique ID has been changed to unsigned long long (_u64)
1291  *) tried with INADDR_LOOPBACK in place of INADDR_ANY
1292  *) also tried with disabled multi(homing) in /etc/hosts.conf
1293  *) Above random kernel socket hangs occur across all VIRGO system calls and drivers transport.
1294  *) Utils kernel socket client to EventNet kernel service also has similar inet_recvmsg/inet_sendmsg panic proble
1295
1296  ----------------------------------------------------------------------------------------------------
```

```
1032. Commits - 11 April 2017 - EventNet and Utils Drivers 64bit
--------------------------------------------------------------------------------------------------------
*) EventNet driver works in 64 bit VIRGO Linux
*) An example eventnet logging with utils virgo_eventnet_log() works now without tcp_sendmsg() related stalls in
*) Return Datatypes for all EventNet operations have been sanitized (struct socket* was returned as int in 32 bu
struct socket*. This reinterpret cast does not work in 64 bit) in eventnet header.
*) utils eventnet log in init() has been updated with a meaningful edge update message
*) kern.log for this has been added to eventnet/testlogs

--------------------------------------------------------------------------------------------------------
1033. Commits - 17 April 2017 - VIRGO64 Memory, CPU, FileSystem, EventNet kernel module drivers
--------------------------------------------------------------------------------------------------------
*) telnet requests to VIRGO memory(kernelmemcache), cpu and filesystem modules work after resolving issues with
*) commented le32_to_cpu() and print_buffer() which was suppressing lot of log messages.
*) VIRGO <driver> ops structures have been updated with correct datatypes.
*) reinterpret cast of struct socket* to int has been completely done away with which could have caused 64bit sp
*) lot of kern.log(s) and screen captures have been added for telnet requests in testlogs/ of respective <driver
*) Prima facie 64bit telnet requests to VIRGO module listeners are relatively stabler than 32bit
*) Previous code changes should be relevant to 32 bit VIRGO kernel too.
*) tcp_sendmsg()/tcp_recvmsg() related hangs could be mostly related to corrupted skbuff queue within each socke
*) This is because replacing kernel_<send/recv>msg() with sock_<send/recv>msg() causes return value to be 0 whil
socket release crashes within skbuff related kernel functions.
*) To make socket state immutable, in VIRGO memory driver header files, client socket has been declared as const

--------------------------------------------------------------------------------------------------------
1034. Commits - KingCobra 64 bit and VIRGO Queue + KingCobra telnet requests - 17 April 2017
--------------------------------------------------------------------------------------------------------
*) Rebuilt KingCobra 64bit kernel module
*) telnet requests to VIRGO64 Queueing module listener driver are serviced by KingCobra servicerequest
*) Request_Reply queue persisted for this VIRGO Queue + KingCobra routing has been committed to c-src/testlogs.
*) kern.log for this routing has been committed in VIRGO64 queueing directory
*) Similar to other drivers struct socket* reinterpret cast to int has been removed and has been made const in q

--------------------------------------------------------------------------------------------------------
1035. Commits - VIRGO64 system calls - kernel module listeners - testcases and system calls updates - 18 April 2
--------------------------------------------------------------------------------------------------------
*) All testcases have been rebuilt
*) VIRGO kernel memcache,cpu and filesystem system calls have been updated with set_fs()/get_fs() blocks for ker
and kernel_recvmsg()
*) Of these virgo_clone() system call testcase (test_virgo_clone) works flawlessly and there are no tcp_sendmsg(
```

```
kernel panics.
*) VIRGO memcache and filesystem system call testcases have usual tcp_sendmsg()/tcp_recvmsg() despite the kernel
being similar to VIRGO clone system call
*) Logs for VIRGO clone system call to CPU kernel driver module have been committed to virgo_clone/test/testlogs

-----------------------------------------------------------------------------------------------------------
1036. Commits - VIRGO64 Kernel MemCache and FileSystem system calls to VIRGO Memory and FileSystem Drivers - 19 A
-----------------------------------------------------------------------------------------------------------
*) Changed iovec in virgo_clone.c to kvec
*) test_virgo_filesystem.c and test_virgo_malloc.c VIRGO system calls testcases have been changed with some addi
*) virgo_malloc.c has been updated with BUF_SIZE in iov_len and memset to zero initialize the buffer. tcp_sendmsg
getting stuck in copy_from_iter_full() memcpy with a NULL Dereference. memcpy() was reading past the buffer bound
didnot work for iov_len.
*) virgo_fs.c virgo_write() memcpy has been changed back to copy_from_user() thereby restoring status quo ante (
because of a kernel panic in older versions of 32 bit VIRGO kernel)
*) Logs for VIRGO kmemcache and filesystem system calls have been committed to respective system call directories
*) With this all VIRGO64 functionalities work in both telnet and system calls requests routes end-to-end from cli
kernel sockets issues resolved fully.
*) Major findings are:
- VIRGO 4.10.3 64 bit kernel is very much stable compared to 32 bit 4.1.5 kernel
- there are no i915 related errors which happened in VIRGO 32 bit 4.1.5 kernel
- Repetitive telnet and system calls requests to VIRGO modules are stable and there are no kernel panics like 4.1
- Google Kernel Address Sanitizer is quite helpful in finding stack overruns, null derefs, user memory accesses e
- 64 bit kernel is visibly faster than 32 bit.
- Virgo Unique ID is now extended to 2^64 with unsigned long long.

-----------------------------------------------------------------------------------------------------------
1037. Commits - VIRGO64 memory and filesystem calls to memory and filesystem drivers requests routing - 20 April
-----------------------------------------------------------------------------------------------------------
*) Changed return value of virgo_cloud_free_kernelspace() to a string literal "kernel memory freed"
*) Logs for VIRGO64 memory and filesystem calls to memory and filesystem drivers requests routing have been comm
both driver directories

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1038. Commits - 27 April 2017
-----------------------------------------------------------------------------------------------
Residual logs for VIRGO 64 bit 4.10.3 kernel committed.

-----------------------------------------------------------------------------------------------
1039. Commits - 25 May 2017
```

```
1377  ------------------------------------------------------------------------------------------
1378  *) Changed LOOPBACK to INADDR_ANY for VIRGO64 kernel memcache listen port
1379  *) All VIRGO64 RPC, kernel memcache, cloud filesystem primitives have been retested
1380  *) VIRGO64 mempool binaries have been rebuilt
1381
1382  ------------------------------------------------------------------------------------------
1383  1040. Commits - 31 August 2017 - NeuronRain ReadTheDocs Documentation - VIRGO64 System calls and Drivers
1384  (http://neuronrain-documentation.readthedocs.io/en/latest/)
1385  ------------------------------------------------------------------------------------------
1386  (*) New directory systemcalls_drivers/ has been added to virgo-docs/ and representative VIRGO64
1387  system calls and drivers functionality logs have been committed for demonstration purpose.
1388  (*) VIRGO64 cloudfs driver has been rebuilt after changing virgofstest.txt file creation filp_open() call
1389  (*) Screenshots and logs for VIRGO64 Clone, Kernel MemCache and Cloud FS SystemCalls-Drivers interaction, socket
1390
1391  ------------------------------------------------------------------------------------------
1392  1041. Commits - 23 September 2017 - Major VIRGO mainline kernel version Upgrade for Kernel Transport Layer Secur
1393  ------------------------------------------------------------------------------------------
1394  (*) Recently released mainline kernel version 4.13 integrates SSL/TLS into kernelspace- KTLS - for the first time
1395  (*) KTLS is a standalone kernel module af_ktls (https://github.com/ktls) implemented by RedHat and Facebook for
1396  within kernelspace itself and reduce userspace-kernelspace switches.
1397  (*) sendfile() system call in linux which is used for file transmission (combining read+write) from one fd to an
1398  KTLS optimization in kernelspace in af_ktls codebase (af_ktls tool)
1399  (*) VIRGO Linux kernel fork-off requires this kernelspace TLS functionality to fully secure traffic from system
1400   cloud node's kernel module listeners
1401  (*) Hence VIRGO64 linux kernel mainline base is urgently upgraded from 4.10.3 to 4.13.3
1402  (*) All system calls and kernel module code in VIRGO64 now have #include(s) for tls.h and invoke kernel_setsockop
1403  kernelspace sockets for SOL_TLS and TLS_TX options and have been rebuilt.
1404  (*) VIRGO64 RPC clone/kmemcache/cloudfs system calls to kernel module listeners have been tested with this new K
1405  on rebuilt VIRGO64 kernel overlay-ed on 4.13.3 64-bit linux kernel
1406  (*) 4.13 mainline kernel also has SMB CIFS bug fixes for recent malware attacks (WannaCry etc.,) which further en
1407  VIRGO64 linux fork-off kernelspace traffic.
1408  (*) New buildscript for 4.13.3 linux kernel has been committed
1409  (*) testlogs for VIRGO64 system calls and driver listeners KTLS transport have been committed in virgo-docs/syste
1410  (*) After this upgrade, complete system calls to driver listener traffic is SSL enabled implicitly.
1411  (*) Updated kernel object files for 4.13.3 build are part of this commit.
1412
1413  ------------------------------------------------------------------------------------------
1414  1042. Commits - Remnant commits for 4.13.3 upgrade - 24 September 2017
1415  ------------------------------------------------------------------------------------------
1416  Updated init.h and syscalls.h headers for virgo system calls
```

```
1417
1418  ------------------------------------------------------------------------------------------------------------
1419  1043. Commits - VIRGO64 4.13.3 KTLS Upgrade - System Calls-Driver Listeners End-to-End encrypted traffic testing
1420  ------------------------------------------------------------------------------------------------------------
1421  (*) VIRGO64 CPU/KMemCache/CloudFS system calls have been invoked by userspace testcases and all primitives work a
1422  (*) Some small modifications to system calls code have been made and rebuilt to remove redundant iovbuf variables
1423  (*) test_virgo_filesystem.c testcase has been updated and rebuilt
1424  (*) kern.log(s) for CPU/KMemCache/CloudFS systemcalls to driver listeners invocations have been committed to resp
1425  directories
1426  (*) virgofstest.txt written to by virgo_write() has also been committed. But a weird behaviour is still observed
1427  (*) No DRM GEM i915 panics are observed and stability of VIRGO64 + 4.13.3 linux kernel is more or equal to VIRGO6
1428
1429  ------------------------------------------------------------------------------------------------------------
1430  1044. Commits - VIRGO64 VIRGO_KTLS branch creation and rebase of master to previous commit - 30 September 2017
1431  ------------------------------------------------------------------------------------------------------------
1432  (*) New branch VIRGO_KTLS has been created after previous commit on 25 September 2017 and all 5 commits after 25
1433  28 September 2017 have been branched to VIRGO_KTLS (which has the #ifdef for crypto_info, reads from /etc/virgo_k
1434  driver module)
1435  (*) Following are the commit hashes and commandlines in GitHub and SourceForge:
1436                git branch -b VIRGO_KTLS
1437                git branch master
1438                git rebase -i <SHA1_on_25September2017>
1439                git rebase --continue
1440                git commit --amend
1441                git push --force
1442  ------------------------------------------------------------------------------------------
1443  1958  git checkout -b
1444  1959  git checkout -b VIRGO_KTLS
1445  1960  ls
1446  1961  git checkout VIRGO_KTLS
1447  1962  git push origin VIRGO_KTLS
1448  1963  git status
1449  1964  git checkout
1450  1965  git checkout -b
1451  1966  git branch
1452  1967  git branch master
1453  1968  git branch -h
1454  1969  git branch
1455  1970  git checkout master
1456  1975  git checkout -b
```

```
1976  git checkout -b VIRGO_KTLS
1979  git push origin VIRGO_KTLS
1990  git rebase -i bb661e908cba2a5357414e89166f29086a28bdf0
1991  git status
1992  git rebase -i bb661e908cba2a5357414e89166f29086a28bdf0
1996  git rebase --continue
1997  git commit --amend
2019  git rebase -i bb661e908cba2a5357414e89166f29086a28bdf0
2029  git rebase --continue
2037  git push --force
2091  git rebase -i bb661e908cba2a5357414e89166f29086a28bdf0
2092  git rebase --continue
2093  git commit --amend
2094  git push --force
2110  git branch
2111  git branch master
2112  git checkout master
2113  git branch
2114  git rebase -i e76b4089633223f610fddc0e0eaff8c2cef8b9f1
2115  git commit --amend
2116  git rebase --continue
2117  git push --force
-------------------------------------------------------------------------------------------------
KTLS in 4.13.3 has support for only private symmetric encryption. It does not support Public Key Encryption yet.
mainstream VIRGO64 code might change a lot for other features. Therefore, VIRGO_KTLS specific crypto_info code ha

-------------------------------------------------------------------------------------------------
1045. Commits - 1 October 2017
-------------------------------------------------------------------------------------------------
kern.log(s) for VIRGO64 systemcalls-driver 4.13.3 64-bit upgrade tests on master branch after reversal and rebase
branching to VIRGO_KTLS. There is a weird General Protection Fault in intel atomic commit work not seen thus far

-------------------------------------------------------------------------------------------------
1046. Commits - VIRGO64 Utils and EventNet Drivers Update for tcp_sendmsg() stack out-of-bounds error - 3 Octobe
-------------------------------------------------------------------------------------------------
(*) Utils Generic Socket Client function virgo_eventnet_log() for EventNet kernel module listener was repeatedly
emitting -32 and -107 errors.
(*) kernel_connect() was guarded by set_fs() and get_fs() memory segment routines to prevent any memory corruptio
(*) After replacing strlen(buf) by BUF_SIZE in msg flags before kernel_connect() stack out-of-bounds error has be
(*) kern.log for this has been committed in drivers/virgo/utils/testlogs/
```

```
(*) Both eventnet and utils drivers have been rebuilt

-----------------------------------------------------------------------------------------------------------
1047. VIRGO64 system calls-drivers on linux kernel 4.13.3 - miscellaneous bugfixes - 5 October 2017
-----------------------------------------------------------------------------------------------------------
(*) kernel_setsockopt() for KTLS has been commented in all system calls and drivers because KTLS functionality ha
VIRGO_KTLS
(*) In virgo_clone.c, iov.iov_len has been set to BUF_SIZE
(*) kernel_connect() has been guarded by set_fs()/get_ds() in VIRGO64 system call clients
(*) test_virgo_malloc.c testcase has been updated
(*) There was a weird problem in in4_pton(): sin_addr.saddr was not set correctly from string IP address and this
(*) in4_pton() is implemented in net/core/utils.c and reads the string IP address digits and sums up the ASCII va
(*) Repeated builds were done trying different possible fixes but didn't work e.g casting saddr to (u8*)
(*) There is an alternative in_aton() function which takes only String IP address and returns address as __be32
(*) After in_aton() in virgo_set() random faulty address conversion does not occur - in_aton() is differently imp
(*) msg_hdr has been initialized to NULL in virgo_set()
(*) Lot of debug printk()s have been added
(*) kern.log (.tar.gz) for RPC clone/KMemCache/Filesystem systemcalls-driver has been committed to virgo-docs/sys
(*) VIRGO Linux build steps have been updated for example commandlines to overlay mainline kernel tree by VIRGO64

commit 4e6681ade4ddbf1bed17f7c115b59a5ebf884256
Author: K.Srinivasan <ka.shrinivaasan@gmail.com>
Date:   Fri Oct 6 11:36:15 2017 +0530

-----------------------------------------------------------------------------------------------------------
1048. VIRGO64 Queueing Kernel Module Listener - KingCobra64 - 4.13.3 - 6 October 2017
-----------------------------------------------------------------------------------------------------------
(*) telnet client connection to VIRGO64 Queue and a subsequent workqueue routing (pub/sub) to KingCobra64 has bee
(*) TX_TLS socket option has not been disabled and is a no-op because it has no effect on the socket.
(*) REQUEST_REPLY.queue for this routing from VIRGO64 queue and persisted by KingCobra64 has been committed to K

commit d4e95b58474838d65da9c69944c6287acbdfe72c
Author: K.Srinivasan <ka.shrinivaasan@gmail.com>
Date:   Fri Oct 6 11:05:21 2017 +0530


-----------------------------------------------------------------------------------------------------------
1049. VIRGO64 System Calls to Drivers and Telnet Client to Drivers on 4.13.3 linux kernel - master branch (after
and branched to VIRGO_KTLS) - test case logs - 6 October 2017
-----------------------------------------------------------------------------------------------------------
(*) VIRGO64 System calls - Clone, KMemCache and Filesystem system call primitives to Driver listeners invocations
```

```
by respective test_<systemcall> unit testcases
(*) VIRGO64 Telnet Clients to Driver listeners invocations have been tested by telnet connections
(*) Master branches in SourceForge and GitHub VIRGO64 do not have KTLS provisions. Only VIRGO_KTLS branch has cry
 for TX_TLS for kernel sockets.
(*) It has been already mentioned in NeuronRain Documentation in https://neuronrain-documentation.readthedocs.io,
VIRGO cloud nodes in the absence of KTLS - most obvious solution is to install VPN client-servers in all nodes wh
 on a secure tunnel (e.g OpenVPN).
(*) VIRGO64 system call clients and driver listeners should read these Virtual IPs from /etc/virgo_client.conf an
  and cloud traffic is confined to the VPN tunnel.

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1050. VIRGO64 SystemCalls-Drivers endtoend invocations unit case tests - on 4.13.3 - VIRGO64 main branch - 11 Oct
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(*) VIRGO64 systemcalls have been invoked from unit test cases (test_<system_call>) in a loop of few hundred iter
(*) No DRM GEM i915 panics or random crashes are observed and stability is good
(*) This is probably the first loop iterative testing of VIRGO system calls and drivers.
(*) Kernel logs for this have been committed to virgo-docs/systemcalls_drivers directory.
(*) Note on concurrency: Presently mutexing within system calls have been commented because in past linux versio
 to execute in kernel space. Mostly this is relevant only to kmemcache system calls which have global in-kernel-m

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1051. VIRGO64 SystemCalls-Drivers concurrent invocations - 2 processes having shared mutex - 14 October 2017
------------------------------------------------------------------------------------------------------------------
(*) VIRGO64 systemcalls are invoked in a function which is called from 2 processes concurrently
(*) Mutexes between the processes are PTHREAD_PROCESS_SHARED attribute set.
(*) test_virgo_malloc.c unit testcase has been enhanced to fork() a process and invoke systemcalls in a function
(*) Logs for the Virgo Unique IDs malloc/set/get/free in the systemcalls side and kern.logs for the drivers have
(*) No DRM GEM i915 crashes were observed
(*) test_virgo_malloc.c testcase demonstrates the coarse grained critical section lock/unlock for kmemcache syste
that should be followed for any userspace application.

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775. (FEATURE) VIRGO64 Kernel Analytics - Streaming Implementation - 13 December 2017 - this section is an extens
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(#) Presently kernel analytics config have to be read from a file storage. This is a huge performance bottleneck
analytics variables written to is realtime. For example autonomous vehicles/drones write gigabytes of navigation
(#) Because of this /etc/virgo_kernel_analytics.conf grows tremendously. File I/O in linux kernel module is also
(#) Previous latency limitations necessitate an alternative high performance analytics config variable read algor
(#) This commit introduces new streaming kernel analytics config reading function - It connects to a kernel analy
on hardcoded port 64000 and reads analytics key-value pairs in an infinite loop.
```

```
(#) These read key-value pairs are stored in a kernel global ring buffer exported symbol (by modulus operator). I
(#) kernel socket message flags are set to MSG_MORE | MSG_FASTOPEN | MSG_NOSIGNAL for high response time. MSG_FAS
in 4.13.3 64-bit which was a problem in previous kernel versions.
(#) kern.log for this has been committed to kernel_analytics/testlogs/
(#) include/linux/virgo_kernel_analytics.h header file has been updated for declarations related to streaming ana
(#) Webserver used for this is netcat started on port 64000 as:
                nc -l 64000
                >k1=v1
                >k2=v2
                ...

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1052. VIRGO64 Kernel Analytics - Reading Stream of Analytic Variables made a kernel thread - 13 December 2017
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(#) This is sequel to previous commit for Stream reading Kernel Analytics variables over a network socket
(#) read_streaming_virgo_kernel_analytics_conf() function is invoked in a separate kernel thread because module i
(#) VIRGO64 config module was loaded and exported kernel analytics variables read over socket by previous spin-o
imported in VIRGO64 config init.
(#) kern.log for this has been committed to testlogs/
(#) Pre-requisite: Webservice serving kernel_analytics variables must be started before kernel_analytics module i
(#) By this a minimum facility for live reading analytics anywhere on cloud (it can be userspace or kernelspace)
to modules on a local cloud node kernel has been achieved - ideal for cloud-analytics-driven IoT

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1053. VIRGO64 System Calls - Drivers - Kernel Analytics Streaming - on 4.13.3 kernel - 15 December 2017
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(#) VIRGO64 System Calls to Drivers invocations on 4.13.3 kernel have been executed after enabling streaming kern
(#) VIRGO64 RPC/KMemCache/CloudFS Drivers import, streamed variable-value pairs exported from kernel_analytics re
(#) VIRGO64 KMemCache testcase has 2 concurrent processes invoking kememcache systemcalls in a loop.
(#) kern.log for this has been committed to virgo-docs/systemcalls_drivers
(#) virgofstest.txt written by CloudFS systemcalls-drivers invocation is also committed to virgo-docs/systemcalls

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1054. VIRGO64 system calls and drivers - Quadcore 64bit - Known Issues - documentation only - 26 May 2019
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1. VIRGO64 system calls to drivers interactions so far have been tested only on dual core 64 bit architecture.
2. In quad core 64 bit there have been random -32,-107, -101 errors in kernel_connect() from system call clients
almost all three types of VIRGO64 system calls - clone/kmemcache/filesystem - to respective drivers
3. These errors do not occur if following in4_pton() invocation is changed to in_aton() before kernel_connect() i
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```
         /*in4_pton(vaddr->hstprt->hostip, strlen(vaddr->hstprt->hostip), (u8*)&sin.sin_addr.s_addr, '\0',NULL);
        sin.sin_addr.s_addr=in_aton(vaddr->hstprt->hostip);

4. Since this problem occurs erratically and only on quadcore 64-bit and reasons for these random -32,-101,-107 e
5. Most likely the u8* cast causes client socket address corruption.
6. Because of random -32,-101,-107 errors, in quadcore, system calls sometimes do not transmit client side comma

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773. (FEATURE) Linux Kernel 5.1.4, PXRC Drone/UAV/Flight Controller, UVC Video WebCam driver, Kernel Analytics, I
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1. Two analytics usecases mentioned in NeuronRainUsecases.txt in NeuronRain AsFer asfer-docs/ have been illustra
2 example drivers for PXRC Drone controller Driver and UVC Video WebCam Driver.
2. PXRC Phoenix RC flight controller is part of linux kernel from 4.17 and kernel major version has been bumped
3. Linux kernel 5.1.4 has been built by a new build script - buildscript_5.1.4.sh.
4. Linux kernel 5.1.4 has recent versions of PXRC drone controller driver and a UVC video webcam
driver (http://www.ideasonboard.org/uvc/faq/)
5. New directory linux-kernel-5.1.4-extensions/ has been created for VIRGO64 code built on kernel mainline versi
for version 5.1.4 because pxrc driver is part of kernel only from 4.17 while code in linux-kernel-extensions/ is
dual core 64-bit architecture.
6. New VIRGO64 build on 5.1.4 kernel is necessary only for PXRC, UVC and kernel_analytics drivers while other VI
ported to 5.1.4 and are still on 4.13.3 kernel.
7. Two drivers for PXRC and UVC Webcam in 5.1.4 have been committed under linux-kernel-5.1.4-extensions/drivers/
8. VIRGO64 kernel_analytics driver for 5.1.4 has been committed under linux-kernel-5.1.4-extensions/drivers/virg
9. Porting VIRGO64 kernel_analytics driver from 4.13.3 to 5.1.4 required changing vfs_read() of /etc/virgo_kerne
kernel_read() in config file read.
10. Drivers code for PXRC is in drivers/input/joystick/pxrc.c has been instrumented with few printk() statements
virgo_kernel_analytics_conf array variable-value pairs exported by VIRGO64 kernel_analytics driver. Kernel analy
imported by #include of virgo_config.h
11. Drivers code for UVC Video WebCam is in drivers/media/usb/uvc. File drivers/media/usb/uvc/uvc_video.c has be
uvc_trace() statements which print kernel_analytics driver exported analytics variable "match" and its boolean v
12. UVC Video WebCam traces are enabled by:
         echo 0xffff > /sys/module/uvcvideo/parameters/trace
13. Example kern.log(s) for PXRC and UVC drivers are committed under drivers/input/joystick/testlogs/kern.log.px
14. Both UVC and PXRC drivers, VIRGO64 kernel_analytics driver and linux kernel 5.1.4 have been built on quadcor
15. This example import of VIRGO64 kernel analytics variables into PXRC drone and UVC webcam drivers demonstrate
16. Driver build shell scripts have been committed to UVC and PXRC driver directories.

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774. (FEATURE) Concurrent Managed Workqueue(CMWQ), VIRGO64 Queueing and KingCobra64 messaging - 12 June 2019 - t
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1657  1. Existing workqueue underneath VIRGO64 queueing and requests routed by it to KingCobra64 messaging are old lega
1658  have been revamped to Concurrent Managed Workqueue which supports concurrent messaging and lot of other options :
1659  2. create_workqueue() in VIRGO64 Queueing has been changed to alloc_workqueue() of Concurrent Managed Workqueue.
1660  3. VIRGO64 Queueing request routing to KingCobra64 messaging has been tested with CMWQ and queueing log and kingC
1661  Queue have been committed to respective testlogs of the drivers
1662  4. reading from stream has been disabled in virgo_kernel_analytics.h
1663  5. Reference - CMWQ documentation - https://www.kernel.org/doc/html/v4.11/core-api/workqueue.html
1664  6. Byzantine Fault Tolerance in KingCobra64 persisted queue can be made available by performant CMWQ and routing
1665  REQUEST_REPLY.queue by any of the practical BFT protocols available.
1666  7. Most important application of CMWQ based VIRGO64-KingCobra64 is in the context of kernelspace hardware messag
1667  analytics driven embedded systems.
1668  8. An example usecase which is a mix of sync and async I/O in kernelspace:
1669          (*) Analytics Variables computed by userspace machine learning are read over socket stream by kernel_anal
1670  exported kernelwide
1671          (*) Some interested Drone driver in kernel (example PXRC) reads the analytics variables synchronously and
1672          (*) VIRGO Queuing routes the queued messages to KingCobra64 driver
1673
1674  Srinivasan Kannan (alias) Ka.Shrinivaasan (alias) Shrinivas Kannan
1675  http://sites.google.com/site/kuja27
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