Container Security

Bachelor's degree graduation project

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Outline

Outcome

Medical cloud

- Container
- Privacy, Security
- Load balanceability, Portability, Manageability

Current outcome

- An easy container with Linux namespace.

```
→ container git:(main) ✗ gcc *.[ch] -o c
→ container git:(main) ✗ sudo ./c "bash"
Success on creating container
Start container: bash with clone id: 193761
In container PID: 1
bash-5.0# ./test.sh
This is the self test script in contaiiner!
Support bash cat echo ls rm hostname, 5 commands.
./test.sh
-----------FILE: test.sh ------------
     1  #!/bin/bash
     2
     3  echo "This is the self test script in contaiiner!"
     4  echo "Support bash cat echo ls rm hostname, 5 commands."
     5
     6  echo $0
     7
     8  echo "-----------FILE: test.sh ------------"
     9  cat -n test.sh
    10  echo "------------------------------------"
    11
    12  echo $(hostname) >天竺鼠車車
    13  cat 天竺鼠車車
    14  rm 天竺鼠車車
    15  ls
------------------------------------
container
bin  dev  etc  home  lib  lib64  mnt  opt  proc  root  run  sbin  sys  test.sh  tmp  usr  var
bash-5.0# exit
```

List of attack surface

- cgroups with race condition
- namespace
  - wrong privileges
  - Cannot cross namespace? Really?
- init.
  - stack overflow(thread)?
  - fork and CoW?
  - defunct processing
- lib/syscall/kernel exploit

FIXME

namespace

- Start from 2.4.19(2003)
- Completed in Linux kernel 3.8(2013)
- System calls
  - clone, unshare, setns
- Nested, scope

```
➜  container git:(main) ✗ sudo unshare --fork --pid --mount-proc bash
[sudo] password for scc:
root@scc-lab:/media/d/git/nsysu/cs/try/lc/container# ps -a
    PID TTY          TIME CMD
      1 pts/1    00:00:00 bash
      8 pts/1    00:00:00 ps
root@scc-lab:/media/d/git/nsysu/cs/try/lc/container# exit
exit
➜  container git:(main) ✗
```

namespace

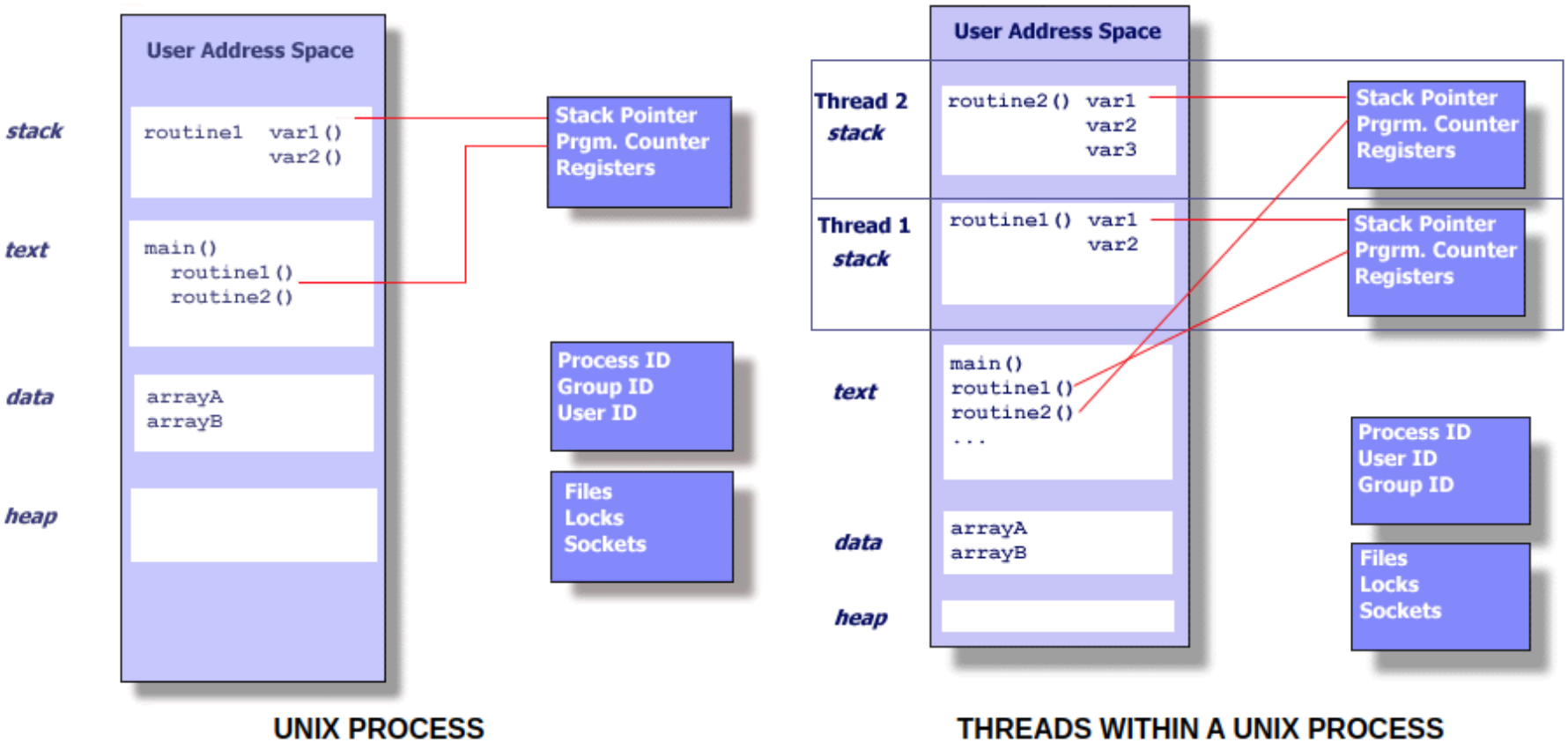
- 6 mechanisms
  - Mount, UTS, IPC, PID, NET, USER
- ps: mount -t proc proc /proc
- $PID = 1$, the "init"[1]
  - SIGTERM, SIGKILL
  - The defunct
- Starting in Linux 3.8, unprivileged processes can create user namespaces, ... unprivileged applications now have access to functionality that was formerly limited to root. ...Thus, it may happen that user namespaces have some as-yet unknown security issues.[2]

cgroups

- Access controller
  - Resource limiting: CPU, Mem, IO...
  - Prioritization: CPU, IO...
  - Accounting: evaluate
  - Control: freeze, check, and resume
- The OOM killer 4.19
  - Guarantee the integrity of the workload.

Stack overflow

- Default: 8MB
- The init of container, confused here.



[3]

Paper review

Have been read papers

- Linux Kernel OS Local Root Exploit[4]
- PINE: Optimizing Performance Isolation in Container Environments[5]
- Study of Security Flaws in the Linux Kernel by Fuzzing[6]

Linux Kernel OS Local Root Exploit

- Dirty CoW
- race condition with mmap
- Counteract
  - Comparing the size of the binary against the size of the original binary[4]
  - systemtap module
  - update && upgrade

Optimizing Performance Isolation

Microservices

- latency-sensitive services
- throughput-first services

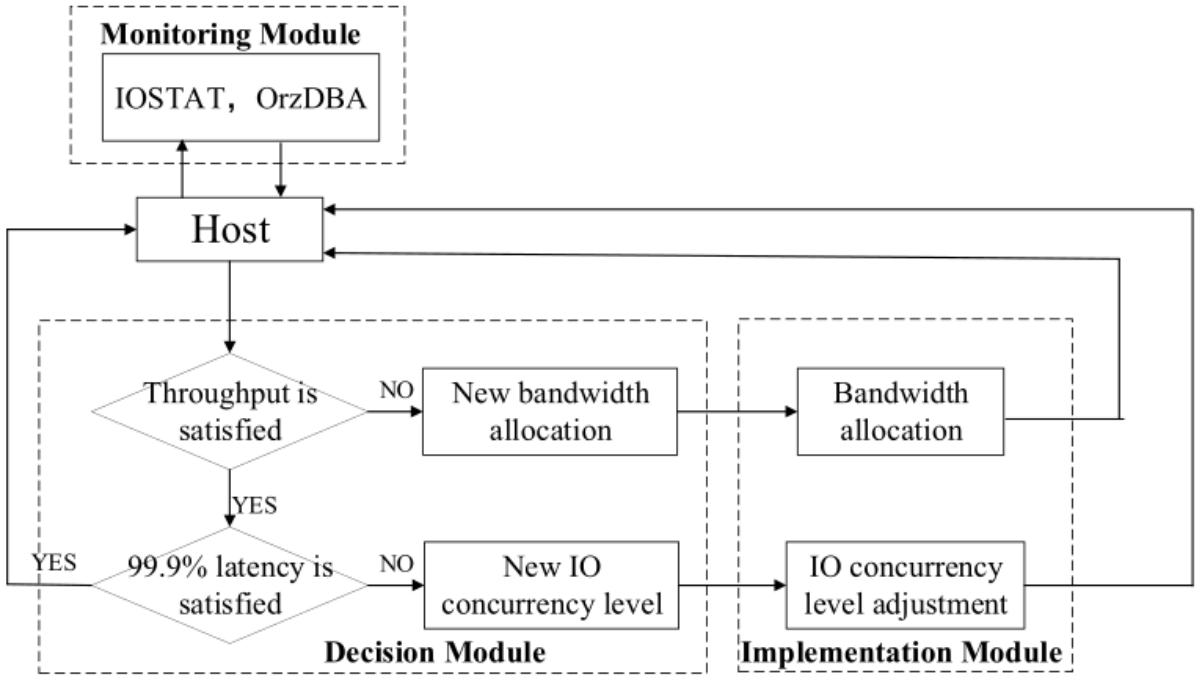


FIGURE 7. The overall flow of PINE.

[5]

Fuzzing

Syzkaller

- Stack overflow
  - Canary
  - KSLR
  - Shadow stack
- Integer overflow
  - Options to detected and SIGKILL
- Heap overflow
  - Check size of the variable in comparison with the size copy_to_user, copy_from_user
  - Guard pages
  - Check functions and glibc's heap protections

Fuzzing

Syzkaller

- Format string injection
  - Detect non-constant format string
- Kernel pointer leak
  - Remove visibility for kernel symbols
  - Block the use of %p
- Uninitialized variables
  - RAII
- Use-after-free
  - RAII too

My container

Code review

My container

```
4 int cont_start(char *argv[], int do_wait);
5 int cont_stop();
```

My container

```
44
45 static inline pid_t loader(char *argv[])
46 {
47     return clone(run, c_stkptr + STK_SIZE,
48                  CLONE_NEWNS | CLONE_NEWUTS | CLONE_NEWPID |
     SIGCHLD, argv);
49 }
50 {
51     c_stkptr = (char *) malloc(STK_SIZE);
52     c_pid = (long) loader(argv);
```

```
38     int ret = execvp(arg[0], arg);
39     if (ret)
40         printf("%s in container\n", strerror(errno));
41
42     return ret;
```

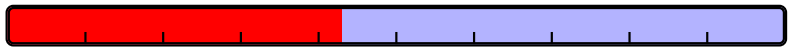
My container

```
25 #else
26     if (chroot(STRINGIZE_VALUE_OF(rootfs)))
27         perror("chroot error");
28 #endif
29     printf("In container PID: %ld\n", (long) getpid());
30
31 static int run(void *argv)
32 {
33     isol();
34     chdir("/");
```

```
15 static long c_pid;
16 static char *c_stkptr;
17
18 static void isol()
19 {
20     unshare(CLONE_FILES | CLONE_FS | CLONE_SYSVSEM |
       CLONE_NEWCGROUP);
21 #ifdef ROOTFS
```

Current progress

Application of MOST

- Papers:  1.0
- FIXME:  0.43
- Pages:  0.5
- My Exp.:  Maybe. . .

Demo

Live demo.

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Reference

References I

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References II

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