VAX'd

Data recovery from a legacy VAX VMS

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NolaCon 2022

whoami

Stephen Halwes aka geno

- Reverse engineer
- Software developer
- Vulnerability researcher
- Linux / security / Rust enthusiast
- Crypto means Cryptography
- Master of none

- Twitter: @genonullfree
- Matrix: @geno.nullfree:matrix.org
- https://github.com/genonullfree

CAESAR CREEK SOFTWARE

Super Mario RPG:
Legend of the Seven Stars

Initial expectations

Hey kid, you wanna recover some data?

Boy, do I!

The Eh-Team

- Jordan Murphy @_ash_matthews_
- Paul Sorensen @PaulJSorensen
- Wayne Campbell @wcampbell42
- Me @genonullfree

Background

First contact
The call

- Learn more about the job
  - ~30 year old server…“some kind of Red Hat Linux”… 🚩
  - Everything’s custom software written in “Advanced Basic”… 🚩
  - The previous bid they got was too high at $50k… 🚩
  - The IT guy that quit had been the sole admin and developer for the machine and was the only one that knew how it was all setup… 🚩

- Sure thing, sounds like a job for us!

The bid

- We’re all Linux nerds, how difficult could this be?
- Estimated time: <4 months
- Bid significantly less than $50k
- Also included a contingency that if we were unsuccessful in recovering the data, they wouldn’t have to pay us anything
- Submitted the bid
- They accepted!
- High-five each other on how smart we are and how easy this will be

Data Recovery

1 Recovery data from a Linux system

Project: Neckbeard

<hacker voice> We're in

- Shipped a copy of the Virtual Machine
- Gave us access to the live, production system
- RDP over VPN to a pivot machine, then telnet to the target box
- Logged into it and...

```
Message from user INTERnet on SRBVAX
INTERnet ACP Activate TELNET Server

%TCPIP-S-STARTDONE, TCPIP$TELNET startup completed
%TCPIP-S-STARTDONE, TCP/IP Services startup completed at 30-OCT-2011 00:02:39.52

%MOUNT-I-MOUNTED, DATA1 mounted on _SRBVAX$DUA1:
%MOUNT-I-MOUNTED, DATA2 mounted on _SRBVAX$DUA2:
%SET-I-INTSET, login interactive limit = 64, current interactive value = 0
  SYSTEM       job terminated at 30-OCT-2011 00:02:42.21

  Accounting information:
  Buffered I/O count:              2934         Peak working set size:    1954
  Direct I/O count:                 930         Peak page file size:      9046
  Page faults:                    15133         Mounted volumes:             2
  Charged CPU time:         0 00:00:52.60       Elapsed time:     0 00:01:21.95

 Welcome to OpenVMS (TM) VAX Operating System, Version V7.3

Username: vmisev
Password:
 Welcome to OpenVMS (TM) VAX Operating System, Version V7.3
    Last interactive login on Saturday, 29-OCT-2011 23:53
$
```

https://vladimirmishev.files.wordpress.com/2011/10/simh-vax_openvms_73_login1.png

Wait, what's a VAX?

Virtual Address eXtension/Virtual Memory System (VAX/VMS)

- Created by Digital Equipment Corporation (DEC) in the '70s
- VAX is the 32-bit CISC architecture
- OpenVMS (VMS) is the operating system name
- VMS is not Unix

VAX vs VMS

Keeping them straight

- VAX is the hardware architecture

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

- VMS is the operating system

OpenVMS

https://vmssoftware.com/products/openvms/

OpenVMS

DEC => Compaq => Hewlett-Packard => VMS Software Inc (VSI)

- Multi-user
- Multiprocessing
- Virtual memory
- Time sharing
- Batch processing
- Transaction processing
- Spiritual predecessor to Windows NT

Albert the Cheshire Cat

Data Recovery

1 Recovery data from a Linux system

Unknown OS: VAX/VMS

Recover data from an unknown (to us) OS: VAX/VMS. 2

Ok, so what now?

Surveying the lay of the land

- What commands or tools exist on the system?
- What could we use to transfer the data?
- Where was the data located?
- What kind of data are we looking to recover?

Some VMS commands
DIGITAL Command Language (DCL)

- VMS / Unix command comparisons:
  - https://www3.physnet.uni-hamburg.de/physnet/vms-unix-commands.html
- Most commands we were not familiar with or never heard of except for...

VMS	*NIX
SET DEFAULT [DIR]	cd [dir]
TYPE [FILE]	cat [file]
SHOW PROCESSES /ALL	ps -l
DIRECTORY	ls
SEARCH	grep

FTP to the rescue!

Just FTP the files off!

- Setup a userspace FileZilla FTP server on the pivot box
- Recursively send files back to it

- High-five each other on how smart we are and how easy this was

A few GB later...

“Just” FTP the files off

- ERROR: Not enough disk space on the pivot machine to host the data
- Disallowed to:
  - Attach a USB drive
  - Add another HDD
  - Disrupt production server

Booting up the VM

Uh...wut

Advanced Virtualization Technologies

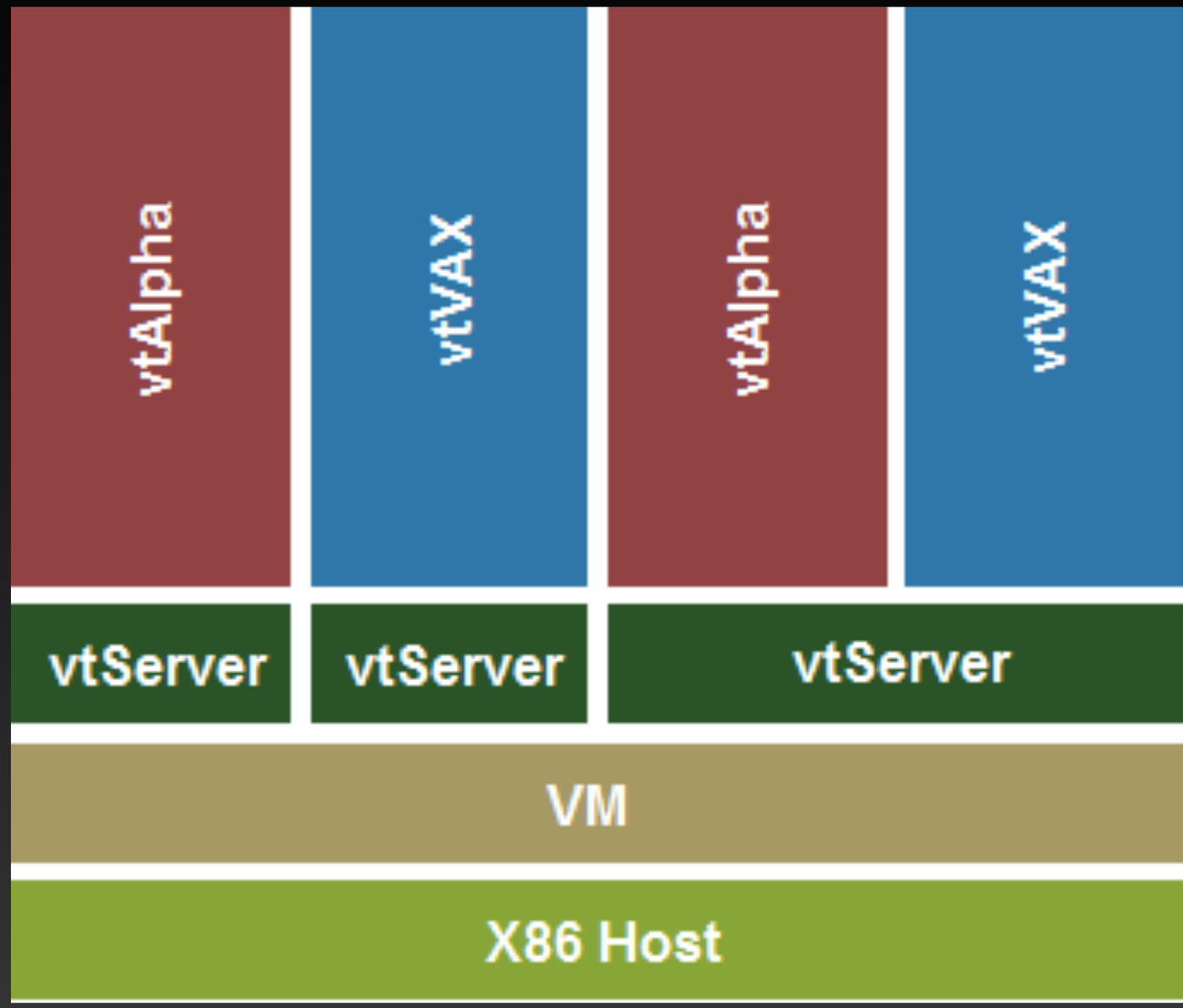
“Modernize Without Making Changes”

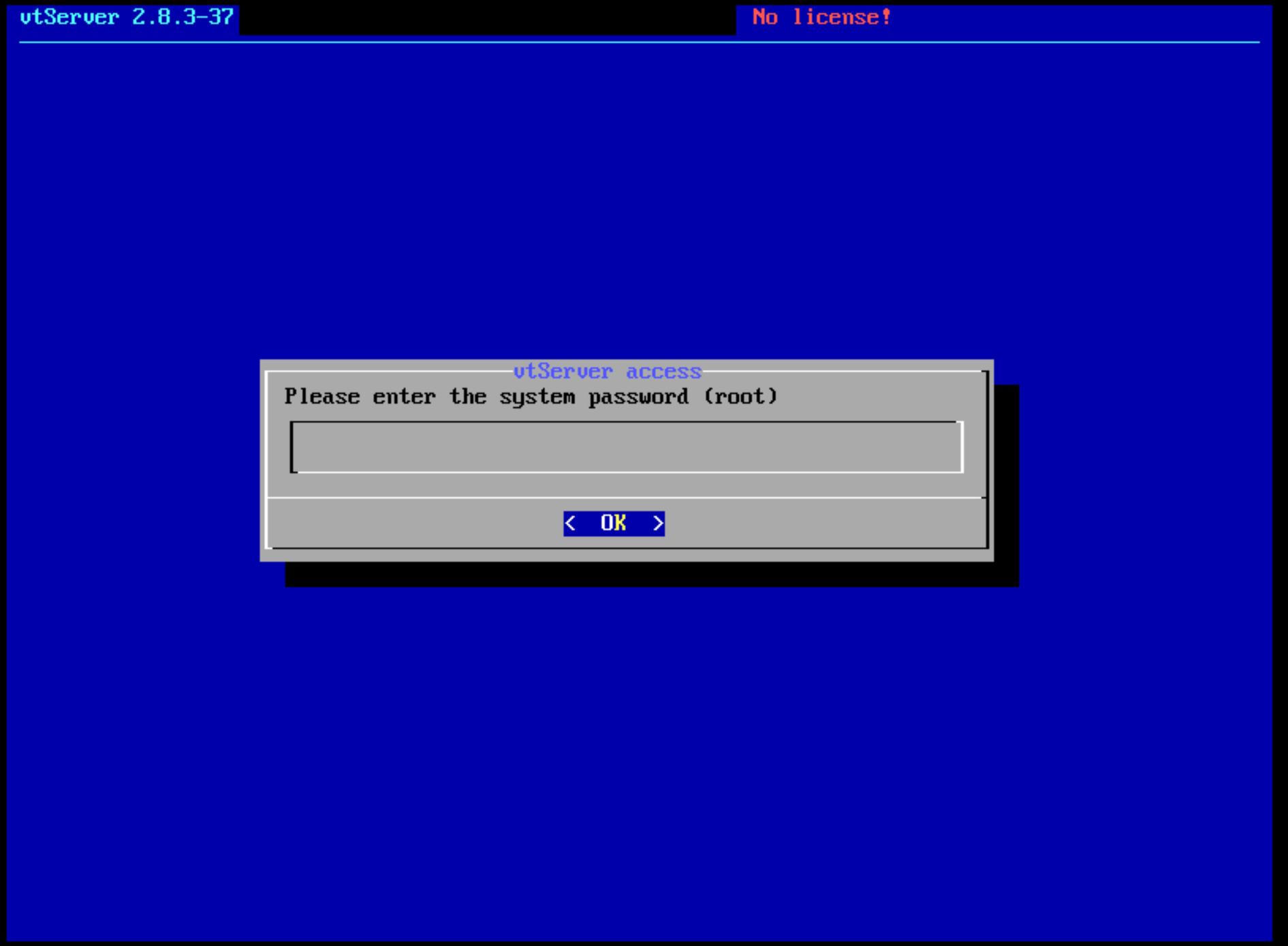
- Run on modern hardware (X86)
- Run on virtual machines (VMware, Hyper-V, KVM, XEN)
- Use the latest storage technologies
- Consolidate multiple VAX and Alpha systems on a single host
- Build installations that are disaster resilient
- Run in the cloud
- Keep your processes as they were

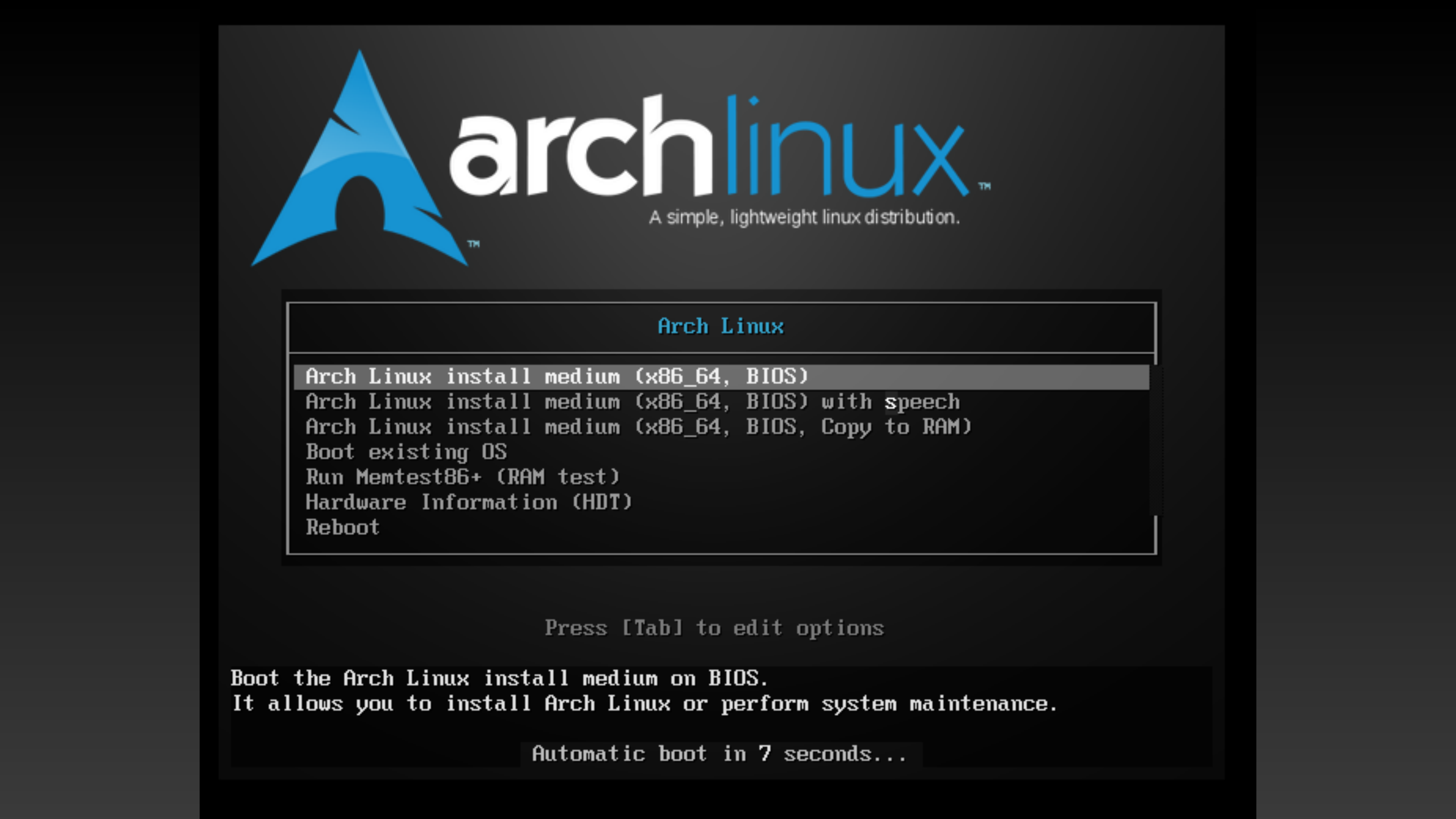
https://www.avtware.com/

Server configuration

- vtVAX running in an AVT VM
- AVT VM running on x86 host




vtServer 2.8.3-37
No license!
vtServer access
Please enter the system password (root)
< OK >


archlinux
A simple, lightweight linux distribution.
Arch Linux
Arch Linux install medium (x86_64, BIOS)
Arch Linux install medium (x86_64, BIOS) with speech
Arch Linux install medium (x86_64, BIOS, Copy to RAM)
Boot existing OS
Run Memtest86+ (RAM test)
Hardware Information (HDT)
Reboot
Press [Tab] to edit options
Boot the Arch Linux install medium on BIOS.
It allows you to install Arch Linux or perform system maintenance.
Automatic boot in 7 seconds...

```
Arch Linux 5.17.5-arch1-1 (tty1)

archiso login: root (automatic login)

To install Arch Linux follow the installation guide:
https://wiki.archlinux.org/title/Installation_guide

For Wi-Fi, authenticate to the wireless network using the iwctl utility.
For mobile broadband (WWAN) modems, connect with the mmcli utility.
Ethernet, WLAN and WWAN interfaces using DHCP should work automatically.

After connecting to the internet, the installation guide can be accessed
via the convenience script Installation_guide.

root@archiso ~ # lsblk
NAME   MAJ:MIN RM   SIZE RO TYPE MOUNTPOINTS
fd0      2:0    1     4K  0 disk
loop0    7:0    0 669.2M  1 loop /run/archiso/airootfs
sda      8:0    0    20G  0 disk
└─sda1   8:1    0    20G  0 part
sdb      8:16   0   800G  0 disk
└─sdb1   8:17   0   800G  0 part
sdc      8:32   0   800G  0 disk
└─sdc1   8:33   0   800G  0 part
sr0     11:0    1 826.3M  0 rom  /run/archiso/bootmnt
root@archiso ~ # mkdir /mnt/{a,b,c}
root@archiso ~ # mount /dev/sda1 /mnt/a
root@archiso ~ # mount /dev/sdb1 /mnt/b
root@archiso ~ # mount /dev/sdc1 /mnt/c
root@archiso ~ # _
```

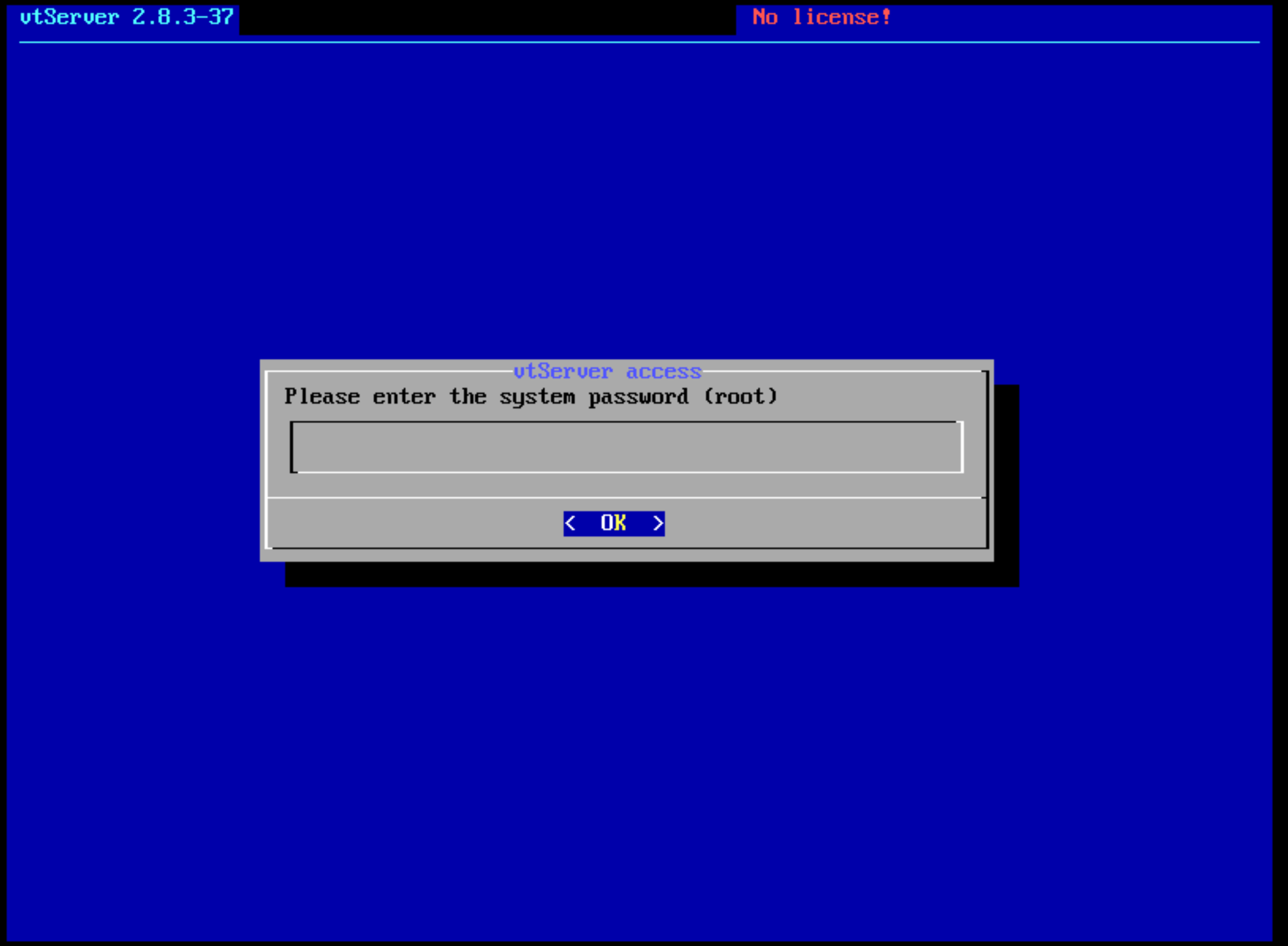
```
root@archiso /mnt # ls *
a:
bin   dev    etc   lib    lost+found  mnt  proc  sbin  swapfile  tmp    update  var      vtVax
boot  disks  home  lib64  media       opt  root  srv   sys       tools  usr     vtAlpha

b:
dkd0.vdisk    dkd300.vdisk  dkd600.vdisk  dke202.vdisk  dke205.vdisk  lost+found
dkd100.vdisk  dkd400.vdisk  dke200.vdisk  dke203.vdisk  dke206.vdisk  v83.vdisk
dkd200.vdisk  dkd500.vdisk  dke201.vdisk  dke204.vdisk  dke207.vdisk

c:
lost+found  xfer
root@archiso /mnt #
```

```
at:*:18585:0:99999:7:::
avahi:*:18977:0:99999:7:::
bin:*:18585:0:99999:7:::
daemon:*:18585:0:99999:7:::
dhcpcd:*:18585:0:99999:7:::
dnsmasq:*:18585:0:99999:7:::
ftp:*:18585:0:99999:7:::
ftpsecure:*:18585:0:99999:7:::
games:*:18585:0:99999:7:::
lp:*:18585:0:99999:7:::
mail:*:18585:0:99999:7:::
man:*:18585:0:99999:7:::
messagebus:*:18585:0:99999:7:::
news:*:18585:0:99999:7:::
nobody:*:18585:0:99999:7:::
ntp:*:18585:0:99999:7:::
postfix:*:18585:0:99999:7:::
root:$y$j9T$f9tgmB/IgJlSCC9BPUlyp0$0fdy3haQRi/h8IVOnUPReI9Vk5V0SNIWYXuyJc2bnZD:18585:0:99999:7:::
sshd:*:18585:0:99999:7:::
statd:*:18585:0:99999:7:::
uucp:*:18585:0:99999:7:::
wwwrun:*:18585:0:99999:7:::
usbmux:*:18585:0:99999:7:::
polkituser:*:18585:0:99999:7:::
haldaemon:*:18585:0:99999:7:::
avtmgmt:$y$j9T$qC8bQsbFrSJ3hgPyd8aTb/$zi/rJEWEY9EWtt7dkglhKgeRrcbctINWeqfIc0iLqg8:19130:0:99999:7:::
```

/mnt/a/etc/shadow

```
at:*:18585:0:99999:7:::
avahi:*:18977:0:99999:7:::
bin:*:18585:0:99999:7:::
daemon:*:18585:0:99999:7:::
dhcpcd:*:18585:0:99999:7:::
dnsmasq:*:18585:0:99999:7:::
ftp:*:18585:0:99999:7:::
ftpsecure:*:18585:0:99999:7:::
games:*:18585:0:99999:7:::
lp:*:18585:0:99999:7:::
mail:*:18585:0:99999:7:::
man:*:18585:0:99999:7:::
messagebus:*:18585:0:99999:7:::
news:*:18585:0:99999:7:::
nobody:*:18585:0:99999:7:::
ntp:*:18585:0:99999:7:::
postfix:*:18585:0:99999:7:::
root::18585:0:99999:7:::
sshd:*:18585:0:99999:7:::
statd:*:18585:0:99999:7:::
uucp:*:18585:0:99999:7:::
wwwrun:*:18585:0:99999:7:::
usbmux:*:18585:0:99999:7:::
polkituser:*:18585:0:99999:7:::
haldaemon:*:18585:0:99999:7:::
avtmgmt::19130:0:99999:7:::
```

/mnt/a/etc/shadow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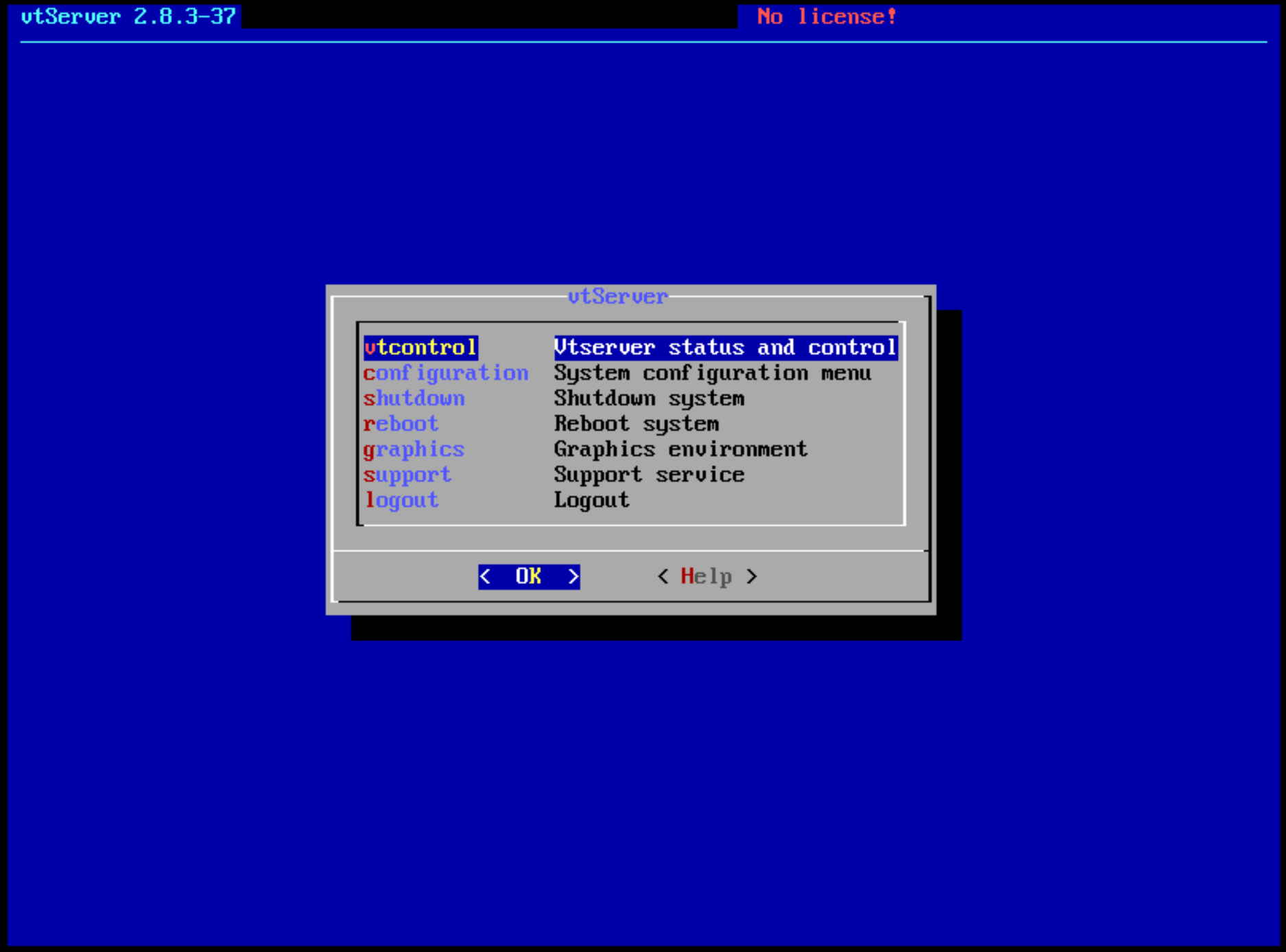
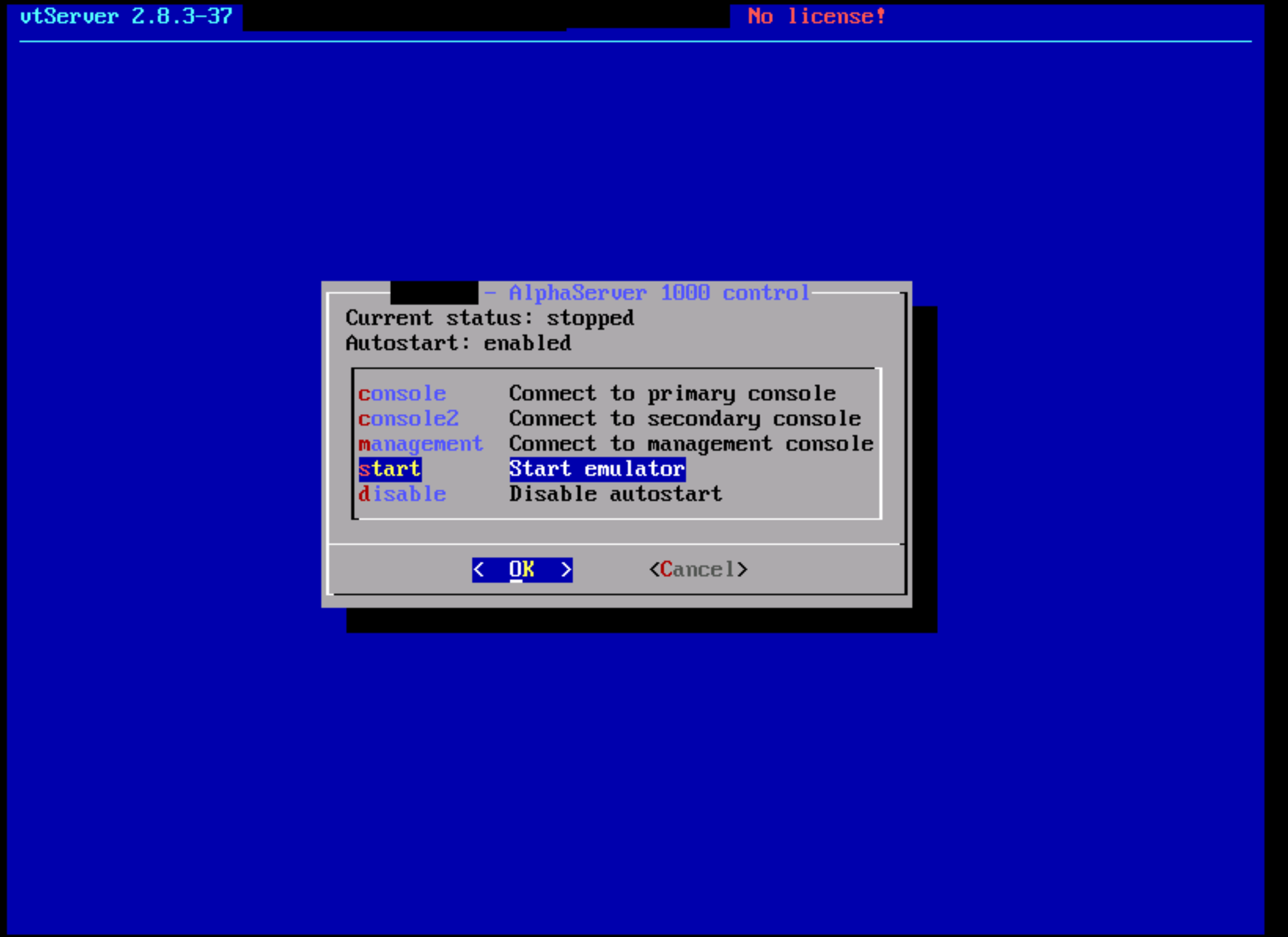
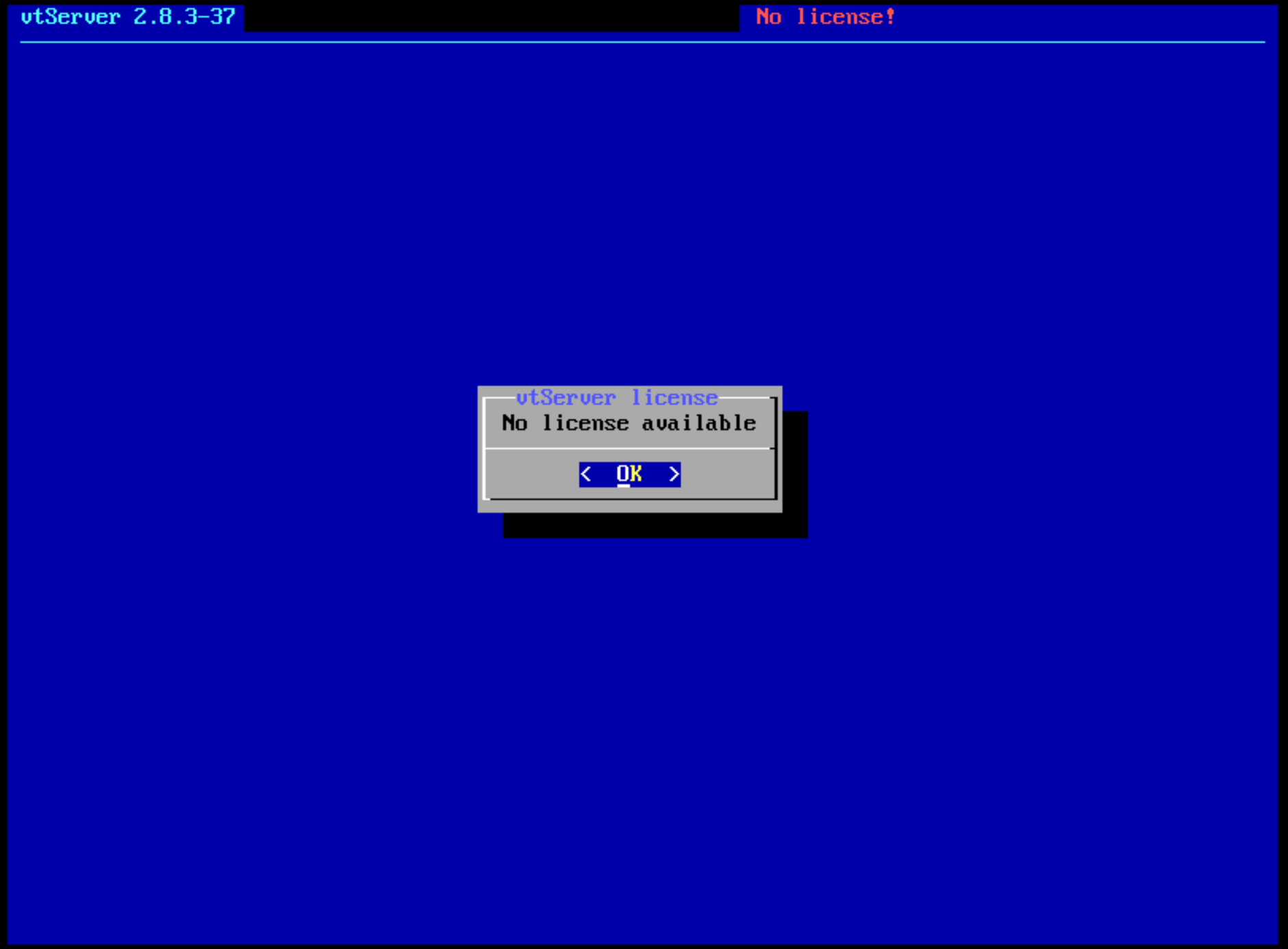

vtServer 2.8.3-37
No license!
vtServer
vtcontrol Vtserver status and control
configuration System configuration menu
shutdown Shutdown system
reboot Reboot system
graphics Graphics environment
support Support service
logout Logout
< OK >
< Help >


vtServer 2.8.3-37
No license!
- AlphaServer 1000 control
Current status: stopped
Autostart: enabled
console Connect to primary console
console2 Connect to secondary console
management Connect to management console
start Start emulator
disable Disable autostart
< OK >
<Cancel>


vtServer 2.8.3-37
No license!
vtServer license
No license available
< OK >

Not so fast, buckaroo

- AVT requires a license :(
- No USB license fob was given for our VM clone
  - In use on their production VM

Investigating the Licensing

License checker

- Identify the binary responsible for validating the USB key fob
- Moment of truth, do we decide to hunker down and do some RE or...?

1

Data Recovery

Recovery data from a Linux system

2

Unknown OS: VAX/VMS

Recover data from an unknown (to us) OS: VAX/VMS.

3

VM within a VM

Recover data from a licensed-locked VAX/VMS emulated within a Linux VM.

Surely there's a ~~better~~ easier way

Continuing to investigate the system…

- We’ve located the virtual hard disks
- Copy the virtual disks off
- Try to mount them on our linux host
  - Of course that doesn’t work

Emulation!

After all, it’s what they’re doing

- There are several VAX emulators to choose from
  - SIMH
  - VAX MP
  - FreeAXP
  - Charon-AXP (Alpha)
  - ...others?

Success…ish!

- Able to boot the VMS image!
- Unable to mount the data drives
  - Disks identify as a RAID5/6
  - No idea how to create / mount RAID drives in OpenVMS
  - Emulator we used had more configuration that we knew how to use

```
root@archiso /mnt # file b/dkd0.vdisk
b/dkd0.vdisk: Files-11 On-Disk Structure (ODS-2); VAX/VMS or OpenVMS file system; volume label is 'A
XPVMSSYS   '
root@archiso /mnt # _
```

```
root@archiso /mnt # file b/dkd0.vdisk
b/dkd0.vdisk: Files-11 On-Disk Structure (ODS-2); VAX/VMS or OpenVMS file system; volume label is 'A
XPVMSSYS   '
root@archiso /mnt # mkdir tmp
root@archiso /mnt # mount b/dkd0.vdisk tmp
mount: /mnt/tmp: wrong fs type, bad option, bad superblock on /dev/loop1, missing codepage or helper
 program, or other error.
       dmesg(1) may have more information after failed mount system call.
32 root@archiso /mnt # _                                                              :(
```

Mounting the drives with ods2util

Loop device

`losetup`

- tl;dr:
  - A loop device makes a file look like a hard drive
- Longer:
  - A loop device maps a file to a block device so it can be accessed as if it were a block device
- Thorough:
  - `man loop`

Setup the disk image as a loop device

```
$ sudo losetup -f vmimage.vdisk
$ sudo losetup
NAME       SIZELIMIT OFFSET AUTOCLEAR RO BACK-FILE                                                DIO LOG-SEC
/dev/loop1         0      0         1  1 /var/lib/snapd/snaps/core_11420.snap                        0     512
/dev/loop4         0      0         0  0 /data/_data/nolacon-2022-neckbeard-talk/ods2util/vmimage.vdisk   0     512
/dev/loop2         0      0         1  1 /var/lib/snapd/snaps/core18_2074.snap                       0     512
/dev/loop0         0      0         1  1 /var/lib/snapd/snaps/core18_2066.snap                       0     512
/dev/loop3         0      0         1  1 /var/lib/snapd/snaps/core_11316.snap                        0     512
```

ods2

```
$ sudo ./ods2 mount loop4
 ODS2 V1.3hb
%MOUNT-I-MOUNTED, Volume VAXVMS047A   mounted on loop4:
$>
```

ods2

```
$> dir

Directory loop4:[000000]

000000.DIR;1          BACKUP.SYS;1          BADBLK.SYS;1          BADLOG.SYS;1
BITMAP.SYS;1          CONTIN.SYS;1          CORIMG.SYS;1          INDEXF.SYS;1
LIBRARY.;1            OPTIONAL.;1           PRODUCTS.DIR;1        REQUIRED.;1
SECURITY_UPD020.A;1   SECURITY_UPD020.B;1   SECURITY_UPD020.C;1   SYS0.DIR;1
V47SECUPD030.A;1      VMS047.A;1            VMS047.B;1            VMS047.C;1
VMSMUP046.A;1         VMSMUP046.B;1         VMSMUP046.C;1         VOLSET.SYS;1

Total of 24 files.
$>
```

ods2

```
$> copy INDEXF.SYS indexf.sys
%COPY-S-COPIED, loop4:[000000]INDEXF.SYS;1 copied to indexf.sys (1041
records)
%COPY-S-NEWFILES, 1 file created
$> exit
$ ls -al indexf.sys
-rw-r--r-- 1 root root 532992 May  8 22:53 indexf.sys
```

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Unknown OS: VAX/VMS
Recover data from an unknown (to us) OS: VAX/VMS.

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VM within a VM
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4
Mount ODS-2 FS
Recover data from RAID disk images.

What if there's an easier way still

Use the ods5fs LKM

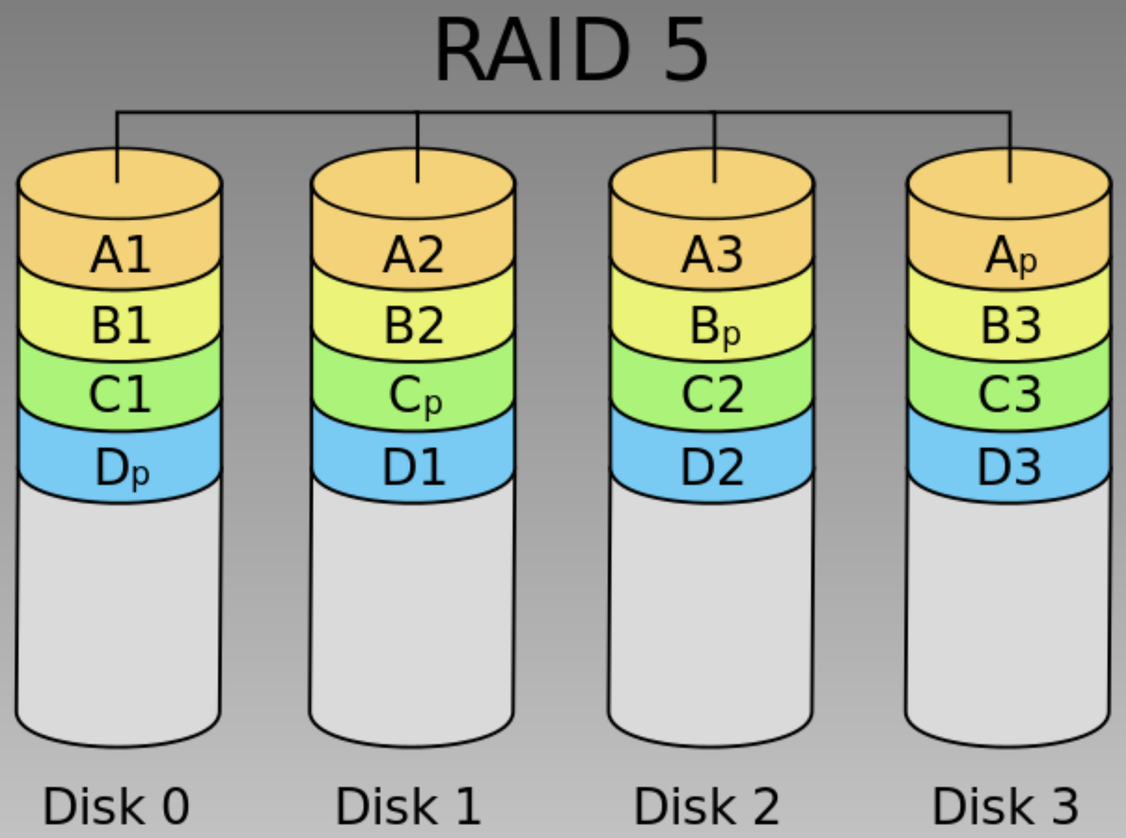
At least this way we don’t have to compile it ourselves

- Lets just use the pre-built TinyCore image we found on the internet with the LKM already loaded!
- Source code for ods5fs has not been released by the author :(
- www.vms2linux.de/TC-remastered.iso

RAID

“Redundant Array of Independent Disks”

- RAID “levels”:
  - RAID 0
  - RAID 1
  - RAID 5
  - RAID 6
  - RAID 10
  - RAID 50
  - Etc...



This RAID is weird, m'kay

- Non-standard RAID, possibly "Declustered Raid"
  - https://en.wikipedia.org/wiki/Non-standard_RAID_levels#Declustered_RAID
- With ods5fs we were able to mount each RAID member separately, and copy off complete files

```
tc@box:~$ sudo losetup -f example.vdisk
tc@box:~$ losetup -a
/dev/loop0: 0 example.vdisk
tc@box:~$
```

Terminal

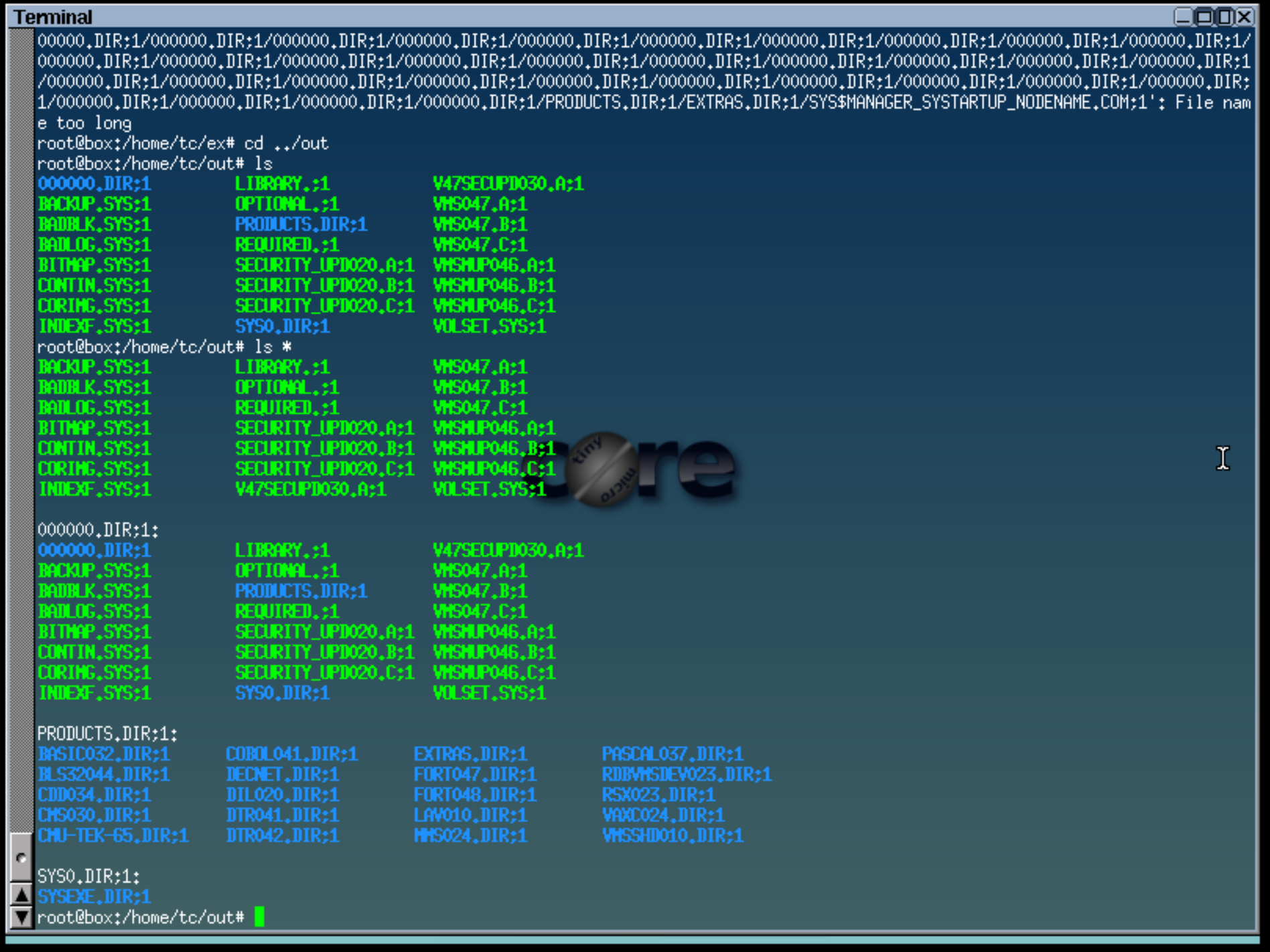
```
tc@box:~$ sudo mount /dev/loop0 ex
tc@box:~$ sudo ls ex
000000.DIR;1          LIBRARY.;1            V47SECUPD030.A;1
BACKUP.SYS;1          OPTIONAL.;1           VMS047.A;1
BADBLK.SYS;1          PRODUCTS.DIR;1        VMS047.B;1
BADLOG.SYS;1          REQUIRED.;1           VMS047.C;1
BITMAP.SYS;1          SECURITY_UPD020.A;1   VMSMUP046.A;1
CONTIN.SYS;1          SECURITY_UPD020.B;1   VMSMUP046.B;1
CORIMG.SYS;1          SECURITY_UPD020.C;1   VMSMUP046.C;1
INDEXF.SYS;1          SYS0.DIR;1            VOLSET.SYS;1
tc@box:~$
```

Terminal

```
root@box:/home/tc/ex# ls
000000.DIR;1            LIBRARY.;1              V47SECUPD030.A;1
BACKUP.SYS;1            OPTIONAL.;1             VMS047.A;1
BADBLK.SYS;1            PRODUCTS.DIR;1          VMS047.B;1
BADLOG.SYS;1            REQUIRED.;1             VMS047.C;1
BITMAP.SYS;1            SECURITY_UPD020.A;1     VMSMUP046.A;1
CONTIN.SYS;1            SECURITY_UPD020.B;1     VMSMUP046.B;1
CORIMG.SYS;1            SECURITY_UPD020.C;1     VMSMUP046.C;1
INDEXF.SYS;1            SYS0.DIR;1              VOLSET.SYS;1
root@box:/home/tc/ex# mkdir ../out
root@box:/home/tc/ex# cp -r * ../out/
```

Terminal

```
.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000
0.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/0000
00.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000
000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/00
0000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/0
00000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/
000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1
/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;
1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/PRODUCTS.DIR;1/EXTRAS.DIR;1/SYS$MANAGER_SYPAGSWPFILES.COM;1': File name too
 long
cp: can't stat '../out/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/00
0000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/0
00000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/
000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1
/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;
1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR
;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DI
R;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.D
IR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.
DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000
.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/00000
0.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/0000
00.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000
000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/00
0000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/0
00000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/
000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1
/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;
1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/PRODUCTS.DIR;1/EXTRAS.DIR;1/SYS$MANAGER_SYSTARTUP_NODENAME.COM;1': File nam
e too long
root@box:/home/tc/ex#
```


Terminal
000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/
000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1
/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;
1/000000.DIR;1/000000.DIR;1/000000.DIR;1/000000.DIR;1/PRODUCTS.DIR;1/EXTRAS.DIR;1/SYS$MANAGER_SYSTARTUP_NODENAME.COM;1': File nam
e too long
root@box:/home/tc/ex# cd ../out
root@box:/home/tc/out# ls
000000.DIR;1 LIBRARY.;1 V47SECUPD030.A;1
BACKUP.SYS;1 OPTIONAL.;1 VMS047.A;1
BADBLK.SYS;1 PRODUCTS.DIR;1 VMS047.B;1
BADLOG.SYS;1 REQUIRED.;1 VMS047.C;1
BITMAP.SYS;1 SECURITY_UPD020.A;1 VMSMUP046.A;1
CONTIN.SYS;1 SECURITY_UPD020.B;1 VMSMUP046.B;1
CORIMG.SYS;1 SECURITY_UPD020.C;1 VMSMUP046.C;1
INDEXF.SYS;1 SYS0.DIR;1 VOLSET.SYS;1
root@box:/home/tc/out# ls *
BACKUP.SYS;1 LIBRARY.;1 VMS047.A;1
BADBLK.SYS;1 OPTIONAL.;1 VMS047.B;1
BADLOG.SYS;1 REQUIRED.;1 VMS047.C;1
BITMAP.SYS;1 SECURITY_UPD020.A;1 VMSMUP046.A;1
CONTIN.SYS;1 SECURITY_UPD020.B;1 VMSMUP046.B;1
CORIMG.SYS;1 SECURITY_UPD020.C;1 VMSMUP046.C;1
INDEXF.SYS;1 V47SECUPD030.A;1 VOLSET.SYS;1
000000.DIR;1:
000000.DIR;1 LIBRARY.;1 V47SECUPD030.A;1
BACKUP.SYS;1 OPTIONAL.;1 VMS047.A;1
BADBLK.SYS;1 PRODUCTS.DIR;1 VMS047.B;1
BADLOG.SYS;1 REQUIRED.;1 VMS047.C;1
BITMAP.SYS;1 SECURITY_UPD020.A;1 VMSMUP046.A;1
CONTIN.SYS;1 SECURITY_UPD020.B;1 VMSMUP046.B;1
CORIMG.SYS;1 SECURITY_UPD020.C;1 VMSMUP046.C;1
INDEXF.SYS;1 SYS0.DIR;1 VOLSET.SYS;1
PRODUCTS.DIR;1:
BASIC032.DIR;1 COBOL041.DIR;1 EXTRAS.DIR;1 PASCAL037.DIR;1
BLS32044.DIR;1 DECNET.DIR;1 FORT047.DIR;1 RDBVMSDEV023.DIR;1
CDD034.DIR;1 DIL020.DIR;1 FORT048.DIR;1 RSX023.DIR;1
CMS030.DIR;1 DTR041.DIR;1 LAV010.DIR;1 VAXC024.DIR;1
CMU-TEK-65.DIR;1 DTR042.DIR;1 MMS024.DIR;1 VMSSHD010.DIR;1
SYS0.DIR;1:
SYSEXE.DIR;1
root@box:/home/tc/out#

FINALLY! Data extraction

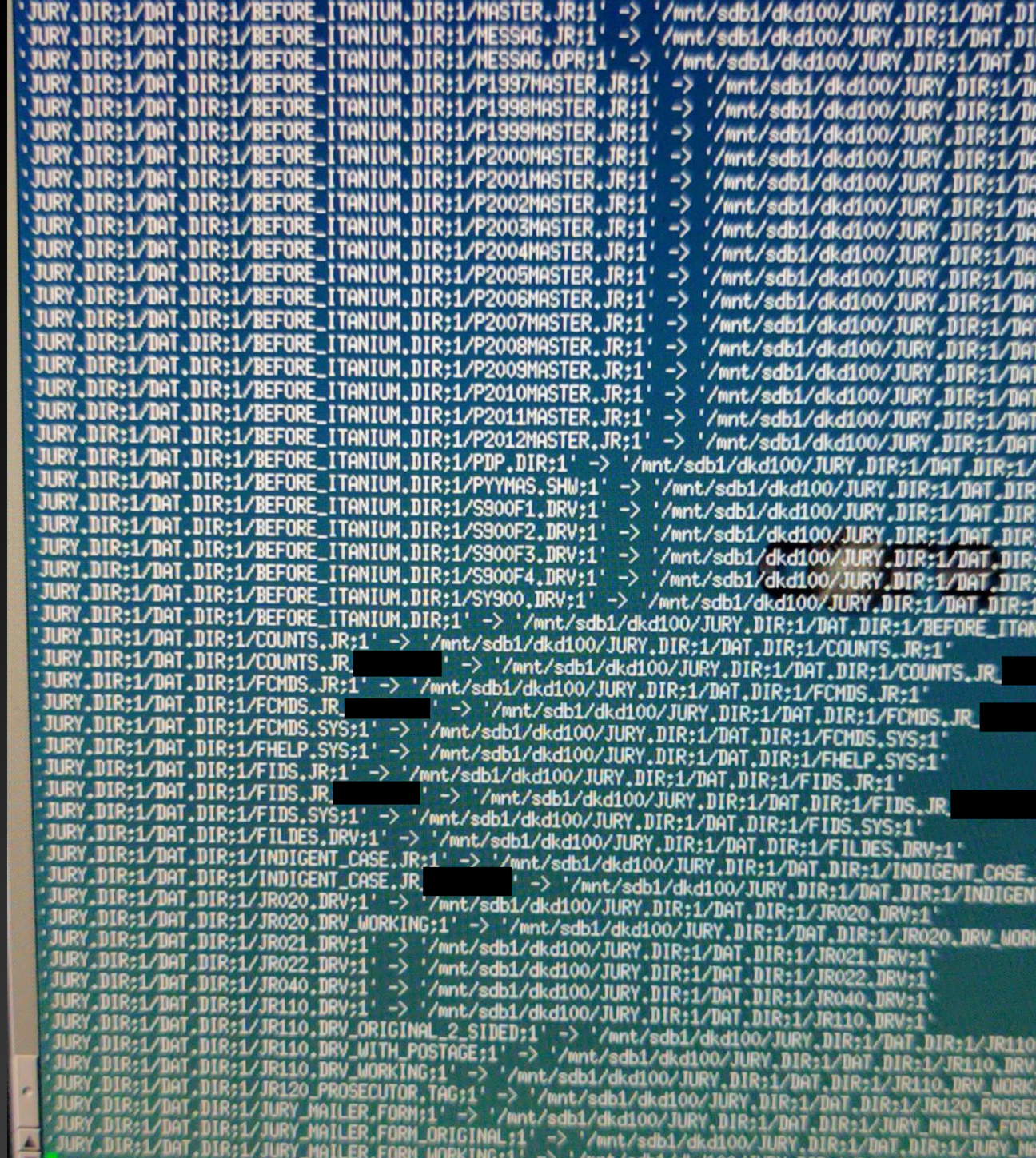
High-five each other on how smart we are and how easy this was

Types of Data Recovered

- This particular VAX/VMS was apparently used for at least:
  - County Payroll
  - Jury / Jail / Juvenile Detention
  - Sewer / Billing
  - Title Records

Copying data

- Copy each disk image separately
- Raw disk images take up ~2TB
- 3,553,517 individual files
- Extracted data takes up 290GB



rmlint

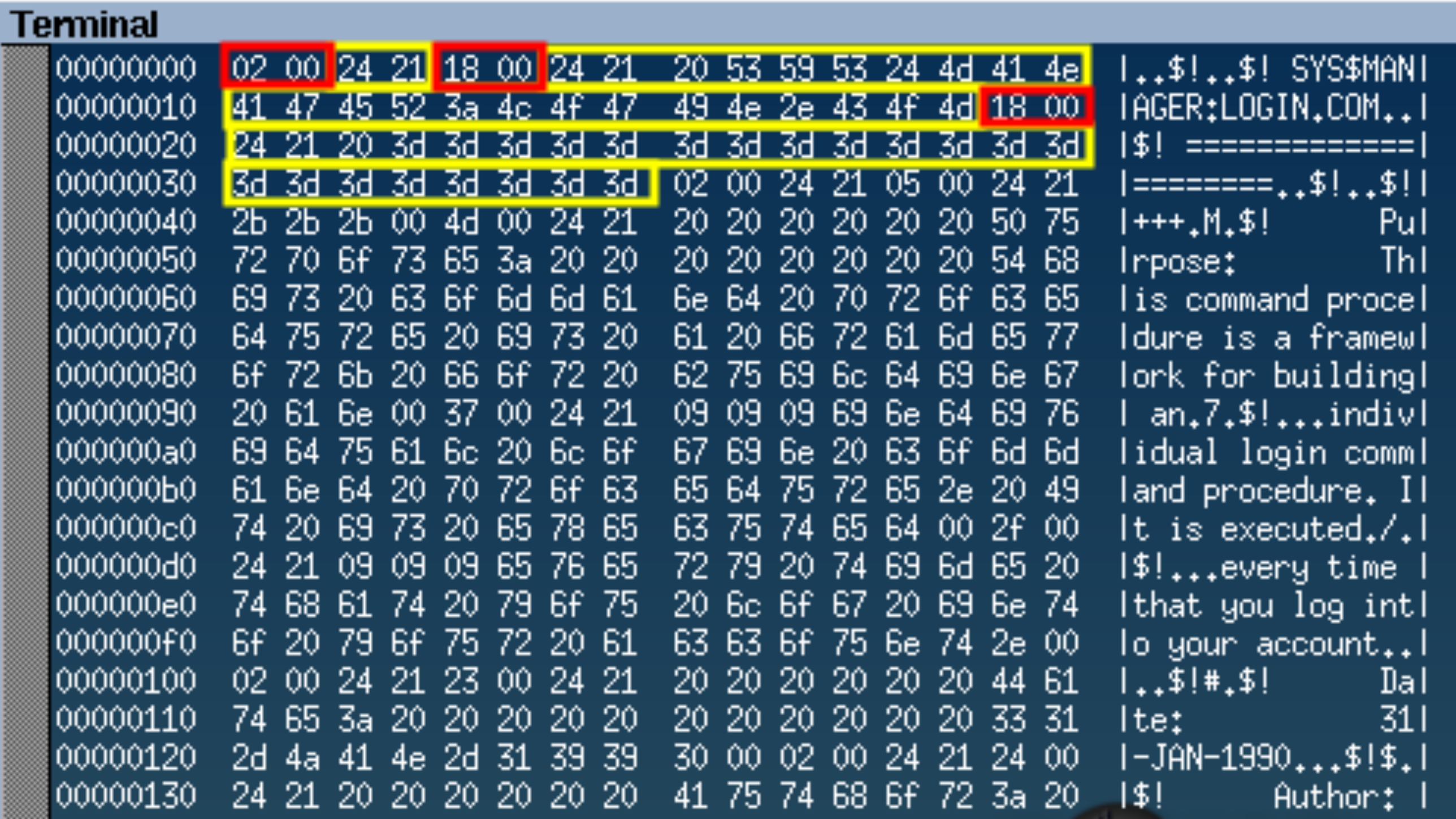
- Used rmlint to identify and remove duplicated files
- Copied in data to a single mount point to validate the folder structure matched the original
- Deduplicated extracted data size: 166GB
- Unique files: 1,909,568

- High-five each other on how smart we are and how easy this was

```
[geno@daedalus vaxuum]$ cat SYS\$MANAGER_LOGIN.COM\;1|head
$!$! SYS$MANAGER:LOGIN.COM$! ======================$!$!+++M$!      Purpose:        This command procedure
is a framework for building an7$!                          individual login command procedure. It is execute
d/$!                    every time that you log into your account.$!#$!      Date:             31-JAN-1990$
!$$!      Author:          Andy Hoffman$!6$!     Company:         Shell UK Limited (Wythenshawe, Manchester
)$!$!      Parameters:      NONE.$!$!      Modifications:$!7$!      31-JAN-1990     Akh     File created a
nd tested4$!    12-JUN-2018     Akh     Added several symbols specific to#$!                              t
he system manager's account.3$! 15-JAN-2019     Akh     Added the call to SET_PROMPT.COM$!---$!5$  IF F$M
ODE() .NES. "INTERACTIVE" THEN GOTO ENDINTER$!C$! Put commands that you want executed only on an interact
ive login3$! between this comment and the "ENDINTER:" symbol.$!E$ SHUTDOWN  == "@SYS$SYSTEM:SHUTDOWN 0 SH
UTDOWN YES NO LATER NO NONE"C$ REBOOT == "@SYS$SYSTEM:SHUTDOWN 0 SHUTDOWN YES NO LATER YES NONE"%$ SHUTDO
WN1 == "@SYS$SYSTEM:SHUTDOWN"$!1$       Set Terminal /Inquire /Insert /Line /Edit$!$    Bl      :== Show
Queue/All/Batch$        Cls     :== Type/Page NL:$      Cp      :== Copy/Log$   Del     :== Delete/Log!$D
ir      :== Directory/Date/Size=All$    Eve     :== Edit/Tpu!$  Hom*e   :== Set Default Sys$Login$
Kill    :== Stop/ID=$       Log*out     :== Logout/Full $       Mpc     :== Monitor Process/Topcpu$     N
cp      :== $Sys$System:Ncp$    Pur     :== Purge/Log $ Rew*ind :== Set Magtape/Rewind$ Say     :== "Writ
e Sys$Output"$  Sd      :== Set Default     !$  Spc     :== Show Process/Contin/Id=$    Sq      :== Show
Queue/All/Device$       Ss      :== Show System%$       Uaf     :== $Sys$System:Authorize$      Up      :
== Set Default [-]$     W80     :== Set Terminal/Width=80!$     W132    :== Set Terminal/Width=132$!$   @
Sys$Manager:Set_Prompt.Com$     Cls$
$ENDINTER:/$  IF F$MODE() .NES. "BATCH" THEN GOTO ENDBATCH$!I$! Put commands you want executed only in ba
tch mode between this comment$! and the "ENDBATCH:" symbol.$!$
$ENDBATCH:$!B$! Put commands that you want executed in any mode of login below.$!$[geno@daedalus vaxuum]$
```

Terminal

```
00000000  02 00 24 21 18 00 24 21  20 53 59 53 24 4d 41 4e  |..$!..$! SYS$MAN|
00000010  41 47 45 52 3a 4c 4f 47  49 4e 2e 43 4f 4d 18 00  |AGER:LOGIN.COM..|
00000020  24 21 20 3d 3d 3d 3d 3d  3d 3d 3d 3d 3d 3d 3d 3d  |$! ==============|
00000030  3d 3d 3d 3d 3d 3d 3d 3d  02 00 24 21 05 00 24 21  |========..$!..$!|
00000040  2b 2b 2b 00 4d 00 24 21  20 20 20 20 20 20 50 75  |+++.M.$!      Pu|
00000050  72 70 6f 73 65 3a 20 20  20 20 20 20 20 20 54 68  |rpose:        Th|
00000060  69 73 20 63 6f 6d 6d 61  6e 64 20 70 72 6f 63 65  |is command proce|
00000070  64 75 72 65 20 69 73 20  61 20 66 72 61 6d 65 77  |dure is a framew|
00000080  6f 72 6b 20 66 6f 72 20  62 75 69 6c 64 69 6e 67  |ork for building|
00000090  20 61 6e 00 37 00 24 21  09 09 09 69 6e 64 69 76  | an.7.$!...indiv|
000000a0  69 64 75 61 6c 20 6c 6f  67 69 6e 20 63 6f 6d 6d  |idual login comm|
000000b0  61 6e 64 20 70 72 6f 63  65 64 75 72 65 2e 20 49  |and procedure. I|
000000c0  74 20 69 73 20 65 78 65  63 75 74 65 64 00 2f 00  |t is executed./.|
000000d0  24 21 09 09 09 65 76 65  72 79 20 74 69 6d 65 20  |$!...every time |
000000e0  74 68 61 74 20 79 6f 75  20 6c 6f 67 20 69 6e 74  |that you log int|
000000f0  6f 20 79 6f 75 72 20 61  63 63 6f 75 6e 74 2e 00  |o your account..|
00000100  02 00 24 21 23 00 24 21  20 20 20 20 20 20 44 61  |..$!#.$!      Da|
00000110  74 65 3a 20 20 20 20 20  20 20 20 20 20 20 33 31  |te:           31|
00000120  2d 4a 41 4e 2d 31 39 39  30 00 02 00 24 21 24 00  |-JAN-1990...$!$.|
00000130  24 21 20 20 20 20 20 20  41 75 74 68 6f 72 3a 20  |$!      Author: |
```


Terminal
00000000 02 00 24 21 18 00 24 21 20 53 59 53 24 4d 41 4e |..$!..$! SYS$MAN|
00000010 41 47 45 52 3a 4c 4f 47 49 4e 2e 43 4f 4d 18 00 |AGER:LOGIN.COM..|
00000020 24 21 20 3d 3d 3d 3d 3d 3d 3d 3d 3d 3d 3d 3d 3d |$! ==========|
00000030 3d 3d 3d 3d 3d 3d 3d 3d 02 00 24 21 05 00 24 21 |========..$!..$!|
00000040 2b 2b 2b 00 4d 00 24 21 20 20 20 20 20 20 50 75 |+++.M.$! Pu|
00000050 72 70 6f 73 65 3a 20 20 20 20 20 20 20 20 54 68 |rpose: Th|
00000060 69 73 20 63 6f 6d 6d 61 6e 64 20 70 72 6f 63 65 |is command proce|
00000070 64 75 72 65 20 69 73 20 61 20 66 72 61 6d 65 77 |dure is a framew|
00000080 6f 72 6b 20 66 6f 72 20 62 75 69 6c 64 69 6e 67 |ork for building|
00000090 20 61 6e 00 37 00 24 21 09 09 09 69 6e 64 69 76 | an.7.$!...indiv|
000000a0 69 64 75 61 6c 20 6c 6f 67 69 6e 20 63 6f 6d 6d |idual login comm|
000000b0 61 6e 64 20 70 72 6f 63 65 64 75 72 65 2e 20 49 |and procedure. I|
000000c0 74 20 69 73 20 65 78 65 63 75 74 65 64 00 2f 00 |t is executed./.|
000000d0 24 21 09 09 09 65 76 65 72 79 20 74 69 6d 65 20 |$!...every time |
000000e0 74 68 61 74 20 79 6f 75 20 6c 6f 67 20 69 6e 74 |that you log int|
000000f0 6f 20 79 6f 75 72 20 61 63 63 6f 75 6e 74 2e 00 |o your account..|
00000100 02 00 24 21 23 00 24 21 20 20 20 20 20 20 44 61 |..$!#.$! Da|
00000110 74 65 3a 20 20 20 20 20 20 20 20 20 20 20 33 31 |te: 31|
00000120 2d 4a 41 4e 2d 31 39 39 30 00 02 00 24 21 24 00 |-JAN-1990...$!$.|
00000130 24 21 20 20 20 20 20 20 41 75 74 68 6f 72 3a 20 |$! Author: |

Vaxuum to clean it up

Custom code

- Loop over:
  - Read in and parse the u16 little endian value
  - Read in value length worth of data
  - Write data out to new “.clean” file

- High-five each other on how smart we are and how easy this was

```
[geno@daedalus vaxuum]$ cat SYS\$MANAGER_LOGIN.COM\;1|head
$!$! SYS$MANAGER:LOGIN.COM$! ======================$!$!+++M$!      Purpose:        This command procedure
is a framework for building an7$!                          individual login command procedure. It is execute
d/$!                    every time that you log into your account.$!#$!      Date:             31-JAN-1990$
!$$!      Author:          Andy Hoffman$!6$!     Company:         Shell UK Limited (Wythenshawe, Manchester
)$!$!      Parameters:      NONE.$!$!      Modifications:$!7$!      31-JAN-1990     Akh     File created a
nd tested4$!    12-JUN-2018     Akh     Added several symbols specific to#$!                              t
he system manager's account.3$! 15-JAN-2019     Akh     Added the call to SET_PROMPT.COM$!---$!5$  IF F$M
ODE() .NES. "INTERACTIVE" THEN GOTO ENDINTER$!C$! Put commands that you want executed only on an interact
ive login3$! between this comment and the "ENDINTER:" symbol.$!E$ SHUTDOWN  == "@SYS$SYSTEM:SHUTDOWN 0 SH
UTDOWN YES NO LATER NO NONE"C$ REBOOT == "@SYS$SYSTEM:SHUTDOWN 0 SHUTDOWN YES NO LATER YES NONE"%$ SHUTDO
WN1 == "@SYS$SYSTEM:SHUTDOWN"$!1$       Set Terminal /Inquire /Insert /Line /Edit$!$    Bl      :== Show
Queue/All/Batch$        Cls     :== Type/Page NL:$      Cp      :== Copy/Log$   Del     :== Delete/Log!$D
ir      :== Directory/Date/Size=All$    Eve     :== Edit/Tpu!$  Hom*e   :== Set Default Sys$Login$
Kill    :== Stop/ID=$       Log*out     :== Logout/Full $       Mpc     :== Monitor Process/Topcpu$     N
cp      :== $Sys$System:Ncp$    Pur     :== Purge/Log $ Rew*ind :== Set Magtape/Rewind$ Say     :== "Writ
e Sys$Output"$  Sd      :== Set Default     !$  Spc     :== Show Process/Contin/Id=$    Sq      :== Show
Queue/All/Device$       Ss      :== Show System%$       Uaf     :== $Sys$System:Authorize$      Up      :
== Set Default [-]$     W80     :== Set Terminal/Width=80!$     W132    :== Set Terminal/Width=132$!$   @
Sys$Manager:Set_Prompt.Com$     Cls$
$ENDINTER:/$  IF F$MODE() .NES. "BATCH" THEN GOTO ENDBATCH$!I$! Put commands you want executed only in ba
tch mode between this comment$! and the "ENDBATCH:" symbol.$!$
$ENDBATCH:$!B$! Put commands that you want executed in any mode of login below.$!$[geno@daedalus vaxuum]$
```

```
[geno@daedalus vaxuum]$ cat SYS\$MANAGER_LOGIN.COM\;1.clean |head
$!
$! SYS$MANAGER:LOGIN.COM
$! ====================
$!
$!+++
$!      Purpose:        This command procedure is a framework for building an
$!                      individual login command procedure. It is executed
$!                      every time that you log into your account.
$!
$!      Date:           31-JAN-1990
```

```
geno@major:/data/_data/neckbeard$ cat dkd/GAMES.DIR\;1/SNOOPY.BAS\;3
>10     ! ***************************************************     !       !<      ! ***************************************
*****************7     PRINT "Direct Your Dog To Any Of The Following Files:"& PRINT "TT:--Keyboard,   LP:--Printer"   INPUT "Wh
PRINT.SNOOPY:9  ! ---------------------------------------------------        !       Print Snoopy Here9      ! ---------------
-----------------------------------          PRINT #1                PRINT #1                PRINT #1&       PRINT #1,"
              XXXX"(   PRINT #1,"                     X    XX">        PRINT #1,"                    X  ***  X                XX
XXX"@   PRINT #1,"                  X  *****  X            XXX     XX"B        PRINT #1,"                XXXX ******* XXX      X
XXX          XX"H       PRINT #1,"              XX   X ******  XXXXXXXXX                XX XXX"J        PRINT #1,"            XX
     X ****  X                          X** X" J       PRINT #1,"           X        XX    XX     X                      X***X"
H       PRINT #1,"          X         //XXXX       X                     XXXX"D        PRINT #1,"         X         //   X
                      XX"B     PRINT #1,"        X         //    X          XXXXXXXXXXXXXXXXXX/"0      PRINT #1,"        X     X
XX//    X          X" . PRINT #1,"        X    X   X     X         X".  PRINT #1,"        X    X    X    X        X" D  PRINT #1,
"         X   X    X    X        X                    XX" F     PRINT #1,"         X    X   X    X        X                 XXX
XX" F   PRINT #1,"          X    XXX      X        X                X  X X  X"H  PRINT #1,"          X             X         X
          XX X  XXXX" H PRINT #1,"           X             X         XXXXXXXX\     XX   XX  X" F        PRINT #1,"            XX
           XX              X     X    X  XX"F   PRINT #1,"              XX            XXXX   XXXXXX/     X     XXXX" B  PRINT #1,
"               XXX             XX***         X     X" @       PRINT #1,"                  XXXXXXXXXXXXX *   *       X     X"@P
RINT #1,"                              *---* X     X     X" > PRINT #1,"                              *-* *   XXX X     X">  P
RINT #1,"                             *- *       XXX   X" <   PRINT #1,"                             *- *X          XXX"@    P
RINT #1,"                            *- *X  X         XXX" B PRINT #1,"                            *- *X    X            XX"
B       PRINT #1,"                          *- *XX    X             X"D      PRINT #1,"                            *  *X* X
 X            X" D     PRINT #1,"                          *  *X * X    X             X"D    PRINT #1,"
    *  * X**  X   XXXX          X"D     PRINT #1,"                          *  * X**  XX     X          X"D    PRINT #1,"
                  *  ** X** X     XX          X" B     PRINT #1,"                          *  **  X*  XXX   X         X"B      P
RINT #1,"                        *  **    XX   XXXX       XXX" B       PRINT #1,"                          *  * *      XXXX      X
     X" B       PRINT #1,"                        *   * *          X     X     X" J      PRINT #1,"         =============   * *
         X     X      XXXXXXXX\"L       PRINT #1,"                *         * *      /XXXXX      XXXXXXXX\      )" L    PRINT #1,
"          =====**********  *     X                    )  \  )" J     PRINT #1,"             ====*         *     X
  \  \   )XXXXX"D       PRINT #1,"        =========**********       XXXXXXXXXXXXXXXXXXXXX"     PRINT #1, FOR I% = 1% TO 5%     P
RINT #1, TAB(15%);G     PRINT #1, "F R O M   S N O O P Y   T O    M Y   F R I E N D   J O N A"          PRINT #1        PRINT #1,
geno@major:/data/_data/neckbeard$
```

```
geno@major:/data/_data/neckbeard$ cat dkd/GAMES.DIR\;1/SNOOPY.BAS\;3.clean
10      ! ******************************************************
        !
        !
        ! ******************************************************
        PRINT "Direct Your Dog To Any Of The Following Files:"
        PRINT "TT:--Keyboard,   LP:--Printer"
        INPUT "Which One "; A$
        IF LEN(A$) = 0
                THEN
                        A$      = "KB:"
        END IF
        OPEN A$ AS FILE #1%
PRINT.SNOOPY:
        ! -------------------------------------------------------
        !       Print Snoopy Here
        ! -------------------------------------------------------
        PRINT #1
        PRINT #1
        PRINT #1
        PRINT #1,"                    XXXX"
        PRINT #1,"                   X    XX"
        PRINT #1,"                  X  ***  X               XXXXX"
        PRINT #1,"                 X  *****  X           XXX     XX"
        PRINT #1,"               XXXX ******* XXX      XXXX          XX"
        PRINT #1,"             XX   X ******  XXXXXXXXX               XX XXX"
        PRINT #1,"           XX      X ****  X                         X** X"
        PRINT #1,"          X        XX    XX     X                     X***X"
        PRINT #1,"         X         //XXXX       X                     XXXX"
        PRINT #1,"        X         //   X                            XX"
        PRINT #1,"       X         //    X          XXXXXXXXXXXXXXXXX/"
        PRINT #1,"       X     XXX//    X          X"
        PRINT #1,"       X    X   X     X         X"
        PRINT #1,"       X    X    X    X        X"
        PRINT #1,"        X   X    X    X        X                   XX"
        PRINT #1,"        X    X   X    X        X                XXX  XX"
        PRINT #1,"         X    XXX      X        X              X  X X  X"
        PRINT #1,"         X             X        X              XX X  XXXX"
        PRINT #1,"          X             X         XXXXXXXX\     XX   XX  X"
        PRINT #1,"           XX            XX              X     X    X  XX"
        PRINT #1,"             XX            XXXX   XXXXXX/     X     XXXX"
        PRINT #1,"               XXX            XX***          X     X"
        PRINT #1,"                  XXXXXXXXXXXX *   *       X     X"
        PRINT #1,"                               *---* X     X     X"
        PRINT #1,"                              *-* *   XXX X     X"
        PRINT #1,"                              *- *       XXX   X"
        PRINT #1,"                             *- *X          XXX"
        PRINT #1,"                             *- *X  X          XXX"
        PRINT #1,"                            *- *X    X           XX"
        PRINT #1,"                            *- *XX    X            X"
        PRINT #1,"                           *  *X* X    X            X"
        PRINT #1,"                           *  *X * X    X            X"
        PRINT #1,"                          *  * X**  X   XXXX          X"
        PRINT #1,"                          *  * X**  XX     X          X"
        PRINT #1,"                         *  ** X** X     XX          X"
        PRINT #1,"                         *  **  X*  XXX   X         X"
        PRINT #1,"                        *  **    XX   XXXX       XXX"
        PRINT #1,"                       *  * *      XXXX      X     X"
        PRINT #1,"                      *   * *          X     X     X"
        PRINT #1,"         ==============   * *          X     X      XXXXXXXX\"
        PRINT #1,"               *          * *      /XXXXX      XXXXXXXX\      )"
        PRINT #1,"           ================  *     X                   )  \  )"
        PRINT #1,"             ====*          *     X              \  \   )XXXXX"
        PRINT #1,"         ==========**********       XXXXXXXXXXXXXXXXXXXXX"
        PRINT #1, FOR I% = 1% TO 5%
        PRINT #1, TAB(15%);
        PRINT #1, "F R O M   S N O O P Y   T O   M Y   F R I E N D   J O N A"
        PRINT #1
        PRINT #1, CHR$(12)
32767   CLOSE Z% FOR Z% = 1% TO 99%
        END
geno@major:/data/_data/neckbeard$
```

Worked great!

Until it didn’t…

Taking a step back

ODS-2 Filesystem

Records Management Services

- Provides interface (API) to interact with the underlying filesystem
  - Get (read)
  - Find
  - Put (write)
  - Update
  - Delete

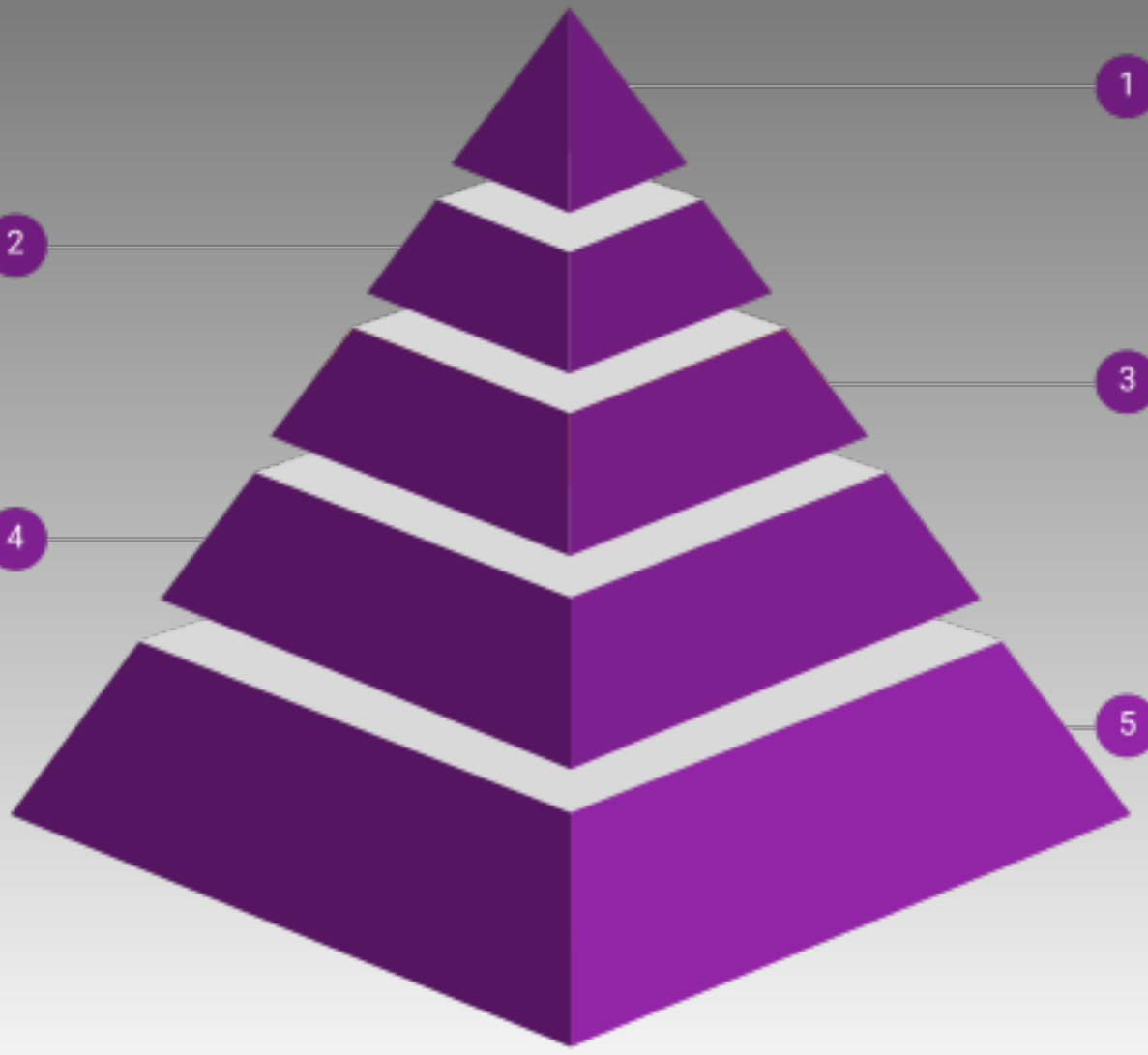
ODS-2
Record Formats

- Fixed
- Stream / Stream_CR / Stream_LF
- Undefined
- Variable

Bingo!

Variable Record Format

VARIABLE: The data portion of each record is preceded with a 2-byte binary count field that specifies the length of the record in bytes, excluding the byte field itself. Each new record begins on an even byte (WORD aligned). A null character is appended to the end of the previous record if necessary so the next record will begin on a padded boundary.



1
Data Recovery
Recovery data from a Linux system

2
Unknown OS: VAX/VMS
Recover data from an unknown (to us) OS: VAX/VMS.

3
VM within a VM
Recover data from a licensed-locked VAX/VMS emulated within a Linux VM.

4
Mount ODS-2 FS
Recover data from RAID disk images.

5
Clean up extracted data
Convert the data from the Variable record format to Undefined (i.e. stream of bytes)

Vaxuum all the things!

- Add in the extra null-padding logic
- And we’re off!

100% complete

High-five each other on how smart we are and how easy this was

Lessons Learned

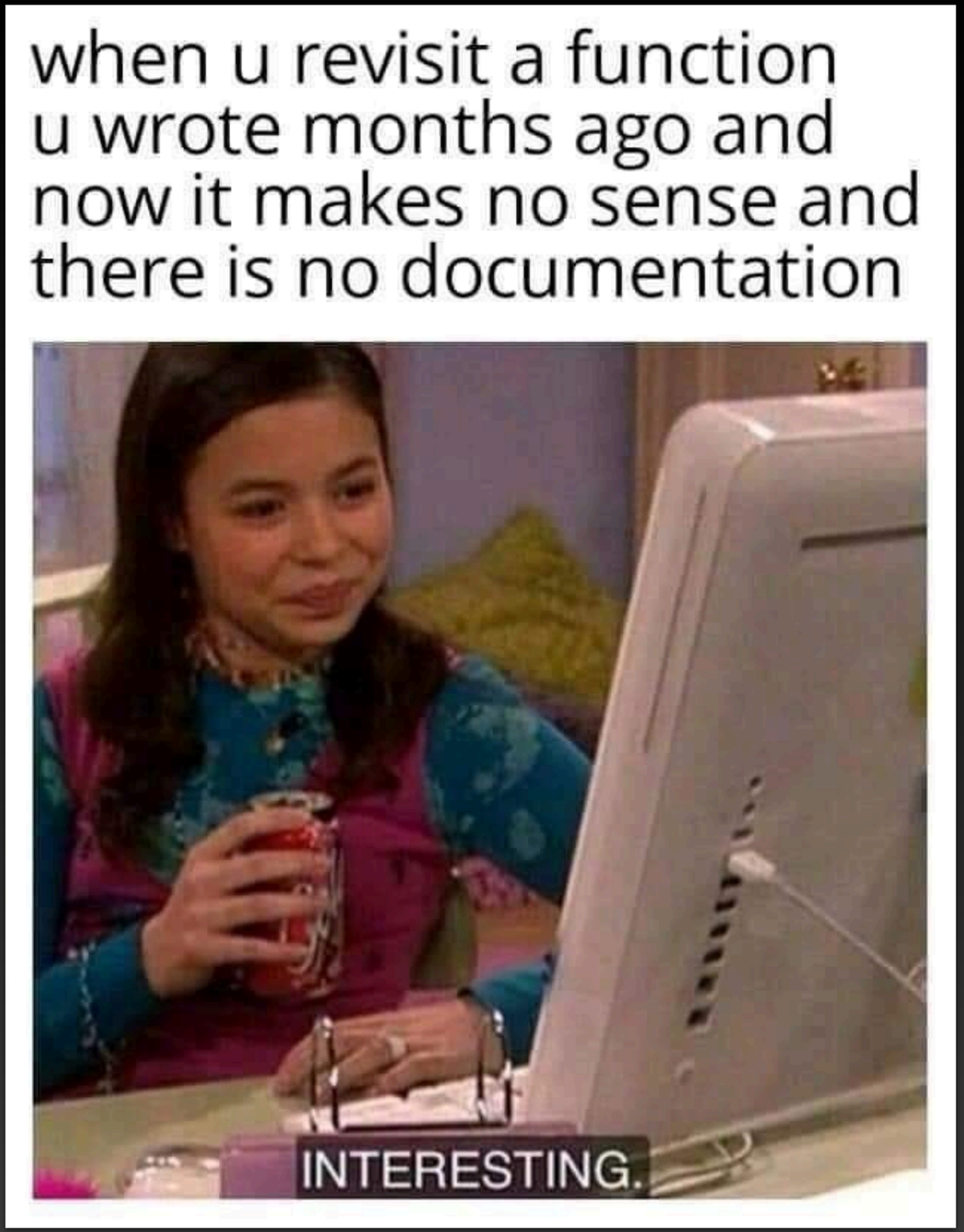
Compensation

- Don’t be afraid to renegotiate a contract when project-altering information is discovered
- Don’t underbid yourself
  - Know your worth and the going rate for the type of work
  - We underestimated the effort involved by at least 4x

Documentation

- Document:
  - Every piece of software
  - Every command

- If at first you don’t succeed, document it anyway



Communication

- Don’t use Signal for project-related communications
  - Use something like keybase.io for better long-term chat history
- Be as upfront with the customer as possible about requirements, expectations, and contract negotiations

Tool List

- Rmlint - https://github.com/sahib/rmlint
- keybase.io - https://keybase.io/
- Ods2fs - http://www.vms2linux.de/ods2util.html
- Ods5fs - http://www.vms2linux.de/TC-remastered.iso
- Vaxuum - https://github.com/genonullfree/vaxuum

Questions?

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Thank you!

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