Full System Preservation and Re-enactment

An example of a client-server setting of scientific data processing

OPF Hackathon – Emulation

Klaus Rechert

Faculty of Engineering, University Freiburg, Germany

Preservation of Scientific Environments

- The system setup to be preserved was an integral part of a large scale local language research program consisting of
  - server machine running on OS/2 v2.1 running a IBM DB2 database
  - 6 client machines offering access to the database over LAN
- The LAN infrastructure was running TCP/IPv4 on TokenRing infrastructure.
- All machines had x86 hardware
  - 486DX2 (clients)
  - Pentium/Overdrive CPU (upgraded from 486) in the server.
  - 8 / 16Mb RAM
  - CirrusLogic VGA graphics 1MB RAM

Disk Imaging

- Generally, two methods are available for disk dumping:
  - The non-intrusive method and the removal of the disks for imaging. The first method is usually the preferred one as the machine isn't required to get disassembled.
  - But in this case two obstacles were to solve: The machines weren't equipped with an Ethernet network card and booting an alternate operating system was challenging. First, the server disk was removed and later on the client disks.

Preservation of Scientific Environments

Preservation of Scientific Environments

Hard Disk Analysis & Imaging

- The server hard disk was equipped with a 1.1Gb SCSI disk
  - 64pin SCSI-2 interface standard from the end 1980ies till the mid 1990ies
  - After this period, this interface was replaced by faster versions but it was still possible to connect via cable converters to a modern SCSI controller
- 5 client hard disks have been recovered
  - All disks identical 240 Mb/IDE, manufactured 12/9/93.
  - the installation on the clients were originally identical
  - only 2 are still fully operable
  - 1 is partly readable
  - the other 2 are not recognized by the controller

Hard Disk Analysis & Imaging

Hard Disk Analysis & Imaging

Imaging the IDE disk of the client was a bit more complicated as several USB and IDE adaptors (Lindy "cable" or older PATA external disk case) failed:

[300.633955] scsi 6:0:0:0: Direct-Access QUANTUM 19234688 0 PQ: 0 ANSI: 2 CCS
[300.634368] sd 6:0:0:0: Attached scsi generic sg2 type 0
[300.634944] sd 6:0:0:0: [sdc] Very big device. Trying to use READ CAPACITY(16).
[300.635821] sd 6:0:0:0: [sdc] Using 0xffffffff as device size
[300.635839] sd 6:0:0:0: [sdc] **4294967296 512-byte logical blocks: (2.19 TB/2.00 TiB)**
[300.637555] sd 6:0:0:0: [sdc] Write Protect is off
[300.637565] sd 6:0:0:0: [sdc] Mode Sense: 00 38 00 00
[300.638381] sd 6:0:0:0: [sdc] Asking for cache data failed
[300.638390] sd 6:0:0:0: [sdc] Assuming drive cache: write through
[300.639296] sd 6:0:0:0: [sdc] Very big device

Hard Disk Analysis & Imaging

- Finally, a primary IDE chipset controller (either Intel875 or Intel865) of a P4 mainboard was able to properly detect the disk geometry. Output of fdisk :

Platte /dev/sda: 245 MByte, 245426688 Byte
13 Köpfe, 51 Sektoren/Spur, 723 Zylinder, zusammen 479349 Sektoren
Einheiten = Sektoren von 1 × 512 = 512 Bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Festplattenidentifikation: 0x00000000

Gerät boot. Anfang Ende Blöcke Id System
/dev/sda1 204867 476033 135583+ 5 Erweiterte
/dev/sda2 * 51 204866 102408 7 HPFS/NTFS/exFAT
/dev/sda5 * 204918 266525 30804 7 HPFS/NTFS/exFAT
/dev/sda6 * 266577 476033 104728+ 7 HPFS/NTFS/exFAT

Hard Disk Analysis: Server Disk

qemu-ndb –c /dev/nbdX kelle-os2.img
kpartx -a kelle-os2.img (alternative)
mount /dev/mapper/loop0pX loop0pX/

loop0p2 - drive C:

loop0p5 - drive D: contains bootcode, seems to run backup procedure. also contains file list of other drives.

loop0p6 - drive E: data partition

loop0p7 - drive F: data partition

loop0p8 - drive G: data partition

loop0p9 - drive H: data/system partition. contains spool/ tmp/ swap/; seems to contain no real data.

Booting Disk Images in QEMU

- Server disk image did not boot in any emulator
  - Probably due to SCSI bootloader configuration
  - System freezes after BIOS POST
- Alternative approach:
  - Install clean OS/2 in an emulator
  - Recreate partition structure of orig. disk
  - Mount original disk image and newly created image
  - Delete content from newly created boot partition and copy the contents from the original partition.

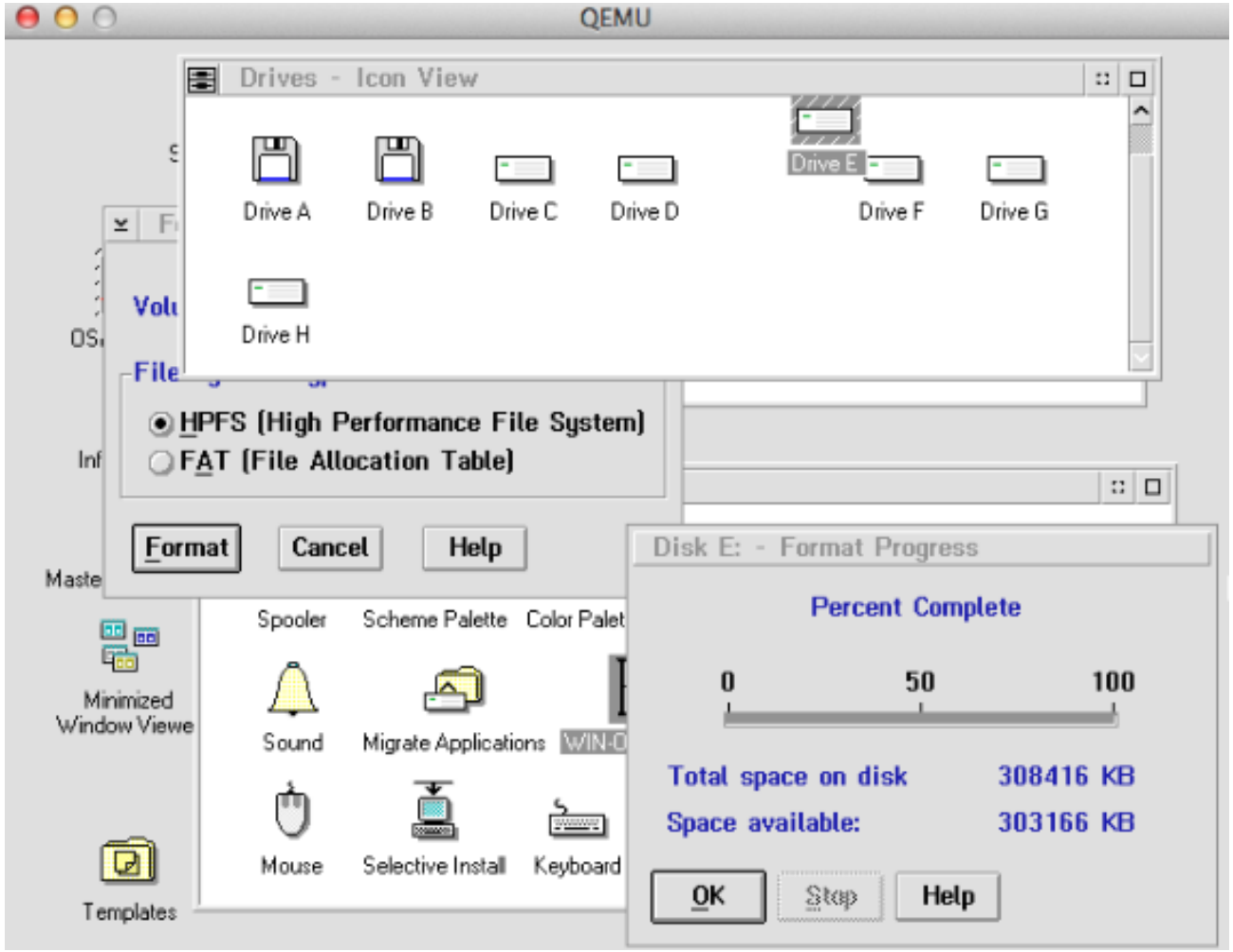
  → The system now boots from disk

  → Lessons learned:

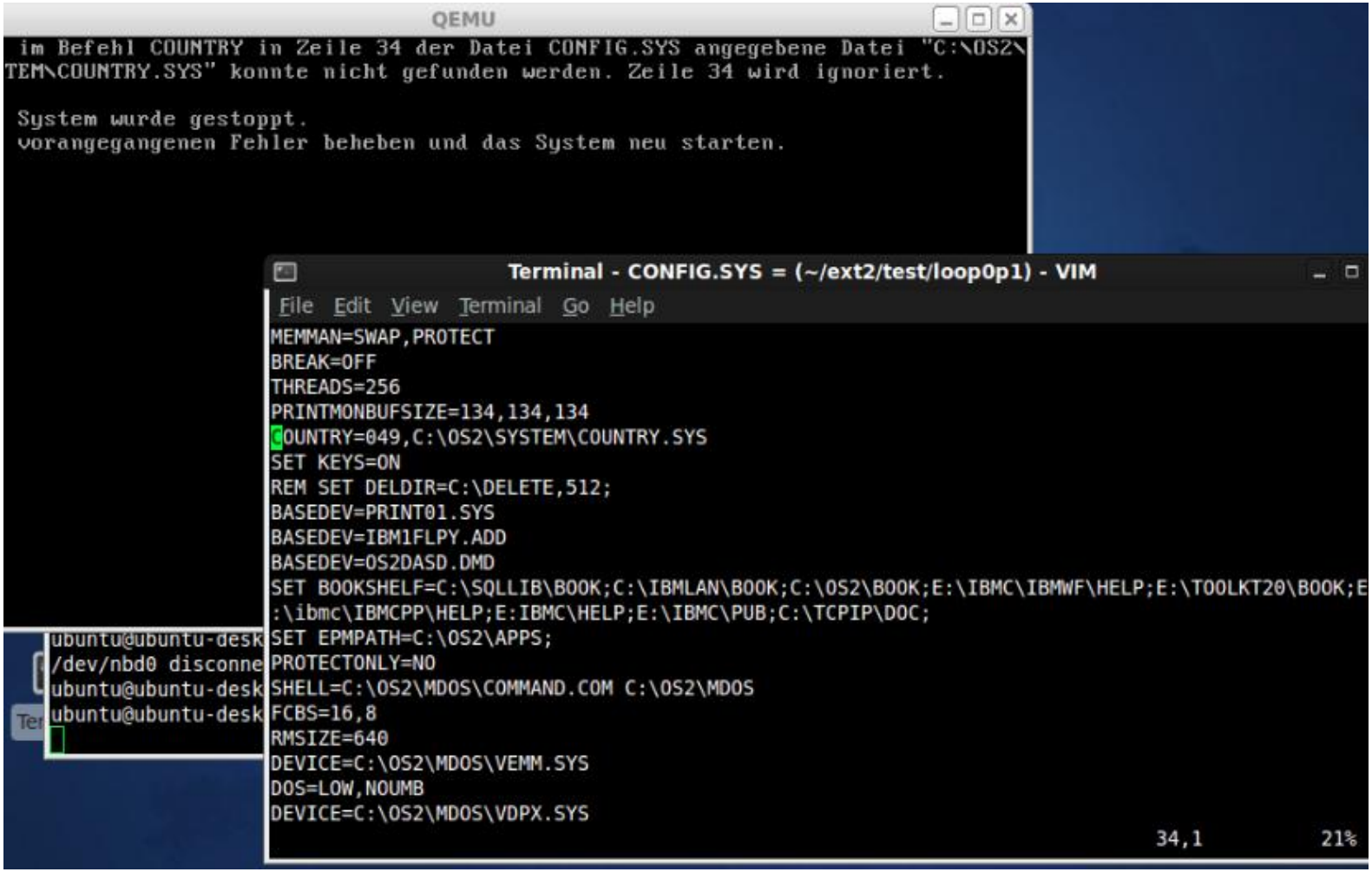
    → Disk container layout seems to be different on native disks.

    → Unmount /Shutdown OS/2 properly, otherwise Linux mounts the disks read-only. No HPFS CHKDSK for Linux available.

Clean Installation & Recreating Partitions



Booting Original Bootpartition! Almost...



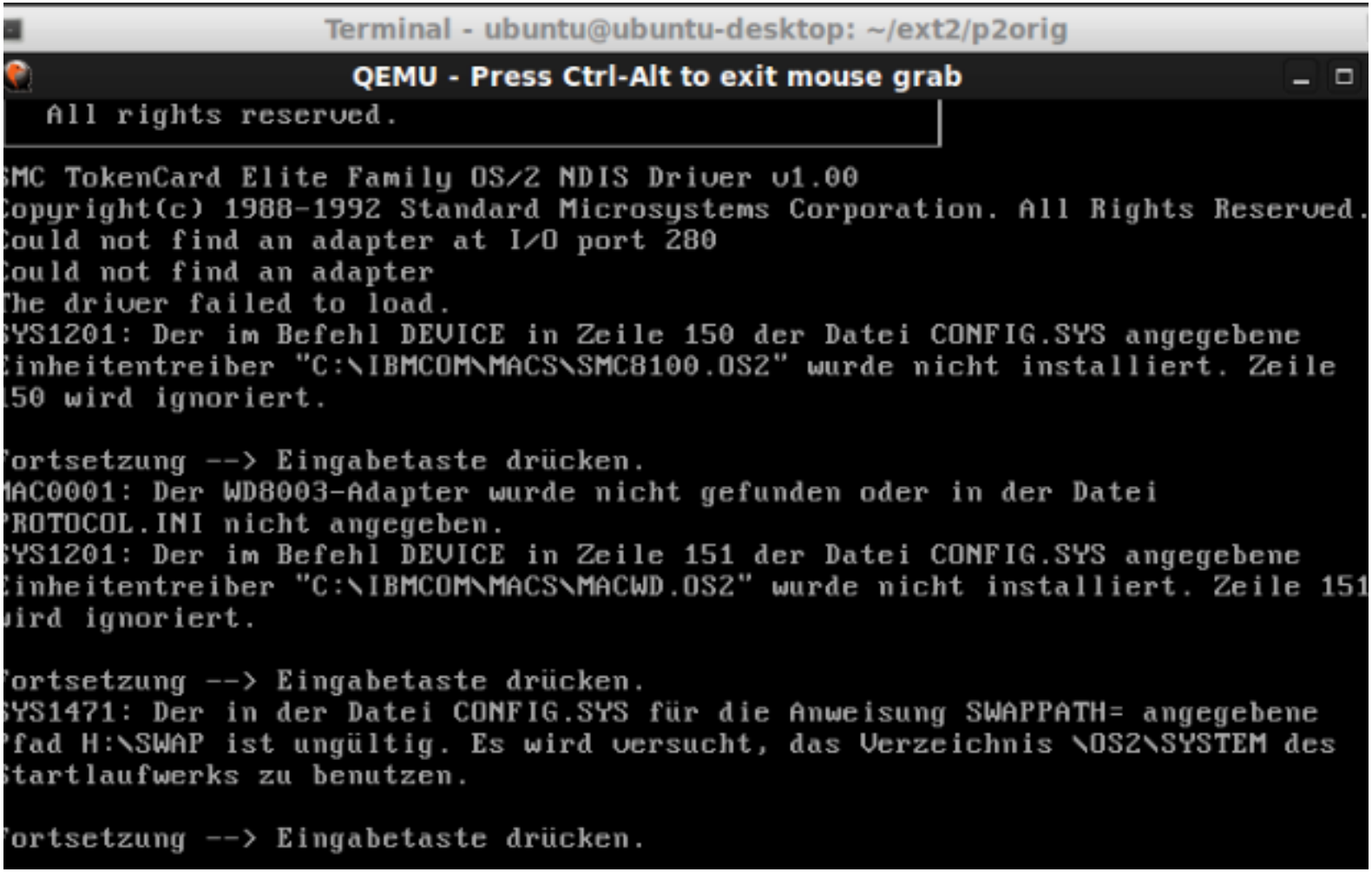
Disk / IDE Bus

- This error seems to be due to missing/wrong disk/fs driver
  - http://www.os2bbs.com/file_c/tips/OSDICNTY.TXT
- Since in qemu the harddisk is connected to a virtual IDE device and the original device was connected to a SCSI controller, CONFIG.SYS has been modified by adding:

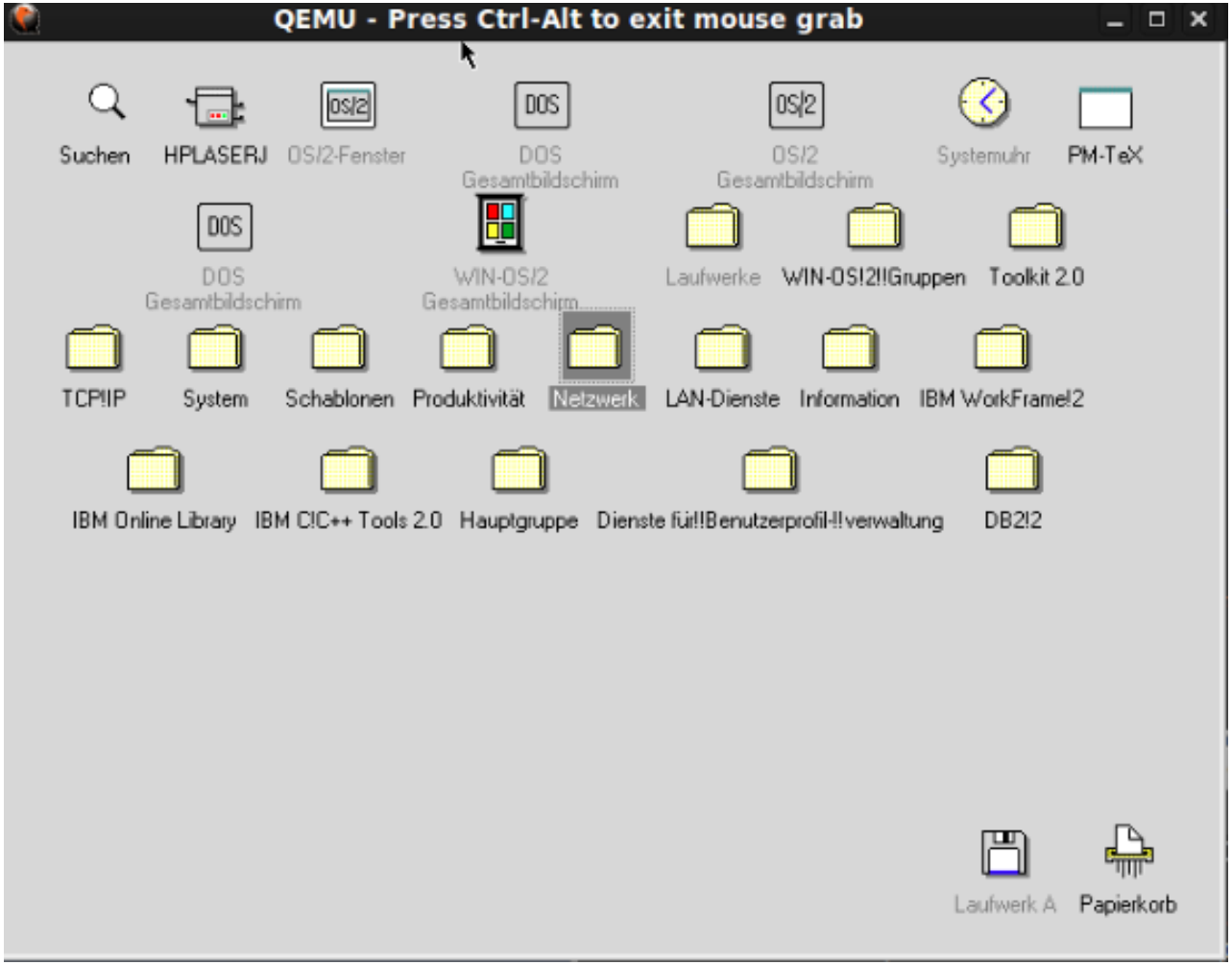
  BASEDEV=IBM1S506.ADD

  and removing all SCSI entries.

Network Driver Errors... OK.



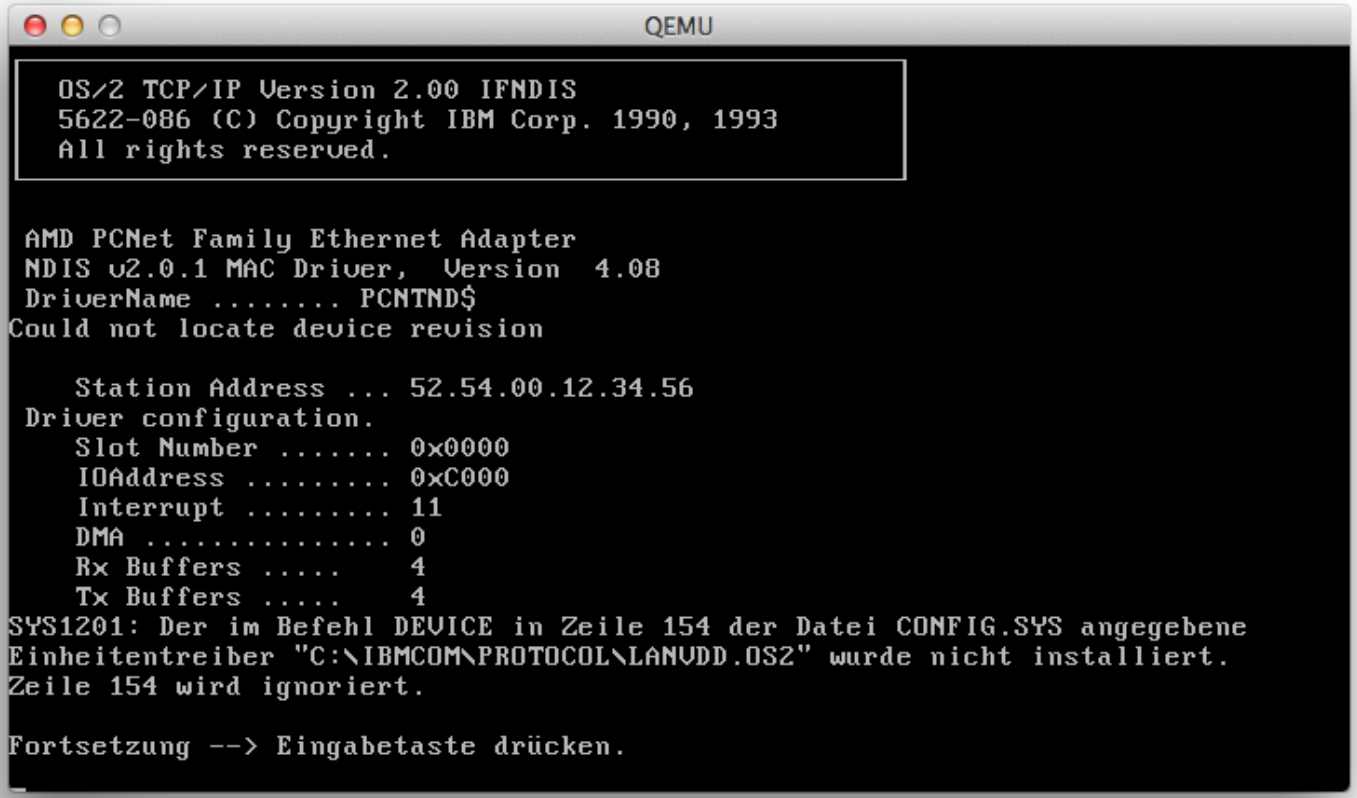
Finally


QEMU - Press Ctrl-Alt to exit mouse grab
Suchen
HPLASERJ
OS/2-Fenster
DOS Gesamtbildschirm
OS/2 Gesamtbildschirm
Systemuhr
PM-TeX
DOS Gesamtbildschirm
WIN-OS/2 Gesamtbildschirm
Laufwerke
WIN-OS/2!!Gruppen
Toolkit 2.0
TCP!IP
System
Schablonen
Produktivität
Netzwerk
LAN-Dienste
Information
IBM WorkFrame!2
IBM Online Library
IBM C!C++ Tools 2.0
Hauptgruppe
Dienste für!!Benutzerprofil-!!verwaltung
DB2!2
Laufwerk A
Papierkorb

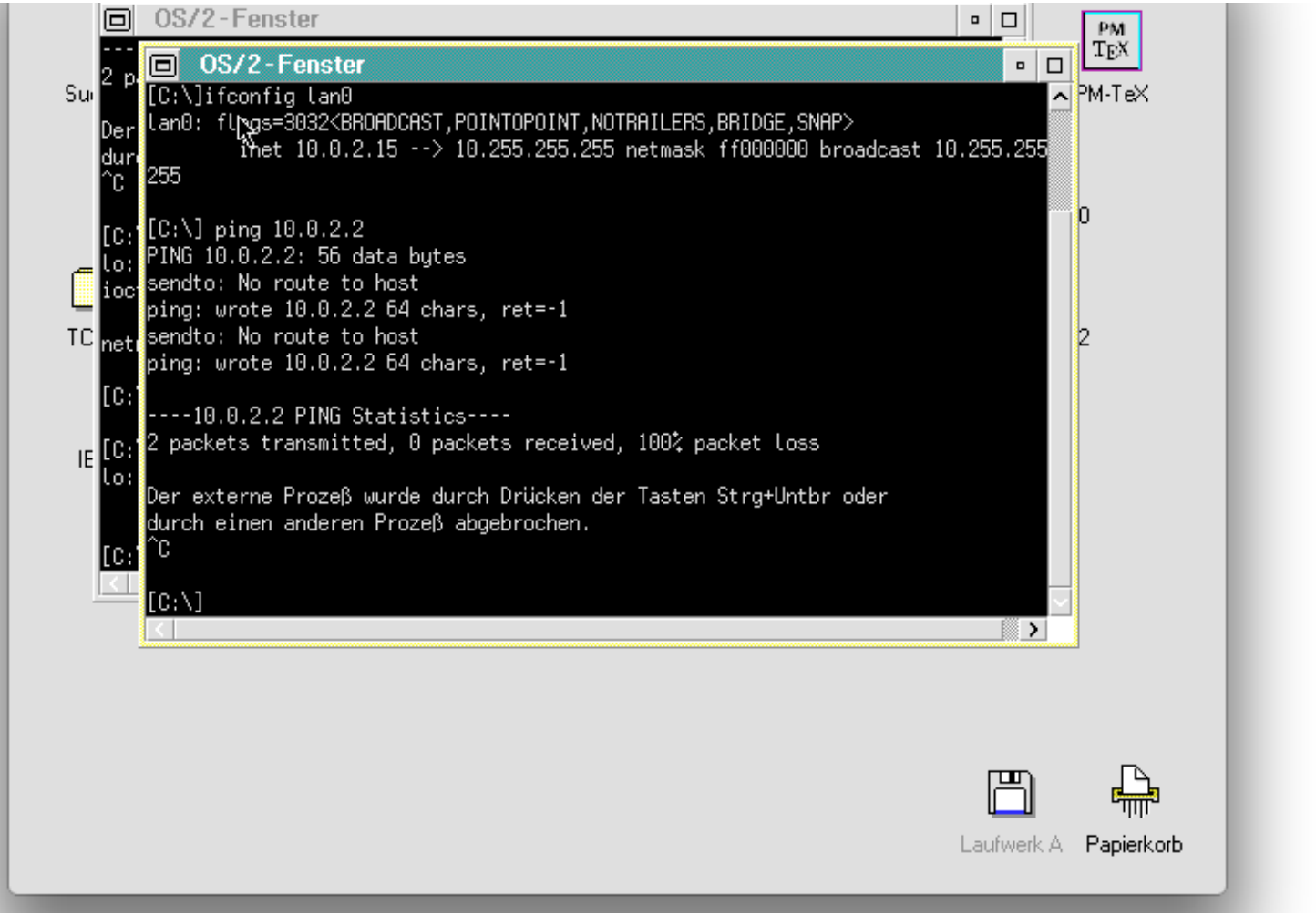
Re-enabling Network Connectivity

- Qemu supports several virtual network cards
  - eg. ne2k_pci, AMD PCNet 2/3, RTL 8039
  - OS/2 driver available
    - http://hobbes.nmsu.edu/h-browse.php?dir=/pub/os2/system/drivers/network
- However...

Re-enabling Network Connectivity



QEMU OS/2 Network Fail



QEMU OS/2 Network Fail

```
15:24:56.390557 ARP, Request who-has 10.0.2.2 tell 10.0.2.15, length 46
15:24:56.390586 ARP, Reply 10.0.2.2 is-at 52:55:0a:00:02:02, length 50
15:24:57.372088 ARP, Request who-has 10.0.2.2 tell 10.0.2.15, length 46
15:24:57.372118 ARP, Reply 10.0.2.2 is-at 52:55:0a:00:02:02, length 50
15:24:58.371727 ARP, Request who-has 10.0.2.2 tell 10.0.2.15, length 46
15:24:58.371761 ARP, Reply 10.0.2.2 is-at 52:55:0a:00:02:02, length 50
15:24:59.371594 ARP, Request who-has 10.0.2.2 tell 10.0.2.15, length 46
15:24:59.371624 ARP, Reply 10.0.2.2 is-at 52:55:0a:00:02:02, length 50
15:25:00.371810 ARP, Request who-has 10.0.2.2 tell 10.0.2.15, length 46
15:25:00.371851 ARP, Reply 10.0.2.2 is-at 52:55:0a:00:02:02, length 50
15:25:01.371638 ARP, Request who-has 10.0.2.2 tell 10.0.2.15, length 46
15:25:01.371667 ARP, Reply 10.0.2.2 is-at 52:55:0a:00:02:02, length 50
15:25:02.371345 ARP, Request who-has 10.0.2.2 tell 10.0.2.15, length 46
15:25:02.371375 ARP, Reply 10.0.2.2 is-at 52:55:0a:00:02:02, length 50
15:25:03.371365 ARP, Request who-has 10.0.2.2 tell 10.0.2.15, length 46
```

- Network packets leave the QEMU NIC and are received by the QEMU, however, do not get picked up by the network driver or NDIS 2 subsystem
- Not related to a specific NIC
- Known issue, seems to work with virt. ISA cards (not tested yet)
  - http://virtuallyfun.superglobalmegacorp.com/?p=529

Next Try: Virtual Box

- Retry same process on VirtualBox
  - No official support for OS/2 2.x and older
- However
  - System starts successfully
  - With network support
    - AMD PCNet 3
    - Bridge and NAT mode tested
  - Unfortunately no CD-ROM support yet

Client Analysis

/dev/nbd0p2 on test/client/c_orig type hpfs (rw)
/dev/nbd0p5 on test/client/d_orig type hpfs (rw)
/dev/nbd0p6 on test/client/e_orig type hpfs (rw)

/dev/nbd1p2 on test/client/c_new type hpfs (rw)
/dev/nbd1p5 on test/client/d_new type hpfs (rw)
/dev/nbd1p6 on test/client/e_new type hpfs (rw)

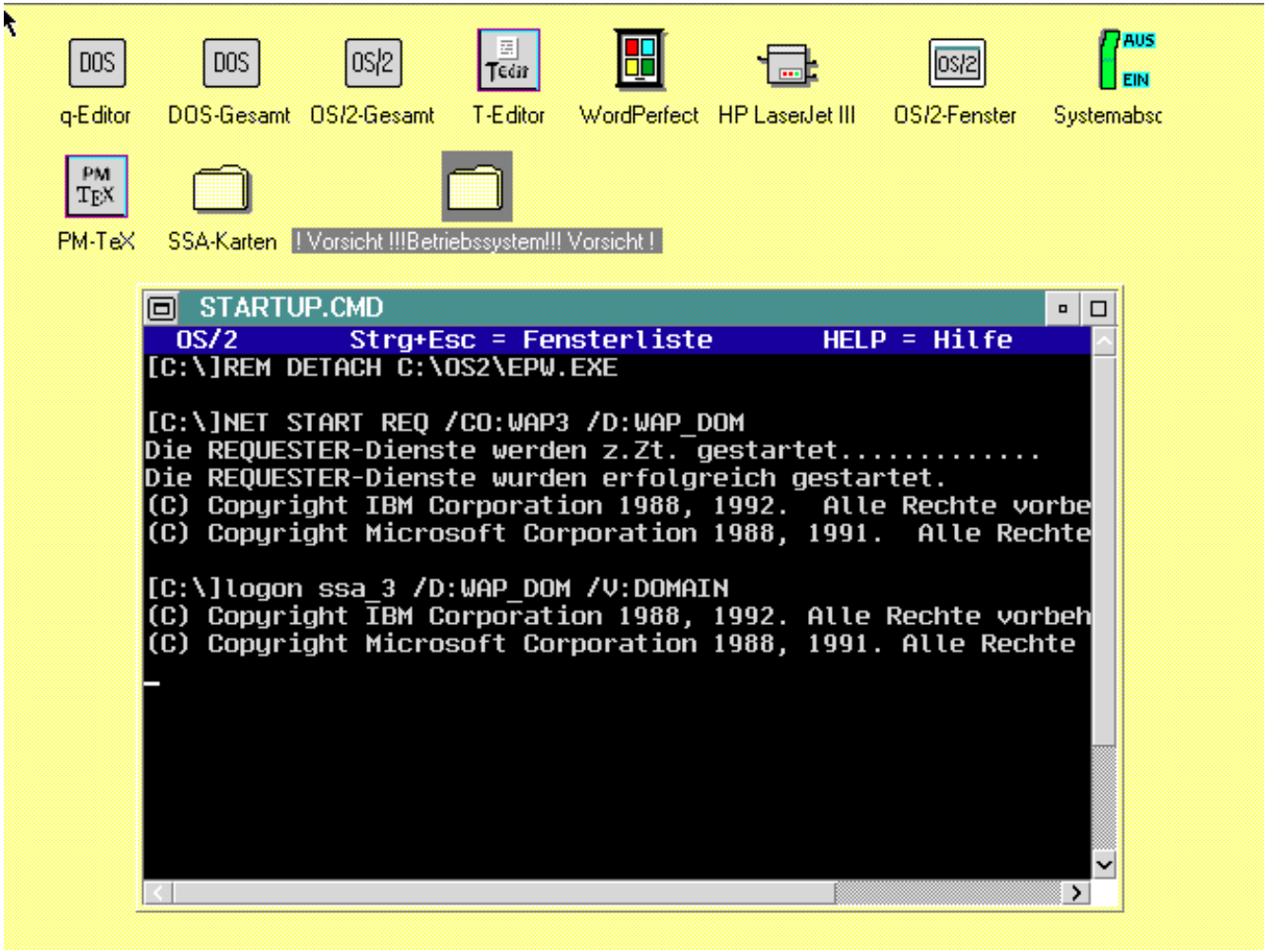
cp –a c_orig c_new etc...

- Usually, a straight forward task. However, we encountered file-system errors (exclusively) on the first partition (p2).
- In contrast, creating a TAR archive directly from the disk works
- Lessons learned (not yet ;))
  - HPFS is a highly sensitive and error-prone file-system

Client Analysis

- Clients used IDE disks. Booting the partition directly in QEMU worked
  - However: file-system issues
- Since we have to use VirtualBox for now
  - VBoxManage convertfromraw ...
  - Booting the resulting VDI failed ☹
- Stick with the approach, proven to be successful for the server disk
  - Successful boot, until GUI starts, due to specific SVGA setup
    - del OS2/svgadata.pmi
    - replace IBMDEV32.DLL with a generic one

Client Analysis



Lessons Learned

- In certain situations system-preservation of a whole computer system is inevitable
  - In a scientific environment certain computer workstations have grown over time
  - During perennial research projects, fluctuation of personnel is common and therewith system knowledge is volatile
  - Complex software workflows have been created, usually involving tailored software components and highly specialized tool-chains paired with non-standard system tweaks

→ Rebuilding the system from scratch is a time-consuming task involving manual labor and requires a technically skilled operator

Lessons Learned

- Time-consuming task if done for the first-time
- Little knowledge on specifics of OS/2 available
  - The Internet does forget! Found a lot of 404 sites!
  - Still some mysterious issues left…
- Network aware emulation components
- Towards efficient full system preservation
  - Efficiently characterize preservation problem:
    - can we perform task directly from the machine?
    - if not, what type of equipment/software etc. is required?

  → Task 1: Feed gained knowledge into distributed characterization wizard / tools

  → Task 2: All steps performed to recreate the environment could/should be automated

  → Task 3: Create test & feedback loop. Capture specific knowledge of preserving certain system types

bwFLA Workflow: Preparation

- The user/owner **characterizes** the computer system to be preserved
- The **imaging process** is prepared either to be carried out **on the target system**, or on **a different (modern) computer system**. The latter option requires dismounting the hard-drive of the target system
- To ensure better compatibility with hardware emulator software, **a distributed knowledge-base** on different operating system regarding their compatibility with emulators and hardware dependencies is part of the bwFLA system-preservation framework.
  - The **user is presented with known issues** based on his previous selections and step-by-step guides describing user-actions to be carried out on the target system

bwFLA Workflow: Imaging

- Based on the user's choices, **a tailored bootable image is generated** and made available for download
  - either to be written on a USB pen-drive or CD/DVD
- After booting the created system on the target system, an **automated process** starts the
  - imaging process
  - gathering of the relevant hardware information
  - uploading of this data to the bwFLA framework
- The only interactive choice allows the user to select the drive to be preserved if multiple options are available

bwFLA Workflow: Test & Submit

- In a final step the disk image generated is **post-processed (if required)** for an appropriate emulator type, chosen based on selection made during the preparation process and information gathered during the imaging process
- Finally, an **emulation component** is invoked **presenting the preserved system** image to the user.
  - If the user approves the result, the image is submitted together with generated technical meta-data to a DP repository for further processing

Discussion

- The workflow has been tested mainly on x86 based systems, mostly due to availability of high-quality emulators
- Adding new, yet unsupported systems is easily possible as long as the original workstation is able to boot a Linux kernel and connect to the network
- In cases of older (potentially highly integrated systems) such as Notebooks without CD-ROM drives, USB-boot capabilities and even without network connection the external imaging workflow remains as a working option
  - In such a case the description of the original system remains to the user and has to be carried out manually
- With integration a distributed digital preservation framework, a common knowledge base on re-enacting ancient computer systems can be built providing step-by-step instruction to non-technical users
- With the integration of a feedback loop, the owner of a system is able to approve desired properties of the system for later access

Hackathon Challenge: iMac (1999)

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- Model: iMac 333 MHz (1999-04)
  - Power PC G3, 333 MHz
  - **MacOS 8.5.1, 8.6**
  - 15″ (13.8″ viewable) CRT
  - max 1024x768
  - ATI Rage Pro
  - 32 MB – 256 MB RAM
  - P-ATA / 6 Gb IDE HDD
  - ATAPI CDROM

- Target Emulator: SheepShaver