**Administering Linux in
Production Environments**

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North Haven, Connecticut, USA

Itinerary

- Introduction
- Production Environment Features
  - Recent Kernel Developments
  - Filesystems: Mundane and Advanced
  - Disk Striping and RAID
  - Parallel Processing and Clustering
  - Enterprise Networking Features
- Deployment Examples
  - File and Print Servers
  - Enterprise User Authentication
  - Beowulf Compute Servers
  - Linux and Databases
  - Linux as an Office PC

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What is a Production System?

- Real world
- System is a tool
- "Money" is involved

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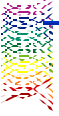Copyright © 1999-2001, Exponential Consulting, LLC

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Commercial Applications

- Major applications are available now:
  - Databases: *Oracle*, *Sybase*, *DB2*, etc.
  - Computational chemistry: *Gaussian 98*
  - CAE: *MSC: Nastran*
  - Others
- Keeping up
  - www.linas.org/linux
  - www.linuxports.com

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Dressing for Success

- Tuxedo vs. Business Suit

- ILM: 11/15/2001

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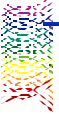Copyright © 1999-2001,
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Recent
Kernel
Developments

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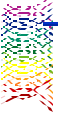Exponential Consulting, LLC

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2.4 Kernel

- Feature Lists:
  - lwn.net/2001/0111/a/wwo2.4.php3
  - January 2001 Linux Magazine

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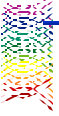Exponential Consulting, LLC

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2.4: Numbers

- 64 GB memory
- >2GB files
- 16 Ethernet adapters
- 10 IDE controllers
- SMP support
  - Support for tons of processes
  - Scheduler improvement
- Billions of users/groups

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Current Linux Limitations

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- Memory size: 64 GB
- File size: 2 TB
- Filesystem size: 2 TB (VFS limitations)
- Filesystem block size=Memory page
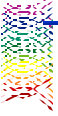 - 4KB (x86)
  - 16KB (IA-64)

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2.4: I/O

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- Modes:
  - Separate block device and file I/O
  - Raw devices
- Devices:
  - I2O
  - USB
  - Firewire (IEEE1394)
  - PC Card
  - Infrared
- APCI support
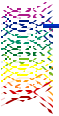- Graphics: Direct rendering manager
- SCSI2: Tagged command queuing

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2.4: Networking

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- Better multiprotocol support
- Rewritten network layer (firewalls, IP masquerading):
  - Packet filtering
  - Network address translation
- ATM and others
- Can now mount NFS3 shares
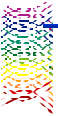
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2.4: VFS and Related Facilities

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- Single buffer for file caching
  - Eliminates synchronization problems
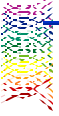- Multiple mount points

- LVM in kernel
- RAID rewrite

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2.4 Bonus Features
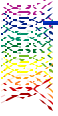
- Memory "Management"
  - New swap space size "recommendations"
  - Fixed around 2.4.10

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12.1

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2.4.15-16

- ext3
  - "experimental"
- InterMezzo filesystem

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Filesystems:
Mundane and
Advanced

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Itinerary
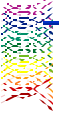
- The VFS
- Local Filesystems
- Journaling Filesystems
- Network Shared Filesystems
- Logical Volume Manager
- Distributed Filesystems

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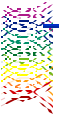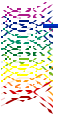
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Spelling 101
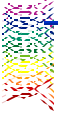
- Filesystem vs. file system

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Virtual File System (VFS)
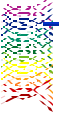
- Kernel subsystem/layer
- Provides a consistent interface for low-level file I/O
- Filesystem need only implement the required functionality using that interface, and it is automatically supported

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VFS Details
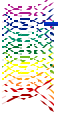
- Structured as an indirection layer
- Specifies low-level entities (objects) ...
  - Inodes, Files, Directories, Superblock,
  - Extended attributes
- ... and required/optional methods for each one

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Filesystem Data Structures

- Superblock
  - FS metadata: label, block size, size, # inodes, …
- Inodes
  - Properties: file type, owners, permissions, times, #links, size, ...
  - Data or Disk addresses or Single/double indirect
- Directory

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  - = File that maps file names to inodes
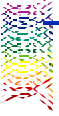
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VFS in Action
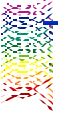
- Command/application invokes system call
- VFS looks up filesystem type in kernel table
- Kernel redirects call to FS-supplied method
- Method runs and accesses disk
  - Device drivers issue needed I/O requests
- Method returns descriptor to desired object
  - Descriptor contains pointers to functions for accessing that object as well as related data (e.g.: mounted filesystem, file, inode, dentry)

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2.4.15+
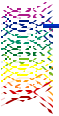
- Journal block device module: designed to add generic journaling capabilities to the VFS

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Filesystems for Local Disks
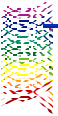
- Many, many supported types:
  - ext2
  - minix
  - CD-ROM: iso9660, MS Joliet extensions,
    - ❖ 2.4: udf for DVD
  - ufs, fat, vfat, umsdos, ntfs, sysv, affs, adfs, hfs, hpfs, qnx4, ...
    - ❖ 2.4: ufs nextstep extensions, efs, ramfs, jffs, cramfs

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Special filesystems

- procfs: /proc
- Pseudo-device: /dev/pts
- devfs:
  - /dev/hda => /dev/ide0/disk0/...
  - **devfsd** to support old device names

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The ext2 Filesystem

- 2GB files and 4TB filesystem
- 255 character filenames
- SetGID directory group ownership inheritance
  - Selectable at mount time
- Variable block sizes
- Performance optimizations:
  - Read-ahead
  - Data block allocation and pre-allocation

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Ext2 FS Tools

- **fsck.ext2**
- **mke2fs**
- **e2label**
- **dumpe2fs**
- **tune2fs**
- **resize2fs**

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The mke2fs Command

- **-b** *block-size*
  - Default: 1024 bytes
- **-i** *bytes/inode* or **-N** *#inodes*
  - Default: 1 inode per 4096 bytes
- **-m** *reserve%*
  - Default: 5%
- **-L** *label*
- **-c** or **-l** *bad-block-file*
- ✗ **-f** *fragment-size*

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dump2efs

```
dumpe2fs 1.18, 11-Nov-1999 for EXT2 FS 0.5b, 95/08/09
Filesystem volume name:   <none>
Last mounted on:          <not available>
Filesystem UUID:          03d2f865-390a-4a5a-9162-8f2fc902d3e2
Filesystem magic number:  0xEF53
Filesystem revision #:     1 (dynamic)
Filesystem features:      (none)
Filesystem state:         not clean
Errors behavior:          Continue
Filesystem OS type:       Linux
Inode count:              264928
Block count:              528948
Reserved block count:     26447
Free blocks:              260025
Free inodes:              184468
First block:              0
Block size:               4096
Fragment size:            4096
Last mount time:          Sun Dec  3 09:33:59 2000
Last write time:          Mon Jan 29 17:41:57 2001
Mount count:              12
Maximum mount count:      20
Last checked:             Wed Sep  6 18:54:01 2000
Check interval:           15552000 (6 months)
Next check after:         Mon Mar  5 17:54:01 2001
Reserved blocks uid:      0 (user root)
Reserved blocks gid:      0 (group root)
```
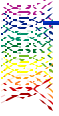
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The tune2fs Command
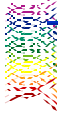
- **-l** to list superblock info
- Modify attributes (mount read-only?)
  - **-c** *max-mounts*
  - **-C** *mount-count*
  - **-i** *check-interval*[**dmw**]
  - **-e** *error-behavior*
    - ❖ **continue, remount-ro, panic**
  - **-m** *reserved%* **or** **-r** *reserved-blocks*
  - **-g** *gid* **and/or** **-u** *uid*

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Contributed ext2 Tools
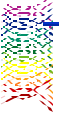
- **ext2fs defrag**
- **ext2fs resize**
- **ext2fsed**
- **ext2undelete**

- See: "Filesystems-HOWTO" (section 6)

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Journaling Filesystems
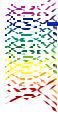
- A single inherent advantage over "traditional" UNIX filesystems

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Journaling Linux Filesystems

- ReiserFS: 2.4.1pre7 and later (SuSE 6.4)
  - www.namesys.com
- ext3: coming in standard 2.4.15
  - e2fsprogs.sourceforge.net/ext2.html
  - www.zip.com.au/~akpm/linux/ext3/ext3-usage.html
- SGI's XFS: 1 May 2001
  - 64-bit; streaming video
  - oss.sgi.com/projects/xfs
- IBM JFS: 28 June 2001
  - 64-bit
  - oss.software.ibm.com/developerworks/opensource/jfs

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ext3

- **mke2fs**'s **–j** option
- Specify separate journal device: **-J** *device*
- Convert existing with **tune2fs –j**
  - Space considerations
- Interoperability with/as ext2

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Reiser Filesystem

- Designed for performance, especially on directories with lots of files, as well as efficient usage of disk space
- Tools:
  - **mkreiserfs** [**-b** *n*]   *n must be 4*
  - **reiserfsck**
  - **resize_reiserfs -s** [±]*size*[**kM**]

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Reiser mount Options

- **mount -o remount,resize=***new-size*

- **mount -o conv**
  - **Reiser 3.5 to 3.6**

- **mount -o notail**

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A Testimonial

>From Source Forge

http://ftp.sourceforge.net/ has 850GB storage, half of which is reiserfs,
half is ext2. Both filesystems have been running flawlessly for > 4 months of
production (actually longer, but wasn't reiserfs before). That server pushes
between 15Mbit and 50Mbit/sec, and pulls/syncs about 2-5Mbit/sec, 24x7.

reiserfs also powers the CVS tree filesystem for cvs-mirror.mozilla.org
(also tokyojoe.sourceforge.net), which is the one and only anonymous CVS
checkout point for mozilla. That server has run flawlessly under very heavy
load since its birth.

I don't get involved in kernel politics, but as a production filesystem, reiserfs
 is ok in my book.

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XFS

- **mkfs -t xfs –l size=6000b /dev/hde1**

- **mount -t xfs -o logbufs=8,logbsize=32768 ...**

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JFS

- **mkfs -t jfs –s 8 /dev/hde1**

- **logredo** *device*

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Comparison

	100% Released	Max. size	Block size	Resize	Dyn. Inode	Use as Boot FS	RAID	LVM	NFSv3	In std. kernel	Ext. Attr.	ACLs	Sparse files	Interop.
ext3	~N	2TB	4K	Y	N	Y	Y	Y	Y	Y	Y	Y	N	n/a
Reiser	Y	2TB	4K	Y	Y	Y	Y	Y	Y	Y	4	N	4	n/a
XFS	Y	2TB	4K	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
JFS	Y	2TB	4K	Y	Y	Y	Y	Y	N	N	N	Y	N

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Journaling and dump

- ext3: **yes**
  - Long history
- ReiserFS: **no**
- XFS: **yes** (**xfs**{**dump,restore**})
- JFS: **no**

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Thanks Chris Marble!

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Mounting Remote Filesystems

- NFS
- Samba: smbfs
- AFS
- ncpfs

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Linux NFS

- Kernel-based NFSv2
- Kernel-based NFSv3
- User space NFSv2

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NFS Components

- Daemons:
  - **portmap, rpc.mountd, rpc.nfsd**
    - ❖ **rpcinfo -p** [*host*]
  - **rpc.lockd, rcp.statd**
- /etc/exports file
  - *dir host*(*options*) …

```
/data2      dalton(rw)  pascal(ro)  henry(rw,all_squash)
            *.vader.com(rw,sync)
/data3/new  192.123.12.0/255.255.255.0(ro)
```

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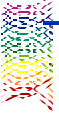
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Other exports Options

- **sync, async**
- **root_squash, all_squash**
- **anonuid=n_1, anongid=n_2**

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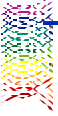

Useful mount Options

- **bg retry=***n*
- **intr** *or* **soft**
- **retrans=***n*
- **nosuid**
- **rsize=8192,wsize=8192** (max. for v2)

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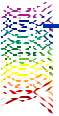
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UID Mapping

- **rpc.ugidd**
- **map_daemon** /etc/exports option

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NFS and Security
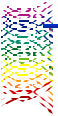
- Limit access to specific machines; avoid blanket exports
- Export read-only whenever practical
- Don't export group-writeable files
- Don't export system files (incl. executables)
- Don't use the **insecure** option (allows access from any port)

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Sharing Filesystems: Samba

- Samba is the solution for sharing filesystems and printers between UNIX and Windows systems:
  - www.samba.org

- Books:
  - Gerald Carter with Richard Sharpe, *Teach Yourself Samba in 24 Hours* (SAMS, Indianapolis, 1999); ISBN: 0-672-31609-9
  - Robert Eckstein, David Collier-Brown and Peter Kelly, *Using Samba* (O'Reilly, 2000); ISBN: 1-56592-449-5

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Samba

~~CIFS~~

- Implements ~~SMB~~ protocol under UNIX
  - Server Message Block is the native protocol for Microsoft networking file/printer sharing:

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Samba

- Features:
  - Filesystem sharing
  - Printer sharing
  - Master browser
  - Domain security
  - Primary domain controller (alpha)

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Samba Daemons

- **smbd** (TCP)
  - Provides sharing services
- **nmbd** (UDP):
  - Handles NetBIOS name server requests
- Execution options:
  - Standalone: **-D**
  - Via **inetd**

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Samba with inetd

- For ~~inetd~~ control, modify /etc/inetd.conf

```
netbios-ssn stream tcp nowait root /usr/sbin/smbd smbd
netbios-ns  dgram  udp wait   root /usr/sbin/nmbd nmbd
```

- and /etc/services:

```
netbios-ssn 139/tcp
netbios-ns  137/udp
```

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The Samba Configuration File

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- /etc/smb.conf
  - [global] section
  - Exported filesystem sections
  - [homes] section: defaults for user home directories
    - ❖ Actual services created on the fly

- **testparm**: verify configuration file structure

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---

global Section

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```
[global]
  hosts allow = vala, pele
  hosts deny = lilith
  valid users = dagmar, @chem, @phys, @bio, @geo
  invalid users = root, admin, bin, system, daemon
  max log size = 2000
  username map = /etc/smbusers
```

KB

Map file entries: *linux = translation* (usually Windows)

```
aefrisch = aeleen
sysadmin=Administrator
chem = @chemistry
```

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Defining Shares

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```
[chemdir]
path = /chem/data/new
comment = New Data
read only = no
case sensitive = yes
force group = chemists
read list = dagmar, @chem, @phys
write list = @chem
browseable= no
admin users = chavez
```

Define a directory for export.
Local path to be shared.
Description of filesystem.
Filesystem is not read-only.
Filenames are case sensitive.
Map all users to this group.
Users/groups w/ read access.
Write access list.
Exclude from browse lists.
Administrative users.

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Group=NIS net group (&) or UNIX group (+)

Connecting to Samba Shares

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- Run **net use** as usual on the Windows system:
  - **net use s: \\dalton\chemdir**
  - **net use x: \\dalton\\homes**
    net use x: \\dalton*username***

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User Home Directories

```
[homes]
   comment = Home directories
   writeable = yes
   valid users = %S
```

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- Effect of map files:
  - *server*\Administrator ⇒ *server*\sysadmin

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Samba Utilities

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- **smbstatus**
- **smbrun**
- **smbclient**
- **smbtar**

- GUI admin tool: **swat**
  - Runs within a browser

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Mounting Windows Filesystems

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- **smbmount**
  - Two versions: smbfs vs. standalone
    - ❖ **smbmount //dalton/chem –c 'mount / mnt …'**
    - ❖ **smbmount //dalton/chem /mnt**

- **mount -t smbfs \
     -o username=aefrisch,password=xxx \
     //dalton/chem2 /chem**

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Passwords and Samba

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- Add to [global] section:
  ```
  encrypt passwords = yes
  security = user
  ```

- Run **mksmbpasswd.sh** to create initial Samba password file:
  cat /etc/passwd | *lpath* **/mksmbpasswd.sh**

  - ❖ Owner: root
  - ❖ Mode: 600
  - ❖ Directory mode: 500

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More Authentication Options

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- Authentication by a different server:

  ```
  security = server
  password server = host
  encrypt passwords = yes
  ```

- Local (UNIX) authentication:

  ```
  security = user
  encrypt passwords = no
  ```

- Windows domain participation:

  ```
  security=domain
  workgroup = domain
  password server = pdc bdc1 bdc2
  encrypt passwords = yes
  ```

- Samba server as the PDC

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Advanced Filesystem Features

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- Larger than 1 disk partition
  - Expandable on the fly
- Distributed across network
  - Load balancing
- Faster I/O
- Fault tolerant

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Logical Volumes

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- Dynamically-resizable filesystem consisting of multiple, independent disk partitions (*physical volumes*), upon which a virtual structure is overlaid:
  - *Volume groups/virtual disks*, divisible into
  - *Logical volumes/virtual partitions,* which hold
  - *Filesystems*

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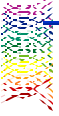
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Linux Logical Volumes

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- Logical Volume Manager (lvm)
  - Still developing
- Veritas Volume Manager
  - $$$$

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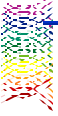
62

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LVM

- www.sistina.com/products_lvm.htm
- Maximum filesystem size: 2TB
  - Limits: 99 VGs, 256 LVs
- Maximum logical volume: 256 GB with standard 4MB physical extent size

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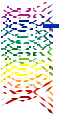
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LVM Commands

- **pv :** **create**, **change**, **display, move, scan**
- **v g:** **create**, **change**, **display, ck, cfgbackup/restore, export, extend, reduce, remove, split, merge , scan**
- **lv :** **create**, **change**, **display, extend, reduce, remove, rename, scan**
  - **e2fsadmin** (requires **resize2fs**)
    - ❖ Resize filesystem and its underlying logical volume in a single operation

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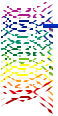Exponential Consulting, LLC

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LVM Example

- Set partition type to **0x8E** (**fdisk**)
- **pvcreate /dev/sdb1 /dev/sdc1**
- **vgcreate vg1 /dev/sdb1 /dev/sdc1**
  - /dev/vg1/group
  - /etc/lvmconf/vg1.conf
- **lvcreate -L 2g -n biolv -r 8 -C y**
  - 8 read-ahead sectors, contiguous
- **mke2fs … /dev/vg1/biolv**
- **mount /dev/vg1/biolv** *l/somewhere*

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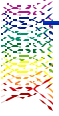
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LVM Snapshots

- Designed to ensure consistent backups
  - **lvcreate --size** *n***m --snapshot --name snap1 \ /dev/my_vg/homes**
  - **mount /dev/my_vg/snap1 /somewhere**
  - Back up /somewhere
  - **umount /somewhere**
- Uses standard VMM copy-on-write

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Distributed Filesystems

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- Various focuses:
  - Handle client network file access and outages gracefully and seamlessly
    - ❖ Goal: remote files are indistinguishable from local files
  - Distribute network I/O among various servers
    - ❖ High availability
    - ❖ Redundancy
  - Share storage among various clients
- Lots of overlap

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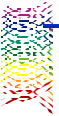Exponential Consulting, LLC

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History

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- AFS
- Coda
- Aura
- InterMezzo

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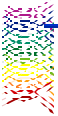Exponential Consulting, LLC

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InterMezzo

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- www.inter-mezzo.org
- Designed for high availability
- A palimpsest on Coda
  - Designed to be simpler

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Concepts

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- *Fileset*: directory subtree ("folder collection")
  - Basic unit served
  - Currently is the entire filesystem
- Change log
  - Filesystem-like journaling to track modifications
- Replication
  - Server to (duplicate) server
  - Client to server after reconnect
- Concurrent conflict handling
  - Current: detect and die

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Components

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- Lento: cache manager and file server
  - User space daemon
- Presto: kernel module (intermezzo.o)

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Installation

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- Kernel support
- Kernel loopback support
- Initial RAM disk for booting

- Group InterMezzo (GID: 4711)
- **mkizofs** [**-t ext3**] **-r** *fsetname* **-j /dev/hda***n*
  - ReiserFS and XFS: maybe

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Converting Existing ext2

75

- **mount -t ext2 -o loop /tmp/cache /izo0**
- **mkdir -p /izo0/.intermezzo***name***/db**
- **chgrp -R InterMezzo /izo0/.intermezzo**
- **chmod 700 /izo0/.intermezzo**
- **touch /izo0/.intermezzo***name***/{kml,lml,last_rcvd}**
- **tune2fs -j /tmp/cache**
- **umount /izo0**

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Configuration: Common

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- /etc/intermezzo/serverdb
  `<serverdb> <server name="library" ipaddr="192.168.0.3" /> </serverdb>`

- /etc/intermezzo/fsetdb
  `<setdb> <fileset name="test" servername="library">`
  `<replicator>clientA</replicator>`
  `</fileset> </fsetdb>`

- /etc/fstab
  `/tmp/fs0 /izo0 intermezzo`
  `loop,fileset="test", prestodev=/dev/intermezzo0,`
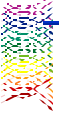 `mtpt=/izo0,cache_type=ext3,noauto   0  0`

- /etc/conf.modules
  `alias char-major-185 intermezzo`
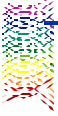
74

More Initial Setup

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- # dd if=/dev/zero of=/tmp/fs0 bs=1024 count=10k
  # mkizofs -F /tmp/fs0

- # mknod /dev/intermezzo0 c 185 0
  # chmod 700 /dev/intermezzo0

- # mkdir /izo0
  # mount /izo0
  # lento

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Configuration: Server

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- /etc/intermezzo/sysid
  <sysid name="library" psdev="/dev/intermezzo0" bindaddr="192.168.0.3" />

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Configuration: Client
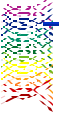
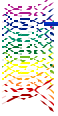79

- /etc/intermezzo/sysid
  <sysid name="clientA" psdev="/dev/intermezzo0" bindaddr="192.168.0.20" />

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Checking the Configuration

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- config_check

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Global File System (GFS)

- www.sistina.com/products_gfs.htm
- Network-shared storage
  - Asynchronous journaling
  - Intelligent locking mechanisms
    - ❖ DMEP device/memexpd
  - Large files (64-bit addressing)
- Requires supported host-bus adapter
  - High speed interconnect like Fibre Channel
  - Storage is placed directly on the network

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GFS Example

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Setting up GFS

- Select hardware approach
  - FC=>Multiported SCSI=>Network Block Device
    - ❖ Future: Gigabit Ethernet TCP/IP storage
  - DMEP hardware=>IP daemon
- Plan configuration:
  - Lock server
  - Topology
  - Component storage
  - Power
  - Clients

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More ...

- Kernel configuration: lots of patches
  - GFS & hardware (FC, for example)
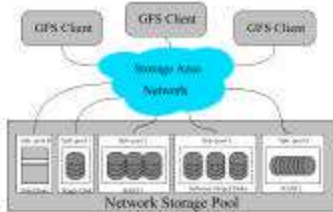- Build & distribute GFS software
- Configure

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Configuring GFS

- Pool:
  - Abstraction for shared storage devices
  - Subpools for devices of same type

83 - Cluster information device (cidev): shared partitions which holds metadata

---

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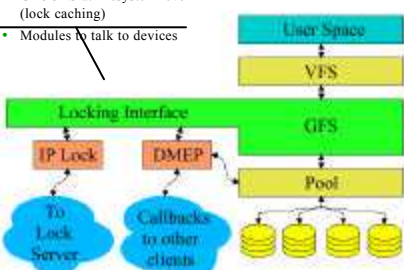## Configuring ...

- **gfsconf**
  - Lock sources
  - Callback ports
  - Timeouts
  - Clients
  - STOMITH methods
    - ❖ "Shoot the other machine in the head"

- Failover for **memexpd**
84 - Still potential bottleneck

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Architecture

Also 2-layered:
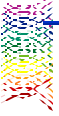- GLOCKS at filesystem level (lock caching)
- Modules to talk to devices

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Disk Striping and RAID

86
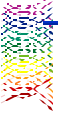

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RAID

- Redundant Array of Inexpensive Disks
- Choices
  - Software
  - Hardware
    - ❖ Controller
    - ❖ Standalone device

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Software RAID Levels
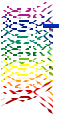
- Linear
- 0: Disk striping for performance
  - Best large transfer I/O bandwidth
  - No loss of storage capacity
- 1: Disk mirroring
  - Best data redundancy
  - Good performance on small transfers

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More RAID ...
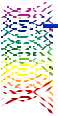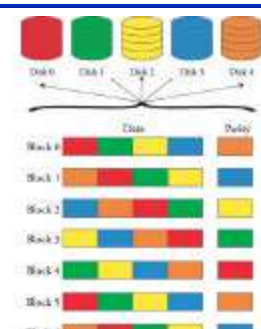
- 4: Disk striping with parity disk
  - Best fault-tolerant sequential file access
  - Not vulnerable to single disk failures
  - Parity disk is a bottleneck for writes
- 5: Disk striping with rotating parity block
  - Optimizes I/O operations/sec
  - Not vulnerable to single disk failures

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RAID 5

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Hybrid Levels

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- RAID 0+1
  - Mirroring of a striped disk: two striped disks which are mirrors of one another. Data is striped across each stripe set, and the same data is sent to both striped disks. Thus, this RAID variation provides both I/O performance advantages and fault tolerance.
- RAID 1+0
  - Striping across mirror sets: Similar in intent to RAID 1+0, it provides equivalent performance advantages and slightly better fault tolerance in that it is easier to rebuild the RAID device after a single disk failure (since the data on only one disk is affected).

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Configuring RAID

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- Enable kernel support
  - May need patches
    - ftp.kernel.org/pub/linux/daemons/raid
    - Red Hat installs for you
- Special files: /dev/ mdx
- Configuration file: /etc/raidtab
  - **mkraid** device
- Persistent superblock
  - Automatic detection of RAID entities
  - **raidstart**/**raidstop** to control manually

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Kernel

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92.1

Kernel Support

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- **make xconfig**=>Block Devices
  - Multiple devices driver support
  - Autodetect RAID partitions
  - RAID levels
    - Linear
    - RAID-0
    - RAID-1
    - RAID-4/RAID-5

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Sample /etc/raidtab Entries

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```
raiddev /dev/md0
   raid-level 0
   nr-raid-disks 2
   chunk-size 64
   persistent-superblock 1
device /dev/sdc1
   raid-disk 0
device /dev/sdb1
   raid-disk 1
```

```
raiddev /dev/md0
   raid-level 1
   nr-raid-disks 2
   persistent-superblock 1
device /dev/sdc1
   raid-disk 0
device /dev/sdb1
   raid-disk 1
```

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RAID 0+1

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```
raiddev /dev/md0
   raid-level 0
   nr-raid-disks 2
   chunk-size 64
   persistent-superblock 1
device /dev/sdc1
   raid-disk 0
device /dev/sdd1
   raid-disk 1
raiddev /dev/md1
   raid-level 0
   nr-raid-disks 2
   chunk-size 64
   persistent-superblock 1
device /dev/sde1
   raid-disk 0
device /dev/sdf1
   raid-disk 1
```

```
raiddev /dev/md2
   raid-level 1
   nr-raid-disks 2
   persistent-superblock 1
device /dev/md0
   raid-disk 0
device /dev/md1
   raid-disk 1
```

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RAID 5 with a Hot Spare

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```
raiddev /dev/md0
   raid-level 0
   nr-raid-disks 5
   persistent-superblock 1
device /dev/sdc1
   raid-disk 0
device /dev/sdd1
   raid-disk 1
device /dev/sde1
   raid-disk 2
device /dev/sdf1
   raid-disk 3
device /dev/sdg1
   raid-disk 4
device /dev/sdh1
   space-disk 0
```

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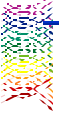## General RAID Considerations

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- RAID 0 stripe size matters for performance
  - Best value high dependant on typical I/O transfer size
    - ❖ Defaults are poor for large I/O operations
  - No substitute for testing (trial and error)
- Underlying filesystem block size = 4KB
  - **mke2fs -b 4 ...**
- Don't overload controllers
- Spend the money if you have it
  - RAID 5 overhead ~ 23% !!

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Slide 101 / 98

Parallel
Processing
and Clustering

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Slide 102 / 99

Configuring Compute Servers

- Parallel program execution
  - SMP: shared memory
  - Distributed parallel: Beowulf and others
    - ❖ Simulates shared memory for discrete systems
  - Can be combined
- Clusters
  - High availability

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Beowulf

- www.beowulf.org
- www.extreme-linux.org
- An idea, obsession, religion

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Two Extremes

- Stone Soupercomputer (Oak Ridge): stonesoup.esd.ornl.gov

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The Other End of the Spectrum
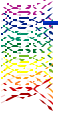
- The Hive (NASA goddard):
  newton.gsfc.nasa.gov/thehive/

101'

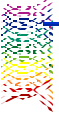---

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Creating a Beowulf System

- Hardware/software installation
- Interconnect
  - Ethernet or better
- Kernel changes
  - Generally integrated into kernel source tree
  - Channel bonding
- Parallel computing environment
  - Administrative setup
- Modified (or parallel-ready) applications

102'

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Appropriate Hardware
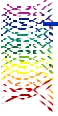
- Memory
- I/O bandwidth
  - Disk
  - Network
- CPU
- Disk
  - Partitioning

102.2

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System Setup

System configuration (e.g., DHCP)
  - Static addressing
- Distributed filesystem choice

- Physical labeling:
  - Node name
  - Configuration
  - MAC Address

102.3

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Interconnection

- Cluster/farm vs. to outside world
  - Switches
  - Security on "world" node
- Channel bonding
- Topology

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102.4

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Configuration
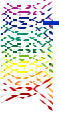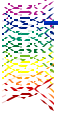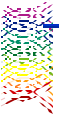
- Setup vs. ongoing

- Automounting
- Distributing configuration files
- Interprocess communication
  - **rsh**
  - **ssh**

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Evaluating
Pre-Packaged Systems
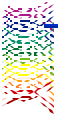
- Do the math to compute *price-performance*
  - Whole system price vs. sum of parts
    - ❖ Discrete systems from commodity vendors
    - ❖ NICs
    - ❖ Switch or hub
    - ❖ Cabeling
    - ❖ Time?
  - Weight price by processor speed
    - ❖ Pre-packaged systems often use older processors

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Example

- Box with 4 Compaq EV5s plus proprietary interconnect for $40K

versus

- Compaq DS20 (2 EV6s with shared memory), listing at around $35K

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Other Considerations

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- Power
- Air conditioning
- Space

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105.1

SMP

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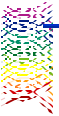
- Enable in kernel:
  - 2.2.x
  - Symmetric multi-processing support: yes
  - Memory type range register (MTRR): yes
  - RTC support: yes
  - Advanced power management: no
- Parallel application
  - OpenMP
    - ❖ Compiler that supports it

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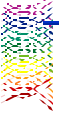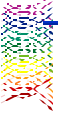Copyright © 1999-2001,
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Clustering

115
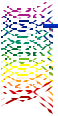
- Not designed for single application/job performance
- Purpose is to combine multiple systems to be presented as a single computing resource to users:
  - Linux Virtual Server (LVS)
  - High availability
  - Load balancing
  - Shared storage

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Linux Virtual Server (LVS)

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- Multiple servers appear as a single system to users (one IP address)
- Some load balancing
  - Implemented via a designated server
  - Fairly simple algorithms
- www.LinuxVirtualServer.org

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LVS

High Availability of Linux Virtual Server

110.1

High Availability Linux

- High-Availability Linux Project: linux-ha.org
  - Compare to fault tolerance: quick recovery vs. never failing
  - Multiple servers
  - Redundant communications channels
  - Shared disks (or distributed filesystem)
  - Resource groups: everything needed for some service/application to work

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Current Components

- **heartbeat**: detects failed servers
- **mon**: service monitoring daemon
- **fake**: provides IP-address takeover
- Architecture for a more elaborate facility

112'

Commercial Products

- TurboLinux Cluster Server
  - $995 for 2 nodes; $1995 for unlimited
  - www.turbolinux.com
- SGI/SuSE: FailSafe *(in progress)*
- Legato Cluster
- LifeKeeper (SteelEye)
- ...
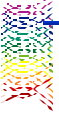
113

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Piranha Project (Red Hat)
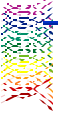
- Free!
- ≡LVS

- Control daemon
- GUI administration tool
- Failover vs. Clustering

- sources.redhat.com/piranha

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114'

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Piranha Options
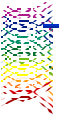
- Routing:
  - Network Address Translation (NAT)
  - Direct
  - IP Tunneling
- Scheduling
  - Round robin
  - Fewest connections
  - With/without weighting (assigned, load averages)

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Typical Piranha Setup
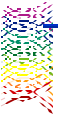
- One routing node
  - Supports one or more virtual servers:
    - ❖ IP address,protocol,port triple
  - Visible from the "external" world
  - Connected to a private network holding the real servers
- Multiple servers
  - Do real work
  - Static data only!

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Piranha Components

- IPVS and other kernel code
- **lvs** daemon: manages routing table
- **nanny** daemon: monitors a server, updates routing info as appropriate
- **pulse** daemon: handles failovers
- **piranha**: GUI configuration/management tool
- /etc/lvs.cf: configuration file

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Enterprise Networking Features
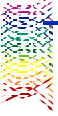
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Standard Services Review

- DNS
  - Dynamic
    - ❖ www.technopagan.org/dynamic/ddns-primer.html
  - Load balancing
    - ❖ www.cs.twsu.edu/~hcvillia/acads/project
- DHCP
- Automounting
  - **autofs** not **amd**
    - ❖ No symbolic links!

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High Speed Networking

- 100 mbps Ethernet: all many sites need
  - All mass-market chipsets supported
  - Issues with dual speed switches
    - ❖ Autonegotiation works best if both ends have it
- Gigabit Ethernet: common chipsets supported

- www.beowulf.org/ linux/drivers/
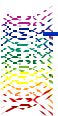
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MLPPP

- Multilink PPP: used to combine two or more PPP links into one, higher bandwidth virtual connection
  - Any connections can be used: modems, ISDN (WANs)
  - Linux implementation is basic: www.linux-mp.terz.de
- Configuration
  - Kernel patches
  - Updated **pppd**
  - Start multiple lines:
    pppd /dev/ttyS0 multilink
    wait for ppp0 interface to be up as usual
    pppd /dev/ttyS1 multilink mp-join ppp0 mp-nonp noip
    wait for ppp0 interface to be up as usual
    pppd /dev/ttyS2 multilink mp-join ppp0 mp-nonp noip

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Virtual Private Networks
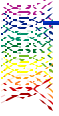
- VPNs use the public Internet as the communications link between sites
  - Data is tunneled in encrypted form
  - Protocols:
    - ❖ PPTP: many security problems
    - ❖ IPSec: emerging standard
    - ❖ ssh: See David Sifry, "Creating VPNs with Linux," *Linux Magazine*, Spring 1999.
      - Virtual Private Server (VPS): Linuxcare
      - www.strongcrypto.com
- VPN is combined with masquerading for use behind firewalls

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TCP Wrappers

- Adds (primarily) host-level access control to **inetd**-based network services
- **tcpd** replaces service executable in /etc/inetd.conf:

```
#service  socket   prot   wait?     user   program          args
telnet    stream   tcp    nowait    root   /usr/sbin/tcpd    telnetd
```

- /etc/hosts.allow and .deny control access
  - allow: `telnetd : LOCAL, mycomp.com, 192.100.43`
  - deny: `ALL : ALL`
- Logs to **syslog** facility

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Tripwire

- www.tripwiresecurity.com
  - Originated with COAST/CERIAS
  - Free and commercial versions for Linux
  - "2.0 adds many enhancements"
- What it does:
  - Documents a known system state
    - ❖ Multiple cryptographic signatures for every item
      - Many algorithm choices
  - Compares current state to the stored state

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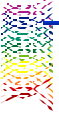
Setting Up and Using Tripwire

- Perform immediate after a clean installation/upgrade
  - Database security (read-only or cryptographic signatures as well)
- Configure system, specifying files to check and ignore
  - Features to handle log files and the like
- Set up and enable automatic periodic monitoring
- Look and and act upon the reports

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Other Monitoring Tools
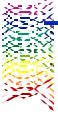
- **saint**: www.wwdsi.com/saint
- **nmap** : www.insecure.com/nmap

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UPS Configuration
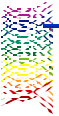
- Connect UPS device to serial port
  - Non-shared IRQ!
  - Cable with 10 Ohm resistor (from manufacturer)
- Run powerd (or other daemon)
  - Master: **powerd /dev/ttyS0 –port** *n*
  - Client: **powerd –host dalton** *n*
- Add inittab entries for power-related events:
  - powerfail
  - powerfailnow
  - powerok

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File Servers
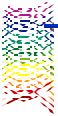
- ★ _____
- ★ _____
- ★ _____
- ★ _____

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Stronger File Permissions:
POSIX Access Control Lists

- More fine-detailed control of file access
  - Specifiable on a per-user/per-group basis
  - Default ACLs flow from the directory location
  - acl.bestbits.at
- Limits total number & size
- ACLs and NFS/Samba

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Example

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u::rwx
g::rwx
o::---
u:chavez:rw-
g:chem:r-x
m:r-x

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- Entries are applied as follows:
  - User owner uses u::
  - Specified users use u:'s
  - Group members use all applying g:'s (incl. g:: if applicable)
    - ❖ Not accumulated!
  - Everyone else uses o:
  - Mask (m:) sets maximum access level except for o access

Enabling ACLs

138

- Patch and build kernel
  - Set development option
- Get/build utilities
- Patch and rebuild ext2fs utilities
- **mount ... -o acl**
- Use **setfacl** and **getfacl** to set permissions
- Do frequent backups

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Adding ACL Capability

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Backing Up ACLs

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- **ACLs:**
  - **getfacl -R --skip-base / > backup.acl**
    setfacl --restore=backup.acl

  - **aget -sdR -e base64 / > backup.ea**
    aset –B backup.ea

- **Files with ACLs:**
  - **star H=exustar … > file.tar**
  - **star -p -x < file.tar**
  - ftp.fokus.gmd.dc/pub/unix/star

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134.1

Encryption

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- Steganography
  - Filesystem hidden in the low bits of each byte of an audio file
  - ban.joh.cam.ac.uk/~adm36/StegFS/
- Encrypted filesystems:
  - ❖ Loop Device mechanism: EncryptionHOWTO.sourceforge.net/
  - ❖ PPDD: linux01.gwdg.de/~alatham/ppdd.html
  - ❖ CFS: http://drt.ailis.de/crypto/linux-disk.html
  - ❖ TCFS: tcfs.dia.unisa.it
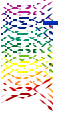
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General Setup Process

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- Patch/configure/build kernel
- Get/build utilities
- Patch/rebuild standard FS tools
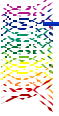
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Print Servers
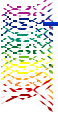
★ _____
★ _____
★ _____
★ _____

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LPRng

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- Enhanced BSD lpd
- Better networking support
  - Smarter clients
- www.lprng.com

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137.1

Slide 145 — lpc

lpc

Subcommand	Purpose
hold queue [job]	Places the specified job or all jobs in the queue into a held state, preventing them from printing.
release queue [job]	Allow the specified held print job(s) to print.
holdall queue	Place all new jobs coming into this queue into the held state. Use **noholdall** to terminate this behavior (held jobs still refused to be explicitly released).
move old-queue job new-queue	Transfer the specified print job between queues.
redirect old-queue new-queue	Redirect jobs spooled to the old queue to the new queue. Specify off for the latter to turn off redirection.
topq queue [job]	Reprint the specified job.
kill queue	Equivalent to **abort** plus **start**: kill the current job, and then restart the queue.
active printer[@host]	Determine whether the specified spool daemon is active or not.
reread printer[@host]	Force the specified spool daemon to reread its configuration files.
class queue class-list	Limit printing from the specified queue to jobs in the specified class-list, where class is usually a comma-separated list of one or more class letters (see below). The keyword off removes any current class restrictions in effect.

137.2

Slide 146 — Printcap Entries

Printcap Entries

```
hp:
 :lp=/dev/lp0
 :cm=HP Laser Jet printer
 :lf=/var/log/lpd.log
 :af=/var/adm/pacct
 :filter=/usr/local/lib/filters/ifhp
 :tc=.common

laser:
 :oh=10.0.0.0/24
 :lp=painters@matisse
 :tc=.common

.common:
 :sd=/var/spool/lpd/%P
 :mx=0
```

137.3

Slide 147 — LPRng Capabilities

LPRng Capabilities

- Bounce queues
- Printer pools
- Local and/or remote filtering
- Program-generated printcap file
- Access control: lpd.perms

```
REJECT SERVICE=X NOT REMOTEHOST=*.ahania.com
REJECT SERVICE=X REMOTEHOST=dalton,hamlet
ACCEPT SERVICE=C SERVER REMOTEGROUP=printop
    LPC=topq,hold,release
ACCEPT SERVICE=R,M,C REMOTEUSER=chavezPRINTER=test
REJECT SERVICE=* PRINTER=test
```

137.4

Slide 148 — CUPS

CUPS

- Common UNIX Printing System
- www.cups.org

- Network-based printing
- Separates job processing and device spooling
- Compatible commands

137.5

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cupsd.conf

ServerName painters.ahania.com	*Server name.*
ServerAdmin root@ahania.com	*CUPS admin's email address.*
ErrorLog /var/log/cups/error_log	*Log file locations.*
AccessLog /var/log/cups/access_log	
PageLog /var/log/cups/page_log	*Printer accounting data.*
LogLevel info	*Log detail (debug, warn, error).*
MaxLogSize 1048571	*Rotate log files when current > this.*
PreserveJobFiles No	*Don't keep files after job completes.*
RequestRoot /var/spool/cups	*Spool directory.*
User lp	*Server user and group owners.*
Group sys	
TempDir /var/spool/cups/tmp	*CUPS temporary directory.*
MaxClients 100	*Max. client connections to server.*
Timeout 300	*Printing timeout period in seconds.*
Browsing On	*Let clients browse for printers.*
ImplicitClasses On	*Implicit classes are enabled.*

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137.6

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Security

- Access control
- Authentication
- Encryption

<Location /classes/checks>	*Applies to class named checks.*
Encryption Always	*Always encrypt.*
AuthType Digest	*Require valid user account and password.*
AuthClass Group	*Restrict to members of the finance group.*
AuthGroupName finance	
Order Deny,Allow	
Deny From All	*Deny all access...*
Allow From 10.100.67.0/24	*Except from this subnet.*
</Location>	

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137.7

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Sharing Printers via Samba

```
[laser4]
    printable = yes
    comment = LaserWriter on dalton
    public = yes
    postscript = yes
    printer name = laz4
    printer driver = Microsoft driver name

[global]
    load printers = yes
    printcap name = /etc/printcap.samba
    printing = bsd | sysv | aix | hpux
[printers]
    writeable = no
    path = /tmp
    auto services = laz4  laz5  monet
```

- Note that this makes *all* printers in the specified file available!

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Printing to a Windows Printer
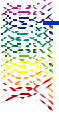
- Standard remote system printcap entry:
  picasso:lp=:rm=vala:rp=picasso:

- Using smbprint:
  gaughin:sd=dir:lp=/dev/null:if=/usr/sbin/smbprint:af=*file*:

  - Place a .config file in the specified spool directory containing password
    ```
    server=zoas
    service=matisse
    password="pwd"
    ```

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Slide 153

Font Management Summary

- XFree86Config FontPath
- fonts.dir and fonts.scale files
  - **mkfontdir**
  - **type1inst**
- Font server: **xfs**
- Ghostscript Fontmap file
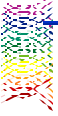
/OctavianMT-Italic	(oci_____.pfb) ;	
/OctavianMT	(ocr_____.pfb) ;	
/OctavianMT-Roman	/OctavianMT ;	

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139.1

Slide 154

Enterprise User Authentication
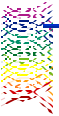
★ _____
★ _____
★ _____
★ _____

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Slide 155

User Authentication
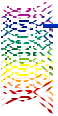
- UNIX standard mechanisms
  - Data files: passwd and group
  - Shadow password file
    - ❖ MD5
- PAM

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Slide 156

PAM

- Pluggable Authentication Modules
  - Linux and Solaris 7
- Per-application (service) configuration files in /etc/pam.d
  - Actual authentication performed by modules: shared libraries (.so files)

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PAM Configuration Files

- Entry format: *type severity path args*
  - *type*: purpose
    - ❖ auth – user authentication
    - ❖ account – account attributes/controls
    - ❖ session – pre/post service activities (logging to syslog)
    - ❖ password – causes password change if applicable
  - *severity*: how results affect outcome
    - ❖ required: failure => access denied
    - ❖ requisite: immediate required
    - ❖ sufficient: success => access granted immediately
    - ❖ optional: result used only if nothing else is deterministic
  - *path args*: path to module and arguments to it

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Example: rlogin

```
#%PAM-1.0
auth       required    /lib/security/pam_securetty.so
auth       sufficient  /lib/security/pam_rhosts_auth.so
auth       required    /lib/security/pam_pwdb.so shadow nullok
auth       required    /lib/security/pam_nologin.so
account    required    /lib/security/pam_pwdb.so
account    required    /lib/security/pam_time.so
password   required    /lib/security/pam_cracklib.so
password   required    /lib/security/pam_pwdb.so
                       nullok use_authtok md5 shadow
session    required    /lib/security/pam_pwdb.so
```

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Will this work??

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Example: su

```
#%PAM-1.0
auth       required    /lib/security/pam_rootok.so
auth       required    /lib/security/pam_wheel.so  group=admins
auth       required    /lib/security/pam_pwdb.so   shadow md5 nullok
account    required    /lib/security/pam_pwdb.so
password   required    /lib/security/pam_pwdb.so
session    required    /lib/security/pam_pwdb.so
```

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PAM Modules

- *pam_deny* (**account**, **auth**, **passwd**, **session**)
- *pam_permit* (**account**, **auth**, **passwd**, **session**)
  - Deny/allow all access by always returning failure/success (respectively). These modules do not log, so stack them with *pam_warn* to log the events.
- *pam_warn* (**account**, **auth**, **passwd**, **session**)
  - Log information about the calling user and host to syslog.
- *pam_access* (**account**)
  - Specify system access based on user account and originating host/domain as in the widely-used logdaemon facility. Its configuration file is */etc/security/access.conf*.
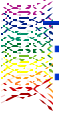
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More...

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- *pam_pwdb* (**account**, **auth**, **passwd**, **session**)
- *pam_unix* (**account**, **auth**, **passwd**, **session**)
  - Two modules for verifying and changing user passwords. When used in the **auth** stack, the modules check the entered user password. When used as an **account** module, they determine whether a password change is required or not (based on password aging settings in the shadow password file); if so, they delay access to the system until the password has been changed.
  - When used as a **password** component, the modules update the user password. In this context, the **shadow** (use the shadow password file) and **use_authtok** options are useful; the latter forces the modules to set the new password to one provided by a previous module in the stack and should accordingly be set when a password checking module is used.

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And More...

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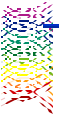
- *pam_cracklib* (**passwd**)
  - Password triviality checking. Needs to be stacked with *pam_pwdb* or *pam_unix*. See the separate discussion below.
- *pam_pwcheck* (**passwd**)
  - Another password checking module, checking that the proposed password conforms to the settings specified in */etc/login.defs* (discussed previously in this chapter).
- *pam_env* (**auth**)
  - Set/unset environment variables with a PAM stack. It uses the configuration file */etc/security/pam_env.conf*.

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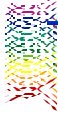**Still More...**

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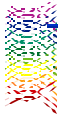
- *pam_issue* (**auth**)
- *pam_motd* (**session**)
  - Display an issue or message of the day file at login. The issue file is displayed before the username prompt, and the message of the day file is displayed at the end of a successful login process.
- *pam_krb4* (**auth**, **passwd**, **session**)
  - Interface to Kerberos user authentication.
- *pam_lastlog* (**auth**)
  - Adds an entry to the */var/log/lastlog* file which contains data about each user login session.

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More Again...

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- *pam_limits* (**session**)
  - Sets user process resource limits (*root* is not affected), as specified in its configuration file, */etc/security/limits.conf*. This file contains entries of the form:

    name   hard/soft   resource limit-value

    where *name* is a user or group name or an asterisk (indicating the default entry). The second field indicates whether it is a soft limit, which the user can increase if desired, or a hard limit (the upper bound which the user cannot exceed). The final two fields specify the resource in question and the limit assigned to it.

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More and More...

- *pam_listfile* (**auth**)
  - Deny/allow access based on a list of usernames in an external file:

```
auth     required      pam_listfile.so onerr=fail sense=allow \
                       file=/etc/ftpusers item=user
```

- *pam_mail* (**auth**, **session**)
  - Displays a message indicating whether the user has mail. The default mail file location (*var/spool/mail*) can be changed with its **dir** argument.

- *pam_mkhomedir* (**session**)
  - Creates the user's home directory if it does not already exist, copying files from */etc/skel* to the new directory.
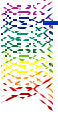
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Some More...

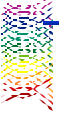- *pam_nologin* (**auth**)
  - Prevents non-*root* logins if the file */etc/nologin* exists, the contents of which are displayed to the user.

- *pam_rhosts* (**auth**)
  - Performs traditional */etc/rhosts* and *~/.rhosts* password-free authentication for **rsh** and **rlogin** sessions between networked hosts (see chapter 8).

- *pam_rootok* (**auth**)
  - Allow *root* access without a password.

- *pam_securetty* (**auth**)
  - Prevents *root* access unless the current terminal line is listed in the file */etc/securetty*.
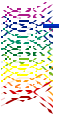
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...The Final Two

- *pam_time* (**account**)
  - Restrict access by time of day by user, group, tty and/or shell.

- *pam_wheel* (**auth**)
  - Designed for the **su** facility, this module prevents root access to any user who is not a member of a specified group (**group**=*name* option), which defaults to GID 0. You can reverse the logic of the test to deny *root* access to members of a specific group by using the **deny** option along with **group**.
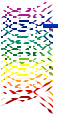
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More on PAM

- The other service:

```
auth     required      /lib/security/pam_warn.so
auth     required      /lib/security/pam_deny.so
...
```

- Module configuration files stored in /etc/security
  - Example: time.conf specifies hours when users may access defined PAM services
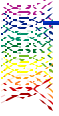
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PAM Futures

- More modules
  - Debugged modules

- New syntax for *severity*:
  return-val=action [, *return-val=action* [,…]]
  - Example: success=ok,open-err=ignore,authtok_a
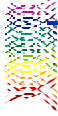
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SmartCards

- Hardware token
  - CryptoCard: www.cryptocard.com

- Card plus reader
  - MUSCLE: Mvmt. for use of smart cards in Linux env.
    - ❖ www.linuxnet.com/smartcard/tutorial.html
  - Schlumberger cards
  - Some with biometric authentication integrated into the reader
  - Radius standard: PAM module

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Networking and Authentication

- Beyond the single system
  - rdist, rsynch
  - NIS
  - LDAP

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LDAP

- Lightweight Directory Access Protocol
- Protocol for accessing general directory services (namespace)
  - DAP, X.500
  - Global structure is defined but little used

  - Software: www.openldap.org
  - Migration tools: www.padl.com/tools.html
    - ❖ Also PAM modules

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Basics

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- Directory not database
  - Entries (objects) and attributes

- Distinguished name:
  - cn=Aeleen Frisch, ou=People, dc=ahania,dc=com
  - uid=chavez, o=SomeCo,c=US
- RDN

158.1

Example User Data

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```
dn: uid=chavez,o= SomeCo ,c=US
uid: chavez
cn: Rachel Chavez
objectClass: posixAccount
objectClass: account
gecos : Rachel Chavez
userpassword {crypt} xxxxxxxxxx
loginShell: /bin/tcsh
uidNumber: 278
gidNumber: 250
homeDirectory: /home/chavez
```
LDIF format

- More object classes
- More attributes
  - First name
  - Last name
  - Email address
  - Kerberos data
  - Phone number
  - Picture
  - Whatever

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Deployment Process

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- Design
- LDAP server:
  - Open LDAP **slapd** (LDAP 3)
  - Netscape Directory Server (LDAP 3)
    - ❖ Replication servers
- Configure
  - /etc/openldap /{slapd ,ldap}.conf
- Migrate existing data into LDAP databases

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Linux Software

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- DB manager: GNU **gdbm** (www.fsf.org) or BerkeleyDB (www.sleepycat .com).
- Transport Layer Security (TLS/SSL) libraries (www.openssl.org).
- The Cyrus SASL libraries (asg.web.cmu.edu/sasl).

```
# rpm -qa | egrep -i '(db|sasl|ssl)'
db- 3.1.17- 13
gdbm-1.8.0-225
sdb-2001.1.18- 0
sdb_en- 2001.1.18- 0
cyrus-sasl-1.5.24- 5
openssl-0.9.6-21
openssl-devel -0.9.6-21
```

160.1

slapd.conf

```
# /etc/openldap/slapd.conf
include     /etc/openldap/schema/core.schema
pidfile     /var/run/slapd.pid
argsfile    /var/run/slapd.args

database    ldbm
suffix      "dc=ahania, dc=com"
rootdn      "cn=Manager, dc=ahania, dc=com"
# encode with slappasswd -h '{MD5}' -s secret -v -u
rootpw      {MD5}Xr4ilOzQ4PCOq3aQ0qbuaQ==
directory   /var/lib/ldap
```

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Starting the Server

- **/etc/init.d/ldap start**

- **Enabling configuration:**
  - **E.g.: SuSE** /etc/rc.config:

    ```
    START_LDAP="yes"
    ```

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- **Populate database/migrate data**
  - **PADL Perl scripts**

160.3

Clients

- **gq**, **web2ldap**, **kldap**, …
- **Netscape**

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Client Configuration File

- /etc/ldap.conf or /etc/openldap/ldap.conf

  ```
  # /etc/openldap/ldap.conf
  URI  ldap://bella.ahania.com
  BASE dc=ahania,dc=com
  ```

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System Level Clients

- LDAP-aware applications:
  - **sendmail** and **Postfix**
  - **Apache**

- Using for authentication:
  - **pam_ldap**
  - **nss_ldap**

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Schema for Authentication

- /etc/openldap/schema/*.schema

objectClass	Schema file
top	core
person	core
organizationalPerson	core
inetOrgPerson	core
account	cosine
posixAccount	ns
shadowAccount	ns
inetLocalMailRecipient	inet*mailrecipient

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nss_ldap

- ldap.conf

```
nss_base_passwd      ou=People,dc=ahania,dc=com
nss_base_shadow      ou=People,dc=ahania,dc=com
nss_base_group       ou=Group,dc=ahania,dc=com
```

- /etc/nsswitch.conf

```
passwd: files ldap
shadow: files ldap
```

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161.4 - **getent passwd**

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pam_ldap

- **rlogin**

```
#%PAM-1.0
auth       required    /lib/security/pam_securetty.so
auth       required    /lib/security/pam_nologin.so
auth       sufficient  /lib/security/pam_rhosts_auth.so
auth       sufficient  /lib/security/pam_ldap.so
auth       required    /lib/security/pam_unix.so
auth       required    /lib/security/pam_mail.so
account    sufficient  /lib/security/pam_ldap.so
account    required    /lib/security/pam_unix.so
password   sufficient  /lib/security/pam_ldap.so
password   required    /lib/security/pam_unix.so  strict=false
session    required    /lib/security/pam_unix.so  debug
```

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Limiting Access by Host and/or Group

- ldap.conf

```
# Allow user access to hosts          # Only this group can access this host
pam_check_host_attr   yes             pam_groupdn cn=dalton.ahania.com,...
                                      pam_member_attribute uniquemember
```

- Directory entries:

```
# List of allowed hosts               # List of allowed users on the local host
dn: uid=aefrisch,ou=People,...         dn: cn=dalton.ahania.com,...
objectClass: account                  objectClass: ipHost
objectClass: posixAccount              objectClass: device
..                                    objectClass: groupOfUniqueNames
host: milton.ahania.com               cn: dalton
host: shelley.ahania.com              cn: dalton.ahania.com
host: yeats.ahania.com                uniqueMember: uid=chavez,ou=People,dc=..
                                      uniqueMember: uid=carter,ou=People,dc=..
```

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Security: Access Control

- slapd.conf

```
# simple access control: read-only except passwords
access to dn=".*,dc=ahania,dc=com" attr=userPassword
   by self write
   by dn=root,ou=People,dc=ahania,dc=com write
   by * auth

access to dn=".*,dc=ahania,dc=com"
   by self write
   by * read
```

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Security: TLS$_{389}$ and SSL$_{636}$

- Key generation:

```
cd /usr/ssl/cert
openssl req -newkey rsa:1024 -keyout slapd_key.pem \
    -x509 -days 365 -out slapd_cert.pem
openssl rsa -in slapd_key.pem -out slapd_key.pem
chown ldap.ldap *.pem (if appropriate)
chmod 600 sl*.pem
```

- Statup:

```
slapd -h "ldap:/// ldaps:///"
```

- slapd.conf

```
TLSCipherSuite HIGH:MEDIUM:+SSLv2
TLSCertificateFile /usr/ssl/certs/slapd_cert.pem
TLSCertificateKeyFile /usr/ssl/certs/slapd_key.pem
```

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Security: Other
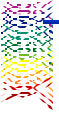
- Kerberos
- SASL

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Compute Servers

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★ _____
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★ _____
★ _____

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Helpful Installation and Configuration Tools

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- **KickStart** (RedHat)
  - Automated installation/reinstallation
  - Ghost, Drive Image
- **cfengine** (www.iu.hioslo.no/cfengine)
  - System monitors and corrects itself by comparing to a stored "healthy" state

171'

(Some) cfengine Capabilities

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- Check and configure the network interface.
- Edit text files for the system and for all users.
- Make and maintain symbolic links, including multiple links from a single command.
- Check and set the permissions and ownership of files.
- Delete junk files which clutter the system.
- Systematic, automated mounting of NFS filesystems .
- Checking for the presence of important files and filesystems .
- Controlled execution of user scripts and shell commands.
- Process management.

171.1

Pieces (1.6)

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- **cfengine**
- **cfd**
- **cfrun**
- cfengine.conf
- cfd.conf

171.2

A Simple cfengine.conf

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```
control:
 actionsequence = ( tidy links )
 access = ( chavez  root )

links:
 /bin -> /usr/bin

tidy:
 /tmp  pattern=* age=7 recurse=inf
```

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Actions

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- mountables, mountinfo, mountall, umount, addmounts
- directories, files, links, required
- copy, tidy, editfiles, disable
- shellcommands, processes
- netconfig, broadcast, resolve, defaultroute
- checktimezone
- mailcheck
- module

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171.4

Examples 1

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```
copy:

    $(masteretc)/hosts.denydest=/etc/hosts.deny o=root mode=0644
    $(masteretc)/ntp.drift dest =/etc/ntp.drift mode=644
    $(masteretc)/shells dest=/etc/shells mode=644

linux:
    $(masteretc)/rc.config dest=/etc/rc.config o=root mode=644

dbdevhost.Hr03::
    /devel dest=/backup/devel  server=dalton  r=1 backup=false
```

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Examples 2

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```
files:

    /etc/security  mode=600  owner=root  group=sys  recurse=inf
        action=fixall

    /usr/bin  checksum=md5  action=warnall

    /home recurse=inf include=*.txt action=compress

    /private acl=secure1  action=fixall

acl:
    { secure1
        method:overwrite
        fstype:nt
        user:chavez:rwx:allowed
        user:mark:all:allowed
        user:toreo:read:allowed
        group:dummy:all:denied
    }
```
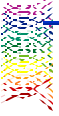
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Classes

- OS
  - ultrix, sun4, sun3, hpux, hpux10, aix, solaris, osf, irix4, irix, irix64
    freebsd, netbsd, openbsd, bsd4_3, newsos, solarisx86, aos,
    nextstep, bsdos, linux, debian, cray, unix_sv, GnU, NT
- host
- host group name
- day of the week
- hour (Hr02)
- minute (Min33)
- 5 minute interval (Min00_05)
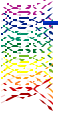- day (Day1)
- month
- year (Yr2001)
- name

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Class Examples

- myclass.solaris.Monday.Hr01::
- sun4|ultrix|osf::
- myhosts.aix!vader::
- December.Day31.Friday::
- any::
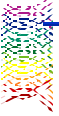
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Distributing the Resources

- Batch processing
  - Multiple queues across many servers
  - Priorities
  - Resource limits
  - Access control
  - Authentication
  - Logging and accounting
- Load balancing
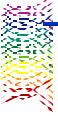
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PBS

- Portable Batch Scheduler
  - Designed for maximal resource usage
  - www.pbspro.com
- Intelligence and control reside in the scheduler, not in the queue attributes
- Site-definable scheduling via configuration and/or hooks for routines
- Separate pre-staging vs. running vs. cleanup

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PBS Implementation

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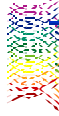
- Master server: **pbs_server**
- Per system: **pbs_mom**

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162.3

Others

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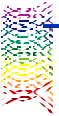
- Maui Scheduler
  - www.mhpcc.edu/maui
- IBM Load Leveler

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Parallel Environments

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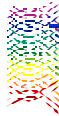
- PVM, MPI
- BSP
- DSM schemes
  - Linda

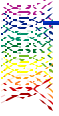Administering
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Parallelization Strategies

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- Master/worker paradigm is dominant
  - Same code for both
- Deciding where to parallelize is the most important question
  - Discrete task -based strategies
    - ❖ When free, worker gets the next bit of work to do
  - Domain decomposition
    - ❖ Worker is preassigned a subset of the entire operation

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Computing π Numerically

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```
get n as input
h = 1.0/double(n);
sum=0.0;
 for (i=1; i<=n; i++) {
    sum += 4.0 / (1.0 + (h*(i-0.5))**2); }
mypi = h*sum;
 print the result
```

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Message Passing Interface (MPI)

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- Processes explicitly send data to one another
  - MPI_Send and MPI_Receive
- www.erc.msstate.edu/labs/hpcl/projects/mpi

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MPI Example

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- main routine:

```
MPI_Init(&argc,&argv);
MPI_Comm_size(MPI_COMM_WORLD, &numprocs);
MPI_Comm_rank(MPI_COMM_WORLD, &myid);
if (myid==0) {
    input parameter n }
MPI_Bcast(&n, 1, MPI_INT, 0, …);

h = 1.0/double(n);   sum=0.0;
for (i=myid+1; i<=n; i+=numprocs) {
    sum += 4.0 / (1.0 + (h*(i-0.5))**2); }
mypi = h*sum;
MPI_Reduce(&mypi, &pi,
MPI_DOUBLE,MPI_SUM,0, …);

if (myid==0) { print the result  }
MPI_Finalize();
```

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BSP

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- Bulk Synchronous Parallel Model
- www.bsp-worldwide.org
- Consists of a small number of operations designed to distribute data during a parallel calculation
  - Structured for asynchronous communication
  - Read/write data from remote process' memory without its participation
  - Send data to a remote process' queue

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Simulating Shared Memory

- Linda
  - www.lindaspaces.com
- Provides a virtual shared memory (VSM)
  - High level operations that can be ignorant of the specifics of communication

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Master

- master function:

```
get n
 out("pi-int", n);
 out("pi-task", n);
 sum=0.0
 worker();
 for (j=0; j<=n; j++)
   in("pi-sum", j, ?sum_j);
   sum += sum_j;
 }
print sum
return;
```

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- For faster performance, change **j** to **?k**
  - Why??

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Worker

- worker function:

```
while (1) {
 rd("pi-int", ?n);
 in("pi-task", ?i);
 if (i==0) { break; }
 out("pi-task", i-1);
 h = 1.0 / double(n);
 sum = 4.0 / (1.0 + (h*(i-0.5))**2);
 mypi = h * sum;
 out = ("pi-sum", n, mypi);
 }
return;
```

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OpenMP

- www.openmp.org
- Standard set of compiler directives for shared-memory parallelism
  - Serial code is unmodified

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OpenMP Example

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```
!$omp parallel do
     do 50 k=1,ntop
         arr(k)=a(k)+b(k-1)*c(k)/(k+1)
50   continue
!$omp end parallel do

     sum=0.0
!$omp parallel default(shared)
!$omp& reduction(+:sum)
     lots of computations
$!omp end parallel
```

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Databases

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Databases

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- mySQL
- PostgresSQL
- Commercial servers: Oracle, Sybase, DB2, …

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mySQL

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- Good for medium size applications
  - If you need to save money …
- Limitations include:
  - Limited SQL
    - ❖ No subqueries:
      select sum(total) from pmts where trx_id in
      (select trx_id from trx_hdr,org where country>1
      and paid=0 and ship>'06/01/1999' and *join*)
    - ❖ Applies automatic default values on inserts
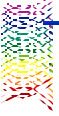 - No transactions
- www.mysql.com

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mySQL Tools

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- **xmysql**: web.wt.net/~dblhack
- **xmysqladmin**
  - www.tcx.se/Contrib/
- **kmysql**: www.xnot.com/kmysql

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Database Programming Interfaces

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- Perl
  - MySQL
  - DBI and DBD drivers
    - ❖ DBD::ODBC
  - Win32:ODBC
- More in Tck/Tk, Python, …
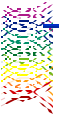
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Office PC

★_____
★_____
★_____
★_____

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Office Applications

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- Applixware
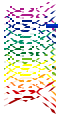- Star Office
  - Microsoft response

- Others
  - WordPerfect
  - Newcomers

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Word Processing

- Convert 1 page test file: Ap4.41 Ap4.42 SO5.1
- Import 10 page sample file: Ap4.41 Ap4.42 SO5.1
- Import 187 page manual chapter: Ap4.41 Ap4.42 SO5.1
- Paragraph styles: Ap4.41 Ap4.42 SO5.1
- Character styles: Ap4.41 Ap4.42 SO5.1
- Superscripts: Ap4.41 Ap4.42 SO5.1
- Footnotes: Ap4.41 Ap4.42 SO5.1
- Tables: Ap4.41 Ap4.42 SO5.1
- Sectioning: Ap4.41 Ap4.42 SO5.1
- Dynamic headers/footers: Ap4.41 Ap4.42 SO5.1
- TOC/Index: Ap4.41 Ap4.42 SO5.1
- Equation editor equations: Ap4.41 Ap4.42 SO5.1
- Manually-constructed equations: Ap4.41 Ap4.42 SO5.1
- Pictures: Ap4.41 Ap4.42 SO5.1

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Word Processing

Word Processing Item	Apple 4.41	Apple 4.42	Star Office 5.1	Apple 5	Star Office 5.2
Convert 1 page test file	YES	YES	YES	YES	YES
Import 10 page sample file	YES	YES	YES	YES	YES
Import 187 page manual chapter	NO	YES	YES	YES	YES
Paragraph styles	YES	YES	YES	YES	YES
Character styles	NO	NO	YES	NO	YES
Superscripts	NO	NO	YES	NO	YES
Footnotes	YES	YES	YES	YES	YES
Tables	YES	YES	YES	YES	YES
Sectioning	NO	YES	YES	YES	YES
Headers/footers	YES	YES	YES	YES	YES
Dynamic headers/footers	NO	NO	NO	NO	NO
TOC/Index	NO	NO	NO	NO	NO
Equation editor equations	YES	YES	YES	YES	YES
Manually-constructed equations	NO	YES	YES	NO	YES
Pictures	YES	YES	YES	YES	YES
Acceptable text conversion	NO	YES	NO	YES	NO
Data fields converted as fields	NO	NO	NO	NO	YES
Data fields automatically updated	NO	NO	NO	NO	YES
Text color	NO	NO	YES	NO	YES
Merging redefined	YES	YES	NO	YES	NO
Name and backed	YES	YES	NO	YES	NO

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Spreadsheets

- Convert spreadsheet files: Ap4.41 Ap4.42 SO5.1
- Convert multisheet workbooks: Ap4.41 Ap4.42 SO5.1
- Formulas: Ap4.41 Ap4.42 SO5.1
- Text color: Ap4.41 Ap4.42 SO5.1
- Text formatting: Ap4.41 Ap4.42 SO5.1
- Graphs (visible): Ap4.41 Ap4.42 SO5.1
- Graphs (correct): Ap4.41 Ap4.42 SO5.1

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Spreadsheets

Spreadsheet Item	Apple 4.41	Apple 4.42	Star Office 5.1	Apple 5	Star Office 5.2
Convert spreadsheet files	YES	YES	YES	YES	YES
Convert multisheet workbooks	YES	YES	YES	NO	NO
Formulas	YES	YES	YES	YES	YES
Text color	YES	YES	YES	YES	YES
Text formatting	NO	YES	YES	NO	YES
Complex combined formatting	NO	NO	YES	NO	YES
Print area/layout settings	NO	NO	NO	NO	YES
Graphs (visible)	NO	YES	NO	YES	YES
Graphs (correct)	NO	YES	NO	YES	YES

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Slide 225

Presentations

- Convert current PPT files: Ap4.41 Ap4.42 SO5.1
- Convert prev. rev PPT files: Ap4.41 Ap4.42 SO5.1

- MS template: Ap4.41 Ap4.42 SO5.1
- Custom template: Ap4.41 Ap4.42 SO5.1
- Notes pages: Ap4.41 Ap4.42 SO5.1
- Drawn graphics: Ap4.41 Ap4.42 SO5.1
- Imported graphics: Ap4.41 Ap4.42 SO5.1

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Presentations

Presentation Item	Applix 4.41	Applix 4.42	Star Office 5.1	Applix 5	Star Office 5.2
Convert current PPT files	NO	YES	NO	NO	YES
Convert prev. rev PPT files	NO	YES	YES	NO	NO
MS template	NO	YES	YES	NO	YES
Custom template	NO	YES	NO	NO	YES
Notes pages	NO	YES	YES	NO	YES
Drawn graphics	NO	YES	YES	NO	YES
Imported graphics	NO	YES	YES	NO	YES
Org charts	NO	YES	YES	NO	YES
Visually rich text	NO	NO	NO	NO	YES
Dynamic text reuse	NO	NO	NO	NO	NO

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Required Applications: Everyday

- File manager
- Outlook
  - Email
  - Schedule
  - Contacts
- Web browser
- Winzip
- Music (CD, MP3)
- Video
- Burn CD
- PDF viewer
- PDA interface
- Games
- Expenses
- Fax

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182'

Slide 228

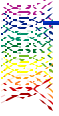## Required Applications: Specialty

- Personal/Baby database
- Image editing
- Vector-based illustration
- HTML editor
- 3D drawing
- Program development

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Required Applications: Administrative

- Database with development environment
- Business finances
- Web server
- FTP server
- File sharing
- Printer sharing
- Remote installation facility
- Scripting

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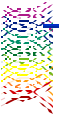## Select the Right Distribution

- Lots of ported, pre-compiled packages
  - SuSE
  - Recent RedHat
  - ?

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Into the Future

- "These are Linux's early days …"
  - The beginning of the end?
  - The end of the beginning?

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