GNU LINUX

UNIVERSITY OF THE
FREE STATE
UNIVERSITEIT VAN DIE
VRYSTAAT
YUNIVESITHI YA
FREISTATA

UFS
UV

WHO USES GNU LINUX

- Runs on: Smartphones, Smart home devices, Desktop computers, Laptops, Tablets, Main Frames, Super Computers, Routers, Switches, TVs, even cars etc.
- Only about 2% of users run on desktop PCs
- The most popular choice to host Web Services and other security infrastructure
  - Most enterprise core systems run on GNU Linux
- All the Top500 clusters run on GNU Linux
- Most Cloud-based solutions are built and run on GNU Linux technology – even Microsoft Azure

WHERE DID GNU LINUX COME FROM

- <u>G</u>NU is <u>N</u>ot <u>U</u>nix
- GNU Linux was derived from Unix and the concept was started in 1983 by Richard Stallman
  - GNU Project and Free Software Foundation
- The GNU Project later got Linus Torvalds involved in 1991 to create the Linux Kernel, which made the distribution of a complete OS possible by 1994
- It is important to the Free Software foundation to refer to GNU Linux; for if only referring to Linux, one unfairly disparages the value of the GNU project on Linux's existence

UFS
UV

WHAT IS LINUX

- GNU Linux is Open Source
- You can opt to pay for support: Red Hat and SUSE Linux
- The core of GNU Linux is the **Kernel**
- GNU Linux is a POSIX compliant OS which makes the applications runnable and portable between most vendor hardware
- The filesystems also use POSIX semantics
  - Holds a hierarchical layout (./   ../   ../../   ../../../)
  - ACL
    - File/Directory permissions (ugw rwx 461)
    - User Permissions and ownerships per file/directory
  - etc.

UFS
UV

KERNEL

- 32 Bit end of life: 2038
- Kernel v6.2 drops support for x486

Version	Original release date	Last release	Maintainer	EOL	Prominent features	
6.5	TBA	6.5-rc3	Linus Torvalds			
6.4	25 June 2023	6.4.7				
6.3	23 April 2023	6.3.13				
6.2	19 February 2023	6.2.16		May 2023		
6.1	11 December 2022	6.1.37	Greg Kroah-Hartman	December 2026	•Multi-Gen LRU page reclaiming (not yet enabled by default) •Btrfs performance improvements •Support for more sound hardware •Improved support for game controllers	
6.0	2 October 2022	6.0.19		January 2023[	•performance improvements on Intel Xeon 'Ice Lake', AMD Ryzen 'Threadripper', AMD EPYC •new hardware support including Intel, AMD, Qualcomm	

UFS
UV

WHAT IS THE OS LIKE

- Hard to initially get your head around, because most users grew up using Microsoft

BSD & Unix

Microsoft Windows

Apple Mac

GNU Linux

UFS
UV

DIFFERENT GNU LINUX DISTRIBUTIONS

UNIVERSITY OF THE
FREE STATE
UNIVERSITEIT VAN DIE
VRYSTAAT
YUNIVESITHI YA
FREISTATA

UFS
UV

GNU LINUX DISTRIBUTIONS

- A Linux distribution consists of:
    - The Linux Kernel
    - System Drivers
    - Software
        - Terminal
        - Applications
            - Libre Office, Firefox, Python
        - Tools
            - Text editors, network debugging, Terminal emulator
        - Compilers
            - Make, GCC, Fortran, Go
        - Libraries
            - Static or Dynamically linked libraries

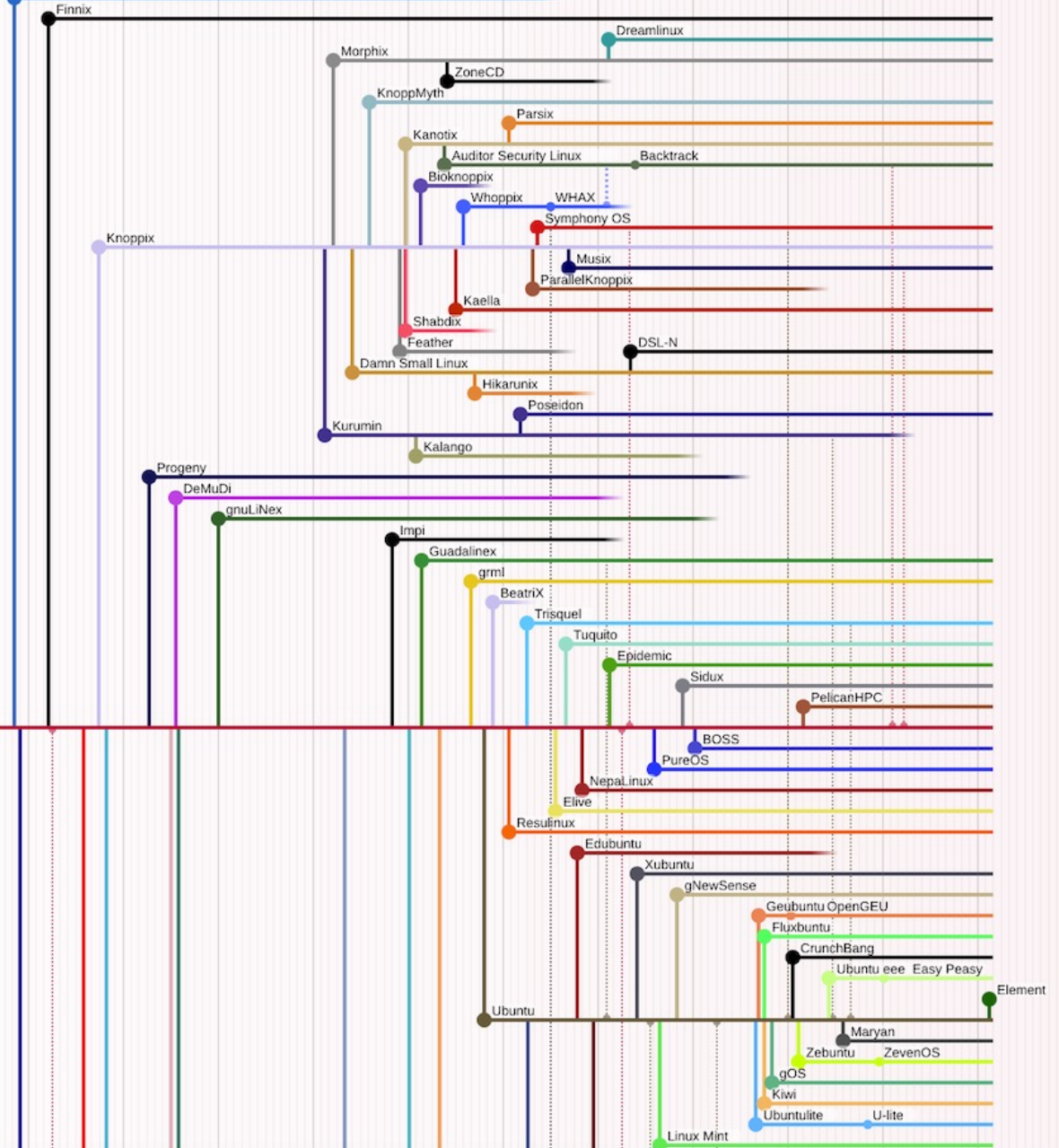- There are several hundred distributions, see:
    - distrowatch.com
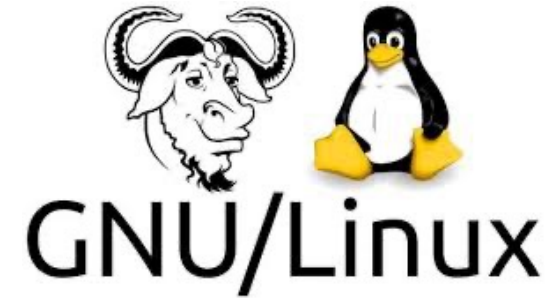
GNU/Linux distro timeline
Version 10.3

Authors: A. Lundqvist, D. Rodic
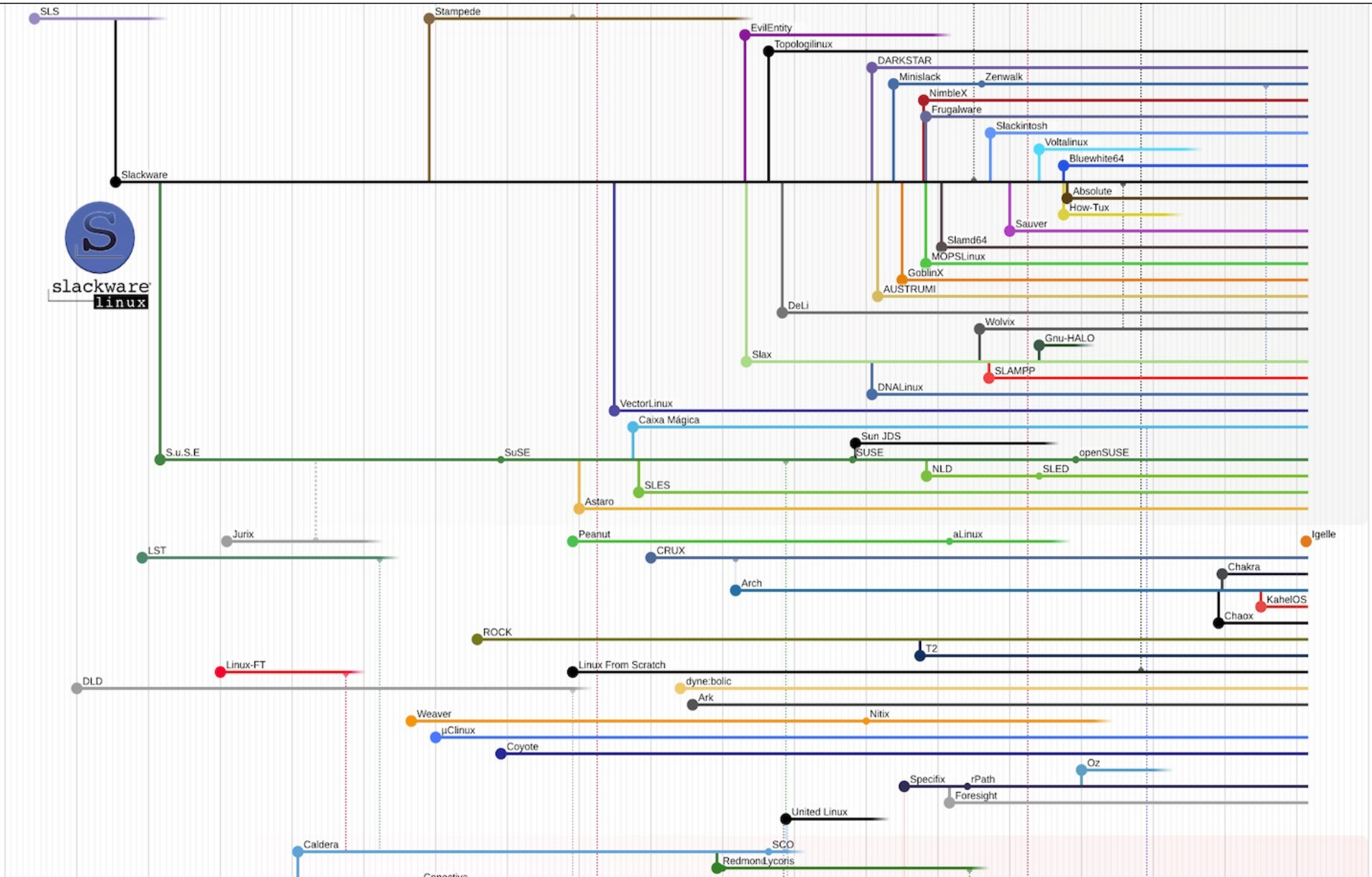web: futurist.se/gldt
email: andreas@futurist.se

Published under the GNU Free Documentation License.

POPULAR DISTRIBUTIONS

- Debian
    - Released 1993
    - Community based
    - Over 50 000 software packages
    - Uses APT (Advanced Package Tool)

    – Ubuntu
        - Linux Mint
    – Lindows
    – Kali

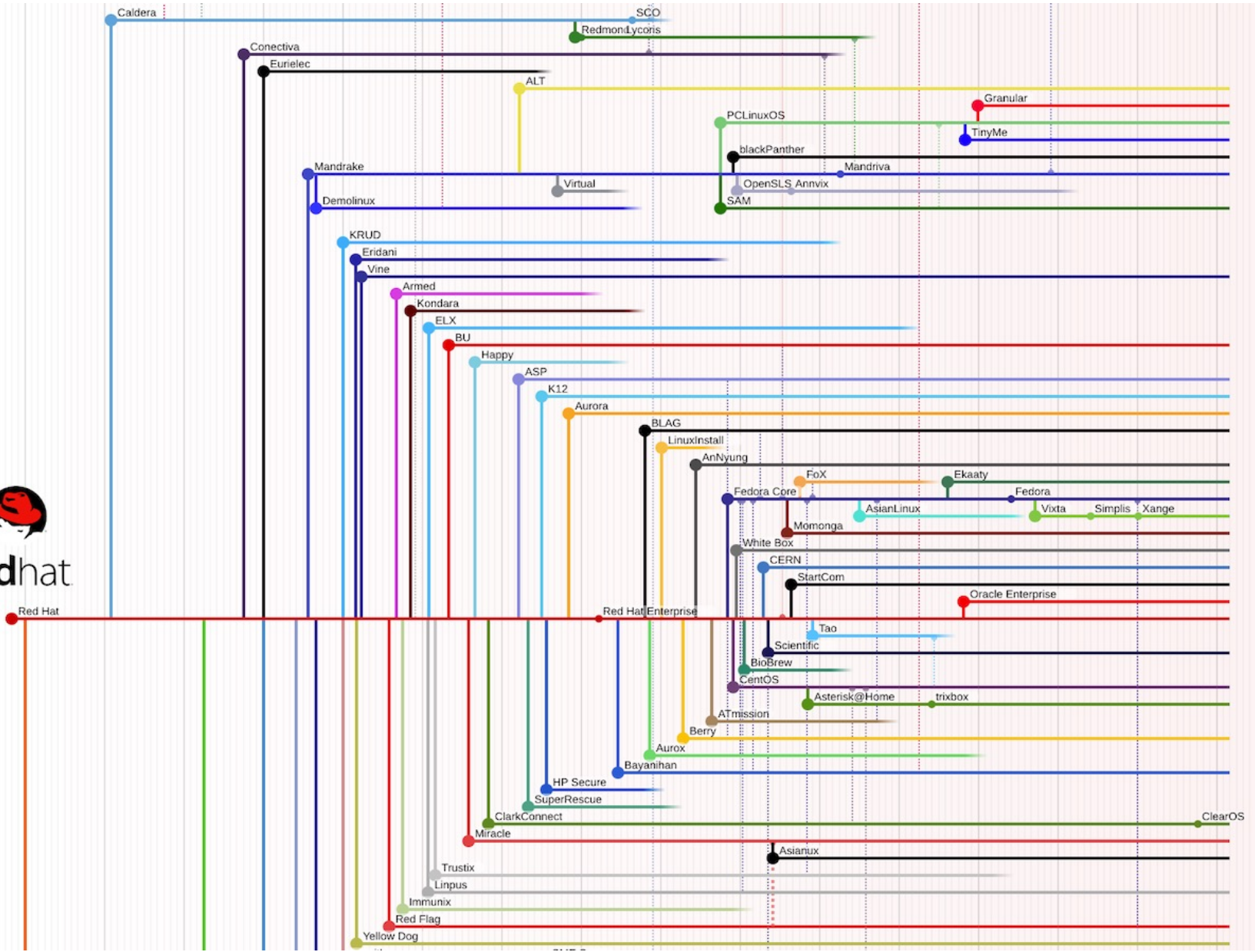Slackware Linux distribution timeline (1992–2010)

POPULAR DISTRIBUTIONS

- Slackware

  - Released 1993
  - Community based
  - More suitable for more advanced Linux users
  - Uses pkgtools (Collective Package Tools)

  - S.u.S.E -> SuSE -> SUSE
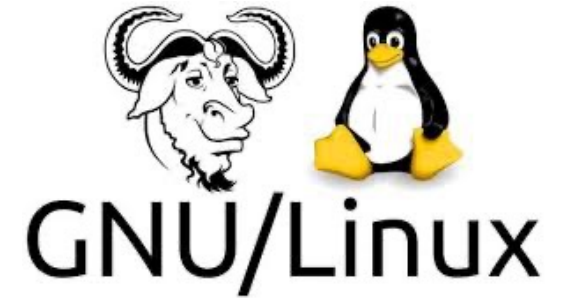 - SLES
  - OpenSUSE

POPULAR DISTRIBUTIONS

- RedHat
    - Released in 1994
    - One of the first commercial distributions
    - Most popular corporate distribution
    - 2012 exceeded over $ 1 Billion in revenue
    - 2019 Big Blue (IBM) acquires for $34b
    - Uses RedHat Package Manager (RPM)
    - YUM (Yellowdog Update Manager)
    - DNF (Dandified YUM)

    - CentOS
    - Fedora Core
    - Oracle Enterprise
    - Rocky
    - AlmaLinux

GNU LINUX DISTRIBUTIONS SUMMARY

- A Linux distribution consists of:
  - The Linux Kernel
  - System Drivers
  - Tools
  - Software
  - Compilers
  - Libraries

- There are several hundred distributions
  - Debian
  - Slackware
  - RedHat

GNU LINUX FILE SYSTEMS

UNIVERSITY OF THE
FREE STATE
UNIVERSITEIT VAN DIE
VRYSTAAT
YUNIVESITHI YA
FREISTATA

UFS
UV

GNU LINUX FILESYSTEMS

- Windows
  - NTFS, FAT32, FAT16, FAT12, FAT, MSDOS
- MAC
  - HFS+, APFS

- Linux
  - Several options for filesystem types
    - XFS, ZFS, EXT4, EXT3, ReiserFS, EXT2, EXT
    - Most generic:
      - EXT4
  - Software RAID
    - Multiple hard drives
    - Logical Volumes
      - ext4 on top

UFS
UV

CHOOSING A FILE SYSTEM TYPE

Filesystem	Indexing	Journal	Extents	COW	Use
ext2	h-tree	n/a	n/a	n/a	Old
ext3	h-tree	x	n/a	n/a	Old
ext4	h-tree	x	x	n/a	Most popular
xfs	b-tree	x	n/a	n/a	Standard
btrfs	b-tree	x	x	x	Flexible, Large Files

*** All the above filesystems can address Exabyte (ext4 up to 64 Zebibyte) of data and is POSIX compliant
NTFS can do 8 PB

- Indexing
  - h-tree: older linear indexing method, slow and not very scalable
  - b-tree: uses a database, files can be allocated in a few microseconds
- Journal: When a FS/System crashes, holds a journal of open files to check
- Extents: Usually a FS has 4k blocks, extents creates sub-allocation blocks (large files)
- CopyOnWrite: Won't overwrite old data blocks, but write new data blocks
                Easy to revert to previous state of a file, makes journal redundant

UFS
UV

EXT FILE SYSTEM SIZE

Common Prefix			Binary Prefix			Filesystem Size
Name	Symbol	Decimal	Name	Symbol	Binary	Max
kilobyte	KB	10^3	kibibyte	KiB	2^{10}	
megabyte	MB	10^6	mebibyte	MiB	2^{20}	
gigabyte	GB	10^9	gibibyte	GiB	2^{30}	FAT16: 16GiB (256KB clusters, 4KB sectors)
terabyte	TB	10^{12}	tebibyte	TiB	2^{40}	EXT2/3: 2-32TiB* FAT32: 16TB (64KB clusters, 4KB sectors)
petabyte	PB	10^{15}	pebibyte	PiB	2^{50}	NTFS: 8PB
exabyte	EB	10^{18}	exbibyte	EiB	2^{60}	EXT4: 1EiB
zettabyte	ZB	10^{21}	zebibyte	ZiB	2^{70}	EXT4: 64 ZiB (4KiB block size)**
yottabyte	YB	10^{24}	yobibyte	YiB	2^{80}	EXT4: 1 ZiB (64KiB block size)**

* 1KiB block size – 8KiB block size
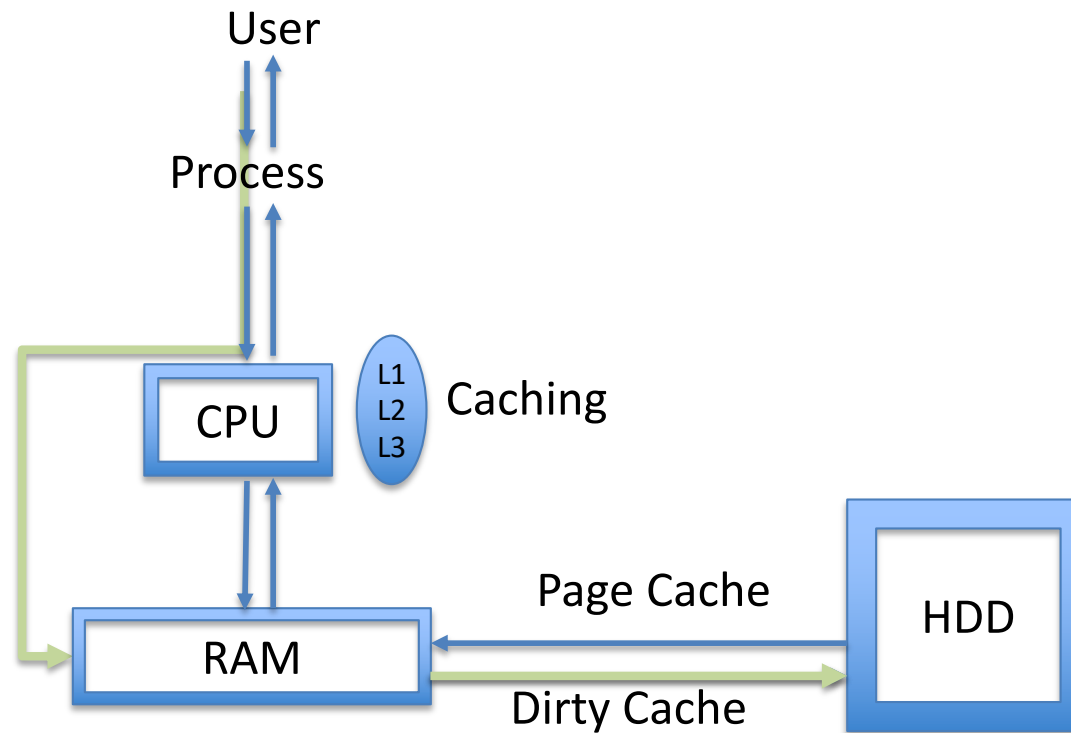
** Theoretical

UFS UV

SWAP SPACE

- Emulated memory on a hard drive
- The rule of thumb was 2 x Size of the RAM
- Use **free**, **ps** and **vmstat** commands to determine the actual need
  - **cat /proc/meminfo**
  - **top** (VIRT = available) (RES= resident = currently using)

- Page Cache: Getting Memory from secondary storage into primary storage – like when reading files from disk. Important **PERFORMANCE ENHANCEMENT**

- Virtual Memory is the total allocable memory, also known as Process Address Space (a 64-Bit system has a total of 32 TB of Virtual Memory)
- Swap is not Virtual Memory.

UFS
UV

MORE ON SWAP SPACE

- Here is a rule of thumb for servers:
    - If you have less than 4GB RAM: 50% of RAM
        - Eg. 4GB RAM system: Allocate 2GB SWAP
    - If you have more than 4GB RAM: 25% of RAM
        - Eg. 256GB RAM system: 64GB SWAP

- However, for Scientific Applications, I would still recommend 50% of RAM for the **nodes**.... up to 128GB of SWAP

- It could also be useful "playing" with swappiness:
    - **cat /proc/sys/vm/swappiness**
    - sysctl: vm.swappiness=xx
    - I would recommend a value of 60 to 80 if you use an SSD

MEMORY CONCEPTS

User wants to access a file from the HDD

PRACTICAL SECTION

UNIVERSITY OF THE
FREE STATE
UNIVERSITEIT VAN DIE
VRYSTAAT
YUNIVESITHI YA
FREISTATA

UFS
UV

VIRTUALIZATION

- Download and install Oracle Virtual Box
- Available for download: http://www.virtualbox.org
- Hypervisor installed on Physical Machine
- Host machine
  - Virtual machine (VM)

UFS
UV

HPC SOFTWARE

- Operating System
  - <u>Rocky</u>, **CentOS**, OpenSUSE
- Compilers & Libraries
  - **[GCC/Fortran, <u>Make</u>, <u>CMake</u>, <u>OpenMP</u>], <u>OpenMPI</u>**, CUDA
  - <u>Intel</u>, PGI both have "Free" editions
- Resource/Workload Management
  - PBS Torque (Adaptive Computing), **<u>Slurm</u>**
- Scheduler
  - **Maui** (Adaptive Computing), Moab
- Environment managers
  - **<u>Environment Modules</u>**
- Monitoring
  - **Ganglia, <u>Zabbix</u>,** iostat, top, htop, vmstat

- **CHPC contestants: You will have to know how to install, configure and use the applications that are underlined**

- **The software in bold is the norm for most HPC worldwide.**

UFS
UV

OPERATING SYSTEM

- CentOS 9.x
    - RedHat Linux derived
    - "Free" version of RedHat Enterprise Linux
    - Written in C
    - Version 7.x - End of Life: 30 June 2024
    - Version 8.x - End of Life: 31 December 2021
    - Version 9.x - End of Life: t.b.a. ± 2027
- Major Changes in v8:
    - Kernel Version 4.18.x
    - systemd
        - journald
- Major Change in v9:
    - Stream

CENTOS

- Top 10% of Fortune 500 runs over 50 000 instances

- China's entire telecoms backend

- RedHat's take on CentOS:

    – Running CentOS in production was the equivalent of running with scissors in your hand ("Go ahead, but you're bound to get hurt!")

CENTOS CLONES

- In 2020 CentOS moved over to CentOS Stream

- "Clones" were created
  - AlmaLinux
  - Rocky Linux

- RedHat Response:
  - Magnus Glantz, principal solution architect at Red Hat:
    - "making money off others' hard work."
    - Well, sure. Most people prefer to get things for free. We'd also like to have unicorns as pets. But in the real world, if you get enough people free riding on a product, that product will go away.

ROCKY LINUX

- 100% Bug for Bug RedHat Release
- Created by the original founder of CentOS
- First released in 2021

- Backed by:
  – ARM, AWS, Google Cloud, Mattermost, Supermicro, VMWare etc.

ROCKY LINUX

- Get media:
- https://mirror.ufs.ac.za/rocky/9.2/isos/x86_64/

  – **Rocky-9.2-x86_64-minimal.iso**   ±1.5GB
  – Rocky-9-latest-x86_64-minimal.iso
- SHA256 Checksum:
  06505828e8d5d052b477af5ce62e50b938021f5c28142a327d4d5c075f0670dc

- With GUI:
  – Rocky-9.2-x86_64-dvd.iso   ±8.8GB

USING ISO

- Network:
  - **DHCP & TFTP**
- Burn a DVD
- **Cloud/Hypervisor**
- USB Memory Stick
  - The GNU Linux/Mac CLI:

    sudo dd if=Rocky-9.2-x86_64-minimal.iso of=/dev/sdd

    - Overrides entire disk – risky, can override HD/SSD
  - Alternative – Installer Helpers
    - Rufus – Windows Only
    - **Ventoy** – Windows/GNU Linux/Mac (with effort)

VENTOY

- Open Source
- Easy to use
- Format/Destroy drive FS once
- Boot multiple ISOs
- Browse images:
  - ISO, WIM, IMG, VHD(x), EFI
- Tested on 1100 images:

UFS
UV

VENTOY

- ## Windows

  Windows 7, Windows 8, Windows 8.1, Windows 10, Windows 11, Windows Server 2012, Windows Server 2012 R2, Windows Server 2016, Windows Server 2019, Windows Server 2022, WinPE

- ## Linux

  Debian, Ubuntu, CentOS(6/7/8/9), RHEL(6/7/8/9), Deepin, Fedora, Rocky Linux, AlmaLinux, EuroLinux(6/7/8/9), openEuler, OpenAnolis, SLES, openSUSE, MX Linux, Manjaro, Linux Mint, Endless OS, Elementary OS, Solus, Linx, Zorin, antiX, PClinuxOS, Arch, ArcoLinux, ArchLabs, BlackArch, Obarun, Artix Linux, Puppy Linux, Tails, Slax, Kali, Mageia, Slackware, Q4OS, Archman, Gentoo, Pentoo, NixOS, Kylin, openKylin, Ubuntu Kylin, KylinSec, Lubuntu, Xubuntu, Kubuntu, Ubuntu MATE, Ubuntu Budgie, Ubuntu Studio, Bluestar, OpenMandriva, ExTiX, Netrunner, ALT Linux, Nitrux, Peppermint, KDE neon, Linux Lite, Parrot OS, Qubes, Pop OS, ROSA, Void Linux, Star Linux, EndeavourOS, MakuluLinux, Voyager, Feren, ArchBang, LXLE, Knoppix, Calculate Linux, Clear Linux, Pure OS, Oracle Linux, Trident, Septor, Porteus, Devuan, GoboLin, SuperGrub2Disk, Proxmox VE, Kaspersky Rescue, SystemRescueCD, MemTest86, MemTest86+, MiniTo, CloneZilla, Berry Linux, Trisquel, Ataraxia Linux, Minimal Linux Live, BackBox Linux, Emmabuntüs, ESET, Enso Linux, Security Onion, Network Security Toolkit, Absolute Linux, TinyCore, Springdale Linux, Frost L, Virage Linux, Blackweb Security OS, R-DriveImage, O-O.DiskImage, Macrium, ToOpPy LINUX, GNU Gui, Austrumi, Zenwalk, Anarchy, DuZeru, BigLinux, OpenMediaVault, Ubuntu DP, Exe GNU/Linux, 3CX Phone, Fatdog, ForLEx, Hanthana, Kwort, MiniNo, Redcore, Runtu, Asianux, Clu Linux Live, Uruk, OB2D, BlueOr, Thinstation, TurnKey, tuxtrans, Neptune, HefftorLinux, GeckoLinux, Mabox Linux, Zentyal, Maui, Reborn C, Linux, Chalet OS, Chapeau, Desa OS, BlankOn, OpenMamba, Frugalware, Kibojoe Linux, Revenge OS, T, Hyperbola, VyOS, EasyNAS, SuperGamer, Live Raizo, Swift Linux, RebeccaBlackOS, Daphile, CRUX, Ur, OSGeoLive, Easy OS, Volumio, FreedomBox, paldo, UBOS, Recalbox, batocera, Lakka, LibreELEC, Parc, Hamara, Rocks Cluster, MorpheusArch, Redo, Slackel, SME Server, APODIO, Smoothwall, Dragora, Lins, LliureX, Freespire, DietPi, BOSS, Webconverger, Lunar, TENS, Source Mage, RancherOS, T2, Vine, Pisi, EasyUEFI, R-Drive, PrimeOS, Avira Rescue System, bitdefender, Checkra1n Linux, Lenovo Diagnostics, C, Kerio Control, RED OS, OpenWrt, MocaccinoOS, EasyStartup, Pyabr, Refracta, Eset SysRescue, Linpack, iKuai, StorageCraft SCRE, ZFSBootMenu, TROMjaro, BunsenLabs, Todo en Uno, ChallengerOS, Nobara, HelenOS, XeroLinux, Tiny 11, chimera linux, ...

- ## Unix

  DragonFly FreeBSD pfSense GhostBSD FreeNAS TrueNAS XigmaNAS FuryBSD OPNsense HardenedB

- ## ChromeOS

  FydeOS, CloudReady, ChromeOS Flex

- ## Other

  VMware ESXi, Citrix XenServer, Xen XCP-ng


```
你好  archlinux-2020-11.01-x86_64.iso
微软  cn_windows11_x64.iso
CentOS-8.2.2004-x86_64-minimal.iso
cloudready-free-92.3.4-64bit.img
deepin-desktop-community-20.2.4-amd64.iso
FreeBSD-13.0-RELEASE-amd64-disc1.iso
synoboot-v1.02b.img
ubuntu-21.10-desktop-amd64.iso
VMware-VMvisor-Installer-7.0.0-15843807.x86_64.iso
WinPE10_8_Sergei_Strelec_x86_x64_2021.07.21_English.iso
```

This ISO file contains USB and network drivers and third-part software.

1.0.64 UEFI www.ventoy.net   h:Help F1:Memdisk F2:Power F3:TreeView F4:Localboot F5:Tools F6:ExMenu

UFS
UV

VENTOY PLUGSON

- VentoyPlugson creates JSON to <u>automate</u> install:

```
Boot without auto installation template

Boot with /ventoy/script/centos_kickstart.cfg
```

SUSE	autoYast XML	autoYast.xml	SLES and openSUSE

UFS UV

Rocky Linux 9.2

Install Rocky Linux 9.2
Test this media & install Rocky Linux 9.2

Troubleshooting   >

Press Tab for full configuration options on menu items.

PARTITIONS AND SIZES

- Use "Own Layout"
- Use a Logical Volume.....or btrfs (more advanced)
- Create the following Partitions as indicated

Mount Point	FS Type	Size
/boot	xfs	1024MiB
swap	swap	2 x RAM Size or 64GB for Nodes
/	ext4	Rest

UFS
UV