The Cloud, Powered by UNIX

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***Abstract*—In 1969, at AT&T's Bell Laboratories, a team led by computer scientists Ken Thompson and Dennis Ritchie created the first version of UNIX for use as a time-sharing computer system. Later on, students and professors at the University of California at Berkeley would expand UNIX into the Berkeley Software Distribution, or BSD for short. UNIX inspired free and open source operating systems such as FreeBSD and Linux and was the basis of Apple's Mac OS. [1]**

***Index Terms*—unix, cloud, server, web, service, freebsd, linux, iaas, caas**

I. Introduction

UNIX is ubiquitous in the cloud. Roughly 80% of websites are hosted on UNIX-based servers, with over 40% of those using Linux [2]. UNIX-based operating systems (OSes) are commonly used in the cloud as they are typically free, open source, resource-efficient and have a powerful command-line interface (CLI) [3].

Fig. 1. FreeBSD, a popular UNIX-based operating system. [4]

II. Advantages and Disadvantages of UNIX

UNIX-based OSes are an attractive and popular choice for the cloud due to their free and open source nature, flexibility and powerful CLI [3].

A. Advantages of UNIX

UNIX-based OSes have several advantages [3]:

- **Portability**
  - They can run on a large number of different hardware platforms.
  - They are written in C, a popular low-level programming language.
- **Memory Usage**
  - They are very memory-efficient.
  - They handle virtual memory well.
- **Powerful CLI:** The CLI comes with a variety of powerful commands that can save a lot of time over having to perform several mouse clicks in a graphical user interface (GUI).
- **Everything as a File:** Several device interfaces are exposed as file-like objects, making them quick and easy to work with, especially in the CLI.
- **Security:** They use UID and GID for user permissions, which control file access.
- **Free and Open Source:** They are typically free and open source, allowing anyone to audit and contribute to them.

B. Disadvantages of UNIX

Unfortunately, UNIX-based OSes have downsides [3]:

- **Not Beginner-Friendly:** They can be have a high learning curve.
  - Most system administration on UNIX-based OSes is done via commands, of which there are many, which users will have to memorise to work efficiently.
  - Some commands have functions that are different to what their name implies.
  - Some commands have syntax that's different to most, adding extra nuances that users must familiarise themselves with.
- **Lack of driver support:** Some devices may not have open-source drivers, official drivers or any drivers at all for these OSes.

III. Useful UNIX Tools

UNIX-based OSes come with tons of useful commands [3]. Here are some listed by [5]:

- **curl:** This command connects to and downloads content from a given URL, making it useful for testing API-endpoints.
  - For example, it can check if they respond to requests, show the HTTP response code (200 for OK, 500 for Internal Server Error, etc.) or even test if a domain name resolves.
  - 'jq' can be used to print an APIs JSON response in a more readable format, with line breaks and indentation. For example: `echo '{...}' | jq`, where `{...}` is a long JSON object.
- **tail:** Outputs the last few lines of a file, which is useful for checking the most recent lines in a logfile.
  - By default, the last 10 lines are printed, but this can be changed with the `-n` argument.

  - `-f` causes `tail` to "follow" the file, showing new lines being written to it in real time.
- **grep:** Shows lines of a file with content that matches a given regex pattern. Useful for searching through log files and can even be used with command output that's piped into it.
- **ps:** Shows running processes and their details such as:
  - The user it's running under.
  - Process ID.
  - Parent process ID.
  - Time it was started.
  - Time it was running for.
- **env:** Sets and prints environment variables and their values.
- **lsof:** Shows opened files and what processes are using them, this includes device interfaces exposed as file objects. Similar to `netstat`, `lsof` can be used to check ports that are being listened to and by what process.
- **nslookup:** Queries domain names, seeing where they lead to or if they're working properly.
- **history:** Shows the users command history. All shells will have a variant of this command.

IV. IaaS V.S. CaaS

There was 2 popular ways of offering UNIX-based hosting: Infrastructure as a Service (IaaS) and Container as a Service (CaaS) [6].

A. Infrastructure as a Service

Infrastructure as a Service (IaaS) is a cloud computing model where vendors provide access to hardware that customers can manage through the internet and host online services such as web applications, data storage or any server software they desire. This hardware is hosted and maintained by the vendors. IaaS allows for businesses to deploy online services without having to invest in their own hosting infrastructure. Virtualisation is typically used to isolate and split the host hardware into smaller virtual machines [6].

The benefits of IaaS are [6]:

- Businesses don't have to expend as much effort in managing, maintaining and expanding their servers, as vendors handle most of it.
  - Most vendors have very high uptime guarantees. For example, DigitalOcean and AWS's instances and Google Cloud's zones guarantee 99.99% uptime, and Google Cloud's instances guarantee 99.5% uptime.
- Because hardware resources are allocated via virtualisation, scaling up or down is a lot faster and can be done via software (i.e. through a web portal or vendor provided CLI).
- It replaces large upfront infrastructure costs and replaces them with a more palatable subscription fee.

B. Container as a Service

Container as a Service (CaaS) is a cloud computing model that involves applications being deployed as containers, rather than via a traditional UNIX application install. These containers also provide isolation from the host system and other containers. Containerised applications run on the host OS instead of utilising virtualisation. CaaS runs on top of IaaS [6].

The benefits of CaaS are [6]:

- Isolation without requiring a separate OS per instance, as containerised applications still run on the host OS, versus a virtual machine per isolated application. This saves on:
  - Processing Power
  - Memory
  - Storage Space
  - Startup Times (for an isolated application)
- Consistent environment for the application within. This reduces the likelihood of unexpected behaviour caused by different environments.

C. IaaS V.S. CaaS

- Due to the fact that CaaS runs on top of IaaS anyway, IaaS is more hardware efficient and less complex.
  - Is it essentially a virtualisation of a basic UNIX-based system, meaning that it is not much different to managing one, reducing complexity.
  - The lack of containerisation on top of IaaS means less overhead.
- CaaS provides isolation without having to have an OS for each isolated application, reducing hardware usage.
- CaaS applications come with their container, and therefore, a consistent environment, instead of hoping that the OS environment they're running on is compatible.

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