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Explain each of the software components of the LAMP stack:

- Linux
- Apache
- MySQL
- PHP

Linux

Description: Linux is an open source (developer maintained and free for anyone to use) operating system (OS) that is based on Unix. Linux was developed by software engineer Linus Torvalds in 1991. It runs computers, servers, mobile phones and lots of other devices.

Function: Linux uses a program interface called the Linux Kernel that allows users to control the systems hardware and software. The kernel is known as a command line interface (CLI). It is a text-based way to interact with a system using keyboard commands. The kernel connects hardware and software allowing users to manage different components including networks, file systems, drivers and more.

On being initiated the Linux system loads a bootloader program called GRUB – Grand Unified Bootloader that starts the Linux Kernel image from the hard disk memory. This enables the kernel to start executing tasks.

Once booted, the kernel is in control of the system and its associated processes. The kernel controls all communication between applications and external hardware devices, sending requests from applications to the devices through drivers. The kernel design is critical to preventing conflicts and maintaining the stability of important processes that make a system work such as Computer Processing Unit (CPU) usage and the execution of applications.

Use Cases: Due to the success of Linux' free open-source nature and global reach of developers. Linux has many use cases.

Many vendors rely heavily on Linux for the functionality of their own software using a collection of Linux Kernel source code so they can deploy their own uses. This can be known as maintaining a 'custom Linux kernel' or 'forked Linux Distribution' and has been critical in the development of enterprise applications such as artificial intelligence (AI), edge computing and the internet of things (IoT).

An example of this would be an American software company, Red Hat, they provide enterprise open-source software products across cloud, infrastructure, application services and more. They created their own version of Linux, which is a commercial Linux distribution (distro) built using the open-source Linux kernel called Red Hat Enterprise Linux. On this product their engineers work on taking an upstream version of Linux and applying extensive testing, quality assurance and patch updates. Offering a version that has special security and management capabilities that is then offered to customers on a subscription basis starting at $383.90 per year.

Programmers who prefer to use a free open-source desktop environment with lots of extra tools often choose Linux as their no.1 choice to install on their PC's. Tools are available such as Linux Fedora which is a free open-source OS based on the Linux kernel that includes software automation for many basic tasks.

Linux is also widely used to connect devices and systems exchanging messages across a network. Cisco is global leader providing network hardware, software and telecommunications who used Linux to underpin a version of its Cisco Internetwork Operating System.

Linux powers more than half of the web servers globally, is used within Headless systems, DevOps environments, within the Internet of Things devices and Supercomputers.

Strength: Flexibility, stability, compatibility and high performance are behind some of the reasons the Linux OS has become one of the world's leading operating systems. This is down to the success of the Linux Kernel.

Security: Linux has lots of built-in security features and user best practises to protect systems from threats. Key features include keeping software updated, using firewalls, disabling root login, managing user permissions, encryptions, hardening services (SSH), monitor and log activity and utilizing other security tools. Security tools that are available include NMAP (network scanner), OpenVAS (vulnerability scanner), Nikto (web server scanner), Firewalld (Firewalls), Anti-virus / Anti-Malware and VPN (virtual private networks). Lots of vendors like Red Hat have their extended versions of Linux. Red Hat Linux Enterprise offers enhanced security features which are also very attractive to businesses looking for enterprise grade security features.

Well known security distros such as Kali Linux offer extra layers of security such as advanced penetration testing, ethical hacking and network security assessments.

Cost: Linux does not charge for licensing. Making it an attractive free alternative to competitors.

Reliability: The free open-source model means ease of access, along with a community of dedicated global developers sharing knowledge allowing developers to combat issues, notify vulnerabilities, failures and bugs. This also allows Linux to ensure that updates are regular, every 10 weeks which increases performance, functionality and device compatibility.

Compatibility: Linux is considered 'backwards compatible'. This means that it is always up to date with patches being released to address security and compatibility issues. With many different Linux distributions available and thousands of applications, Linux is considered highly compatible.

Cloud Computing: Linux is the underlying OS in many cloud computing instances. AWS, Azure, GCP, the three main cloud computing providers all offer Linux Kernel distros on their platforms. This is due to the flexibility, scalability and cost effectiveness. Making it a go to choice for cloud providers and cloud-hosted applications.

Scalability: Linux' kernel is built with a modular approach and is customizable. This means that developers can add or remove features and drivers (software that communicates with hardware) as needed without effecting the entire system. It can run on a vast array of hardware from minimal systems to the world's fastest super computers and large data centres. It is known for its stability and ability to require little downtime / re-boots which is vital for large-scale operations. All this combined makes it an excellent choice for scaling infrastructures both on premises and off premises as-well as combining effectively with cloud solutions for extra back-up and security layers.

Limitations: Linux can be tough for beginners to learn, especially those unfamiliar with the command-line interface. Some hardware components lack good driver support for Linux which can lead to compatibility issues. Many games are still not available on the Linux platform, although with release of Proton software which allows for many Windows games to be accessible via Steam, (cloud-based gaming platform) some titles are still not available. There are also some compatibility issues within games such as anti-cheat software and other incompatibilities meaning other titles may not be available.
Many applications especially those developed by Microsoft such as Microsoft Office and Adobe Creative Suite do not have Linux versions.

Alternatives: The main alternatives to Linux are other operating systems such as Microsoft's Windows, Apple's macOS, or other free and open-source systems such as ChromeOS, FreeBSD or ReactOS.

Linux Vs Windows

Microsoft's Windows is widely regarded as the main competitor to Linux and holds most of the global market share estimated to be around 70%.

Cost: Windows requires licence fees and varies per user compared to Linux which is free. Both operate different models and suit different organisations based on financial and operational models.

Licensing: Whereas Linux' open-source platform requires no purchase fee's Windows requires purchasing for legal use. This makes Linux super attractive to the everyday user, start-ups and environments where budget requirements need to be met, and everyday support is not vital. The cost varies per user on Windows based on version, hardware purchases, and costs can skyrocket for multiple licences especially with Windows Server Editions. Businesses who prefer Windows require it for its integration with essential software. The cost provides value with features such as regular updates, advanced security measures and professional support, which is crucial for business operations.

Customization: Linux is open-source and provides source code access and is highly customizable. This allows customers to assess their needs and tailor a solution based on system requirements which contrasts with Windows. Windows offers limited customization primarily through settings and options; this is to protect the source code and value of its applications.

Servers: Linux servers are widely known to be stable and are the backbone to many enterprise level organisations and is the primary choice for cloud and virtualisation infrastructures (running a hyper-visor layer with multiple virtual machines running on a single physical server). Microsoft takes second place here. While not as dominant in terms of numbers when it comes to server environments, Windows Server offerings integrate seamlessly with Microsoft Active Directory, SQL Server, SharePoint, and Exchange which are all Microsoft products creating an environment easier to manage. Windows Server is known for ease of use and its GUI with tools like Windows Admin Centre. Microsoft has developed a programming language called .NET, applications built with this sometimes see no other option than being hosted on Windows Server.

Networks: Both Linux and Windows support TCP/IP and DNS protocols. Both are interoperable with each other's network. Microsoft is preferred in corporate environments due to features like Active Directory where Linux takes the edge in server environments, embedded systems and networking gear (routing, switches) due to stability, security and efficiency.

Scalability: For businesses that require to scale their operations or need a tailored solution, Linux offers a distinct advantage by allowing extensive customization without the costs. This is great for start-ups and tech companies that need to scale quickly, without significant overhead expenses. Linux can effectively manage large workloads consistently and is deployed in large-

scale cloud environments and supercomputing. Windows offers a more robust approach with reliable and familiar tooling such as Active Directory which helps manage thousands of user accounts and permissions efficiently. Windows is favourable in environments that already have Microsoft technologies, and the ease of use can be favourable when integrating with existing environments.

Use: Windows offers a friendly user interface (GUI) and is easy to use, the Linux command-line can be daunting for new users and non-technical users.

Compatibility: Windows is excellent for commercial and popular software whereas Linux is not so strong across the mainstream. Linux is excellent within its own community and integrates with lots of different hardware. Windows can integrate seamlessly into environments with Microsoft products.

Support: Day-to-day professional support is offered by Windows especially those tied into contracts. Linux is community driven and therefore varies.

Security: Windows is known for its robust security features, although does suffer more attacks because of its widespread use. Linux was generally considered to be more secure due to its permission structure and community driven patching. However there have been many recent exploits targeting Linux operating systems. Both have strong pre-built in security features, such as Windows Microsoft Defender and Linux' robust user privileges and permissions model. Both integrate well with other software, Anti-viruses and Anti-Malware.

Performance: Linux is generally considered to be more lightweight and offers better efficiency and resource management. Linux is praised for its ability to run smoothly across various hardware. It runs well on systems with limited processing power due to its minimal resource usage. Windows can be optimized but can be resource intensive due to its graphical user interface and array of background services.

Conclusion: Both Windows and Linux are great operating systems. Linux is a free option geared towards providing a lightweight, customizable, secure OS that relies on its community and open-source code that allows for better speed, many distros and applications. Linux offers strong security features and ability to support enterprise level architectures. Windows is the more expensive option, has a beginner friendly UI, better for gaming, provides structured support, offers some essential business applications along with leading security, but may substitute performance for robustness in certain areas. Microsoft provides reliable security and can support complex enterprise environments. Servers, users, developers and educational settings are strong footholds for Linux OS. Business environments, general users and personal computing tend to be where Windows picks up a larger share of the market. Depending on what your requirements are will depend on which OS offers the better solution.

Apache

Description: Apache is a free open-source web server that powers many websites by handling requests and serving content to web browsers. It is known for its modular design, cross platform capability across OS such as Linux, MacOS and Windows. Developed in 1995 and is maintained by the Apache Software Foundation. It quickly became one of the most widely used web servers due to its reliability, flexibility and extensive modular support.

Function: The Apache web server accepts requests from web browsers using the HTTP/HTTPS protocols that are on ports 80 & 443 respectively. The Apache web server processes those requests and retrieves the requested files such as images, HTML, CSS and displays web pages to the browser. Apache is a key component in the LAMP web application stack which compromises of Linux, Apache, MySQL, & PHP.

Most web servers have a similar architecture. Firewalls, Load balancers, Web Servers (Apache Web server) & Database Servers.

Apache functions to communicate over networks from client to server using the TCP/IP protocol. Apache can be used for various protocols but the most common is Hyper Text Transfer Protocol/Secure. The HTTP/S defines how the messages are formatted and transmitted between web browsers and web servers, instructing them how to handle requests.

The Apache HTTPS server allows you to configure its behaviour through Apache configuration files. By default, Apache listens to the IP Addresses configured in its configuration files that are being requested.

Apache can accept and route specific traffic to certain ports and domains. You can have virtual hosting on a single server as Apache can be configured to handle multiple domains and ports. By default, Apache runs on port 80. For example, Apache can have one domain listening on port 80, another on port 8080 (commonly used alternative port to 80 as a proxy server, although can be a security risk if not secured properly), and a third on port 443 using HTTPS all on Apache.

Once a message reaches its destination Apache sends notice to the original sender that their data has arrived successfully. If there is an error in receiving data or packets were lost in transit, the destination host or client sends a Not Acknowledged, or NAK message, to inform the sender that the data needs to be re-transmitted.

Use Case: Due to its strong hosting, Apache serves as the choice for many enterprise level businesses who look to make use of its capabilities. Many financial apps, data analytics platforms and most noticeably e-commerce platforms such as Walmart use Apache. Apache has the ability to deal with thousands of daily transactional requests and provides a seamless user experience. Apache also hosts companies' intranets, websites, private and secure networks that share resources and data confidentially and securely. Modern DevOps

environments also take advantage of Apache load balancing; servers also act as reverse proxies for demanding web applications.

Many websites and web applications use Apache for its compatibility with most widely used scripting languages such as Python & PHP which makes it a preferred choice and takes up around 25% of the worlds market share. Content management systems like WordPress and Drupal are powered by Apache servers alongside powerhouse CRM platforms like Salesforce. Other users include music streaming giant Spotify and media news sites such as The Guardian.

Strengths:

Cost: Apache is an open-source software that is complete free even if used commercially.

Compatibility: The Apache server is compatible with many programming languages including, Python, PHP, Perl and many others. Apache is compatible with many kinds of platforms including Linux, Unix, Windows, and MacOS. It has a modular architecture than can enable new features and functionality being added quickly and easily.

Virtual Hosting: Apache's virtual hosting is cost effective and highly scalable. You can run a virtualised environment running multiple websites on a single server enabling enterprises to manage multiple domains without extra costs and quickly spin up virtual instances as needed.

Customizable: Open source meaning the code can be adjusted to the needs.

Reliability & Performance: Highly reliable and offers excellent performance. Apache delivers content at great speed returning user requests to the client in seconds.

Use: Is easy to install and can be used on every operating system. Has impressive documentation that is extensive and useful.

Load balancing: The Apache server's load balancing capabilities allow it to optimize resources during high traffic on popular sites and applications. Apache servers are also effective at caching, storing and reusing frequently requested pages to reduce workload.

Security: Apache has a good track record of security and receives regular updates and improvements for the security system. The Apache layer supports SSL/TLS (Secure Sockets Layer/Transport Layer Security) encryption protocols that govern how computers communicate. Apache allows customers to customize their level of encryption by using a module known as mod_ssl. Apache supports a wide-ranging powerful authentication and authorization tools that allow users to monitor and restrict resources. Examples: advanced password protection, IP Address allowlisting, LDAP (Lightweight Directory Access Protocol) and more. Apache can be configured to use different kinds of firewalls according to the needs of a specific compute environment. ModSecurity is an example of an open-source web application firewall that helps protect sensitive web applications from attacks aimed at the application layer.

Limitations: Security Flaws: Relies heavily on configuration and ongoing maintenance; software must be updated. Server requires hardening by running the sever as an unprivileged user to limit potential damage if compromised. Requires minimising of the information Apache discloses in its response by hiding the server version and type. Disabling any unnecessary modules to reduce the attack surface. Requires implementing security layers: The use of a firewall to add an extra layer of protection. A Web Application firewall (WAF) like ModSecurity to inspect and filter traffic in real-time. All other software on the system must be secure not just Apache.

Preventative Measures: Must be taken to avoid a Denial-of-Service Attack, including hashing Syn packets & implementing Syn cookies.

Vulnerabilities: Ability to modify the configuration offered an invitation to various threats when the code is tampered with, insecure gates open.

Performance: Extremely heavy traffic sites can cause performance issues.

Alternatives: Many alternatives exist such as Nginx, Apache Tomcat, Node.js, Lighttpd, Cherokee, Microsoft IIS, Appweb and Hiawatha to name a few.

Apache Vs Microsoft IIS

Cost: Apache web server is free, and so is Microsoft IIS, but there is a catch. You can only have access to Microsoft IIS if you have purchased Microsoft's Sever Operating system. You would also be required to pay for any underlying hosting services and underlying server with Microsoft IIS.

Licence: No required licence fee for Apache where Microsoft's IIS does not specifically require a licence to use the web server software, you must have a licensed copy of Windows Server.

Compatibility: Microsoft IIS was primarily built to work in conjunction with its own products and services unlike Apache which is highly compatible with lots of other languages and platforms. Microsoft IIS is great if you want to simplify the development and deployment for .NET and ASP.NET applications and is a strong solution for integration with other Microsoft environments. Hence why it only has a 6% share of the global web services market.

Security: As with all Microsoft's products it has a fairly robust nature, but is not without its own flaws. Microsoft IIS new flaw enables remote code execution by unauthorized attackers. The new vulnerability in internet information (IIS) Inbox COM objects could allow attackers to execute arbitrary code on effected systems. Apache has many security practises that need implementing such as hardening the server to provide a secure environment.

Use: Microsoft IIS uses a control panel like interface which can be considered more user friendly by design.

Performance: Apache is often the go to choice for developers looking for versatility and community driven support. IIS is optimized for handling media rich websites and enterprise applications benefitting from other Microsoft integrations and continuous updates.

Conclusion: Based on market share Apache web services dominates due to its versatility, ease of access, superior integration with other platforms and supported technologies. Microsoft IIS has strengths when delivering a capable solution within its Microsoft infrastructure environment, delivering exceptional performance for media rich websites and applications.

MySQL

Description: MySQL is the world's most popular open-source Relational Database Management System (RDBMS) that uses Structured Query Language (SQL) to create and manage databases. As a relational database, MySQL stores data in tables of rows and columns organized into schemas. A schema defines how data is organized and stored and describes the relationship among tables.

Function: Each software application needs a repository to store data so that the data can be accessed, updated, and analysed. MySQL is considered a relational database because it stores data in separate tables rather than in one big database. The data structure is organised into files for quick access. This logical data model is governed by rules, and is structured with objects such as data tables, views, rows, and columns which offers a flexible environment for DBA's (database administrators) and developers.

The MySQL Database is a client / server system that consists of multithreaded SQL Server that supports different back ends, programs and libraries, admin tools, and a wide variety of application program interfaces (API's). Developers can easily link the library into applications to get smaller, faster, easier-to-manage products.

Use Case: MySQL databases handle many of the world's largest E-commerce applications including Uber and Booking.com. It is highly popular for its ability to manage user profiles, credentials, user content, and financial data, including payment systems, along with fraud detection.

Social Platforms X, Meta, and LinkedIn all rely on MySQL. MySQL powers SaaS and independent software vendors such as IBM due to its speed and ability to get a product to market.

Strengths:

Cost: MySQL is free like many other databases; however, there are commercially available licences and paid versions with additional features and support which may be required depending on each use case.

Performance: MySQL is second amongst all databases behind Oracle. One reason is its speed. The MySQL database can perform large amounts of data queries without slowing down. It is a proven high-performance database that has many editions to support any demand.

Reliability: MySQL has been tried and tested for almost 30 years giving it a leading reputation with some of the world's largest companies who use it to run their most critical business applications.

High Availability: MySQL offers a complete set of fully integrated replication technologies for high availability and disaster recovery. It offers recovery point zero (zero data loss) and recovery time objective zero seconds (automatic failover) which make it an excellent choice for business that have service level agreement commitments and is great for storing critical business data.

Security: Fully compliant in both data protection and with industry government regulations including the European Union General Data Protection Regulation, the Payment Card Industry Data Security Standard, the Health Insurance Portability and Accountability Act, and the Defence Information Systems Agency Security Technical Implementations Guidelines. Many CVE's have been identified in MySQL over the years and so it requires enhanced security features as it is one of the most frequent victims of database cyber-attacks. It has powerful pre-built authentication to restrict access to only authorized users and supports a wide range of authentication methods from system-based authentication like PAM to more secure SHA-256 based on multi factor authentication methods. It can limit where users are connecting from and allowing only certain network addresses or machines to access the database. It can enforce password policies to enable stronger passwords.

Scalability: MySQL scales to meet the demands of most accessed applications. Its native replication architecture enables organisations to scale applications to support tens of millions of users and more.

Flexibility: The MySQL Document store gives users maximum flexibility in developing traditional SQL and NoSQL schema-free database applications.

Compatibility: MySQL is compatible with a wide variety of OS including Linux, Windows, macOS and connects with many programming languages such as Jave, Python, and PHP through official connectors and drivers. It extends its compatibility across hardware, application platforms, and many cloud databases are based on MySQL such as Azure Database for MySQL.

Use: MySQL is easily installed in minutes, and the database is relatively easy to manage.

Limitations: MySQL has limitations as it has a lack of built-in sharding for horizontal scaling and a maximum row size of 65,535 bytes. Data cannot be stored in precision as it can only use seconds and not milliseconds. Queries can fail if the system runs out of temporary space. Backups can require you to freeze a master server and the lack of reliable active-active configurations can complicate backups. The maximum number of partitions for a table is 8192. There is a limit of 16 keys per Index (for MyISAM).

Alternatives: There are plenty of alternative relational databases to choose from that include, MongoDB, MariaDB, Microsoft SQL Server, Oracle, AWS DynamoDB, PostgreSQL, Apache Cassandra and more.

MySQL vs Oracle

Oracle is a robust enterprise grade relational database offering advanced features, scalability and comprehensive support in contrast to MySQL's cost effective, ease of use and access alongside its open-source model.

Cost: MySQL has a free Community Edition and Enterprise Edition starts at $2,140 for 1-4 socket servers. The most expensive version is MySQL Cluster Carrier Grade Edition at $10,700 for small servers and $21,400 for larger configurations. Oracle Database Enterprise Edition processor licenses cost around $47,500 per processor core with two standard licenses costing $17,500 each. Oracle does have free version, but it is very restricted.

Scalability: MySQL works well for small to medium businesses and has an Enterprise Edition for large scale applications whereas Oracle is designed for large-scale, mission critical applications.

Performance: Oracle is a much more powerful database that MySQL and is able to process over 108,167 transactions per second often making it the choice for Enterprise level organisations and suited to heavy user traffic. MySQL is less powerful in comparison and is more suited to medium sized businesses. Oracle is also able to provide fine-tuned data and stores data in millisecond values.

Security: MySQL has a solid security platform and offers SSL, authorization and auditing in its enterprise edition. Oracle offers some more advanced features here such as SQL Firewall, Database Vault, Label Security and very comprehensive encryption and access control.

Support: Optional paid support and great community support from MySQL. Oracle is targeted towards the enterprises with 24/7 enterprise support and has detailed documentation.

Conclusion: MySQL and Oracle both offer fantastic databases. MySQL has features that can support large data sets but is not on the same level as Oracle for enterprise grade databases. MySQL is also great for companies with a tighter budget as it can be nearly half the price of Oracle when it comes to some enterprise versions. If money is not an issue, Oracle overall is

a more superior database and deals with data in more granular details like the ability to store data in milliseconds, these details makes it a choice for formula one teams such as Red Bull racing who use it for race simulations and many other enterprise level organisations.

PHP

Description: PHP is one of the world's most widely used web languages and stands for (Hypertext Preprocessor). PHP is used by over 75% of the world's applications. PHP is an open-source server-side scripting language used mainly in web development. This language is widely used and can be embedded into HTML. Whilst being used in conjunction with the front-end PHP is considered a back-end scripting language.

Function: PHP is used primarily used with HTML to allow developers to create HTML web pages and update databases. It uses scripting that is executed on the server. PHP files can incorporate text, HTML, CSS, JavaScript and PHP Code. The code execution happens on the server and is then delivered to the browser as HTML. PHP can be embedded into HTML and helps create dynamic web pages and can also be used to create standalone applications, collect form data, control user access and receive cookies. It is universally compatible with all major OS systems and has a very simple coding pattern.

Use Case: PHP's design makes it a great choice for CMS (content management systems), dynamic web applications, gaming applications and community portals. CRM systems such as HubSpot and Salesforce both use the PHP programming language because of how it interacts with the front-end and databases. PHP support for object-oriented programming features alongside its compatibility have made it a choice for over 240 million websites and other content management systems such as WordPress, Drupal and Joomla.

Strengths:

Cost: Freely available open-source language that has a strong foundation of developers that support its community.

Compatibility: Integrates with every single operating system reducing any compatibility issues and works well with the foundations of front-end web development technologies including HTML, CSSS and JavaScript. PHP also integrates well with most web servers adding to its compatibility.

Performance: PHP is known for its great loading time and can contribute to websites increase in speed.

Use: PHP is open source and generally easy to use.

Security: PHPs has a community driven security and best practises must be used when using PHP.

Scalability: PHP has some good characteristics for scaling including horizontal scaling (adding more servers) techniques such as caching, database optimization and uses popular architectural patterns in enterprise projects such as microservices which has benefits like being agile, can be used in high demand applications, is resilient, flexible and helps manage complex applications by breaking them down into smaller manageable parts.

Limitations: PHP has some inconsistences within its naming conventions and along with some inconstant syntax. On the performance side it can be slower than other server-side languages such as Java. In terms of security, PHP has some obvious flaws. You must take measures to help keep your PHP secure such as hiding the PHP version by disabling expose_php in the php.ini file. Using generic login error messages. Using prepared statements to help prevent SQL injection attacks. Validating user input using filters. PHP can be vulnerable cross-side scripting attacks. Its weak typing system leads to bugs and inconstant data, truly a developer's worst nightmare.

Alternatives: PHP's alternatives are JavaScript, Go, Python, Ruby, Rust, Node.js and C# to name a few.

PHP vs Python

Python is a computer software language that is widely used to build websites and software. It is a general-purpose language and is not specialised towards a specific area although it does have its use cases. Due to the ease of its learning, robust nature and solid security it has become the staple to a lot of data analysis and machine learning. Google, Netflix and Meta use Python for back-end services like machine learning and data analysis and Spotify, and Uber use it for web development showing its versatility.

Cost: Both are free open-source programming languages.

Licenses: Both are free to use commercially; Python is developed under an OSI approved open-source licence making it the go to choice for security applications.

Use: Both are open source and have a great community to help keep updated with strong documentation to lean on. Python is thought to be significantly easier to learn and is often the first-choice language of many newbies. PHP is often used in conjunction with the front-end whereas Python has a wider use across web development and programming.

Compatibility: Both provide powerful and well-developed web frameworks. PHP has large companies that use its mature frameworks such as Symfony and Laravel for web development. Python's two most famous web-based frameworks are Flask and Django. Developers usually prefer Django over PHP frameworks for its easier syntax and more robust

programming nature. Both languages are cross platform PHP can run universally whereas Python runs on Windows, macOS and Linux. Python is also pre-installed on many Linux devices and can be installed on distros such as Kali Linux as can PHP.

Security: Python holds a licence to OSI development and frameworks like Django boasts many pre-built-in features that help safeguard apps from vulnerabilities and security threats. PHP has many vulnerabilities in comparison so Python trumps in this area quite convincingly.

Library Management: Python uses Pip for dealing with its packages and ensures a rapid, easy development process. PHP has a wider assortment of packages, but Python is deemed to be stronger here.

Conclusion: PHP offers a solution that is very clearly targeted towards the CMS eco space and is widely used in the development of dynamic web pages picking up a 75% market share of website builds. It is floored in some areas like security and its general nature means it can be unreliable. Python is secure, robust and offers more general uses and much easier to use. It may not be as competitive when it comes to working in tandem with HTML but due to its secure nature, many uses and robust nature it is the winner for a more complete programming language.

Describe the role that each of these components plays within the stack, as well as potential alternatives for these components, such as:

- Windows/MacOS
- NGINX/Oracle
- MariaDB/MongoDB
- Python/Perl

Linux

Role in the Lamp Stack: The Linux operating system is the foundational or base layer within the LAMP stack that the entire architecture is built upon. It manages the hardware resources, handles process scheduling, memory allocation, device drivers and provides the file system where the other software components Apache, MySQL and PHP are all installed and tasks are executed. The Linux kernel CLI is used to execute tasks.

The Apache server runs on Linux to serve web pages to users. In order for Apache to be able to run correctly it requires access to the network stack and file system that Linux provides.

MySQL runs on Linux to store and manage the data.

PHP runs on Linux to interact with the database and process dynamic content via the web server.

Alternatives: Below are a few of alternatives to replace Linux in the LAMP stack.

WAMP: Windows, Apache, MySQL, PHP

One of the main benefits of using Windows would be having access to Windows OS as the underlying platform. This would benefit developers using a Windows PC for their development.

MAMP: MacOS, Apache, MySQL ,PHP

MacOS users may prefer to use their own set-up and preferred environment for the build.

Other mentions.

SAMP: Solaris (another Unix based system), Apache, MySQL, PHP

Virtual Machine Environment: Running a Virtual Machine on top of the underlying operating system is used in modern day development, this set-up means the underlying host is not as critical. For example, you may have a Windows environment but spin up a virtual machine running Linux on top of Windows/macOS. The benefits of doing this could be to experiment with a new OS without reformatting your hard drive, develop software in a separate controlled environment, or to test software and experiment inside the VM without harming your original software / OS.

Apache:

Role in the Lamp Stack: The Apache web server is the second layer within the LAMP stack and is sometimes described as the server's backbone. The Apache module stores website files and exchanges information with a browser using HTTP protocols for transferring website information in plain text. The Apache web server accepts requests from web browsers using the HTTP/HTTPS protocols that are on ports 80 & 443 respectively. The Apache web server processes those requests and retrieves the requested files such as images, HTML, CSS and displays web pages via the server. Apache stores website files (HTML, CSSS, JavaScript, images) in directories like /var/www/ or specific directories. It also generates log files (access and error logs). The Apache server will receive incoming requests from the web browser and

if it is a static file, it will return the request directly with the appropriate content. If the request is for dynamic content, the server will pass the request to the PHP component. The PHP component finds and loads the appropriate file that can process the request.

In order for Apache to be able to run correctly it requires access to the network stack and file system that Linux provides. The Apache Web Server runs on Linux and if you understand the configuration on Linux, it can be easily applied to other OS.

Alternatives: Below are a couple of alternatives to replace Apache in the LAMP stack.

WIMP: Windows, IIS, MySQL, PHP.

By replacing Apache with Microsoft's IIS you would most likely make a change to the underlying operating system in order to incorporate IIS. This is due to the compatibility or therefor lack of between Linux & Microsoft's IIS which integrates seamlessly with Windows and not so well with Linux.

LEMP: Linux, NGINX, MySQL, PHP.

NGINX uses an event driven architecture rather than a multi-threaded architecture. This means that NGINX can handle multiple requests simultaneously without having to make a new thread for each request. This means that is can be more efficient and effective at scaling when compared to Apache. NGINX is lightweight and is growing in popularity amongst developers.

MySQL:

Role in the Lamp Stack: MySQL is the third layer and plays the role of the relational database within the LAMP stack. The database manages and organises the data, storing and querying the information within the database. Data can be easily accessed and manipulated using SQL queries. MySQL is a multi-threaded, multi-user, SQL database management system. MySQL runs on the Linux OS. The MySQL client listens to requests on Port 3306 TCP. The database can store data such as customer records, sales and inventories. When a user searches for information, the web server queries the stored data. Some PHP functions may require information from the database when receiving a request from the Apache web server. If such a request is made the PHP code will retrieve the information from the stored data within the MySQL database. PHP passes the results to the web server in HTML format. At the same time, it also stores new data in the MySQL database. The Apache web server then sends the dynamic HTML results to the user's browser.

Alternative: Below are example's where MySQL is replaced in the LAMP stack.

LAPP: Linux, MySQL, PostgreSQL, PHP.
This LAPP stack is considered by many to be a more powerful alternative to the more

popular LAMP bundle and has other benefits as it can be combined with many other free open-source software packages including:

Netsniff-ng – for security and testing, Snort, an intrusion detection (IDS) and intrusion prevention (IPS) system, RRDtool for diagrams, Nagios, Collected or Cacti for monitoring. Wikipedia use a customized version of the LAPP stack and have additions such as Linux Virtual Server for load balancing, and Ceph and Swift for distributed object storages.

MEAN: MongoDB, Express.js, Angular.js and Node.js. This stack is an alternative that is based on JavaScript technologies. Within this structure the MySQL database is replaced with MongoDB. It is a database that works well with JSON which is a type of JavaScript for reading data. Within this platform Express.js is a framework that provides open-source tools for backend applications. Node.js is a platform that runs JavaScript applications and Angular.js is an open-source front-end framework

PHP

Role in the Lamp Stack: PHP is the fourth and final layer within the stack. It is a popular scripting language that allows websites to run dynamic processes. Web developers embed PHP into HTML to show real-time or updated information on websites. PHP allows the web server, database and OS to process request from the browser. PHP may receive requests from the web server for dynamic content. Once PHP receives the request it will find and load the appropriate PHP file which can process the request. The file will contain code for generating dynamic content such as converting measurement units or creating a chart. PHP may be required to gather information from the database and the PHP code retrieves the information from the database and uses it to process the function.

The returned response is then passed to the web server in HTML format and at the same time the PHP code will be storing new information into the MySQL database. The Apache web server then sends the dynamic HTML result to the user's browser, completing the request.

Alternatives:

LAMP: Linux, Apache, MySQL, Python.

Python, as discusses previously Python is a general use programming language whereas PHP is web focused. Depending on the focus or goal of the application or service required would completely effect choosing PHP over Python. For web, PHP may be more suitable, for pretty much anything else Python is and can be used.

MERN: MongoDB, Express.JS, React, Node.JS. When comparing the programming language in this alternative stack. React is the library that is built on JavaScript and is responsible for the dynamic aspect of web development. When comparing it to PHP, React is a much more

modern and well-structured language, not without its flaws, but is able to produce cutting edge User Interface designs and integrates better with newer technology.

Describe how these software components interact with each other, produce a diagram showing how they link together.

The diagram below shows how the LAMP stack is integrated with each other. The Linux OS provides the foundation that holds the software stack together. It provides the base operating system and Apache, MySQL and PHP are installed and configured on top of it.

Step-by-step interaction

A user will make a HTTPS request through a web browser.

The Apache web server receives the HTTP request.

Depending on the nature of the request, if it is for static files, the Apache web server will respond directly by serving the requested data from the file system typically located under /var/www/ on a Linux system.

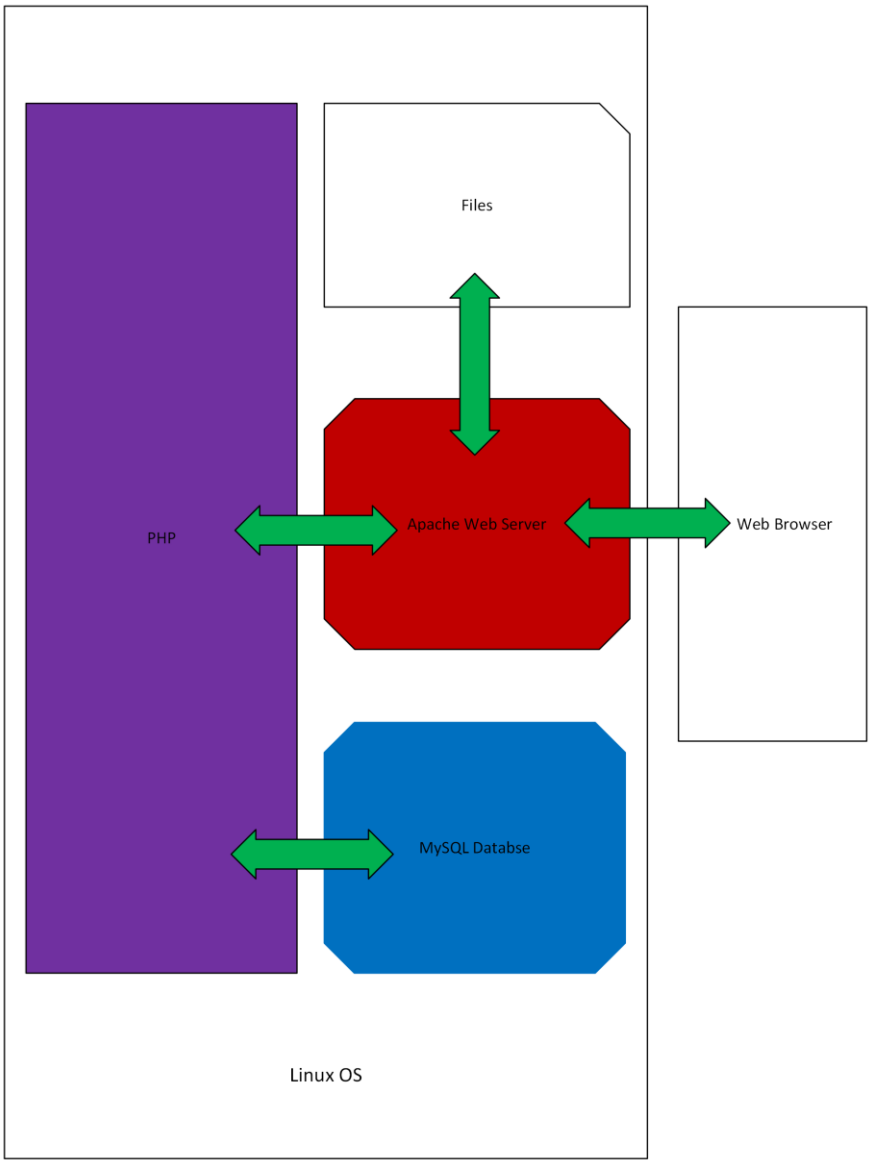
If the request is made for dynamic content the Apache Web Server will pass the request to the PHP component.

PHP will receive the request and will find the corresponding PHP file along with the code inside that can process the request.

If the request requires a function to access data from within the database, the PHP code will retrieve stored information from within the MySQL database.

Once the PHP code has completed the function it will pass the results back to the Apache web server in HTML format. At the same time, it also stores new data in the MySQL database.

Finally, the Apache web server will then return the dynamic HTML results to the user's web browser.



Research what objectives you may set for deployment of a LAMP stack web server, remember to consider:

- Cybersecurity objectives
- Legislation/Regulatory objectives
- Performance, accessibility, user experience etc.

Cyber Security Objectives

The core cyber security objectives of confidentiality, integrity and availability of the system and data should be set for deployment of a LAMP stack web server.

Confidentiality: Protecting sensitive data from unauthorized access and disclosure.

SSL/TLS (HTTPS) - To encrypt data in transit.

Encryption of data – Within MySQL database.

Restricted Access – To config files and directories. (using .htaccess)

SSH – Secure admin access with authentication and strong passwords / Fail2Ban.

Integrity: Maintaining the accuracy, consistency, and trustworthiness of data and system resources.

Validate & Sanitize User Input – in PHP to prevent SQL Injection & XSS attacks.

Web Application Firewall – Use ModSecurity with OWASP (Open Web Application Security Project) core rules to detect and block common attacks.

Implement File Permissions – based on the least privilege (user should only have access to data and files they need to perform tasks.)

Availability: Ensuring the system and its service are accessible to authorized users when needed.

Implement Firewalls: e.g. IPTables (a firewall system that configures packet filtering rules) to block unauthorized traffic and only open necessary ports (80/443).

Disable unnecessary services and modules: Within the OS and Apache to reduce attack surface.

Update all Software and Patch: All software updates must be required across Linux, Apache, MySQL and PHP to mitigate known vulnerabilities.

Accountability: Ensure that actions can be attributed to specific users and that they cannot deny their actions.

Logging and Monitoring – Use Grafana for server metrics and something like Elasticsearch or Logstash for log management. Or Datadog for server and log monitoring with dashboards and alerts.

Non-Root Accounts: for different tasks and services, following least privilege.

Disaster-Recovery: The ability to restore the system and data in the event of data loss or disaster incident.

Back-up – have a backup and disaster recovery plan for all data especially MySQL database. Isolated back up servers, off prem cloud hosting back up files.

Legislation and Regulatory Cyber Objectives

There are no laws specifically in place for the LAMP stack as it is an open-source technology stack. However, other legislation and regulatory rules apply to how the LAMP stack is implemented and how the data is processed.

General Data Protection Regulation (GDPR): If a web application possesses personal data of EU or UK citizens it must comply with GDPR. Technical measures must be taken such as data encryption, access controls, and a plan for data breach. (72 hours)

Children's Online Privacy Protection Act (COPPA): This rule applies to data held in the US by regulating the collection of personal data to children under the age of 13. For global applications legislation across countries must be taken into consideration.

Cybersecurity Regulations

NIS2 Directive (EU): The EU wide and related national laws in the UK enhance cybersecurity requirements for operators of essential services and digital service providers and they must perform regular risk assessments, apply robust security measures and report incidents rapidly.

Cyber Resilience Act (CRA): This came into effect in late 2024 and introduces mandatory cybersecurity requirements for all products with digital elements sold in the EU market.

Performance

By applying security best practises, you can keep up-to date with industry standard security measures. Performance can be increased with updates and hardware upgrades.

Updates: Keep the OS and all software packages (Apache, MySQL, PHP) up to date to patch vulnerabilities and keep performance at a peak.

Security Configuration: Hardening the configuration of each component to ensure security. Implement Firewalls, Anti-virus, Anti-Malware, implement access control policies, multi-factor authentication, download any modules that extend the current software's security or

improves performance if it is secure, validate user input, use SSH/TLS, encrypt data and have strong password policies.

Hardware: You can increase the RAM to enable your machine to process at faster speeds as well as increasing the number of cores. Upgrade the CPU, for e.g. if you are using Intel i5 Core Processor upgrade to an i9.

Software: Keep all software installations on the latest versions. Implement caching to reduce repeated database queries and use load balancing to distribute heavy traffic across the server. All these methods will result in performance optimisation and give the user a better user experience.

What hardware **could** be involved in the server deployment, **not just** within the server itself.

In a server deployment core hardware that is involved includes:

Motherboard, Central Processing Unit (CPU), Network Interface Card (NIC), Power Supply Unit (PSU), Random Access Memory (RAM), Hard Disk Drives (HDDs), Solid State Drives (SSDs), Graphical Processing Unit (GPU), Ethernet Cable / Cables, Router, Screen, Rack /Chassis, Keyboard and Mouse.

Define '**Apache Hardening**' and detail some basic steps:

- **Identify** the some of the Apache **configuration** files
- Find some **modules** that can be used to **harden** the server

Apache Hardening:

Definition: The term hardening is the process of making a system / application / software more secure. In this instance it would mean making the Apache Web Server more secure by making it 'hard target' be reducing its attack surface. The goal is to reduce an attack surface and the number of entry points or vulnerabilities an attacker could exploit, making the system / application more resilient to cyber-attacks.

Apache Configuration Files: httpd.conf (main config commonly found in /etc/httpd/conf/httpd.conf in Linux); DocumentRoot "/var/www/html" specifies the location of the HTML files. Iptables (if used for firewall) /etc/sysconfig/iptables.

Modules:

ModSecurity: Is a small module that works like an application firewall and can be installed via Linux.

mod_authz_core – This is a core module that is built into Apache and provides the main access control logic.

mod_authz_host – Also prebuilt in by default and enables IP or hostname-based restrictions.

mod_auth_basic – Another core module is an authentication module that implements the HTTP Basic Authentication standard.

mod_ssl – is an optional module for the Apache HTTP Server and provides strong cryptography for the apache v1.3 abd v2 webserver via the SSL and TLS protocols.