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APPLICATION DEVELOPMENT ASSIGNMENT 1

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Introduction

In this report will present information about the tools, technical, framework, languages that are being used today to develop a website product. From there, making comparisons and judgments to choose the right set of tools to develop FPT Learning system.

The project's models will be reported to be clarified, demonstrated and selected to suit the project's requirements.

1. Design tools

1.1. UML definition

UML, short for Unified Modeling Language, is a standardized modeling language consisting of an integrated set of diagrams, developed to help system and software developers for specifying, visualizing, constructing, and documenting the artifacts of software systems, as well as for business modeling and other non-software systems. The UML represents a collection of best engineering practices that have proven successful in the modeling of large and complex systems. The UML is a very important part of developing object-oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects. Using the UML helps project teams communicate, explore potential designs, and validate the architectural design of the software. (visual-paradigm, n.d.)

Example using UML Tool:

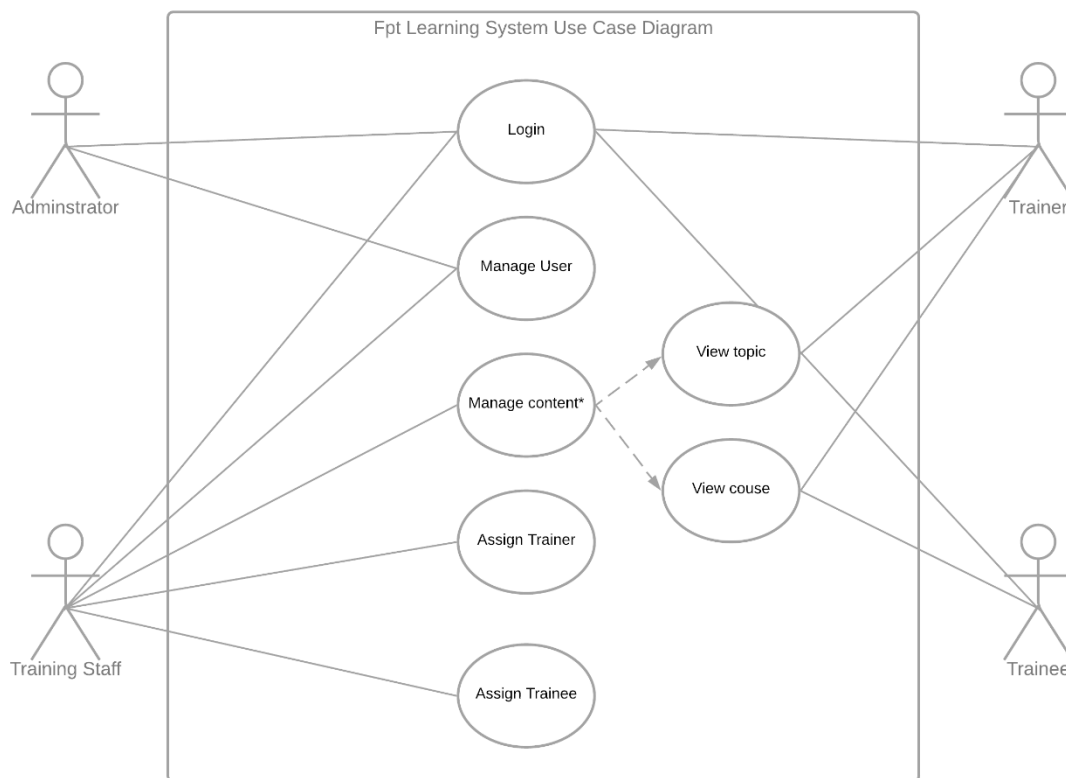


Figure 1. FPT Learning Use Case Diagram example

1.2. Chosen design tools

- **IDE and Editors:**

- **Visual Studio Code:**

VS Code is a most light-weight cross-platform Editor with thousands of Plugins available that make VS Code a powerful IDE for developing .Net Core Applications. It's open-source & available for Windows, macOS, Linux & works great even on systems with low resources (CPU, RAM & Hard Drive).

C#plugin is also available for Editing, IntelliSense & debugging .Net Core Applications.

- **JetBrains Rider:**

Rider is another Fast & Powerful Cross-Platform .Net Core IDE by JetBrains based on IntelliJ platform and ReSharper. It has the power of ReSharper for refactoring & built-in decompiler for exploring libraries source code. It also supports version control using Git, Mercurial, Subversion, TFVC, and Perforce.

It has many Built-in features & can also be extended using many useful Plugins available for Rider.

- **Visual Studio:**

Visual Studio is considered as one of the most powerful IDE available for developing powerful Desktop, Mobile, Web & Desktop Applications. Now It's also available for macOS users as well. The only reason that most of the developers moved on the VS Code is that Visual Studio is not so friendly for low resources systems.

It also has built-in Git support & many other great features.

Features	Visual Studio Code	JetBrains Rider	Visual Studio
IntelliSense	✓	✓	✓
Debugging	✓	✓	✓
Built-in Unit-Testing	X	✓	✓
Refactoring	✓	✓	✓
Decompiling	X	✓	✓
Open Source	✓	X	X
Light-weight	✓	X	X
Extensions	12000+	1500+	9000+
Platforms	Windows, macOS, Linux	Windows, macOS, Linux	Windows, macOS

Table 1. Comparison IDE and Editors table

Based on current machine configurations of Developers and current Windows 10 operating system. Visual Studio is the best choice that meets many project requirements. With these features such as **Great IntelliSense, Easy Debugging, Refactoring, Unit Testing, Live Share Screen to work together in real-time, about 9000+ Plugins** the developers will make the project easier.

Visual Studio 2019:

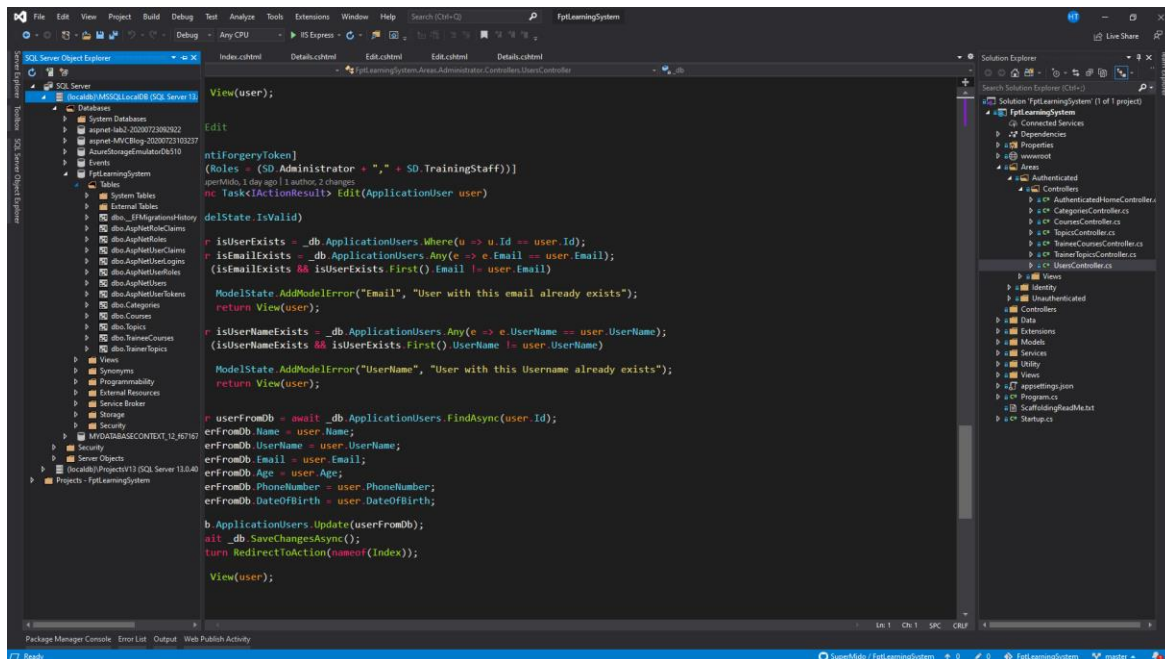


Picture 1. Visual Studio 2019. (techtalk, n.d.)

Microsoft Visual Studio is an integrated development environment (IDE) from Microsoft. It is used to develop computer programs, as well as websites, web apps, web services, and mobile apps. Visual Studio uses Microsoft software development platforms such as Windows API, Windows Forms, Windows Presentation Foundation, Windows Store, and Microsoft Silverlight. It can produce both native codes and managed code.

Visual Studio includes a code editor supporting IntelliSense (the code completion component) as well as code refactoring. The integrated debugger works both as a source-level debugger and a machine-level debugger. Other built-in tools include a code profiler, designer for building GUI applications, web designer, class designer, and database schema designer. It accepts plug-ins that expand the functionality at almost every level—including adding support for source control systems (like Subversion and Git) and adding new toolsets like editors and visual designers for domain-specific languages or toolsets for other aspects of the software development lifecycle (like the Azure DevOps client: Team Explorer).

Visual Studio supports 36 different programming languages and allows the code editor and debugger to support (to varying degrees) nearly any programming language, provided a language-specific service exists. Built-in languages include C, C++, C++/CLI, Visual Basic .NET, C#, F#, JavaScript, TypeScript, XML, XSLT, HTML, and CSS. Support for other languages such as Python, Ruby, Node.js, and M among others is available via plug-ins. Java (and J#) were supported in the past. (wikipedia, n.d.)



Picture 2. Visual Studio 2019 Interface

- **Operating system:**

Comparison Table Linux vs MAC vs Windows

The basis of Comparison	Windows	MAC	Linux
File structure	Windows follows a directory structure to store the different kinds of files of the user. It has logical drives and cabinet drawers. It also has folders. Some common folders like documents, pictures, music, videos, and downloads. All these files can be stored in these folders and also new folders can be created. It also has files which can be a spreadsheet or an application program. It can have extensions as .txt, .jpg etc. In addition to this Windows also provides a recycle bin where all deleted files can be stored. The recycle bin can be configured to increase its size.	The file structure of MAC is commonly known as MAC OS X. If you go to dig into your MAC's hard disk through finder you will see many directories. The root directory of MAC may encounter when they visit their own MAC book. You can explore the file system and directory structure by going to directories like /Application, /Developer, /sbin, /tmp, etc.	Linux has a completely different file structure form Windows and MAC. It was developed with a different codebase. It stores data in the form of a tree. There is a single file tree and all your drives are mounted over this tree.
Registry	Windows registry is a master database that is used to store all settings on your computer. It is responsible to store all user information with its passwords and device relate information. The registry also has an editor which allows you to view all keys and values or even drivers if necessary.	MAC stores all application settings in a series of .plist files that have the various preferences folder in MAC. This .plist file contains all properties in either plain text or binary format. These are stored at: /Library/Preferences folder	Linux also does not have a specific registry of its own. All application setting is stored on a program basis under the different users in the same hierarchy format of the files being stored. There is no centralized database for storing these details and so periodic cleaning is also not required.
Interchangeable Interfaces	Windows interface was not interchangeable until Windows 8. Windows XP had some improvements but not par. Start menu, taskbar, system tray, and Windows Explorer.	MAC has a facility to bridge virtual network interfaces. This can be done by going to system preferences and managing the interfaces.	Linux is easy to switch interfaces. You can switch the environment without having to carry all installations. There are utilities like GNOME and KDE which help in

			catering to these needs. They help in focusing on different aspects.
Command terminal	A terminal or command prompt is a black box ideally used to execute commands. It is also called the Windows Command Processor. It is used to execute commands and different batch files. It can also be used for administrative functions and troubleshoot and solve all windows issues.	MAC provides a console as a terminal application. It has a console, command line, prompt, and terminal. The Command line is used to type your commands. Prompt will provide you with some information and also enable you to run commands. A terminal is an actual interface that will provide the modern graphical user interface as well. You can find terminal at Applications -> Utilities.	Linux also provides a terminal. You can find terminal at: Applications -> System or Applications -> Utilities. In addition to this, there is also a shell prompt. The most common shell used in bash. It defines how the terminal will behave and look when it is run.
Support framework	ASP.NET Framework, ASP.NET Core	ASP.NET Core	ASP.NET Core
Support IDE	Visual Studio Code, Visual Studio	Visual Studio Code, Visual Studio	Visual Studio Code

Table 2. Comparison Table Linux vs MAC vs Windows. (educba, n.d.)

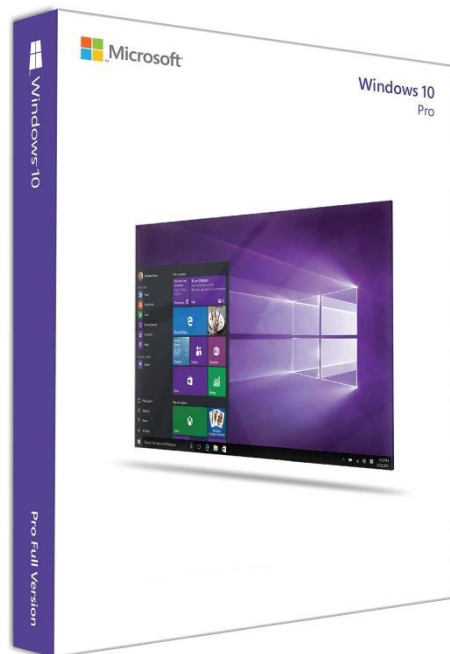
Comparison Table Windows 10 Home vs Windows 10 Pro:

Features	Windows 10 Home	Windows 10 Pro
Windows Hello	✓	✓
Device encryption	✓	✓
Firewall and network protection	✓	✓
Internet protection	✓	✓
Parental controls / protection	✓	✓
Secure Boot	✓	✓
BitLocker device encryption	✗	✓
Windows Information Protection (WIP)	✗	✓
Windows Defender Antivirus	✓	✓

Table 3. Comparison Table Windows 10 Home vs Windows 10 Pro. (microsoft, n.d.)

Based on the comparison results, **Windows 10 Pro** has most of the functionality to implement a cross-platform application with IDEs and equivalent tools to complete the project.

Windows 10 Pro:



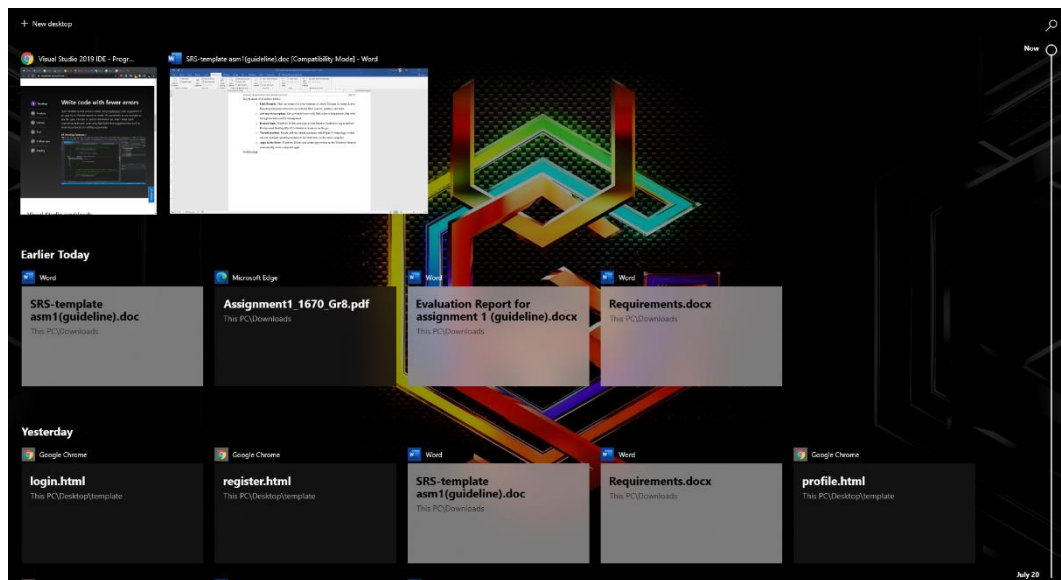
Picture 3. Windows 10 pro. (fptshop, n.d.)

Windows 10 pro is a version intended for individual users but has more advanced features. Support IT to manage devices and applications in small businesses, protect sensitive data ... In addition to allowing users to access Windows Update for Business. Windows 10 Pro is best suited for users in the IT field and has more functions than Windows 10 Home. However, if your computer has a low profile, just to serve the most basic needs in the family, Windows 10 will be a more affordable and economical choice.

The Pro edition of Windows 10, in addition to all of Home edition's features, offers sophisticated connectivity and privacy tools such as Domain Join, Group Policy Management, Bitlocker, Enterprise Mode Internet Explorer (EMIE), Assigned Access 8.1, Remote Desktop, Client Hyper-V, and Direct Access.

Key features of Windows 10 Pro:

- **Link Domain:** That can connect to your business or school Domain or Azure Active Directory directory service to use network files, servers, printers, and more.
- **Advanced encryption:** Get a security boost with BitLocker to help protect data with encryption and security management.
- **Remote login:** Windows 10 lets users sign in with Remote Desktop to log in and use Professional Desktop (Pro PC) whether at home or on the go.
- **Virtual machine:** Create and run virtual machines with Hyper-V technology so that can run multiple operating systems at the same time on the same computer.
- **Apps in the Store:** Windows 10 lets users create an app section on the Windows Store to conveniently access corporate apps.
- **Multitasking:** All key notifications and settings are gathered in one easy-to-access screen.



Picture 4. Multitasking in windows 10 pro

- **Browser**

	Google Chrome	Mozilla Firefox	Internet Explorer	Safari
Cloud bookmark sync	With a Google Account	Via plugin	X	With a MobileMe account
Session management	✓	✓	Via plugin	Through history menu
Private browsing	✓	✓	✓	✓
Download manager	✓	✓	✓	✓
Fullscreen mode	✓	✓	✓	X
Tabs on the side	✓	Via plugins	X	X
Custom extensions	✓	✓		X
Layout engine	WebKit	Gecko	Trident	Webkit
Javascript engine	V8	TraceMonkey	Chakra	Nitro
Open-source	✓	✓	X	X

Table 4. Comparison table browser in 2019. (socialcompare, n.d.)

The future of web development continues to look brighter and brighter! While only a few years ago we had a limited set of tools for debugging JavaScript, tinkering with CSS, and viewing HTML, today there are a variety of powerful options. Now that Google Chrome has become cross-platform, fully integrated the WebKit Web Inspector, and added extensions, it is a versatile tool for helping developers improve their pages. So, Google Chrome was used to develop this FLS application.

Google Chrome:



Picture 5. Google chrome logo

Google Chrome is a cross-platform web browser developed by Google. It was first released in 2008 for Microsoft Windows and was later ported to Linux, macOS, iOS, and Android where it is the default browser built into the OS. The browser is also the main component of Chrome OS, where it serves as the platform for web applications.

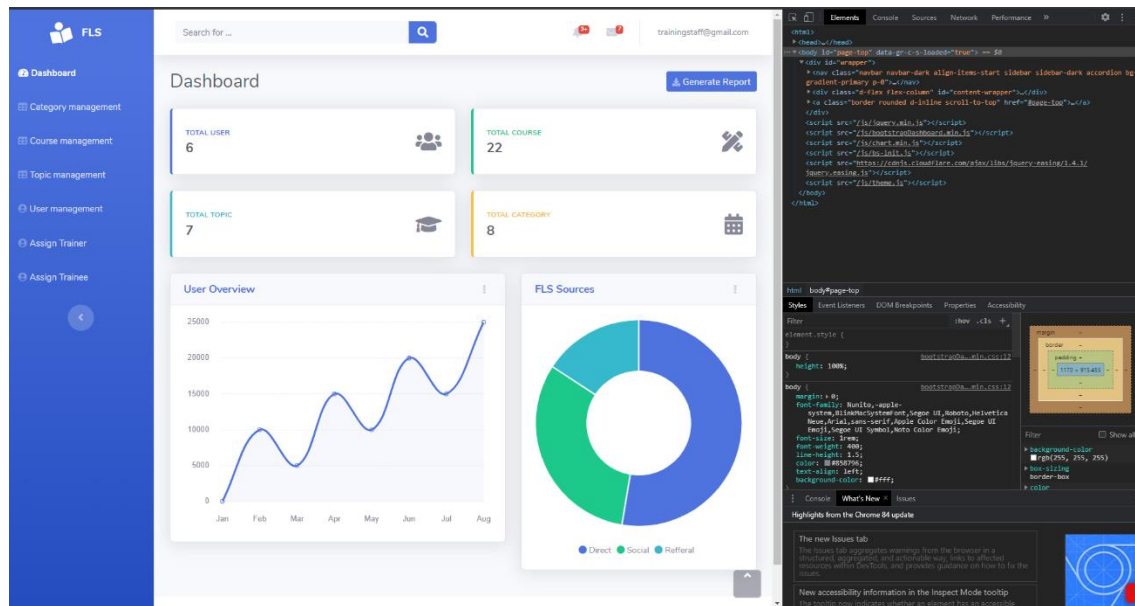
Most of Chrome's source code comes from Google's free and open-source software project Chromium, but Chrome is licensed as proprietary freeware. WebKit was the original rendering engine, but Google eventually forked it to create the Blink engine; all Chrome variants except iOS now use Blink.

(Wikipedia, wikipedia, n.d.)

Chrome Developer Tool:

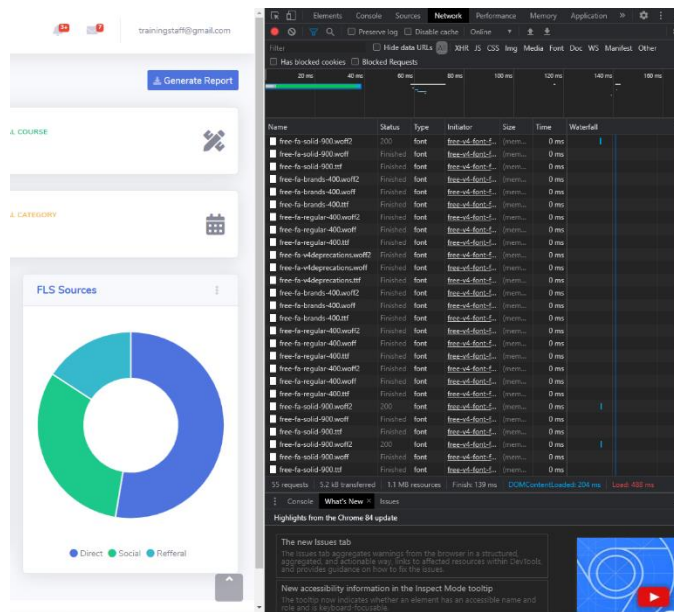
The Chrome Developer Tool is a suite of tools that are hugely supportive for developers built into Google Chrome. DevTools provides web developers with internal access to their browsers and web applications. Use DevTools to efficiently edit HTML, CSS, and JavaScript and get insights to optimize code.

- **Elements:** This tab displays the HTML of the web page elements. We can directly edit the CSS of an element into the right pane, see the results immediately. (This is a pretty cool feature from the Firefox add-on Firebug, which is praised by many web developers/web designers). Besides, if we have to design a responsive web, we can also click on the mobile icon to test the website on the screen of devices with different resolutions.



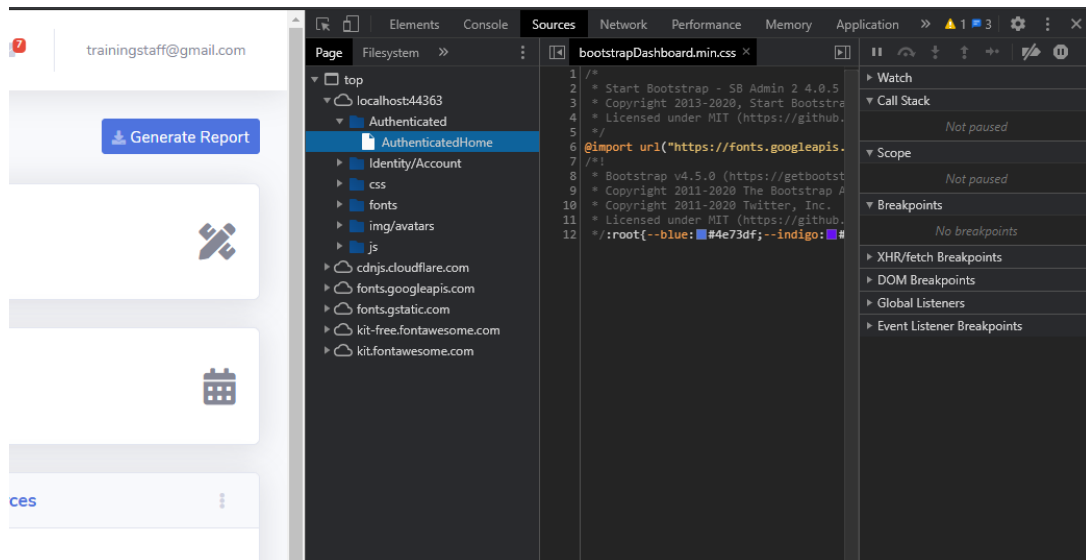
Picture 6. Elements tab in google chrome developer tool

- **Networks:** In this tab, the user can see all things downloaded by the browser from the server: HTML, CSS, JS, images, ... often use this tab to view page load time, to optimize and speed up.



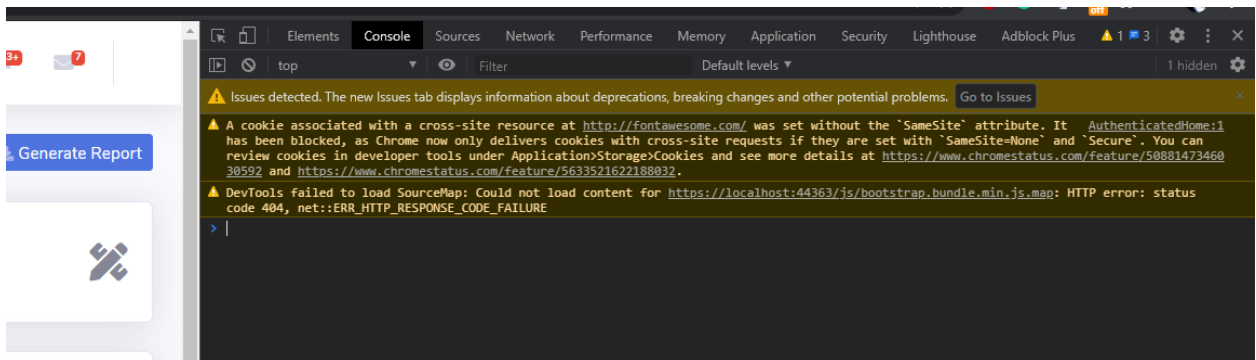
Picture 7. Network tab in google chrome developer tool

- **Sources:** This tab displays the js files that the browser can load. On this tab, you can debug code js with breakpoints or if the code is too long to save time, the user can add the debugger line where the user wants to check.



Picture 8. Source tab on google chrome developer tool

- **Lighthouse:** This tab has the function of moderating the speed of the website, giving tips to speed up. Go to this tab and click Run, Developer Tool will measure, compare the loading speed of Web Site, check if Website has been optimized or not, then give ways to speed up. A pretty cool and interesting function.
- **Console:** The errors related to javascript (not loading, lack of opening and closing brackets, semicolon, ...) will be displayed in this tab. We can directly enter the js code here to run, this is a great feature to be able to test each js code individually.



Picture 9. Console tab on google chrome developer tool

Design UI:

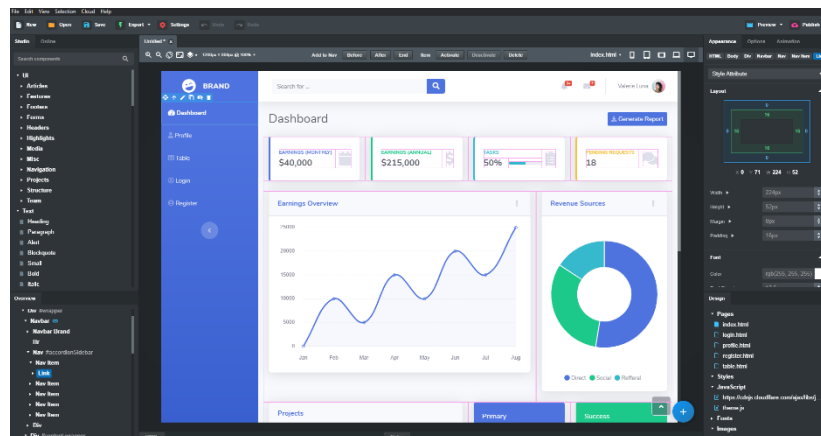
- **Bootstrap Studio**



Picture 10. Bootstrap studio logo. (allpcworld, n.d.)

Bootstrap Studio is a powerful desktop app for designing and prototyping websites.

- **The Interface:** Bootstrap Studio has a beautiful and powerful interface, which is built around the simplicity of drag and drop. This makes it the perfect tool for prototyping and designing web pages and apps.
- **Beautiful Templates:** The app comes with several premium, fully responsive templates that you can customize. Each template consists of multiple pages and widgets you can pick-and-match into the perfect website.
- **Beautiful Components:** Bootstrap Studio comes with a large number of pretty components for building responsive pages. We've got headers, footers, galleries, slideshows, and even basic elements like spans and divs. See some of them below.
- **Realtime Preview:** Bootstrap Studio has a powerful feature called Preview. With it, you can open your design in multiple web browsers and devices, and every change you make within the app will be shown instantaneously everywhere.
- **Editing Code:** For some things, drag and drop aren't enough. This is why Bootstrap Studio gives you full control over your markup when you need it. You can import and edit CSS, SASS, JavaScript, and HTML in our Sublime Text-like editor.



Picture 11. Bootstrap Studio interface

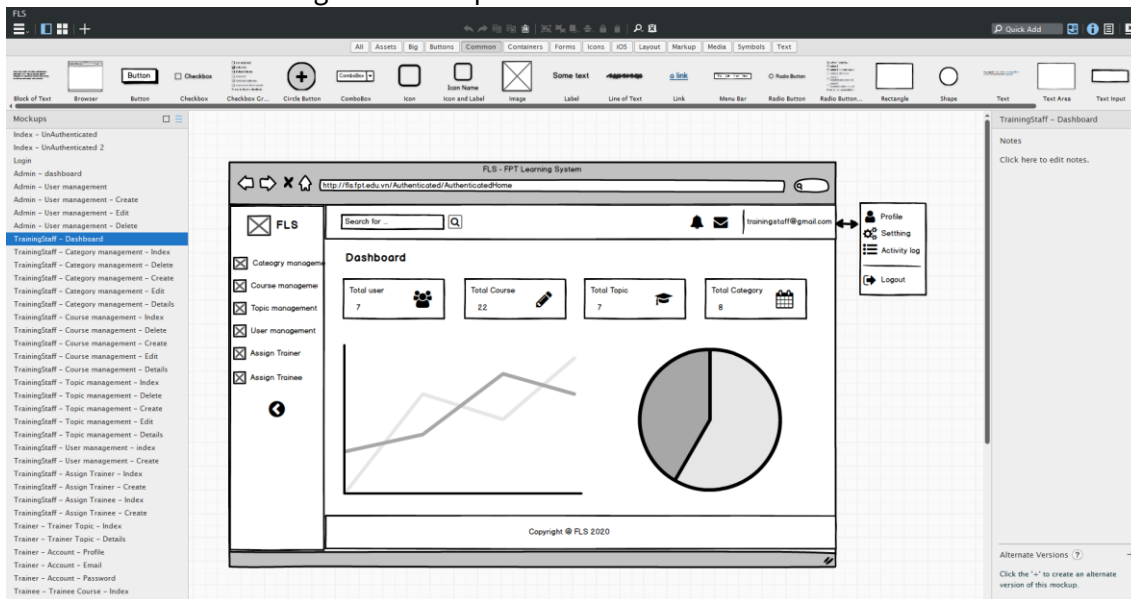
- **Balsamiq Mockup 3**



Picture 12. Balsamiq logo. (webdesign, n.d.)

Balsamiq Wireframes is a user interface design tool for creating wireframes (sometimes called mockups or low-fidelity prototypes).

Balsamiq Mockups 3 is the result of nearly a year of heads-down coding to create the product that our customers have been asking for and the product we wanted for ourselves.



Picture 13. Balsamiq interface

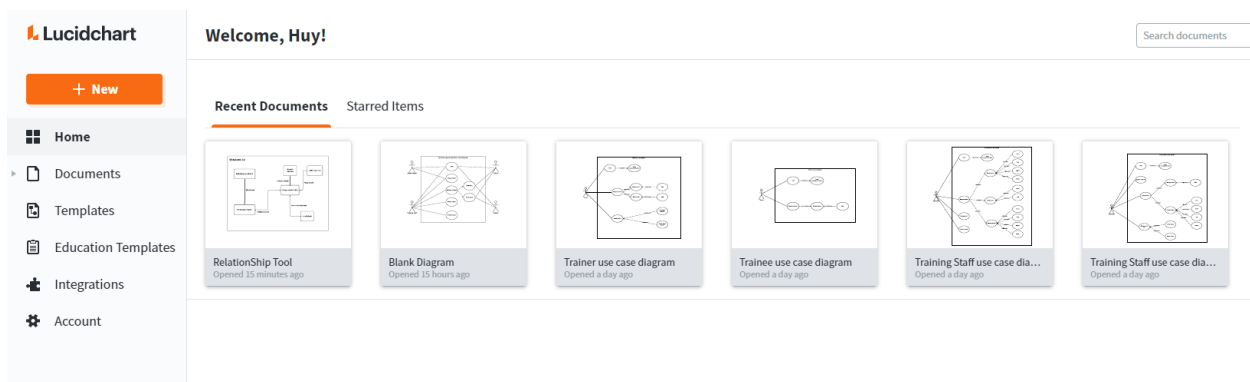
- **Lucidchart**



Picture 14. Lucidchart logo

Accomplish more by collaborating in real-time. Accelerate understanding and drive innovation with powerful diagramming, whiteboarding, and data visualization.

Lucidchart helps users sketch and share professional flowchart diagrams, providing designs for anything from brainstorming to project management



Picture 15. Lucidchart interface

By using lucidchart that developer can make:

- Diagram and flowchart
- Software and system design
- Process mapping
- Org chart design
- Agile planning
- Whiteboard

1.3. The relationship between selected tools for FPT Learning System

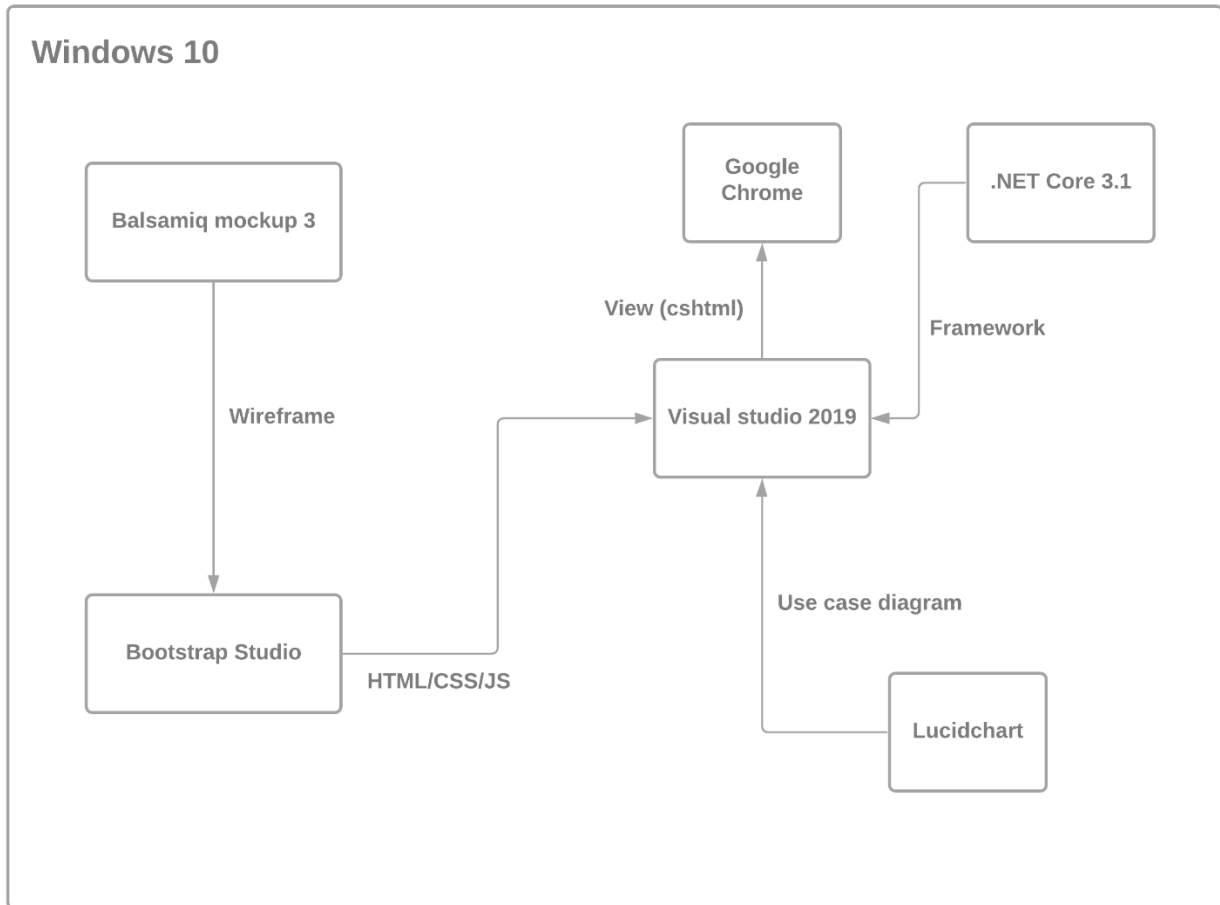


Figure 2. The relationship between selected tools

- **Balsamiq mockup 3:** Create Wireframe
- **Bootstrap Studio:** Using wireframe to design UI for system
- **Lucid chart:** Create a use case diagram for each role
- **.NET Core 3.1:** The framework support for Visual Studio 2019
- **Visual studio 2019:** Using HTML/CSS/JS from bootstrap Studio to create layout and view for system
- **Google Chrome:** Will show the result of an application from Visual Studio 2019

2. Development tools and techniques

2.1. Cloud provider

A cloud service provider is a third-party company offering a cloud-based platform, infrastructure, application, or storage services. Much like a homeowner would pay for a utility such as electricity or gas, companies typically have to pay only for the number of cloud services they use, as business demands require.

Besides the pay-per-use model, cloud service providers also give companies a wide range of benefits. Businesses can take advantage of scalability and flexibility by not being limited to physical constraints of on-premises servers, the reliability of multiple data centers with multiple redundancies, customization by configuring servers to your preferences, and responsive load balancing that can easily respond to changing demands. Though businesses should also evaluate security considerations of storing information in the cloud to ensure industry-recommended access and compliance management configurations and practices are enacted and met. (azure.microsoft, n.d.)

Types of cloud services:

Most cloud computing services fall into four broad categories: infrastructure as a service (IaaS), platform as a service (PaaS), serverless, and software as a service (SaaS). These are sometimes called the cloud computing "stack" because they build on top of one another. Knowing what they are and how they're different makes it easier to accomplish business goals.

- **Infrastructure as a Service (IaaS):**

IaaS contains the basic building blocks for cloud IT. It typically provides access to networking features, computers (virtual or on dedicated hardware), and data storage space. IaaS gives users the highest level of flexibility and management control over IT resources. It is most similar to the existing IT resources with which many IT departments and developers are familiar. (amazon, amazon, n.d.)

- **Platform as a service (PaaS):**

PaaS removes the need for users to manage underlying infrastructure (usually hardware and operating systems) and allows users to focus on the deployment and management of applications. This helps users be more efficient as users don't need to worry about resource procurement, capacity planning, software maintenance, patching, or any of the other undifferentiated heavy lifting involved in running applications.

- **Software as a Service (SaaS):**

SaaS provides users with a complete product that is run and managed by the service provider. In most cases, people referring to SaaS are referring to end-user applications (such as web-based email). With a SaaS offering, users don't have to think about how the service is maintained or how the underlying infrastructure is managed. The user only needs to think about how the user will use that particular software.

- **Amazon Web Services**



Picture 16. Amazon web services logo

Amazon web services is a fully developed cloud computing platform powered by Amazon.com. Web services are sometimes referred to as cloud services or remote computing services. The first AWS services were launched in 2006 to provide online services for websites and client-side applications. To minimize sudden power outages and ensure system robustness, AWS is geographically diverse by region. These regions have centers in East America, West America (two locations), Brazil, Ireland, Singapore, Japan, and Australia. Each region is composed of many smaller geographic areas known as availability zones.

Services from AWS:

- **CloudDrive** allows users to download and access music, videos, documents, and photos from Web-connected devices. The service also allows users to stream music to their device
- **CloudSearch**, a scalable search service that is used to integrate custom search capabilities into other applications.
- **Dynamo database** (also known as DynamoDB or DDB), a fully managed NoSQL database service known for low latency and scalability
- **Elastic Compute Cloud**, allowing business subscribers to run applications
- **ElastiCache**, a fully managed caching service, is compatible with Memcached, a high-performance, open-source, distributed object memory storage system for speeding up dynamic Web applications by offloading database.
- **Mechanical Turk**, an application programming interface (API) that allows developers to integrate human intelligence into remote procedure calls (RPC) using human networks to perform machine tasks. mismatch.
- **RedShift**, a petabyte-scale data warehouse service designed for analytical workloads, connects with standard SQL-based clients and business intelligence tools.
- **Simple Storage Service (S3)**, a high-speed, low-speed service designed for online backup and storage of data and application programs. (viblo, n.d.)

- **Heroku: Cloud Application Platform**



Picture 17. Heroku logo

Heroku is a cloud platform that allows developers to build, deploy, manage, and extend applications (PaaS - Platform as a service).

Heroku is versatile and easy to use, providing for a single, straightforward path to getting a product to its users. Heroku helps developers focus on product development, regardless of server operation or hardware.

Users can use Heroku for free with a multitude of extremely useful support addons, it is considered one of the attractive services. Supports many programming languages such as:

- NodeJS
- Ruby
- Python
- PHP
- Java
- Scala
- Clojure
- Go
- Kotlin

The Heroku developer experience is an app-centric approach for software delivery, integrated with today's most popular developer tools and workflows

- **Heroku Runtime:** Heroku runs apps inside dynos smart containers on a reliable, fully managed runtime environment. Developers deploy their code written in Node, Ruby, Java, PHP, Python, Go, Scala, or Clojure to a build system that produces an app that's ready for execution. The system and language stacks are monitored, patched, and upgraded, so it's always ready and up-to-date. The runtime keeps apps running without any manual intervention.

- **Heroku Developer Experience (DX):** The Heroku Developer Experience is an app-centric approach to software delivery so developers can focus on creating and continuously delivering applications, without being distracted by servers or infrastructure. Developers deploy directly from popular tools like Git, GitHub, or Continuous Integration (CI) systems. The intuitive web-based Heroku Dashboard makes it easy to manage app and gain greater visibility into performance.
- **Heroku Operational Experience (OpEx):** The Heroku Operational Experience is a key component of the platform. It helps developers through troubleshooting and remediation of common issues and customizing their ops experience to quickly identify and address negative trends in their application health. Heroku provides a set of tools to alert users if something goes wrong, or to automatically scale web dynos if the response time for web requests exceeds a threshold user specifies. Application metrics, Threshold Alerting, and Autoscaling are some of the features users get access to with no extra cost.
- **Data Services and Ecosystem:** Heroku Elements let developers extend their apps with Add-ons, customize their application stack with Buildpacks, and jumpstart their projects with Buttons. Add-ons are 3rd party cloud services that developers can use to immediately extend their apps with a range of functionality such as data stores, logging, monitoring, and more. Heroku provides three fully-managed data service Add-ons: Heroku Postgres, Heroku Redis, and Apache Kafka on Heroku.
- **Security and Compliance:** Developers from around the world entrust sensitive data to Heroku, and nothing is more important to us than honoring our custodial commitments to protect this data. Heroku regularly performs audits and maintains PCI, HIPAA, ISO, and SOC compliance to further strengthen our trust with customers. Learn more by visiting our compliance center.

- **Microsoft Azure: Cloud Computing Services**



Picture 18. Microsoft Azure logo

Azure is a fully integrated cloud solution used to build, deploy, and manage applications across Microsoft's global data center network. Integrated tools, DevOps, and a community of supporters you build efficiently from simple mobile applications to large-scale solutions.

Azure helps accelerate application to market faster, with integrated tools, from mobile DevOps to serverless computing. Users can build the way they want, using open source tools and technologies. Azure supports a wide range of operating systems, programming languages, frameworks, databases, and devices. Specifically:

- Continuously innovating and providing high-quality applications.
- Delivering Cross-Device experiences with support for all mobile platforms.
- Run any Stack- Linux-Based and Windows-Based and use advanced features like Kubernetes Cluster in Azure Container Service.
- Users can use features such as Windows Azure, Azure Services Platform, .NET Services, SQL Services ...

- **Google Cloud Platform**



Google Cloud Platform

Picture 19. Google Cloud Platform logo

Google Cloud Platform (GCP), is a platform of cloud computing allowing organizations and businesses to create, build, and operate their applications under the name of the system that Google creates. Popular Google applications using Google Cloud Platform which are currently very popular are Youtube, Chrome, Google Apps, Google Maps, Google Search, ...

Google Cloud Platform aims to help users solve all the necessary issues such as Mobile, Developer, Management, Networking, Computer Engine, Storage, Big Data, ... From the benefits of the Google Cloud platform, this business can do other things needed to grow the business more without having to consider the underlying systems.

In addition to the above services, Google Cloud Platform also makes a difference from other Cloud service platforms. These are the services placed directly by google. There is a Datacenter service system with the highest level of data security and safety. Besides, Google Cloud Platform also meets the most stringent standards for a cloud computing system.

Google Cloud Platform offers includes the following main products:

- Services - Cloud Endpoints, Translate API, Prediction API
- Big Data - BigQuery, Cloud Dataflow, Cloud Dataproc, Cloud Pub / Sub
- Storage - Cloud Storage, Cloud Datastore, Cloud SQL, Cloud Bigtable
- Compute - App Engine, Compute Engine, Container Engine

Comparison of AWS, Azure, and GCP

- **Compute Services:**

Services	AWS	Azure	GCP
IaaS	Amazon Elastic Compute Cloud	Virtual Machines	Google Compute Engine
PaaS	AWS Elastic Beanstalk	App Service and Cloud Services	Google App Engine
Containers	Amazon Elastic Compute Cloud Container Service	Azure Kubernetes Service (AKS)	Google Kubernetes Engine
Serverless functions	AWS Lambda	Azure Functions	Google Cloud Functions

Table 5. Compare compute service

- **Database Services:**

Services	AWS	Azure	GCP
RDBMS	Amazon Relational Database Service	SQL Database	Google Cloud SQL
NoSQL: Key-Value	Amazon DynamoDB	Table Storage	Google Cloud Datastore and Google Cloud Bigtable
NoSQL: Indexed	Amazon SimpleDB	Azure Cosmos DB	Google Cloud Datastore

Table 6. Compare database services

- **Storage Service:**

Services	AWS	Azure	GCP
Object Storage	Amazon Simple Storage Service	Blob Storage	Google Cloud Storage
Virtual Server Disks	Amazon Elastic Block Store	Managed Disks	Google Compute Engine Persistent Disks
Cold Storage	Amazon Glacier	Azure Archive Blob Storage	Google Cloud Storage Nearline
File Storage	Amazon Elastic File System	Azure File Storage	ZFS/Avere

Table 7. Compare Storage service

- **Networking Services:**

Services	AWS	Azure	GCP
Virtual Network	Amazon Virtual Private Cloud (VPC)	Virtual Networks (VNETs)	Virtual Private Cloud
Elastic Load Balancer	Elastic Load Balancer	Load Balancer	Google Cloud Load Balancing
Peering	Direct Connect	ExpressRoute	Google Cloud Interconnect
DNS	Amazon Route 53	Azure DNS	Google Cloud DNS

Table 8. Compare networking services

- **Pricing:**

Machine type	AWS	Azure	GCP
Smallest Instance	In the case of AWS, a very basic instance that includes 2 virtual CPUs and 8 GB of RAM will cost you around US\$69 per month.	For the same type of instance, i.e., an instance with 2 vCPUs and 8 GB of RAM, in Azure, will cost you around US\$70/month.	Compared to AWS, GCP will provide you the most basic instance, containing 2 virtual CPUs and 8 GB of RAM at a 25 percent cheaper rate. So, it will cost you around US\$52/month.
Largest Instance	The largest instance offered by AWS that includes 3.84 TB of RAM and 128 vCPUs will cost you around US\$3.97/hour.	The largest instance offered by Azure includes 3.89 TB of RAM and 128 vCPUs. It costs around US\$6.79/hour.	GCP takes the lead here with its largest instance that includes 3.75 TB of RAM and 160 vCPUs. It will cost you around US\$5.32/hour.

Table 9. Compare pricing

- **Establishment:** With a head start of 5 years, the winner here is **AWS**.
- **Availability zones:** With a greater number of regions and availability zones, the winner here is **AWS**.
- **Market shares:** With around one-third of market shares in its name, the winner here is **AWS**.
- **Growth rate:** Having a growth rate of almost 100 percent, the winner is **GCP**.
- When it comes to the number of services, the winner is **AWS**.
- Regarding the integration with open-source and on-premise systems, such as MS tools, that are mostly used in almost all organizations, the winner is **Azure**.
- **Pricing Models:** With more customer-friendly pricing models and discount models, the winner here is **Google Cloud**.

Vendor	Strengths	Weaknesses
AWS	<ul style="list-style-type: none"> • Dominant market position • Extensive, mature offerings • Support for large organizations • Extensive training • Global reach 	<ul style="list-style-type: none"> • Difficult to use • Cost management • Overwhelming options
Microsoft Azure	<ul style="list-style-type: none"> • Second largest provider • Integration with Microsoft tools and software • Broad feature set • Hybrid cloud • Support for open source 	<ul style="list-style-type: none"> • Issues with documentation • Incomplete management tooling
Google	<ul style="list-style-type: none"> • Designed for cloud-native businesses • Commitment to open source and portability • Deep discounts and flexible contracts • DevOps expertise 	<ul style="list-style-type: none"> • Late entrant to IaaS market • Fewer features and services • Historically not as enterprise-focused

Table 10. Compare Cloud provider Strengths and Weaknesses

With information about cloud computing services above. Choosing a cloud computing model to solve the problem is very difficult. Based on the properties of the project requirements, **Microsoft Azure** is the best choice. Because:

- **Publish:** User can Publish an ASP.NET Core app to Azure with Visual Studio
- **SQL Database:** Azure SQL Database is based on the latest stable version of the Microsoft SQL Server database engine. Users can use advanced query processing features, such as high-performance in-memory technologies and intelligent query processing. With Azure SQL Database, you can create a highly available and high-performance data storage layer for the applications and solutions in Azure. SQL Database can be the right choice for a variety of modern cloud applications because it enables you to process both relational data and non-relational structures, such as graphs, JSON, spatial, and XML.
- **App service:**
 - **Managed production environment:** App Service automatically patches and maintains the OS and language frameworks for you. Spend time writing great apps and let Azure worry about the platform.
 - **Containerization and Docker:** Dockerize your app and host a custom Windows or Linux container in App Service. Run multi-container apps with Docker Compose. Migrate your Docker skills directly to App Service.
 - **DevOps optimization:** Set up continuous integration and deployment with Azure DevOps, GitHub, BitBucket, Docker Hub, or Azure Container Registry. Promote updates through test and staging environments. Manage your apps in App Service by using Azure PowerShell or the cross-platform command-line interface (CLI).
 - **Visual Studio and Visual Studio Code integration:** Dedicated tools in Visual Studio and Visual Studio Code streamline the work of creating, deploying, and debugging.
- **Pricing:** In this project using the GitHub Student Developer Pack, the project will have Free access to 25+ Microsoft Azure cloud services plus \$ 100 in Azure credit.

Microsoft's greatest appeal is, of course, to Microsoft shops. All of the user existing .Net code will work on Azure, the user's Server environment will connect to Azure, and the user will find it easy to migrate on-premises apps. Furthermore, Azure's deep focus on the hybrid cloud will help you bridge the legacy data center environment with the rapidly scalable (and feature-rich) Microsoft cloud.

.NET core and Microsoft Azure Cloud Architecture:

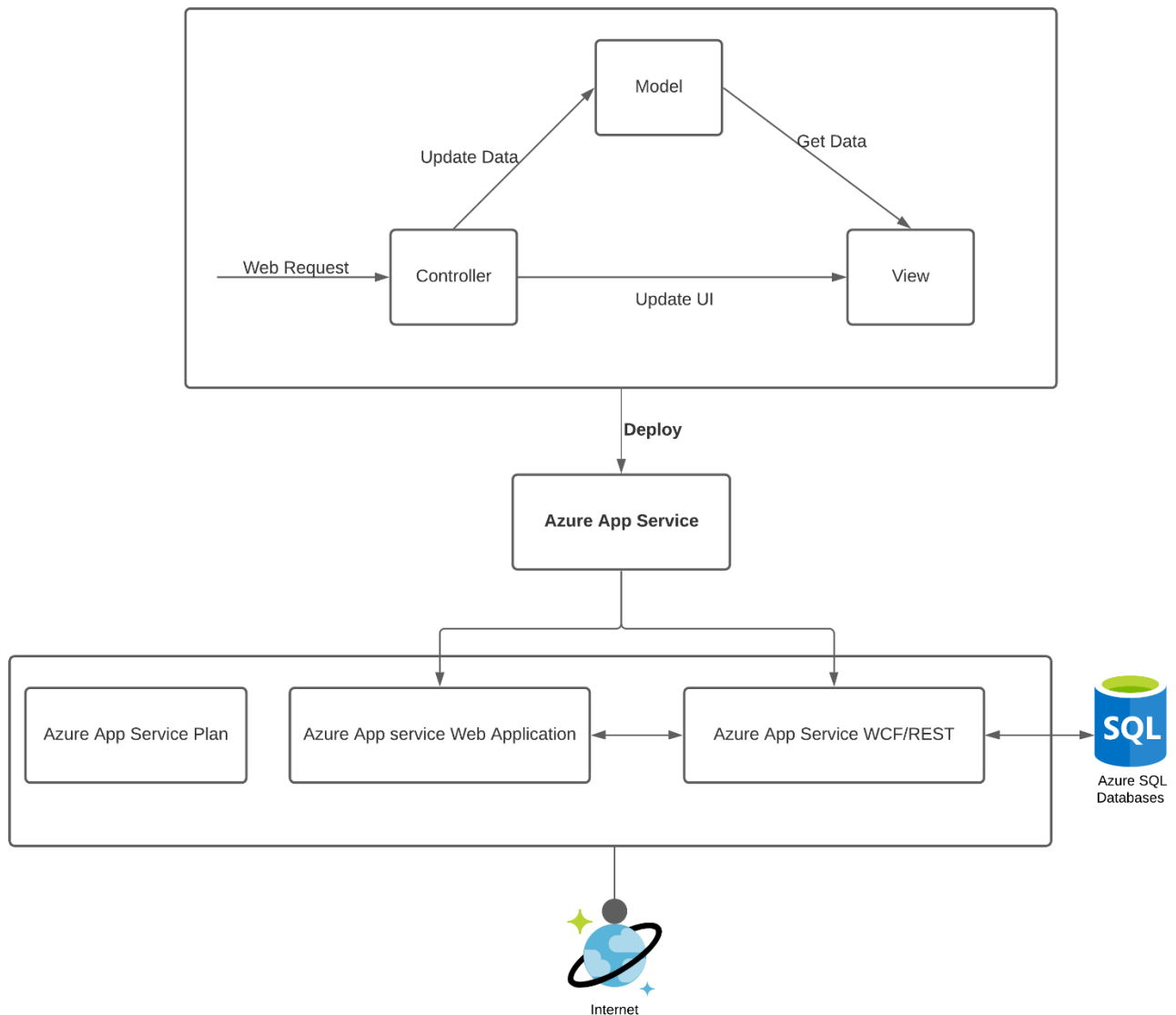


Figure 3. .NET core and Microsoft Azure Cloud Architecture

The project chose Azure SQL Database for its dynamic scalability, built-in intelligence optimization, and global scalability and availability. They leveraged Azure Database Migration Service to migrate their on-premises database to Azure SQL.

For the app tier, the project chose Azure App Service, a PaaS service that enables them to deploy the app with just a few configuration changes using Visual Studio.

The project chose to deploy web apps, one for the customer-facing front-end website, a REST services app that talks to both the front-end app and the database, and processes business logic. The below describes the migration process: Provision an Azure SQL Database instance in Azure. After the app website is migrated to Azure, the WCF/REST services app will point to this instance.

- Assess the database using the Data Migration Assistant and migrate it using the Database Migration Service.
- Provision of the two web apps.
- Set up Azure DevOps: create a new Azure DevOps project, and import GitHub repo.
- Configure connection strings so that the web tier web app, the WCF/REST services web app, and the SQL instance can communicate.
- Set up build and release pipelines to create the app, and deploy to two separate web apps.

2.2. Development languages

- PHP



Picture 20. PHP logo

PHP (recursive acronym for PHP: Hypertext Preprocessor) is a widely-used open source general-purpose scripting language that is especially suited for web development and can be embedded into HTML. (php, n.d.)

In another way, PHP is a server-side scripting language. that is used to develop Static websites or Dynamic websites or Web applications. PHP stands for Hypertext Pre-processor, which earlier stood for Personal Home Pages. PHP scripts can only be interpreted on a server that has PHP installed. The client computers accessing the PHP scripts require a web browser only. A PHP file contains PHP tags and ends with the extension ".php".

PHP can help users create highly interactive "dynamic" websites. It is considered a very suitable web language and can be easily embedded in HTML pages. With the support of PHP, the visibility of the website becomes easier to understand and use. Not only that, but PHP also helps the website be compatible with many popular browsers in the world. As a result, the website will experience fewer compatibility errors. Increase the user experience of the website.

Not only creating dynamic web pages, but PHP programmers can also do the following:

- Files can be created, opened, read, written, deleted and closed on the server via PHP
- PHP can crawl the form.
- PHP can send and receive cookies
- This language can also help to add, delete, modify data in the database
- PHP can be used to control user access.
- PHP can encrypt data

Laravel



Picture 21. Laravel logo

Laravel is a free and open-source PHP framework, developed by Taylor Otwell and aimed at supporting the development of model-view-controller (MVC) web applications. The salient features of Laravel include clear - clear syntax, a modular packaging system and dependency package management, various ways to access relational databases, and more. Deployment support into application maintenance.

Laravel is released under the MIT license, with a source code hosted at Github.

Use of the Laravel framework:

- **Creating layouts:** It is a great way to get the lightweight-designed templates that help a user to develop or create a layout. This layout includes text, images, code structures, and so on.
- **Bcrypt hashing:** With Laravel, one gets to enjoy the Object-Oriented and default libraries. With the implementation of such libraries, a user can perform Bcrypt hashing.
- **Model view controller:** It helps to handle the overall activities related to web tasks. With such control, the overall performance gets improved.
- **Artisan tool:** It has a default artisan tool which helps function as a tool for the command line.
- **Unit testing:** It supports unit testing simply and easily. This helps to adopt new changes within the software. (quora, n.d.)

Advantages of Laravel Framework:

- **Constructive authorization:** It is a great tool to implement authentication and authorization tasks properly. With this tool, the complex activities get out.
- **Object-oriented library:** It has numerous libraries that are object-oriented along with the default libraries. The Authentication Library is also advantageous for users.
- **MVC assistance:** The top-class services within this structure gather huge attention due to the presence of MVC. The presentation and logic get cleared with such a feature.
- **High-tech security:** Throughout any web project, security is a primary concern for any developer. In such a structure, web development is supported by high-tech security such as passwords, encrypted codes, SQL statements, and so on.

- **ASP.NET**

- **.Net Core vs .NET Framework**

- **.NET Core:**

ASP.NET Core is a new open-source and cross-platform framework for building existing applications based on cloud connectivity, like web apps, IoT, and backend for mobile. As a cross-platform framework, .NET supports most operating systems such as Windows, Linux, and macOS. The .NET Core framework includes .NET Core, ASP.NET Core, and Entity Framework Core. These technologies differ from the .NET Framework in that they run the CoreCLR runtime (used in Universal Windows Platform).

- **.NET Framework:**

The .NET Framework is a programming platform and also a platform to execute applications primarily on the Microsoft Windows operating system developed by Microsoft. Programs written on the .NET Framework are deployed in a software environment (as opposed to a hardware environment) known as the Common Language Runtime (CLR). This software environment is a virtual machine that provides services such as software security, memory management, and exception handling. There are two supported .NET implementations for building server-side apps: .NET Framework and .NET Core. Both share many of the same components and users can share code across the two. However, there are fundamental differences between the two and the choice depends on what the user wants to accomplish.

.NET Core	.NET Framework
Developer have cross-platform needs	User's app currently uses .NET Framework
The developer is targeting microservices.	User's app uses third-party .NET libraries or NuGet packages not available for .NET Core.
The developer is using Docker containers.	User's app uses .NET technologies that aren't available for .NET Core
Developers need high-performance and scalable systems.	The user's app uses a platform that doesn't support .NET Core. Windows, macOS, and Linux support .NET Core.
Developers need side-by-side .NET versions per application.	

Table 11. Comparison between .Net Core and .Net Framework

- **Node.js**

JavaScript

JavaScript is an event-based language, so anything that happens on the server generates a non-blocking event. Each new connection generates an event; data received from an upload form generates a data-received event; Querying data from the database also generates an event. In practice, this means that a Node.js website will never be locked up and can support tens of thousands of users at the same time. Node.js plays the role of the server - Apache - and interprets the application code that runs on it. Like Apache, there are many modules (libraries) that can be installed to add additional features and functionality - like data storage, Zip file support, Facebook login, or payment gateways. Of course, it doesn't have as many libraries as PHP, but Node.js is still in its early stages and has a very strong community behind it.

A core Node.js concept is asynchronous functions - so basically everything runs on the platform. In most server scripting languages, the program must wait for each function to finish before it can continue running. With Node.js, you define the functions that will run to complete a task, while the rest of the application is still running concurrently. (techmaster, n.d.)

Node.js framework



Picture 22. Node.js logo

Node.js is a framework for writing server-side JavaScript applications. It is built on top of the V8 JavaScript runtime and uses an event-driven, non-blocking I/O model that makes it perfect for data-intensive, real-time applications.

Node is often used to build back end services that communicate with client-side applications. These applications get and send data through a back-end service called an API. The API serves as an interface between different programs so they can talk to each other. A web app and a mobile app below can leverage the same API to store data, send emails, push notification, or initiate workflows on the server.

Advantages of Node.js:

- Node.js is an open-source framework under the MIT license. (MIT license is a free software license originating at the Massachusetts Institute of Technology (MIT).)
- Uses JavaScript to build the entire server-side application.
- The lightweight framework that includes bare minimum modules. Other modules can be included as per the need of an application.
- Asynchronous by default. So, it performs faster than other frameworks.
- The cross-platform framework that runs on Windows, MAC or Linux
- Rest API: Node JS platform supports developing RESTful Web Services API very easily.
- Unit Testing: In Node.js application, we need to write code in JavaScript. Today we have many JavaScript Unit Testing frameworks and tools like Jasmin Framework.

Disadvantages of Node.js:

- Node JS does not support multi-threaded programming this is the reason why it only preferred for the lightweight applications (online games, chat). If the user is using it for heavy application, the choice is wrong.
- Node JS API has some consistency issues. Most of the time the new API comes with many backward changes, then the programmers are required to make changes in the code to make it compatible.
- The Events Loop is the main feature of Node.js, and there may be too many call-back is running in code.
- Most of the time relational databases behave strangely while working with node.js. If the issue persists, the developers can use NoSQL database(MongoDB) in Nodejs.

Comparison between ASP.NET and PHP:

	ASP.NET	PHP
Type	Web Application Framework was developed by Microsoft.	Server-side scripting language. Open-source.
Web size	Suitable for Medium and Large Websites	Small to medium web
Cost	Loss of license fees	Free and available
Solution	Focus on Security and Functionality	Focus on the customer interaction interface
Community	Smaller PHP community	Bigger community than ASP.NET
Security	High security	Less secure than ASP.NET
Speed	Fast. Fast enough on the Desktop app	Fast. Slower on Desktop apps
Customization	Low customization	Allows for high customization

Table 12. Comparison between ASP.NET and PHP

Thus, both of the frameworks have their advantages over the cons. Since the project is highly secure and complex, using ASP.NET will be prioritized. Besides the limitations of ASP.NET is the low community, royalty fees, support mainly on Windows, but besides, there are many outstanding advantages over PHP that the processing speed will be faster, and easy to fix. error correction when programming more than PHP and especially with high stability.

Comparison between ASP.NET and Node.js:

	ASP.NET	Node.js
Suitable For	It operates simultaneously on multi-threads. This means you can develop a website within a span of a few days. Moreover, an essential website could be ready with an effort of just a few hours.	It is suitable for building asynchronous apps as it functions on one thread via non-blocking I/O calls, enabling it to support numerous parallel connections without thread context switching.
Benefits	Due to integrated Windows authentication and per-application configuration, the majority of apps remain free from any attacks. It significantly reduces the total code used to build huge apps.	Developers heavily praise it because they possess the freedom to share one language on the server and the client-side.
Real-Time Usage	Numerous websites that we are accessing on the web are made via ASP.NET.	It can maintain & control over a massive amount of customer data.
Language	It is based on C#. ASP.NET provides a strict type system and compile-type error checks, which is dependent on Microsoft's TypeScript.	It is based on JavaScript. To integrate JavaScript into the project, you have to become an expert on asynchronous programming, which requires some time.
Speed	Bundle of conventions inherited by ASP.NET enables you to enhance your code and keep it precise and compact. But, diverting from these configurations will lead to manual configuration, that's somewhat challenging and consumes some more time.	Being asynchronous, it can handle several callbacks consequently.
Support	It has a broader community of developers on the StackOverflow as compared to the GitHub.	Node has more than 70K+ stars & 170+ repositories on the GitHub. However, it has low support for StackOverflow.
Availability	The most recent ASP.NET core is considered as a highly scalable framework with some unique solutions that increase the development speed	It consists of a wide number of small and reusable libraries, which helps you to achieve more by writing less code.
Tools	There are a bunch of tools present in the market, such as LINQPad, NDepend, ELMAH, etc. which you can use to create innovative and next-gen websites and web apps. In general, developers prefer to use tools such as Visual Studio, Web Essentials, and Resharper.	You can utilize any popular TextEditor for developing any web application using Node.js. However, a standard option is to use WebStorm (IDE) because it increases overall productivity and enhanced support from the community.
Hosting	To host applications built using ASP.NET, you have several options like AWS, Microsoft Azure, and Google Cloud Platform.	There are limitations on Node.js when developers choose to host their applications. Therefore, the majority of developers choose to host by forming their own Linux Web Server.

Performance	While comparing ASP.NET vs Node.js performance, it varies based on the requirements of the project. Node.js manages tasks easily where less computation is needed; however, as the task becomes more CPU-intensive, Node.js fails.	A vast amount of developers stated that they had observed better performance after transferring their apps to Node.js.
Processing Model	It works on the synchronous model and is multi-threaded, i.e., it successively handles all the requests present in the thread pool.	As it works on Asynchronous programming, which enables a server to address multiple requests simultaneously without blocking them. Although it runs on the single-thread, it looks after multiple background threads to schedule several tasks.

Table 13. Comparison between ASP.NET and Node.js

- **Suitable For:** **ASP.NET** is a clear winner because it gives developers the freedom to create highly alluring and engaging, and complex websites proficiently.
- **Benefits:** **Node.js** because you have only one code for deployment and its ability to scale applications fast.
- **Real-Time Usage:** **ASP.NET** wins in this case because it powers countless websites on the web.
- **Language:** **ASP.NET** is the clear winner because it uses a strict type system and gives options to check compile-type errors.
- **Speed:** **Node.js**, the reason it gives developers the freedom to code without any restrictions and is adaptable. Also, developers can access native & third-party libraries in their web development projects.
- **Support:** Here, there is a **tie** between ASP.NET vs Node.js because both server-side languages are widely accepted by the developers all over the sphere.
- **Availability:** The winner here is **Node.js** because it allows you to enhance your project's speed by integrating small & reusable libraries.
- **Tools:** Without any doubt, **Node.js** is the winner because it supports the majority of text editors in the market.
- **Hosting:** The winner here is **ASP.NET**, as it offers better options for hosting than Node.js
- **Performance:** **Node.js** wins the battle between Node.js vs ASP.NET performance as it operates effectively in a wide number of conditions.

Node.js vs Asp.net Core both have its advantages and disadvantages user can use base on the project requirement, that performance of node.js is better to compare to asp.net also notice that bug fixing and maintenances are easy in case of asp.net, code readability is easy in case of asp.net so we can easily learn within less time can do development if we are new to both languages. On the other side of the user want better performance in the case of a multi-threaded application user should use node.js. But

with the project's requirement that prioritizes stability, Real-Time Usage, programming language, security, and hosting, ASP.NET has superior features compared to Node.js.

.NET core MVC overview in the project:

MVC Architecture separates the application into three main components:

- **Mode:** The model represents the data and does nothing else. The models are independent of the controller or the view
- **View:** Views are the components that display the application's user interface (UI). Typically, this UI is created from the model data
- **Controller:** Controllers are the components that handle user interaction (HTTP Request). The controller works with the model, and ultimately select a view that displays UI.

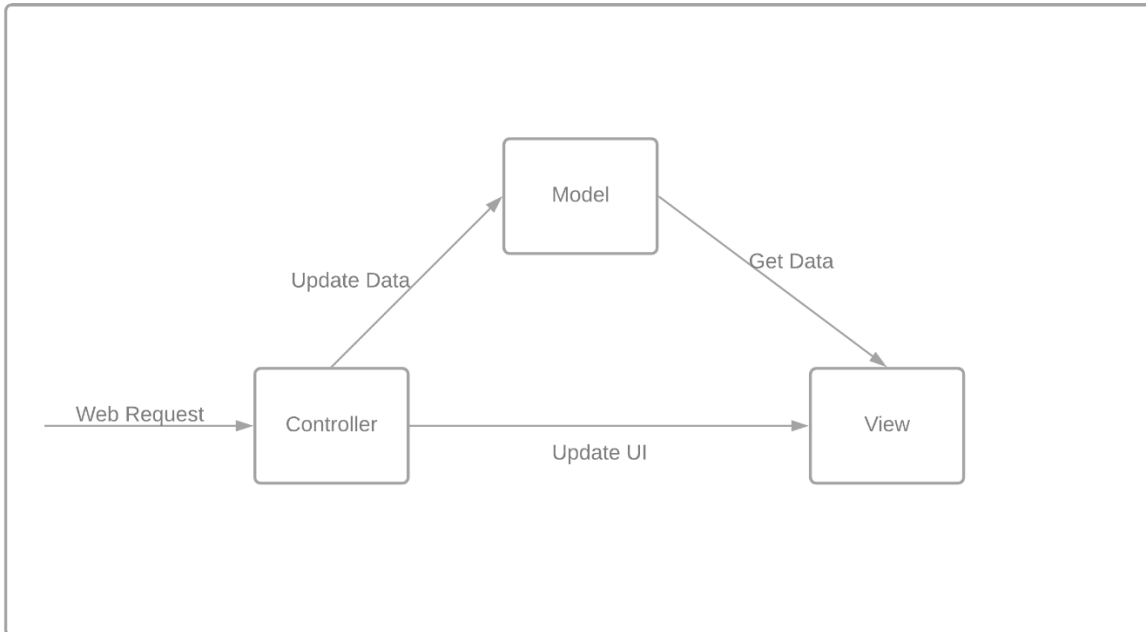


Figure 4. ASP.NET Core MVC Architecture

By using this **MVC architecture** with **.NET core** some benefits will be made for project:

- Easy code maintenance easy to extend and grow
- MVC Model component can be tested separately from the user
- Easier support for a new type of clients
- The development of the various components can be performed parallelly.
- It helps you to avoid complexity by dividing an application into the three units. Model, view, and controller
- It only uses a Front Controller pattern that processes web application requests through a single controller.
- Offers the best support for test-driven development
- It works well for Web apps which are supported by large teams of web designers and developers.
- Provides clean separation of concerns (SoC).
- All classes and objects are independent of each other so that you can test them separately.
- MVC allows logical grouping of related actions on a controller together.

2.3. Database servers

- MySQL



Table 14. MySQL logo

MySQL is an Oracle-backed open-source relational database management system (RDBMS) based on Structured Query Language (SQL). MySQL runs on virtually all platforms, including Linux, UNIX, and Windows. Although it can be used in a wide range of applications, MySQL is most often associated with web applications and online publishing.

MySQL is an important component of an open-source enterprise stack called LAMP. LAMP is a web development platform that uses Linux as the operating system, Apache as the webserver, MySQL as the relational database management system and PHP as the object-oriented scripting language. (Sometimes Perl or Python is used instead of PHP.)

MySQL is based on a client-server model. The core of MySQL is MySQL server, which handles all of the database instructions (or commands). MySQL server is available as a separate program for use in a client-server networked environment and as a library that can be embedded (or linked) into separate applications.

MySQL operates along with several utility programs that support the administration of MySQL databases. Commands are sent to MySQL server via the MySQL client, which is installed on a computer.

MySQL was originally developed to handle large databases quickly. Although MySQL is typically installed on only one machine, it can send the database to multiple locations, as users can access it via different MySQL client interfaces. These interfaces send SQL statements to the server and then display the results. (searchoracle, n.d.)

- **SQL Server**



Table 15. SQL Server logo

SQL Server is a relational database management system, or RDBMS, developed and marketed by Microsoft.

Similar to other RDBMS software, SQL Server is built on top of SQL, a standard programming language for interacting with the relational databases. SQL Server is tied to Transact-SQL, or T-SQL, Microsoft's implementation of SQL that adds a set of proprietary programming constructs. (sqlservertutorial, n.d.)

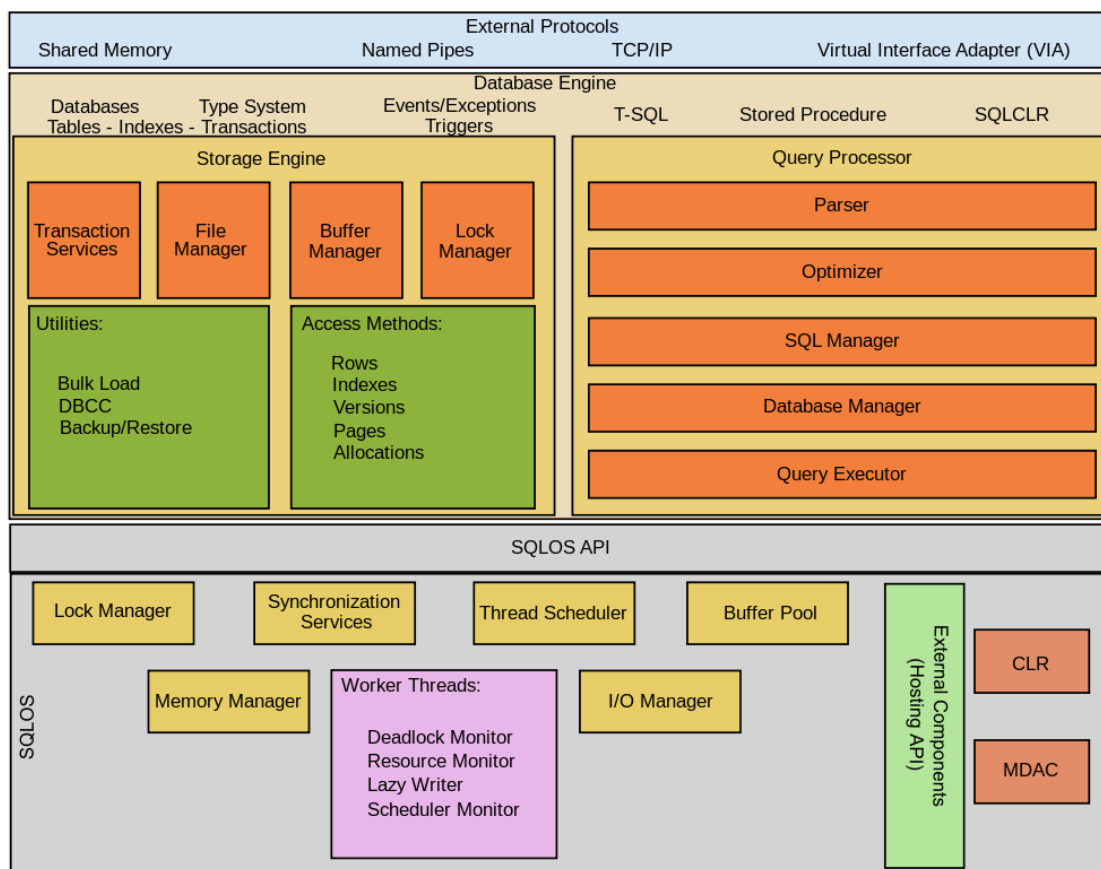


Figure 5. SQL Server Architecture

Usage of SQL Server:

- To create databases.
- To maintain databases.
- To analyze the data through SQL Server Analysis Services (SSAS).
- To generate reports through SQL Server Reporting Services (SSRS).
- To carry out ETL operations through SQL Server Integration Services (SSIS).

SQL Server Components:

SQL Server works in a client-server architecture, hence it supports two types of components – (a) Workstation and (b) Server.

- Workstation components are installed in every device/SQL Server operator's machine. These are just interfaces to interact with Server components. Example: SSMS, SSCM, Profiler, BIDS, SQLEM, etc.
- Server components are installed in a centralized server. These are services. Example: SQL Server, SQL Server Agent, SSIS, SSAS, SSRS, SQL browser, SQL Server full-text search, etc.

- **MongoDB**



Picture 23. MongoDB logo

MongoDB is a general-purpose, document-based, distributed database built for modern application developers and the cloud era. No database makes users more productive, which means it stores data in JSON-like documents. We believe this is the most natural way to think about data and is much more expressive and powerful than the traditional row/column model. (mongodb, n.d.)

- MongoDB stores data in flexible, JSON-like documents, meaning fields can vary from document to document and data structure can be changed over time
- The document model maps to the objects in your application code, making data easy to work with
- Ad hoc queries, indexing, and real-time aggregation provide powerful ways to access and analyze your data
- MongoDB is a distributed database at its core, so high availability, horizontal scaling, and geographic distribution are built-in and easy to use
- MongoDB is free to use. Versions released before October 16, 2018, are published under the AGPL. All versions released after October 16, 2018, including patch fixes for prior versions, are published under the Server Side Public License (SSPL) v1.

MongoDB advanced:

- High availability through built-in replication and failover
- Horizontal scalability with native sharding
- End-to-end security
- Native document validation and schema exploration with Compass
- Management tooling for automation, monitoring, and backup
- Fully elastic database as a service with built-in best practices

Comparison between MySQL and SQL Server:

Both MySQL and SQL Server, both are relational database management systems or RDBMS. MySQL is open source and is free to use whereas SQL Server is a licensed product of Microsoft.

	MySQL	SQL Server
Owned/Developed By	MySQL is owned by Oracle.	SQL Server is developed by Microsoft.
Language support	MySQL supports programming languages like C++, Java, and has running support for Perl, TCL, and Haskell.	SQL Server supports programming languages like C++, Java, Ruby, Visual Basic, Delphi, R.
Storage Space	MySQL needs less amount of operational storage space.	SQL Server needs a large amount of operational storage space.
Query Cancellation	MySQL does not support midway query execution cancellation.	SQL Server allows canceling query execution midways.
Back-Up	MySQL blocks the database while taking the backup.	SQL Server does not block the database during the backup process.
Cost	MySQL is free to use.	SQL Server is costly.
Data File Manipulation	Data files can be manipulated while running.	Data file manipulation is not allowed under security consideration while running.
Available Editions	MySQL Standard Edition, MySQL Enterprise Edition, and MySQL Cluster Grade Edition.	Enterprise, Standard, Web, Workgroup, or Express.

Table 16. Comparison between MySQL and SQL Server

- MySQL available for free since it is open-source, But SQL Server is not open source.
- MySQL offers only updateable views, SQL Server offers indexed views which are much more powerful, performing wise.
- MySQL doesn't support XML, Where SQL Server XML supports it.
- Auto tuning is not supported in MySQL, But can in SQL Server.
- User-defined functions are not supported in MySQL But supported in SQL Server.
- Transaction support is very much limited in MySQL, But extensively and fully offered in SQL Server.
- Stored procedures and full joins not offered in MySQL But offered in SQL Server.
- The cursor feature is not there in MySQL but is there in SQL Server.
- Job scheduling and profiling not available in MySQL, But available is SQL Server.

Between the various database management software options available, Microsoft SQL Server is one of the most powerful software for the project.

Comparison between MongoDB and SQL Server:

	MS SQL Server	MongoDB
Storage Model	RDBMS	Document-Oriented
Joins	Yes	No
Transaction	ACID	NO
Agile practices	No	Yes
Data Schema	Fixed	Dynamic
Scalability	Vertical	Horizontal
Map Reduce	No	Yes
Language	SQL query language	JSON Query Language
Secondary index	Yes	Yes
Triggers	Yes	No
Foreign Keys	Yes	No
Concurrency	Yes	No
Company Name	Microsoft	MongoDB.Inc
License	Commercial	Open Source
Implementation Language	C++	C++
Operating System	Windows	Windows, Linux, OS X
Drivers	.NET, Java, PHP, Python, Ruby, Visual Basic	Dart, Delphi, Erlang, Go, Groovy, Haskell, Java, JavaScript, Lisp, Lua, MatLab, Perl, PHP, PowerShell, Prolog, Python, R, Ruby, Scala, Smalltalk
Server-side scripts	Transact SQL and .NET languages	JavaScript's
XML Support	Yes	No
Storage Model	RDBMS	Document-Oriented

Table 17. Comparison between MongoDB and SQL Server

Both MongoDB vs SQL Server performance are popular choices in the market; let us discuss some of the major difference between MongoDB and SQL Server:

- MongoDB is more fast and scalable in comparison to the SQL server.
- MongoDB doesn't support JOIN and Global transactions but the SQL server supports it.
- MongoDB supports a big amount of data but the MS SQL server doesn't.
- MongoDB support Agile practices but MS SQL server doesn't support it.
- MongoDB schema is dynamic but MS SQL server schema is fixed.
- Ms. SQL server provides XML support but MongoDB doesn't

Base on the comparison between MySQL, SQL Server, and MongoDB and the system requires that **SQL Server** was used to develop database because:

Ensures Security of Data: MS-SQL Server gives developers the advantage of working with a table structure based on rows, which allows the connection of correlated data elements and functions. Many other Database Management Systems (DBMS) are less secure, while MS-SQL enables you to maintain the security, integrity, and consistency of the data you're working with. This is especially important when customer information is on the line and they need to know they can trust your security.

Optimizes Data Storage and Accuracy: This gives developers the benefit of getting rid of the need to duplicate data storage within a database when developers are working from a different computer. Other advantages of this structure are that it provides integrity when referencing the database.

Simple Installation and Automatic Updates: SQL Servers use Policy-Based Management to keep security policies compliant and updated. This means that only authorized personnel will be able to access the database. It also allows having security events and audits automatically written for file logging.

Simple Management and Maintenance: SQL servers boast effective data management and data mining tools which, in combination with disk partitioning, allows developers the benefit of the best maintenance available.

Database architectures in ASP.NET core:

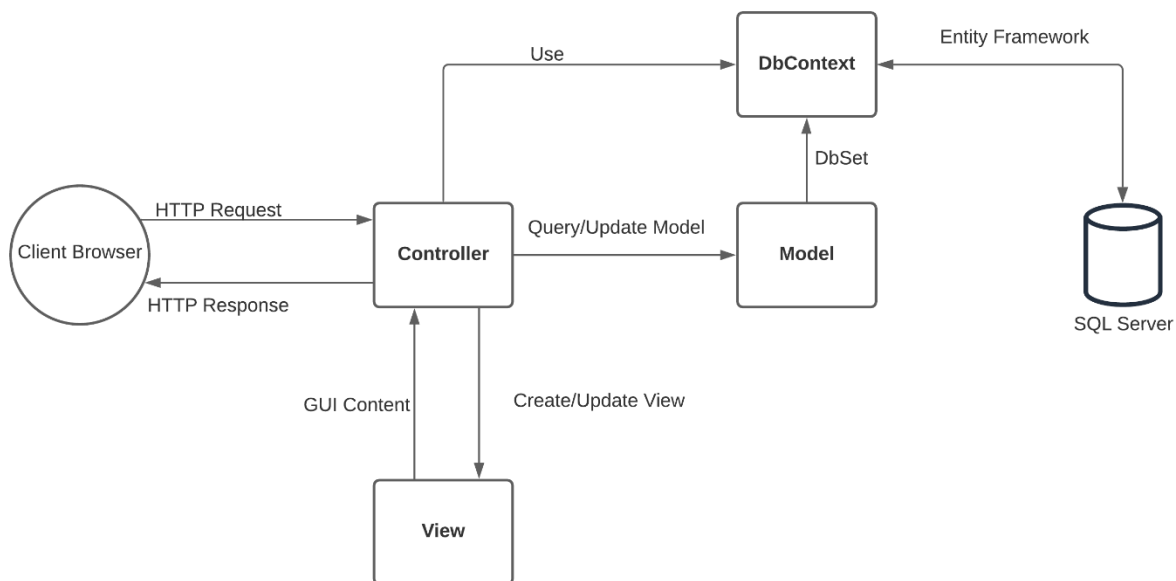


Figure 6. Database architectures in ASP.NET core

2.4. Software Models

- **Waterfall model**

The Waterfall Model was the first Process Model to be introduced. It is also referred to as a linear-sequential life cycle model. It is very simple to understand and use. In a waterfall model, each phase must be completed before the next phase can begin and there is no overlapping in the phases.

The Waterfall model is the earliest SDLC approach that was used for software development.

The waterfall Model illustrates the software development process in a linear sequential flow. This means that any phase in the development process begins only if the previous phase is complete. In this waterfall model, the phases do not overlap. (tutorialspoint, tutorialspoint, n.d.)

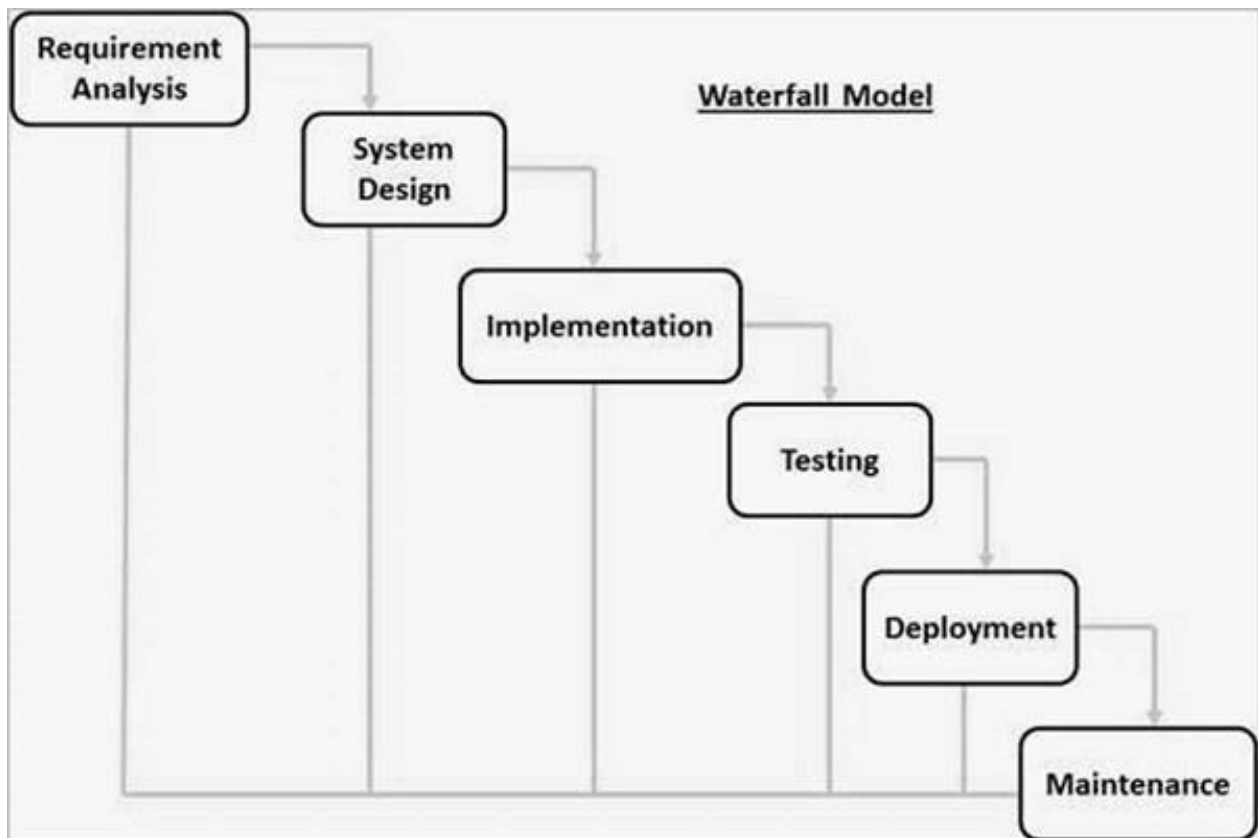


Figure 7. Waterfall Model – Design

- **Requirement Gathering and analysis:** All possible requirements of the system to be developed are captured in this phase and documented in a requirement specification document.
- **System Design:** The requirement specifications from the first phase are studied in this phase and the system design is prepared. This system design helps in specifying hardware and system requirements and helps in defining the overall system architecture.
- **Implementation:** With inputs from the system design, the system is first developed in small programs called units, which are integrated into the next phase. Each unit is developed and tested for its functionality, which is referred to as Unit Testing.
- **Integration and Testing:** All the units developed in the implementation phase are integrated into a system after testing of each unit. Post integration the entire system is tested for any faults and failures.
- **Deployment of the system:** Once the functional and non-functional testing is done; the product is deployed in the customer environment or released into the market.
- **Maintenance:** Some issues come up in the client environment. To fix those issues, patches are released. Also to enhance the product some better versions are released. Maintenance is done to deliver these changes in the customer environment

When to use SDLC Waterfall Model:

- Requirements are not changing frequently
- Application is not complicated and big
- Project is short
- Requirement is clear
- Environment is stable
- Technology and tools used are not dynamic and is stable
- Resources are available and trained

- **V-model**

The V-model is an SDLC model where the execution of processes happens sequentially in a V-shape. It is also known as the Verification and Validation model.

The V-Model is an extension of the waterfall model and is based on the association of a testing phase for each corresponding development stage. This means that for every single phase in the development cycle, there is a directly associated testing phase. This is a highly-disciplined model and the next phase starts only after completion of the previous phase. (tutorialspoint, tutorialspoint, n.d.)

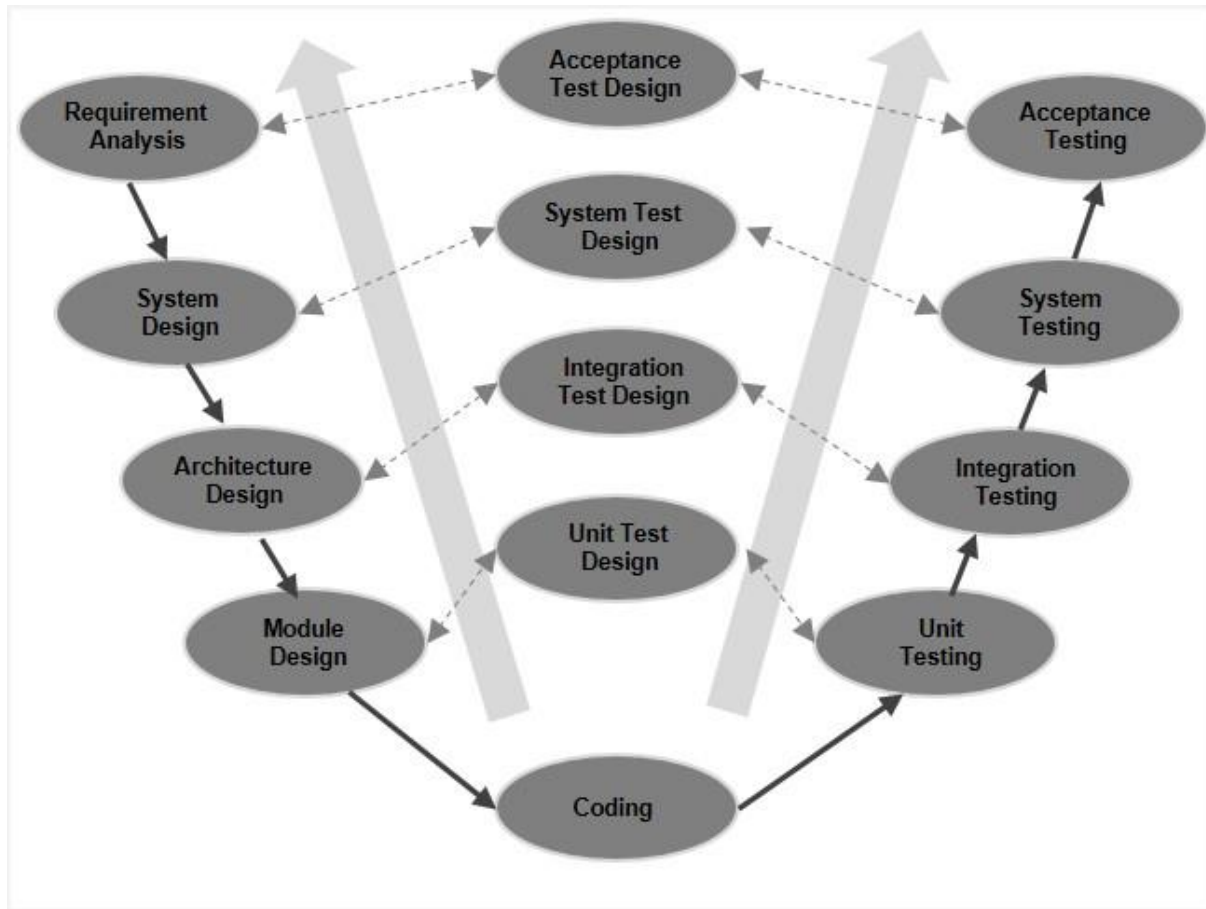


Figure 8. V-Model design

- The left side of the model is Software Development Life Cycle - SDLC
- The right side of the model is the Software Test Life Cycle – STLC

When to use SDLC Waterfall Model:

- Requirements are well defined, clearly documented, and fixed.
- The product definition is stable.
- Technology is not dynamic and is well understood by the project team.
- There are no ambiguous or undefined requirements.
- The project is short.

- **Business Requirement Analysis:** This is the first phase in the development cycle where the product requirements are understood from the customer's perspective. This phase involves detailed communication with the customer to understand his expectations and exact requirement. This is a very important activity and needs to be managed well, as most of the customers are not sure about what exactly they need. The acceptance test design planning is done at this stage as business requirements can be used as an input for acceptance testing.
- **System Design:** Once you have clear and detailed product requirements, it is time to design the complete system. The system design will have the understanding and detailing the complete hardware and communication setup for the product under development. The system test plan is developed based on the system design. Doing this at an earlier stage leaves more time for the actual test execution later.
- **Architectural Design:** Architectural specifications are understood and designed in this phase. Usually, more than one technical approach is proposed, and based on the technical and financial feasibility the final decision is taken. The system design is broken down further into modules taking up different functionality. This is also referred to as High-Level Design (HLD).
- **Module Design:** In this phase, the detailed internal design for all the system modules is specified, referred to as Low-Level Design (LLD). The design must be compatible with the other modules in the system architecture and the other external systems. The unit tests are an essential part of any development process and help eliminate the maximum faults and errors at a very early stage. These unit tests can be designed at this stage based on the internal module designs.
- **Coding Phase:** The actual coding of the system modules designed in the design phase is taken up in the Coding phase. The best suitable programming language is decided based on the system and architectural requirements.
- **Unit Testing:** Unit tests designed in the module design phase are executed on the code during this validation phase. Unit testing is the testing at the code level and helps eliminate bugs at an early stage, though all defects cannot be uncovered by unit testing.
- **Integration Testing:** Integration testing is associated with the architectural design phase. Integration tests are performed to test the coexistence and communication of the internal modules within the system.
- **System Testing:** System testing is directly associated with the system design phase. System tests check the entire system functionality and the communication of the system under development with external systems. Most of the software and hardware compatibility issues can be uncovered during this system test execution.
- **Acceptance Testing:** Acceptance testing is associated with the business requirement analysis phase and involves testing the product in the user environment. Acceptance tests uncover the compatibility issues with the other systems available in the user environment. It also discovers the non-functional issues such as load and performance defects in the actual user environment.

- **Agile Model**

Agile SDLC model is a combination of iterative and incremental process models with a focus on process adaptability and customer satisfaction by rapid delivery of working software product. Agile Methods break the product into small incremental builds. These builds are provided in iterations. Each iteration typically lasts from about one to three weeks. Every iteration involves cross-functional teams working simultaneously on various areas like:

- Planning
- Requirements Analysis
- Design
- Coding
- Unit Testing and
- Acceptance Testing.

At the end of the iteration, a working product is displayed to the customer and important stakeholders. (tutorialspoint, n.d.)

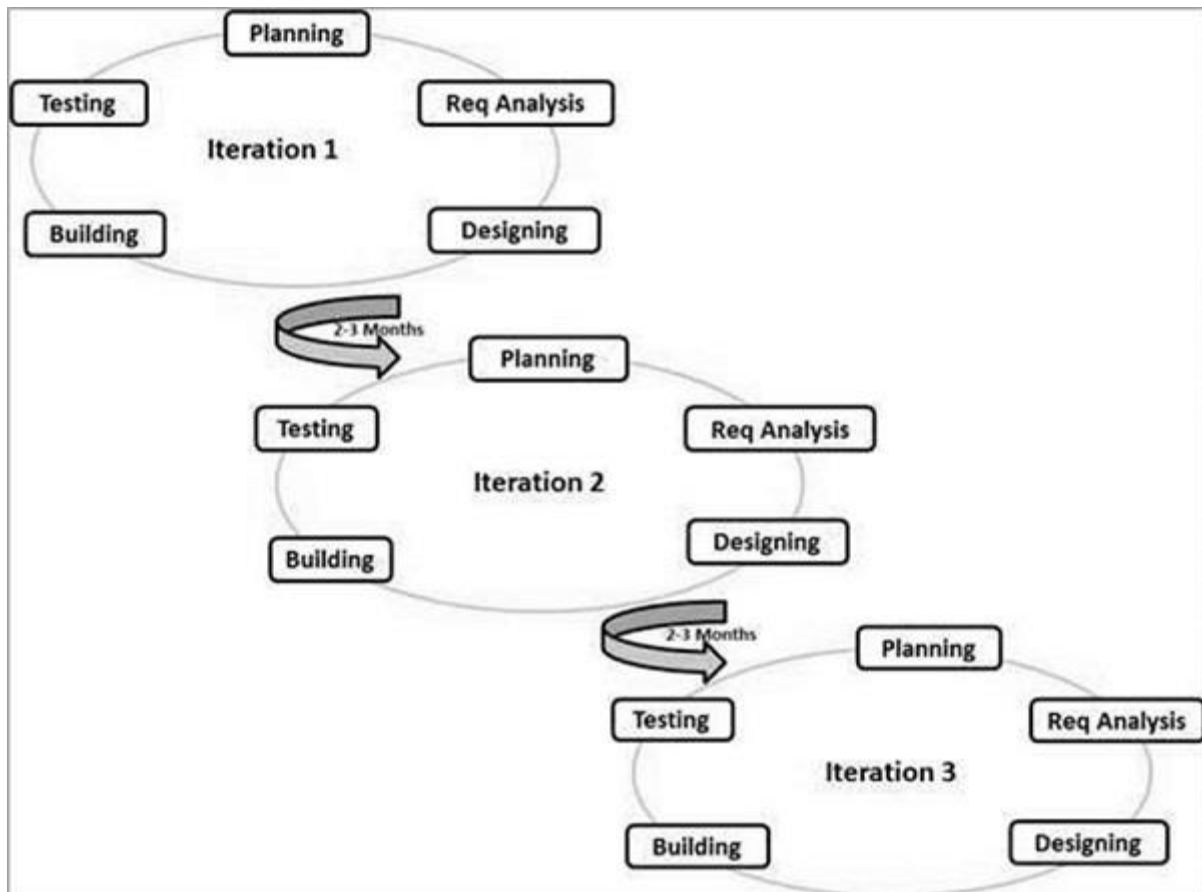


Figure 9. Agile model design

Following are the Agile Manifesto principles:

- **Individuals and interactions:** In Agile development, self-organization and motivation are important, as are interactions like co-location and pair programming.
- **Working software:** Demo working software is considered the best means of communication with the customers to understand their requirements, instead of just depending on documentation.
- **Customer collaboration:** As the requirements cannot be gathered completely at the beginning of the project due to various factors, continuous customer interaction is very important to get proper product requirements.
- **Responding to change:** Agile Development is focused on quick responses to change and continuous development.

When to use an Agile model:

- When new changes are needed to be implemented. The freedom agile gives to change is very important. New changes can be implemented at very little cost because of the frequency of new increments that are produced.
- To implement a new feature the developers need to lose only the work of a few days, or even only hours, to roll back and implement it.
- Unlike the waterfall model in an agile model very limited planning is required to get started with the project. Agile assumes that the end-users' needs are ever-changing in a dynamic business and IT world. Changes can be discussed and features can be newly effected or removed based on feedback. This effectively gives the customer the finished system they want or need.
- Both system developers and stakeholders alike find they also get more freedom of time and options than if the software was developed in a more rigid sequential way. Having options gives them the ability to leave important decisions until more or better data or even entire hosting programs are available; meaning the project can continue to move forward without fear of reaching a sudden standstill.

Difference between Agile and Waterfall Model:

Agile	Waterfall
It separates the project development lifecycle into sprints.	The software development process is divided into distinct phases.
It follows an incremental approach	The waterfall methodology is a sequential design process.
Agile methodology is known for its flexibility.	The waterfall is a structured software development methodology so most times it can be quite rigid.
Agile can be considered as a collection of many different projects.	Software development will be completed as one single project.
Agile is quite a flexible method that allows changes to be made in the project development requirements even if the initial planning has been completed.	There is no scope of changing the requirements once the project development starts.
Agile methodology, follow an iterative development approach because of this planning, development, prototyping, and other software development phases that may appear more than once.	All the project development phases like designing, development, testing, etc. are completed once in the Waterfall model.
The test plan is reviewed after each sprint	The test plan is rarely discussed during the test phase.
Agile development is a process in which the requirements are expected to change and evolve.	The method is ideal for projects which have definite requirements and changes not at all expected.
In Agile methodology, testing is performed concurrently with software development.	In this methodology, the "Testing" phase comes after the "Build" phase
Agile introduces a product mindset where the software product satisfies the needs of its end customers and changes itself as per the customer's demands.	This model shows a project mindset and places its focus completely on accomplishing the project.
The agile methodology works exceptionally well with Time & Materials or non-fixed funding. It may increase stress in fixed-price scenarios.	Reduces risk in the firm-fixed-price contracts by getting risk agreement at the beginning of the process.
Prefers small but dedicated teams with a high degree of coordination and synchronization.	Team coordination/synchronization is very limited.
Products owner with team prepares requirements just about every day during a project.	Business analysis prepares requirements before the beginning of the project.
The test team can take part in the requirements change without problems.	It is difficult for the test to initiate any change in requirements.
Description of project details can be altered anytime during the SDLC process.	Detail description needs to implement a waterfall software development approach.
The Agile Team members are interchangeable, as a result, they work faster. There is also no need for project managers because the projects are managed by the entire team	In the waterfall method, the process is always straightforward so, the project manager plays an essential role during every stage of SDLC.

Table 18. Difference between Agile and Waterfall Model

Difference between V-model and Waterfall model:

Waterfall model	V-model
The cost of the Waterfall model is low.	V-model is expensive.
The simplicity of the Waterfall model is simple.	The simplicity of the V-model is Intermediate.
The flexibility of the Waterfall model is Rigid.	The flexibility of the V-model is Little flexible.
The waterfall model is a sequential execution process.	It is also a sequential execution process.
The waterfall model's steps move linearly.	V-model's steps don't move linearly.
The re-usability of the Waterfall model is Limited.	V-model can be Re-use to some extent.
User involvement in the Waterfall model is only in the beginning.	User involvement in V-model is also only in the beginning.
In Waterfall model testing activities start after the development activities are over.	V-model testing activities start with the first stage.
The guarantee of success through the Waterfall model is low.	The guarantee of success through the V-model is high.
The waterfall model is a continuous process.	V-model is a simultaneous process.
Software made using the Waterfall model, the number of defects is less in comparison to software made using V-model.	Software made using V-model, the number of defects is greater in comparison of software made using the Waterfall model.
A requirement specification in the Waterfall model is necessary in beginning.	A requirement specification in V-model is also necessary in beginning.
The waterfall model is less used nowadays in software engineering.	V-model is widely used in software engineering.

Table 19. Difference between V-model and Waterfall model

Analyze the requirement to choose the right model:

- **Requirements:** The requirement put into a single document and used for verification of each stage, are composed alongside constraints and functional and non-functional needs of the project
- **Design:** Based on the requirements of the project, the design was presented following the project requirements. From the designer, it is possible to verify the exact details of the project.
- **Implementation:** The documentation of the requirement is clear, but the original designs and after a while modified to suit the requirements of the product. This requires a new design to be created and validated before implementation can be completed.
- **Verification:** Developed and built solutions are further tested against requirements to determine that the project is properly meeting the original requirements. If not, the shortcomings must be re-verified.
- **Maintenance:** Problems will increase or need a new version of the product, planned changes will be made.
- **With the waterfall model:** each stage can only continue once each previous stage has been completed
- The project is small and the requirement is clearly defined and very understood

The requirement of the FPT Learning System very well knows, clear, and fixed. The system definition is stable and the technology stack is understood. And in the Waterfall model, very little customer interaction is involved during the development of the product. Once the product is ready then only it can be demonstrated to the end-users. So, the **Waterfall model** was used for the FPT Learning System.

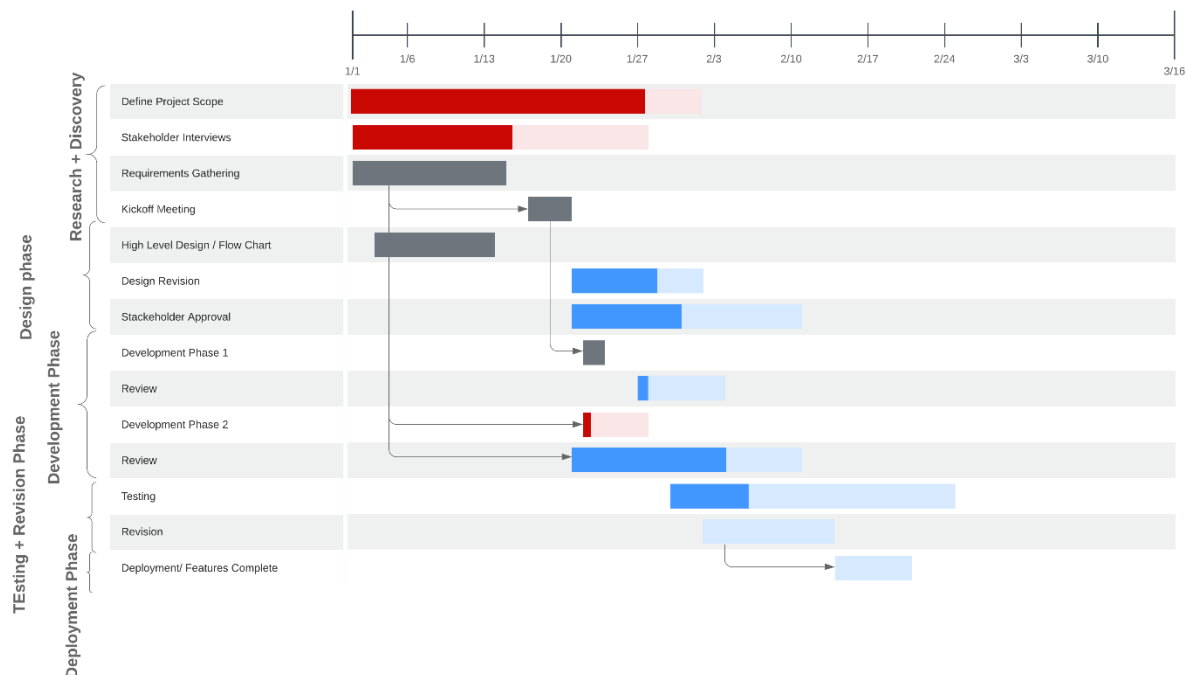


Figure 10. Example Waterfall model in FLS Project

Conclusion

The report pointed out and compared tools, cloud computing, programming languages, databases, and software models to implement the FPT Learning System project based on the requirements of the Application Development course. The Tools and technologies mentioned may not be the best for a project, but with the above technologies, it is possible to fulfill all the requirements given by the project.

Overview tool and techniques in the project:

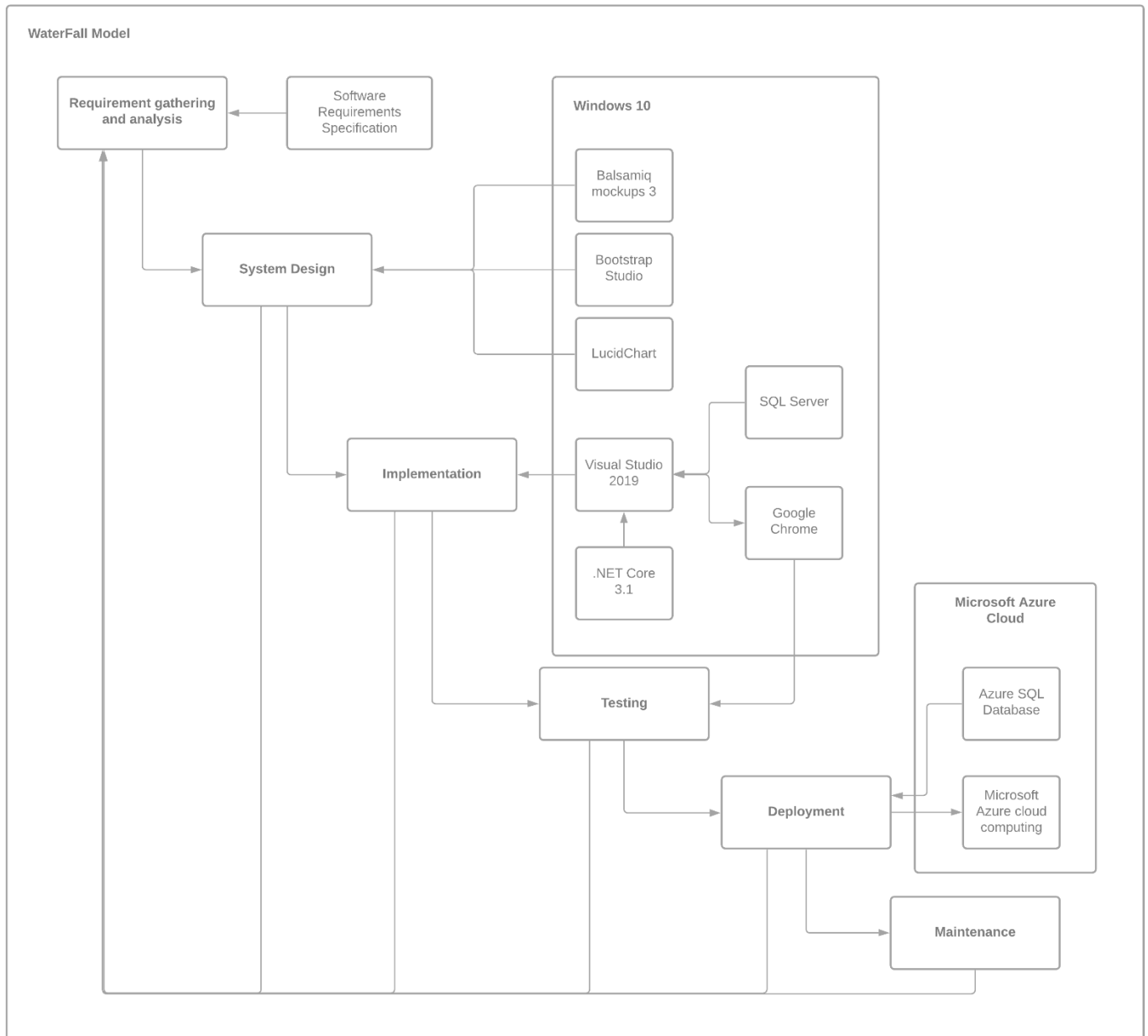


Figure 11. Overview tool and techniques in project

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