Chapter – 3

Study of Related Technology

3.1 Introduction
This chapter gives introduction to the tools and technologies used to design and implement the proposed model of decision support system. Detailed information of each tool is beyond the scope of this document, yet, each tool is described with enough detail so that reader can become familiar with that tool.

3.2 Tools and Technologies
During the research work, following tools and technologies are used to simplify the job of analysis, design, and coding activities.

3.2.1 Operating System: Windows 7 Enterprise
Windows 7 is an operating system produced by Microsoft for use on personal computers, including home and business desktops, laptops, net books, tablet PCs, and media center PCs. It was released to manufacturing on July 22, 2009, and became generally available for retail worldwide on October 22, 2009, less than three years after the release of its predecessor, Windows Vista. Windows 7's server counterpart, Windows Server 2008 R2, was released at the same time. Windows 7 is succeeded by Windows 8 [26]. Of course, being a Microsoft product, Windows 7 is not a freeware or open source operating system. License is necessary to use it.

3.2.1.1 Editions of Windows 7
The different editions of Windows 7 have been designed and marketed toward people with different needs. Out of the different editions (Starter, Home Basic, Home Premium, Professional, Enterprise, and Ultimate), the Starter edition has been designed and marketed for lower cost notebooks, Home Basic for emerging markets, Home Premium for normal home users, Professional for businesses, Enterprise for larger businesses and corporations, and Ultimate for enthusiasts [26].

3.2.1.2 New features of Windows 7
Among Windows 7's new features are advances in touch and handwriting recognition, support for virtual hard disks, improved performance on multi-
ore processors, improved boot performance, Direct Access, and kernel improvements. Windows 7 adds support for systems using multiple heterogeneous graphics cards from different vendors (Heterogeneous Multi-adapter), a new version of Windows Media Center, a Gadget for Windows Media Center, improved media features, the XPS Essentials Pack and Windows Power Shell being included, and a redesigned Calculator with multiline capabilities including Programmer and Statistics modes along with unit conversion for length, weight, temperature, and several others. Many new items have been added to the Control Panel, including Clear Type Text Tuner Display Color Calibration Wizard, Gadgets, Recovery, Troubleshooting, Workspaces Center, Location and Other Sensors, Credential Manager, Biometric Devices, System Icons, and Display. Windows Security Center has been renamed to Windows Action Center (Windows Health Center and Windows Solution Center in earlier builds), which encompasses both security and maintenance of the computer. Ready Boost on 32-bit editions now supports up to 256 gigabytes of extra allocation. Windows 7 also supports images in RAW image format through the addition of Windows Imaging Component-enabled image decoders, which enables raw image thumbnails, previewing and metadata display in Windows Explorer, plus full-size viewing and slideshows in Windows Photo Viewer and Windows Media Center [26].

The taskbar has seen the biggest visual changes, where the old Quick Launch toolbar has been replaced with the ability to pin applications to the taskbar. Buttons for pinned applications are integrated with the task buttons. These buttons also enable the Jump Lists feature to allow easy access to common tasks. The revamped taskbar also allows the reordering of taskbar buttons. To the far right of the system clock is a small rectangular button that serves as the Show desktop icon. This button is part of the new feature in Windows 7 called Aero Peek. Hovering over this button makes all visible windows transparent for a quick look at the desktop. In touch-enabled displays such as touch screens, tablet PCs, etc., this button is slightly (8 pixels) wider in order to accommodate being pressed by a finger. Clicking this button minimizes all windows, and clicking it a second time restores them. Additionally, there is a feature named Aero Snap that automatically maximizes a window when it is dragged to the top of the screen. Dragging windows to the left/right edges of the screen allows users to snap documents or files on either side of the screen for comparison between windows, such that the windows vertically take up half the screen. When a user moves windows that were maximized using
Aero Snap, the system restores their previous state automatically. This functionality is also accomplished with keyboard shortcuts. Unlike in Windows Vista, window borders and the taskbar do not turn opaque when a window is maximized with Windows Aero applied. Instead, they remain translucent. Windows 7 includes 13 additional sound schemes, titled Afternoon, Calligraphy, Characters, Cityscape, Delta, Festival, Garden, Heritage, Landscape, Quirky, Raga, Savanna, and Sonata. Internet Spades, Internet Backgammon and Internet Checkers, which were removed from Windows Vista, were restored in Windows 7 [26].

Users are also able to disable or customize many more Windows components than was possible in Windows Vista. New additions to this list of components include Internet Explorer 8, Windows Media Player 12, Windows Media Center, Windows Search, and the Windows Gadget Platform. A new version of Microsoft Virtual PC, newly renamed as Windows Virtual PC was made available for Windows 7 Professional, Enterprise, and Ultimate editions. It allows multiple Windows environments, including Windows XP Mode, to run on the same machine. Windows XP Mode runs Windows XP in a virtual machine and redirects displayed applications running in Windows XP to the Windows 7 desktop. Furthermore, Windows 7 supports the mounting of a virtual hard disk (VHD) as normal data storage, and the boot loader delivered with Windows 7 can boot the Windows system from a VHD; however, this ability is only available in the Enterprise and Ultimate editions. The Remote Desktop Protocol (RDP) of Windows 7 is also enhanced to support real-time multimedia application including video playback and 3D games, thus allowing use of DirectX 10 in remote desktop environments. The three application limit, previously present in the Windows Vista and Windows XP Starter Editions, has been removed from Windows 7. All editions include some new and improved features that originated with Vista, such as Windows Search, Security features, and some features new to Windows 7. Optional Bit Locker Drive Encryption is included with Windows 7 Ultimate and Enterprise. Windows Defender is included; Microsoft Security Essentials antivirus software is a free download. All editions include Shadow Copy, which—every day or so—System Restore uses to take an automatic "previous version" snapshot of user files that have changed. Backup and restore have also been improved, and the Windows—installed by default—replaces the optional Recovery Console of Windows XP.

Windows 7 includes improved globalization support through a new Extended Linguistic Services API to provide multilingual support (particularly in Ultimate and Enterprise
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editions). Microsoft has also implemented better support for solid-state drives, including the new TRIM command, and Windows 7 is able to identify a solid-state drive uniquely. Native support for USB 3.0 is not included due to delays in the finalization of the standard. Microsoft announced that color depths of 30-bit and 48-bit would be supported in Windows 7 along with the wide color gamut sRGB (which for HDMI 1.3 can be converted and output as xvYCC). The video modes supported in Windows 7 are 16-bit sRGB, 24-bit sRGB, 30-bit sRGB, 30-bit with extended color gamut sRGB, and 48-bit sRGB [26].

3.2.1.3 Removed features from Windows 7

Certain capabilities and programs that were a part of Windows Vista are no longer present or have been changed, resulting in the removal of certain functionalities. These include the classic Start Menu user interface, some taskbar features, Windows Explorer features, Windows Media Player features, Windows Ultimate Extras and Ink Ball. Four applications bundled with Windows Vista – Windows Photo Gallery, Windows Movie Maker, Windows Calendar and Windows Mail – are not included with Windows 7, but applications with close functionality are instead available for free in a separate package called Windows Live Essentials which can be downloaded on the Microsoft website [26].

3.2.1.4 Windows 7 Hardware Requirements

Windows 7 have mainly two versions; 32-bit, and 64-bit. Table 3.1 [25] shows minimum hardware requirements to use Windows 7 operating system.

<table>
<thead>
<tr>
<th>Component</th>
<th>Minimum System Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor (CPU)</td>
<td>1- GHz or faster, 32-bit (x86) or 64-bit (x64) processor</td>
</tr>
<tr>
<td>Memory</td>
<td>1 GB RAM (32-bit)</td>
</tr>
<tr>
<td></td>
<td>2 GB RAM (64-bit)</td>
</tr>
<tr>
<td>Graphics Processor</td>
<td>Support for DirectX 9 graphics with WDDM 1.0 or higher driver</td>
</tr>
<tr>
<td>Hard Disk</td>
<td>16 GB available disk space (32-bit)</td>
</tr>
<tr>
<td></td>
<td>20 GB available disk space (64-bit)</td>
</tr>
</tbody>
</table>

Table 3.1: Windows 7 Hardware Requirements [25]

3.2.2 IDE: Microsoft Visual Studio 2008

IDE means Integrated Development environment. IDE provides development environment for coding various applications.
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In the past, it seemed that Microsoft had just as many development environments as it had languages or technologies. For example, before the introduction of Visual Studio .NET 2002, web development required one environment, Visual Basic development another, and C++ development yet another. You had to choose the appropriate development environment for the specific type of programming you were trying to accomplish. With the release of the new Visual Studio Integrated Development Environments (IDEs), you can now build all the possible .NET classes, components, and applications from a single environment – Visual Studio [24].

Visual Studio enables you to build any type of .NET components or application. When you use this tool, you can choose any of the Microsoft .NET compliant languages for building your applications; plus it allows you to create Windows Forms, XML Web services, .NET components, mobile applications, ASP.NET applications, and more [24].

Visual Studio 2008 was released in early 2008, by Microsoft. It is an extremely versatile and powerful environment for developing .NET applications. Visual Studio 2008 has following features which make developer’s job easy [23].

(i) Components of IDE: Visual Studio 2008 has components like toolbar, menu bar, tool box, design pane, solution explorer, properties pane, and error list pane.

(ii) Code and Text Editor which includes code snippets, IntelliSense statement completion, IntelliSense support for object properties, methods and events, and Refactoring support (restructuring of code).

(iii) Debugging tools to observe run time behavior of the program.

(iv) Unit testing feature by auto-generation of the code to test your application.

3.2.3 Framework: ASP.NET 3.5

3.2.3.1 The .NET Framework

The .Net Framework is a development framework created by Microsoft to enable developers to build applications that run on Microsoft and other platforms. The .NET framework has two components: (i) Common Language Runtime and (ii) .NET Framework class library.

The Common Language Runtime (CLR) is the agent that manages your .NET applications at execution time. Applications that run on top of the CLR are known as managed code; all others are known as unmanaged code.

The .NET Framework class library is a comprehensive set of reusable classes that provides all the functionalities your applications needs. This library enables you to develop
applications ranging from desktop Windows applications to ASP.NET web applications, and Windows Mobile applications that run on Pocket PCs.

(i) Common Language Runtime: The Common Language Runtime (CLR) is the virtual machine in the .NET Framework. It sits on top of the Windows operating system. A .NET application is compiled into a byte code format known as MSIL (Microsoft Intermediate Language). During execution, the CLR JIT (just-in-time) compiles the byte code into the processor’s native code and executes the application. The CLR also provide services like memory management, garbage collection, thread management, exception handling, and security.

(ii) .NET Framework Class Library: The .NET Framework class library contains classes that allow you to develop the following types of applications:

- Console applications
- Windows applications
- Windows services
- ASP.NET web applications
- Web services
- Windows Communication Foundation (WCF) applications
- Windows Presentation Foundation (WPF) applications
- Windows Workflow Foundation (WF) applications

The library’s classes are organized using a hierarchy of namespaces. For example, all the classes for performing I/O operations are located in the “System.IO” namespace, and classes that manipulate regular expressions are located in the “System.Text.RegularExpressions” namespace.

The .NET Framework class library is divided into two parts

- Framework Class Library (FCL)
- Base Class Library (BCL)

The BCL is a subset of the entire class library and contains the set of classes that provide core functionalities for your applications. BCL is available to all the languages using the .NET Framework. It encapsulates all the common functions such as file handling, database access, graphics manipulation, and XML document manipulation.
The FCL is the entire class library and it provides the classes for you to develop all the different types of application listed previously [23].

Following figure shows components of .NET Framework. All the components mentioned above are shown according to their hierarchy. In the figure 3.1, the layer consisting of ADO.NET and XML deals with database. (ADO – ActiveX Data Object, and XML- Extensible Markup Language)

![Components of .NET Framework](image)

Figure 3.1: Components of .NET Framework [36]

3.2.3.2 Evolution of .NET Frameworks

Microsoft officially released the .NET Framework in January 2002. Since then, the .NET Framework has gone through a few iterations. Latest version of .NET is .NET 4.5. Since the research work is carried out with .NET 3.5, the context of discussion is kept only up to .NET 3.5.

While technically you can write .NET applications using a text editor and a compiler, it is always easier to write .NET applications using Visual Studio, the integrated development environment from Microsoft. The latest version of Visual Studio is Visual Studio 2012.

The following table 3.2 shows the various versions of the .NET Framework, their release dates, and the versions of Visual Studio that contain them [23].
### Table 3.2: Version of .NET Frameworks and Visual Studio [23]

<table>
<thead>
<tr>
<th>Version</th>
<th>Version Number</th>
<th>Release Date</th>
<th>Versions of Visual Studio Shipped</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.0.3705.0</td>
<td>2002-01-05</td>
<td>Visual Studio .NET 2002</td>
</tr>
<tr>
<td>1.1</td>
<td>1.1.4322.573</td>
<td>2003-04-01</td>
<td>Visual Studio .NET 2003</td>
</tr>
<tr>
<td>2.0</td>
<td>2.0.50727.42</td>
<td>2005-11-06</td>
<td>Visual Studio 2005</td>
</tr>
<tr>
<td>3.0</td>
<td>3.0.4506.30</td>
<td>2006-11-06</td>
<td>Shipped with Windows Vista</td>
</tr>
<tr>
<td>3.5</td>
<td>3.5.21022.8</td>
<td>2007-11-19</td>
<td>Visual Studio 2008</td>
</tr>
</tbody>
</table>

Figure 3.2 shows evolution of .NET Framework from .NET 2.0 to .NET 3.5.

![Additive Versions of .NET Framework](image)

As one can see in the figure 3.2, more services and classes are added in newer versions of .NET. When newer version comes, classes of older versions are inherited.

### 3.2.4 Server-side scripting language: C# .NET

C# is an object oriented programming language. It inherits many of the best features of C++ and Microsoft Visual Basic, but with some of the inconsistencies and anachronisms removed, resulting in a cleaner and logical language. C# also contains a variety of useful new innovations that accelerate application development, especially when used in conjunction with Microsoft Visual Studio .NET [21].

In C# .NET, the C# compiler specifically targets .NET which means that all code written in C# will always run within the .NET Framework. This has two important consequences for the C# language:
(i) The architecture and methodologies of C# reflect the underlying methodologies of .NET.

(ii) In many cases, specific language features of C# actually depend upon features of .NET, or of the .NET base classes.

One important thing to make clear is that C# is a language in its own right. Although it is designed to generate code that targets the .NET environment, it is not itself part of .NET. Some features are supported by .NET but not by C#, and some features of the C# language are not supported by .NET (for example, some instances of operator overloading) [20].

3.2.5 Back-End: SQLEXPRESS

SQL Server is a database product from Microsoft. It offers an excellent mix of performance, reliability, ease of administration, and new architectural options, yet enables the developer or DBA to control minute details when desired [22].

SQLEXPRESS is inbuilt database provided with Visual Studio 2008. It provides all the non commercial features of SQL Server. It is very useful for students and non commercial users of database.

Since in the research work carried out, currently there is no requirement of large database, SQLEXPRESS is sufficient.

3.2.6 Other Technologies: AForge.NET Framework

AForge.NET is an open source C# framework designed for developers and researchers in the fields of Computer Vision and Artificial Intelligence - image processing, neural networks, genetic algorithms, fuzzy logic, machine learning, robotics, etc.

The framework is comprised by the set of libraries and sample applications, which demonstrate their features:

- AForge.Imaging - library with image processing routines and filters;
- AForge.Vision - computer vision library;
- AForge.Video - set of libraries for video processing;
- AForge.Neuro - neural networks computation library;
- AForge.Genetic - evolution programming library;
- AForge.Fuzzy - fuzzy computations library;
- AForge.Robotics - library providing support of some robotics kits;
- AForge.MachineLearning - machine learning library;
- etc.
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The work on the framework's improvement is in constants progress, what means that new feature and namespaces are coming constantly [27]. The latest version is 2.2.5.

This framework is very useful in the field of digital image processing, by means of its library files and filters.

“AForge.Imaging”, which is the biggest library of the framework so far, contains different image processing routines, which are aimed to help as in image enhancement/processing, as in some computer vision tasks [27]:

- Linear color correction filters (RGB/HSL/YCbCr correction, brightness/contrast/saturation correction);
- Nonlinear color correction filters (contrast stretch, histogram equalization, color remapping, gamma correction);
- Image re-coloring filters (grayscale, sepia, hue modifier, rotate channels, invert);
- Pixel filtering by color (RGB, HSL, YCbCr color spaces);
- Color channels manipulations (RGB and YCbCr color spaces);
- Color reduction (including color dithering);
- Binarization filters (threshold, threshold with carry, ordered dithering, Bayer dithering, Floyd-Steinberg dithering, Burkes dithering, Jarvis-Judice-Ninke dithering, Sierra dithering, Stucki dithering);
- Adaptive binarization (simple image statistics, iterative thresholding, Otsu thresholding);
- Adaptive local thresholding;
- Convolution filters (mean, blur, sharpen, edges, Gaussian blur, custom convolution filters);
- Mathematical morphology filters (erosion, dilatation, opening, closing, top hat, bottom hat, hit-and-miss);
- Edge detectors (homogeneity, difference, sobel, canny);
- 2 source filters (merge, intersect, add, subtract, difference, move towards, morph, thresholded difference, thresholded euclidean difference);
- Blobs processing (counting, extraction, filtering, connected component labeling);
- Filling holes in binary images;
- Corner detectors (Moravec, Susan);
- Quadrilateral transformation and corners' finding;
- Resize and rotation (nearest neighbor, bilinear, bicubic);
- Transformation to/from polar coordinates;
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- Hough transformation (line and circle transformations);
- Exhaustive template and block matching;
- Image color statistics (RGB, HSL, YCbCr) and vertical/horizontal statistics (RGB);
- Smoothing filters (Median, Mean, Conservative Smoothing, Adaptive Smoothing, Bilateral);
- Texture generators (clouds, marble, wood, labyrinth, textile);
- Texture filters (texturing, merging, filtering);
- More effects, like pixelating, jittering, oil painting, water wave, image warping, etc;
- Noise generators (additive, salt-and-papper);
- Document skew checker for checking rotation of scanned documents;
- Stereo anaglyph image creating;
- Flood fill filters (using specified color or calculate mean color of the area);
- Flat Field Illumination correction, Simple skeletonization, Shrink, Canvas crop/fill/move, mirroring, Bayer filter, mask/masked filter;
- Fourier transformation (low-pass and hi-pass filters);
- Some image decoders for custom image formats (PNM, FITS);
- etc.

The usage of library files and filters is demonstrated in document where and when needed.

3.2.7 Hardware: Flat Bed Scanner (HP ScanJet 4670)

Scanning is a process of converting any picture data in paper, to a digital image. Apart from photographs, scanners can also be used to digitize texts in paper, which can then be converted to any format. Several types of scanners are available in the market to suit the needs of different applications. These include [19]:

(i) Sheet-fed scanners
(ii) Flat bed scanners
(iii) Hand Held scanners

Though these equipments look so different from one another, the basic principle behind them remains very much the same. A scanner head is used to read the image data with the help of light beams and the reflections are recovered by a series of light sensitive diode crystals that ultimately transmit the corresponding digital information to the system – in form of electrical signals [19].
Figure 3.3 shows working principle of flat bed scanner [26].

![Flat Bed Scanner Diagram](image)

**Figure 3.3: Working Principle of Flat Bed Scanner [26]**

At the start of scanning process, a powerful light source illuminates the paper containing the picture data – placed upside down. The idea is that the blank or white spaces will reflect more light, when exposed, than inked or colored dots.

The scanning head is located right below the glass plate. When a scanning process is initiated using the scanning application, a motor moves the scanner head on the other side of the plate, slowly from bottom to top. The scanner head, capable of sensing the light that is bounced off from the various portions of the paper, transmits the data through a series of mirrors to a light sensitive diode matrix system.

These diodes react to the exposure of light, by transmitting electric currents proportional to the intensity of light falling on them. These electric signal are converted to digital data, by digitization processed mentioned in chapter 1 [19].

### 3.3 Summary

This chapter gives overview of the study of the technologies used to design and develop the decision support system for healthcare. It introduces windows 7 operating system, Visual Studio 2008, ASP.NET 3.5, C#.NET, SQLEXPRESS, and flat bed scanner. The main purpose of this chapter is to introduce the reader of this document to the above mentioned technologies.