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SOFTWARE ARCHITECTURE AND DEVELOPMENT PLAN FOR HOTEL MANAGEMNET SYSTEM

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ABSTRACT

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In today's engineering world there are standards to be followed when introducing a new system. A system development lifecycle is a structured process consisting different steps which enables developers to achieve the desired product with minimum risk, cost, and time. A software must go through different phases in its lifecycle development such as analysis, design, coding, testing, deployment, and maintenance.

This thesis aims at exploring the design phase of software development by using a sample web-based hotel management system. The project discusses observed hotel management problems in developing countries and suggests a solution with detailed description of desired customer and management approach. It also presents the suggested system architecture components and their relationship using different UML diagrams.

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ABSTRACT

Key words
Hotel Management, Requirement Analysis, Software Architecture, System Design, Threat Modelling, UML.

CONCEPT DEFINITIONS

DDOS	Distributed Denial of Service
HCM	Hybrid connection manager
OOD	Object Oriented Design
SDLC	System Development Life Cycle
SQL	Structured Query Language
STRIDE	Spoofing Tampering Repudiation Information disclosure DOS Elevation of privilege
UML	Unified Modelling Language

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ABSTRACT
CONCEPT DEFINITIONS
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1 INTRODUCTION

Hotel management is one of the business sectors that shows constant progressions in use of technologies. This process of evolving includes computerized room reservation and hotel resource management. There are also few head turning advancements with self-check-ins, self-checkouts, and mobile room key accesses. As there are always front and back runners in a race, the are also hotels in developing countries who still uses time consuming paper-based employee and hotel service management system. In such hotels, making reservation is hard since customer does not know the existence of the hotels, except locals. Even if their existence is known, one has to make a phone call or contact local travel agents to make room reservations. The hotel management system designed in this paper delivers basic services of providing hotel information, allow users to reserve and cancel rooms, process reservation payments online through hotel website. It also provides organized hotel room and employee management system.

This paper covers the design and analysis phase of the life-cycle development plan of the desired web-based hotel management system architecture. Software development life cycle (SDLC) is a structured approach that software engineers has to follow when developing a new system. This approach has five common steps, analysis, design, coding, and deployment phases.

The analysis phase of the system development plan is the phase where the behavioral and functional features of the system are identified. It answers the questions like ‘what the system does?’, ‘who are the primary users?’ and ‘what is its functional capacity?’. This is achieved by classifying and identifying system specifications as functional and non-functional system requirements. Functional requirements determine the basic features of the system that indicate what input it takes, how it processes it and what outputs it gives. The non-functional requirements define the quality attributes of the system including performance, security, and other system capabilities.

The system design is the phase where developers try to address the system requirements identified in the analysis phase of the development plan. It starts by understanding how the system works to achieve the desired system functionality. This is done by using Unified Modeling Language (UML) diagrams which visualizes the components of the system architecture. Since there are so many UML diagrams with different purposes, only few and the basics are used for this project.

This work also includes threat modeling of the system which has become the essential part of system design as data is always required to be in movement. This section identifies potential threats that could lead to loss of confidentiality, integrity, and availability of the system. This is done by decomposing the system into components, sampling out possible threats and suggesting prevention techniques.

Generally, the project explores all the behavioral and structural features of a web-based hotel management system which is believed to provide organized and time saving compare with existing system in lower standard hotels in developing countries. It also describes the two phases of system development plan namely system analysis and design. The thesis also contains sample interface designs targeting different users of the system.

2 PROBLEM IDENTIFICATION AND SYSTEM DESCRIPTION

In today's world tourism and hospitality have a great impact on countries' economic growth (Tourism Review 2019). Many developed countries have understood this impact and gives the industry the necessary attention. This can be proven by the advanced hotel management systems which includes electronic self-room reservation and self-check-in kiosks. On the other hand, in developing countries like Ethiopia only few hotels which are bigger and high service standard have advanced room booking and management system. There are many medium and small sized hotels which are located in key tourism areas that provide only hotel room services without restaurant and bars included in them. These hotels encounter problems to connect with international customers and lack of efficient system to manage rooms and staff members which results in poor service quality.

In the existing systems customers/travel agents are required to book hotel room through phone call or personal visit. The hotels also have paper based or outdated data management system. This disrupts staff coordination and smooth flow of the service, costing the hotels valuable time, money, and customer satisfaction. It also can lead to high risk towards confidential data loss.

The system suggested in this paper solves most of these problem by providing web-based room reservation system and employee/room management. Since websites are the main platforms to search and find hotel services, the web-based room reservation system provides the hotels with global reach and customers with suitable information and effortless service. The system also enables the hotels to achieve organized and smooth employee and room management by using applications that allows better data storage with reduced data redundancy, secure information access and efficient updates.

3 SYSTEM ARCHTICTURE ANALYSIS

3.1 Introduction to Software Architecture

System architectures have two major components, hardware, and software. The hardware component includes client computers, servers and network that connects the two. In the hardware architecture the client computers are responsible for displaying information and passing commands, in another word, as an input and output medium of the system whereas the server process and stores data. This relationship is defined in the server-client architecture of the system. (Dennis, Wixom & Roth 2012.)

Software architecture is an abstraction of the software component of a system that describes the behaviour of the system and how its elements communicate with each other. It provides different architectural views to different audiences such as architects, programmers, evaluators, configuration managers and customers. This divisions provides detailed descriptions such as the functionality of the system (user interface), how the components connect to each other and work together, non-visible/non-functional features of the system, how the development should be managed and how the software is implemented on the hardware infrastructure. Software architecture is shaped based on the most important requirements of the system. These requirements are classified as functional and non-functional requirements. (Hanmer 2013, 11.)

3.2 System Requirement Analysis

System requirement analysis is a structured approach of identifying expected features and resources that are needed to achieve the desired product. The requirement analysis in software architecture helps to simplify the modelling and coding phase of system development. Requirements needs to be gathered and analysed before documentation in order to study and understand the practicality of the product to be developed. Using properly analysed system requirements to develop a product helps software engineers not only to meet customer satisfaction but also achieve system security. (Dennis, Wixom & Roth 2012; Software testing help 2020.)

3.2.1 Non-Functional Requirement Analysis

Non-functional requirement of a system explores the qualities of the system. These requirements help developers to set restrictions on the design and specify scope of the system based on performance, response time, security, memory capacity and many more other non-functional aspects. There are four major categories of non-functional requirements, operational requirements, performance requirements, security requirements and cultural and political requirements. (Dennis, Wixom & Roth 2012.)

Operational requirements help identify the operating environment that is needed for the system to achieve its functional target and specifies how it interacts with other systems. These requirements include hardware and software specifications according to the operating system software, database system software and network system needed for the product to perform. It also specifies what other systems needs to be integrated with the system and how they can interoperate with each other. Operational requirements should also identify conditions in which the system can be maintained in the constantly changing technology sector. This indicates how the system should be able to adapt to operational environment changes and be modified to advanced versions. (Dennis, Wixom & Roth 2012.)

Performance requirements specifies how well the system performs under given environment and timeline. These mainly identifies response time, capacity, availability, and scalability of the system. Response time specifies how long the system should take to perform a specific task considering development costs and user expectations. Capacity requirement analyses the system's ability as how many operations can it handle requested by thousands of users simultaneously. Performance requirements also comprises availability which specifies the ability of the system to provide its functions whenever it is requested whereas scalability specifies the system's capacity to adjust performance according to changes in application demand. (Dennis, Wixom & Roth 2012.)

System security requirements are very essential in today's world where there is fast rise of risks against valuable information protection. These requirements enable developers to maintain the confidentiality, integrity and availability of data that is exchanged throughout the system. This can be achieved for example by identifying role-based access control measure, authentication and authorization requirements, encryption requirements and virus protection measures. (Dennis, Wixom & Roth 2012.)

Different countries have different standards and policies to be followed when it comes to system developments. This includes legal requirements imposed by local governments regarding system infrastructure and security. This standards and regulations can be addressed by carefully analysing cultural and political requirements. These requirements also include language specification which identifies what and how many languages the system should support considering targeted local and international users. There are also unstated norms that a developer has to consider during development and implementation of the system such as date and time inputs. (Dennis, Wixom & Roth 2012.)

The Table below (TABLE 1) includes lists of non-functional requirements of the hotel management system to be designed. The requirements are grouped into the four categories discussed above.

TABLE 1. Non-functional requirements of the hotel management system

Type of Requirement	Specification
Operational Requirements	• The system should be able to work on Internet Explorer, Google Chrome, Safari, Opera, Mozilla Firefox, Microsoft Edge, and other web browsers. • The system should be able to fully function on smart phones and mobile devices • On-premises devices should always have internet connection to allow real-time database updates • The system should be able to operate on different operating systems including every generation of Microsoft Windows, Mac, and Linux. • The system should be able to connect with online payment methods including PayPal and TransferWise. • The system should be able to support maintenance within two weeks of notice.
Performance Requirements	• Response time for visible pages for customers should be less than 5 seconds excluding online payment transactions. • Response time for visible staff members should be less than 10 seconds excluding payment transactions.

	• The system should be able to support 500,000 customers in total. • The system should be able to support a maximum of 1000 customers simultaneously in peak hours. • The system server should be able to handle 1000 requests per second. • The website should be able to generate 5000 daily customer interactions. • The system should be able to run all times except schedule updates and maintenances. • Maintenance should not exceed a maximum of 8 hours in a day and 16 hours in a month.
Security Requirements	• Customers can only view room availability, book room, cancel room and pay for room reservation through secured payment method. • Front desk can only view hotel room status, update room occupation status, update check in and check outs and process payment through cash register. • Housekeeping manger can edit room cleaning status, update housekeeping shifts and update minibar use. • Housekeeper can edit room cleaning status and update minibar use. • General manager should be able to view and edit all tasks that can be accessed by staff members, can view and update employee information, view and update staff work shifts. • Data transaction from customer to the system through websites will be encrypted. • The system should ask staff members to authenticate themselves using employee Id and password before they are granted any access.

	• Passwords of every stuff member should be updated every one year • All on-premises devices should be equipped with strong antivirus software. • All security measure should be updated 3 every month
Cultural and Political Requirements	• The system should be able to support Amharic and English languages • Currency should be stated in the system as (United States dollar) USD and ETB (Ethiopian birr). • Date input in the system should follow date month and year format (DD.MM.YYY).

3.2.2 Functional Requirements Analysis

The functional requirement analysis in software design is essential in determining the functionality and behaviour of the system to be developed by specifying how the system interact with the user, what input it should be able to take and what tasks it should be able to perform successfully (Dennis, Wixom & Roth 2012). In the hotel management system, there are different users with different roles that the system should interact accordingly. These users are the customers and stuff members. The functional requirements of the system in each user category are listed in the table (TABLE 2) below.

TABLE 2. Functional requirements of the hotel management system

User category	Specifications
Customer	• The system should display room availability and price • The system should enable user to input personal information • The system should direct user to secure payment method • The system should send notification to confirm room reservation.

	• The system should enable users to cancel room reservation.
Stuff member	• The system should have Authentication page with username password. • System should have 'forgot password' option on the authentication page that sends a link to verified email or phone number to set different password. • The system should enable user to view, edit and add employee information. • The system should enable user to view and edit room occupation status • The system should enable user to view and edit room cleaning status including minbar usage. • The system should enable user to process payment using cash register machine.

3.3 Server-Client Architecture

A hotel system network has three components, the clients, server, and the network connection in between. There are three kinds of system architecture based on the role of server and client computers, sever based, client based and sever-client architecture. In server-based architecture the server performs all the functions of the system such as data storage, data access logic (database queries) and application logic (operating system, application software and webpages). The client computers are used only as input and output medium. This kind of architecture is easy to manage and secure since there is no software application on client computers. (Dennis, Wixom & Roth 2012.)

In client-based architecture client computers are responsible for the data access logic, application logic and presentation logic (input-output device) whereas the server is used just to store data. This architecture is applicable when the client computers and the server are connected using local area network. In client-based architecture the data is more vulnerable to threats as it always has to be transferred and processed in client computers. (Dennis, Wixom & Roth 2012.)

Server-Client architecture defines a system network in which centralized server is used to provide resources and services to many clients using remote devices. In this architecture the server is responsible for data storage, data access logic and application logic. The client computers serve as presentation logic and also shares responsibility with the server on the application logic. This architecture type is best suited to the hotel management system due to its scalability (can be easily enhanced in capacity when demand increases), better response time during workover load, availability of development tools and lower cost. (Dennis, Wixom & Roth 2012.)

The hotel management system in this paper is going to use recent generation of windows server hybrid with Microsoft Azure SQL service. This gives high availability, scalability, and global reach to the designed system. The hybrid also enables owners to set strong security measures as desired or comply with legal requirements. (Azure Fundamentals.) cf. (Microsoft 2020).

In this architecture (Figure 1) there is Windows server application on-premises which runs room and employee management applications shared with client computers used by staff members. The system will use Windows SQL and Windows Web server provided by Microsoft Azure. There will be a hybrid connection manger on the premises which calls out and connects with the Hybrid relay on behalf of on-premises applications. The Azure connection relay securely connects the Microsoft Azure resources and services to applications with on-premises applications.

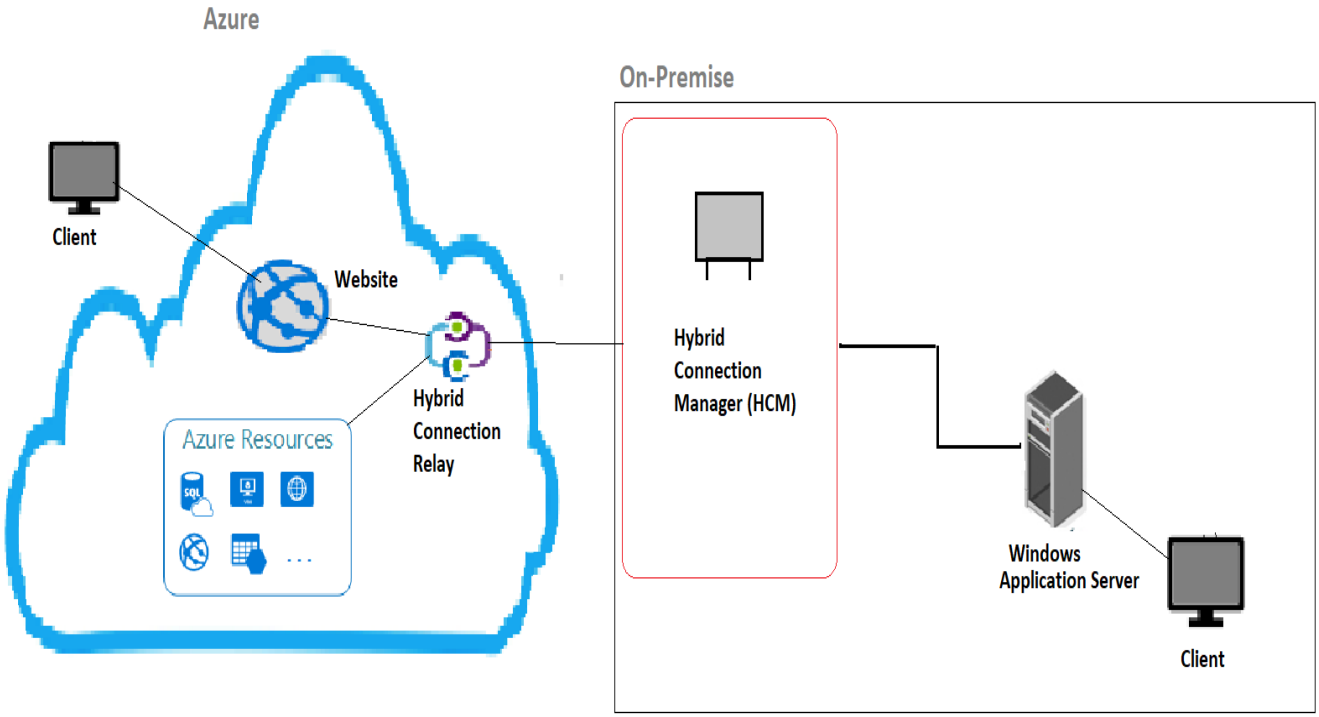

FIGURE 1. Hybrid Server-Client Architecture of the Hotel management system

4 SYSTEM ARCHITECTURE DESIGN

The architecture design phase of the system development process is a phase in which system developers determine the components, interface and the data that goes through the system. Subsystems of the architecture will also be identified together with the dependencies between them. This is possible by using visual modeling of the components and the subsystems. The modern system modeling to be used in this thesis is the UML (unified modeling language). It is a standard system modeling language which is used to specify, document, and develop complex systems using set of diagrams. (Lano 2005.)

Diagrams in UML are divided into two categories, behavioral and structural diagrams, according to the emphasis they give to different aspects of the system to be developed. The behavioral diagrams visualize the dynamic behavioral aspects of components of the system. This includes use case, activity, state, and sequence diagrams. Structural UML diagrams are those that visualizes the static aspects of objects of the system and how they relate with each other. These diagrams describe the main structural elements of the system which are stable with time unlike behavioral UML diagrams in which the elements display series of changes with time. Structural diagrams include class, component, and deployment diagrams. There are more than 13 UML diagrams that falls up on the two categories but only few are included in this paper which are believed to best describe the hotel management system to be designed. (Otero 2012, Chapter 2.)

4.1 Use Cases Diagram

Use case diagrams are behavioural diagrams that visualizes the interaction between actors and the system. Actors, can be users or other systems, are entities that control the functionality of the system. Use cases diagram provides a simplifies view of what the system does by identifying system functionalities and how they interact with internal and external actors. In the hotel management system there are five actors, the general manager, housekeeping manager, housekeeping, front desk(reception) and customer, which have different roles that the system responds to accordingly. (Otero 2012, Chapter 2.)

The use case diagram for the system is presented on FIGURE 2 below.

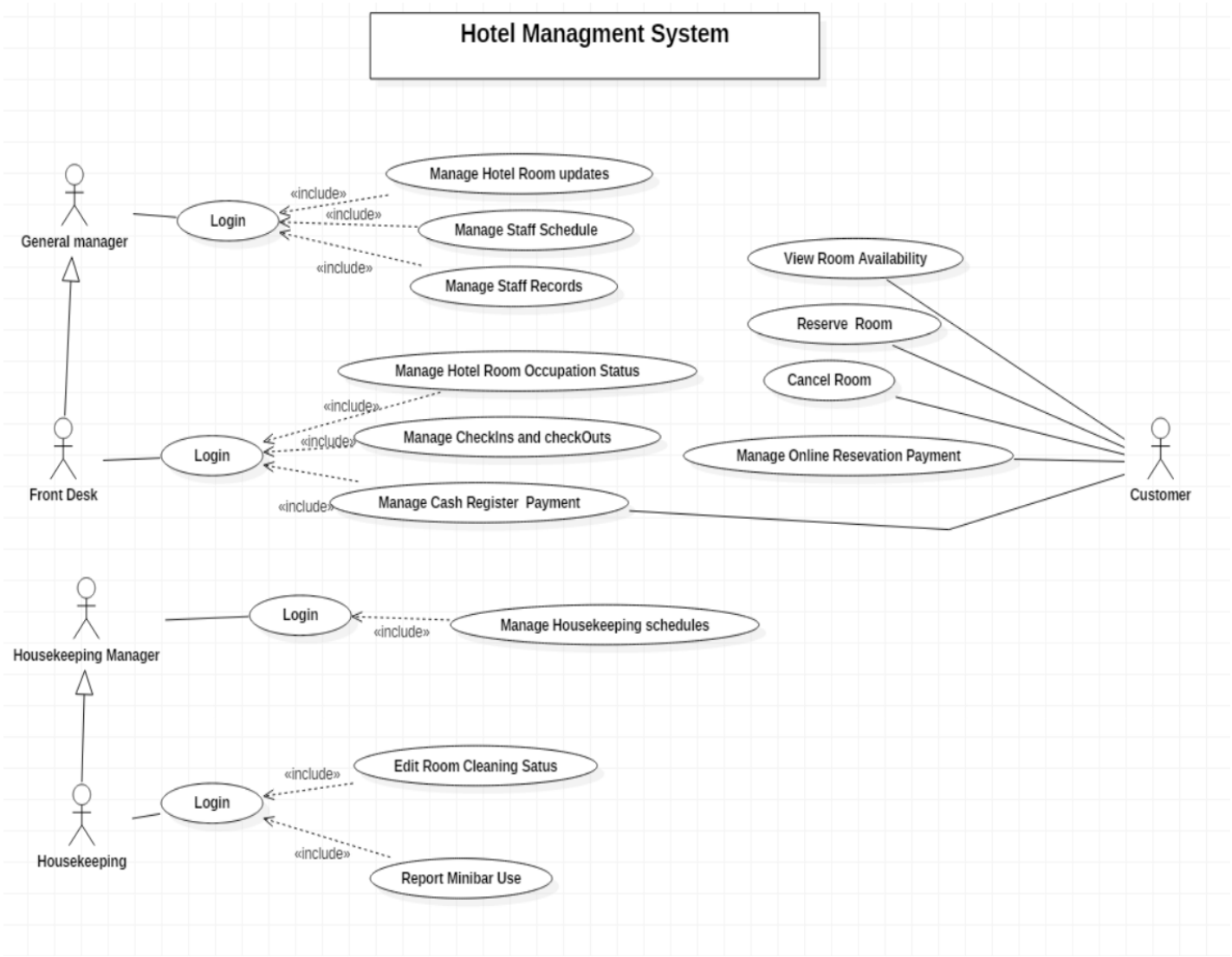

FIGURE 2. Use case diagram for hotel management system.

A use case diagram can be supported by a case description for more understanding. This description can provide more detailed information which are not included in the diagram due to simplicity and readability demands. TABLE 3 includes use case description of the hotel management system.

TABLE 3. Use case description for hotel management system

Use Case 01	Manage Hotel Room Updates
Actor	General manager
Description	The system enables the general manager to view, add, and edit hotel room information.

Pre-condition	The general manager should open hotel management system and login to the system.
Post-condition	Undefined
Basic flow	1. The user login to the system. 2. The user selects Manage Hotel Room option. 3. The system displays list of rooms available in the hotel that are sorted according to their size and price. 4. The system displays add room, remove room, edit room, and view room information (including price, room size, bed, accessories, occupation status) options.
Alternative Flow	
Assumptions	
Exceptions	
Use Case 02	Manage Staff Schedule
Actor	General manager
Description	The system enables the general manager to view and update staff work schedule.
Pre-condition	The general manager should open hotel management system and login to the system.
Post-condition	Undefined
Basic flow	1. The user login to the system. 2. The user selects Manage Staff Schedule option. 3. The system displays date (current date as default), list of department schedules (housekeeping and reception) and create new schedule options. 4. The user selects date and department schedule from the options. 5. The system opens Microsoft excel and displays list of people and shifts hours for the specific day. 6. The system enables the user to view, edit, save, print, and send staff schedule.
Alternative Flow	1. The user login to the system. 2. The user selects Manage Staff Schedule option.

	3. The system displays date (current date as default) list of department schedules (housekeeping and reception). 4. The user chooses Create New Schedule option. 5. The system opens Microsoft excel.
Assumptions	
Exceptions	If the user chooses past dates on the Manage Staff Schedule screen, the system will only allow the user to view, print and send the selected schedule option.
Use Case 03	Manage Staff Records
Actor	General manager
Description	The system enables the user to view and update hotel employee records.
Pre-condition	The user should open hotel management system and login to the system.
Post-condition	Undefined
Basic flow	1. The user login to the system. 2. The user selects Manage Staff Records option. 3. The system opens excel and displays list of employee records. 4. The system provides view, add, edit, and save options to the user.
Alternative Flow	
Assumptions	
Exceptions	
Use Case 04	Manage Hotel Room Occupation Status
Actor	Front desk
Description	The system enables the receptionist to check room availability, room cleaning status and room booking status.
Pre-condition	The user should open the hotel management system on company computer and login.
Post-condition	undefined
Basic flow	1. The user login to the system. 2. The user selects Manage Hotel Room Occupation Status option

	3. The system displays list of rooms with cleaning status (ready/ cleaning), occupation status (vacant/booked/occupied), check-in and check-out options. 4. The user clicks on drop down menu on occupation status for a specific room. 5. The system displays list of status options, vacant, booked and occupied. 6. User selects options according to customer check-in and check-out requests.
Alternative Flow	
Assumptions	
Exceptions	
Use Case 05	Manage Check-Ins and Check-Outs
Actor	Front desk
Description	The system enables the user to process check-ins by inputting customer information and check-outs by processing payments.
Pre-condition	The user should open the hotel management system on company computer and login.
Post-condition	
Basic flow	1. The user login to the system. 2. The user selects Manage Hotel Room Occupation Status option 3. The system displays list of rooms with cleaning status (ready/ cleaning), occupation status (vacant/booked/occupied), check-in and check-out options. 4. The user clicks on Check-in or Check-out option on the room requested. 5. If (Check-in): - the system displays a page where the user can inter customer information. If (Check-out): - the system directs user to room usage cost summery and then to cash registry payment processing page.
Alternative Flow	
Assumptions	

Exceptions	
Use Case 06	Manage Cash Register Payment
Actor	Front desk / Customer
Description	The system enables the front desk to process check out payments using Cash registry method. The customer plays a role by inserting card and inputting card pin code.
Pre-condition	The user should open the hotel management system on company computer and login.
Post-condition	The system prints out receipt.
Basic flow	1. The user login to the system. 2. The user selects Manage Hotel Room Occupation Status option 3. The system displays list of rooms with cleaning status (ready/ cleaning), occupation status (vacant/booked/occupied), check-in and check-out options. 4. The user Check-out option on the room requested. 5. The system opens cost summary page (days stayed * room price + additional services) and displays Edit, Discard, and Continue options. 6. The user chooses Continue. 7. The system directs to payment page that allows card or cash payment. 8. The customer inserts card and input pin. 9. The system accepts payment and print receipt.
Alternative Flow	If customer pays in cash, the receptionist must confirm payment on the system manually.
Assumptions	
Exceptions	If the system rejects card payment, the system provides Try Again option. The customer then removes and insert card again and input pin code.
Use Case 07	Manage Housekeeping Schedule
Actor	Housekeeping manager
Description	The system enables the user to view and update housekeeping staff weekly schedule.

Pre-condition	The user should open the hotel management system on company computer and login.
Post-condition	
Basic flow	1. The user login to the system. 2. The user selects Manage Housekeeping Schedule option. 3. The system displays Date, Room Cleaning Status, Housekeeping Schedule, and Create New Schedule options. 4. The user selects date and Housekeeping schedule from the options. 5. The system opens Microsoft excel and displays list of people and shifts hours for the specific day. 6. The user can view, edit, save, print, and send schedule for the specific day.
Alternative Flow	If the user selects Create New Schedule option, the system open Microsoft excel.
Assumptions	
Exceptions	
Use Case 08	Edit Room Cleaning Status
Actor	Housekeeping
Description	The system enables the user to view and update room cleaning status.
Pre-condition	The user should open the hotel management system on company tablet and login.
Post-condition	Room cleaning status will be set to ready for booking and check-in.
Basic flow	1. The user login to the system. 2. The system displays list of assigned rooms, room cleaning status (ready/cleaning), occupation status (vacant/occupied) and minibar report. 3. The user clicks on drop down menu on the cleaning status section of the cleaned room and selects the option Ready.
Alternative Flow	
Assumptions	The Housekeeper can only edit room cleaning status and minibar report.
Exceptions	

Use Case 09	Report Minibar Use
Actor	Housekeeping
Description	The system enables the user to report items used from the minbar that is found in the room.
Pre-condition	The user should open the hotel management system on company tablet and login.
Post-condition	The system sends list of items used and their price to the cost calculating software.
Basic flow	1. The user login to the system. 2. The system displays list of assigned rooms, room cleaning status (ready/cleaning), occupation status (vacant/occupied) and minibar use report. 3. The user clicks on minibar use option corresponding with the desired room. 4. The system displays list of items available in the minibar, their price, number of items used (with drop down menu that includes number of items) and check box in a table format. 5. The user can click on the check box of items that are used and select the number of items from the dropdown menu. 6. The user clicks on save.
Alternative Flow	
Assumptions	The Housekeeper can only edit room cleaning status and minibar report.
Exceptions	
Use Case 10	View Room Availability
Actor	Customer
Description	The system provides information on the type of rooms, price, and availability on requested dates. The system also enables user to easily search room availability by entering desired date and room type.
Pre-condition	The user opens the hotel website on personal computer or mobile device.
Post-condition	Room type, price and picture displayed.
Basic flow	1. The opens the hotel website and clicks on Find Room.

	2. The system displays list of available rooms, price, and search option. The search option has two input fields, Room type and Date (starting and ending period). 3. The user inputs room type and the time length desired to stay in the room on the search field and clicks search. 4. The system displays available requested room types, their price and picture with Book Now option under them.
Alternative Flow	
Assumptions	
Exceptions	The system displays 'No Available [room type searched] Rooms at the Moment', if the system could not find results that match with the search criteria.
Use Case 11	Reserve Room
Actor	Customer
Description	The system provides information about available rooms and allows user to book desired room.
Pre-condition	The user opens the hotel website on personal computer or mobile device.
Post-condition	The system sends booking confirmation to user email address.
Basic flow	1. The opens the hotel website and clicks on Find Room. 2. The system displays list of available rooms with Book now option. 3. The user clicks on Book now. 4. The system directs to a page where the user can enter all necessary personal information (full name, Id number, phone number and email address) and process online booking payment through secure payment methods including PayPal and TransferWise. 5. The system sends confirmation email.
Alternative Flow	
Assumptions	
Exceptions	
Use Case 12	Cancel Room Reservation
Actor	Customer

Description	The system provides information reserved rooms and allows users to cancel unwanted reservations.
Pre-condition	The user opens the hotel website on personal computer or mobile device.
Post-condition	The system sends confirmation email for reservation canceling with refund information.
Basic flow	1. The opens the hotel website and clicks on Find Reservation. 2. The system displays a login box with text fields to enter reservation number and email address. 3. The user inputs reservation number (from confirmation email) and email address and press login. 4. The system directs to a page with reserved room information and Cancel Reservation option.
Alternative Flow	
Assumptions	
Exceptions	
Use Case 13	Manage Online reservation Payment
Actor	Customer
Description	The system enables user to process booking payment using secure online payment methods.
Pre-condition	The user opens the hotel website on personal computer or mobile device. The user chooses the best suited room from available rooms list. The user inputs all necessary information for room reservation
Post-condition	User receives payment confirmation together with room confirmation email.
Basic flow	1. The user selects 'Continue to payment' option after filling reservation information. 2. The system directs user to a page where the user selects suitable payment method from the available options. 3. The system direct to the chosen payment method. 4. User inputs requested payment credentials and confirm payment.
Alternative Flow	
Assumptions	

Exceptions	

4.2 Activity Diagram

Activity diagram is a behavioural diagram that shows dynamic aspects of a system. It describes the flow of the system from an initial system triggering act of a user to decision making steps and system outputs. The diagrams below visualize the workflow of the hotel management system for room reservation (FIGURE 3) and daily system use for hotel stuff members (FIGURE 4). (Gennick 2003.)

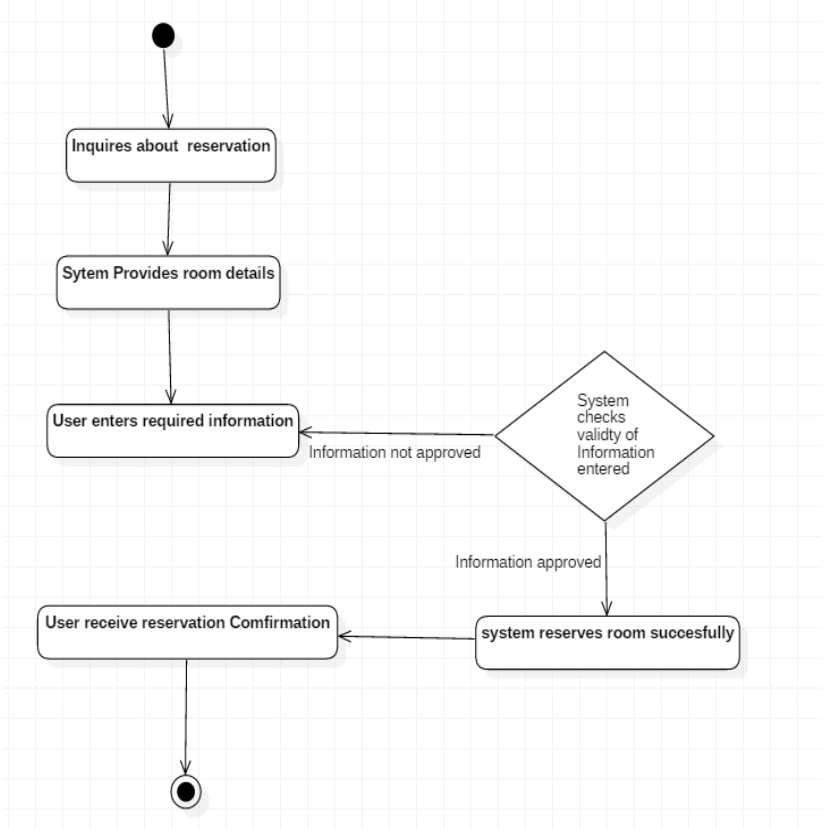

FIGURE 3. Activity Diagram for room reservation (customer).

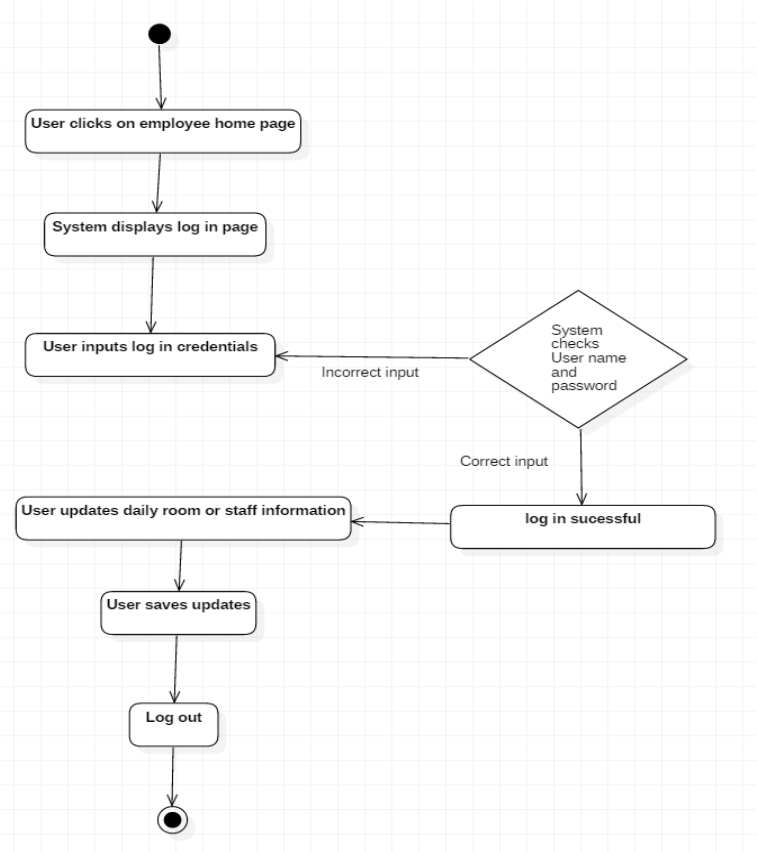

FIGURE 4. Activity Diagram for hotel employees and management.

4.3 Sequence Diagram

Sequence diagrams shows the interaction of components of a system in sequence of time. In this diagrams time is indicated in the vertical axis, while system objects are aligned on the horizontal axis. It also visualizes the order of execution of messages and decisions in the architecture of the system to be designed. The sequence diagram (FIGURE 5) below describes the process of setting room status, room booking, check-ins and check-out in order of time. It also shows which objects of the system are responsible for certain actions. (Gennick, 2003.)

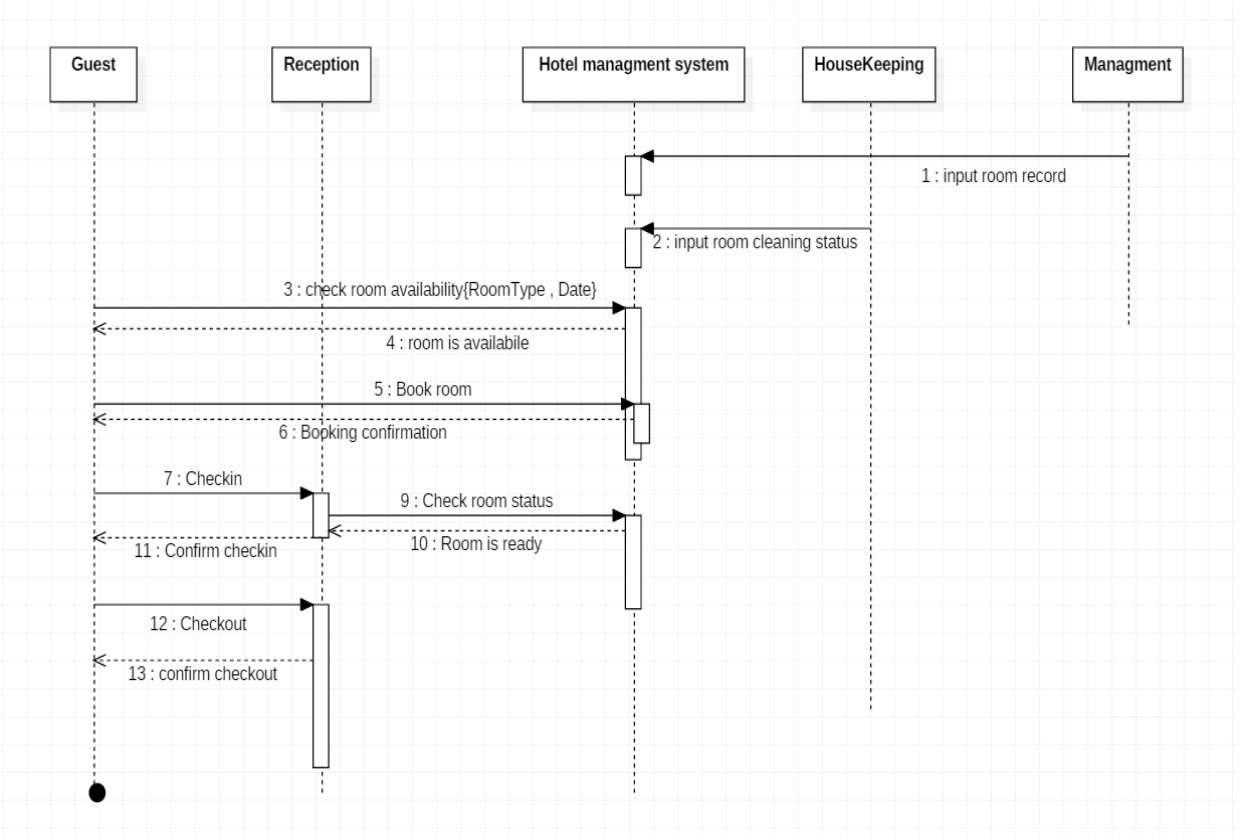

FIGURE 5. Sequence diagram for hotel management

4.4 Class Diagram

Class diagrams are structural diagrams which visualize classes of a system and their relationship. Class is an object that have its own characteristics which are represented by attributes, what data the class contains, and operation which describes what the class does. The diagram contains rectangles with three compartments for class, attribute (with value type next to them in bracket) and operations (also with value type) respectively from top to bottom. These classes are also connected to each other showing the relationship between them. Class diagrams can also be used to generate executable code of the system. The diagram (FIGURE 6.) below explains the classes of the hotel management system and their relationship. (Gennick, 2003.)

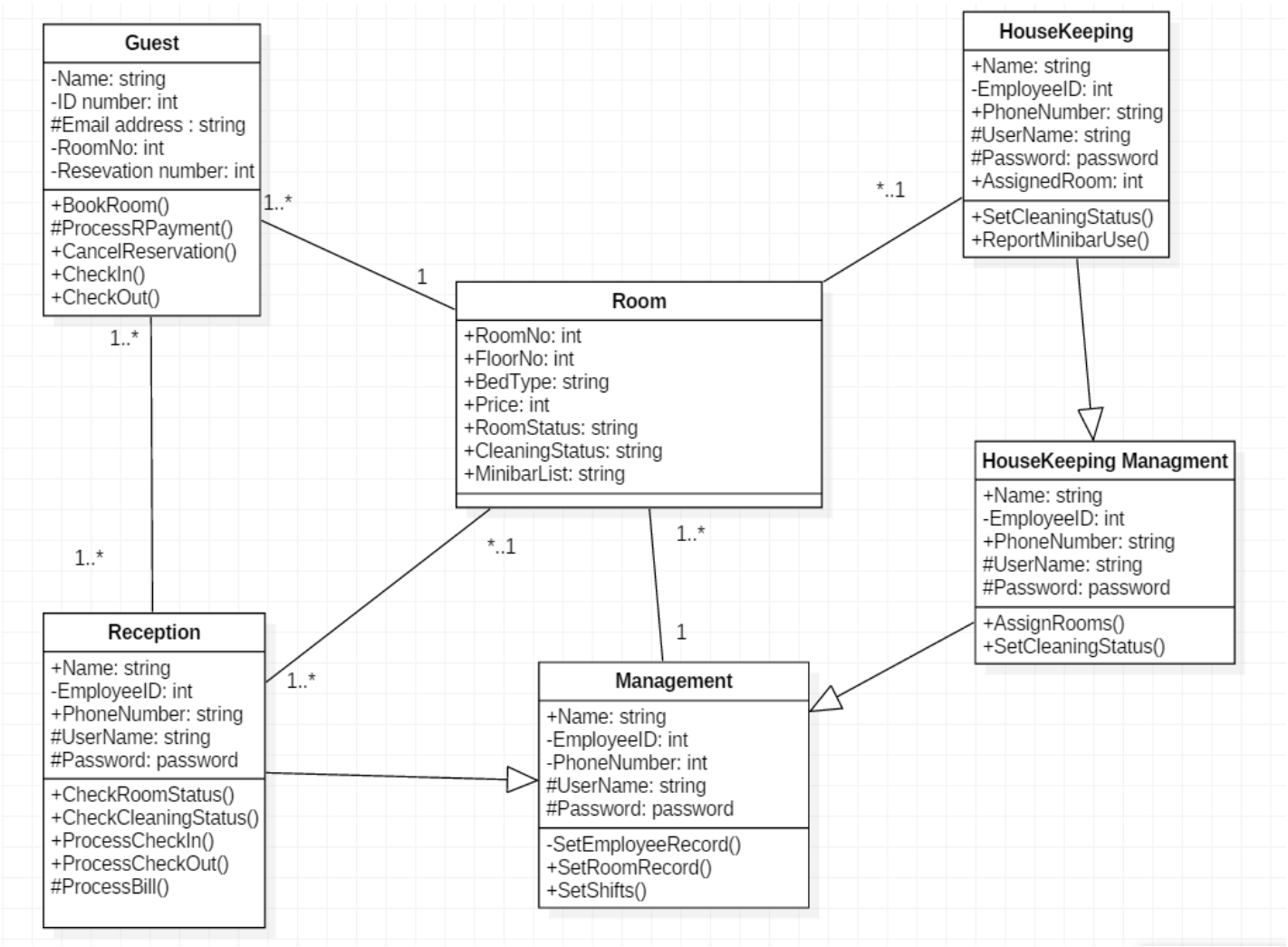

FIGURE 6. Class diagram for hotel management system.

4.5 User Interface Design

User Interface is the visual structure of a system that interacts with users and external systems. It mainly contains navigation fields, input mechanisms and output fields. User interfaces should be attractive, simple, and informative on how to use them. The hotel management system has different users which it interacts differently. Hotel employees can access the system using software installed on company devices. Staff members also interact with different user interfaces according to their role-based access limit. This is explained in the home page user interfaces found below (FIGURE 7 for management, FIGURE 8 for Front desk and FIGURE 9 for Housekeeping department). Customers can access the system though website which have the format explained on FIGURE 10. (Dennis, Wixom & Roth 2012.)

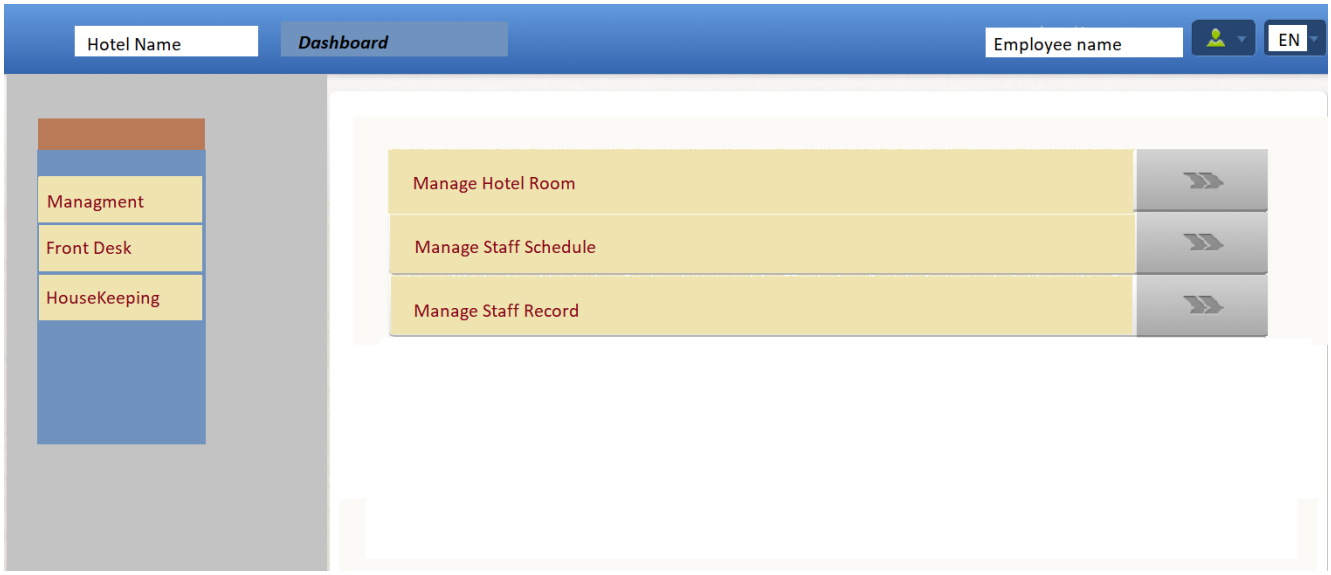

FIGURE 7. Home page User interface for Management

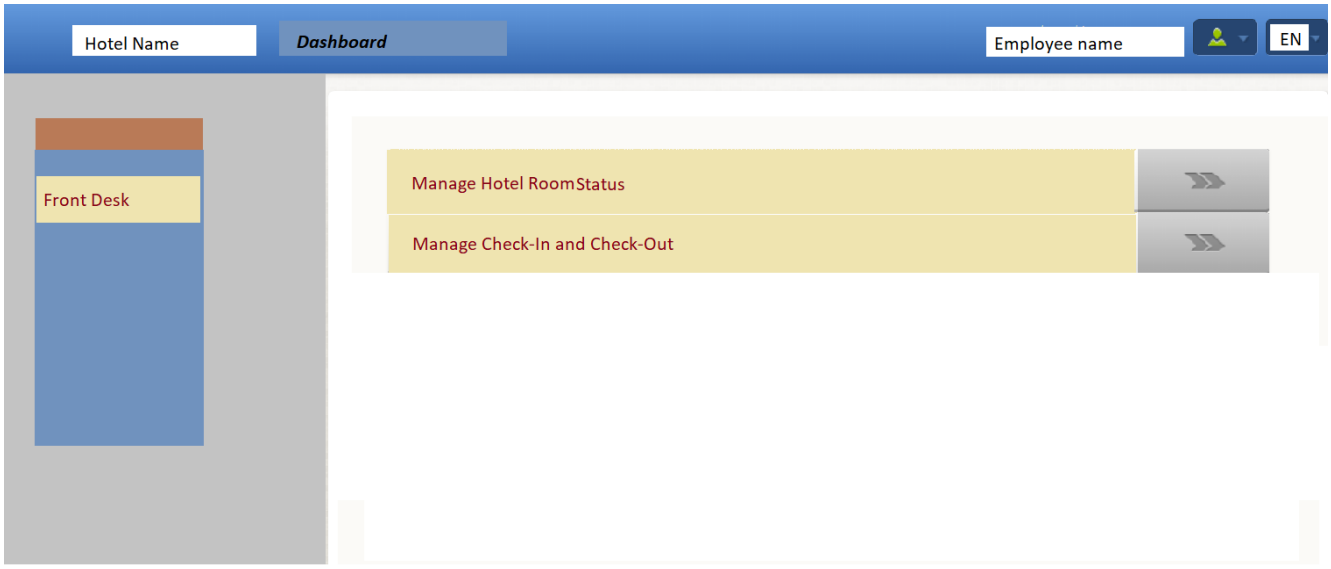

FIGURE 8. Home page User interface for Front Desk

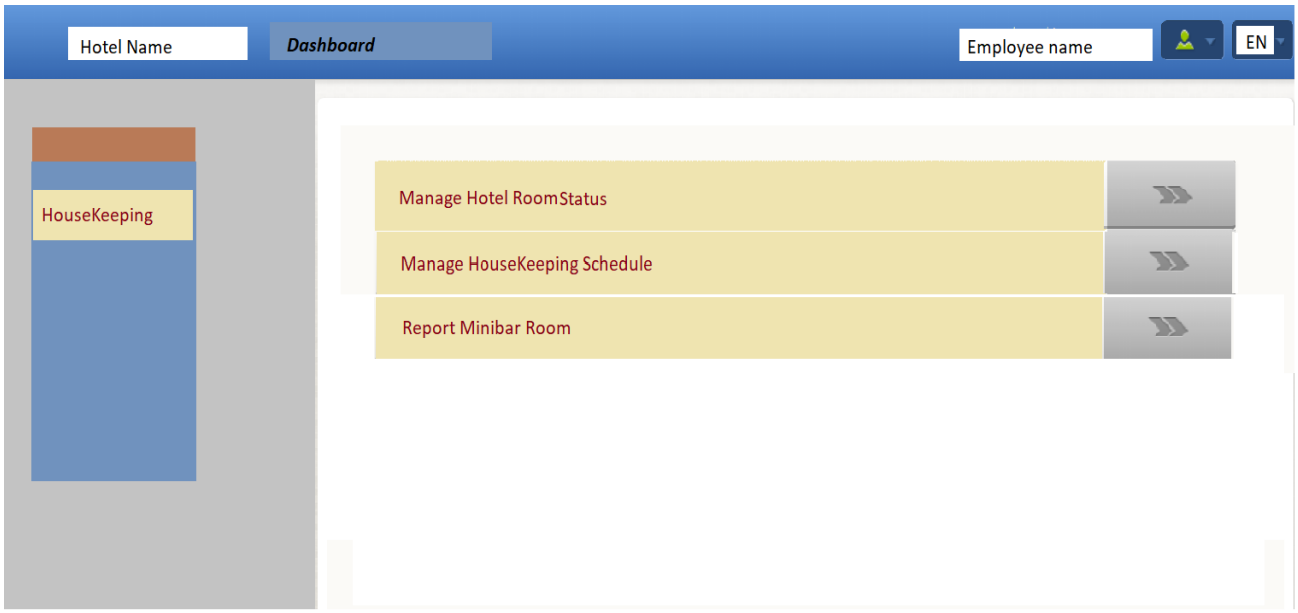

FIGURE 9. Home page User interface for Housekeeping Management

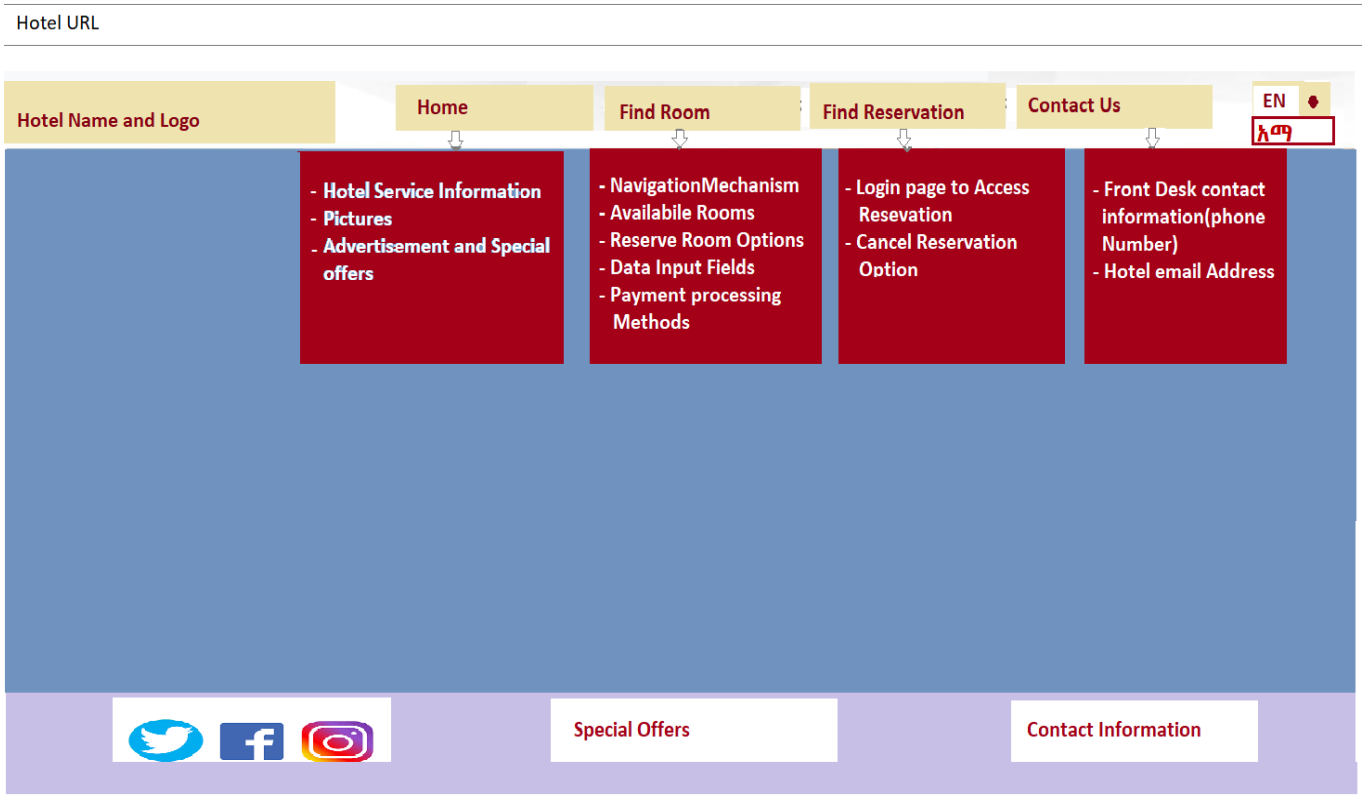

FIGURE 10. Hotel website format

4.6 Suggested Technology Tool

The hotel management system can be built on ASP.NET Core framework. ASP.NET Core is a cross-platform framework that allows the system to run on Windows, Linux, and Mac operating systems. It is also mostly used to build cloud-based applications that makes it more suitable to achieve the desired Azure hybrid server-client architecture of the web-based hotel management system. ASP.NET have built-in JavaScript frameworks, Angular and React, which helps developers create high-quality front-end features. It also has built-in programming model called Razor page which provides filtering and authorizing mechanisms to achieve role-based access control which plays the key part in the system security plan. (Develop ASP.NET Core MVC apps 2020.) cf. (Microsoft 2020).

4.7 SYSTEM THREAT MODELING

Security is a main concern when developing a new software product in today's world where there are so many advanced threats awaiting to disturb flow of the system or steal valuable data that is transported within. It is important to determine those threats in the design phase of the development plan to deliver highly secure system. This can be done by threat modeling which is a process of identifying system vulnerabilities and determining preventing techniques. Threat modeling can be accomplished in three steps, decomposing system to easily distinguish different trust boundaries and identify threats, categorizing threats according to risk level and finally establish preventive methods. System decomposition for the hotel management system can be done by using the flow chart (FIGURE 11) below.

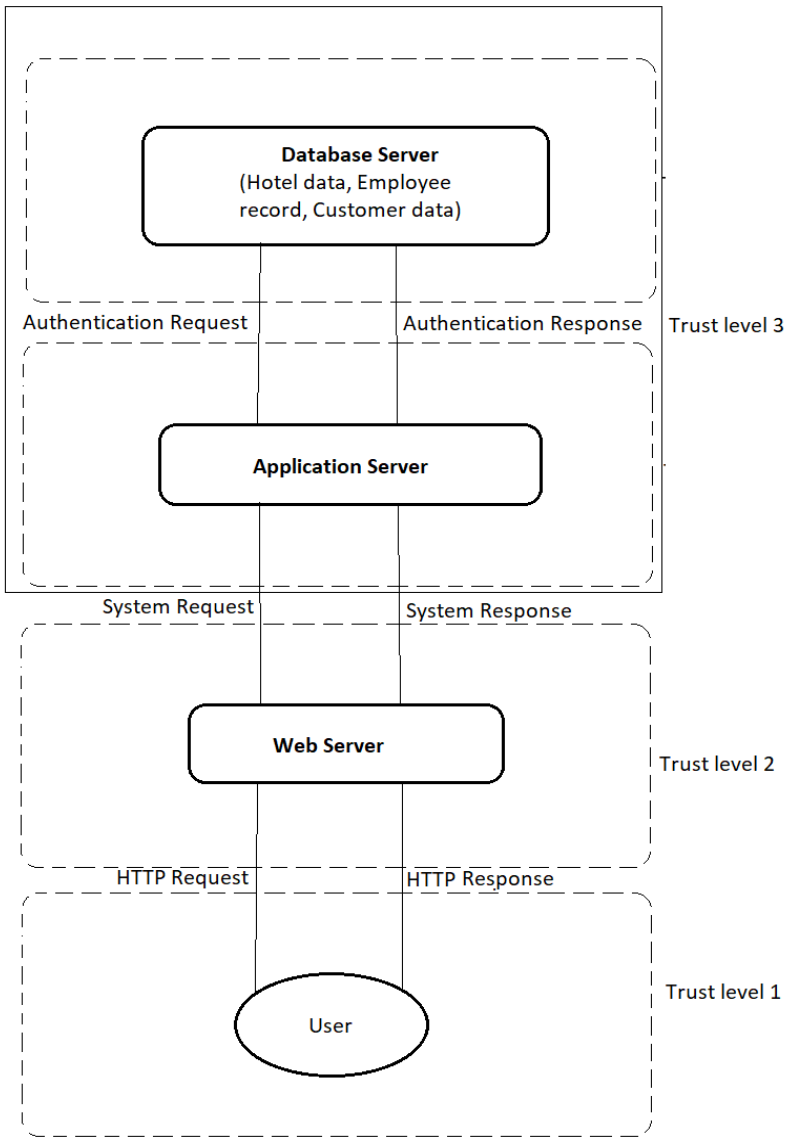

FIGURE 11. Hotel management system flow diagram

As we can see from FIGURE 11, the hotel management system has three trust levels based on boundaries of the different components of the system. Risk level increases as we go up from user computers with less trust level to database servers which needs higher restrictions and protections. After decomposing the system, it is important to identify what kind of risks the threats are going to impose on the system and sample out those threats to explore preventive options. There are many threat categorizing frameworks available including STRIDE, DREAD, VAST, Trike and NIST. STRIDE is the well-known modeling approach which is also used to determine potential threats to the hotel management system designed on this paper. (Fruhlinger 2020.)

STRIDE helps to locate threats that violate the confidentiality, integrity, and availability of the system. the word STRIDE is an abbreviation for the six kinds of threats knows as spoofing, tampering, repudiation, information disclosure, denial of service and elevation of privilege. The table below (TABLE 4) presents potential threats, threat category and suggested preventive approach to the hotel management system. (The STRIDE Threat Model.) cf. (Microsoft 2009).

Trust Level	Threat	Threat Category	Prevention Approach
1	- Fraud on online reservation payment - Card data security - Falsifying identity to access online reservation information - Malware	Spoofing	- Use trusted online payment methods. - Use strong Encryption - Verify view reservation request using booking confirmation number and email address. - Strong firewall and anti-malware measures.
2	- Interrupted website availability - Malicious website content modification - Overloading website with flooding HTTP request	Tampering with data and Denial of service	- Provide alternative data communication link. - Build multi layered network defense system. - Provide fault tolerant system with redundant server.

			- Ensure continuous data backup. - Ensure use of hashing and hash detection system.
3	- Unauthorized access to employee records and customer information. - Overloaded applications which result in data inaccessibility and authorized user Denial of service - Service loss - Hacking - Impersonation - Malicious modification of data and process flow	Spoofing, Tampering with data, information disclosure, denial of service and elevation of privilege.	- Provide role-based access control. - Provide employee authentication system based on username and password. - Provide fault tolerant system with redundant server. - Develop DDOS response plan - Constant system flow checkup. - System should allow constant security updates.

TABLE 4. Sample threats to the hotel management system

5 FURTHER DEVELOPMENT

The hotel management system in this work can deliver basic hotel reservation and employee management service for low standard hotels which provides only room renting services. The system can further be developed for the use of bigger standard hotels adding restaurant and bar service features. This can be done by studying all requirements and finding ways to integrate them with the existing ones. The system can also be improved by incorporating better performing record management software and designing the user interface by the help of human-computer interaction experts.

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