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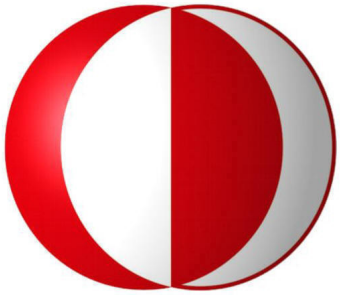

Ceng 491
Detailed Design Report

Massively Multiplayer Online Role Playing Game Project
Virtual Turkey

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1 Introduction

This document contains the detailed design descriptions of "Virtual Turkey" which is a massively multiplayer online role playing game (MMORPG). The approach used in this specification is adapted from IEEE recommended practices [1]. MECAC, the project group, assumes full responsibility of the requirements presented in this document.

1.1 Problem Definition

Turkey has variety of places with cultural inheritance to visit. In order to bolster touristic interest in Turkey, we will develop an online multiplayer game which will provide culture enthusiasts around the world the opportunity to preview sightseeing places in Turkey.

"Virtual Turkey" project has started in 2006. Prof.Isler has assigned specific parts of the project to students in his lectures. The project was later supported by METU Informatics Institute (BAP-2006-07-04-03), and had number of developers working on it. The aim of the project was to introduce the sightseeing places in Turkey. In the scope of the project, important landmarks of some Turkish cities has been modeled by number of contributors. However, the codebase of the project is inconsistent as of now since lots of developers have worked on it. Moreover, latest version of "Virtual Turkey" has network problems. Single server can only support three players concurrently. To meet the requirements of an MMORPG, the game being developed is expected to support thousands of players concurrently. Initial design of the project involved fast rendering of complex models.

This project will later be published under GNU license when it reaches the maturity of other well-known open source MMORPGs.

1.2 Purpose

This detailed design report intends to provide complete design descriptions of "Virtual Turkey". The descriptions suggested in this document will serve as a guideline throughout the development process of this project. The end-product will be tested against the requirements to ensure the quality of the software produced.

1.3 Scope

This document contains a complete description of the detailed design of "Virtual Turkey". This framework covers essentials of the MMORPG project. Its main intention is to provide software design description of the system according to Software Requirements Specifications.

1.4 Overview

The report contains seven sections. First section introduces the project "Virtual Turkey". In the second section, system overview is explained. The details of the project is started to be given in section 3. This section explains the design considerations. Data design and system architecture are described in section 4 and 5, respectively. User interface of the game is presented in section 6. Finally, libraries and tools, planning of the project are presented and the report is concluded.

1.5 Definitions and Abbreviations

DoS	Denial of Service
GNU	GNU is not Unix
GUI	Graphical User Interface
IP	Internet Protocol
MMORPG	Massively Multiplayer Online Role-Playing Game
MPI	Message Passing Interface
NPC	Non-Player Character
RSA	Rivest, Shamir and Adleman
SDD	Software Design Descriptions
SRS	Software Requirements Specifications

1.6 References

[1] IEEE, IEEE Std 1016-1998 *IEEE Recommended Practice for Software Design Descriptions*. IEEE Computer Society.

2 System Overview

The MMORPG project, Virtual Turkey, mainly serves the purpose of introducing the worth seeing monuments all around Turkey. The map of Virtual Turkey with missions is given in Figure 1. The player will be traveling the country in order to collect coins and the gold scattered over some secret places. While visiting and learning about the invaluable historical places of Turkey to carry out the quests, the player will have more chance to gain treasure; however, the treasure has to be hidden due to non-transportable nature of it, which makes

Figure 1: Virtual Turkey

the game more mysterious and riveting. Each player is planned to have several attributes to make the game-play more realistic. Player needs these attributes in order to use quest system, trade system, and chat system.

Quest System description includes the format of the quests, quest preliminaries and quest completion conditions. As a preliminary condition, the player will be asked to have a specific item in his backpack or an amount of gold owned. These two options are the only planned conditions for the time being. In addition, players will have a limit on how many quests they can take; thus, if this limit is reached, the player will automatically be rejected. To finish a quest, the player will have to go to a certain place, pick up a certain treasure or item. To add a new dynamic to the game, the place of this goal will not be given to the player, instead, a riddle with an answer which tells the place will be told to the player.

Trade system will consist of item description, trade conditions, and actual trade system. An item is any object that a player can own. According to this description, items will be tradable and be of some value. There will be usable items and non-usable items. Usable items are items that will be in the backpack waiting to be used by the player. On the other hand, non-usable items are items that will be traded or have a value but will not be usable by the player such as diamond. Moreover, there will be no restrictions on trade between players. Sample trade system is given in Figure 2.

The chat system is simple and user-friendly. A review of the current state is done based on game-concept and it is decided that the chat module will stay the same.

Figure 2: Trade System

3 Design Considerations

3.1 Design Assumptions, Dependencies and Constraints

Security: The communication between the server and the client component of MMORPG should be encrypted with RSA algorithm. Server should also check the cheating case by offloading major physics calculations to server-side. In order to prevent abuse of the server component, software on the server of MMORPG should block the recurring requests from the same IP address. Server should log common proxy addresses as well to check if the client is performing DoS attack.

Software System Attributes:

1. Maintainability: The modification of the source code should be disabled. The extensions should be applicable directly without modification to the back end. The patching service should be regarded as a different component in case extensions would be offloaded to a different server.

2. Portability: Both the client and the server component of the software should be portable. The target hardware platform for client component is unknown. Only requirement for the client software to be deployed is the operating system which should

belong to Windows NT family. The server side of MMORPG should be independent of specific hardware or software configuration.

3. Scalability: Most important software system attribute of "Virtual Turkey" is its scalability. Deploying additional servers and dividing the persistent world should not require additional extension on the client software.

3.2 Design Goals and Guidelines

In order for "Virtual Turkey" to be massively multiplayer, the server should support 1000 users concurrently. The communication delay between the server and the user should not exceed 0.1 second. The database transaction should not consume more than 10% of the time needed to process single request from client. The client software should enable the users to log-on the MMORPG within 5 seconds. In less than 10 seconds, the clients should be able to sign-in to the system.

In order for the MMORPG to be maintainable, the GUI of the server component should be robust for the administrator to update information or monitor the network traffic. The administrator should be able to log-on to the server within 5 seconds even when the server supports a thousand players online. When the administrator clicks "Manage Accounts" or "Manage NPCs" buttons, the GUI should show the requested information within 10 seconds and commit the changes within a minute. Monitoring network traffic should not increase the overhead on server-side as such information can directly be computed on-the-fly. When the administrator clicks monitor network traffic, the GUI on the server component should show the current traffic summary within 10 seconds.

4 Data Design

4.1 Data Description

The focus of the data model presented in this section is on Character and NPC data objects. Account, Vehicle, and Treasure data objects are associated with Character object. NPC object, on the other hand, stores the information about the trade items of it. Non-playing characters has no associated vehicles or accounts as it can be observed from Figure 3. Following sections describes all the data objects and their major attributes in more detail.

Quest This data object represents quest given by non-player characters. Database needs to store the identifier of the quest which is only major attribute of it.

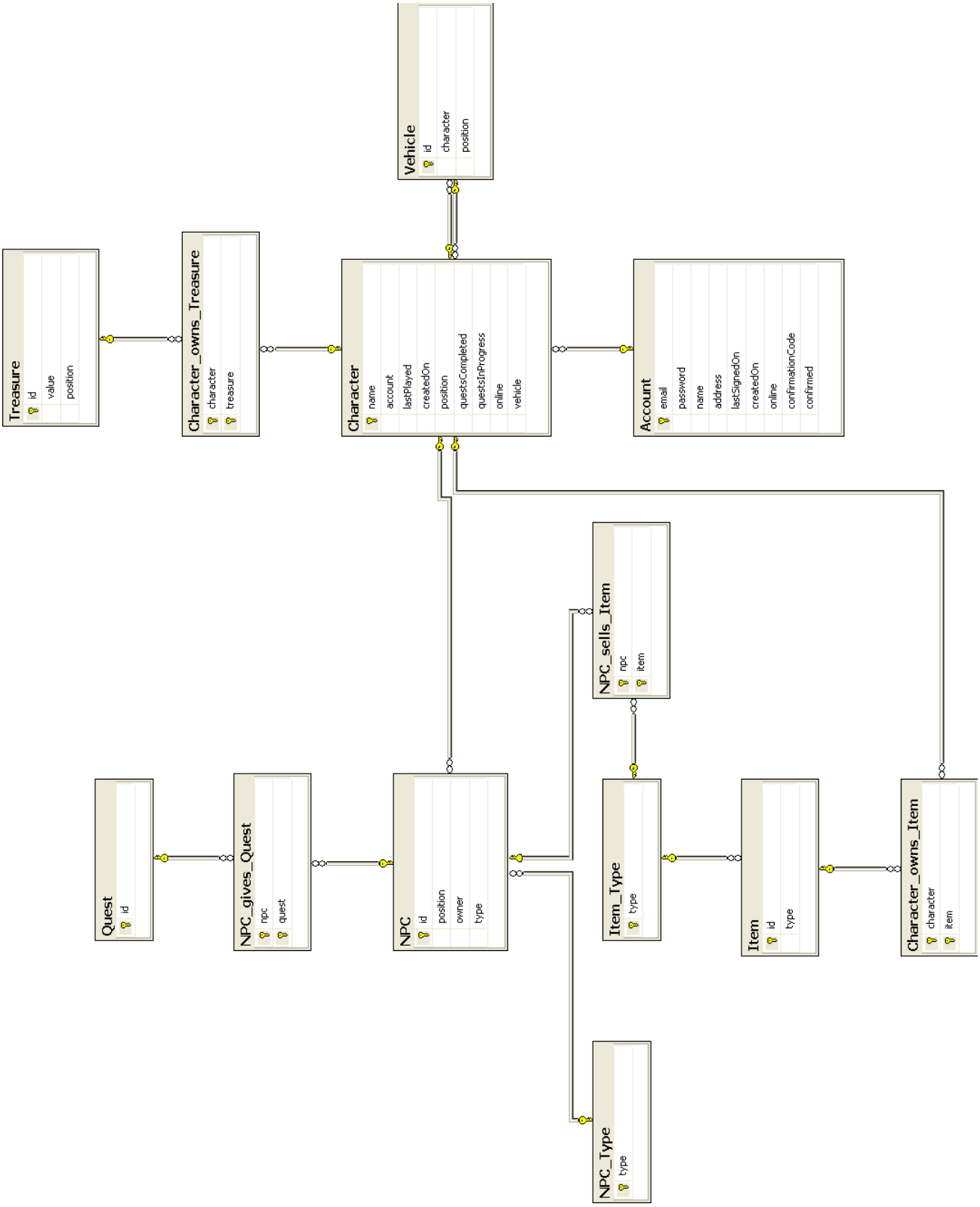


Figure 3: The Complete Data Model

NPC The NPC data object - as its name suggests - represents a single non-player character in "Virtual Turkey" MMORPG. Besides its unique identifier, it has three major attributes, namely, position, owner, and type.

Character This data object represents the character of the user associated with the account. The user character may have associated Vehicle or Treasure data objects.

Vehicle This data object represents the vehicle in "Virtual Turkey". Only characters can use the vehicles in the MMORPG to transport their characters between different locations of the persistent world. Each vehicle can be associated with only one character.

Account This data object stores the account information of players. The account data object does not store the character information. However, it references a character data object. This approach enables players to have multiple characters in MMORPG.

Treasure This data object represents the treasure items that the characters possess. The treasure data objects have associated value and position in the virtual world. These data objects are intended to be traded for items by characters.

4.2 Data Dictionary

This section describes the major system entities along with their types and descriptions. Attributes of each system entity have been listed.

Figure 4: Quest Data Object

Quest

id: The unique identifier of the quest data object. It is stored as integer.

NPC

id: The unique identifier of the NPC data object. It is stored as integer.

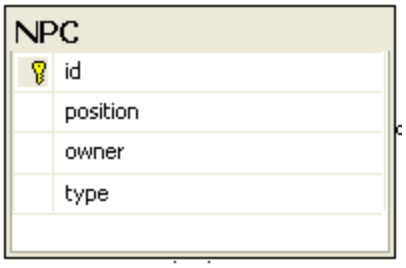


Figure 5: NPC Data Object

owner: The owner character of the NPC data object. It is stored as integer.

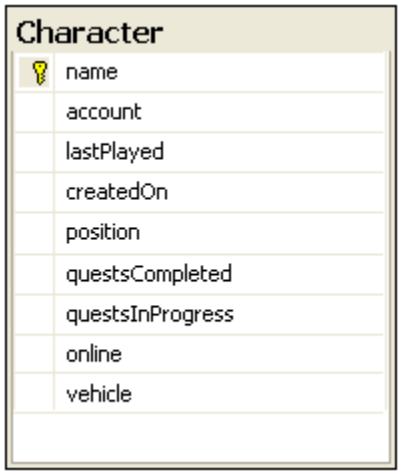


Figure 6: Character Data Object

Character This data object represents the character of the user associated with the account. The user character may have associated Vehicle or Treasure data objects.

name: The unique identifier of the Character data object. It is stored as string.

account: References corresponding Account data object. It is stored as integer.

last played: The time that the character last played "Virtual Turkey". It is stored as date object.

created on: The time that the character has been created by the user. It is stored as date object.

position: The location of the character in the persistent world of MMORPG. It is stored as three integers.

quests completed: The quests that the character has completed successfully. It is stored as list of integers pointing to quest objects completed.

quests in progress: The quests that the character has attempted to complete. It is stored as list of integers pointing to quest objects that are in progress.

is online: The boolean attribute showing whether the character is connected to persistent world or not. It is stored as a boolean variable.

vehicle: The current vehicle of the character that references a Vehicle data object. It is stored as integer pointing to corresponding vehicle system entity.

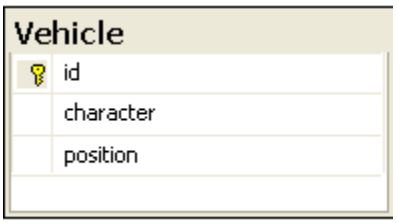


Figure 7: Vehicle Data Object

Vehicle This data object represents the vehicle in "Virtual Turkey". Only characters can use the vehicles in the MMORPG to transport their character between different locations of the persistent world. Each vehicle can be associated with only one character.

id: The unique identifier of the Vehicle data object. It is stored as integer.

character: References to the corresponding character object that owns the vehicle. It is stored as integer.

position: The current location of the Vehicle in the persistent world of MMORPG. It is stored as three integers.

Account This data object stores the account information of players. The account data object does not store the character information. However, it references a character data object. This approach enables players to have multiple characters in MMORPG.

e-mail: The email address of the account owner. It is stored as string.

password: The password of the account owner. It is stored as encrypted string.

name: The nickname chosen by the account owner. It is stored as string.

address: The address of the account owner. This attribute is optional. It is stored as string.

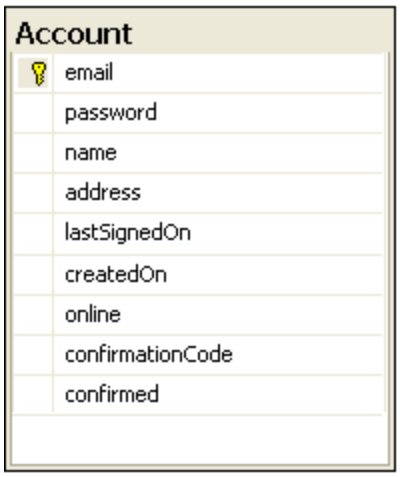


Figure 8: Account Data Object

last signed on: The last date when the account holder has logged-in. It is stored as date object.

created on: The date when the account was created. It is stored as date object.

online: Boolean attribute showing if the account owner is connected. It is stored as boolean variable.

confirmation code: The confirmation code for account owner. It is stored as encrypted string.

confirmed: Boolean attribute showing whether the account was confirmed or not. It is stored as a boolean variable.

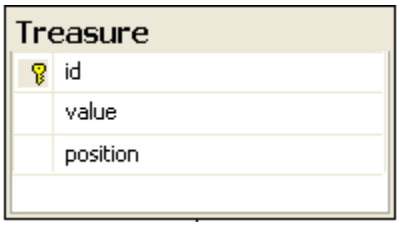


Figure 9: Treasure Data Object

Treasure This data object represents the treasure items that the characters possess. The treasure data objects have associated value and position in the virtual world. This data objects are intended to be traded for items by characters.

id: The unique identifier of the treasure data object. It is stored as integer.

value: Value of the treasure data object. It is stored as integer.

position: The location of the treasure data object in the persistent world of MMORPG. It is stored as three integers.

4.2.1 Relationships

This section describes the relationship between the data objects described in the previous section.

NPC - Quest: Each NPC may be associated with one or more quests. Those quests are to be completed by characters. However, a quest may not be associated with multiple NPCs.

NPC - Item: Each non-playing character may own one or more items. However, an item cannot be owned by multiple non-playing characters. NPCs are able to trade the items with playing characters.

Character - Item: Each character may own one or more items. However, an item cannot be owned by multiple characters. Characters can trade the items and treasures with other characters or NPCs.

Character - NPC: Each non-playing character is owned by only one character. An NPC without an owner or a character without an NPC can exist.

Character - Vehicle: Each character can only own one vehicle in the MMORPG. A vehicle cannot be associated with multiple characters.

Character - Account: Each character can be associated with at most one account. However an account owner may own multiple characters.

Character - Treasure: A character may collect zero or more treasure, however a treasure can only be owned by a single character.

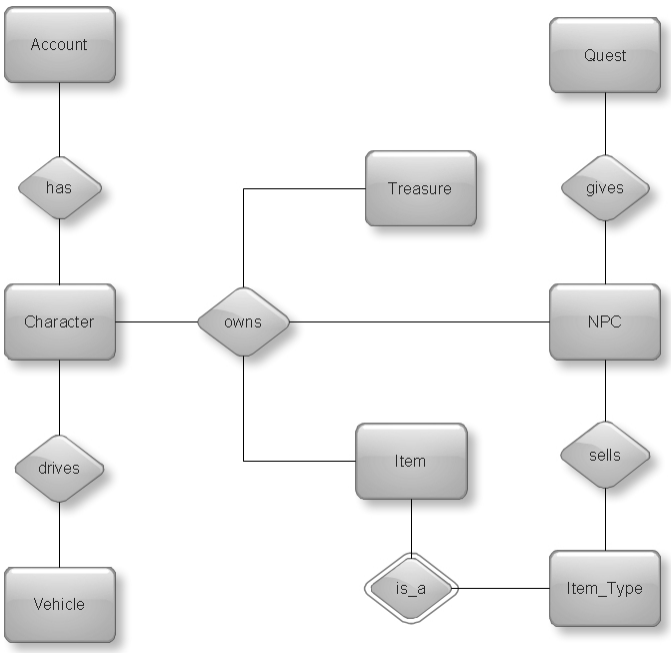


Figure 10: Entity Relationship Diagram

5 System Architecture

5.1 Architectural Design

The game architecture has been shown in Figure 13. As seen in Figure 'Virtual Turkey" has two main parts, clients and server. The relationship between these two parts is accomplished by package transferring between each part's own communication layer.

Game loop, which belongs to clients component, interacts with NPC part of the server component and during the interaction, information is passed to NPC through communication layers. Information can be gain gold, next position of character, vehicles etc. It also initiates the game to start.

Database inside the server component stores the information such as account information of the users, last position of the players, and their attributes. It also has a connection with server physics engine, which enables the physical system of the game. Following sections of this document decomposes overall architecture of the system to its components and their descriptions.

Client: The client package is structured to handle game loop, physics and communication between server. Figure 11 shows the arhcitectural design of the client. As seen from the figure, communication layer is responsible for all actions that users take. Game loop subcomponent keeps client state consistent with game logic. Physics subcomponent is responsible for physical interactions of the player with the virtual world. All of these subcomponents will be described in following sections of this document.

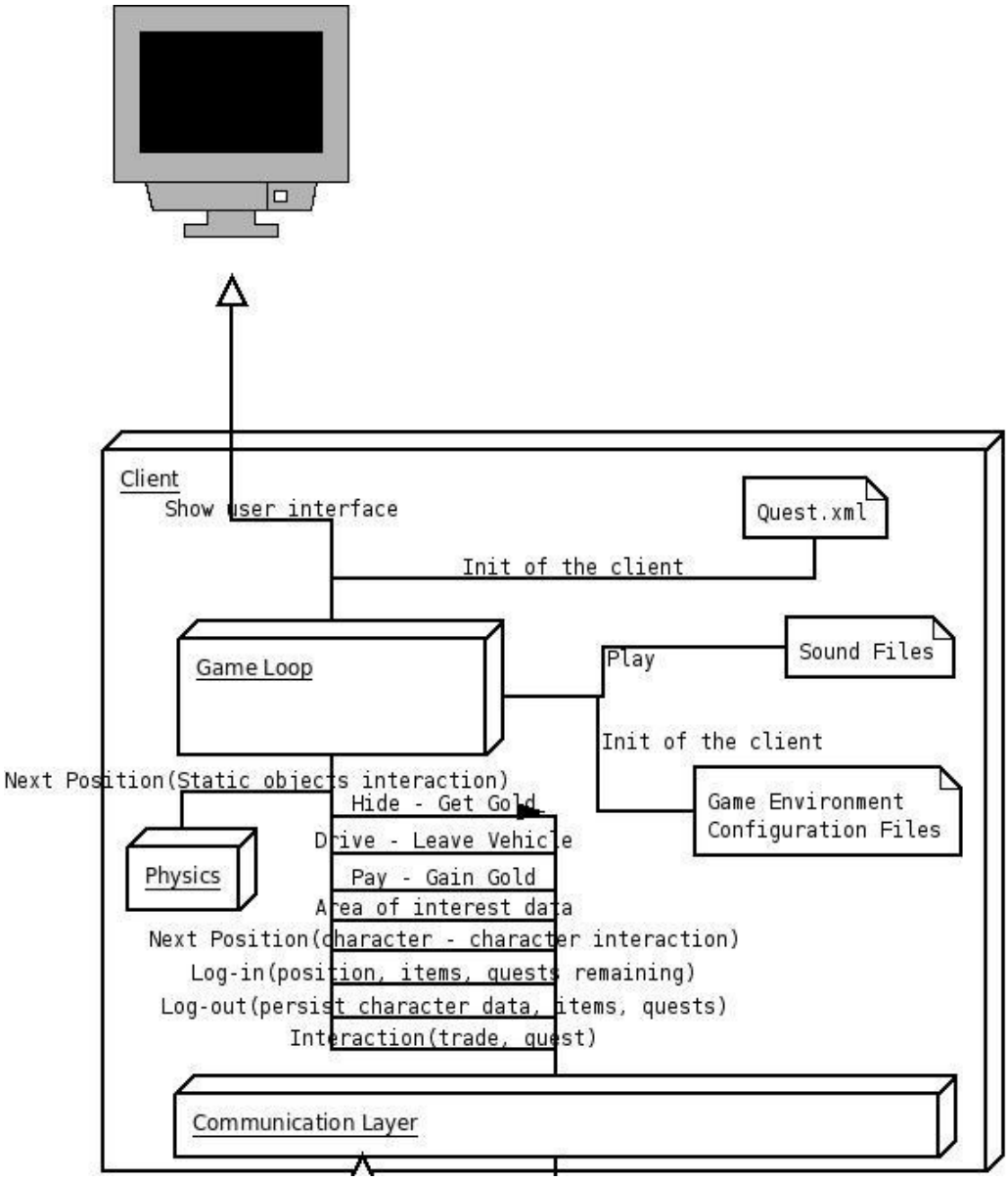


Figure 11: Client Architecture

Server: Server package is structured to handle non-playing characters, communication between clients, and game logic. Figure 12 shows the archtiectural design of the server. As seen from the figure, NPC subcomponent handles all non-playing characters in the game. NPC clients are responsible for quests in the game logic. Communication layer of the server package is most complicated component. It handles client status updates, area of interest calculations, and balances the network load. Server package also includes physics engine. This engine will be responsible for verification of the clients physical interactions. Server physics subcomponent will also detect cheating. User states, account data, and all other information is stored in database subcomponent. All of these subcomponents will be described in following sections of this document.

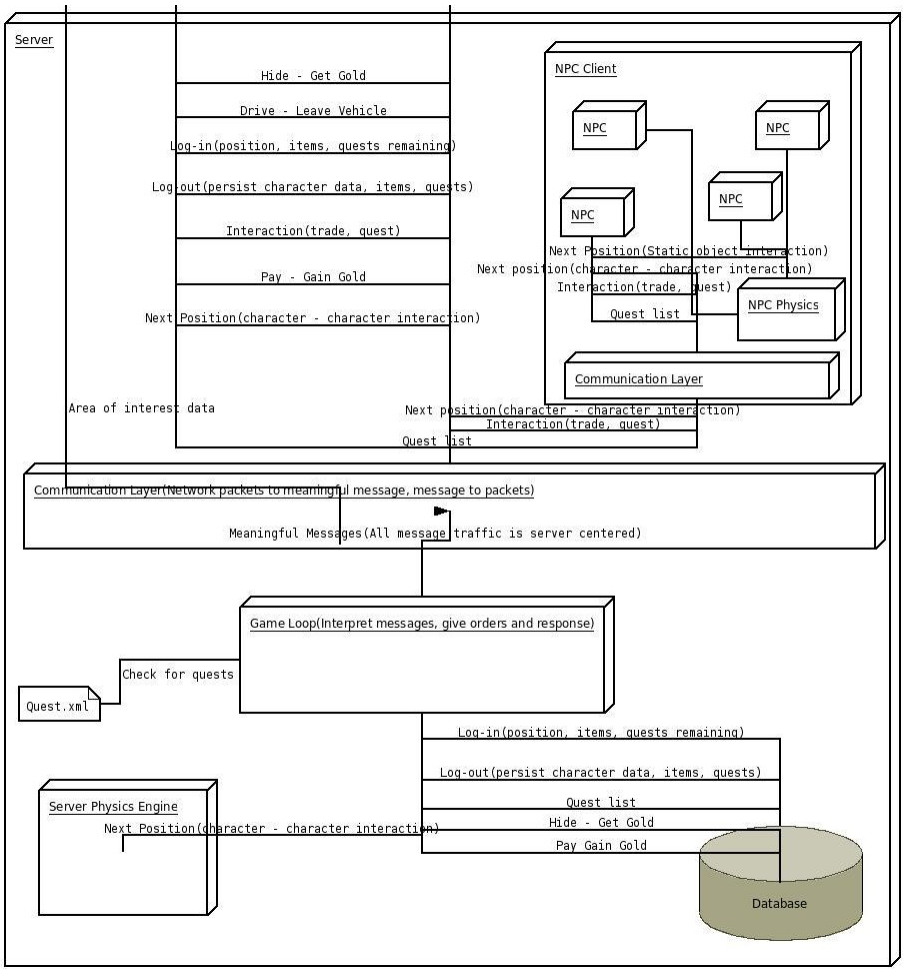
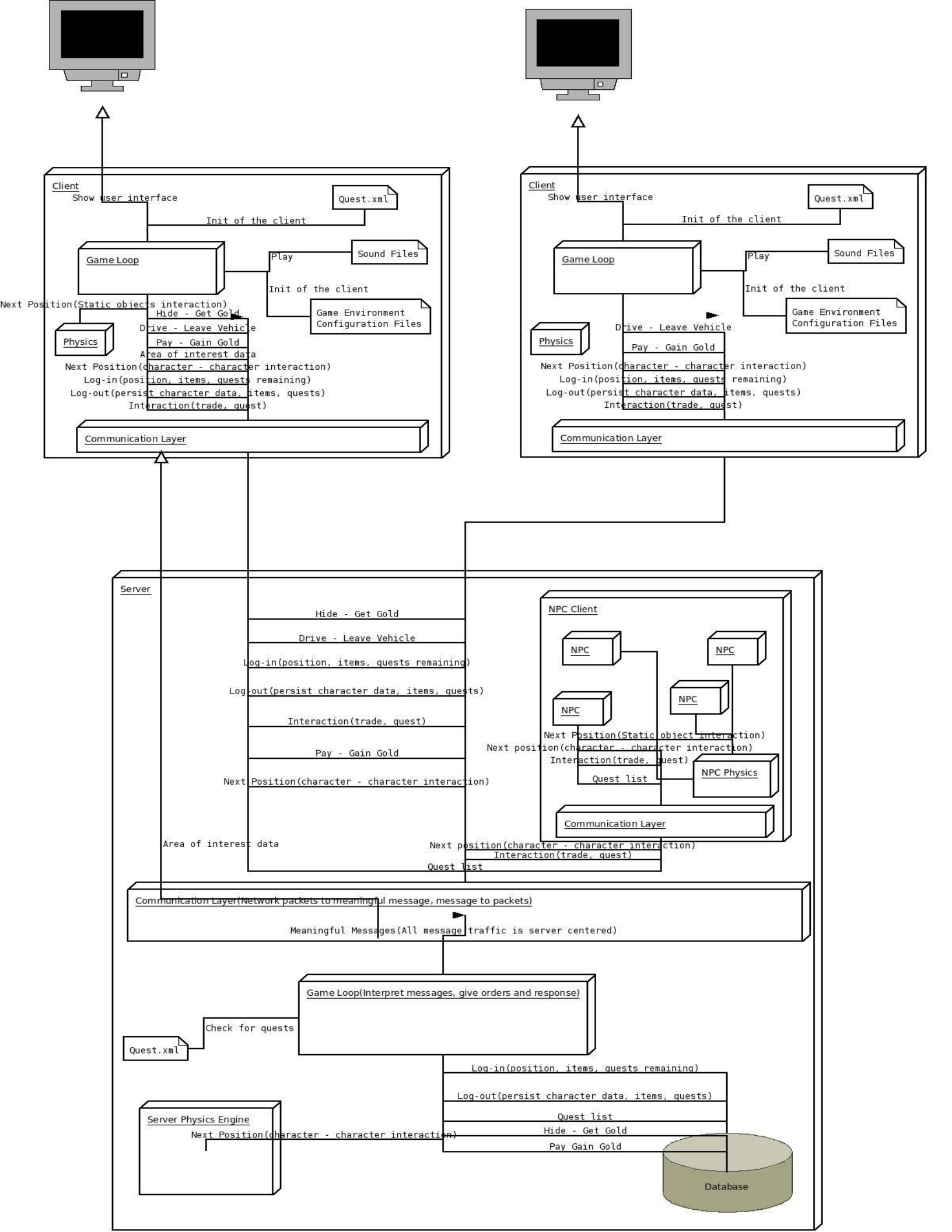


Figure 12: Server Architecture


Client
Show user interface
Quest.xml
Init of the client
Game Loop
Play
Sound Files
Init of the client
Game Environment Configuration Files
Next Position(Static objects interaction)
Hide - Get Gold
Drive - Leave Vehicle
Pay - Gain Gold
Area of interest data
Next Position(character - character interaction)
Log-in(position, items, quests remaining)
Log-out(persist character data, items, quests)
Interaction(trade, quest)
Physics
Communication Layer
Client
Show user interface
Quest.xml
Init of the client
Game Loop
Play
Sound Files
Init of the client
Game Environment Configuration Files
Drive - Leave Vehicle
Physics
Pay - Gain Gold
Next Position(character - character interaction)
Log-in(position, items, quests remaining)
Log-out(persist character data, items, quests)
Interaction(trade, quest)
Communication Layer
Server
Hide - Get Gold
Drive - Leave Vehicle
Log-in(position, items, quests remaining)
Log-out(persist character data, items, quests)
Interaction(trade, quest)
Pay - Gain Gold
Next Position(character - character interaction)
NPC Client
NPC
NPC
NPC
NPC
Next Position(Static object interaction)
Next position(character - character interaction)
Interaction(trade, quest)
Quest list
NPC Physics
Communication Layer
Area of interest data
Next position(character - character interaction)
Interaction(trade, quest)
Quest list
Communication Layer(Network packets to meaningful message, message to packets)
Meaningful Messages(All message traffic is server centered)
Game Loop(Interpret messages, give orders and response)
Check for quests
Quest.xml
Log-in(position, items, quests remaining)
Log-out(persist character data, items, quests)
Quest list
Hide - Get Gold
Pay Gain Gold
Server Physics Engine
Next Position(character - character interaction)
Database

5.2 Description of Components

This section describes the major components of 'Virtual Turkey". All of the components are organized under two packages. As seen from Figure 14, the communication between the two packages is carried out through a TCP channel.

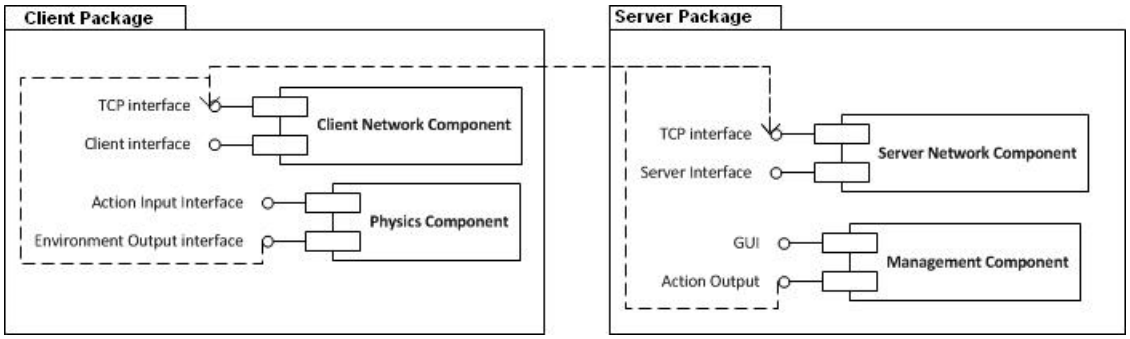


Figure 14: Component Diagram

5.2.1 Client Network Component

This component of the MMORPG describes how the clients communicates with the server through the network.The game play heavily depend on the quality of network connections. Elegant design is a must for "Virtual Turkey" to be massively multiplayer game. Following sections elaborates more on design of network component.

Processing narrative for client network component Major responsibility of the network component is to handle message transmission between from the client to the server. Some of the possible messages are enumerated below. In the processing detail of this component, the meanings of the messages will be described.

enum ClientToServerMessageTypes
{
Register , Login, Logout, Chat,Update,TreasureHide, TreasureDig, QuestRequest , QuitQuest, CompleteQuest , QuestApproval,QuestQuitOK, QuestDisApproval , QuestCompleteOK, QuestCompleteNotOK, TradeApproval, TradeDisApproval,TradeOK, TradeNotOK, TradeRequest,Trade
}

client network component interface description The input interface of the client network component interacts with the graphical user interface of the clients. The messages encoded according to network protocol is transmitted through network. The output interface of the client network component is a TCP channel ultimately reaching to server's network interface.

client network component processing detail This section describes the details of how client network component interacts with the client user interface and server network interface to achieve communication in between. The major functions of the component along with its attributes are described in the following sections.

Register This network interaction creates a new user account. A confirmation code will be send from server to users email address as a result of this transaction. The attributes of this interaction is as follows.

Client to Server		Server to Client	
Header	**Arguments**	**Header**	**Arguments**
Register	Username, email password ,player model	RegisterOK	Username, password
		RegisterDenied	Username, password

Figure 15: Register message

Login This function will let a user to connect to the game server. The username and password will be given to the server and the server will check the name and password from the database. if the check returns true, the server will return to the client the client ID, else, username and fault will be returned.

Client to Server		Server to Client	
Header	**Arguments**	**Header**	**Arguments**
Login	Username, password	LoginOK	Client ID
		LoginNotOK	Username

Figure 16: Login message

Logout The client will send her/his player id and success or fault will be returned.

Client to Server		Server to Client	
Header	**Arguments**	**Header**	**Arguments**
Logout	Client ID	LogoutOK	
		LogoutNotOK	

Figure 17: Logout message

Chat Player sends her/his chat data, and it is forwarded to other clients. Client to Server Server to Client(s)

Client to Server		Server to Client(s)	
Header	**Arguments**	**Header**	**Arguments**
Chat	ChatData	Chat	String ChatData

Figure 18: Chat message

Update This network interaction is the main routine of the game. Once the GameTick occurs in the clients, they will send their data to the server, and the server will forward their data to other clients according to their area of interest.

Client to Server		Server to Clients(the clients which are in the area of interest of that client)	
Header	**Arguments**	**Header**	**Arguments**
Update	PlayerData	Update	Environment data, player data
		UpdateTreasures	Treasure data (which

Figure 19: Update message

Treasure Hide Once a player wants to hide his treasures (golds, money), the information will be send to the server and the server will process the action.

Treasure Dig Once a player wants to take back his or another ones treasures (golds, money) , the information will be send to the server and the server will process the action.

Client to Server		Server to Client	
Header	**Arguments**	**Header**	**Arguments**
TreasureHide	Client ID, Treasure Value	TreasureHideOK	Treasure ID, Treasure value, client ID
		TreasureHideNotOK	Client ID

Figure 20: Treasure hide message

Client to Server		Server to Client	
Header	**Arguments**	**Header**	**Arguments**
TreasureDig	Client ID, TreasureID,	TreasureDigOK	Client ID , Treasure ID
		TreasureDigNotOK	Client ID , Treasure ID

Figure 21: Treasure dig message

Quest The quests will be done only with an NPC. Once a player wants to be in a quest with an NPC, the related data will be forwarded. The NPC will check if the player meets the requirements or not, and the quest request is approved or disapproved. Client1 is the player and client2 is the NPC. Client to Server (and forwarded to the NPC) Server to client (The data is coming from NPC) Header Arguments Header Arguments

Client to Server(and forwarded to the NPC)		Server to client (The data is coming from NPC)	
Header	**Arguments**	**Header**	**Arguments**
QuestRequest	Quest ID, client1 ID, client2 ID	QuestApproval	Quest ID, client1 ID, client2 ID
QuitQuest	Quest ID, client1 ID, client2 ID	QuestDisApproval	Quest ID, client1 ID, client2 ID
CompleteQuest	Quest ID, client1 ID, client2 ID	QuestQuitOK	Quest ID, client1 ID, client2 ID
		QuestCompleteOK	Quest ID, client1 ID, client2 ID
		QuestCompleteNotOK	Quest ID, client1 ID, client2 ID

Figure 22: Quest message

Trade A player can make a trade with a NPC or another player. If the trade request is approved, the trade should start. Trade Client1 Client2 Itemlist means, client1 wants to buy Itemlist from Client2. If client1 has enough money, the trade returns success, else returns fault.

Client to Server(data is coming from client1 and forwarded to client2)		Server to Client(data is coming from client2 and going to client1)	
Header	**Arguments**	**Header**	**Arguments**
TradeRequest	Client1 ID , Client2 ID	TradeApproval	Client1 ID , Client2 ID
Trade	Client1 ID, Client2 ID, ItemList	TradeDisApproval	Client1 , Client2 ID
		TradeOK	Client1 ID, Client2 ID
		TradeNotOK	Client1 ID, Client2 ID

Figure 23: Trade message

Dynamic behavior of client network component The behavior of client network component has been exemplified in Figure 24.

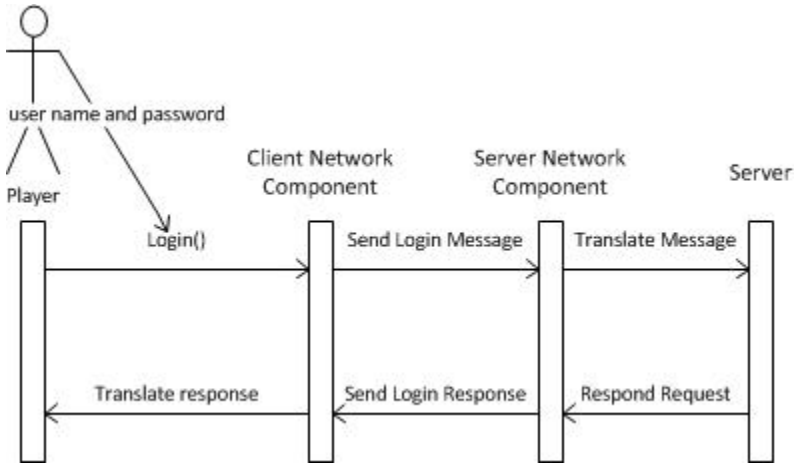


Figure 24: Sequence diagram for client network component

5.2.2 Server Network Component

This component is responsible for updating the information of clients while balancing the network load on the server.

Processing narrative for server network component There are a number of messages that are sent to client according to their requests. The types of the messages are given below. For actual interpretation of these messages, one can refer to client network component. More importantly, this section describes the prioritization in sending these messages. The band-width of the server computer has to be utilized as it is a limited budget. The details of this utilization is given in following sections of this document.

```
enum ServerToClientMessageTypes
{
RegisterOK , RegisterDenied, LoginOK, LoginNotOK, LogoutOK,
LogoutNotOk, Chat,Update, UpdateTreasures ,TreasureHideOK, TreasureHideNotOK,
TreasureDigOK, TreasureDigNotOK, QuestRequest , QuitQuest , CompleteQuest
QuestApproval,QuestQuitOK, QuestDisApproval , QuestCompleteOK, QuestCompleteNotOK,
TradeApproval, TradeDisApproval,TradeOK, TradeNotOK, TradeRequest, Trade
}
```

server network component interface description The server network component interfaces with all client network components in a full-duplex manner. The transmission in between is a TCP channel over the Internet.

server network component processing detail The most important attribute of server network component that affects the processing is its nxn state matrix where n is the number of players. This matrix holds the update information that has to be sent to each other. A formula that computes the interest area of each player determines the prioritization of each update message.

For example, an update from a player far away reaches slowly compared to an update from a near-by player. This optimization is perhaps the most important factor enabling Virtual Turkey to be massively multiplayer.

The terms and the weights of the priority formula is tentative as an optimal formula requires massive amount of experimentation. The processing of server network component is given below as a pseudo-algorithm.

1. Gather update information from clients.
2. Put the information into NxN matrix where N is the number of players and matrix[i][j] denotes the update that has to be sent from player i to player j.
3. Compute the most urgent set of messages that fits the bandwidth of the server.
4. Send the urgent messages and go-back to 1.

Alg.1 Pseudo-algorithm of server network component.

Dynamic behavior of server network component The behavior of server network component has been exemplified in Figure 25.

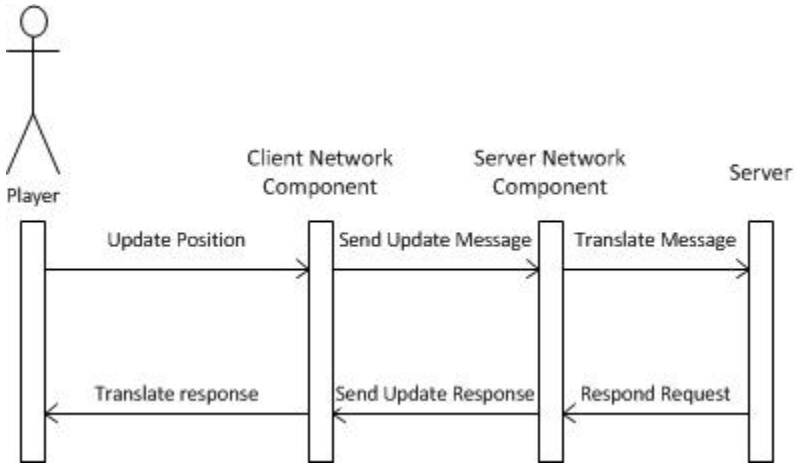


Figure 25: Sequence diagram for server network component

5.2.3 Physics Component

This component is responsible for physics calculation for the persistent world of MMORPG. The computation includes collision detection and all other sorts of physical interactions of the players. For the purpose of preventing cheating, major computation and checking of the physics engine will be performed on the server-side.

Processing narrative for physics component The physics component will be present in both clients and the server. Processing of both sides is similar except the fact that the end-results are different. The output of the physics component will be used for cheating checking on server-side while the same results - if not modified - will be used in graphics engine on client-side.

physics component interface description The physics component on client side interfaces with client graphical user interface. Each movement update of a player is sent to physics component and resulting computation is sent to the graphics engine. The result can be hit-back from a wall, or position change of running action. Every result is crosschecked with the server.

The interface of the physics component is little bit different although the processing is - and should be- exactly the same. The server-side physics engine receives the update information through the server network component and transmits the output to the client

network component. The result of this calculation is mostly confirmation of the client physics engine results. In case of cheating, the physics component of the server sends log-out message to client network component.

physics component processing detail There are two major functions of physics component. These are collision detection and position calculation. Description of the two functions are given below. The computation is handled by a JigLibx physics engine that is specifically developed for Microsoft XNA framework.

Collision detection : It will calculate the distance between objects in the persistent world. A collision will be reported in case two objects closer than a threshold.

Position calculation : For each moving object the physics engine will compute the next position according to friction, velocity, and other environmental parameters in the game.

Dynamic behavior of physics component The behavior of physics component has been exemplified in Figure 26.

5.2.4 Management Component

The management component will provide the utilities that system administrators need. It encapsulates several crucial processing units of the game such as data management, non-playing characters, and game loop. Object-oriented design of each subcomponent enables single and consistent interface to other components in the system.

Processing narrative for management component This component resides on server-side. The major sub-components are quest system, virtual environment management, account management, and NPC handling. These functions are to be used by the administrator of MMORPG. The software requirement specification for the Virtual Turkey necessitates the management tools described in this section. Description of the processing details for each sub-component are described in the following sections of this document.

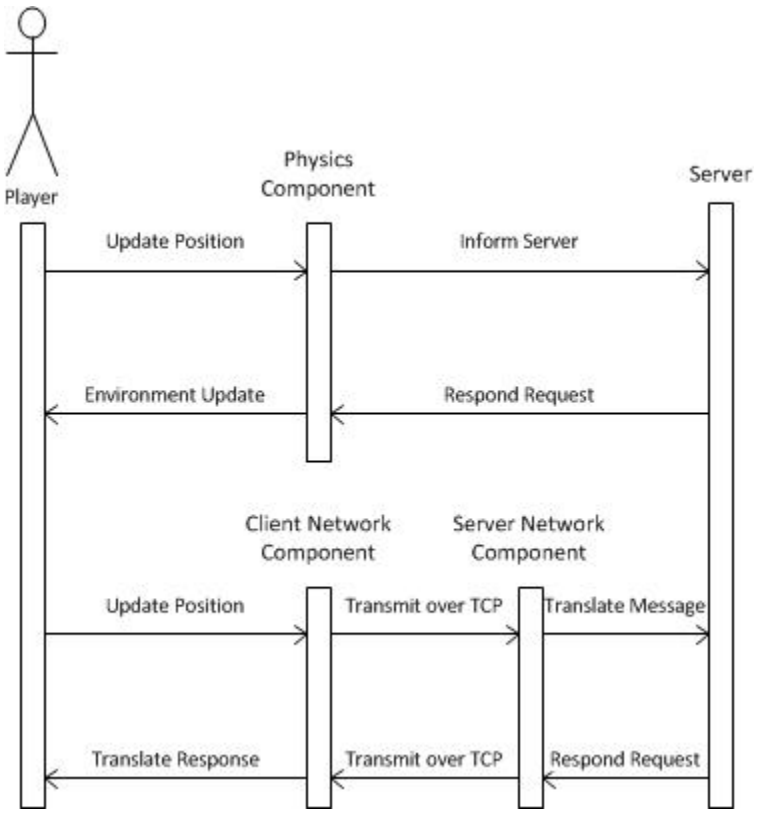


Figure 26: Sequence diagram for physics component

management component interface description The component interfaces with administrator via a graphical user interface. The input from Administrator will be handled directly within management component. The results of administrator actions will be transmitted to other components if necessary.

management component processing detail The processing functions for each subcomponent is given in this section. Following paragraphs describe the detailed description of the subcomponents.

Quest Management The quest system will be able to handle the main questing aims, such as a reward system and task completion systems. The quest management tool enables the administrator to add and remove quests from the GUI. This management involves the management component interact with the database to perform transactions.

Virtual Environment Management The administrator will use the management component to edit the virtual environment. Each change in the persistent world will be reflected to the clients using the network component of the server.

Account management Accounts of the players will be managed through interface of the management component. Common tasks are deletion and insertion of accounts.

NPC handling Each NPC will be handled by a thread running on server, but separate from the server program. Thus, communication with server and NPC threads should be implemented in order to provide the game NPC feature.

Dynamic behavior of management component The behavior of management component has been exemplified in Figure 27.

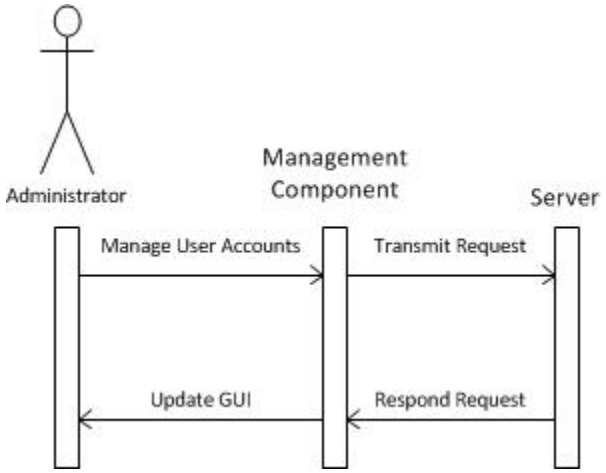


Figure 27: Sequence diagram for management component

5.3 Design Rationale

The decomposition of the MMORPG to the components described above is agreed upon all group members. The most discussion was on distribution of physics component to the server and the client. The suggested component design prevents cheating. The trade-off was between cheating detection and server load. Opponents of this design emphasized the need for low-cost server. However, we have agreed on the fact that the persistent world MMORPGs have a lot of cheating players and there is a compelling need for cheating detection.

Another point where MECAC group members were separated is on server network architecture. Current design suggests a centralized server-client network architecture. This requires huge server cost for achieving massive number of players. However, peer to peer architectures are also considered while proposing this detailed design document. Although such an MMORPG could be novel research, the we have decided to pursue the standard centralized design due to time limitations.

6 User Interface Design

6.1 Overview of User Interface

The interaction between the user and the game is done via user interface. First, the user enters server IP and his login information. If it is authenticated, the game starts. The most extensive interaction is occurred in this stage. There are many user interfaces connected to the main gameplay screen. The user reaches these interfaces and plays the game via keyboard controllers. The connected interfaces are explained in section 6.2. Main keyboard controllers are W, A, S, D keys. These keys enable the character - the user - to walk through the game. According to view angle of the camera, W key moves the character forward, S key moves it backward, and A and D keys moves it left and right, respectively. Moreover, the character can move diagonally by hitting two keys at the same time. These keys are also active when the character rides in a vehicle or an animal, which can be accomplished by hitting Enter key. Q and ESC keys enable the user to reach other interfaces. The character carries the gold with C key, and hides it with H key. When the user quits the game, interaction between the user and the game is over.

6.2 Screen Images

6.2.1 Connection Screen

The first step when the user runs the game is entering the IP of the server. If IP is valid, the user connects to the server, else warning screen denoting that the connection is unsuccessful appears.

Figure 28: Connection Screen

6.2.2 Account Screen

Figure 29: Account Screen

If the user has already have an account, he enters login button. To create a new account, he selects create account button.

6.2.3 Create Account Screen

Username, password and e-mail fields are filled in by the user. If the username and e-mail is unique, the account is created when he hits OK button.

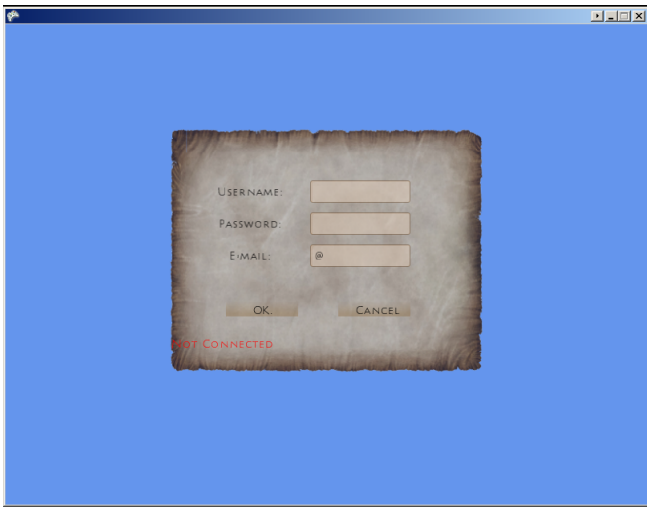


Figure 30: Create Account Screen

6.2.4 Login Screen

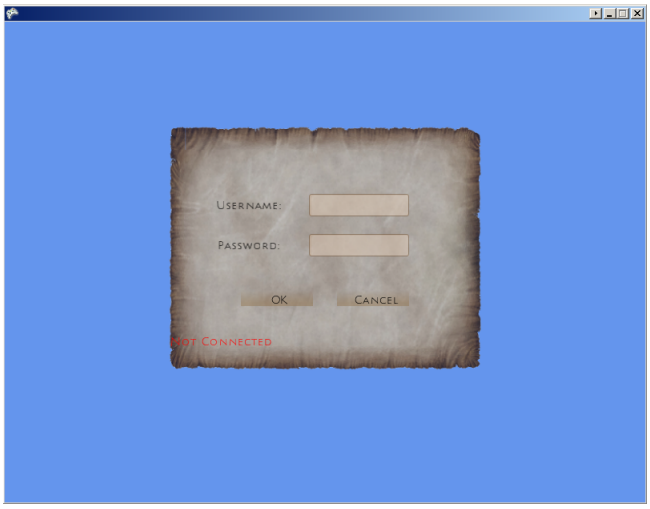


Figure 31: Login Screen

The user enters his username and password to this screen to login his account.

6.2.5 Display Screen

This is the main display screen. There is a user's avatar, gold bar and character's name, and level on the top left corner of the screen. The chat box is on the bottom right corner. On the top right corner, there is a mini map, which shows the position of the user on the map.

Figure 32: Display Screen

6.2.6 Turkey Map Screen

Figure 33: Turkey Map

This is the 2D map screen where player can choose where to go and see which monument is where. From the main display screen, player can come to map screen by hitting ESC and choosing "Map Screen".

6.2.7 Quest Details Screen

This is the screen where player sees the details of the quest, which are related to the continuation of the player in the game. By hitting Q key, player can see this screen.

Figure 34: Quest Details Screen

6.2.8 Trade Screen

Figure 35: Trade Screen

This is the screen of trade operation. Player can trade with an NPC or another player in this screen. Player can reach this screen when he is in the interaction screen with an NPC or a player.

6.2.9 Character Information Screen

When the player hits left CTRL key, this character information screen comes. All information about the character is displayed in this screen, such as visited places, gained gold, and time

Figure 36: Character Information Screen

played. Moreover, by clicking "Friends" button in the character information screen, a player can see his friend list, information about his friends, and can send messages to them.

6.2.10 Options Screen

Figure 37: Options Screen

By hitting ESC and choosing "Options", the player comes to this screen. From here, he can reach video options, audio options, controller settings option, and gameplay options.

Figure 38: Video Options Screen

6.2.11 Video Options Screen

This is the video options screen where player can change detail level in the game or screen resolution. This screen is reached from options screen.

6.2.12 Audio Options Screen

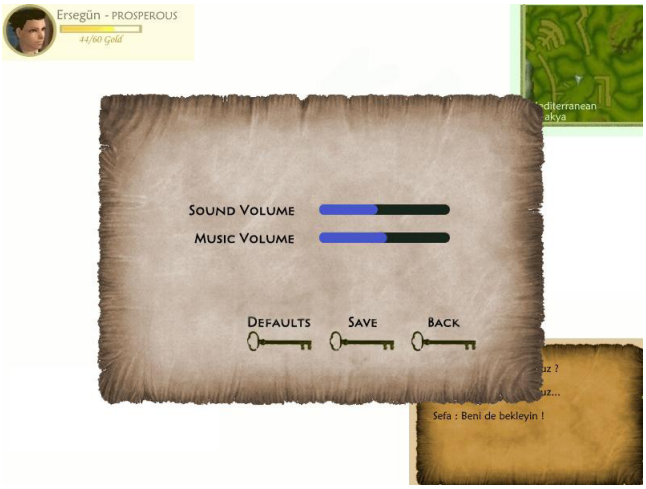


Figure 39: Audio Options Screen

This is the audio options screen where player can change sound volume or music volume. This screen is reached from the options screen.

6.2.13 Controller Settings Screen

Figure 40: Controller Settings Screen

This is the controller settings screen from where player can change the controls of the game. This screen is reached from options screen.

6.2.14 ESC Menu Screen

Figure 41: ESC Menu Screen

This is the ESC menu screen, which can be reached by user's hitting "ESC" button. From here, player can access options or map screens. He can also choose logout or quit game options.

6.3 Screen Objects and Actions

When the user executes the game, the first screen that he comes across is the login window. Once the user enters server IP and his login information, the game starts. From this point, the interfaces that the user will see are denoted in Figure 42.

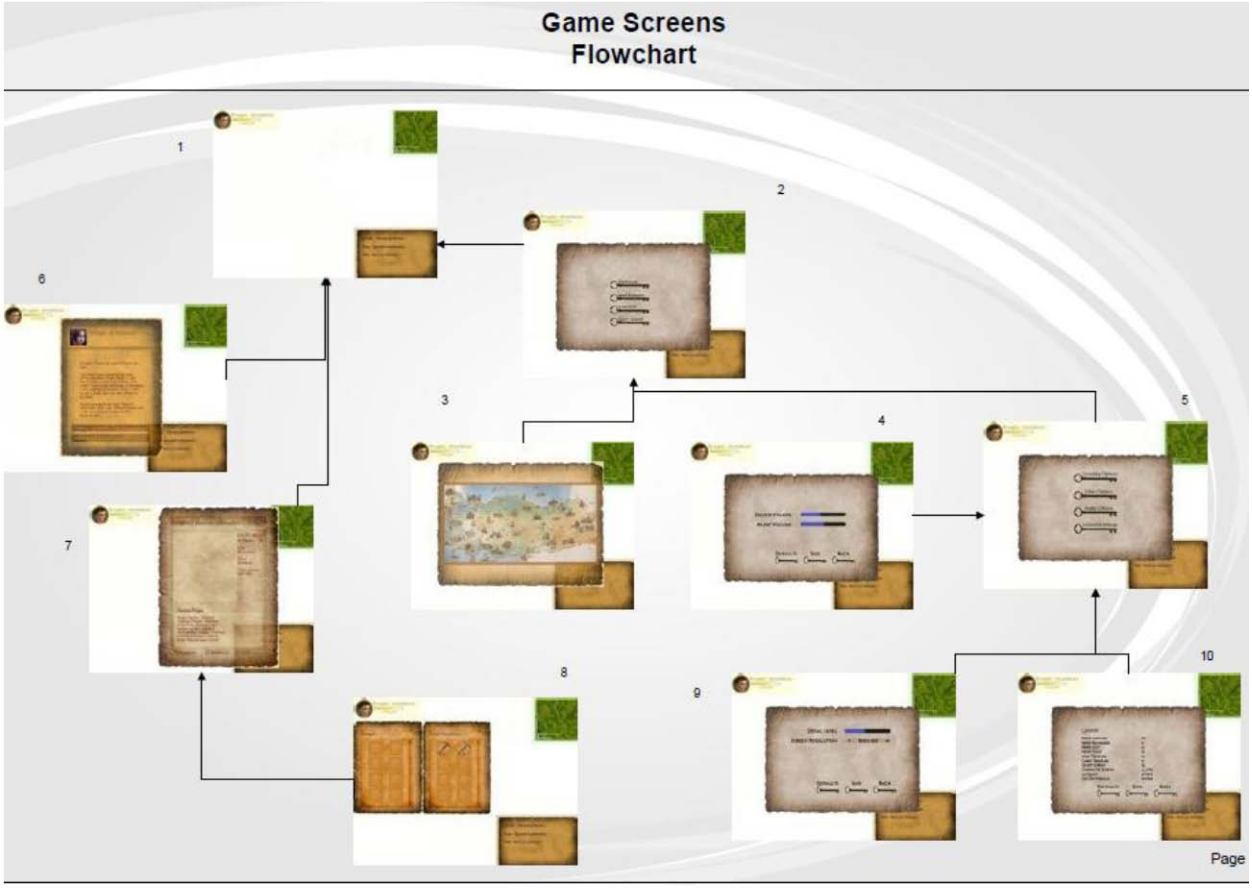


Figure 42: Game Screen Flowchart

The interface denoted with 1 in Figure 42 is the main display screen. Once the user hits ESC, second interface, ESC menu screen, will be available. When the user selects map screen in this page, third interface, Map screen, will be seen. Options screen, denoted with 5 in Figure 42 is connected to audio options screen, video options screen, and controller settings screen, number 4, 9, and 10, respectively. Main display screen is also connected to quest screen, number 6, and character info screen, number 7. From character info screen, the user can reach trade screen.

7 Detailed Design

7.1 Client Network Component Design

Classification This component can be classified as a subsystem of client package.

Definition & Responsibilities This component of the MMORPG handles the client communication with the server through the network. Major responsibility of the network component is to handle message transmission between from the client to the server.

Constraints Memory latency and processing latency are the two most important constraints that client network component has. The system will support memory space up to 1K for each client. For processing latency, synchronization and timing between client network and server are important. The server must respond to client's requests in 3 seconds.

In case of network failure, this component should generate Network exception to be handled by client package. This component should also check the consistency of the messages received. In case of invalid messages that are received by client, this component should send a special message to server after reporting an exception to client package.

Composition Client network component has two main subcomponents, TCP network connection and UDP network connection subcomponents. As their names suggest, these subcomponents are responsible for maintaining a TCP and UDP connections respectively.

TCP Network Connection maintains the interaction between server and client over the Internet. TCP component should enable consistent message passing interface ensuring the ordering and acknowledgments of the messages sent. In case of a connection failure, this subcomponent should report the exception to client network component. This is not necessarily an erroneous condition. In case that only TCP subcomponent fails, UDP component can be utilized to maintain the communication.

UDP Network Connection component should provide an insecure message passing interface to client network component. Therefore, there are no failure exceptions for this subcomponent. Client network component should never rely on messages sent by this component.

Uses/Interactions Client network component is in interaction with physics network component using TCP interface. Physics component uses this component to send the results of performed physics computations.

Server network component is the other component that client network is in interaction with. As explained before, client network and server network send messages each other to maintain a working game routine. All state changes made in client network side, such as login, logout, chat, are reported to server network, and server responds to these messages accordingly.

There is no direct interaction with client network component and management component. However, server network component plays the intermediate role with an indirect interaction.

Resources The component uses Lidgren as software library. The library uses a single UDP socket which delivers a simple API for connecting a client to the server, reading and sending messages. The specific details of processing resource usage have been given in constraints section. Moreover the component uses Ethernet card to connect server network over the Internet.

Processing Processing details of this component has been outlined in system architecture section.

Interfaces/Exports The input interface of the client network component interacts with the graphical user interface of the clients. The messages encoded according to network protocol is transmitted through network. The output interface of the client network component is a TCP channel ultimately reaching to server's network interface.

7.2 Server Network Component Design

Classification This component can be classified as a subsystem of server package.

Definition & Responsibilities The purpose of this component is to enable communication with clients. This component is responsible for updating the information of clients while balancing the network load on the server. This component prioritizes the messages that are sent to clients.

Constraints Memory latency and processing latency are the two most important constraints that server network component has. For processing latency, synchronization and timing between client network is important. The server must respond to client's requests within a second.

In case of network failure, this component should generate Network exception to be handled by server package. This component should also check the consistency of the messages received. In case of invalid messages that are received by server, this component should send report an exception to server package.

Composition Server Network Component has two major subcomponent. These are TCP component and UDP component. They are used for reaching to clients.

Although TCP ensures ordered delivery of packets, it is an expensive protocol. Moreover, even though UDP is unreliable, it is more usable for communication between server and clients.

Uses/Interactions Server network component is in interaction with physics network component using TCP interface. Physics component uses this component to send the results of performed physics computations.

Client network component is the other component that client network is in interaction with. As explained before, client network and server network components send messages to each other to maintain the game logic. All state changes made in client network side, such as login, logout, chat, are reported to server network, and server responds to these messages accordingly.

Resources The component uses Lidgren as software library. The library uses a single UDP socket which delivers a simple API for connecting a client to the server, reading and sending messages. The specific details of processing resource usage has been given in constraints section. Moreover the component uses Ethernet card to connect the server to the network.

Processing Processing details of this component has been outlined in system architecture section.

Interfaces/Exports The server network component interfaces with all client network components in a full-duplex manner. The transmission in between is a TCP channel over the Internet.

7.3 Physics Component Design

Classification This component can be classified as a module that will be used both in client package and server package.

Definition & Responsibilities The purpose of this component is to model physical interactions of players. This component is responsible for physics calculation for the persistent world of MMORPG. The computation includes collision detection and all other sorts of physical interactions of the players. For the purpose of preventing cheating, major computation and checking of the physics engine will be performed on the server-side. The physics component will be present in both clients and the server. Processing of both sides is similar except the fact that the end-results are different. The output of the physics component will be used for cheating checking on server-side while the same results - if not modified - will be used in graphics engine on client-side.

Constraints Physics component should not consume more than ten percent of the overall processing power in client side. Server side physics component should consume less than thirty percent of the overall execution time. Note that these execution times are valid regardless of the actual processing unit. Physics component on client side should allocate less than 10MB of memory. This limitation is extended to 300MB on server side.

Note that the some of the physics calculations should be transmitted over network from client to server. This type of physics calculations are explained in system architecture section of this section in detail. This is required to prevent cheating. Overhead communication for physics calculation checks should be less than five percent of the overall calculation between server and client.

In some cases, client may perform invalid actions due to a bug in client software. In this case, this component should interact with the client network component to report this case. Server will send a valid physics state to client upon receiving this special message.

Composition Physics component has two major subcomponents. These are namely collision detection, object physics subcomponents.

Collision detection subcomponent should monitor the objects registered to physics engine. In case of collision, the detected collision should be reported to client package via a special exception. Binary space partitioning algorithm should be used in this subcomponent. In the case that an object collides with another one with more than 5 unit margin, an exception should be reported to client package. This is not necessarily an erroneous condition. Client package may decide to avoid this condition and report it to the server or allow the two objects to pass each other.

Object physics subcomponent should enable programmer to define objects and their physical properties. Therefore, object physics subcomponent should provide an interface to define an object. This subcomponent should report erroneous conditions to base physics

component and client package consequently. This subcomponent should also interface with collision detection subcomponent to provide the physical properties of the object. For example, collision of a soft object with a rigid one is should result in different outcome than a rigid to rigid collision.

Uses/Interactions Physics component interacts with three components. These are server network component, client network component, and the management component. The properties of these interactions are described in the following paragraphs.

Physics component has modules on both server side and client side. Therefore, this component uses both server and client network components to send the computation results. In client side, the physics component should send the results and parameters of major physical computations performed on client side. The message protocol used in this interaction should be identical to that one used in interaction between physics component and server network component.

In server side, physics component should check the computations performed by clients. To achieve this, physics component should register a protocol to server network component. When a message complying with this component is received, server network component should interact with physics component to check the calculation. When a cheating player has been detected in case of this interaction, the physics component should interact with server network component to log out the player, and report this case to the management component. The interaction between physics component and server network component is not limited to cheating detection. In all erroneous cases where client is assumed to be performing an illegal action without cheating, this component should report this illegal action to management component. This interaction between management component and physics component is extremely crucial since these reports will enable the administrator monitor Virtual Turkey.

Resources Physics component consumes major processing power on server side. It also requires multi-threaded execution not to prevent the server from handling its other major functions. This component also utilizes memory to queue the messages received from client on server side.

Database is another important resource that the physics component utilizes on server side. To check if the clients are cheating, physics component utilizes the database to get the last recorded position of the players.

On client side, physics component uses much less resources. It only requires small amount of memory and processing power to function. The details of this usage has been given on

constraints section.

Processing This component utilities the JigLibX for all physics calculations. All physics calculations are interpreted as calls to JigLibX libraries. Processing details of this component has been outlined in system architecture section.

Interfaces/Exports The physics component on client side interfaces with client graphical user interface. Each movement update of a player is sent to physics component and resulting computation is sent to the graphics engine. The result can be hit-back from a wall, or position change of running action. Every result is crosschecked with the server.

The interface of the physics component is little bit different although the processing is - and should be- exactly the same. The server-side physics engine receives the update information through the server network component and transmits the output to the client network component. The result of this calculation is mostly confirmation of the client physics engine results. In case of cheating, the physics component of the server sends log-out message to client network component.

7.4 Management Component Design

Classification This component can be classified as a subsystem of server package.

Definition & Responsibilities The purpose of this component is to provide the administrator utilities for managing the server. It encapsulates several crucial processing units of the game such as data management, non-playing characters, and game loop. Object-oriented design of each subcomponent enables single and consistent interface to other components in the system. This component resides on server-side. The major sub components are quest system, virtual environment management, account management, and NPC handling. These functions are to be used by the administrator of MMORPG. The software requirement specification for the Virtual Turkey necessitates the management tools described in this section.

Constraints Management Component Design has many constraints since it has many processing units. For processing on data management and game loop unit, enough memory has to be accessible to manage data properly and store status and information of each player. Moreover, non-playing characters unit on this component has to interact with Server and Client component to interchange updating and status information of non-playing characters.

Composition Management Component has three main subcomponents that are data management, non-playing characters handling, and game loop. Data management has several parts, such as account management, quest management. Account management as its name suggests, manages account of players through user interface of management component. Quest management basically deals with essential questing aims. The other subcomponent, Non-playing characters handling takes hold of each NPC on server by using threading system. By the help of this threading system, each handled NPC are gathered on and separated from server.

Uses/Interactions Management Component has two major interactions that are between both client and server since it is actually a module on client and server.

Information such as each player's status are gained on client packet and it collaborates this information with management component. On the server packet, some environmental data which is hold by management component is adjusted. Moreover, information of handled NPCs which is hold in data management is interchanged between server and client by the help of server networking.

Resources Management Component uses many resources. In many subcomponents and parts of them, databases are used as MySQL Data Management Library to provide utilities that administrators need. Database in server side stores account information and status of players. Besides, quest management needs database to store handled questing aims.

Processing Processing details of this component has been outlined in system architecture section.

Interfaces/Exports The component interfaces with administrator via a graphical user interface. The input from Administrator will be handled directly within management component. The results of administrator actions will be transmitted to other components if necessary.

8 Libraries and Tools

Both the client and the server component of MMORPG will be an application for Windows NT family of operating systems. As both components will be developed with C# programming language, Microsoft's .NET 4.0 software framework will be needed. XNA 4.0 runtime libraries will be used for client-side graphics computation. The physics engine of client will

be leveraged by JigLibx which is specifically designed for XNA. For network communication, the client and the server software will depend on LidGren library.

The interaction between server and client will be maintained on TCP channel. All other communications will be carried out on shared memory. The components within the server will use MPI to communicate over shared memory.

9 Time Planning

The plan is to prepare the detailed design report and prototype demo till the end of the semester. Second semester mainly will be based on configuration management, system design development, and system testing.

9.1 Term 1 Gantt Chart

Number	Task	Start	End	Duration
1	**Project Management**	14/10/2010	27/5/2011	226
2	Proposal Report	25/10/2010	4/11/2010	11
3	Software Requirements Specifications Report	5/11/2010	5/12/2010	31
4	Initial Design Report	6/12/2010	16/12/2010	11
5	Detailed Design Report	17/12/2010	4/1/2011	19
6	Web Page	12/12/2010	27/5/2011	167
7	Blog Management	12/12/2010	27/5/2011	167
8	**System Component Analysis**	20/11/2010	10/1/2011	52
9	Server - Client Analysis	20/11/2010	12/12/2010	23
10	Database Analysis	20/11/2010	20/12/2010	31
11	Network Analysis	20/11/2010	1/1/2011	43
12	NPC Analysis	20/11/2010	7/1/2011	49
13	AI Analysis	20/11/2010	10/1/2011	52

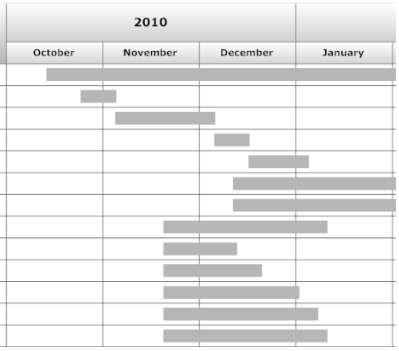


Figure 43: Term 1 Gantt Chart

9.2 Term 2 Gantt Chart

Number	Task	Start	End	Duration
1	**System Configuration**	15/2/2011	1/4/2011	46
2	Server Configuration	15/2/2011	22/2/2011	8
3	Client Configuration	23/2/2011	1/3/2011	7
4	Network Traffic Monitoring	2/3/2011	10/3/2011	9
5	Database Optimization	11/3/2011	18/3/2011	8
6	NPC Management	19/3/2011	26/3/2011	8
7	AI Configuration	27/3/2011	1/4/2011	6
8	**System Design Development**	2/4/2011	25/4/2011	24
9	Client GUI Design	2/4/2011	4/4/2011	3
10	Server GUI Design	2/4/2011	4/4/2011	3
11	Scenario & Character Design	5/4/2011	8/4/2011	4
12	System Resource Development	9/4/2011	13/4/2011	5
13	3D Terrain Modeling	14/4/2011	16/4/2011	3
14	3D Character Modeling	14/4/2011	16/4/2011	3
15	Character Animation	17/4/2011	19/4/2011	3
16	Sound Integration	19/4/2011	21/4/2011	3
17	Camera & Light Adjustments	19/4/2011	21/4/2011	3
18	**System Testing**	26/4/2011	20/5/2011	25
19	Server - Client Test	26/4/2011	1/5/2011	6
20	Network Traffic Test	2/5/2011	6/5/2011	5
21	Database Test	7/5/2011	10/5/2011	4
22	NPC Test	11/5/2011	13/5/2011	3
23	AI Test	11/5/2011	13/5/2011	3
24	Alpha Test	14/5/2011	16/5/2011	3
25	Beta Test & Debugging	16/5/2011	20/5/2011	5
26	Finalization	21/5/2011	27/5/2011	7
27	Post Production	21/5/2011	27/5/2011	7

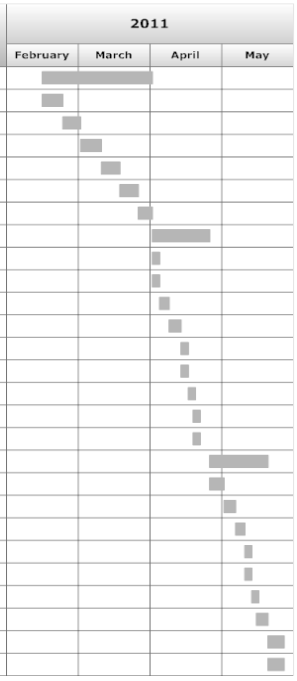


Figure 44: Term 2 Gantt Chart

10 Conclusion

In this document, detailed design for 'Virtual Turkey" has been presented. The design for data model, system architecture, and user interfaces have been outlined. Decomposition of the system to its components has been presented in system architecture section. This design document will guide the implementation. MECAC assumes full responsibility for the design suggested in this document.