EXPLORING LEARNING THROUGH GAMES

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Abstract

Despite the popularity of video games, their effectiveness as a learning tool has still been in doubt. While most commercial games boast a huge customer base and are built for the sole purpose of fun, serious games face more obstacles. The largest hurdle to designing serious games is to balance conflicting values of game designers and educational content designers. Designing engaging serious games requires knowledge from the domains of learning, cognition, and fun. Criteria for the success of a serious game include both fun and effective learning of the educational concepts. This project attempts to look at serious games and their potential as learning tools. Packet Man is an educational game that teaches players the basic concepts of routing through an internet. Playtesting sessions yielded useful insights into which elements work and which do not work for all users. Finally, a case is made for considering games as useful learning tools to motivate students to learn subject content.
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Chapter 1 Introduction

1.1 Objective

The last decade has seen a rapid rise in the popularity of video games. While most video games are built primarily for entertainment purposes, they also provide new ways for people to learn, analyze, and explore. The genre of serious games aims to teach knowledge through games. With the help of interactive learning through games, people are capable of retaining knowledge and developing skills. The primary purpose of our project is to implement game learning and explore the effectiveness of such an approach. We developed a game that enables students to learn basic concepts of how a packet routes through the Internet.

1.2 Learning through games

Some of the principal types of learning concepts used for learning in games include:

*Experimental learning:* This type of learning is based on the principle “If you do it, you learn it”. Players must navigate game scenarios and make decisions with consequences (Merrilea 2007).

*Inquiry-based learning:* This type of learning is based on the principle “What happens when I do this.” A player has the freedom to explore, discover, and experiment to reach the goal (Merrilea 2007).
**Self-efficacy:** The principle is “If you believe you can do it, you will try longer and harder, and you will succeed more often than you would otherwise.” In games, points, levels or magic swords are awarded at positive decision points, encouraging players to continue (Merrilea 2007).

**Goal setting:** The principle is “You learn more if you are working toward a well defined goal”. A principle of science can be taught not only by playing games but also by designing games. Players have the knowledge as well as designers, but designers understand the depth and complexity of the topic (Merrilea 2007).

### 1.3 Concepts and principles

Our game aims to teach basic concepts in networks by allowing the player to experience how a packet is routed through the Internet from source to destination. The player assumes the role of Packet Man and as a packet has to successfully reach the destination. In route, Packet Man has to face obstacles, like hackers that can corrupt the transported data. During the journey, the player will learn the several basic services that are used in the Internet. Packet Man learns some important terms involved in Internet packet routing, like the IP address, MAC address, and Port Number. The game flow describes how a packet goes through different TCP/IP layers at the source and destination. The game also teaches some concepts about routers, such as the operation of the switching fabric, routing tables, and includes the concepts of a packet being dropped if it times out or becomes corrupted in transit.
1.4 Encouragement for students

Studies show that educational games lack the joy of play associated with commercial games (Susi, Johannesson and Backlund, 2007). An educational game, for instance, cannot compete with a commercial game with respect to the funativity quotient (Elements of the game contributed to the feeling of fun). However, these conclusions based on the false assumption that people play games only for fun and entertainment. Instead people play games for a variety of reasons, and we consider one of them: a desire to assimilate knowledge. We believe that the goal of serious games is much more than mere entertainment and it is harder to set design goals for games created to teach particular concepts than it is to design those purely built for fun. We nevertheless included a reasonable amount of funativity without compromising the learning nature of our game. Different players need different emotions to engage with the game, and the game provides challenging goals, so the player to reaches the destination safely. The game is challenging as well as informative. At the end of the game, the player will be familiar with basic concepts of DNS, routers, and the TCP/IP stack.

1.5 Tools and technology

Our choice of a game engine is the 3D Game Studio, which is a game development, game creation, and game authoring system containing the A7 game engine (Engine details 2007). The system contains three subsystems: the MED, used for creating models; the SED, the script editor; and the WED, the level management tool. It uses the lite-C script for programming, its own physics engine, and a library of 3D objects, artwork, scripts, and pre-made games.
1.6 Report Organization

Chapter 2 gives a review of the literature. Related to the genre of serious games and its impact in varied fields. Chapter 3 discusses the approaches and the design choices created to teach players. Game flow is also discussed. Chapter 4 presents the game story, character development, and description of the game world. Chapter 5 analyses the play testing sessions and their results. Chapter 6 discusses design changes made both during the course of the project and after the play testing sessions. Chapter 7 provides the conclusion and future work.
Chapter 2  Literature Review

The primary purpose of creating games is entertainment. Games used for an additional purposes, like education or training, are called serious games (Susi, Johannesson and Backlund, 2007). These games have been adopted in the areas of defense, medicine, architecture, education, and government (Smith, 2007). Serious games allow interested participants to learn and practice in situations difficult to experience in the real world.

Games have the potential to engage students. Serious games focus on problem solving as well as other important learning outcomes. Through serious games, one can develop analytical and strategic skills and insight, learning, and recollection capabilities (Susi, Johannesson and Backlund, 2007). Even violent games can be beneficial if they provide an outlet to alleviate frustration. In addition, gamers develop their thinking strategies toward more analogical thinking rather than trial and error thinking. Game elements like competitive scoring, increasing difficulty, and role playing have proven the value of serious games in corporate training. The negative effects of video violence and gaming such as increased aggressiveness and increased violence are still a subject of ongoing research (Susi, Johannesson and Backlund, 2007).

In 2002 one of the biggest initiatives for serious games occurred with the release of America’s Army (www.americasarmy.com). The United States military developed this popular game and released it free of cost in order to simulate an experience of army life. Col. Wardynski
envisioned “using computer game technology to provide the public a virtual soldier experience that was engaging, informative, and entertaining” (Mendoza, 2008). The game was used as a training application in military; government sectors, and provided virtual army experience. The success of the game was a strong motivation for game designers of this genre. Investigations of the effects of serious games on driving skills (Backlund, Engström and Johannesson, 2006) reveal that prior experience in racing video games has a positive impact on the real-life driving performances. According to gaming instructors, gamers were ranked higher on their overall driving skills than students with relatively low experience in computer games. The results from this study support developing serious games for traffic safety instructions.

Research was conducted on the driving behaviors of traffic school students (Backlund, Engström and Johannesson, 2006). The students were divided into two categories: depending on their experience in racing, action and sports games (RAS-games) the two categories are gamers, and non-gamers. Students whose rating was 1-2 (of 5) were classified as “non-gamers”; those whose rating was 4-5 (of 5) were classified as “gamers.” Students were ranked on the base of 7-pointer scale higher for their skill and attitude. In quick decision making, gamers were ranked 4.8 and non-gamers 3.1. Risk assessment: Gamers were ranked 4.4 and non-gamers were ranked 3.9. Safety margins: gamers were ranked 4.5 rather than non-gamers 3.7. In overall driving skill, gamers were ranked 4.9 whereas non-gamers ranked 3.9. Gamers were more aware of the necessity of driving safety margins and were quicker in decision making. Results show that serious games can be helpful to provide serious knowledge along with entertainment and to provide new ways for people to learn, analyze and explore. (Backlund, Engström and Johannesson, 2006)
Advocates of serious games argue that serious games have a significant potential for learning (Shaffer et al. 2005) (Van Eck, 2006). Serious games have the potential to facilitate different types of learning. Because of the extensive opportunities for drill and practice, players (learners) master skills or information by practicing repetitively. By practicing, learners retain information and acquire skills. Serious games allow learners to practice those situations that are difficult to experience in the real world like mixing lethal chemicals to observe the results (Susi, Johannesson and Backlund, 2007).

A study conducted to investigate the effects of interactivity on science learning among college students revealed that knowledge gain was higher under interactive conditions. Metalloman, a serious game developed by researchers at the University of Southern California and used to teach physiology concepts, was used as a platform for experiments. Conditions were divided into two basic categories: interactive (Game) and non-interactive (Text). In game conditions, participants played the game once. Student interacted and navigated independently to gain knowledge. In text conditions, educational text was shown on the computer screen. Students were allowed to read at their own pace and in the order of their choice. Results showed that a knowledge gain, gained interest in topic, a marginal means of presence as well as means of enjoyment were highest in interactive game conditions and lowest in non-interactive, text conditions. The above results support the use of interactivity for teaching students subject content (Wong et al. 2007).

It is argued that serious games have considerable potential for developing cognitive skills such as critical thinking, problem solving, decision-making, and collaborative social skills (Van Eck,
Games can be used as an effective tool for enhancing learning and understanding of complex subject matter (Susi, Johannesson and Backlund, 2007).

Game Impact Theory encourages industries to adopt game technologies (Smith, 2007). Five forces are compelling industries like defense, architecture, education, government applications and city planning to adopt the game technologies, to replace other industry-specific computer hardware and software suites. These forces are hardware costs, game software power, social acceptance, other industry success, and native industry experimentation (Smith, 2007). To reduce hardware costs most game industries create efficient products that do not require the purchase of new hardware. The aim of a computer game is for the user to be able to use the product without reading the manual. This expertise in creating an effective human interface can be applied to overcome the problem of having complex user interface. The quality of communication enabled by game technologies motivates different industries, like the Entertainment and, Training industries, to adopt them (Smith, 2007). For example, in the television industry, the Discovery and History channels have applied 3D visualization as well as physical modeling to illustrate the behavior of animals, machinery, and the universe. The game industry and its technologies also impact the education industry (Smith, 2007).

Serious games have the ability to motivate and engage students (Rosas et al., 2003). Consequently, researchers and educators are taking an interest in the potential of games for enhancing learning. Studies have demonstrated that the use of games in a learning context can increase student motivation.
Chapter 3 Methodology

Serious games use the medium of games to teach a lesson or provide an educational experience in addition to fun. Today’s students, who have grown up with digital technology, are capable of taking advantage of educational games. A serious game is successful when the player understands the issue that the game is trying to address while having fun. Games are created for entertainment, so creating a serious game with is its entertainment factor is essential. Packet Man tries to teach players how the Internet works and the basic concepts involved in routing the packet from source to destination.

3.1 Educational Content in Packet Man

3.1.1 What is Internet?

The Internet is a network of many interconnected computing devices. These devices are known as hosts or end systems. End systems are connected by communication links through intermediate switching devices called routers. The transmitted information is routed from the sending end system through a series of intermediate communication links and routers toward the receiving end system. The Internet uses packet switching to allow multiple end systems to communicate. In packet switching, the source breaks messages into smaller packets, and each packet traverses through communication links and routers between source and destination hosts. The routers switch the packet from input ports to appropriate output ports. Packets may be dropped due to broken links and delays.
3.1.2 Internet Protocol Stack

An Internet stack consists of five layers: application, transport, network, data link, and physical. Application, transport and network layer protocols are implemented on the end systems whereas link and physical layers are implemented on the network interface associated with the given communication links. The message transmitted is created at the source on the application layer, which is then passed to the next layer. At each layer, the message breaks into data units, and a header attaches to each data unit. The data units move to the physical link and start traveling toward the destination. The destination end system receives the data units and sends them to the protocol stack. At each layer, the corresponding header is removed and passed to the next layer until it reaches the application layer.

**Application Layer:** The message is created at the source containing different fields like hostname, message type and content. The hostname is converted into IP address by DNS. The IP address is used by routers to route the packet towards the destination. The packet is then passed to the next layer, which is the transport layer.

**Transport layer:** Two extra fields, port numbers of the source and destination, are added to the packet received from the application layer. The packet is then passed to the network layer.

**Network Layer:** At the source network layer, a header containing the address of the next hop is added to the packet. Network layers route the packet along a correct path to the destination. Routers are a part of the network layer. They are intermediate devices that connect the source and destination hosts. Routers consist of input ports, switching fabric, a routing processor, and output ports.
**Link Layer:** The link layer provides the procedural and functional services needed to send a packet across local network entities.

**Physical Layer:** The physical layer is the link’s actual transmission medium between two nodes. It transmits the raw bits across two nodes as instructed by the data link layer.

### 3.2 Using Experimental Learning in Implementation

Students can learn through serious games by playing and navigating through the game world. The virtual world in Packet Man is designed to mimic the Internet. The source and the destination hosts are designed to showcase the layers of the Internet protocol stack. The player can learn the concepts of the Internet by playing the role of a packet sent from source to destination. The player has to protect the packet from hackers and reach the destination on time to avoid the losing situation of time out. Making the player play the role of a packet uses the idea of “learn by doing” as defined in experimental learning (Merrilea 2007). By walking through the world and experiencing the same situations as a packet in Internet, players can learn complex concepts in an easier environment (Shaffer et al. 2005). The player goes through each of the layers in the protocol stack in game, collecting items in each layer. This process depicts how a packet is attached with a header at each layer before routing it into the Internet. Similarly, the player has to provide these items at the destination to proceed from the physical layer upwards to the application layer. The headers are removed at each layer before being passed to the layer above. The game has tunnels as links (physical layer) that interconnect the end systems, and the player has to pass through routers to reach the destination. This navigation helps the player understand that the end systems are interconnected by communication links and routers. The
player has to work toward the goal of reaching the destination within a specified time to avoid being timed out and becoming a dropped packet. The scenario described above helps the player understand how a packet travels. But the player will not understand the basic terms involved until detailed guidance is provided. The header items that have to be collected at each layer have significance, and splash screens provide the player information on why he is collecting those items. Packet Man’s game world follows the approach of experimental learning that allows a player to experience scenarios and decisions that he has to make as a packet.

### 3.3 Knowledge Domain to Game Domain Mapping

![Diagram showing Knowledge Domain and Game Domain Mapping](image)

Figure 3-1: Knowledge Domain and Game Domain Mapping
**Knowledge Domain (KD):** Knowledge Domain is a concept you want player to learn.

**Game Domain (GD):** Game domain is a field through which player will acquire the knowledge.

The above figure shows the mapping between knowledge domain and game domain explaining how we applied knowledge into game. It describes one condition which is only a part of the concept included in Packet Man. The knowledge domain includes the network concept we are trying to teach the player and the game domain is the field that incorporates this concept. For example consider the networks concept of headers. The packet starts at the application layer of the source computer and has to travel all the way to the destination computer application layer. The packet needs to attach headers at each layer which are detached at the corresponding destination layer. Without attaching the header the packet is not passed to the next layer. Application layer attaches its header (IP address) to the packet before sending it to transport layer. Transport layer attaches its header (Port Number) and sends the packet to network layer. Here the condition is that application layer’s header should be attached to packet before continuing further to the next layer. To explain this concept through Packet Man we tried to incorporate the condition by having the player collect the IP address from the DNS office before he/ she can collect the port number from the TCP office in the transport layer.

### 3.4 Game Play

#### 3.4.1 Overview

Game Play shows how the game functions and what is the game flow? A third person camera is used in the game. It does not occupy a character but typically floats behind and above the main
camera. Third person cameras are generally preferred in action adventure games, and thus Packet Man.

3.4.2 Controls

3.4.2.1 Procedures

Click the new game button on the screen to start a new game.

Keys to move the packet:

W  Move forward
S  Move backward
A  Move left
D  Move right

Spacebar  Jump

3.4.2.2 Interface

Game interfaces create game experiences and should be easy to understand for the target audience. The Packet Man game interface is designed to include the health status of the packet, the inventory of header items collected and the informative screens to give the players feedback. It also teaches some important terms involved in networking. The basic metaphor of the game is the inventory of header items collected by the player. This inventory tries to teach how headers
are attached to the packets at each layer of the source. These headers are used to find the destination and detach at the layers of destination. The health of the packet is displayed on the screen for the player to visualize the state of the packet. Low on health indicates the fear of the packet drop and the need for the player to collect a health shield.

Informative screens are used to provide feedback to the player. Whenever the player collects header items, a short descriptive screen appears to give details about the term. Other feedback is provided to warn the player about the hackers present in the Internet.

Level wise interface description:

**Level 1:** Interface is designed to meet the requirements to teach how the packet has to travel through different layers of TCP/IP stack at the source. The player can imagine and understand that the player travels through the layers, from top to bottom, at the source.

![Figure 3-2: Level 1 interface](image)
**Level 2:** The interface is designed to show how the player travels through the physical layer and needs to go through different hops before reaching the destination. This level depicts that hosts are connected through communication links and routers.

![Level 2 interface](image)

*Figure 3-3: Level 2 interface*
**Level 3**: Level 3 is designed to show the layered architecture of the destination end system. The player can understand that the packet is passed through these layers from bottom to top in order to deliver the data to the destination. The packet is passed from the network layer to the transport layer and, finally, to the application layer.

![Level 3 interface](image)

*Figure 3-4: Level 3 interface*
3.4.2.3 Rules

The player has to collect the header items provided at each layer. The Failure to collect an item at any layer would forbid the player from collecting the item at the next layer.

The player has to have all the header items from the source; otherwise, he cannot arrive at the destination. He needs to provide the item at the respective layers of the destination.

The player needs to avoid broken links and hackers to save the packet from being dropped.

3.4.2.4 Conflict

Obstacles: Other packets traveling through the Internet are obstacles to the player. The player packet can be delayed if it bumps into these packets.

Opponents: Hackers in the Internet try to steal and change important data carried by the packets. These hackers stop the player from reaching the data to the destination.

3.4.2.5 Resources

Health: The Packet is dropped when the health is low. The player needs to stay away from hackers to avoid a decrease in health. Health shields are provided to increase the packet health.

Inventory: The Packet is attached with header items at each layer of the source, and these headers are required at the respective destination layers. An inventory is provided to keep track of header items collected as the packet moves toward destination.
**Time:** The packet has to reach the destination on time to avoid timing out and dropping. Time is provided as a resource to let the player know that he has to reach the destination in the given amount of time.

![Figure 3-5: Inventory, Health and Time resources in the game](image)

3.4.2.6 Scoring/Winning conditions

The scoring condition is to avoid hackers and collect health shields on the way toward the destination.

The winning condition of the game is to reach the destination by avoiding data corruption carried by the packet and avoiding packet drop or packet timeout.
3.4.3 Levels

Packet Man is comprised of three levels.

**Level 1:** The source from where the player starts the game. The player has to go through different layers and collect the header items at each layer.

**Level 2:** The player has to go through different routers connecting the source and destination. They are interconnected through cables that are tunnels in the game.

**Level 3:** This is the destination is where the player needs to deliver the data. Again, the player has to go through different layers to accomplish the objective.
3.4.4 Flowchart

Figure 3-6: Flowchart describing game flow
Chapter 4    Game Development

4.1 Game Story

4.1.1 Synopsis

Packet Man is a packet. He carries data that has to reach the destination successfully without getting corrupted. As he makes his way through the various layers, Packet Man has to collect certain items needed for him to reach the destination. He will also have to be wary of hackers who try to corrupt the data. Packet Man has to collect shields that protect the data from hackers. Packet Man will also have to make choices on his route and avoid busy or broken routes. At his destination, Packet Man has to submit all the items he has collected at each layer in order to deliver the data to the recipient.

4.1.2 Complete Story

Packet Man is a story of a packet containing data that has to reach the destination without getting corruption. Packet has to travel through different layers and routers on the Internet to reach the destination. Packet Man will be provided with informative splash screens on his route.

Packet Man starts from the source with data. On his way, he has to collect certain items as he passes through each layer of Level 1. He has to collect each item in sequence. Any missing item will not allow him to collect the next item. Failure in collecting all items will result in not proceeding to the next level. Packet Man has to know the MAC address of the next hop in the Internet toward the destination.
When Packet Man gets into a router, he has to make choices for the route he will take toward the destination. Packet Man is provided with information to decide the route to take. He has to reach the destination without being dropped or delayed. Packet Man will be dropped if the health is low and will be delayed by wrong choice of a route. There are many hackers waiting in the Internet to hack the data carried by packets. A shield gives Packet Man extra health. The shield represents encryption that secures data and provides protection against hackers. Delay and dropped packets make Packet Man unable to complete the mission and ultimately to lose the game. So Packet Man has to be careful while making his journey through the Internet toward the destination.

Once Packet Man successfully bypasses the Internet and reaches the destination, he again has to go through different layers of destination. At each layer, he needs to provide the items collected from Level 1. He can only make it to the next layer by providing the appropriate item required by the layer. Once he provides all the items and passes all the layers, he can deliver the data to the recipient.

4.2 Character Development

4.2.1 Character Design:

Characters play important roles in completing any game or story. Proper and relevant characters are a must for any game to be successful. Every character is defined differently in the game according to its behavior and characteristics. There are player characters (PC) and non-player characters (NPC) in the game. Non-player characters are designed to provide challenges to the player character Packet Man. These characters increase the game play and are as important as the
player characters. Besides these types there can be other characters that might not be so important, but add to the game play.

Packet Man game is designed to teach the basic concept of how a packet is routed through an Internet. Packet Man plays the role of a data packet in the Internet. The hackers in the Internet are the NPC characters. They represent the antagonists. Packet man has to avoid them to prevent data corruption. There are other packets, too, in the Internet, so we designed the other packets as non-player characters accompanying Packet Man. Packet Man should not bump into these packets to avoid delay.

4.2.2 Character Types

4.2.2.1 PC’s (player character)

Packet Man is the only player character in the game. Packet Man has to complete the game by facing challenges and making decisions while trying to complete every goal presented in the game at each level thus leading to the final objective of the game. Packet Man is controlled by the player, and his behavior depends on how the player plays. Player makes decisions through the character of Packet Man.

Figure 4-1: Packet Man
4.2.2.2 NPC’s (non-player character)

Enemies

Hackers are the enemies of Packet Man, and they are present in the Internet. Hackers try to hack the data carried by the packets. These characters provide challenges to the player, and player has to be aware of them. These may lead to a decrease in the health of the player finally resulting in a dropped packet. The player cannot control them, these characters act on free will.

Friends and allies

Other packets in the Internet are also included. These packets are not harmful to the player, but they may act as obstacles and may delay the packet. These packets also lead to congestion in the Internet. The player should avoid bumping into these packets to avoid delay. The player cannot control them; these characters act on free will.
4.2.3 Guidelines

Besides characters, guidelines also aid to the appeal of the game. Guidelines in a game must be adequate and appropriate to provide the player feedback. Consequently, we included splash screens in our game at each level. Whenever a player collects an item, a splash screen provides information regarding the importance of the item in the Internet. When player bumps into any hacker, another splash screen warns him to be cautious of other hackers. Also, help is provided for the player to understand the rules and procedures of the game. This information helps the players, and it makes the game easy to play. When players play multiple times, they do not like to read such screens repeatedly. The player can skip the information by pressing the skip button on the screen.

Figure 4-4: Splash screen guideline for player about hackers in Internet
4.3 Game World

4.3.1 Overview

Packet Man is a serious game that aims to teach the audience how a packet routes through an Internet from source to destination. The game world in Packet Man is basically the Internet world and includes different devices in the computer network such as source and destination hosts, routers and cables. The game world includes characters that depict the packets routed in the Internet and hackers who try to obtain important information carried by the packets. The game has different routes to reveal all type of routes including congested, broken and long routes. It also shows the different layers in the TCP/IP stack and the headers required at each layer for a packet to reach to the next layer in the stack.

4.3.2 Key Locations

Based on the game story, the game world is comprised of the following key locations:

Source: The player (Packet Man) starts the game from the source. This location is composed of the layers of TCP/IP stack, including the application, transport, and network layer. The player has to collect all the header items required to attach the packet at each layer or he cannot move to the next layer of TCP/IP stack.

Routing office: At this location, the player is provided with the MAC address of the next hop. The player has to go through different routing offices that connect the source and destination devices. The player also has to choose the right tunnel (channels) toward the destination to reach the destination on time without getting corrupted or dropped.
**Tunnel:** The location depicts the channels that connect different routers (routing offices) and other devices (source & destination) participating in the Internet. Tunnels can be broken or congested with traffic. The player has to go through the tunnels to reach the next hop.

**Destination:** The final location of the game. The player has to go through different layers of the TCP/IP stack again. Starting from the network layer player has to provide the header item attached to the packet to move toward the transport layer. When all the items are detached and the player reaches the application layer, the data can be delivered to the destination to complete the objective of the game.

### 4.3.3 Travel

Traveling is the best way to explore any world. The same applies to game world. Player can explore, understand and attain the objective of the game by traveling. The Packet Man game allows the player to explore the Internet world. The player can learn the basic concept of how a packet routes from source to destination in the network. The journey starts at the source from where Packet Man is instructed to carry data to the destination. We have tried to convey the concept of layering by structurally designing the destination host as comprising of each of the layers in the Internet stack, one on top of another. We hoped the student would learn the Internet protocol stack. Once the player succeeds in traveling to destination by making his way through the Internet, he successfully completes the journey by delivering the data at the application layer.
In the above figure the player enters the transport layer to collect the header item without collecting application layer header item. The inventory does not have the IP address item displayed and hence the player is not allowed to collect the item. An alert message is displayed to let the player know that application layer header item needs to be collected before attempting to collect transport layer item. This will allow the player understand that at each layer headers are attached to the packet and only then the packet is sent to the next layer.
In the above figure the inventory has the IP address item. The player can collect the transport layer header item (port number). This will allow him to collect the next layer header item and continue further.

Figure 4-6: Transport Layer Header item
In the above figure the packet has reached the routing office from where it has to pass through different routers to reach the destination. Here the player is collecting the shield which increases the health of the packet to safeguard from hackers on the way towards destination.
The above figure shows the packet reaching the destination network layer. The player has to provide the items collected at the source in order to go to the next layer. This will help the player understand that the headers attached at the source are detached at the destination at the corresponding layers.
The above figure shows that the mission is completed and the packet successfully reached the destination thus indicating that the player has won the game.
4.3.4 Physical Objects

Packet Man game includes the following physical objects.

**Header items:** At each layer of the source there are header items that are abstract objects. Player needs to collect these items at each layer or he will not be able to complete the goals.

![IP Address Port Number](image)

Figure 4-10: Header items

**Shield:** These objects are present in the router level. Shields help the player increase the health and save the packet from being hacked. Again, these are abstract objects.

![Shield](image)

Figure 4-11: Shield

**Information screens:** Information screen objects pop up either showing information about some important aspects of the network or to give feedback to the player.
MAC Address is a physical address that uniquely identifies each node in the network. In TCP/IP, when provided with an IP address, ARP (Address Resolution Protocol) helps find the MAC address of a node on the same physical network.

Figure 4-12: MAC address Information Screen
Chapter 5  Playtesting

Playtesting is a process essential to the success of a game because it allows the game designer to gain valuable feedback from a target audience. Further, it is important to note that it is different from an internal design review and quality assurance testing. An internal design review consists of the game developers playing and discussing the game features. Quality assurance testing is about testing each of the game features for correctness. Playtesting is a design process that allows the game designer to know if the game succeeds in involving the player the way the designer wanted.

5.1  Preparing for Playtesting

The initial playtesting in the concept and production phases is primarily performed by the game developers to understand how the game works. The self-testing in the earlier phases helps develop the fundamental ideas and know if the game is reaching its design goals. The next level of playtesting involves bringing in friends and colleagues who have the patience to play an incomplete prototype of the game. This stage is important because the game is still in development, and feedback from a person outside the project team is needed to discover things that may have been forgotten. It is, however important, to keep in mind that playtesting with confidants is not the ideal form of testing. Friends have a personal relationship with the designer, which clouds their fairness in giving feedback.

When the game is close to playable, it is time to start searching for the right playtesters. The ideal playtesters are people unknown to the designers and are part of the target audience. For an
educational game like Packet Man, an ideal playtester would be a young person attending college who wishes to know how an Internet works. Selecting diverse playtesters among the target audience will allow for a wider range of feedback.

5.2 Conducting the Playtesting Session

*Introduction:* Welcome the playtesters and thank them for participating. Introduce the team and a bit of what you are doing. Tell them how this session will help you improve your game and appreciate them for taking their time out to playtest the game.

*Warm up Discussion:* Ask the testers whether they are experienced gamers. Tell them Packet Man is an educational game and aims to explain how a packet is routed through the Internet.

*Play Session:* This is an alpha release of the game still under development. Stand behind the playtesters and ask them to say what they are thinking while they play the game. Make sure to note down where the players had a problem in the game.

*Discussion on Game Experience:* Close the session and ask the testers for feedback. Tell them your objective in building the game and ask them a few questions.

5.3 Playtesting feedback

Different methods of playtesting exist. We used feedback forms that we gave to each tester. The feedback form contains a list of standard questions. This method of playtesting allows for high quantitative feedback (Fullerton 2008). We have tried to keep the number of questions in the
feedback forms brief as the quality of responses from the playtesters deteriorates beyond 20 or more questions.

The following are the list of questions used in the playtesting session of Packet Man.

**In-Game Questions:**

1. Why did you make that choice?
2. What is confusing you?
3. What did you think that would do?

**Post-Game Questions:**

**General Questions:**

1. What was your first impression of the game?
2. Did the game drag at any point?
3. Did you feel like the game was informative?

**Formal Elements:**

1. Describe the objective of the game.
2. What part of the game do you feel could be improved?
3. What was the most important decision you made during the game?

**Dramatic Elements:**

1. Did the game’s story appeal to you?
2. How would you make the story and game work better as a whole?

**Rules and Interface:**

1. Were the instructions easy to understand?

2. How did the controls feel?

3. Would you suggest any changes to the controls?

**Educational Elements:**

1. What was the basic objective of Packet Man?

2. How does the routing table in the second level help Packet Man reach his destination?

3. What can harm a packet while it is traveling?

4. Name two layers that Packet Man has to visit before he can reach his destination.

5. What is an IP address?

6. What layer does Packet Man travel through?

**End of Session:**

1. What elements of the game were attractive?

2. If you could change one element, what would it be?

3. Given a choice, would you consider educational games as a learning tool as opposed to lectures.

The in-game questions aimed to uncover anything confusing to the player while navigating the game. The testers were asked the reason for their choices they made in the game and whether the
effect of making the choice was appropriate. The feedback revealed that people generally had a good reason for their choices and the effect of making that choice was appropriate. For example, a player’s reason for staying away from the hacker was that he did not want to lose his data. This response proves that the feature of a hacker stealing data is being conveyed to the user.

The general questions asked the testers their first impression of the game. A lot of testers were comfortable inside the environment of a 3D educational game. The testers felt it was informative though they wanted more educational elements in the game. They seemed motivated at the idea of learning through games.

The formal elements questions address the structure of the game. The testers felt the objective of the game, which required they route a packet through the Internet, was understandable. They felt the game story could be improved to motivate the player to reach the destination.

The dramatic elements questions address the emotional involvement of the player with the game. The dramatic elements are where a balance has to be established between the funativity and the educational aspect of the game. Testers felt more sounds and better interaction of the storyline with the game could improve the dramatic aspects of the game.

Most testers were comfortable with the rules and interface design. The controls were easy to handle and the rules to finish missions were satisfactorily shown using the splash screens. However, a few testers wanted to use the arrow keys for movement instead of the provided {w, a, s, d} keys.

The number of questions asked about the educational aspects of Packet Man was relatively high considering the goal of the project was to explore learning using games as an educational tool. The questions regarding the objective of Packet Man and the need to avoid data loss through
contact by hackers were answered by most testers. The questions regarding terms, such as what an IP address is, proved to be more difficult to learn. Discussions with testers revealed that the “Skip” button on splash screens was used by the players to skip without reading the information given. A better design approach might be to quiz the player immediately after he picks up the IP address item, so the player learns what he picked up. The testers were also able to adequately answer that the packets travel through the physical layer. This knowledge indicates that the level design of the physical layer might have helped in the player learning through the experience of traveling through the layer. The exact functionality and use of the layers were poorly answered, which indicates that more information might have to be provided to tell the player why the Internet architecture needs layering.

The end-of-session questions concerned the overall impression of the game. The testers seemed to like the graphics, user interface, and controls. They seemed to like the in-game feedback at most levels. They wanted more variation in the background music though. The testers felt that learning through games was more fun than attending lectures. However, most testers would not be willing to substitute games for classroom lectures. Instead, they would rather use them as an additional learning tool.
The first prototype of Packet Man was built focusing on the dramatic elements. While the dramatic elements improved player involvement and funativity, they impeded the educational content because players found it difficult to focus on learning. This focus problem was due to the player being too involved in interactions or missions that had no educational elements. The design was subsequently changed to a game built on the science of learning, with the funativity elements aiding educational elements.

The feedback gained from the playtesting session was valuable. The various suggestions made by testers were examined and we decided on a few changes to enhance the player. While the testers were pleased with the overall structure of the game, they wanted to see more dramatic elements in the game. The hacker, which acted as the enemy, was previously stationary and testers wanted a more active hacker to make the game more challenging. We redesigned the hacker, so he moves around in the tunnel and tries to attack Packet Man. The music was another aspect of the design that needed to be revamped. A variety of music to enhance the dramatic elements has been added. An increased number of signboards and closed paths have also been added to improve player feedback. The closed paths in the first level will help the player from wandering and losing his way.
Chapter 7  Conclusion and Future Work

7.1  Conclusion

Learning through games is an effective method to enhance and retain the knowledge gained in the classroom. Games can be used as learning aids. The motivation to learn through playing games is high and the ability to retain such knowledge learned will be high, too, because the player experienced learning by doing in a virtual world. Making design goals for a serious game to teach people is much harder than those for commercial games built only for fun. This project reveals the need to understand more deeply the pros and cons of using educational games for learning.

An insight we gained during the playtesting sessions was that different players have varying rates of learning. Among the playtesters, 60% of them were the computer science students and 40% were students from electrical engineering. These playtesters were having the basic knowledge of computer networking. For example, some of the students were having an idea of how DNS work; some of the students were having an idea of layered architecture. Gamers in general have different levels of expertise while playing a game. The same is true of gamers in an educational game. They have variable learning curves. Some of the playtesters from electrical engineering and computer science had played so many games. Playtesters (gamers) were navigating the scenarios in the game and thus were having an edge over the Playtesters (non-gamers) with respect to knowledge gain and game play. One vital element of games is the amount of feedback given to the player regarding the things they do in games. A player should be assured with an adequate feedback of every action he takes in the game. While we have provided adequate feedback in Packet Man, different players require different levels of feedback. For example,
gamers (playtesters) themselves find out, how to move the character (WASD keys & with the mouse) but, non-gamer (playtesters) were needed help and instructions. A related issue is the varying difficulty by monitoring the progress of the player. A game that moves at a rate matching the player’s capabilities and keeping it challenging enough without making it too hard involves the player to the maximum.

People prefer the traditional classroom experience when it comes to learning (Wong et al. 2007). Also building educational games is a highly time consuming process and one that presents as a difficult design problem. Creating games is a complex task consisting of many elements. The success of an educational game depends on an interactive storyline, accurate scenarios and how closely the player identifies himself with the character.

7.2 Future Work

Future work on making the game a multiplayer game where each human player is a packet competing against each other would enable a better immersive player experience.

One of the toughest problems with building educational games is deciding on the basic game design. Developers should focus primarily on the desired learning outcome rather than the funativity part of the game. Dramatic and game elements should serve to aid the learning, not the other way around.

Educational games can serve as a bridge between theory and practice. Players frequently learn through simulated, in-game virtual environments. It is thus important to emphasize the correctness of the game because players generally like to explore the virtual world and manage
to discover spaces (broken links: not a part of terrain) not a part of the primary game flow. If they find any in-game elements that have not been adequately detailed, they may be puzzled by the behaviors. This confuses the players and their focus is diverted from the educational elements.
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3dgamestudio game development system, http://www.3dgamestudio.com/
Appendix A – Game Development System

3dgamestudio is a game development system used for developing Packet Man. This system includes 3D and 2D game engine, level editor, model editor, script editor with lite-C language, compiler and debugger. It includes additional in built elements like textures. It is easy to use system because it helps the developers and provides many online resources like tutorials, different in built models and other elements. It also contains a game template system for basic shooter game and RPG game. To create complex games there is a script editor and developer can use lite-C or other programming language. The latest version released is A7. It was released in 2007 and is one of the fastest game engines available.

A 1   A7 Game Engine

A7 game engine is used to control the behavior of the game world. A7 game engine uses the Adaptive Binary Tree manager to switch between indoor and outdoor levels and BSP rendering tool for indoor levels. It also contains physics engine to manage multiple physical objects and collision engine to detect and manage collision between objects. It has lighting engine and also includes different camera portals. A7 also incorporates the sound engine which helps add sound effects to the game. It includes the network game engine which allows the player to save and load a game. Its client/server mode helps support multiplayer games over a network. It also has 2D game engine but it is not as powerful as 3d game engine.
3dgamestudio provides editors using which the developers can create 3d games. Models and terrains can be created and their behaviors can be defined using the scripting language.

The following are the three editors provided by 3dgamestudio system:

**World Editor (WED):** The main editor of game studio is world editor also known as level editor. Here the developer can edit and create different levels using BSP by adding objects and attaching scripts to control their behavior. We can also add actions to the objects. The WED shows 4 views – top view, back view, side view and 3D view. It also provides with the list of objects currently included in the level. We can also manipulate objects, create objects and also build and run the level.

**Model Editor (MED):** The model editor allows creating models and terrains. The MED has four views similar to WED. Models can be human models or complex models like car, helicopter or other objects. Models are created by meshes put together to form a shape. There is a skin editor which can be used to provide texture to the models. MED uses UV mapping to texture the models. The models can be animated using skeleton of bones or by adding frames.
**Script Editor (SED):** The script editor is where the code for running the game is created using scripting language. The code that defines the actions of the objects in the game is written and compiled in the script editor. This is a basic text editor with compiler and debugger. The script can be Lite-C script or C-Script.

### A 3 Programming Language

Programming language used in creating Packet Man game is Lite-C. Lite-C is a lightweight version of C/ C++. It is easier to learn because pointer handling and other complex functions are automatically handled by Lite-C. Missions to a game can be added by Lite-C scripts. These scripts can be used to manage behavior, reaction, movements of different objects of the game. Lite-C provides direct access to DirectX and OpenGL functions. Lite-C scripts compile faster which is very useful because the game can include many objects and many different functions attached to each object of the game.

(3D Game Studio, 2007)