Behavioural Aspects of Interactive TV

Harikrishnan D
Assistant Professor
IT Division
Cochin University
College Of Engineering
Kuttanadu,Pulincunnu

Dr Sahithi P Siva
Academic Leader
Faculty of Computing
London Metropolitan
University,UK

Remya Gopalakrishnan
Assistant Professor
ECE Department,
College of engineering,
punnapra

Jyothish Chandran G
Assistant Professor
ECE Department
SAINTGITS College Of
Engineering, Kottayam

ABSTRACT
Technological advancements, explosion of tools and integrated developing environments, availability of literature and guidance have made the development of applications for the Web and mobile platforms immensely popular for both the experienced and novice developers. However, in comparison, developing applications for the Television (TV) platform is still not something that many people talk about, even though TV is the most popular technology compared to personal computers today. This paper investigates the state of the play, technical and infrastructural support available and the general interest in developing applications for the TV platforms.

Firstly, the paper discusses the currently available applications that one could classify as typical application for the TV platform, for example Teletext, Channel listings etc. It investigates the popularity of these applications in terms of their usage by the intended audience, i.e. general public, and why the developer's community haven not fully embraced this technology in comparison to platforms such as the Web and Mobile. Secondly, it looks into the technical understanding necessary for developing and deploying these applications and reports its findings on the support available in terms of development tools and the TV service platform and architectural support available, from the developer's standpoint. The focus will be a review of the technical aspects related to convergence of TV broadcasting and the Internet. For example – a) issues concerning conversion between the MPEG format on the TV side to IP format on the server side and vice versa, b) issues related to RTP transportation using TCP and UDP, and c) a discussion on issues such as synchronization and encoding during the convergence.

Keywords
MPEG -2, RTP, UDP, MPEG-4, DVB-HTML

1. INTRODUCTION
The Television was one of the major inventions of the 20th century. By virtue of its capability to entertain and educate at the same time, the Television became a tightly integrated part of daily life. Another 20th century invention that transformed lives was the Personal Computer. While the Television dominated people's realm of interest till the end of the last decade, the Personal Computer has managed to capture the interest and attention of the younger & older generations in recent times. With features like video-on-demand, it has become possible for people to view Television programs on the Computer. Even though Personal Computer has achieved enviable popularity among a large section of the society, there still are sections that have found it difficult to adapt to the technology. These groups include the elderly population as well as the group of people who are extremely hesitant to educate themselves with the basic knowledge of operating computer. These sections of the population prefer the Television as their medium of choice for information. Thus arises the technical challenge of making available the services provided by the Personal Computer on the Television for the elderly and technology-averse crowd.

The solution to this dilemma is the convergence of television and the computer. This can influence the behavioral aspects of the society. The convergence can be achieved in two ways [1] 1.Implement the technology to view programs broadcasted through different channels in a computer.2.Use the TV as the medium for accessing the computer services including web services. Web enabled TV is an example of this. The first method is already in use and is very popular. The second method was launched in mid90's but did not prove to be successful due to its complexity

During past decade, a huge amount of investment had gone into develop an efficient TV interface for accessing the information from the computer. Philips has developed a high definition TV that can be used to access the system information from the user by embedding a special processor inside the TV itself. Highly interactive television has also been developed, including the game consoles like X-Box, which are very popular nowadays with the help of special types of set top boxes that would act as the interface between the web and the television. Though these systems provide high interactivity and effectiveness, they were not able to make a huge impact among the people as compared with other technologies which were able to do it in the market. This is because of the unavailability of a standardized TV system that can perform specialized computer tasks using the web technologies.

All these issues point to lack of proper investigation on the behavioral aspect of the system. It is important to conduct a detailed research about these aspects and find out the possibility of developing an improved system. Altogether the paper addresses the key issues to be resolved which are related with the TV system's behavior as well as it's interaction with the user.

2. THE BEHAVIOURAL ASPECTS TO BE INVESTIGATED

The paper focuses on various issues as part of its investigation which are as follows:

1. The transformation of the content from TV system to IP format and vice-versa.

2. The possibility of a specially devised Hub for Establishing a heterogeneous mode of interaction between different components associated .

3. How to present data in a TV interface

2.1. The transformation of the content from TV system to IP format and vice-versa

The basic investigation starts from acquiring the background knowledge about the different technologies used with existing systems, different standards for representing the data in a TV system and various types of computer servers. Philips™, Microsoft™ and Google™ had developed systems to provide a web interface for TV using a set top box (STB). Recently Netflix Inc announced new high definition TV sets, in collaboration with LG™, to provide online services for extracting details on videos from the server along with other TV programs with the help of a sophisticated remote controller using special functionalities for accessing the web services [2].

2.1.1 Application model for data transportation

The basic model for the execution of various applications, needed for data transportation, is based on the Carousel application in Java™ platform which is explained by [3], [4].

The broadcasting in the TV environment is bidirectional including the return channel communication. The equipments included for this purpose are NHS Hub, broadcast equipments (head-end) and application servers like a web server and a data base server.

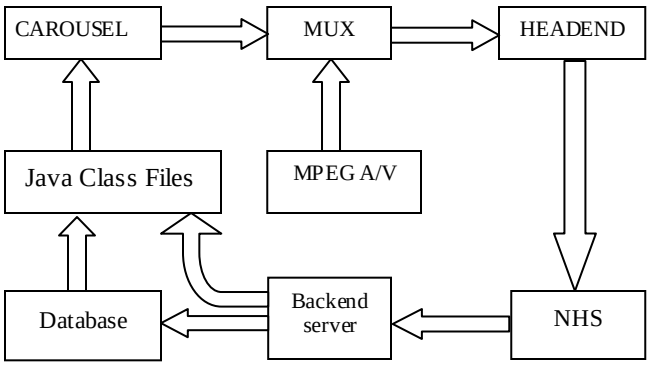


Figure 1: Application execution using Carousel[3]

Figure 1 show how an application is to be played-out continuously using a Carousel. The content is broadcasted to the head-end as a transport stream which is formed by multiplexing the application and its audio/visual material in the MPEG format. This content will be received and decoded in NHS Hub. It's audio and video information will be played based on the Java™ application execution. If the user wants to interact with application again, the information will be sent to the server via a return channel (e.g.: modification or updating of a database).The transmission of data between the TV system and the computer servers is established with the help of MHP applications using data transport APIs.

2.1.2 Transmitting TV broadcasting data over IP network:

The basic format for sending TV information is in MPEG form which uses transport stream for its transmission. NHS server is a remote server which is communicated using IP network. This paper explains the transportation of information based on MPEG-2 and MPEG-4 format.

MPEG-2 uses mainly three popular methods in transmitting video stream over an IP network [5]

- Encapsulating MPEG-2 Transport stream in IP/UDP.
- Encapsulating MPEG-2 Transport stream in IP/UDP/RTP.
- Encapsulation of streams in UDP and RTP.

2.1.2.1 Encapsulation of transport stream in IP/UDP

The transport stream packet in MPEG-2 format will be selected. Each packet is of size 188 bytes which will be encapsulated directly into an UDP datagram format. This will be achieved by separating the transport stream across the number of UDP datagram. There will be a maximum of 7 packets associated with each datagram in an Ethernet based network where Maximum Transmission Unit (MTU) has the size of 1500 bytes (1500/188=7 packets). The encoded information given to NAL (Network Abstract Layer) will be taken to RTP payload. There is some additional information required for the broadcast like clock information specified in Program Clock Reference (PCR) in MPEG TS or in RTCP in native RTP, the application program information transported in PAT or PMT tables in MPEG TS or in SDP in native RTP etc[6].

2.1.2.2 Encapsulation of transport stream in IP/UDP/RTP

IP consists of a header and a payload. The payload consists of UDP packet information. Correspondingly, UDP payload contains RTP packet and RTP contains video data. Total header information is of size 40 bytes; i.e. IP header (20 bytes), UDP header (8 bytes) and RTP header (12 bytes). The final payload contains 1125 bytes data.

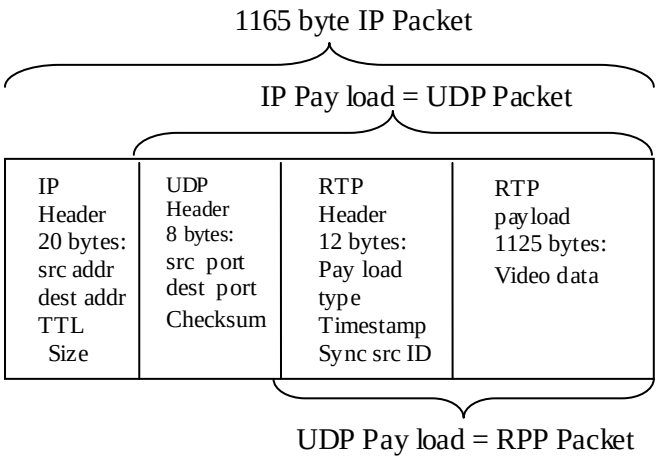


Figure 2: Encapsulating RTP encapsulating UDP in IP packet payload [7]

2.1.2.3 Encapsulation of elemental streams using UDP and RTP

Different types of information like sound, video and other data are carried onto separate streams over IP where RTP is used for encapsulation.

2.1.2.4 DMIF based architecture for MPEG-4 streaming

MPEG-4 uses DMIF (Delivery Multimedia Integration Framework) based architecture for streaming it over the Internet. For the MPEG-4 based transmission, there are mainly two communication planes used in DMIF namely control plane and data plane[8].

The control plane performs the following functions

It manages the session which are associated to overall MPEG-4 presentations.

It manages the channels for the individual elementary stream.

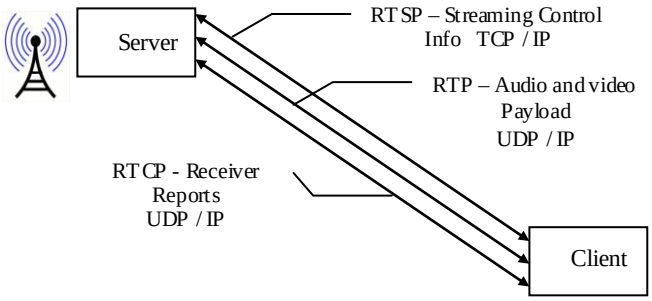
It controls the transmission of user data and commands. MPEG-4 uses the application interface of DMIF for this, which is known as DAI (DMIF Application Interface).

DMIF control plane can use any session layer protocols like RTSP (Real Time Streaming Protocol) and SDP.

In order to access the remote server, a session has to be established with the server. The request from the client (NHS Hub processor) application for establishing the session will be sent to the server. This request includes information for initiation, control and termination of the session. It will be traversed through the transport layer of DMIF to the application thread which listens to the server (using DAI). This will be taken to the application layer of server using the transport connection (TCP or UDP). While the session is initiated, server will send an Initial Object Descriptor (IOD) to the client.

The descriptors like IOD, SOD (Stream Object Descriptor) and BIFS contain information about the creation of channel in the client side for transporting data. It also provides details about how SL packets are accessed in the broadcasting channels. Based on the information available in the descriptors, client will select different data plane channels (i.e. TransMux channels). With the help of control command namely 'play' issued by control plane, client application will request the server to send the data for presentation. The server will request the elementary stream application to send the data to the client [6],[8].

Transportation of the data and the control information between the client (TV system) and the server including the protocol stack used are shown in the Figure 3.



Application Control	Audio data, Video data, Receiver
RTSP	RTP/RTCP
TCP	UDP
IP	
Radio link / Datalink	
Physical Layer	

Figure 3: Data transportation between client and server and the protocol stack used[9]

When MPEG-4 data is to be transmitted in an IP network, SL packet stream which are passed through DAI will be encapsulated in to the payload of RTP packet. If there are multiple SL packets to be transmitted, packets will be multiplexed using a multiplexer like FlexMux. RTP will be encapsulated into UDP and the UDP header will be encapsulated into the IP payload. Here, UDP is preferred over the TCP connection. Even though TCP is a reliable connection, the time for the connection establishment is high. The time factor is crucial for this kind of real time transmission [6],[10].

2.1.3 Choosing a fast and reliable transport protocol

Two types of transport protocols used to transmit MPEG data in the IP network using RTP are UDP and TCP. TCP is reliable and connection oriented but at the same time it is very slow due to the time taken for establishing connection and resending the packet if it is lost. On the other hand, UDP is connectionless and fast. In a real time transmissions using RTP, packets are encapsulated to UDP or TCP payload, but using UDP is the most popular method for this type of transmission. For the implementation of the NHS system, reliability is one of the major factors to be taken into consideration. Various options for achieving reliability are given below:

Even though TCP is reliable than UDP, reliability can still be achieved in UDP transmission at the application layer level during the transfer process.

Microsoft has used R-UDP (Reliable UDP) protocol in the IPTV which provides all the features needed to achieve reliability through the UDP protocol.

By including the RTP packet on to the TCP payload using RTSP (Real Time Streaming Protocol) and STSP can provide the desired reliability.

Transportation using USP (Universal Serial Protocol) which provides an efficient conversion of data from one format into another with high reliability can be taken into consideration.

2.1.4 Various issues related with convergence

The various data transportation issues of the convergence of TV and server need to be addressed while designing the NHS system. These are as follows -

★ Synchronization

The server component of the TV interface system will receive the content in IP format. The user application receives the content in digital Television format. A synchronization of different events associated with the mapping of broadcast content with the Internet application is necessary for the transformation from TV content to the IP content and vice versa.

The synchronization is achieved by using DSM-CC Stream Events which consists of an event identifier and a time reference. Event identifier identifies each stream event uniquely. Time reference shows the triggering of an event at a particular point in the stream. A single DSM-CC event ID can have several time references so that several different firing times can be created by sender to the same broadcast event. The specific TV content can be viewed based on specific group of viewer's interest using this method. A Meta data stream event and specific content information will have to be sent to the IP channel using the DSM-CC streams. The DSM-CC streams will be added with the Transport Stream in MPEG-2 format[11].

★ Encoding of Information

The information carried by MPEG-2 Transport Stream has to be encoded before transmitting to an IP network and decode in the server side. AVC and AAC are the encoding standards used for encoding video and audio data respectively. AVC uses H.264 specification for the encoding of the MPEG-2 stream. The output of the encoder will be encapsulated by a Network Abstract Layer (NAL) defined by AVC which forms the basic fragments of video that will need to be transmitted. NAL consists of video information in the form of video slices. Each video slice consists of separate block of data. A process of transcoding by which original data will be decoded into an intermediate format (e.g. PCM is used for audio decoding and YUV for video decoding) which will be encoded into the resulting file in the target format [5], [7].

Since the traffic characteristics of TV communication and Internet communication is entirely different, it is important to provide proper exchange of signalling and controlling information between the TV interface and the server. In order to provide a broadcasting service, a multicasting technology with its own signalling mechanism, that is entirely different from existing one, is used by the Internet. In the present system, end to end call connection is established with the help of single signalling protocol to be used for the accessing network and the core network.

It is important to provide control requirements for providing the bandwidth for different channels through which applications will have to be sent. Transport protocols should provide reliable interconnection with the server and the TV for data transmission. The network traffic may be affected by congestion, so it is important to provide a congestion controlling mechanism in the network. The network should also give QOS (Quality of Service) and FEC (Forward Error Correction) because of the packet loss between transmission and delay with packet correction due to error [5].

2.2 Establishing a heterogeneous mode of interaction between different components associated using Hub

The most important and integral part in the NHS interactive TV system is to design an interface for connecting TV systems with the IP network. This interface device is known as Hub[12].

The various components to be included while designing an NHS Hub are as follows:

- It should have a processor with all the functionalities of a microprocessor.
- Various types of Memory chips like RAM and ROM to be used for data store.
- Input and output controller for providing 1. Software Interface using set of APIs to establish the connection of NHS Hub with the TV screen, Database server through IP network and also the Remote controller 2. Hardware components for helping software module for its execution.
- Micro Kernel based real time operating system available in the ROM.
- Decoding the MPEG data from TV.Synchronization of audio and video streams.
- Creating NTSC, PAL or SECAM signal for the Television set.
- Network Interface including software modules supported with necessary APIs and the hardware components.
- Security chip uses encryption and decryption of information to be transmitted between the NHS server and the TV interface system.

There are some constraints to be analysed while designing an Hub which are as follows

- Limited memory capacity will be a limitation to store the necessary information for the interaction of TV and the SERVER.
- Processor is not capable of providing extended functionality.
- System will become expensive in order to add more functionality to the system.
- Software interfaces should be flexible and adoptable to the further changes (e.g. adopting a new standard).

2.3 Data presentation

The Television displays the linear content and web provides the interactive content where content can be searched and also indexed easily by navigating from one page to another. During the convergence of web and TV, the data from the web has to be displayed in the TV interface. The User Interface should be designed efficiently so that web content can be presented in TV format in an effective manner. There are various standards used for this purpose[3],[4].

There are different mark-up languages and the styling mechanisms available in the W3C standard to present the data in the browser. DVB uses XHTML as its mark up language. Modularization standard associated with XHTML is used to create new HTML language for TV system named as DVB-HTML.

MHP uses DVB Intrinsic Event module that contains TV oriented events where a set of XHTML events will be replaced by those needed for establishing a TV environment. The different MHP applications like Xlets or DVB-J can be integrated in DVB-HTML document. DVB-HTML provides a mean by which all the audio and video information available with MHP transport stream for DVB services can be accessed. The service provider can send

stylised and formatted data in a packet format with the help of the DVB-HTML applications

The DVB-HTML application follows a well defined life cycle in the user agent for the process of document downloading, decoding, rendering and interaction. The content provider will give instructions for this through a signalling mechanism as defined in the Transport Stream format in MPEG-2, DVB and MHP standards. The content available in the user interface, that uses DVB-HTML, will have to be stylised properly by separating contents and decorating it before rendering. The decoration of contents will be done with the help of CSS2.

3. EMULATOR DESIGN

The proof of concept of the proposed work is demonstrated by developing a working software emulator named as the 'NHS*i*TV - consisting of a TV screen operated by remote control which allows a toggle between live TV mode and NHS*i*TV mode. The basic model of the system consists of two parts: remote control and TV interface. A specially devised remote control is designed for this purpose. The buttons in the remote is designed in such a manner that TV interface is used for viewing channels and also for accessing the specific application from the computer server(in 'NHS*i*TV', the data from hospital database server).The different types of users can access the TV interface by entering their user id and password in the remote control(patients and doctors are the different users in hospital system).

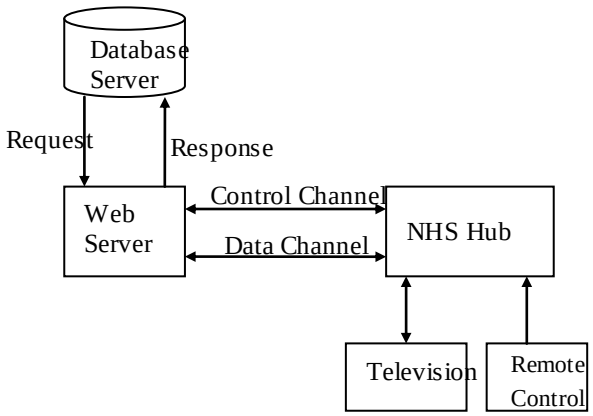


Figure 4: NHS*i*TV System Architecture

3.1 Proposed NHSiTV system architecture

The different components of the proposed architecture are NHS Database, Web Server, NHS Hub, Remote control and Television. NHS Database stores all the information about patient, doctor and staff of NHS. This will be accessed by using the request and will send the result as a response. Web Server will store and process all the information in the web. The request for database information from TV interface is broadcasted to the IP network. This is stored in the web server which will be taken to the Data base server. A Remote control with specially designed buttons will be used for providing the user input. User can select either NHS information or TV broadcasting channels using toggle buttons in the remote control. Television will display the information using the TV broad casting format and standards.

There are mainly two types of channels used for transporting information from TV interface to the server namely Control channel and Data channel. Control channel will carry the various control information like control commands, signalling information and session information etc. Data channel will carry the data to be transmitted between the server and TV.

NHS Hub acts as a bridge between the IP network and the TV broadcast environment. NHS Hub has its own processing capability by using a micro controller based CPU. It uses a real time operating system which will be embedded in a ROM. The translation of the broadcasting content to the IP content and vice versa will be achieved by the set of software modules associated with the NHS Hub which is shown in the Figure 5.

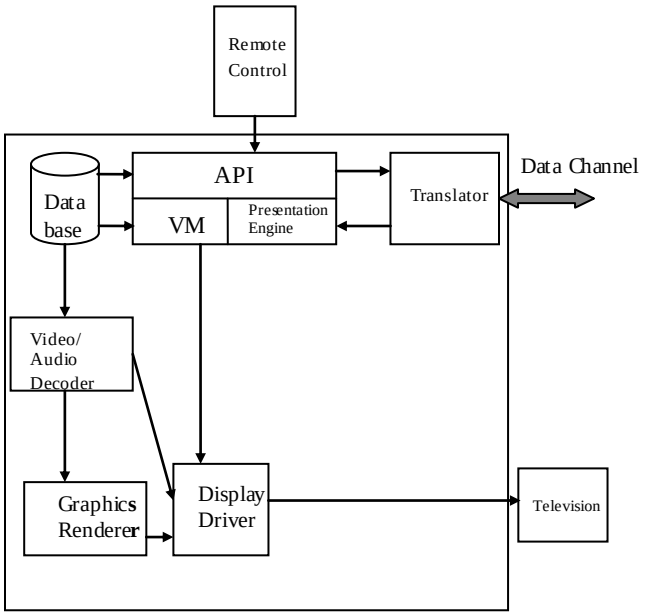


Figure 5: Software Architecture of NHS*i*TV Hub

NHS Hub uses various applications supported by different APIs for the implementation of this system. The user input from the remote control has to be taken to the TV screen. The transition of the state from remote control button event to the TV presentation will be handled by the Virtual Machine (VM) and presentation engine with the help of set of APIs.

The presentation engine will handle the data presentation in the TV screens. The presentation engine will perform the transformation of the data from NHS Database to the TV presentation format with the help of various applications like CE HTML and DVB-HTML.

The translator module will handle the protocol conversion between TV and IP network. TV content in the form of MPEG streams has to be transported to server via an IP network. So there should be some mechanism to handle the transformation of MPEG to IP and vice versa. The application modules in the Translator will handle this by performing various operations like packet encapsulation, synchronization etc.

4. CONCLUSION

This paper mainly focused on the investigation aspects of a TV based system like various issues during mapping the TV broadcasting into an IP network. Various transport mechanisms used for this purpose are well explained here. The proof of concept of the research has been created using a software emulator. This research can be used as a foundation for a detailed research on developing such system which can access a specific computer application in a server using a TV interface.

5. REFERENCES

[1] Kate, W. T. and Radha, H. 1998. Bringing the Web to the TV: Convergence Scenarios. Workshop. http://www.w3.org/Architecture/1998/06/Workshop/paper38.

[2] Clark, D and Wingfield, N. .2009. Internet-Ready TVs Usher Web In to Living Room. Wallstreet Journal. http://online.wsj.com/article/SB123111603391052641.html

[3] Jones, J. 2002. DVB-MHP/Java TV data transport mechanisms. In Proceedings of the 40th International Conference on Tools Pacific: Objects for Internet, Mobile and Embedded Applications, vol. 21, pp. 115–121, ACM, Sydney, Australia.

[4] Gil, A., Pazos, J., Lopez, C., Lopez, J., Rubio, R., Ramos, M. and Diaz, R. 2002. Surfing the Web on TV: the MHP approach. In Proceedings of the IEEE International Conference on Multimedia & Expo (ICME '02), vol. 2, pp. 285–288, Lausanne, Switzerland.

[5] ITU .2009. WG 4 Living lists on IPTV network control aspect www.itu.int/ITU-/IPTV/events/072006/docs/OD/FGIPTV-OD-0011e.doc>

[6] Morris. S, Smith-Chaigneau. A. 2005. Interactive TV Standards. Publisher: Focal Press.

[7] Fisher,Y., Felts, B. and MacAulay, A. 2005. IP Streaming of MPEG-4: Native RTP vs MPEG-2 Transport Stream. Journal http://www.envivio.com/pdf/RTPvsTS-v4.pdf

[8] Mohamed, A., Pourmohammadi, Y., Asrar Haghighi, K. and Alnuweiri, H. M. 2001. Streaming MPEG-4 over IP and Broadcast Networks: DMIF based Architectures.In proceedings. of International Packet Video workshop (PV2001). pp 218-227.

[9] El-Zarki,M.2001. Video over IP . http://www.ics.uci.edu/~magda/Presentations/landscape_part3.pdf

[10] Herpel, C. 1998. Architectural Considerations for Carriage of MPEG-4 over IP Network, ISO/IEC JTC1/SC29/WG11 N2615.

[11] Belleguie, L. 2008. Synchronization of Digital Television Programs with Internet Web Application. US Patent App.

[12] Tanenbaum, A. 2000. Computer Networks. Third Edition. Publisher: Prentice-Hall India.