Infrastructure for IP Networks

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Abstract -- **The Internet -- a *network of networks* is a global system of interconnected computer networks that uses the standard Internet protocol suite *(TCP/IP)* to serve several billion users worldwide. It has no centralized governance in either technological implementation or policies for access and usage. Only the overreaching definitions of the two principal name spaces in the Internet, the Internet Protocol address space and the Domain Name System, are directed by a maintainer organization, the Internet Corporation for Assigned Names and Numbers (ICANN). The technical underpinning and standardization of the core protocols (IPv4 and IPv6) is an activity of the Internet Engineering Task Force, a non-profit organization of loosely affiliated international participants that anyone may associate with by contributing technical expertise.**

Keywords:Internet protocol, TCP/IP, VoIP, IPTV, IP Addressing, ISP Servers

I. INTRODUCTION

THE INTERNET is a global system of interconnected computer networks that use the standard Internet protocol suite (*TCP/IP*) to serve several billion users worldwide. It is a *network of networks* that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless and optical networking technologies. The Internet carries an extensive range of information resources and services, such as the inter-linked hypertext documents of the World Wide Web (WWW), the infrastructure to support email, and peer-to-peer networks.

Most traditional communications media including telephone, music, film, and television are being reshaped or redefined by the Internet, giving birth to new services such as voice over Internet Protocol (VoIP) and Internet Protocol television (IPTV). Newspaper, book and other print publishing are adapting to website technology, or are reshaped into blogging and web feeds. The Internet has enabled and accelerated new forms of human interactions through instant messaging, Internet forums, and social networking. Online shopping has boomed both for major retail outlets and small artisans and traders. Business-to-business and financial services on the Internet affect supply chains across entire industries.

II. HISTORY OF DATA NETWORKS

The origins of the Internet reach back to research commissioned by the United States government in the 1960s to build robust, fault-tolerant communication via computer networks. While this work together with work in the United Kingdom and France lead to important precursor networks, they were not the Internet. There is no consensus on the exact date when the modern Internet came into being, but sometime in the early to mid-1980s is considered reasonable.

The funding of a new U.S. backbone by the National Science Foundation in the 1980s, as well as private funding for other commercial backbones, led to worldwide participation in the development of new networking technologies, and the merger of many networks. Though the Internet has been widely used by academia since the 1980s, the commercialization of what was by the 1990s an international network resulted in its popularization and incorporation into virtually every aspect of modern human life.

The Internet has no centralized governance in either technological implementation or policies for access and usage; each constituent network sets its own policies. Only the overreaching definitions of the two principal name spaces in the Internet, the Internet Protocol address space and the Domain Name System, are directed by a maintainer organization, the Internet Corporation for Assigned Names and Numbers (ICANN). The technical underpinning and standardization of the core protocols (IPv4 and IPv6) is an activity of the Internet Engineering Task Force (IETF), a non-profit organization of loosely affiliated international participants that anyone may associate with by contributing technical expertise.

As of June 2012, more than 2.4 billion people—over a third of the world's human population—have used the services of the Internet; approximately 100 times more people than were using it in 1995.This works out to 34.2$ of the world population.

WORLDWIDE:	2,405,518,376	
-Asia:	1,076,681,059	
	(44.8% of internet users worldwide)	
-Europe:	518,512,109	(21.5%)

- North America:	273,785,413	(11.4%)
- Latin America / Caribbean:	254,915,745	(10.6%)
- Africa:	167,335,676	(7.0%)
- MiddleEast:	90,000,455	(3.7%)
- Oceania / Australia:	24,287,919	(1.0%)

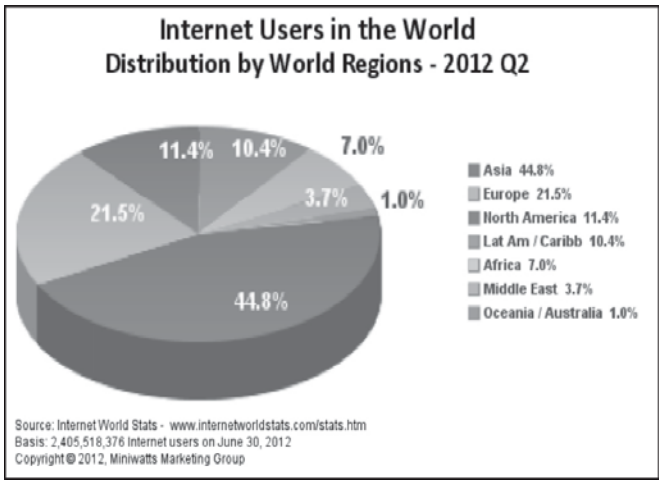

Figure 1. Internet users in the world.

In the developing world, 31% of the population is online, compared with 77% in the developed world. The number of users in Asian countries including china is 1.08 billion, which is about 40%.China is far ahead of India in terms of number of users. It has 538 million as compared to 137 million in India. The main reason of China overtaking India in Internet penetration is due to developing local language skills (Fig.2).

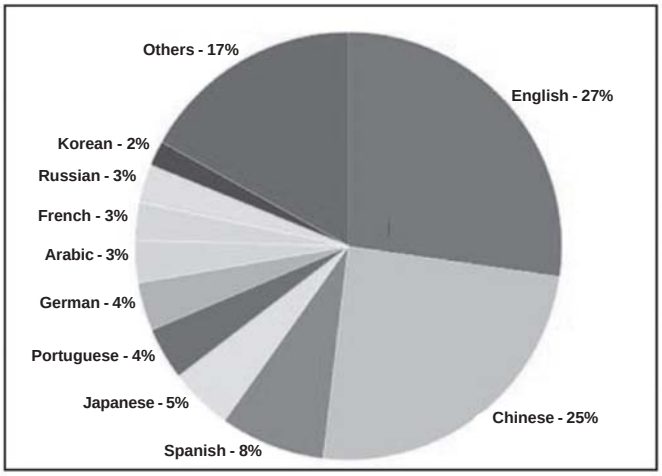

Figure 2. China is overtaking India in Internet penetration.

III. THE IP NETWORK

The Internet is a global system of interconnected computer networks that use the standard Internet Protocol Suite (TCP/IP) to serve billions of users worldwide. It is a network of networks that consists of millions of private, public, academic, business, and government networks of local to global scope that are linked by a broad array of electronic and optical networking technologies.

TCP facilitates the exchange of data (the message) directly between two computers (hosts/clients) on a network-Data Encapsulation or packaging data. IP handles the addressing and routing of data (the message) across the networks.

As an example we can understand TCP/IP with the help of a simple analogy of sending a packet . The IP is writing address on the packet while the TCP is the packet itself. The transport to carry this package is the physical or data layer. The topmost layer called data shown on diagram below is the application part i.e. tracking of package or the courier.

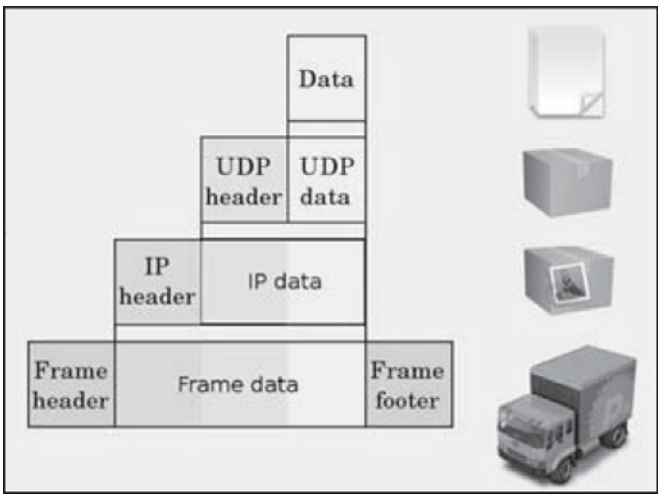

Figure 3. How packet is prepared and sent.

We can now compare the TCP/IP with the seven layers of OSI. Layer 3 of OSI is the IP layer . Layer 4 and layer 5 are the TCP layers. Layer 6 and layer 7 are the application services like email, www. Etc. services.

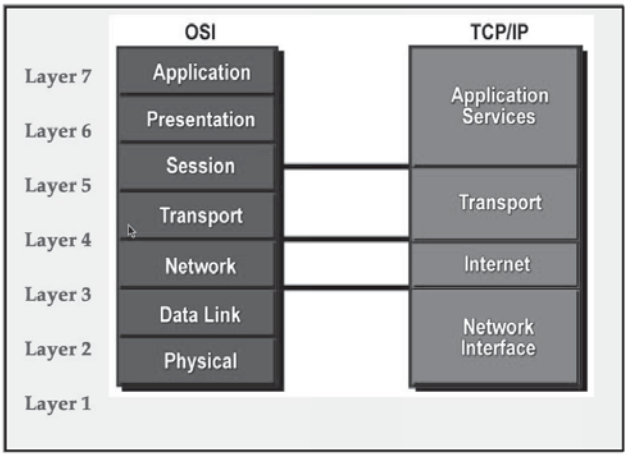

Figure 4. Seven layers of OSI.

IV. WHY IP NETWORKS ARE ADOPTED EVERYWHERE

Internet Protocol (IP) was designed in such a way that it could scale indefinitely with respect to applications and users it can support in an environment of unpredictable growth, allowing "networks of networks" to be constructed. It is a Bidirectional technology.

- Internet Protocol (IP) was designed in such a way that it could scale indefinitely with respect to applications and users it can support in an environment of unpredictable growth, allowing "networks of networks" to be constructed.
- It is open and available to everyone, encouraging rapid innovation.
- It is application-independent, requiring no proprietary application-layer gateways. Services are placed at the edges of the network rather than integrated into the network itself.
- The ability of packets to carry globally meaningful addresses enables network nodes to make autonomous decisions in processing each packet.
- Competing technologies to IP: None, came & died e.g. ATM.

V. IP ADDRESSING

Like any voice networks where the phone users are known by theirtelephone numbers, the situation in IP Networks is a mix of alphanumeric address. Though we donot have pure numbers in our daily use of IP networks, but the network addresses are given by the ISP servers. These numbers are 4 bytes separated a dot like 192.162.1.1. Therefore, each ISP is provided a list of addresses he can use.

32-bit numbering system

- Divided into network ID and host ID
- Grouped into Classes A, B, C, D and E
  - Classes A, B and C are the ones relevant to commercial use
  - Class A: 0-128, Class B: 129-191 Class C: 192-225 Class D: 226-239, Class E: 240-254
- Several IP addresses have been reserved for private and other uses
  - Addresses used in Network Address Translation (NAT)
  - Addresses used of IP multicasting

In order to increase the number of hosts the operators use DHCP (Dynamic Host Configuration Protocol). When a host logs on to Internet, the Host address is given by ISP servers such as BRAS (Broadband Remote Access Servers) that primarily have the capability of AAA (Accounting, Authorization and Authentication). When the host logs off the address is put back into the pool and when next host logs on the same address may be allotted to different host.

There is another feature called Subnet mask being used to increase number of users i.e. to subdivide the main address into small number of addresses. The advantages of sub-netting are:

a) Traffic flow control
b) Router Implementations
c) Preserve Confidentiality
d) To take care of dispersed sites.

VI. IPV4 AND IPV6

Presently we are using IPV4 (IP Version4) of addressing . As mentioned earlier, this is a 32 bit addressing system divided into four blocks of 8 bits each. This gives us the number of addresses approx.. 4.2 billion. Initially, this was considered sufficient as the number of hosts is about one billion.

We are going to enter into an era of intelligent homes and intelligent cities wherein each device or RFID will be given an IP address. So it was felt that we will fall short of IP addresses. The international committee on Internet decided to go in for 128 bit addressing. This is called IPV6 (IP version 6) This will give us number of IP address as 5x1023.

VII. COMPONENTS OF AN IP NETWORK

An IP network is designed based on multiple factors like services to be offered: Internet/ VPNs/ IPTV etc, PoP locations, bandwidth requirements, access mechanisms etc.

- A network would consist of switches and routers. A router is a special type of computer. It has the same basic components as a standard desktop PC. It has a CPU, memory, a system bus, and various input/output interfaces. A router Stores routing tables and is responsible for all routing in the IP network. The router routes packets based on the IP addresses that are assigned to each host on the network, and at like endpoint identifiers. IPv4 is the most prevalent IP addressing version in use today. However, the IPv4 addresses are limited in numbers, and we need more addresses to connect more devices on the Internet. Hence the trend is now to move to a bigger addresses space that is defined in version 6 of addressing and generally written as IPv6. Where IPv4 has a 32 bit address and can cater to 232 addresses, IPv6 has 128 bit addresses and can accommodate 2128 devices.

Like any telephony network there are basically three components

- Core
- Distribution
- Access

*Applies regardless of the size of the network (Global/ National/ City).

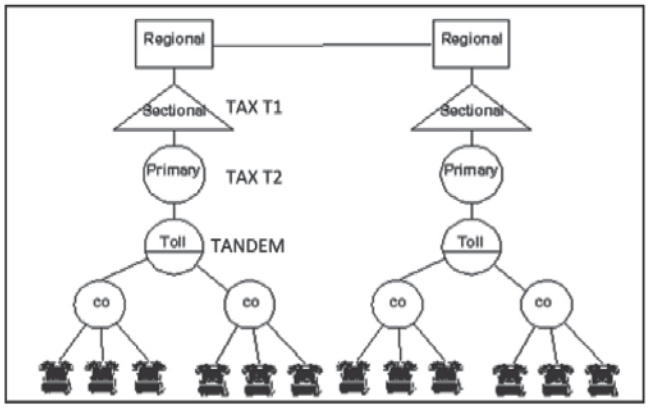

Figure 6. Hierarchical public switched network.

Since data Networks on IP follow four layers as given in the preceding para 3.0, there is a need for introducing application layers also. These application layers are connected to core networks in IP infrastructure. Basically the applications are mail servers, web servers and content data networks (CDN). Therefore, IP networks can be classified as:

- Networks
- Access mechanism
- Support Systems
- Applications Specific

NETWORKS

As seen from figure above, there is a core network at the top layer. The core network is configured on Multi Protocol Label System (MPLS). In a normal network deployed in aggregation and access stage, the routers have to read IP address of each packet received and there being complex routing in a large network, there is a delay in processing the packages. More so when the IP traffic is growing by leaps and bounds daily, there is need to curtail delays in sending packets. To make the network routing faster, MPLS system is deployed at the core segment. In MPLS, a virtual address is added at the entry point which routes the packages faster.

Access Networks: Access networks in a broadband network consist of CPE (Customer Premises Equipment) and DSLAM (DSL Access Multiplexers). The DSLAMS are located in the premises of ISP(Internet Service Providers) and CPE is at the users place.

A Digital Subscriber Line Access Multiplexer (DSLAM) allows telephone lines to make faster connections to the Internet. It is a network device, located in the telephone exchanges of the service providers, that connects multiple customer Digital Subscriber Lines (DSLs) to a high-speed Internet backbone line using multiplexing techniques.

The CPE is in two parts namely splitters and ADSL (Asymmetrical DSL). The splitters have the following functions

- Separates the 300 Hz to 3500 Hz voice channel from upstream and downstream channels.
- Pass voice, dial tone, ringing and on/off hook signals
- Consists of a lowpass filter (LPF) for POTS and a highpass filter (HPF) for upstream/downstream channels
- Passive device
- Contains lighting protection circuitry.

Support Systems: To make the networks adopt to the users conveniences and make it more efficient, support systems are added in the networks. One such system which is applicable to India is called NIXI(National Internet Exchange of India. These exchanges are part of NIIB (National Internet Infrastructure Backbone) which was created to make networks adopt to Indian

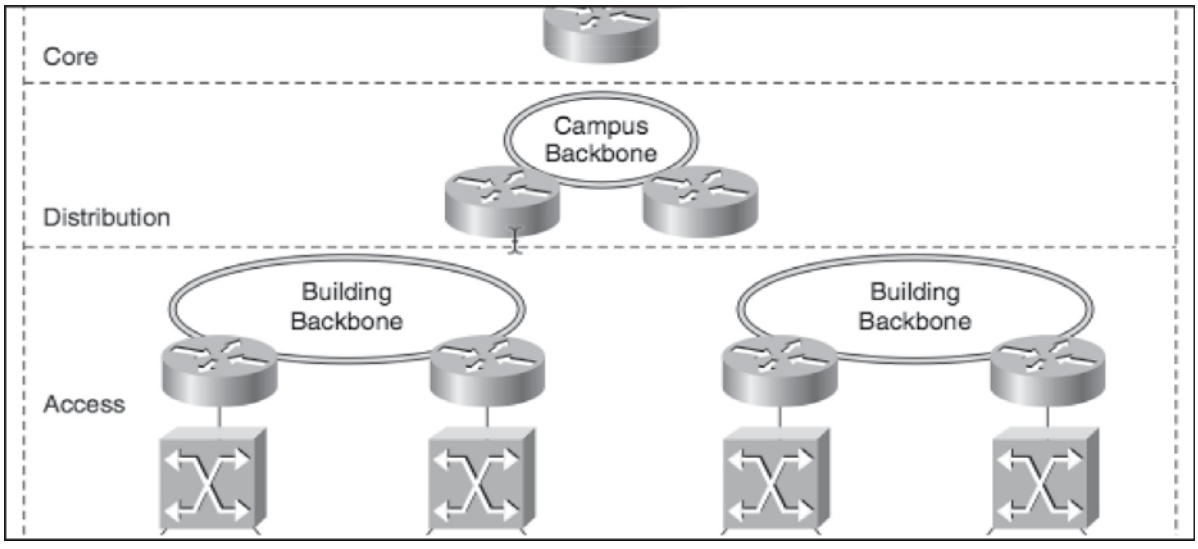

Figure 7. Internetwork IP structure.

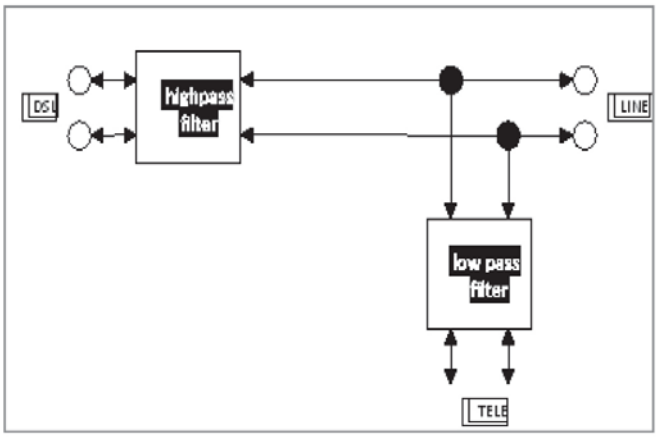

Figure 8. Working of a splitter.

conditions. These NIXI exchanges were added into the network in year 2003.

Before 2003 all the domestic traffic used to travel on international circuits and causing network congestions on international routes and also adding to costs. Therefore it was decided to set up 7 NIXI exchanges in Delhi (Noida), Mumbai, Kolkatta, Chennai, Hyderabad, Bangalore and Ahmedabad. These NIXI exchanges are connected on the core networks and any domestic traffic is passed into domestic networks.

Domain Name Service (DNS): One of the most interesting and important parts of internet is the Directory service or Domain Name Service .DNS enables Human readable names to be quickly translated into IP addresses that are needed to route the packets across networks.

The human readable addresses are structured from right to left e.g. akg@ernet.com. First we know that it .com domain. Similarly if it is akg@ernet.edu it is edu. domain. So to find any address on the servers, the servers have to be updated on daily basis otherwise the traffic will go around and finally some service will guide to the correct addressee.So the Internet network information center (Inter NIC) will update the address as soon as it is registered. Similarly each country has domain name like .in is India, etc.The example on the diagram above shows how DNS works .

Applications: This is an important part of the internet and the real growth factor of IP. Basically the following are some of the applications.

- Email servers
- Web servers
- Caching Servers/ CDN
- IPTV head-ends.

Email servers exchange messages over the Internet using the SMTP protocol. Client applications log into the servers to send and receive email using one of several protocols, including POP3, IMAP, and MAPI.

Webserversor World wide web (W.W.W) has essentially transformed the way we now use these servers for any query.

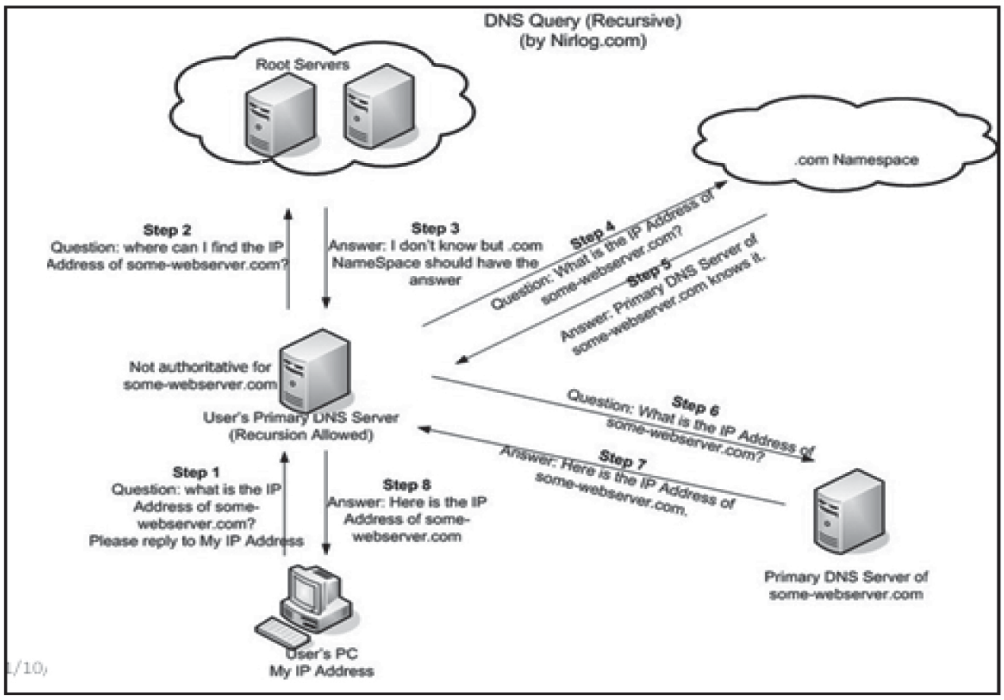

Figure 9. Support systems.

The two developments that made WWW very useful are browsers, hypertexts and Hyperlinks. Especially Hyperlinks has made the most dramatic effect on the web browsing. This is a link on the page where with one clicl we open another page and get more information we are seeking.

URL (Universal Resource Locators) is another important aspect of web browsing. The URLS get their IP addresses from DNS . URL is the most user friendly aspect of the IP.

Caching Servers or CDN (Content Delivery Networks)are an important part of the internet. CDN is data Bank examples Google, Music etc. where we look for all types of content. These servers are located on the core and the information ifs retrieved from these servers. Many servers are based in other countries and therefore the link has to be extended on international data networks. However big content providers have placed their servers in the host countries and therefore basically all information is retrieved from these servers. These are called EDGE SERVERS. These servers are getting updated from their Primary servers located in their parent country.

IPTV (Internet Protocol television) is a system through which television services are delivered using the Internet Protocol suite over a packet switched networks such as the internet, instead of being delivered through traditional terrestrial, satellite signal, and cable television formats.

IPTV services may be classified into three main groups:
Live Television with or without interactivity related to the current TV show;
Time shifted television: catch-up TV (replays a TV show that was broadcast hours or days ago), start-over TV (replays the current TV show from its beginning);
Video on Demand (VOD): browse a catalog of videos, not related to TV programming.
Various components required to provide IPTV services are shown in the diagram above. Basically it has three main parts namely: Head end where all contents as mentioned are encrypted and stored. Then there is operation system including billing and data storage for user profile. The at user premises there is setup box, and equipment like TV, Phone and Laptop etc.

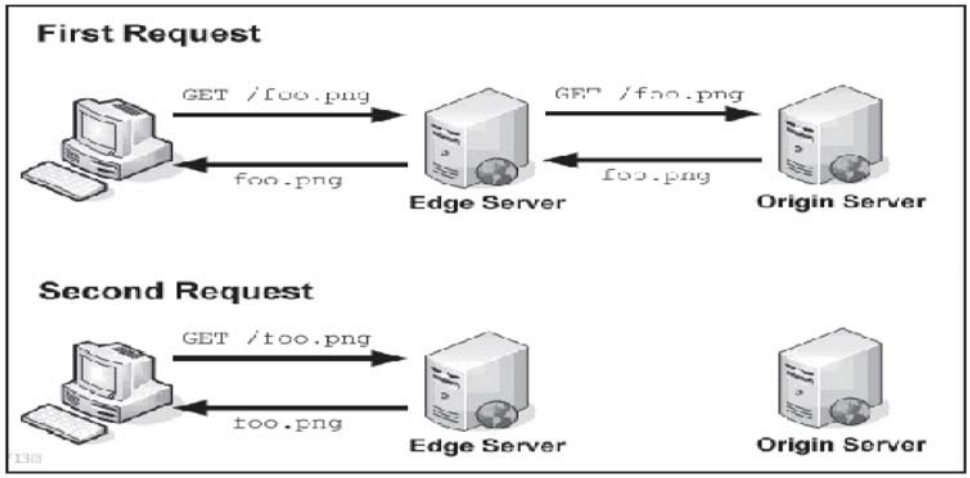

Figure 10. Caching.

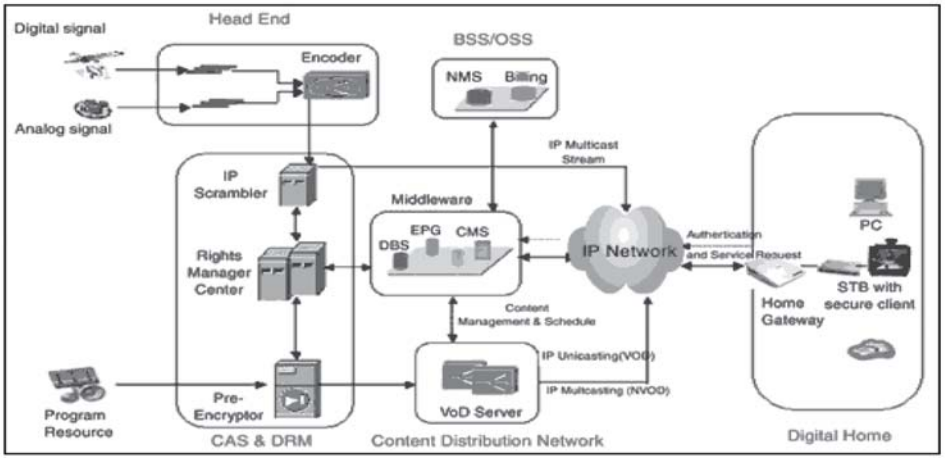

Figure 11. Schematic diagram of Internet Protocol television.

VIII. FUTURE TRENDS

Internet of things to transform economy and society
Key elements of The Internet of Things:

- Telemetry, M2M and RFID;
- Fast broadband;
- Smart Grids;
- Mobile broadband;
- Key applications of The Internet of Things:
- Cloud Computing;
- Smart Transport;
- Smart Cities, buildings and communities;
- Mobile location based services.

The Internet of Things (IoT) is going to be a real game-changer. It will transform every single sector of society and the economy; and it will be out of this environment that new businesses – and indeed new industries – will be born. The infrastructure that is now being built offers a range of features such as ubiquitousness, affordability, low latency, high speed and high capacity. It will link – apart from individual people – millions of devices, such as sensors, that will enable us to manage our environment, infrastructure, and our society as a whole much more efficiently.

The Internet of Things requires a co-ordinated approach which will encompass many different industries. Initially a trans-sector approach by utilities, telecoms, ICT and government is required to progress this concept further and other industries will continue to come onboard as it develops further.

There are a number of applications already emerging as a result of more powerful networks, such as cloud computing; complex event planning; behavioral attitudinal geolocation and Deep Packet Inspection (DPI). The rapid increase of IPv6 is also important for the development of the various applications across the different sectors, as each power point, each sensor; each monitoring device will need an IPv6 address for it to be able to communicate with any other part in the global network.

Cloud computing has a great future and will be a key application of the Internet of Things. The development of cloud computing takes the form of a business transition - and company strategies and policies will need to be changed before its potential can be fully monetized by businesses. Organizations need to start seeing ICT as more than just an infrastructure issue and rather as potential business opportunity. Cloud computing is becoming a valuable business tool – one that will differentiate one company from another.

Mobile technology will also be a key component in terms of its tracking and location abilities. Developments in Mobile Location Based Technology; RFID and geo-location should be closely watched. Key commercial uses for devices enabled by location based technologies include services such as emergency roadside assistance; traffic and navigation information; 'enhanced' information services; and location-sensitive billing.

IX. REFERENCES

[1]. *Broadband Telecommunications Hand Book* by Regis J. Bates McGraw-Hill Telecom.
[2]. Routers – Downloaded from Internet.
[3]. *ADSL: Standards, Implementation, and Architecture,* by Charles K. Summers.
[4]. *A Study on Broadband* by Triona Sherlock.
[5]. *Cisco Internetwork Design* by Mathew H Berkner.
[6]. Global Internet Usage- http://en.wikipedia.org/wiki/Global_Internet_usage.
[7]. Consultative Paper TRAI- May 12, 2008.
[8]. How content delivery networks (CDNs) work Posted at November 29, 2011 07:15 am by Nicholas C. Zakas.
[9]. PLUS Various sites on internet including ITU sites.

Manjit Singh did his B.Tech from Thapar Institute of Engineering and Technology in the year 1966. He joined Department of Telecom through Indian Telecom Service. He held various managerial positions in Operations and maintenance, Planning and Development and Project Implementation. Joined private sector after seeking VRS and was President of HFCL looking after Wireless Mobile Technologies in the company.

He was trained in NEC Japan and LM Ericsson Sweden for different Switching Technologies.

He has attended many ITU and APT conferences in India and abroad and delivered lectures on different topics in telecom. He has also authored many technical articles.