Chapter 1

BASIC CONCEPT AND ISSUES OF MULTIMEDIA

WHAT IS MULTIMEDIA?

It is said that in the future, multimedia shall be the rule and monomedia shall be the exception. Multimedia is a tele-service concept that provides integrated and simultaneous services of more than one telecommunication services, namely, voice-world, video-world and data-world. *Truly*, multimedia is supposed to provide such service *in real time and in interactive mode*. Typical examples of multimedia applications are: WWW, video conferencing, video on demand, interactive TV, interactive movies, electronic magazines and journals, groupware, digital video editing and home shopping.

Multimedia is fast emerging as an important tool of information technology and as a basic tool of tomorrow's life. Multimedia proposes to simulate human-like communication and services in an environment of "You see as I see" and "You feel as I feel". Virtual reality is envisaged in multimedia services. Multimedia transfers your message in your way. Multimedia is believed to prosper with the general human trend from "nice to have" to "value to have" to "essential to have". With multimedia a society with "plug and play", "look and feel" and "point and feel" and "point and click" shall emerge. In near future, we shall have multimedia cities and centres. Interactive multimedia is a service, which provides simultaneous access, dissemination, transportation and processing of more than one information services like voice, video and data in the interactive mode and in the real time environment. Multimedia is to integrate three communication worlds, namely, telephone world, data world and video/TV world into a single communication world. Multimedia application shall comprise of more than one information types, namely the nonreal time service of data, images, text and graphics, and the real time service of voice and video. Future world of information and communication shall be converged to multimedia application and shall provide comfort, competition, mobility, efficiency and flexibility. As per Fred T. Hofstetter "Multimedia is the use of a computer to present and combine text, graphics, audio and video with links and tools that let the user navigate, interact, create and communicate". Technologically multimedia shall be "service of services" and non-technically a "community of communities". Multimedia shall enable people to communicate and access at any time and anywhere at reasonable costs with acceptable quality and manageability. Location of man, materials and machine shall be irrelevant in business in the era of multimedia. It is said

that “It makes no sense to ship atoms when you can ship bits”. “Virtual reality with virtual presence in virtual worlds, virtual cities, business centers, virtual schools and virtual rooms will emerge in the near future ... For example, virtual reality at short notice allows collaboration between changing partners on specific tasks, sitting at virtual writing tables without real offices and addresses other than the network. Transactions in this enhanced telecooperative working environment would be electronic analogies of the normal world.” Faster work flow, comprehensive 24-hour service, remote operation and maintenance, easier trouble shooting, life long and leisure time activities, less travel, less cost and more fun shall be the important attraction of the multimedia world. Multimedia communications provide a chicken-egg benefits to information world, and have acceptance at all levels: (1) contact acceptance, viz., service availability, user-interface, (2) economic acceptance, viz., less cost, more benefits, (3) content acceptance, viz., quality, and (4) social acceptance, viz., desirability, privacy.

Multimedia refers to the integration of multiple media such as voice, video, data, text, animation and graphics etc. Basic three communication media or services are Voice, Video and Data; and in terms of these the multimedia can graphically be seen as in Fig. 1. Multimedia is therefore 2 or more in 1, and in general, N (N>1) in 1 service.

Multimedia is telling stories or having entertainments or giving education etc. with sound, video and picture etc. In general, multimedia delivers information with audio, video, picture etc.

THINK TANK

1. When a teacher teaches in the class, does he do some multimedia service?
2. Multimedia = Information collection, processing, representation, storage and transmission and exchange. Is it correct? If “yes” how then is media associated with so many components? Is there any collection medium, processing medium, storage medium, representation medium and transmission and exchange medium?

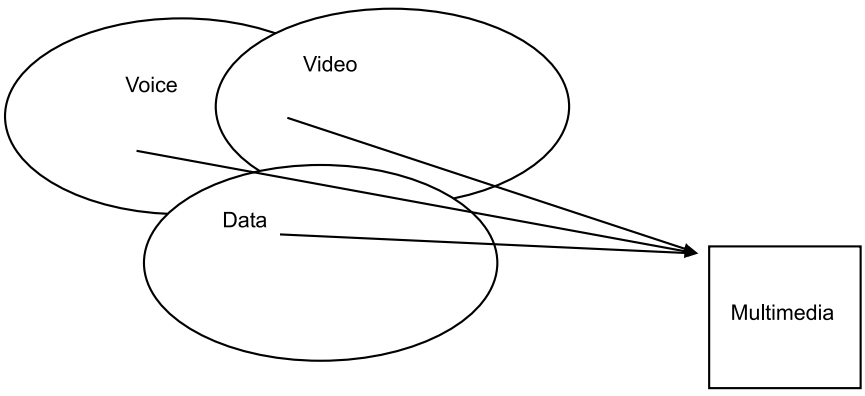


Fig. 1: Multimedia as combination monomedia

SAYING DIFFERENTLY

The world has passed through a few revolutions, namely Agricultural Revolution, Automobile Revolution and Industrial Revolution. It is currently in the age of Information Revolution. The age of information revolution is dominated by a singlemost important technology known as Information Technology (IT). IT deals with data collection, data processing to generate information and information transmission. Multimedia is a communication service of the 21st century. It will be the power of Knowledge Age that is believed to come after Information Age. But what is, in fact, communication? Nature has made three kinds of living things in the world: Plants, Animals and Humans. But they have different levels of communication power. Plants have no communicating power. Animals have very limited such power whereas humans have huge communicating power. It is conclusively established that the level of intelligence increases and enhances with communicating power. This has made us, the humans what we are today. Communication provides services by which intelligence, knowledge base, and power of creativity enhance. Therefore, it is imperative that improved communication services, flexible communication services, value added communication services and integrated communication services are the need of ever and of any time. In that process, multimedia has come up as one of the immediate solutions in the 21st century. Multimedia is expected to achieve these enhanced features by realizing communication services with different classic environments during service such as

- You see as I see
- You feel as I feel
- I enjoy as I like
- I access as I require

While offering services with such flavors, multimedia promises to transmit

- Your message in your way
- Your image in your fashion
- Your data in your format
- Your world in your mode.

IS THE TV SERVICE A MULTIMEDIA?

No! The multimedia does not mean only integrated and simultaneous service of more than one media. It must have the following three characteristics: (1) more than one media giving integrated simultaneous service, (2) the service shall be real time and (3) service shall be interactive in nature. Although TV service reveals the first characteristic, and sometimes has the third characteristic; but it hardly reveals the second characteristic. TV service is not multimedia service. However, the multimedia services that reveal all the three characteristics are known as *real time interactive multimedia,* examples of which are video conferencing, video phones. The another class of multimedia is known as *distributed multimedia,* example of which is interactive CDs (like Multimedia CD, Games, Computer-aided training CD). These multimedia sources are not real time interactive, and only reveal first and third characteristics of multimedia services (Fig. 2).

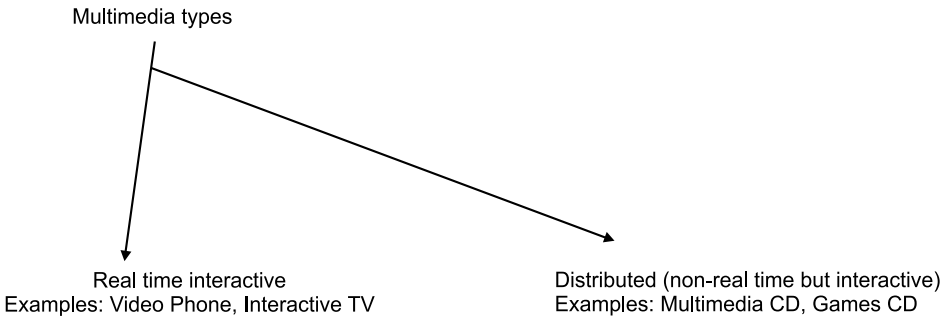


Fig. 2: Types of multimedia

HYPERMEDIA VERSUS MULTIMEDIA

Text media may be classified into two groups: linear and non-linear. A book is an example of linear medium (Fig. 3). A book is written for reading from the beginning to the end. The hyper text is non-linear. In non-linear media, accessing or reading is not necessary from the starting to the end. Links and jumping without loss of meaning and continuity are essential parts of non-linearity. We may think of sequential memory versus random access memory to compare linear media versus non-linear media. Hypermedia refers to media like text, graphics, images, sound and video with property of non-linearity. Book is one example of linear media whereas WWW (World Wide Web) is one of the best examples of hypermedia. Multimedia refers to computer-based information representation of different media like text, graphics, images, animation, video, audio and sound, whereas the hypermedia can be seen as an application of multimedia.

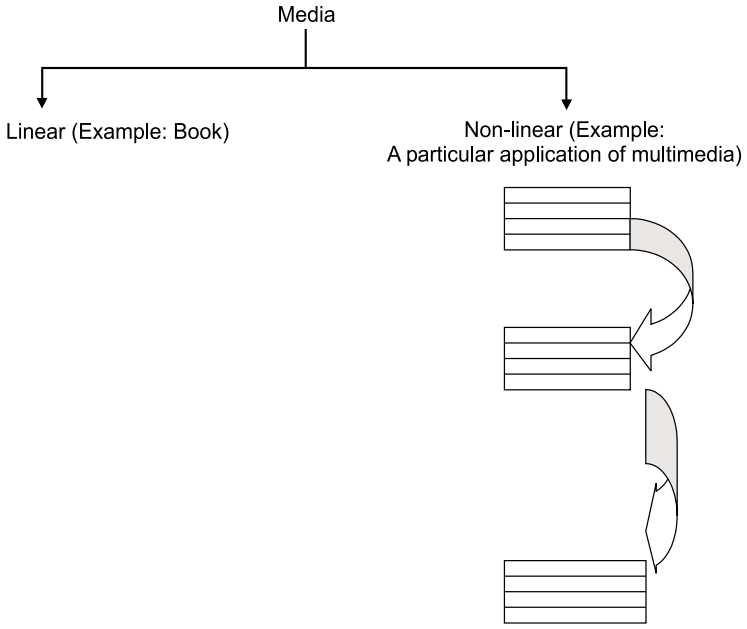


Fig. 3: Hypermedia vs. multimedia

WHY MULTIMEDIA?

Multimedia refers to the use of various media to communicate messages. It is often said, with voice you can communicate with about 70% efficiency, but with voice and video with 90% efficiency. Simultaneous delivery by multiple media for communicating messages and content increases the delivery efficiency, the message impact and the multisensory experience. Multimedia increases receiver's knowledge and understanding of the received messages. Computer Technology Research of 1993 says: *"People retain only 20% of what they see and 30% of what they hear. But they remember 50% of what they see and hear, and 80% of what they see, hear and do simultaneously."*

THINK TANK

1. The efficiencies of consumption of information by three different monomedia services are n1, $n2$ and $n3$. When these monomedia services are combined to deliver a multimedia service, the efficiency becomes n where $n > n1, n2, n3$. Can you suggest a formula to evaluate n for given $n1$, $n2$ and $n3$?
2. Assume that efficiency equals to capture capacity. In that case a formula as sought in (1) above may be:

   $n = n1 + n2 + n3 - (N - 1).m$ (where m = common capture capacity of all three monomedia, which is the lowest of all monomedia, N = total number of monomedia).

   For example, if $n1$, $n2$ and $n3$ are respectively 70%, 60% and 80%, we can reasonably assume m = 60%. Then $n = (70 + 60 + 80 - 2 \times 60) = 90\%$

   What is your opinion about the formula suggested here? Where is the flaw in the formula, if any?

A Chinese proverb tells, "Tell me and I shall forget; show me and I shall remember; involve me and I shall understand." This is what is the spirit behind multimedia.

WHAT ARE THE MAJOR TOPICS OF MULTIMEDIA?

- Multimedia Network and Communication
- Source Coding
- Multimedia Technology
- Multimedia Standards

WHAT IS MULTIMEDIA COMMUNICATION?

Multimedia communication refers to the transmission of the multimedia information over multimedia networks. Multimedia networks are to support transmission of multiple media, namely voice, video, text, data, graphics and still images often at the same time in interactive and possibly real time modes. The several components of a multimedia network are shown in Fig. 4 ($a - d$). The basic five communication networks used to provide multimedia communication services are: telephone (circuit-switched network), data networks (packet-switched networks), broadcast networks (television), ISDN and BISDN.

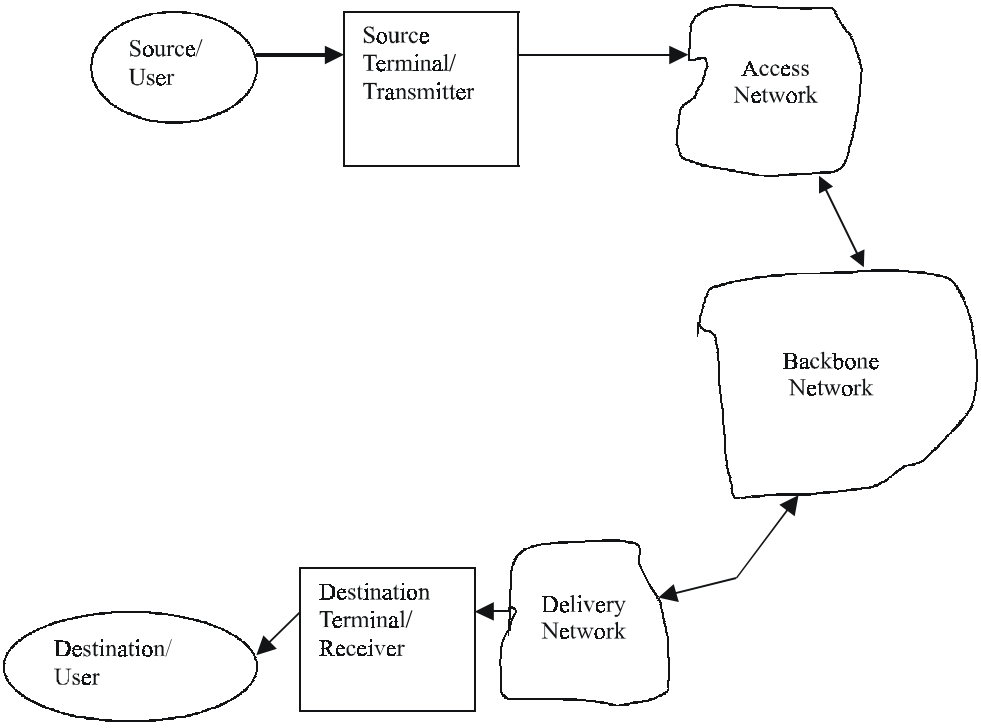


Fig. 4(a): Components of multimedia network

The source is actually the media to be transmitted. The media to be transmitted is often represented in the digital form.

The source terminal does the job of compressing source data.

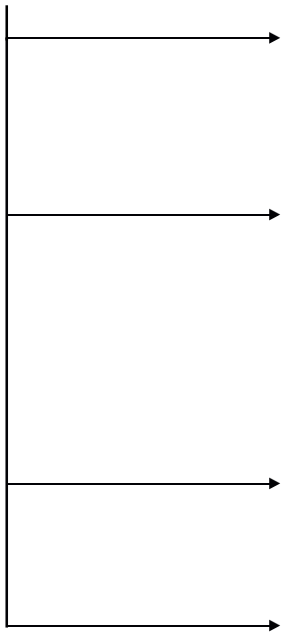
The access and the delivery networks, often known as last-mile network, are shared capacity networks. The first five entries in Table (1) are used as access/ delivery networks.

The backbone networks may be circuit switched telephone network, packet switched data network, and Internet. The access and the delivery networks are shared networks and therefore have packet loss and delay and rate constraint characteristics. The backbone network has the characteristics of bandwidth, latency, jittering, skew, packet loss and possible QoS (Quality of Service).

The destination terminal does the decompression and delivers media to the destination.

THINK TANK

1. Explain: “Multimedia is the integrated handling of information consisting of time-dependent and time-independent data types”.
2. Explain: “Hypermedia is a multimedia system that contains portions of information called nodes and semantic relationship called links between those nodes”.
3. Explain: “Multimedia Communication = Multimedia Systems + Telecommunication Services”.



Telephone Networks/Circuit Switched Networks

I. PSTN (Public Switched Telephone Network) (backbone, access, delivery)

II. PBX (Private Branch Exchange) (backbone, access, delivery)

Packet Switched Networks/Data Networks

I. Internet (backbone)

1. LAN (Local Area Network) (access, delivery)
2. Intranets (access, delivery)
3. ISPN (Internet Service Provider Network) (access, delivery)

II. X.25 (Backbone, access, delivery)

Long Haul Broadcast Networks

I. Satellite/Terrestrial (backbone, access, delivery)

II. Cable (backbone, access, delivery)

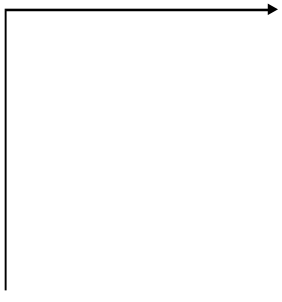
Integrated Services Digital Network (ISDN)

I. NISDN (access, delivery, backbone)

II. BISDN (access, delivery, backbone)

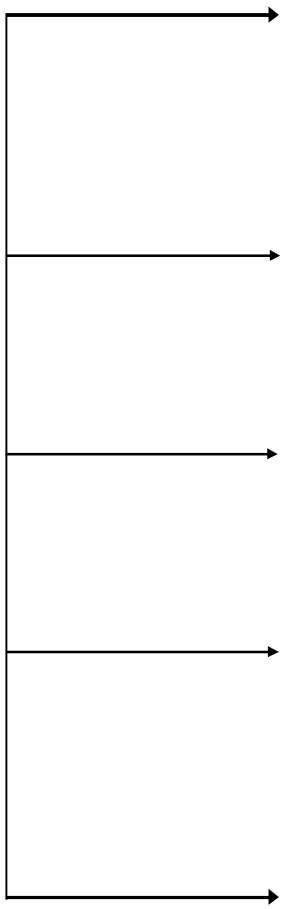
	Circuit-switched networks	Packet-switched networks		Broadcast networks	Integrated services digital networks (ISDN)
Backbone	PSTN, PBX	X.25	Internet	Satellite,	NISDN
Access and delivery			LAN, ISPN, Intranet	Terrestrial Cable	(Narrowband ISDN), BISDN (Broadband ISDN)
	Multimedia Applications and Services				

Fig. 4(b): Multimedia communication networks



Circuit Switched Telephone Networks

1. Fixed and Mobile Telephony
2. Video Telephony
3. Voice Mail
4. Fax
5. Video Conferencing
6. Entertainment/Video on Demand
7. Access to Internet



Packet Switched Internet

1. E-mail/File Transfer
2. Multimedia Mail
3. Video Telephony/Video Conferencing/Internet Phone
4. E-commerce

Broadcast Networks/Satellite and Terrestrial

1. Analog and Digital Audio/Radio and TV Broadcast
2. Interactive TV
3. Video/Movie on Demand

Cable Networks

1. Analog and Digital Audio and TV
2. CD, Video/Audio on Demand/Interactive TV
3. Access to Internet/PSTN

NISDN

1. Digital Telephony/Fax
2. Video Telephony and Conferencing
3. LAN Interconnection
4. Access to Internet

BISDN

1. ATM LAN: Interactive Services
2. ATM MAN/ ATM WAN as Backbone: High Speed/High Bit Rate Interconnection

Fig. 4(c): Multimedia networks and their services

Multimedia Services/Traffic	⟶	Supporting Communication/Network Technologies
Voice/Audio/Telephone	⟶	ISDN, SONET, **ATM**
Video Real Time	⟶	SONET, **ATM**
Video Distributive	⟶	IP, SONET, **ATM**
Data	⟶	IP, ISDN, **ATM**

Fig. 4(d): Services versus technology: It is apparently NOTICED THAT FUTURE IS WITH ATM

Table 1: Characteristics of different services

Services	*Typical supporting network*	*Time sensitive/ Latency*	*Burstiness*	*Error tolerant*	*Typical bit rate*	*Directionality*	*Typical session holding time*
Audio/Voice	PSTN/ Telephone	Yes	No	Yes	64 Kbps	Bi-directional	Minutes
Digital video (real time)	Cable/ Terrestrial/ Satellite	Yes	Moderate	Yes, but limited	Around 1 Mbps	Bi-directional	Minutes/ Hours
Digital video (distributive)	Do	No	Moderate limited	Yes, but Mbps	A few	Directional	Hours
Data	Internet/ Packet Switched Network	No	Yes	No	A few Kbps	Directional	Hours

In fact, different services of multimedia bear different characteristics (Table 1) requiring different networks to support different services. For example, data is known as BAD IT, where “B” refers to bursty; meaning that for a very long time there may not be any data for communication, but suddenly there may emerge a huge chunk of data for a short duration. Thus, the network and transmission link should have the provision to cope up with the wide data-rate variation. In voice communication the data rate is fairly constant. “A” refers to asymmetric, meaning that flow of data is heavily tilted towards unidirectional transport. On a single stroke of command, a destination may have to response for a long period towards source; the one example of which is the transfer of bank details from a branch bank to the headquarter of the bank. In the voice communication the bi-directional flow variation is around 40% to 60%. “D” stands for delicacy. The data is delicate. It is more error-prone. This is because, in the data communication, the machines are involved. Unlike voice communication, human perception and intelligence are absent in data communication. So care must be taken to protect data from error. “IT” stands for Insensitive to Time. Data normally does not require real time transport or on-line interactive communication. Data may tolerate delay. Thus, data transport may be made with intermediate buffering and storage while being delivered in between the source and destination. In fact, voice can tolerate error to some extent but not delay whereas data can tolerate delay but no error. For example, delay for voice must be less than 100 ms. The error of data transport depends on Bit Error Rate (BER). If BER = 10^{-3}, it says that on average out of transmitted 10^3 bits, one bit will be in error. The tolerable BER in data transport should be less than 10^{-2}. It is the “B” and “IT” features of data that gives rise to the concept of packet and packet switching as most appropriate for data networking. A session is called *bursty* if $\lambda T << 1$, where λ and T are respectively *average data arrival rate* and *average delay* between the source and the destination. For data, $\lambda T < 0.01$.

THINK TANK

1. Basic three services of Audio, Video and Data have different characteristics thereby requiring different switching techniques for transport. Then how is it possible to provide all the three services in integrated manner through a single multimedia communication network?
2. Can you suggest a modified Internet, a new version of current IPv4 Internet that may support all services?
3. Accurate, secured and high rate transport of data by the information networks are the basic issues for development of network techniques. In view of this, how do you like to see any multimedia network or what do you like to choose as the most appropriate network of the existing ones as multimedia network?
4. See and explain the figures in Appendix 1 for multimedia.

BOX 1: LAWS OF INFORMATION TECHNOLOGY AND AFTERMATH

Information technology refers to the information collection, processing and transportation. Technology as such is the synergy of two emergent technologies: Computer and Communication. It is understood that information technology is changing leaps and bounds in regard to how the individual technologies are progressing may be seen.

Laws of Computing

There are several empirical laws that correlate, govern and predict the technological progress and growth of Computing Technology in the last few decades. These are:

Joy's law, which states that the computing power, expressed in MIPS (Millions of Instructions Per Second), doubles every 2 years.

Moore's laws, which states that (a) the number of components on an IC would double every year (this is the original Moore's law predicted in 1965 for the then next ten years), (b) the doubling of circuit complexity on an IC every 18 months (this is known as revised Moore's law), (c) the processing power of computer will double every year and a half (Moore's second law which closely resembles to Joy's law).

Law of "Price and Power", which states that over the years the computing, processing, storage and speed up power of computers will continue to increase whereas the price of computers will continue to fall.

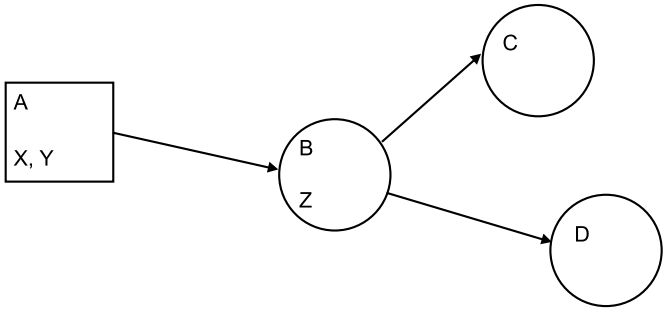


Fig. 1: Illustration for concept of information

Out of all the above stated laws, the more recognized and elegant law are Moore's laws of integration. In the chip level integration till date, Moore's laws say the last word. Since the inception of digital electronic in the brand name of ENIAC in 1948, the computer has gone through a number of generations, and it is now in the fifth generation. The so vast and rapid changes of five generations of the computer technology just over a period of 50 years result on the one hand in the reduction of size and cost of computers, and on the other hand in the tremendous increase in the processing power and capacity of computers. The credit for these goes to IC technology. Out of the many others the famous empirical laws known as Moore's Laws basically govern the pattern of growth of computers and that of IC technology. Mr Gordon Moore, Head of Research & Development of Fairchild, coined these laws around 1965. From SSI to ULSI, the trend set (Table 1) by Moore's laws is followed. But beyond ULSI, what is there? The extrapolation of the trend predicts that the future will be the age of molecular dimension inherited by the already established subject of molecular electronics that is based on organic materials rather than inorganic semiconductors. Beyond ULSI, the further integration on a chip will face serious problem from physical constraint like the quantum effect. This may lead to the death of Moore's laws. But another interesting dimension may be added to the cause of the death of Moore's laws. This is based on the law of "Price and Power". It is said that: "The price per transistor will bottom out sometime between 2003 and 2005. From that point on, there will be no economic point in making transistors smaller. So, Moore's laws end in a few years". "In fact, economics may constrain Moore's laws before physics does."

Table 1: Generation of IC integration

Generation	*Number of components*
Small Scale Integration (SSI)	2 – 64
Medium Scale Integration (MSI)	64 – 2000
Large Scale Integration (LSI)	2000 – 64,000
Very Large Scale Integration (VLSI)	64,000 – 2,000,000
Ultra Large Scale Integration (ULSI)	2,000,000 – 100,000,000

BILLION-TRANSISTOR IC—HOPE OR HYPE?

Presently ICs are made of around 250 million transistors. If Moore's laws continue to hold good, it is predicted that by 2010, ICs will be made of billion transistors. The threats to the survival of Moore's laws are heat dissipation and quantum effect that is a physical limit to IC integration. Several predictions were therefore earlier made for imminent death of Moore's laws. Contrary to these predictions, Moore's laws are surviving and hold true for IC integration. Recent two research reports have further showed confidence of survival of Moore's laws for at least another few years.

A survey conducted jointly by IEEE (Institute of Electrical and Electronics Engineers) and the Response Center Inc of USA (a market research firm) over the fellows of IEEE showed that 17%, 52% and 31% respondents respectively predict the Moore's laws continuation for more than 10 years, 5–10 years and less than 5 years. The average predicted life term for the laws is then about 6 years. Moore's laws existence if then guaranteed up to 2009, by the time of which following the laws the billion transistors IC will be a reality.

The expectation of realizing billion transistors IC by 2010 has been further brightened by the current research of Intel expanding Moore's laws. Mr. Pat Gelsinger's vision of expanding Moore's laws includes Intel's 90-nanometer fabrication process. Although several alternative technologies, namely quantum computing, biocomputing, molecular electronics and chemical computing, are under investigation as possible replacement to digital computing, the year 2010 may achieve the landmark of billion transistors IC, another leap forward in IC technology—really a high hope and not a hype.

AFTER MOORE'S LAWS?

The quest for an ever-decreasing size but more complex electronic components with high speed ability gave birth to MSE (Molecular Scale Electronics). The concept that molecules may be designed to operate as a self-contained device was put forward by Carter, and he only proposed some molecular analogs of conventional electronic switches, gates and connections. The basic concept is to use spin of a molecule for representing 1 and 0 of computing rather than a transistor's ON and OFF states. For example, positive spin of a molecule may represent 1 and negative spin as 0. This will be achieved in molecular scaling. MSE is a simple interpolation IC scaling.

Scaling is an attractive technology. Scaling of FET and MOS transistors is more rigorous and well-defined than that of a bipolar transistor. But there are problems in scaling of silicon technology. In scaling, on the one hand propagation delay should be minimum and packing density should be high; on the other hand these should not be at the expense of the power dissipated. With these scaling rules in mind, scaling technology of silicon is to reach a limit. Another thing is that scaling can be due to the quantum nature of physics. At this junction molecular scale (MSE) scaling technology is being shown importance.

But problem is how can the properties of individual molecules and/or small aggregates be studied. Fortunately, day-by-day, we are evolving new techniques and methods to tackle this problem. At present, we are having technologies like STM (scanning tunneling microscope), AFM (atomic force microscope) and NFOM (near field optical microscope) etc. In addition, sub-micron lithography, L-B films and adsorption/reaction in 2D/3D are also there. L-B technique is particularly important because it provides one of the few ways of marketing separate electrical connection to two ends of a molecule.

Till MSE technology is matured, silicon based IC technology will continue to be governed by Moore's laws.

Laws of Communication

The laws governing the progress of communication technology are:

Ruge's law, which estimates that the communication capacity necessary for each MIPS is 0.3-1Mbps (Million of Bits Per Second).

Metcalfe's law, which states that if there are 'n' computers in a network, the power of the computers in a network like Internet is multiplied by 'n' square times. **This law estimates that** from a figure of 0.25×10^{12} in 1988 to 2433600×10^{12} in 2000, a 9734400 ($\cong 10^7$) times increase over a gap of only 12 years in power of networking was made possible. What a future is ahead! Super information power or infinite information power!

Due to this power, the flexible transport technology, ATM and very high rate carriers like SONET/SDH, the requirement of any services at any time, anywhere with a single device and with a single communication number may be possible even through modest Internet, which was basically designed to carry data only.

A few basic requirements of the information networks are: first, the accurate or the reliable (error-free) transport, second, the secured transport and the high data rate transport of information, third, due to integration of services over networks, high data rate networks are in demand, whereas high data rate increases BER. The data rate follows Edholm's law (Table 3 in the main text may be referred to) that states the data rates for all three communications, namely wired, nomadic and wireless, are as predictable as Moore's laws. The rates are increasing exponentially and the slower rates trail the faster rates within a predictable time gap.

Striking Change in the Definition of Information due to IT: The Real Aftermath

The father of information, Shannon defined information from communication engineering point of view. In Shannon's information theory, more entropy means more information. While according to the probabilistic second law of thermodynamics, more entropy means more disorder. Does it mean that more information results in decrease in order? If "yes", how? The entropy of thermodynamics (the decrease in order) is a measure of how much a reaction is irreversible. The steam engine on its orderly works produces some waste heat energy. The waste heat of a steam engine that causes the hot atoms to randomly bouncing around is improbable to get back into orderly atoms. Once you get some information, you get so by consuming some energy either by computer processing or by network information downloading or by other means of communication. These functions produce some waste heat that is not reversible. Thus, durable definition entropy, a measure of information of Shannon perfectly matches with the entropy of the thermodynamics.

Shannon's theory of information is a measure of uncertainty—the more you know, the less you are certain. How is it? The information, that Shannon described, is the information received by a receiver from an information source. As the information source has more uncertain messages, the receiver gets more information. Let us consider Fig. 1. Initially, "A" is an information source with two messages, X and Y of equiprobable. "A" is the transmitter to "B". "B" is the information source to "C" and "D". B gets information $I = -P(x) \log P(x) - P(y) \log P(y)$ from "A". Thus, "A" knows more. Now by the process, "A" becomes the information source of three messages, X, Y and Z with, say, equiprobable. Also "B" can produce the current messages with more uncertainty for the receivers, C and D. Thus, it is the reference that solves the puzzle.

But the appropriate definition of information in the IT age is due to Tom Stonier. Recently, Tom Stonier has speculated in his work "Information and Internal Structure of the Universe" that there is an analogy between mass/matter, energy/heat and information/order of an organization. It has been argued that information (I) resident in any organization is proportional to the order (O) of the organization:

$$I = C.O$$

where C is the constant of proportionality. If this relation exists there may be a possibility of interchangeability of information with energy (which, otherwise speaking, will establish a measurable and quantifiable relation between Industry based society with Information based society). Tom Stonier established an exchange rate which is:

1 Joule per degree Kelvin = 10^{23} bits of information.

It may raise many criticisms and questions, but there is a direction, which if proved correct in future, may lead to a conclusion that information is not something external to nature, but a fundamental unit of nature.

Table 2: Comparison of bit rate of support networks with that of multimedia services/Required compression ratio

Service/Network Channel	*Bit rate of channel*	*Multimedia sources (uncompressed bit rate (U) and required compression ratio for channel support (CR))*									
		Telephone service		*Wideband speech*		*NTSC TV*		*HDTV*		*Film quality*	
		U	CR	U	CR	U	CR	U	CR	U	CR
POTS	28.8–56 kbps	96 kbps	2:1	224 kbps	4:1	168 Mbps	4000:1	933 Mbps		2300 Mbps	
PC Local LAN	30 kbps		3:1		7:1		5600:1		31000:1		76000:1
MODEM	56 kbps		2:1		4:1		3000:1		17000:1		41000:1
ISDN	64 – 144 kbps		Nil		2:1		1166:1		6400:1		16000:1
TI (DSL)	1.5 Mbps		Nil		Nil		112:1		622:1		1500:1
ADSL	1.544–8.448 Mbps (download) 16–640 kbps (upload)		Nil		Nil						
VDSL	12.96–55.2 Mbps		Nil		Nil						
Ethernet	10 Mbps		Nil		Nil		17:1		93.3:1		230:1
Fast Ethernet /FDDI	100 Mbps		Nil		Nil		1.68:1		9.33:1		23:1
Giga Bit Ethernet	1000 Mbps		Nil		Nil		Nil		Nil		2.3:1

Shannon's theory demonstrated the inverse relationship between information and entropy in case of communication or information processes. The inverse relationship holds good for physical or life processes also. By the relation between information and knowledge as demonstrated by several works it will be a reasonably good assumption that knowledge is proportional to information. Hence the entropy and the knowledge hold an inverse relationship to each other. The laws of thermodynamics, particularly the second law of thermodynamics, govern physical or life processes. The second law of thermodynamics is related to entropy, which is a measure of disorder. An orderly system is associated with entropy minimization. Entropy minimization means minimization of energy, space and time for a given amount of effort. Life is an open system that exchanges energy and information with its surroundings for any effect due to any cause. The second law of thermodynamics confirms that an open system or the life system can be made more knowledgeable (more ordered or reduced entropy) only by increasing the disorder in its surroundings or environment. Thus, the knowledge increases order of organization or otherwise speaking minimizes the organizational consumption of energy, space and time. Therefore, the justification of the theory of Tom Stonier may hold good very much.

These developments are the manifestation of the basic law of nature that in this universe if anything remains constant then it is nothing but the "change".

What is the Need of Source Compression?

The typical uncompressed bit rates of different multimedia sources are shown in Table 2. The comparison of these bit rates with the support bit rates of the access networks of Table 2 of Box-1 will demonstrate the requirement of the compression.

Table 2: Data rate growth of different communication/network technologies

Year	*Wired*		*Nomadic*		*Wireless*	
	Technology/ Standard	*Data rate*	*Technology/ Standard*	*Data rate*	*Technology/ Standard*	*Data rate*
1975–1984	Ethernet	2.94 Mbps	Hayes Modem	110 bps	Wide area paging	A few hundreds bps
	Ethernet	10 Mbps	Modem	9800 bps	Alphanumeric paging	A few Kbps
1985–1994	Ethernet	100 Mbps	Modem	28.8 Kbps	Cellular/GSM	≈50 Kbps
			Modem	56.6 Kbps		
			IEEE 802.11b	11 Mbps		
1995–2004	Ethernet	1 Gbps	IEEE 802.11g	108 Mbps	PCN/UMTS	>2 Mbps
					B3G (beyond 3 G)	12 Mbps
					MIMO	200 Mbps

The need of data compression may critically be viewed in two angles:

- Storage requirement: Uncompressed data require huge memory space for storage that may not be available at the current pace of technology. The compression comes as a solution to this problem.
- Communication requirement: This has already been illustrated in Table 2. Uncompressed data may require long time and cost for communication or transport.

However, the rapid growth of both computer and communication technologies may in some extent provide solution alternative to compression. As an example, in Table 2 the growth of data rates under different communication/network technologies is shown. The data rate follows Edholm's law that states the data rates for all the three communications, namely wired, nomadic and wireless are as predictable as Moore's laws. The rates are increasing exponentially and the slower rates trail the faster rates within a predictable time gap.

BOX 2: NEW INTERNET AND IP VERSIONS

The famous empirical laws known as Moore's laws have been guiding the developments of computer generations for the last three decades. Recent prediction is that the law will survive for at least another two decades. The growth of Internet hosts and users may be

another straight application of Moore's laws. It appears that the Internet users and hosts will double after each 18 months. With the pace of exponential increase of Internet users and hosts, the new generations of Internets are coming up.

INTERNET 2

Despite the tremendous and unprecedented growth of the Internet users, the Internet is poorly suited to the real time interactive services. Although TCP provides guaranteed delivery of data, yet latency involved is noticeable. Delays in the Internet are typically tens or hundreds of milliseconds, 500 millisecond being a typical example. Note that delay in geostationary satellite communication is around 470 millisecond. Moreover, latency in the Internet is variable and unpredictable. Therefore, the need is to go for a faster version of the Internet. The faster version of the Internet must go up with higher bandwidth so that time latency shall go down, thereby providing better service to voice and video that are time sensitive in nature. Internet 2 project initiated in 1996 is moving quickly to implement a high-speed Internet. Internet 2 is a project of around 172 member universities. Internet 2 has a long history of coming up. High speed Internet initiatives were taken up in different projects: The National Science Foundation Advanced Network Infrastructure and Research Program of USA started a project in 1996, Internet 2 or I2 project was taken up in October, 1996 by a group of universities for research collaboration, the task of managing Internet 2 project was taken up by the University Corporation for Advanced Internet Development of USA in October, 1997, and the next generation Internet initiative was taken up by the USA Government in October, 1997. Internet 2 is aimed to realize a backbone network with bandwidth over 10 GBPS (giga bits per second), hundreds of Giga PoPs, and techniques of providing quality service. The design, technology choice and the standards are as follows: (1) Internet 2 design shall be proposed to be based on Giga PoP (Point of Presence) having at least 622 MBPS (million bits per second) capacity. Actually concept of PoP is due to access of Internet from PSTN/ISDN (Public Switched Telephone Network/Integrated Services Digital Network), (2) The Internet Engineering Task Force is happening over either of the two protocol standards, Internet multicasting protocol, known as IP multicasting and upgraded version of IP, known as IPv6. IP multicast makes use of bandwidth efficiently, and IPv6 has built in Q-o-S (Quality of Service) and security and higher address space. In multicasting, a packet is not addressed to any host but a group of hosts. Host can decide whether to accept or reject the data. Multicasting is not like broadcast mode, in which a packet is sent to all machines in the network. Multicast uses bandwidth efficiently because it sits between unicast IP (one to one) (mostly used in the Internet) and the broadcast IP traffic (one to all). It is often observed that "IP multicast is simply a must for the survival of the Internet", (3) As ring topology has a reasonable scaling properties, for Internet 2 ring topology is the obvious choice, (4) For the support of MBPS/TBPS, fiber is the clear choice for interconnection cabling, (5) Now to attach IP routers of the Internet 2 to fiber ring, the proposal under consideration is to map IP routers atop ATM (Asynchronous Transfer Mode) switching node. The convergence of ATM and IP is therefore need of the hour. Convergence is the solution of 'what is there' and 'what would be there'. At the service level, we need convergence for all services with desired Q-o-S. This could be achieved with convergence at the level of switching and routing. IP has global coverage of switching and routing, whereas ATM not. But Q-o-S routing and switching is not possible with IP, whereas it is

possible with ATM. ATM is a connection oriented technology for all services and hence guaranteed service or delivery is possible. IP provides only best effort delivery as it is a connection-less technology. Therefore, IP and ATM are perfect match for convergence rather than being competitors. Unique and new services envisaged in Internet 2 are: immersive virtual reality style work environment known as telemersion, digital libraries, virtual laboratories etc. It is told that "A digital library system requires the integration of many underlying technologies. These include storage and storage management, content capture and creation, search and access control, distribution, and security and rights management." Accessing, downloading and retrieval time shall be low so that users find it comfortable. This is guaranteed by high speed Internet 2. Internet bandwidth is not enough for high quality digital library system.

OTHER INTERNETS

Two other proposals for development of the Internet are: (i) undersea superspeed Internet and (ii) wireless Internet. A proposal for a global optical-fiber undersea cable network called Project Oxygen has significant industry support and financial backing. This project is called "the best of bandwidth on demand" project as per the company release. Experts say "Project Oxygen is the most ambitious communication project in the 20th century... The Internet and video transmission are the major drivers for the expansion....a global optical fiber network could erase the boundaries between Internet and the traditional communications, and shift the profit model from voice service to data and video." Construction of the undersea network that began in September, 1998 is now in operation over USA, Spain and Singapore. The major trans-Atlantic and trans-Pacific links are also operational. The speed of cable is 1920 GBPS with minimum capacity of 640 GBPS. It is reported that with undersea Internet, a video-based Internet shall come with over 10,000 video channels. A revolution in wireless has reached. In 10 years time, we can have mostly wireless devices, equipments and computers. These need to be connected to the Internet. For this, a situation may require to have all wireless networks including wireless Internet.

FAST Approach Internet

Recently, California Institute of Technology has announced the development of a new TCP (Transmission Control Protocol) known as FAST approach that is promised to increase Internet download speed to a great extent. Two trial tests confirmed the improvement of the

Table 1: Comparison of FAST with traditional

		Throughput in Mbps	*Transfer rate in Gbytes*
Test 1	Traditional	266	111
	Fast	925	387
Test 2	Traditional	931	390
	Fast	1797	753

proposed scheme over traditional approach (Table 1). In traditional TCP, a packet is transmitted only after the receiver acknowledges the correct receipt of the previous packet. In the FAST approach, the system automatically adjusts the data transmission based on the measured expected delay of sending a data and of receiving its acknowledgement.

Besides, while the traditional approach uses binary data for transmission, the FAST approach uses multibit data. The modifications have brought the throughput and speed advantage to the new approach.

HEADER Compressed IP and IPTV

Internet is for traditional data. To make it to carry other time-sensitive services like voice and video, many new versions are coming up. Although fixed and simple header approach in IPv6 may be applicable for low quality time sensitive services, yet other developments are coming up fast. In order to reduce latency, an approach called header compressed IP has been proposed. In the scheme, it is suggested that common headers like IP source and Destination addresses may not be required in all the IP packets. Similarly, the sequence number may be used with bias or offset technique. Another approach has been started to define separate IP for TV services.

THINK TANK

1. Justify that multimedia services provide the following benefits:
   - Cost effectiveness
   - Time effectiveness
   - User-friendliness
   - Location independency

   Hints: First two benefits may be seen in terms of video conferencing, third benefit may be seen in terms of tele-education and last benefit may be seen in light of tele-medicine.

2. Justify that the multimedia is basically a fusion of more than one communication service media, namely voice, video, data, text, graphics and animation etc., under computer plus network control.