Procedure International Journal of Science and Technology

(International Open Access, Peer-reviewed & Refereed Journal)

(Multidisciplinary, Monthly, Multilanguage)

ISSN : 2584-2617 (Online)

Volume- 2, Issue- 7, July 2025

Website- www.pijst.com DOI- 10.62796/pijst

Computer Network: An Instrument for Development

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Abstract

Computer networks have emerged as transformative instruments for economic and social development in the modern era. They serve as vital infrastructures enabling communication, information exchange, and resource sharing across organizations, communities, and nations. Networks accelerate economic growth by supporting e-commerce, e-banking, and digital enterprises while simultaneously enhancing productivity and innovation. Socially, computer networks strengthen connectivity, broaden access to information, and promote collaborative learning, thereby fostering social capital and cultural preservation. They also play a pivotal role in critical sectors such as education, healthcare, governance, and agriculture through applications like e-learning platforms, telemedicine, health information systems, and e-governance. Technological advancements, including cloud computing, the Internet of Things (IoT), and 5G communication systems, further expand their developmental potential by offering real-time solutions, intelligent resource management, and high-speed connectivity. Despite challenges such as infrastructure limitations, cybersecurity threats, and the digital divide, successful global case studies demonstrate that computer networks remain essential catalysts for sustainable development. Policy interventions and collaborative efforts from both governments and private sectors are imperative to harness their full potential for inclusive growth and equitable progress.

Keywords: Computer Networks, Development, E-Governance, E-Learning, Telemedicine, Cloud Computing, Digital Divide

Introduction

Computer Networks have emerged as effective catalysts for Development. The term refers to the telecommunication networks that allow computers to interchange data, information, and resources. Computer Network technologies have become essential to modern organisations. Organisations deploy networks to reduce overall costs and increase efficiency. Computer Networks assist organisations in Making effective use of

Information Technology (I. Dafalla & D. Balaji, 2015).

Computer Networks also satisfy a broad range of economic and social development needs of communities at all stages of development. They accelerate global communication and help individuals attain a higher quality of life (Paul Okinyi & Nyanchama Nyabuto, 2015). Computer Networking technologies help preserve and propagate language and cultures, promote economic development, and improve governance and living standards. Access to various economic and social sectors—including agriculture, banking, education, energy, health, commerce, governance, employment, and government administration—is enhanced through the use of Information and Communication Technologies (Chigbu & Dim, 2012).

The Role of Computer Networks in Development

The developmental process involves an economic status transition with an associated enhancement in the quality of life of the population. The physical and social transformation is substantial. The essential attributes such as the pursuit of higher living standard, better education, investment in new technology, and technological independence are inevitable constituents of development. A variety of factors or agents can potentially drive the developmental process. The computer, for example, has the reputation of problem-solving device and an instrument for development. These general-purpose characteristics of the computer have spurred the successful utilization of computers in several socio-economic fronts, such as education, industry, agriculture, transportation, finance, business, and administration.

These solutions based on computer technology have inspired a large number of governmental and non-governmental organizations to qualify the role of computer as an instrument for socio-economic development. However, a computer solution typically requires insight, expertise, and investment, and is not available to the majority of the population. This fact has resulted in the utilization of computer networks for the socio-economic development of the population. A computer network is a data communications system that interconnects a collection of terminals, computers, and data storage devices. It is an essential tool for the transfer of information from one place to another, which consequently leads to economic development. The network enables e-banking, e-commerce, and e-business, which in turn improve the economy.

Moreover, it facilitates better and faster communication; produces a better connectivity among all people; and increases productivity, innovation, and creation of wealth. It also enables sharing of data and programs, perpetuates learning and exploration, and enhances the global economy and connectivity. The network, therefore, influences the social development of the country through e-learning, e-healthcare, e-governance, and e-administration, among others, and is consequently an instrument for development (Qureshi, 2005).

(I) Economic Growth: Computer networks play a supporting role in facilitating economic growth. Development refers to progress or growth, and it is closely linked with economic advancement. Economic growth occurs when a country experiences an increase in the production and consumption of goods and services (Jimenez et al., 2013). Networks aid the engines of economies and thus drive development (Qureshi, 2005).

(ii) Social Connectivity: Computer networks are primarily directed towards enhancing social connectivity. Connecting individuals through computational means increases interactive capacity, thereby augmenting productivity. The resultant value of these networks is designated as social capital (Haque et al., 2011). Social capital is defined as the collective knowledge and experience that community members possess about each other, along with their interaction patterns governed by formal and informal

rules. Although quantifying social capital presents challenges, it exerts a considerable influence on economic growth. It supplies a distinctive mode of connectivity, wherein personal and professional relationships, religious affiliations, and tribal ties create profound interconnectedness. The magnitude of social capital expands in proportion to interaction intensity and diminishes when left unused. It operates as a resource deployed in achieving objectives, akin to technology and labor. Cultural and institutional frameworks determine trust levels across various countries, thereby affecting the capacity to formulate and foster social capital. Technological advancements impact the construction and utilization of social capital, especially within the context of online communities and digital interactions (G. Fitzsimons, 2006).

(iii) Access to Information: The remarkable ability of computer networks to provide access to information has a profound impact on the economic and social sectors, of which development is a function. Access to information is an important economic tool involved in resource allocation decisions, such as price determination. Successful decision-making requires obtaining adequate knowledge or data, and computer networks provide an efficient means of data collection and communication for decision-making (Paul Okinyi & Nyanchama Nyabuto, 2015). Socially, knowledge acquired from computer networks is beyond price and promotes understanding and tolerance, bridging the gap between societies and nations and helping to build a world community. Development perspectives indicate that access to information touches more aspects of development than previously considered. Governments often claim they have no money, but having met neighbouring countries that appear behind economically, it is clear that the problem is often the information available on how to negotiate grants and develop projects. Computer networks play an important role in national development and are a catalyst for development when the situation is created for their benefits.

Types of Computer Networks

Computer networks have been developed and are used to assist communication and controlling problems. The rapid development of computer and communication technology furthers the scope of computer networks and data communications. Due to computer networks, a person can send a file to the other side of the world, quickly and effectively. The ability to offer information to the target people directly becomes simpler and quicker. From the economic point of view, computer networks play a vital role in the development of a country. Government departments, offices, organizations, and corporations have realized the importance of computer networks as they cut down the cost of a single job and increase the efficiency multiple times in almost no time. Computer networks have been a significant issue for many organizations. It is no wonder; it has become one of the fastest growing areas of information and communication technology, and it has become a general trend to have a computer network for economic, social, and cultural growth. (G. Fitzsimons, 2006)

(i) Local Area Networks (LAN): Local Area Networks (LANs) play a crucial role in development by enabling efficient data transfer among terminals, computer systems, and peripheral equipment within a building or cluster of buildings. Originally described as an information transport system for data transfer among terminals, computer systems, and peripheral equipment within a building or cluster of buildings, a LAN system suitable for teaching laboratories facilitates the easy connection of various equipment while remaining relatively inexpensive. The network consists of microprocessor-based protocol interface units connected to a common twisted-pair cable, providing virtual circuit service via a CSMA/CD technique and supporting several simultaneous independent virtual circuits (Edmund Wickliff, 1986).

The design of campus networks targets efficient resource sharing and information access among users, while performance concerns such as latency and delay become critical under increasing network traffic. Network simulation, using tools like the OPNET Modeler, supports pre-deployment modeling and performance analysis of LANs by imitating real-life scenarios; this approach saves costs and enables accurate forecast of future performance. LANs connect computers through active and passive devices such as switches and hubs to facilitate resource sharing. Accurate modeling requires ensuring behavioral equivalence and validation between the model and the real system. Protocols such as the Internet Protocol (IP) enable communication between devices and the exchange of information irrespective of operating systems. Ethernet serves as the underlying transmission medium for IP by framing the data (A. Atayero et al., 2012).

The implementation of Network Systems Local Area Network (LAN) is essential for institutions like the Ministry of Industry Pusdata to operate with a shared database and convenient access to information. The system benefits from distributed processing, allowing terminals to be added or removed without operational disruption. Nodes communicate using CSMA/CD, which detects an incoming channel, while communication protocols define operational methods and ensure system reliability ((Nur) Azizah & J. (Ir) Jalinas, 1996).

(ii) Wide Area Networks (WAN): A Wide Area Network (WAN) is a computer network that spans multiple Local Area Networks (LANs), often using different technologies and operating under separate administrative domains. WANs constitute the infrastructure behind most services and are critical for private and government operations such as monetary transactions. Network designers have yet to develop a cost-effective WAN that satisfies the requirements and constraints of all potential users within a region. Optimizing transaction times and ensuring user satisfaction remain important issues, and WAN optimization devices have proven effective in enhancing the end-user experience. The costs associated with WAN deployment depend on numerous regional parameters, including population size, geographic extension, traffic density, bandwidth, and socioeconomic factors. Consequently, the planning of WANs necessitates consideration of economic interactions and indicators across regions. Modern WANs frequently encounter congestion caused by multimedia services, Web traffic, videoconferencing, Voice over Internet Protocol (VoIP), and unified communications, which place substantial stress on the network infrastructure (Ahmedi & Mitrevski, 2014).

WAN-in-Lab is a hardware testbed designed to facilitate the development, testing, and evaluation of state-of-the-art, high-speed network protocols. Employing real carrier-class hardware, the testbed enables detailed performance measurements without the artifacts commonly introduced by simulation or emulation tools. Wide accessibility and openness are central to WAN-in-Lab's mission, making it a valuable resource for the global networking research community. Protocol development typically progresses through mathematical modeling, simulation, emulation, and deployment on production networks. While mathematical modeling offers the ability to study entire protocol classes, it often requires substantial simplifications. Simulation provides flexibility but is considerably slower than real time and does not involve actual protocol implementations. Emulation platforms can introduce significant artifacts, especially at link rates approaching multiple gigabits per second. Although production networks deliver realistic testing environments, their limited availability and dependence on cooperative operators restrict their suitability for exploring failure modes and handling highly loaded scenarios. WAN-in-Lab aims to bridge the considerable gap that exists between emulation and production environments (S. Lee et al., 2007).

(iii) Metropolitan Area Networks (MAN): Metropolitan Area Network (MAN) is a network that usually covers a city or a large area. It can be viewed as a large network either as a connection of campus networks or a large Ethernet network with 100 Mbits/sec or more per second data rate (Ahmedi & Mitrevski, 2014). An IEEE group has started working to develop a standard for the MAN called IEEE 802.6. A cable TV company uses the technology of MAN to deliver cable TV services and offers it to educational or municipal communities at the same time depending upon their policies (Alejandra Bernal et al., 2017). MANs can be implemented with Extended Local Area Network (E-LAN) connection where LANs can be connected through ATM services or Frame Relay services or through satellite communication if a TV cable company is willing to install it.

Technological Advancements

Emerging technologies such as cloud computing, the Internet of Things (IoT), and 5G communication networks promise to empower computer networks with additional capabilities potentially valuable for development. Cloud computing enables organizations to store, manage, and process data on remote computing resources over the internet, fostering business model and production process innovation. The IoT facilitates intelligent equipment deployment, allowing real-time access to and updates of service status, which can substantially reduce operational costs. 5G wireless systems offer high data rates and low latency, advancing the world of wireless communication and securing higher operational efficiency (Paul Okinyi & Nyanchama Nyabuto, 2015).

(i) Cloud Computing: Cloud computing has transformed the-information technology landscape, removing dependencies on local computers and enabling data storage and usage from any internet-enabled device. For students, it offers a convenient way to submit assignments without physically visiting the educational offices—provided an internet connection is available. The real benefit lies in its role as a common connect point, regardless of user location. Just as a telephone network provides interconnectivity, cloud computing offers a network of storage and data processing, ready when needed. Users can run any type of application or even complete operating systems on cloud platforms.

This network allows a myriad of devices—desktop PCs, laptops, tablets, smart phones—to carry the data storage facility not just on itself but also on the cloud. The concept of Cloud is a logical space, a giant repository of data accessible to users at any time from anywhere. Its usefulness is unquestionable in many walks of life, including education for the user group of students, teachers, administrators, and parents. Cloud, a house of data and a source of specific service, is a tool for development and creates the future of human endeavor.

(ii) Internet of Things (IoT): The Internet of Things (IoT) refers to the paradigm in which everyday objects are equipped with microcontrollers, transceivers, and protocol stacks to communicate with each other and users, making the Internet more immersive and pervasive. A variety of Internet-enabled objects such as home appliances, surveillance cameras, sensors, actuators, and vehicles can be accessed anywhere and at any time, opening the door to numerous applications in home automation, medical aids, energy management, automotive, and traffic management. The key strength of IoT lies in its high impact on everyday life and human behavior, with potential benefits spanning domestic, healthcare, industrial automation, logistics, and transportation sectors (Rajashekhar, 2016).

IoT is defined as a collection of objects connected to an Internet-like structure. The term also applies to any non-traditional computing device with a network connection.

Examples include weather-monitoring stations and air conditioners connected to the Internet. Development of IoT applications is hindered by the lack of available design tools, methodologies, and interoperability. A standards-based, open-source hardware and software platform with full documentation and educational materials can greatly accelerate application development. Low-power Internet-enabled embedded systems used in sensor and control networks belong to the emerging IoT space (Peter Kimsey, 2014).

(iii) 5G Technology

The last decade has witnessed rapid progress in the evolution of mobile communication, which has transformed from simple voice and short-message services to sophisticated communication that supports a massively advanced network, allowing us to create a fully connected society. The development of 3G and 4G networks mainly aimed to satisfy data-service needs; however, today's diverse applications and the huge number of users place enormous demands on wireless networks in terms of data rate, speed, efficiency, quality of experience (QoE), and battery life (Indudhar Goudar et al., 2017). To fulfil these requirements, 5G technology is expected to be deployed in the near future.

Building on the achievements of preceding generations of mobile networks, 5G is designed to provide a wide range of advanced features, such as ultra-dense networks, the coexistence of multiple radio access technologies (RATs), direct device-to-device (D2D) communication, and massive capacity capable of supporting 1000 times more services. According to specifications released by the International Telecommunication Union (ITU), 5G targets data rates of 1–19 Gbps and a capacity of 36 TB per month per user. Rather than simply broadening network coverage or increasing spectrum resource availability, 5G aims to deliver a radical new user experience based on an interface that accommodates diverse applications, with a particular emphasis on artificial-intelligence (AI) applications. The technology shifts the paradigm from human-centric to both human-centric and machine-centric design, thereby redefining mobility challenges. The principal building blocks of 5G include the air interface, spectrum, and network devices; a significant realignment of priorities among these elements is anticipated over the next decade.

Healthcare and Computer Networks

Health is an indispensable aspect of human development. The burden of ill health calls for efficient and effective means for delivering quality healthcare services to the masses, especially those in the rural areas. Telemedicine systems assist in providing healthcare services even in the remotest parts of the country that may not have proper medical establishments or facilities (Afaq Qureshi et al., 2014). The use of healthcare and e-health applications has been on the increase with the development and penetration of the Internet in many countries of the world. Electronic Healthcare Record (EHR), a digital format of the traditional paper-based health records, has been one of the most widely used e-health applications where it helps to automatically collect and process information generated by health centres. Geographical Information Systems (GIS) assist the healthcare workers in tracing the health patterns and trends of possible outbreaks of diseases in a particular area and preventing them before they worsen into an epidemic (Batta et al., 2016). They also help the country to sustain health interventions such as international and national immunisation programmes. Health Information Systems (HIS) form the basis of multiple digital technologies and are very effective in coordinating different health-related agencies and units to work along together in an efficient manner. Such systems assist government and its agencies,

policymakers, and other stakeholders in making informed decisions in the healthcare sector, especially in the areas of adequacy and allocation of resources, planning and evaluation of services, and equity and utilisation. They are also the main significant components of monitoring and evaluating global health goals and targets as indicated in the UN Millennium Development Goals and the World Health Report. Applications such as Radio Frequency Identification (RFID) assist in inventory management by helping to easily trace the whereabouts of all equipment, devices, and also patients' records that are already on the system; thereby preventing bottlenecks and delays in the healthcare delivery cycle.

(i) Telemedicine: Healthcare is a major sector where computer networks assist development. The current global situation is a trigger for digital innovations and the way in which the healthcare industry can adopt them in everyday processes among healthcare professionals, healthcare authorities, patients, health systems and industries at large.

Telemedicine is traditionally recognised as one of the main drivers and enablers of the digital transformation in health. Until today, this concept has always been considered as "the provision of healthcare services at distance" but the actual definitions found in the literature are far from representing the comprehensiveness of the related domain. Such a body of knowledge can in fact be best summarised by the World Health Organisation, which defines telemedicine as "the delivery of healthcare services, where distance is a critical factor, by all healthcare professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of healthcare providers, all in the interests of advancing the health of individuals and their communities." Many good examples have been already presented regarding the role of telemedicine in the developing world (COMBI et al., 2016).

(ii) Health Information Systems: Health Information Systems (HIS) refer to the organized collection, storage, management, and transmission of health-related data, facilitated by healthcare organizations and supported by formal procedures and rules. HIS enables formulation of policies aligned with health progress goals, allowing medical authorities to monitor and forecast disease spread through shared data and information management. The internet fosters telemedicine, where doctors communicate live with patients and specialists across distances. Computerised Patient Record Systems make full patient histories instantly accessible at the point of care, enhancing consultation quality and supporting medical research, as exemplified by kidney disease management systems.

The adoption of ICT in HIS faces challenges of security, privacy, and confidentiality, causing apprehensions among healthcare providers who require assurances of data protection and meaningful usage. Nonetheless, the growth and diffusion of mobile technologies, desktop computers, the internet, and other critical ICT components have accelerated the adoption process. Investigations reveal that computerised HIS can reduce paperwork, improve availability of Health Management Information System (HMIS) data, enable information integration, enhance data legibility, and contribute to reduction of medical errors. As a constituency devoted to ensuring the quality of human life, health institutions will benefit immensely from the improved integration of ICT into their operations (Githiomi et al., 2016).

(iii) Data Management

Data management is a foundational function of computers. A computer network

collects, stores, and makes information available for community use. The technology enhances relationships among individuals, groups, and organizations (Johnson et al., 2001). Networks permit increased productivity and the capacity to locate new information sources. They facilitate communication and provide increasingly rapid methods for doing so. Good training on the use and application of the technology is essential. Extensive preparatory work is needed for good data to be collected and made accessible (Rhode et al., 2017). Documenting the frequency and extent of communication facilitates the analysis of information flow. A planning exercise is advisable to define the types of information needed, to analyze effective dissemination methods, and to identify local support and distributed responsibilities. The use of a network without careful attention to these considerations may lead to a limited quantity of unreliable information.

Future Trends

Vivian and Yu presented an AI-integrated approach capable of automated network selecting, network access, application matching, and seamless handover, addressing critical requirements and challenges such as heterogeneous network integration, e-business support, user QoS differentiation, contextual information, support for scaling and configuration, seamless service, and more. This position paper motivates research directions for pervasive wireless networking. (Du Preez, 2009) emphasized that many countries lack the infrastructure to generate their own power, limiting ICT development to urban areas. The Internet remains difficult to access for those who cannot read or do not speak a primary Internet language, complicating digital inclusion. Network infrastructure is expensive and requires specific skills, hindering connectivity in developing economies.

(i) Artificial Intelligence in Networking

Artificial Intelligence (AI) has emerged as a promising area of technological development, drawing the attention of corporations, governments, academia, and global organizations worldwide. Its numerous applications in computer networking have resulted in significant benefits. In the domain of computer networks, AI techniques are applied to routing protocols, radio frequency spectrum management, energy efficiency, intrusion detection systems, and virus detection methods. Various AI paradigms—including rule-based systems, fuzzier systems, neural networks, genetic algorithms, and logic programming—are employed to address these challenges. Recent advancements in AI, such as deep learning, promise further enhancements to networking applications, expanding the scope and effectiveness of AI-driven solutions (M. Sivalingam, 2021).

(ii) Sustainable Networking Solutions

Sustained development in Africa depends on guaranteeing African countries uninterrupted, affordable, and high-capacity Internet connectivity (Ag Info Project Design Team, 2007). Computer and network design must target emerging Africa-specific applications, such as agricultural management on porous wireless farm grids or massive, high-altitude access to compute clouds. Dynamic client mobility requires network-neutral operation across multiple heterogeneous physical infrastructures, whether public or private. Addressing sustainability requires preserving nature, securing the economy, and maintaining society's social fabric simultaneously. Current communication networks cannot simultaneously maximize all three dimensions, so the key performance indicator for future networks is "sustainability." The STAMINA project targets enabling future high-capacity networks to optimize a sustainability utility function: maximizing the three aspects simultaneously, adapting natively to

environmental, social, and financial context changes, and supporting efficient policy control (Fuchs & Fuchs, 2017).

Conclusion

The Internet and computer networks have emerged as transforming forces, reshaping numerous economic and social sectors while generating new benefits worldwide. The deployment of broadband Internet, coupled with mobile and social networking technologies, enables real-time sharing of files, photos, videos, and audio by individuals, companies, and governments (Pedzai, 2010). This rapid evolution fosters innovation, entrepreneurship, and creativity, simultaneously driving economic growth and contributing to social development. Widespread adoption of broadband technology supports the development of myriad user-friendly applications, yielding diversified benefits for both users and suppliers and acting as a catalyst for economic gain and social advancement.

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Cite this Article-

"Sarthak Singh; Dr. Chandan Kumar" "Computer Network: An Instrument for Development", Procedure International Journal of Science and Technology (PIJST), ISSN: 2584-2617 (Online), Volume:2, Issue:7, July 2025.

Journal URL- https://www.pijst.com/

DOI- 10.62796/pijst

Published Date- 04/07/2025