

A Survey of Application of Technological Convergence in Different Fields

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Abstract - Technological convergence provides a way to merge different areas of technology to perform tasks better and more efficiently. With technological convergence, industrial boundaries are becoming blurred, allowing service providers to offer services in multiple markets with better results. This paper highlights a number of areas where technological convergence has emerged, including medical care, nanotechnology, social media, smart phones, emails, printing, telecommunications, data storage, and network virtualization. Along with advantages of technological convergence, some challenges requiring closer attention from various stakeholders are discussed.

Keywords - Technological Convergence, Social Media, Smartphones, Telecommunications, Storage, Network Virtualization, Nanotechnology

1. WHAT IS TECHNOLOGICAL CONVERGENCE?

Borés, Saurina and Torres [1] define technological convergence as “a process by which the telecommunications, broadcasting, information technologies and entertainment sectors (collectively known as ICT – Information and Communications Technologies) may be converging towards a unified market”. Technological convergence has both technical and functional sides. The technical side refers to the ability of any infrastructure to transport any type of data, whereas the functional side means the ability of consumers to seamlessly integrate various functions in computation, entertainment, and voice in unique devices to execute multiple tasks.

2. LITERATURE SURVEY

Nnyström and Hacklin in their paper “*Operator value-creation through technological convergence: The case of VoIP*” raise some questions concerning technological convergence and its role in telecommunications, which can be characterized by increasing competition and rapid technological development. The paper thus suggests that technological convergence may be used as a tool to create value for service operators in the field of telecommunications. Jon Kleinberg (2012) in his review article “*The convergence of social and technological networks*” discusses that the availability of rich and plentiful data on human interaction has closed an important feedback loop, allowing for the development and evaluation of models of social phenomena at a large scale and using those models to design new computing applications. The World Health organization (2010) in their article “*Convergence of medical devices and information technology*” sums up the information gathered by conducting literature reviews and surveys, and by convening meetings of specialist consultants determines whether medical devices currently on the global market are meeting the needs of healthcare providers and patients so that, if not, it can propose appropriate remedial action based on robust research Kang and Oh (2012) in their paper “*The Emerging Trend of Technological Convergence and Tasks for Science Parks*” suggest some tasks for the development of science parks and highlight some other factors such as identifying the potential for technological convergence, establishing a convergent ecosystem by building connections across stove-piped systems, effecting a technological convergence platform, and conducting further research to strengthen plans for converging technologies.

3. EXAMPLES OF TECHNOLOGICAL CONVERGENCE IN DIFFERENT FIELDS

Based upon benefits and services offered by technological convergence, a number of areas are explored as follows:

3.1 Developments in Media

Traditionally there was some restriction regarding the type of media content or the device on which such content has to be played. Like video players, which were bounded to television only to display content, music was bounded to compact disks or tape decks, and video games were bounded to specially designed consoles. However, now communication across different devices with different formats is feasible. For example, modern game players, in addition to providing users with the primary task of games, can also allow users to listen to music and connect online and interact with other users, among other tasks.

3.2 Technological Convergence in Authentication

In the past, to access each web-based application, a particular sign-in protocol was required. Such protocol cannot be used to authenticate other web applications. However, with technological convergence, a single sign-in protocol can be used for authenticating different applications and getting access to them, as in the case of many portals such as Facebook and Gmail. Therefore, such facility helps to remove excessive overhead in remembering a number of authentication user IDs and passwords.

Moreover, new authentication techniques such as biometric authentication using fingerprint recognition technologies, pattern matching, and recognition of human heart beats through- the iris are becoming more popular.

3.3 Technological Convergence in Printing

Additive manufacturing, also known as 3-D printing[2], is coming into picture. 3-D printing is the process in which a 3-D solid object is produced according to a digital file. 3-D printing can find numerous applications in different ways such as the following:

- I. To print organs from a patient's own cells, the patient is no longer dependent upon the donor for specific organs.
- II. The automobile industry can make use of 3-D printers for prototyping vehicle parts to save time and effort in comparison to traditional methods.
- III. The aerospace industry is using 3-D printers to design rocket engine injectors in a much more efficient manner.
- IV. Formation of hearing aids and jaw bones is another application where 3-D printing is produced with much better results.

3.4 Technological Convergence in Education (Edtech)

Technology has brought about a revolution in the way knowledge is passed from an instructor to a student. Today, distance, device compatibility, and accessibility no longer serve as constraints for acquiring knowledge. Various devices such as tablets are being introduced to work in conjunction with cloud-based models at the back end for the easy sharing of content among knowledge seekers. Classrooms are embedded with smart technologies making use of numerous multimedia devices, and the simultaneous sharing of online lectures across remote locations is feasible. Google hangouts are the example of such a knowledge-sharing technique. Numerous platforms are developed by universities for open discussions among researchers to better compose problems and identify more optimal solutions.

3.5 Virtual Reality Is Becoming Real

More companies are investing in products supporting virtual reality. Virtual reality helps in digital enhancements by adding a virtual digital layer over personal reality. Development of hand controllers that help in actual manipulation and touching of virtual things are areas where companies are focusing on, as well as other areas such as photogrammetry and video photogrammetry, which help in scanning both living and no living things in a room and then converting them into 3D digital images. In the near future, there may no longer be displays and screens because technological convergence is expected to allow users to see virtual television anywhere, anytime.

3.6 Advances in Telecommunications

Network convergence allows network operators to use their own networks to their maximum advantage to reduce network capital costs and thus consumer costs in providing new telecommunications services [3]. Technological convergence has led to certain smart devices such as smart phones that can perform various tasks in an efficient manner. There is no need for separate devices for many functions. In addition to the primary task of calling, smartphones can provide video calling, internet access, data sharing, and data storage by providing vast storage capacity, acting as a modem for internet access to other devices. In this way, functions are efficiently integrated into a single device such as a smartphone.

3.7 Convergence in Banking

For financial tasks such as fund transfers, bank users had to visit banks. For withdraw cash, they used ATMs by standing in lines. Now such tasks can be done through SMS services, and therefore the need for physical devices for such banking tasks has been decreasing due to internet banking.

3.8 Technological Convergence on the Internet

The most representative example of technological convergence is the Internet, which is a platform providing various kinds of facilities. Now there is no requirement to purchase media players because diverse tasks such as entertainment, radio, television, book reading , and games can be viewed and used online.

3.9 Network Virtualization towards Convergence of Networking

Application of service-oriented architecture (SOA) in the field of network virtualization has attracted much interest in the academia and the corporate sector . Network virtualization uses various tools such as virtualbox, and SOA enables a network-as-a-service (NaaS), which facilitates the convergence of networking and cloud computing. Therefore, this facility allows cloud service models to be unconstrained to three popular services, namely software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS) [4]. There are many benefits of virtualization through technological convergence.

- I. The capacity to rapidly save, copy, and provision a virtual machine;
- II. Dynamic sharing of inactive resources throughout server platforms;
- III. Higher technology standardization;
- IV. Seamless failover when a virtual server component fails;
- V. Reduced complexity;
- VI. Easy scalability for application by active application to a server with more resources;
- VII. Resource optimization to drive great efficiency at the data center;
- VIII. Cloud computing with the formation of internal clouds and giving the ability to interface to external clouds.

3.10 Hyper-Converged Storage

Hyper-converged storage combines storage, virtualization, computation, and networking in one physical unit managed as a single system [5]. It provides many facilities:

- I. Better control over storage to provide a virtual server environment;
- II. Administrators with a single pane of glass management capabilities;
- III. Hyper-converged storage nodes can be connected and scaled horizontally;
- IV. Capability for the administrator to create a distributed storage infrastructure in which direct-attached storage (DAS) components from different physical servers are combined to create a logical pool of disks.

3.11 Convergence Is the Key in Cloud Computing

Convergence is the key in cloud computing, where many advancements occur in the computation, network utilization, and storage for new facilities such as decreased developmental costs and increased mobility in accessing applications anywhere, anytime on any device [6]. Cloud and big-data technologies are converging to offer a more cost-effective delivery model for cloud-based big-data analytics. Cloud computing models have a benefit in accelerating the potential for a scalable analytical solution, providing a service known as analytics as a service (AaaS).

3.12 Convergence in Medical Facilities

There are specific challenges that have been identified in the healthcare industry before the emergence of technological convergence. Some issues are related to costs, resources, demographics, access, quality, and patient centricity. Convergence in medical facilities refers to the convergence of digital healthcare, pharmaceutical, and medical device Industries[7]. This concept embodies many types of novel combinations representing the combination of therapeutic, diagnostic, and digital IT applications. Such convergence is expected to provide better utilization of technologies for improved monitoring, management, and individual/societal health as well as the use of diverse components such as wireless devices, hardware sensors, microprocessors, social networking services, personal information, and big data. Some salient features of technological convergence in the medical field can be summarized as follows:

- I. Anywhere, anytime connectivity
- II. Technical support
- III. Multiple connectivity options
- IV. Standards-based approach
- V. Support for legacy devices
- VI. Data security and compliance
- VII. EMR integration
- VIII. Multi-modality and multi-format support
- IX. Configurable data storage
- X. Flexible user interface
- XI. Extendible and reusable devices
- XII. Audit trails and logging

3.13 Convergence of Nanotechnology and Modern Biology

Nanotechnology is the science and technology of microscopic forms, namely things that are smaller than 100 nm in size. Single nanometer is 10^{-9} meters or around three atoms long. Scientists have discovered that matters at the micro level, small particles, thin films, and others can have distinct properties from similar substances at a larger scale. The National Nanotechnology Initiative (NNI) [7] marked a decade ago the global emergence of nanoscale science and engineering. Recent studies of biological systems at the nano level have led to the emergence of dynamic science and technology domains resulting in the combination of diverse fields such as medicine, biotechnology, biology, physical sciences, and molecular engineering. The main focus of this integrated domain is to understand dynamic sciences, living and thinking systems, regenerative medicine, the synthesis of new drugs and their targeted delivery, neuromorphic engineering, and development of an environment that can be sustained in the long term.

3.14 Technological Convergence in Social Media

Social media are progressing through conversation, collaboration, and co-creation. In addition to performing the primary task of communication, social media can be further extended to perform tasks in digital marketing. Instead of digital marketing on social media in which all users are shown the same advertisement, things can be changed through what is known as people-based marketing, in which content delivery for digital marketing is dynamic in nature to be user-specific and thus dependent on age, gender, preferences for particular brands, and information related to different occasions. Such a method of digital marketing is expected to increase desired outcomes. Evaluation of the success rate of such advertising can be done using urchin traffic monitors (or modules). In collaboration with the global positioning system, social media can also provide location-based services (LBSs), which combine the GPS and instant-messaging techniques to discover and share information on other users within a specific geographic range. Therefore, LBSs allow users to obtain a live feedback on what people are communicating.

3.15 Convergence of IMS and Web Services

Web services and IP multimedia subsystems (IMSs) [8] have distinct service delivery platforms (SDP) as well as advantages. IMSs deal with integrated network of telecommunications providers for IP use. Web services provide a standard way for interoperability across IT applications on diverse platforms. Recently, there has been convergence in access to multimedia services through the combination of IMSs and web services to limit platform heterogeneity and resources.

3.16 Voice over Internet Protocol (VoIP)

VoIP is a representative example of technological convergence[9]. VoIP provides additional facility for users to make voice calls through the broadband instead of a regular landline phone. VoIP converts the user's voice into a digital signal over the Internet. VoIP allows users to make calls directly through a computer or a special VoIP phone. Wireless hotspots allow telephone connections easy. Fig. 1 illustrates the VoIP scheme.

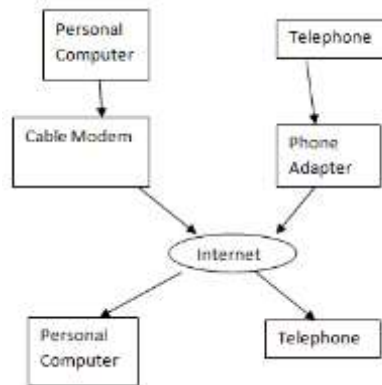


Fig.1. VoIP

4. Desktop Virtualization with a Converged Infrastructure

Desktop virtualization[10] [11] is a new technology that converges servers, storage devices, networks, and management platforms. Deployment of desktop virtualization combines these resources into a single entity to simplify the provision of various services. With this approach, centralized management of the whole infrastructure can be achieved for a better view of how resources are used for better network and data resource management (Fig. 2).

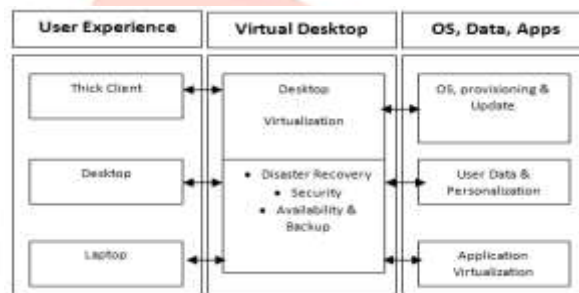


Fig. 2 Desktop Virtualization

5. CONCLUSIONS

Technological convergence plays a crucial role in society from economic, social, and developmental perspectives. Technological convergence can bring about new opportunities to meet development goals and bridge the digital divide. Technological convergence, together with technological standardization, can enable transparent and modular communication between diverse devices over the network. Technological convergence provides advantages for service providers for coordinated and more efficient service delivery. However, technological convergence has some limitations related to interoperability, interconnection, consumer protection, and universal access. Other include new regulatory frameworks related to licensing and regulation of providers, bandwidth shortage, infrastructure upgrades, strategic alignment by service providers, privacy, security, and reliability. In this regard, a systematic approach is needed to better facilitate technological development through convergence.

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