

Review of Infrastructure Transformations of Information and Communication Technology in the World



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Abstract

This research aims to investigate the revolutions and developments in disseminating an IT infrastructure in the world. To reach this purpose, the various English and Persian literatures have been investigated to complete the findings as well as statistics of databases such as UNESCO and International Telecommunication Union (ITU). The results show that the information infrastructures in developed countries are more advanced than the other places of the world such third world countries; in addition, the first group countries (developed countries) have a considerable distance with the second group countries (third world countries) in terms of the internet clienteles, accessibility, bandwidth and

speed, penetration rate, usability cost, and dissemination. Political, social, economical, and cultural different factors have played an important role in developing and disseminating these infrastructures but the economical factors (and expensive costs of modern information technologies) are the most important factor among the other factors. Although there is a significant distance between developed and developing countries, but in recent years developing countries have increasingly progressed in developing and disseminating of information infrastructures.

Keywords:

Information and communication technologies, infrastructures, Indicators, penetration rate

Introduction

The American Heritage College Dictionary defines infrastructure as (1) a fundamental basis, especially for an organization or system; (2) the basic facilities, services and installations for a community or society to function, such as transportation and communications systems. Thus, an infrastructure is the base upon which something else "runs" or "operates", without which operations are not possible (1). Infrastructure is a resource and capability which enables information sharing through the interaction between technology and people in the organization who share the different elements (2).

Along with use of ICT in all human life aspects, the world is rapidly becoming an information society. Nowadays internet access possibility and the use of information resources in all human societies has a progressive process; and different societies due to multiple infrastructures benefit from the required information technology and communications. Developing infrastructure Communication, legislation and training familiar work force for information and communication technology are examples of the efforts made in this regard.

ITI represents the IT resources that facilitate business applications. In the 1980s, IT was becoming known to help firms raise entry barriers, increase bargaining potential with suppliers and customers, and offer new products and

services (3). In the 1990s ITI was being defined as shared, tangible, technological resources including platform technologies (i.e., hardware and operating systems), networks and telecommunication technologies, data, and software applications (4). Since then the objective is to find the ways IT can help generate business advantages. However, over the years, a number of scholars have noted that sustaining the advantages of IT might be difficult, because such applications are eventually imitated and appropriated by competitors [5,6,7]. There are theoretical, methodological, and measurement matters producing inconsistent results, and the growing awareness is that IT cannot be a primary source of competitive advantage (8). Today, organizations are recognizing the importances of effective ITI (Downes, 2003) (9) while the development and operation of flexible ITI is of administrative concern (10). ITI effectiveness can be assessed using criteria such as reliability, operation with low downtime; flexibility, efficiently adapting to changing business requirements; and upgradability, efficiently adapting to or deploying multiple, complex technologies as required (11). IT is a broad term referring to a combination of ITI, human resources, and IT-enabled abstracts (12) and therefore each aspect should be studied individually in order to understand their effects on a firm. ITI (a big part of a company's IT budget)

encompasses the services shared and coordinated throughout a firm, usually by the IT division, and also goods such as hardware platforms, operating systems, network and telecommunications (e.g. e-mail, instant messaging, and groupware), software applications, databases, intranet, and the Internet [13,14,15,16].

At the present time, the importance and necessity of information technology and communications is to the extent that the relative advantage of resources and natural resources – that is specific for the developing countries have lost its value against competitive advantage of technology – which is particular for the developed countries. Therefore, investment in this section plays an important role in high added value and improving the processes.

Infrastructure is available in different forms and methods, including tools and equipments and communication technologies such as telephones, mobile and Internet. Therefore, developments in information technology in the present era and how such technologies are distributed worldwide is the main issue of the present study. For this reason, considering the expansion of information technology infrastructure, understanding of information technology infrastructure and scattering it all over the world, comparing countries in terms of technologies capabilities and look at ranking countries in different parts of the world is embedded in the scope of the investigation and review of the present study.

What is certain is that the explosion of information technologies and the phenomenon of data explosion, the importance of relevant infrastructure are located in the shadow. So, the Third World countries and some developing countries have failures because of poor technology infrastructure and they are faced with serious problems in the efficient and appropriate use of these technologies.

Review of the related literature

Several studies have been conducted on the development of information technology and creating the necessary infrastructure. The outcome of these researches indicates that the development of information technologies in the 21st century has a very rapid growth especially in recent years. Among these researches the followings can be outlined:

Effective information and communication systems or infrastructures require reliable, low-cost and widespread technological resources (information infrastructures) such as computers, software and all the components of the telecommunications infrastructure for processing data and information, that could offer Africa cost – effective and appropriate technologies to “leap-frog” over several generations of intermediate technologies still in use in the industrial world. Information is needed for production of goods and services, and for making wiser decisions that still must be collected, processed, stored and utilized. It is a general consensus that information is an indispensable tool for the continued survival of an organization be it private or public (17).

However, the on-going information explosion and extensive use of infrastructures in industrial economies contrast sharply with the “information poverty” of developing countries (18). This poverty takes many forms of planning without facts, an unreliable information support to decision-makers, inadequate financial control and cumbersome reporting and monitoring systems, limited access to information within and among countries, professionals and researchers without access to national statistics and internal research findings, scares information support to knowledge workers, insufficient information on natural resources, underused indigenous and locally produced knowledge, poor access to timely information on national and international markets by developing countries like African countries where manpower face major problems in acquiring, retrieving, processing and disseminating various types of information. Many other problems or factors that have affected and still affect the development of information infrastructure and information transfer in Africa are examined and noted in this work.

The importance of communications infrastructure

We stand at a critical juncture in the development of our nation’s information infrastructure. The growing convergence of computer and communications technology has brought tremendous benefits to large organizations and technically sophisticated individuals. Those with the resources and the know-how have at their fingertips powerful information and communications tools: worldwide electronic mail, instant database access from any location, high-quality image storage and retrieval systems, and video-conferencing systems. Access to such services enhances the professional productivity, personal growth, and even the cultural life of those who use them. For these people, the information revolution has arrived.

Yet, neither industry efforts nor telecommunications public policy has been successful at bringing the benefits of information age services to the mass market. These new technologies have tremendous potential for improving health and education services, for enhancing cultural and political expression, and for promoting new kinds of entertainment. But the underlying services are still unaffordable and inaccessible to the vast majority of the American public.

However, the political dynamics of the telecommunications debate have largely stalled real progress on infrastructure in the last ten years, as entrenched commercial interests wrestle over who will control and dominate markets such as information services, equipment manufacturing, and long distance service. We believe it is time to refocus the de-bate by seeking near-term technological, economic, legislative, and regulatory solutions which will encourage the rapid development of a diverse information services market and help realize the democratic potential of new information media.

Many voices in the communications infrastructure debate have suggested that information age services can only be brought to the American public by a massive, sudden investment in fiber optic cable to each home and office. But

this view has only aggravated the gridlock by posing an “all or nothing” choice. We fully agree that the nation will need some such very high-capacity infrastructure in the future, but there are many steps along the way to that network (or networks) of the future. If we are to make progress in the near term, we must identify short-term goals that are achievable politically, technologically, and economically. We must find a way to jump-start the mass-market information revolution in the next five years, rather than waiting 20 to 30 years for a fiber optic network to be installed nationwide.

In the review of the literature and foreign language, we find that in the first decade of the 21st century, several researches have been accomplished in the issue of information technology and related infrastructure. But it seems that due to the passing of developed countries from this point, at the moment and in the middle of the second decade of the 21st century, the flexibility of this infrastructure and adapting it to the needs of users is an important issue that has engaged researcher minds.

In order to use and develop a national information infrastructure and its feasibility in America, Kapor and Weitzner (2010) have done a research entitled ‘the development of national information and communication infrastructure’ (19).

Enakrire and Onyenania (2007) have conducted a more widely study in which the factors which are involved in the development of information technology infrastructure in Africa have been examined (20). This study has been considered the challenge of this phenomenon in the Africa continent while dealing with the concept and status of information infrastructure. Factors such as communications, political crises, war, coup, poverty and illiteracy, social and cultural diversity, the lack of communication facilities and etc. among the involved issues have been engaged in the development of information technology in the continent.

The above study, in terms of population coverage, includes African countries live in information poverty and they have the lowest profit of information technologies. Therefore, it can provide a true picture of the information gap among these countries and developed countries which it reflects their deep lack of information technology and relevant infrastructure.

In this regard, Chanopas, Krairit and Khang (2006) in a study entitled ‘Managing information technology infrastructure’ evaluated the flexible framework and its characteristics in order to use flexible infrastructure (21). The aim of this study is to provide an operational definition of the flexible information technology infrastructure and to provide a framework to identify its components. Developing the results of four components of detection (connection, compatibility, modularity, and competence of personnel in information technology) has been made to clear the next five components (scalability, continuity, speed, convenience and modernism). The originality and value of this study is to provide an empirical evidence of

the developing country, for the first time, to fill a significant gap in the scientific literature. Also, Blanning (1997), in his research entitled ‘the national information infrastructure in the Asia / Pacific countries’ has mentioned that “recently many Asia / Pacific countries have begun their design of national information infrastructure (20). For example, the application of information technology in Singapore in 2000 is to transfer a City State into a Smart Island and the prospects in Malaysia in 2020 is focused to create a multimedia foyer. IT infrastructure programs in 12 Asia / Pacific countries is investigated. They are newly-developed countries (young lions, including China, Malaysia, the Philippines, Thailand and Vietnam), the average level countries (advanced tigers, including Hong Kong, Singapore, South Korea, Taiwan) and advanced countries (mature leopards, including: Australia, Japan, New Zealand). APEC has also been examined. This was used in the establishment of APII (Asia / Pacific Information Infrastructure).

Research Objectives

The aim of this study is to explain the information infrastructure and its indicators in countries around the world. In covering this purpose, the distribution and spread of the infrastructure in developed and developing countries also will be studied. Also, the following sub-goals, besides the main aim of this study, will be considered:

- 1) The visual presentation of the information infrastructure in the world;
- 2) The introduction of information infrastructure in the form of technology, methods and systems of knowledge in order to process and exchange information;
- 3) To providing an operational definition the flexibility of information technology infrastructure;
- 4) To provide a framework to assess flexible IT infrastructure components.

A look at the range of information technology in the world

The World Economic Forum has released the latest edition of its report based on ‘information technology in the world’. This report classified 144 countries in terms of growth and satisfaction based on the information and communication technologies. Table 1 shows the list the top ten countries. In this report, a special glance is taken to the 4 main criteria: information technology infrastructure; the use of information technology in government, businesses and individuals; business environment and innovation; and the economic impact of information technology. Also body of the report and statistical data confirms that the digital technologies have left a visible impact on the economic growth and job creation. But the report said that the digital gap between developed countries and developing countries is increasing which this is because of the absence of a healthy environment for competition and innovation.

Table 1: Top ten economically developed country in the field of information technologies (2013)

Rank	Country	score	2012 Rating
1	Finland	5.98	3
2	Singapore	5.96	2
3	Sweden	5.91	1
4	Netherlands	5.81	6
5	Norway	5.66	7
6	Switzerland	5.66	5
7	England	5.64	10
8	Denmark	5.58	4
9	America	5.47	8
10	Taiwan	5.47	11

In table 2, index of the access to information and communication in various Asian countries during the years 2008-2012 is shown. In the meantime, an attempt is made on the distribution of countries according to developed, developing and backward Asian countries. Information of

the table shows that Singapore, Japan and Korea have a far better situation compared to countries such as Iraq and Vietnam in terms of access to facilities and the use of ICT. Iran does not have a proper position but with respect to Iraq and Vietnam, it is in a better position.

Table 2: Indices of the core of home and personal use of ICT according to data from previous years (2012-2008)

country	Home percentage use										personal percentage use					
	radio		TV		telephone		Cell phone		computer		internet		Cell phone		computer	
	year	%	year	%	year	%	year	%	year	%	year	%	year	%	year	%
Singapore	----	----	----	----	2011	88.8	2011	97.0	2011	86.1	2011	84.8	2009	86.9	2009	69.7
Japan	----	----	2008	98.9	2010	85.8	2010	93.2	2012	80.9	2012	86.0	2010	73.6	2010	67.4
Korea	----	----	2011	98.9	2011	93.9	2011	97.0	2012	82.3	2012	97.4	2011	87.2	2011	83
Qatar	2010	48.4	2012	94.4	2012	58.9	2012	99.3	2012	91.5	2012	88.1	2012	87.5	2010	62
Turkey	----	----	----	----	2011	50.7	2011	68.4	2012	50.2	2012	47.2	----	----	2011	44.3
UAE	2010	48.8	2010	95.6	2010	45.7	2010	96.8	2012	85.0	2012	72.0	----	----	2008	74
Egypt	2012	55	2011	95.9	2011	43.4	2011	92.6	2012	37.9	2012	32.3	2011	71.5	2011	32.8
Iran	2010	55	2010	98.7	2010	94.8	2010	85.7	2011	33.4	2010	21.4	2010	49.8	2010	24.6
Iraq	2008	47.5	2008	98.1	2008	17.0	2008	94.3	2008	18.2	2008	8.6	----	----	2008	13.7
Vietnam	2011	4.6	2011	87.8	2009	46.2	----	----	2011	16.0	2010	12.5	----	----	----	----

IT infrastructure

Popoola (2002, p. 42) highlighted information infrastructure as “human regulation, telecommunications, information technology, government support and other information institutions” (23). They are IT infrastructures that build on centralized systems architectures such as Web servers (Eugenia Unity Desktop, www.eugenia.com). It can be seen as IT and other basic infrastructures needed in the acquisition, processing, storage and dissemination or transfer of information by means of computers, office machines and telecommunications.

Computers provide the processing, inputting, storage and retrieval facilities; while telecommunications provide the facilities for the transfer or communication of data and information that further facilitates the establishment and use of the information highway (internet), a network of independent information and communication technologies (telephone lines television) cables, communication satellites, computers, data transmitters etc) that are converging into an integrated system. The information

highway has been regarded as an integral part of the information infrastructure (23). He inferred that it is believed that information infrastructure must serve as a means to support GNP (Gross National Products) goals across the globe. It could therefore be described as the range of equipment including computer technology, applications, basic technologies that help to process information, which also culminated in the development of the GII.

This is a seamless web of communication networks, computers, database and consumer electronics that puts vast amounts of information at user’s finger tips (24). Through the GII, users around the world will be able to access libraries, databases, government departments, and private organizations located anywhere in the world (25).

As the global business environment has become more dynamic and complex, competition among companies has become increasingly intense amid ever tighter budget constraints. This tension has forced organizations to make the management of all its resources a priority. The

improvement of productivity, cycle times, customer service and responsiveness has become ever more critical. At the same time, business executives are expected to make quick but careful decisions that will take advantage of emerging opportunities. Therefore, they are beginning to realize the importance of information technology (IT) and understand its role in changing and improving the way businesses operate.

Although IT is an important tool in attaining the desired growth and competitiveness of today's businesses, it may also constitute a major portion of an organization's capital investment [26,27,28]. As reported by Cuneo (2005), average IT spending among the companies in InformationWeek 500 during 2001-2005 was approximately US\$ 300 million per year (28). Moreover, IT spending in the US economy has increased by more than 200 per cent since 1970 (29). IT investment and its payoffs have always been important to executives but now there is another issue which is increasingly concerned under ever-changing business environments. The question is, with a large investment, how can IT infrastructure be managed to best achieve today's business goals as well as future demand? The simple answer is that IT infrastructure must be flexible enough to handle changes.

Major obstacles in the implementation of information infrastructure

Creation and implementation of IT infrastructure in developing and developed countries is faced with numerous problems and obstacles. These problems are the outcome of the digital divide in the world among which has emerged between the North and the South. On the other hand, domestic and local problems of these countries have delayed the development of infrastructure and the development of information technology. These factors are included in the overall ranking on economic political, social and cultural factors. But the other main factors regarding the use of technology which can be outlined are the information poverty, cultural poverty, economic problems and high IT interconnection costs, information literacy level, political conflict and social heterogeneity, lack of strategic planning and national policy.

Enakrire and Onyenania (2006) have considered those factors in the development of information technology infrastructure involved in Africa in which they are considered as the poor countries of the Third World. Factors such as poor communication, political crisis, war, coup, poverty and illiteracy, social and cultural diversity, the lack of communications facilities and equipment are the main challenges for the development of information technology in this continent (20).

In general, the major barriers to Third World countries for the absence of access to information technology include the followings:

- 1) The lack of attention to information authorities and notification and production and low information processing;
- 2) preventing the free flow of information in authoritarian and dictatorial countries and focus on the rulers and government information;
- 3) The lack of civil rights and free access to information for citizens;
- 4) Taking the information security view as a threat rather than an opportunity;
- 5) Lack of skilled manpower;
- 6) Lack of adequate infrastructure for networking;
- 7) poverty, illiteracy and lack of education;
- 8) war, coup, revolution, ethnic and sectarian divisions and, consequently, political instability;
- 9) information gap between the North and South countries;
- 10) the positive economic outlook As a wealth of information.

Flexible frameworks in IT infrastructure

In the age of communication and information, users of information systems adopted new approaches in the field of search and information retrieval; and significant challenges were places against system administrators in the field of services and products with high quality and pure information. These approaches were emanated from the qualitative and quantitative improvement of information literacy, diversity in updating needs and changes in the behavior of the users. The use and development of flexible infrastructure that can be responsive to the growing needs of present and future users is the consequence of the new wave. Flank of information and research in this field have guided the researchers to study the access to models and frameworks in the context of expansion of flexible infrastructure in their minds.

Since flexibility is important in every field of management, and businesses are increasingly dependent on IT, flexibility in IT infrastructure has become a major concern of management teams. The challenge of the investment decision is to choose an IT infrastructure that is able to support both present and future applications. Flexible IT systems help develop cost-effective new products and services (16). Growth and competitiveness depends on the flexibility of IT infrastructure because it allows organizations to develop new initiatives quickly [30,31]. Conversely, inflexibility is the difficulty that developers often encounter with user demands that require IT to do things it was not designed to do (32). An infrastructure that does not support a business can immediately lead to lost sales and goodwill (33).

Subsequently, many researchers [34,35,36,37,38,39] also delineated the features of 'adaptive/responsive/flexible/dynamic IT infrastructure' which has provided the foundation for a new IT management style. Nevertheless, early studies often described the benefits of a flexible IT infrastructure but they did not actually define it. The exact definition of IT infrastructure flexibility is seldom found in IT literature. Byrd and Turner (2000) offered the following definition:

IT infrastructure flexibility is the ability to easily and readily diffuse or support a wide variety of hardware, software, communication technologies, data, core applications, skills, competencies, commitments, values within the technical physical base and the human component of the existing IT infrastructure (40).

Later, Byrd (2001) posited an even more comprehensive definition:

IT infrastructure flexibility is the ability of the infrastructure to support a wide variety of hardware, software and other technologies that can be easily diffused into the overall technological platform, to distribute any type of information (data, text, voice, image, video) to anywhere inside of an organization and beyond, and to support the design, development and implementation of a heterogeneity of business applications (41).

Figure 1: Weill and Broadbent model in the field of information technology infrastructure

Weill and Broadbent model (1998) includes 5 levels. Order of this plan (pyramid) is composed of information technology components and top of the pyramid ends to the local program. As it can be seen, in the bottom of the

pyramid, the three components of information technology infrastructure, human resources, and shared information technology services have been considered in a format (16). Intermediate format the pyramid is the share of IT standards in an interaction program. These programs include local business applications (bank loan applications, insurance, business, etc.) and in the right part of the figure the evidence of these levels is given.

With the increasing development of information and communication technology in today’s turbulent world, access to information regarding the country situations is not a proper measure of comparison between them. Nevertheless, many international organizations are trying to identify and institutionalize a set of development indicators for information technology and communications to enable such a comparison to be provided. The International Union of Telecommunications and UNESCO can be referred to as some of these organizations.

In table 3, the penetration rate of information technology development indicators in developed and developing countries and the whole world is studied. Considering the information in table 3, it can be concluded that the penetration rate of key indicators for information technology in developed countries compared to developing countries and even the whole world enjoys a better situation.

Table 3: Key indicators of information and communication technology in the world

Index country	telephone Subscribers		broadband telephone Subscribers		Cellular mobile subscribers		Mobile broadband subscribers		Fixed-line broadband subscribers		Family with one computer		Household Internet Access		Internet users	
	nu mb er	Penet ration rate	nu mb er	Penet ration rate	nu mb er	Penet ration rate	nu mb er	Penet ration rate	nu mb er	Penet ration rate	nu mb er	Penet ration rate	nu mb er	Penet ration rate	nu mb er	Penet ration rate
Devel oped	531	4.7	322	26	1.5 38	122.6	788	63.3	322	26	–	75.5	–	74.0	913	73.5
Devel oping	655	11.3	316	5	4.8 76	84.3	768	13.3	316	5	–	27.6	–	24.0	1.5 84	27.5
Whol e word	1.1 86	16.9	638	9	6.4 11	91.2	1.5 56	22.1	638	9	–	40.7	–	37.4	2.4 97	35.7

(Total and penetration) in 2012

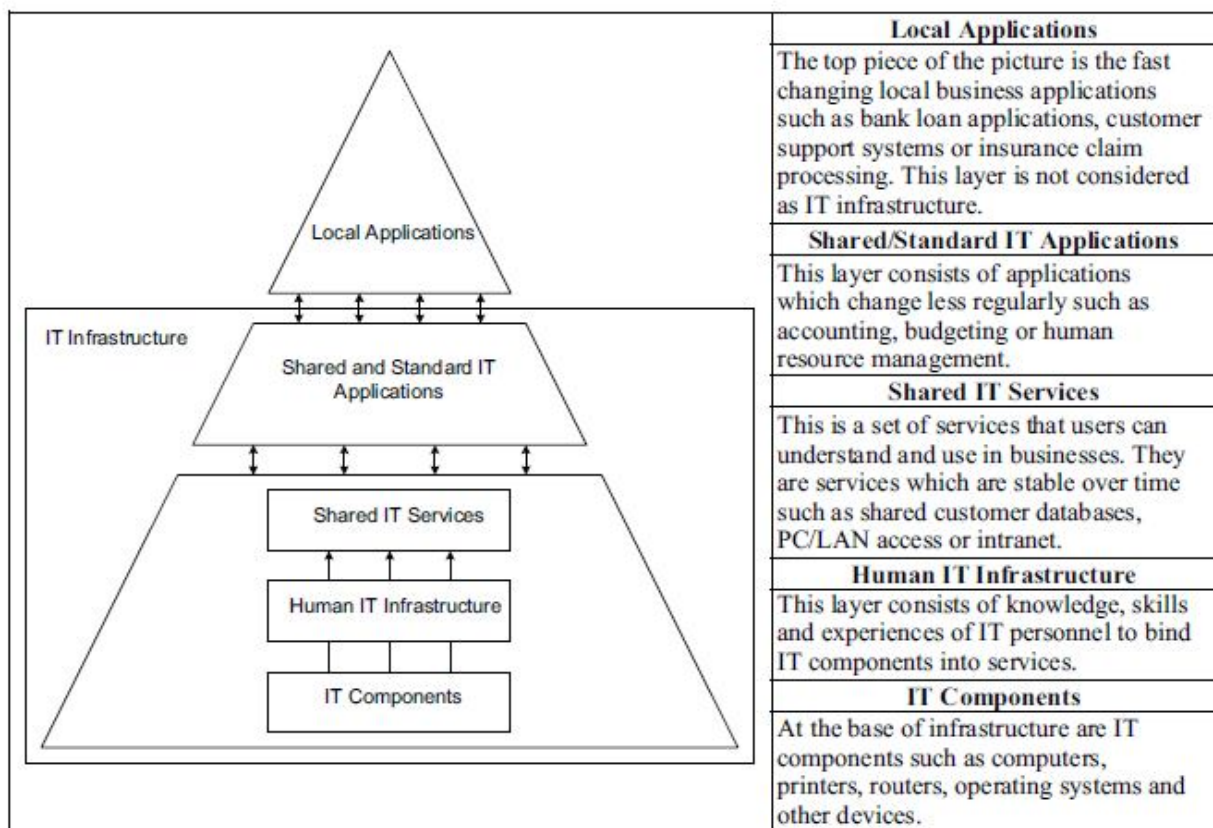
- The numbers are calculated per million
- Home of the dash means no detailed statistics

Table 4 considered the subscribers’ status of information technology in the continents and the geographical divisions. In this table, in addition to the continental divisions, commonwealth countries and Arab League have been separately studied. The table shows that Europe has higher indicators compared to other continents and regions in the

table. It also enjoys a higher penetration rate in the use of information technology. Only in the field of cellular mobile subscribers’ index, Commonwealth Countries Union enjoys a higher Penetration rate compared to Europe and the whole world.

Index country	telephone Subscribers		Active mobile Broadband Subscribers		Cellular mobile subscribers		high-speed lines subscribers		Family with one computer		Household Internet Access		Internet users	
	num ber	Penetr ation rate	num ber	Penetr ation rate	num ber	Penetr ation rate	num ber	Penetr ation rate	num ber	Penetr ation rate	num ber	Penetr ation rate	num ber	Penetr ation rate
Africa	11	1.4	60	7.1	501	59.8	2	0.3	–	7.8	–	5.3	120	14.3
Arab union	35	9.4	53	14.3	374	101.6	10	2.6	–	34.0	–	29.6	124	33.7
Asia-Pacific	525	13.2	625	15.8	3.290	83.1	275	6.9	–	31.0	–	28.6	1.133	28.8
CIS countries	73	25.9	101	36.0	444	158.9	32	11.3	–	50.4	–	42.1	130	46.4
Europe	250	40.2	314	50.5	768	123.3	161	25.8	–	76.2	–	74.6	443	71.2
America	271	28.6	377	39.8	998	105.3	152	16.0	–	58.4	–	54.0	542	57.2

- The numbers are calculated per million
- Home of the dash means no detailed statistics
- The penetration rate is calculated per 100 inhabitants
- Union of Commonwealth countries



Source: Weill and Broadbent, 1998

Figure 1: Weill and Broadbent model in the field of information technology infrastructure

Conclusion

What is important regarding various human changes is to encounter and coordinate information technology infrastructures with modern information requirements of the users. Therefore, it is believed that the investment regarding information technology infrastructures will respond future demands of the users. It is said that the main requirement for the success of the long term strategic investment and planning in the field of information infrastructure creation relates to its level of flexibility to support the present and future plans. Infrastructure flexibility may respond information and unknown needs of the users in the future. Infrastructure flexibility may also facilitate and accelerate the development of the new plans and support new business plans to guarantee consumer-oriented needs. So, many researchers account for the features of information technology infrastructures such as adaptability, responding, flexibility and dynamics. According to this study it is understood that the concept of flexibility covers the concepts of information technology hardware and software support, information distribution and transfer, planning, development and implementation of business plans. These concepts should be compatible with technical-physical indices of human.

The statistics regarding information infrastructures claims that the distribution of these technologies in the world follows specific disciplines and post-industrial societies are suffering from the digital gap resulting from the poor information level of societies which is resulted from the economic poverty of such societies. Investigating the tables

of this study indicates that most of African countries, some Asian and Arabic countries are considered developing countries. Such countries encounter many problems with supplying necessary food for their people due to lack of information and information infrastructure.

Recommendations

The results of the study show that the wave of applying information and communication technology is extending in the world. To implement the information technology infrastructures to meet the necessary requirements and challenges some recommendations are presented below:

1. To lower the gap between the developing and developed countries in terms of information technology infrastructures, it is necessary to invest on the new potentials for information technology infrastructures in the developing countries.
2. Accessibility to internet and computer in educational centers in the developing countries is of utmost importance.
3. To facilitate the use of information technology infrastructures in the developing countries by the cultural, political and social contribution must be taken into consideration.
4. Promoting the literacy level of society and familiarity with technical dimension of such technologies may empower the government to implement technology infrastructures.
5. The strategic planning for information technology infrastructures must be flexible enough to profit from it in the present and future.

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