Making ICT Based Services Accessible for the Last Mile People

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Abstract: Around 70% of the populations in developing countries live in the rural, remote villages. Although growth of the cellular phone network for the last two decades enables such *last mile people* to access the internet, use of ICT based services through internet is not still popular to them. ICT based services such as e-government, e-health, or e-learning have a great potential to improve their quality of life. The authors describe general challenges to realize ICT based services, which are poor internet accessibility especially for bulk data contents, poor literacy of the users, and low financial affordability. The authors present a solution using delay tolerant network (or DTN for short) to overcome these challenges. Bangladesh, as a representative of the developing country, is taken as an example to design the solution with consideration of the country-specific, social aspects. The solution utilizes the public local transportation system for bearers of DTN bundles and the village information center as access points to the ICT based services in remote villages for sustainable service delivery.

Keywords: ICT4D, Developing Countries, Rural Areas, Delay Tolerant Network, e-Services

1. Introduction

People at the base of the economic pyramid (or BoP for short) is the largest but poorest community comprising 69% of the world population. Their living depends on their income less than 2 dollars a day. Majority of these people is found in slams in the city and rural villages. Throughout their life they spend most of their time for managing immediate necessities of living such as foods, clothes, and shelters. Infrastructural support from the government is poor in the remote villages. Most of the places are out of the power grid. No water or sewerage are available there. Although the tube well is the only source of safe drinking water, even tube well is in scarcity in some areas.

Comparing physical and social infrastructures, ICT infrastructure can be built at lower financial investment. 3G mobile service is getting popular even in developing countries and 90% of world population can access to the internet although their bandwidth may not sufficient for bulk data contents. The life quality of the BoP people can be improved significantly with easy access to information or services delivered by the internet. Farmers living in the remote villages are not aware of improved cultivation techniques, information about the high yield seeds, *etc*. Teaching them modern farming techniques would result in cultivating healthy crops at lower cost. Information on basic healthcare, nutrition, hygiene makes them live healthy and being safe from falling illness frequently.

There are numerous ICT based services nowadays that target the BoP people to improve their living. Services related to e-Learning, e-Health, e-Governance can demonstrate significant improvement in their life. Informal education and learning solutions may help village adults know solutions to their day-to-day problems. Knowledge and information to face daily challenges are the main tool for eradicating poverty. There are examples of many innovative e-Health solutions working for cure and prevention of diseases as well as supporting and training semi-skilled health workers. Considering the BoP people living in the remote village, e-Health solutions work better for preventing illness. Essential public services can be provided to them through e-Governance [1]. That improves transparency and efficiency of governmental services and reduces the cost to provide the services for the poor people.

In this article, the authors discuss how to provide internet accessibility to the *last mile* people, namely BoP people living in the remote village, to improve their quality of life by ICT based services with consideration of social aspects. Bangladesh, from where the first author comes, is the country that the authors are targeting in this article since it is a representative BoP country. The economic condition of Bangladesh has been improved for these ten years, however, 40% of the population is still in BoP. The authors believe Delay Tolerant Network (or DTN for short) [2] is a promising technology for this purpose. The authors propose use of DTN to solve the problem of data transportation in remote villages.

The article describes a conceptual framework to overcome the challenges of data transportation in the remote villages for ICT based services. The authors intend to solve the problem of transporting data from the main server available in the internet to the remote village through DTN. The rest of the article is organized as follows: Section 2 elaborates related works. Section 3 describes challenges to provide ICT based services through DTN for the last mile people and requirements of the system. Section 4 elaborates considerations on social aspects. Section 5 presents the proposed solution. Finally, Section 6 concludes the article.

2. Related Works

There are numerous examples of ICT based services for the BoP people. In the early 2000s the systems were developed as parts of research activities sponsored by Governments, NGOs, United Nations, World Bank, *etc*. Inspired by the results of those experiments in the last few years, commercial applications are also developed. None of those employ DTN nor can reach the last mile people.

For example, Bhoomi [1], the most widely discussed

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e-Government system in the world, was launched by the government of Indian State of Karnataka. Presently, the system maintains 20 million land records and serves 6.7 million farmers. Due to absence of infrastructural support in remote villages, penetration of the system is stopped in 177 offices for the entire state. Therefore, the villagers need to travel more than 100 kilometers to access the service. India has some other successful, large scale e-Government services with similar implementation structure.

An example of successful e-Learning system is Pustakalaya [3], which is offering e-Learning service for poor villagers in Nepal. In addition to the ICT solution, this system is also installed in the remote villages with static database. The database is upgraded once a year or more. Here again the reach of the system is abstained due to infrastructural constrains in the remote villages.

An example of the procurement system is e-Choupal [4]. It is operated by ITC Limited, a business group in India, to link the village farmers directly to the buyers of agricultural products such as soybean, wheat, coffee, and prawns. e-Choupal tackles with challenges posed by Indian agriculture, characterized by fragmented farms, weak infrastructure, and involvement of intermediaries. In this system, computers with internet connection are installed in villages of India to offer farmers up-to-date marketing and agricultural information. Each *kiosk* is operated by a *sanchalak*, a trained farmer. The computer is housed in the sanchalak's house and linked to the internet via phone line or VSAT connection. Each installation serves an average of 600 farmers in the surrounding ten villages within about 5 km radius. The sanchalak bears some operating cost but in return earns a service fee for the e-transactions made through his e-Choupal. The warehouse hub is managed by the same traditional middle-men, now called *samyojaks*, but with no exploitative power due to the reorganization. These middlemen make up for the lack of infrastructure and fulfill critical jobs like cash disbursement, quantity aggregation and transportation. Today the initiative of ITC has empowered the lives of people living in 10 states where 40,000 villages have 6,500 e-Choupals and around 4 million farmers have been empowered.

The Continuous Professional Development (CPD) [5] is an e-Learning program to train the nurses and midwives in Malawi, an African country. The project is launched to increase the medical worker. Presently, one nurse is available for 3,680 people. The project ensures strengthening of health service delivery. The goal of the project is to facilitate e-Learning to access up-to-date information for nurses and midwives through computer hubs. Presently, the system is implemented in 6 places to serve 150 nurses.

From the above examples, we can conclude that the existing ICT based services for the last mile people extend their service scope gradually with expansion of the scope of the internet service. Although the GSM/3G cellular phone makes the last mile people accessible to the internet, its bandwidth is limited to access ICT based services with bulk data contents. However, growth of globally available internet bandwidth in the recent years indicates that it would take significant time to make internet services with bulk data contents available for all [6, 7].

On the contrary to the above examples, the authors propose a solution that will allow the ICT based services with bulk data contents to be offered in areas beyond the regular internet. Although the performance of the solution cannot be expected similar to that of the internet, it can be considered as an interim solution. In this circumstance authors' proposed solution can be considered as a new dimension among contemporary researches.

3. Challenges and Requirements

In this section the authors summarize general challenges to deliver ICT based services to the last mile people. The authors are planning to provide a solution using DTN. Requirements of the solution posed by those challenges are also described.

3.1 Challenges

The challenges for ICT based service delivery to the last mile people living in the remote village are similar, independent from the geographical location such as mountainous areas, remote islands, and sparsely populated desert areas in developing countries.

Poor internet accessibility: Systems for ICT based services require a data communication facility. However, such facility is often unavailable or unsatisfactory. VSAT or dedicated radio link may be considered as traditional solution. In that case the cost of service delivery would go beyond the affordability of the poor villager. The GSM/3G cellular phone is getting available and popular even for the last mile in some BoP countries. However, their bandwidth is insufficient to transfer bulk data contents.

Poor literacy of the users: Illiteracy is a common problem in all BoP countries. It is more acute in the remote villages. Besides that, people in the remote village has little experience to use devices to access ICT based services. Therefore, text intensive user interface designed for common users with higher ICT aptitudes, which requires the keyboard for example, may not be adopted for these people.

Low financial affordability: Economic hardship makes it impossible for the BoP people to buy or own their ICT access devices. Moreover, ultimate cost of service usage is always a concern for the people straggling for their basic necessities like food.

3.2 Requirements

The following requirements should be satisfied in order to make the ICT based services available in remote villages by employment of DTN.

Establishing and Maintenance of DTN: Establishment of DTN is a mandatory requirement in authors' approach and, at the same time, it is a big organizational challenge. We need cooperation of the local public transportation system to deliver DTN bundles. Addition to establishment of DTN, we need a

responsible organization to maintain DTN facilities for sustainable country-wide service delivery. Especially, we need a public facility providing ICT based services at the terminal points, namely remote villages.

DTN-Internet Interface: We need to develop a suitable protocol for data exchange between DTN and the internet. Most ICT based services helpful for the last mile people are available in the internet, however, they live in the area beyond its scope. Hence, data coming from the main server in the internet needs to be transferred from the internet to DTN at the nearest access point of the destination and the reverse process needs to be applied to send data from DTN to the internet. An appropriate mapping protocol needs to be devised in this regard.

Data Traffic Reduction: Even in case we employ DTN, allowance of data traffic can be limited by resource capacity of the system in the remote village or the on-board system of the public transportation vehicle responsible for DTN bundle delivery. We cannot enrich resources of these systems excessively to make them affordable even for the remote village with limited income.

BoP Friendly User Interface: User interface of the system must be suitable for low ICT aptitude people to operate. Considering illiteracy of these people, we should minimize use of text in the user interface. In most cases, the situation should be expressed using graphic or audio description.

Thrifty Power Consumption: Remote villages are often out of the power grid. If needed, electric power is supplied by diesel power generators and/or solar cells. Power supply in these forms are unstable and, in general, power tends to be used for daily necessities by priority rather than for ICT based services. Therefore, power consumption of the local system must be minimized so that solar cells can drive the system.

4. Considerations on Social Aspects

Although BoP countries have common problems, their societies are different. Therefore, ideal design and implementation of the ICT based services with data transfer by DTN can be different depending on the country or even on the region. Since it is difficult to give a unified design and implementation of the system applicable to all the BoP countries, the authors target Bangladesh, a small country in the South Asia. The population of Bangladesh is about 160 million. More than half of its population belongs to the BoP category. Therefore, people of Bangladesh can be considered as ideal representation of BoP population.

4.1 Urban and Rural areas of Bangladesh

In Bangladesh, 30% population lives in the urban areas and enjoy moderate infrastructural support, compared to other developed countries. Internet accessibility is provided in different forms such as DSL/ADSL, optical fiber, microwave link, WiMax, GSM/3G cellular phone, *etc*. The most common means for the voice call is cellular phone. The fixed phone is available but in a limited capacity only in urban areas. The national power grid covers urban areas in full.

Rural areas suffer from poor infrastructural support. The telecommunication network for the fixed phone does not cover 80% area, while the cellular phone covers almost of the country. Half of the rural areas are out of the national power grid. Most rural areas rely on solar energy for lighting.

BoP population in Bangladesh, the authors are targeting in this article, lives in sub-urban areas, villages close to the urban area, and remote villages.

Sub-urban areas such as slams. Power is available even in slams. Sometimes, internet access by WiFi, DSL/ADSL, and microwave link are also available. However, establishment of the shared internet access facility would allow more BoP people to use ICT based services with small service fee.

Villages close to the urban area. Infrastructure such as power is moderately improved. Although higher financial activities can be observed in the area, 50% of villagers can be regarded as BoP. They work for agricultural works, factory works, day laborers, and other manual laborers. Different types of internet accessibility are available. Villagers can use mobile internet services with reasonable bandwidth. It is possible to access ICT based services normally in these areas. Establishment of the shared internet access facility would further increase of the services because of its affordable cost.

Remote villages without any internet services. Villagers living in these villages work for agriculture and related businesses. They have never experienced any sort of ICT based services. The authors are referring the people of this group as *last mile people* in this article. These remote villages are mostly deprived from other infrastructural facilities as well.

4.2 Public Transportation Systems in Bangladesh

The authors propose to employ public transportation systems as bearers of DTN bundles. Therefore, characteristics, reliability and accessibility to the last one mile of these public transportation systems are important concerns. The public transportation system in Bangladesh can be divided into long distance, regional, and local transportation systems.

Long distance transportation: Buses, trains, and ferries/ships connects different regional cities to Dhaka, the capital city. The bus is the most reliable if they are compared. However, highways suffer from unpredictable traffic jams due to insufficient road network. Actually, people in Dhaka spends a great deal of the daytime in heavy traffic jams in the city. Therefore, the bus cannot be operated dead on schedule at all. The public owned train system suffers from inefficiency and it is not regarded as practical transportation.

Regional transportation system: Mostly buses connect the regional destinations. Regional roads are in inferior quality, therefore, small vehicles operates in those roads and suffer from extreme indiscipline. In true sense, there is not a schedule for their operation. Figure I shows a picture of the regional bus.

Figure I: Regional Bus

Local transportation system: Road quality is very poor in rural areas. Different types of small vehicles are operated in the local roads, for example, three wheelers such as *tempu*, *nosimon*, *votvoti*, baby taxi; or four wheelers such as human hauler, *leguna*. Figure III shows a picture of the leguna.

Figure II: Leguna

The bus is the most reliable from the viewpoint of keeping schedule. However, there are some areas to where the bus reaches, since there is no paved road to there. We need to depend on the leguna or the tempu, to deliver DTN bundles although they do not maintain any schedule.

4.3 VIC: Village Information Center

As the authors mentioned in the previous chapter, we need a public facility providing ICT based services at the remote village. The village information center (or VIC for short) is a candidate for this purpose.

The VIC is a shared facility to provide various computer services at the village. It is owned by the government and leased to local entrepreneurs for its operation. Villagers can use the services offered by the center by themselves or with assistance of the operator. Villagers pay small service charge for using services. The VIC is operated by solar power in the village out of the power grid. In most cases the VIC provides internet access service offered by the mobile phone operators although its bandwidth is limited. Moreover, the VIC offers other services such as official document composing, printing, e-mailing, training such basic computer literacy, *etc*. The VIC without internet connectivity provides only off-line services.

5. Proposed Solution

The authors is proposing to provide ICT based services to the last mile people in BoP countries such as Bangladesh by employing DTN for data transmission for the aim to improve their quality of life. This chapter shows a plan of the system under fore-mentioned challenges, requirements, and social aspects.

5.1 Applications

None of the e-services for BoP people mentioned in Chapter 2 employs DTN and takes the people living in the last mile without internet accessibility in account.

The authors believe that e-Learning would be an attractive DTN application for the last mile people in developing countries since knowledge and information are essential for those people to fight against poverty. Moreover, e-Learning system might be considered as a supplement in absence of formal education system in place.

The system is designed to be used within the internet as well as beyond the scope of the internet. The content provider and the users living in the sub-urban areas can access the system directly in the internet. In the remote village, VIC is assumed to facilitate accessing the service by the villagers.

5.2 Overall Structure of the System

Figure III shows the overall structure of the DTN based e-Learning system.

The local system in the VIC is the shared facility for the remote villagers to access ICT services. Considering low literacy and ICT aptitude of targeting users, user interface must be graphics, audio, and/or video based basically. The users cannot adopt text based user interface. Moreover, the system should be implemented to save power consumption as much as possible since remote villages are often out of the power grid and power is supplied unstably with solar cells or the diesel power generator shared in the village.

The *Content Server* hosted in the internet is a facility to publish contents accessed by remote villagers. The server maintains all the available contents as well as the detailed database of them.

The *DTN Relay Center* is a facility as a gateway interfacing the internet and DTN with Internet-DTN mapping function. It is located at the nearest place to the VIC where stable and broadband internet access is available. It equips internet connection to interact with the content server and a WiFi router to interact to the after-mentioned *mobile DTN nodes* boarded on

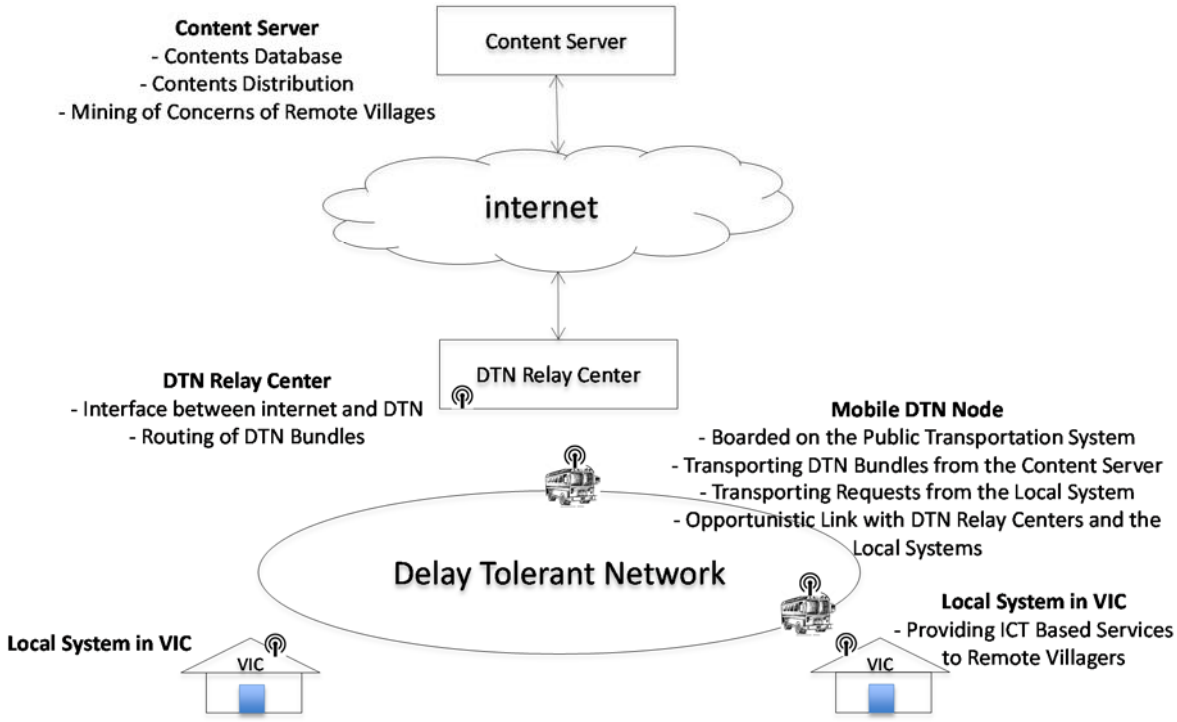

Figure III: Overall Structure of the System

the vehicles. It receives IP packets from the internet and converts to the DTN bundles and sends them to the desired VIC over the mobile DTN nodes. It also receives data bundles from the mobile DTN mobile nodes and converts them into IP packets and sends to the content server over the internet.

The *Mobile DTN Nodes* boarded on the vehicles equips a WiFi router to connect to the DTN relay center or the local system in the VIC. The mobile DTN nodes acts only as a bearer bringing DTN bundles between VICs and DTN relay centers. Mobile DTN nodes, DTN relay centers, and local systems in the VIC are configured as independent nodes of the DTN. They look for WiFi signals nearby constantly for opportunistic connection, that is, the mobile DTN nodes are connected to the DTN relay center or the local system in the VIC when it comes within their WiFi ranges.

5.3 Use Cases of the System

Use cases and stakeholders in each use case of the system are described below.

Accessing contents in the village: The user looks for the contents on the local system in the VIC according to his/her interested categories such as agriculture, nutrition, hygiene, preventive healthcare etc. Sub categories can be also specified if available, for example, irrigation, fertilization, pesticide etc. for agriculture. Every content is accompanied by text, graphics, and audio description. Literate users can look for his/her interested contents by reading the text description and also illiterate users can do by looking graphic description or listening audio description. If the selected content is available in the local storage in the VIC, the local system shows, prints, or plays it depending on its media type. If the selected content is not available in the local storage, the local system displays a message informing the user of unavailability of the content and retrying later. The local system compose a request for the content to the content server. The request is transferred to the content server through DTN and the internet. The content server sends the requested content back to the village. The content will arrive the local system in the next available opportunity.

Uploading contents from the internet: Any pre-registered content providers can upload contents. NGOs and governmental agencies working for development of the people living in remote villages are possible content providers. They can upload their contents after passing the authentication process. They need to provide necessary information that should be registered in the content database on uploading the content. The content server registers the content to the database and initiates the process sending contents to the VIC according to the predefined push logic.

Uploading contents from the village: The pre-registered user logins to the local system in the VIC and uploads the content in the same way as in the content provider in the internet. The local system compose a request for uploading to the content server. The request with the content is transferred to the content server through DTN and the internet. The content server registers the content to the database and initiates the process sending the content to the local systems in other VICs according to the predefined push logic.

5.4 Scheme of Content Distribution

Use of DTN for content delivery can be a tentative solution for bulk data transfer such as contents with rich images or

movies until cellular phone networks enabling broadband data communication gets popular also in rural villages. Note that, in developing countries such as Bangladesh, GSM/3G cellular phones are still used mainly for vocal phone calls, not for internet access, and a certain population of remote villagers has difficulty to read text based information.

Nonetheless, minimization of traffic is still essential to reduce the cost of the mobile DTN node. More traffic needs more storage of the mobile DTN node, therefore, it increases the cost of its hardware and limits the number of the mobile DTN node to be deployed. Less mobile DTN nodes reduce opportunities of content delivery and increases turnaround time.

Full replication of the contents in the content server is not practical for the local system in the remote village. That requires so much capacity of storage and leads to unaffordable price of the local system.

Considering these problems, the authors are planning to design a scheme of content distribution suitable for our purpose, namely e-Learning for last one mile people.

Contents to be desired by remote villages are supposed to show geographical and time localities. For example, people in the area where diarrheal disease are spreading will be interested in learning protective techniques of diarrhea, not of malaria or other diseases, especially during its epidemic.

These geographical and time localities contribute to minimize traffic between the content server in the internet and local systems in remote villages and reduce storage resource requirement. The local system in remote villages stores the full replication of the content database for responsive content search, however, it stores only the contents that users in the village browsed recently or possibly browse in near future. The content server not only sends the contents on response to the requests from the local system in each remote village but also pushes the contents in that users in the village will have interested. Concerns of each remote village are mined from the past requests of the contents from the village.

6. Conclusion

ICT based services such as e-Government, e-Learning, e-Health, *etc.* have great potential to improve quality of life in BoP people in developing countries. Internet accessibility is mandatory to get benefits of these services. Although internet accessibility in remote villages in where a great deal of BoP people lives has been improved for these years due to spread of GSM/3G cellular phone networks, its bandwidth is not sufficient to send bulk data contents such as movies. It will take quite a long time until sufficient bandwidth gets available in remote villages. Therefore, the authors proposed to employ DTN to deliver such contents to the last mile people with help of the public transportation system as a tentative solution.

Illiteracy of remote villagers is a social barrier, unstable power supply is a technical barrier, and cost of the system is financial barrier to bring ICT based services to the last mile people. It is too naïve that employing DTN for service delivery to solve the problem. A total solution considering non-technical challenges is needed. The solution must be devised with considering not only general circumstances in BoP countries but also specific circumstances of the targeting country. The targeting country in this article was Bangladesh. The authors surveyed public transportation systems in Bangladesh as bearers of DTN bundles and proposed to utilize the village information center, a facility almost available at any village to provide various computer services, as access points to ICT based services in remote villages.

Future work includes more detailed design of the system and conducting a case study.

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