e-Services for the Last Mile People of the Developing Countries

モハマド, アシフル ラーマン

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e-Services for the Last Mile People of the Developing Countries

Md. Asifur Rahman

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Department of Advanced Information Technology

Graduate School of Information Science and Electrical Engineering

Kyushu University

Abstract

Services being delivered through ICT, especially World Wide Web, fall into the category of e-Services. e-Money, e-Commerce, e-Business, information bulletined board, email, different types of e-Government services, etc. are the popular examples of such services. Nowadays, e-Services influence our life in a great extent. It allows the service provider to serve more people with greater efficiency using fewer resources. Therefore, consumers get better service at lower price. People can consume many services sitting at the home. It saves time and money.

People living in the remote areas of the developing countries cannot access e-services mainly because of: i) Very few e-services suitable for them; ii) No electricity to run necessary devices in this regard; iii) No internet service to access world wide web; iv) They cannot afford possessing ICT access devices like PC, Tab, Smart phones etc.; v) No access to electronic payment system.

In this research, we intended to develop solutions so that the existing constraints can be successfully overcome to make e-Service available to the last mile people. We conducted several surveys in Bangladesh to collect requirements of the last mile people. We analyzed the requirements carefully and developed the solutions to fulfill the their exact need. We implemented some of our developed solutions in a remote village in Bangladesh. This gave us the opportunity to receive the feedback from the actual users directly. We emphasized on the socioeconomic and human factors more while finding the solutions.

We developed and tested an e-Money service for the unbanked poor people. Using the

service, villagers convert physical cash into e-Money from the local merchant. Later they can spend or withdraw money as and when required. We further reduced the overhead cost of the service by sharing the same platform with other service providers. We found in the experiment that, the outstanding balance of e-money is very little for the merchants. Therefore does not need regular external intervention regarding physical cash.

Besides e-money, we also developed and tested e-learning system for the illiterate people. This is a video content based system where users can find any video based on some specified criteria. Using this system people can learn new skills and techniques related to cultivation, harvesting, nutrition, childcare, preventive healthcare, and many more. To make this system meaningful to the illiterate people in the developing countries, we developed the user interface to be suitable for them. The illiterate people can use the system alone without any help. We found in the evaluation that the developed user interface performs better than the user interface developed using the recommendations made by previous researchers.

We developed an innovative business model to optimize solar electricity generation, usage, and distribution, so that, the last mile people can consume electricity at a price close to the existing alternatives. In this regard, we developed specialized LED lamps meeting the necessary lighting demands. We found that, one-watt LED lamp can satisfy their purpose. Presently villagers are using 60W AC bulb for the same purpose. We maintain the whole service in DC to avoid two-way AC-DC conversion loss. We also provided DC nano-grid service in the vicinity.

We proposed delay tolerant network based solution to transport bulk data from remote areas to the cities and vice versa over public transportation network. This arrangement can be treated as an interim measure until quality internet service is available in the remote areas. In this regard we proposed a change in the bundle protocol to reduce end-to-end bundle delivery time. According to the original mechanism of the bundle protocol, both data bundle and its acknowledgement travel the similar path over vehicular network. In our proposed solution,

the data bundle would travel over the vehicular network whereas the acknowledgement bundle would be sent using SMS service over GSM network.

Finally we proposed a shared e-service access facility: VIC (Village ICT-access Center). The center would deliver different e-services and other ICT based services with local demand like, document composing, document copying, and so on. It would also distribute electricity among the villagers. The shared facility would distribute the overhead cost among all services. Adding more and more services would increase the financial self-sustainability of the facility. In a pilot implementation we found this facility to be almost financial self-sustainable with e-money and solar electricity distribution service.

Problems related to e-service delivery to the last mile people are multifaceted. Therefore we wanted to address those holistically. The technological aspects of electric power solution are not within the scope of this research. Therefore, we solved this problem from economic point of view. Similarly illiteracy, a social problem, is addressed with a technological solution. We hope to implement the research finding in Bangladesh soon. Feedback from the real users would allow us to improve the solution further.

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Chapter 1

Introduction

Services that involve ICT at least in some part from the service production to final consumption path, are defined as e-Services. Presently we see many services, like e-Money, e-learning, etc., where the whole process is taken care of by ICT devices and systems. e-Services redefined our life in many aspects. Some services made our lives safe and some other made us comfortable. However, last mile people are mostly unaware of such services. Reasons are diverged. In short, the overall situation is not in favor of offering e-Services to the last mile people. This thesis describes our works with an endeavor of creating successful e-Services for the last mile people.

1.1 Overview

Developing countries possess higher population density. Around a third of the global land area is account for majority global population. Two third of the population in the developing countries are identified as BOP (base of the economic pyramid) population, who are living less than two dollars of earning in a day [1]. Unemployment and illiteracy is high. Inhabitants mostly depend on agriculture and livestock rearing related activities. Illiterate rural people fail to learn scientific methods and techniques to increase production. In many cases they are

also being deprived from supply of high yield seeds, fertilizer and modern equipment. Despite their hard work, they are not being able to earn sufficient to maintain a descent living due to use of indigenous skills, techniques and practices. Natural calamities like epidemic spread of diseases, flood, cyclone, draught, pest in crops, etc. cause severe damage to their financial ability on a regular interval and make them even poorer.

Insufficient financial capability of the governments, unplanned and improper usage of resources, and corruption are causing slow development of the basic infrastructure in the rural areas of the developing countries. Children need to walk tens of miles to reach school on an average in Nepal, 19 doctor for every 10,000 people in China [2], 34% of the rural population cannot access safe drinking water in Cambodia, and so on facts indicate the harsh situation of availability of basic infrastructure in the remote rural areas of the developing countries. As a consequence poverty, illiteracy, child mortality, malnutrition, etc. are high. Therefore, for generations, their skills are not being updated, earning less, and being defeated by nature. Considering the growth of capacity development of the governments of developing countries, it can be assumed that significant time would be required to ensure descent infrastructural facilities for the last mile people.

In the present age of technology, ICT (Information and Communication Technology) has emerged as a very effective tool to deliver knowledge and information to the people. People living in the developed countries as well as urban areas of the developing countries are getting full benefit of this technological advancement. Governments are offering different public services using ICT platform (e-Government services). The performance of the overall service delivery has largely been improved by these initiatives. For instance, Bhoomi [3], an e-Government service being offered by the Indian state of Karnataka, delivers the land record and management service of the state government. Previously people used to spend considerable amount of time and money to travel hundreds of miles for receiving the service. Presently the same service can be received in less time due to use of ICT. The cost of service consumption (travel cost,

cost of time spent, service charge) for the citizens is also reduced. e-Money services like credit card, debit card, local money, etc. may increase flexibility of using cash, reduce physical cash circulation in the market, reduce the risk of carrying physical cash, and so on. e-Commerce services may allows business entities to access more customers in less expense and therefore can offer products and services at lower price. e-Choupal, an e-Commerce service introduced by Indian conglomerate ITC, allows the marginal farmers to sell their produced goods to the buyers directly avoiding intermediaries [4]. In a very short period of time it became very popular as it offers benefits to both buyer and seller. The farmers can sell their goods in higher price and cost to the buyers still remains low.

By virtue of rapid growth of mobile phone network, majority of the world population is covered collectively by all mobile phone network operators [5]. Mobile phone network operators are challenged by cost of technology, unavailability of power, low population density, and so on to expand the service in the remote areas. It is found that availability of mobile phone in an area increases the average income level of the residents [6]. In the recent years, the mobile phone service providers are also providing internet service within their coverage areas. Although the quality of service is not satisfactory, this opens a door to offer ICT based services (e-Services) to the last mile people. Researchers around the world are developing and piloting innovative e-Services to improve the living quality of the last mile people. Unavailability of power in the remote areas of developing countries is the biggest obstacle for expanding e-Services up to the last mile. Solar energy based electricity could be seen as an interim solution to ensure power supply to the e-Service delivery points in the remote areas. Different innovative business models are also being tested to reduce the cost of the solar electricity to a level affordable to the poor villagers.

There was a myth among the business community that poor people cannot afford to consume state-of-the-art technology based services because of their low purchasing capacity. There is another perception that because of their low IT aptitude, poor people will hesitate

to use ICT based services. C. K. Prahalad in 2002 first showed that despite small individual purchasing ability, poor people collectively possess a huge business potential. In most of the cases they purchases products and services in small quantity, however, pays higher per unit price than that of an urban consumers [1]. Therefore, the business community introduced new and innovative business model to cater the BoP business segment. This new concepts encouraged corporate bodies to design and develop new products and services for the people living in the remote areas. As a result, we find that poor people in the developing countries comprise the majority users of many state-of-the-art technology based products and services like mobile phone, solar electricity solution. Mobile phone, which is known for personal use in the developed countries, is being shared by a group of people to exchange news and information among the peers and family members. Solar electricity is being used to charge the mobile phones, operating BTS (Base Transceiver Station) of the mobile phone operators, lighting the household by charged lamps. It is found that the mobile phone subscribers of the developing countries comprise the majority users [5]. It is also found that the same population also uses the large portion of the electricity produced from solar electricity generation technology. In this regard it should be noted that the need of a service or product and its usage pattern by the rural people in the developing countries is different from that of people living in the developed countries and urban areas of the developing countries. It is important to develop the right product and service based on their exact requirement and use of suitable business model so that poor people can afford it.

1.2 Objective

The objective of this research was to facilitate the last mile people, the people living in the remote areas of the developing countries, to use ICT based services (e-Services) so that they can improve their living quality in absence of adequate physical infrastructure. The experiments conducted and the proposals and recommendations made during this work do not

intend to justify inadequate existing physical infrastructure in the remote areas of the developing countries. Rather, we have accepted the fact that the infrastructural facilities are inadequate in the remote areas of the developing countries and the people living in those areas need e-Services urgently. We also understand that given the present socioeconomic condition prevailing in those countries, the people would not get minimum descent infrastructural facilities in the near future. Therefore, our business model, proposals, and standards can be considered as supplements to the existing infrastructural facilities in the remote areas. The outcome of our research initiatives would help the relevant public and private service providers to offer suitable services for the people in the remote areas to live in a better way.

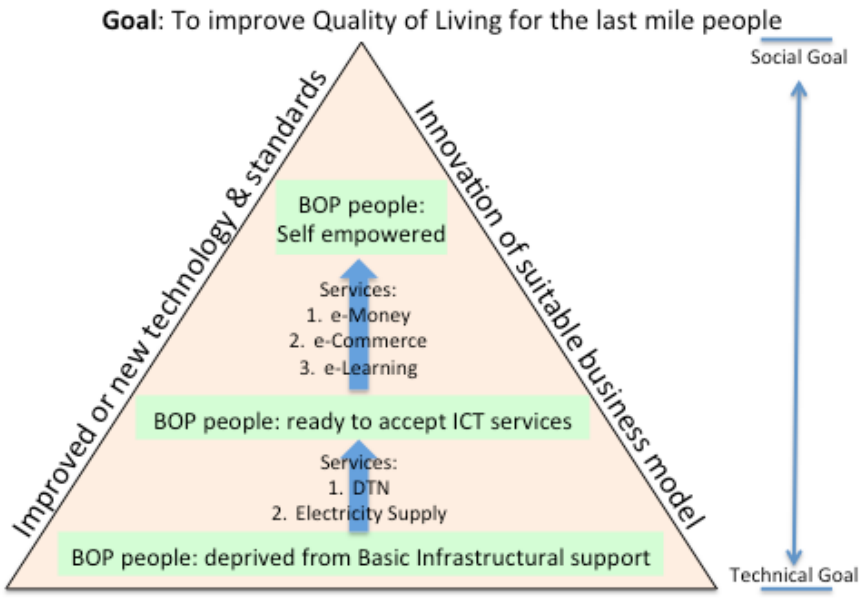

Figure. 1.1: Overall work flow of the research

We identified the challenges to introduce e-Services in the remote areas. The challenges along with the our effort corresponding to the challenges are listed below:

(1) **Inadequate electric power supply:** Both the service providers and consumers need to use electricity to run the service access devices. In absence of affordable and stable

grid power, both parties need to depend on expensive solar electricity generation system. Reducing the cost of solar electricity production was not within the scope of this research. However, we worked on improving efficiency in electricity storage, distribution, and usage. Therefore, the cost of consumption could be reduced. We also involved microfinance institutions to extend support to the poor villagers arranging signup money.

(2) **Absence of electronic payment system:** Electronic payment system is an essential precondition for delivering e-Services. Use of electronic money in any form is fully absent in the remote areas. Typically the last mile people are unbanked and possess low financial affordability. We found their transaction amount varies between 50 cents to few dollars. It is difficult to justify such small transactions using existing e-Money systems. We proposed an e-Money system with affordable operating overhead in this regard.

(3) **Poor internet connectivity:** Mobile phone network operators are providing internet service in the remote areas of many developing countries. However, the quality of service is not suitable to access many e-Services. Therefore, we proposed DTN (Delay Tolerant Network) based data communication system as an interim solution [7]. We proposed some improvements in the Bundle Protocol of DTN [8]. The mentioned improvement reduces the end-to-end data transfer time.

(4) **Illiteracy:** The existing e-Services assumes that the users would be literate and would possess a descent IT aptitude. However, many last mile people are illiterate. Due to illiteracy, people cannot access the traditional ICT services by themselves. A service delivery agent helps them to receive the service. Therefore, the cost of service increases due to addition of the service delivery agent as an intermediary. We proposed some recommendations to develop user interface that would allow illiterate users use computer-based systems independently.

Most part of the rural Bangladesh, a representative of developing country, is out of regular

grid electricity network. Financially better off families in the village use solar home systems (SHSs) for lighting their houses at night. The capacities of these SHSs are low to support commercial usage or home appliances like television, refrigerator, etc. Diesel generators are often used in the villages to produce and distribute electricity in the shops of the market for 3 to 4 hours at night. In both cases the power supply is limited and quite expensive. Despite using these alternatives, we may plan for a dedicated high capacity solar electricity generation system for our VIC (Village ICT-access center), a shared ICT service delivery center, so that the villagers can access the e-Services. This approach would increase the cost of delivery of the services and eventually may make the services too expensive for the poor villagers to consume. In our experiment we developed a DC nano-grid system for a locality and supplied the electricity to its vicinity as on demand. In response to a detailed requirement survey, we developed a unique business model consisting two different types of users: DC grid users and rechargeable lamp users. We operated a pilot project in the Barishabo union of Kapasia upazila of Gazipur district of Bangladesh for 2 years. We found that the villagers can consume electricity at a price that is very close to that of existing alternatives. Therefore, if needed, we may use this commercially sustainable business model to produce and supply electricity to e-Service delivery center as well as to the poor villagers [9].

Like basic infrastructures, formal financial services are also absent in most of the villages. Though different types of e-Money system and corresponding electronic payment systems are widely available and being used over internet around the world. The poor villagers cannot use those services for many reasons. There is no formal banking channel available in many villages. Therefore, banks cannot issue debit or credit cards to the villagers. In the recent days, mobile banking service has been expanded in many villages. In a survey, we found that, the villagers transects very small amount of money. Usually the worth remains from 50 cents to few dollars. The costs of the public services are also of the similar value. According to the present business model being adopted for mobile banking in different countries this small value

transaction is not allowed. Therefore we developed an e-Money platform specially suitable for small value transaction processing and piloted the system in Bangladesh for 2 years [10]. It is a prepaid limited purpose e-Money. Users do not require bank account to subscribe this service. The platform can work both online and offline mode. In this work we used Kyushu University developed multipurpose IC card management system VRICS (Value and Right Circulation Control System) to offer multiple services for the villagers. In addition to offering e-Money service, this card can be used for other services like savings and loan services, e-Health, e-Government service, and so on by other service providers. Therefore, the overhead cost of the system is divided into different services and the cost of service delivery for one service can be successfully reduced to an affordable range. During 2 years of piloting the service, we found all the participants could use the service regularly. The local service agents were also happy with the revenue earning for offering the service.

Availability of mobile phone network in many rural areas of the developing world solved the connectivity problem in the remote areas. While analyzing the spread of different e-Government services offered by different Indian states and also other services around world for the rural populations we found that very few of those use internet service over mobile phone network. The overall performance of the internet service over mobile phone network found very poor. This is due to the fact that the voice service is given higher priority than data service by all mobile phone operators. Because the revenue earned from voice service is much higher than that of data service. So the internet service quality suffers during the pick time, therefore, remains unpredictable. Later this fact found true during a survey conducted by us on the internet service quality over mobile phone network in Bangladesh. To overcome this problem we proposed the use of DTN (Delay Tolerant Network) to transmit data from the remote areas to the central server. DTN uses hop-to-hop store and forward technique to transmit data from source to destination. Although DTN guarantees end-to-end data transfer, but both the source and destination does not remain connected simultaneously. In this proposal

we recommended the design of the services in a way that does not need the local server to be synchronized with the central server through online link. Rather the local servers would be periodically synchronized using DTN. We also proposed slight modification of acknowledgement send/receive mechanism of DTN using SMS service over mobile phone network [11]

At the initial stage we developed services like e-money and assumed that, some selected trained operator would operate it. The financial return from the service can easily justify the involvement of an intermediary. Later we were planned to develop services like e-Learning service, which does not have any direct financial return. Therefore does not justify the involvement of an intermediary. We designed this service to work in a local server with some video based e-Learning contents. The contents would teach the modern skills and techniques that can improve the quality of life of the villagers. For example, there are contents to use organic farming, fruit farming, livestock rearing, etc. However, we faced the challenge of making the service self operated for the villagers. Because of illiteracy it is not possible for the villagers to use the system without help from others. Therefore, we developed a system having a suitable user interface for the illiterate people to use independently. At first we developed the user interface based on the recommendations and standards proposed by existing researchers. Unfortunately in our specific case the user interface could not deliver satisfactory performance. Later we changed the user interface in an evolutionary process with constant feedback from the users. The later mentioned user interface showed significantly better performance. Finally we made some new recommendations for developing user interface for illiterate users [12].

We analyzed the social need of the last mile people. Based on their need we developed services using suitable technology. We also considered existing infrastructural support available in the target area. In some case we improved the existing technology, standards and processes developed and/or proposed by other researchers. In some other cases we proposed innovative business models that help achieving our goal holistically.

1.3 Contribution

The experiments conducted and projects undertaken during this research were targeted towards the solution to address the challenges to deliver e-Services for the last mile people. In this endeavor this research have 4 major contributions.

Firstly, there are some successful e-Government services. However, successful e-Services introduced by commercial enterprises are rarely found. Poor villagers cannot get the benefits from the services like e-Money, e-Commerce. Our experiments showed that it is possible to develop financially self-sustainable e-Services for the poor villagers. In this regard our contribution is to develop the appropriate services based on the requirements of the targeted users.

Secondly, many part of the remote rural areas remain out of the electric power grid network in developing countries. Poor villagers cannot afford to use solar home systems for lighting their home at night. We identified the exact need of lighting from the poor villagers. We also identified other small commercial demand. Our main contribution in this case is to develop a business model to distribute solar electricity generated in a common place in large quantity. We distributed electricity using DC nano-grid and rechargeable LED lamps designed to fulfill their exact need. The cost of electricity consumption is found to be very close to that of existing sources.

Thirdly, Existing mobile internet service in the rural areas of developing countries is not suitable for accessing e-Services. We propose to use DTN as an interim arrangement in this regard. However, we need to establish a vehicular network over public transportation system to implement DTN. Considering the inconsistent public transportation system end-to-end data transfer over DTN would take long time. Our main contribution in this regard is to propose modification in the data received acknowledge send-receive mechanism in Bundle Protocol. This modification would reduce the data transfer time.

Lastly, a suitable user interface for the illiterate people would allow them to use the e-Services independently. The villagers can avoid an intermediary while using the services. Therefore, the cost of service would be reduced. In this regard our contribution is to develop such user interface. We also made some recommendations in addition to the existing ones to develop user interface for the illiterate people.

1.4 Outline

Rest of this thesis is organized as follows:

The social background of this research work is explained in chapter 2. The readers not familiar with the socioeconomic condition of the remote areas of developing countries would have an idea about the context of this research work. It would help them to evaluate the relevance of its contributions. It contains the demographic information, existing infrastructural situation, and socioeconomic conditions in details.

Availability of electricity is an essential precondition for accessing e-Services. Many parts of the rural areas of developing countries are out of electric power grid network. Chapter 3 describes our initiatives to provide electricity in the rural areas. We also described our experience from a pilot project we run in Bangladesh. Different aspect of the project like: requirement analysis, LED lamp design, areas to reduce loss in the existing process, business model we applied, etc. are described in details.

Electronic payment system is another essential requirement for receiving e-Services. Poor people living in the rural areas of developing countries are unbanked. Therefore, they cannot use the existing e-Money systems. Moreover, existing e-Money systems do not support very low value transactions. Chapter 4 details our effort to find a solution in this regard.

Although mobile phone network is expanding in a very rapid speed to cover the remote areas of the developing countries, the present quality of mobile internet service is not suitable

for using online services. Therefore, we proposed a delay tolerant network (DTN) over vehicular network based interim solution in this regard. Chapter 5 explains how this arrangement can be used in the remote areas of the developing countries. It also elaborates our proposed improvement in the bundle protocol.

Many people living in the remote areas of the developing countries are functionally illiterate. They are not able to use any e-Service independently. Therefore, the service providers need to arrange an additional operator to deliver the services to the end users. Introducing a service delivery agent increases the cost of the service. However, there are some services like e-health, e-Money, demand privacy and therefore, is not suitable to use via another person. We developed a user interface especially suitable for illiterate people so that the illiterate people can use e-services independently without any help from others. Chapter 6 explains our work in this regard.

Chapter 7 contains a discussion on all our initiatives holistically. It also explains the necessity of a shared ICT access facility in the village and how it can be made a financially self-sustainable one.

Chapter 8 concludes our works. Furthermore, it identifies the limitations and list the future works.

Chapter 2

Social Background

Geographical conditions of the remote areas of different countries in South America, Africa or Asia are different. Some are surrounded by mountains, Some are covered by deep forest, some are located within deserts, and some are in plain land with little infrastructural support. Ethnically people belong to different raises in different countries. They also represent different culture, uses different language, bears different values. However, their social background is similar in many aspects. Last mile people of all those countries face similar challenges, shares the similar hardship. Therefore, the findings of this research are more or less applicable to all people living in the remote areas of different parts of the world.

2.1 The Population

The definition of remote area differs from country to country. In a country like Japan we might think of a remote area is an island hundreds of miles away from the shore or a locality within a mountain terrain, few hundred miles away from the nearest city or town. However, in developing countries, the remote areas may not be far away from the nearby locality. A remote area may be located within hundred miles from the city. The characteristic that is used to describe the remoteness is hard to reach by road. Because no road connectivity exists to access

the area. There is no electricity because the national electric power grid does not have enough capacity to incorporate that area. They are deprived from schools, hospitals, banks, post office, etc. due to capacity limitation of those institutions. That is, we are considering the typical rural areas in the developing countries, where descent infrastructural support is unavailable, as remote area.

Six out of 7.1 billion people in the world live in the developing countries. Traditionally governments of those countries do not possess the capacity of improve the infrastructural facilities. Due to higher population growth rate, developing countries would have more people in future. Governments of many developing countries are not in a position to increase their investment in infrastructural development in the rural areas. Therefore, present situation is expected to prevail for quite a long time.

Traditionally these people suffer more from different natural calamities. Their homestead is not protected enough to keep them safe from heavy rain or flood. They cannot afford to have proper medical treatment during illness. Poor pregnancy care, infant hygiene situation, and malnutrition result in high child mortality. Due to poverty children need to earn for their living from a very young age. They have very minimum ability and receive inadequate governmental support to fight epidemic spread of disease. Similarly they possess very low capacity to face calamities like draught, pest attack, flood, and so on.

About half of the people living in the remote areas are functionally illiterate. Part of them did not go to school due to financial constrain of the family. Parents preferred them to participate in the domestic help then attending school. Part of them did go to school but could not complete for the similar reason. Rest of them did finish schooling, however, cannot read and write comfortably. They are unable to break the vicious cycle of poverty mainly because of illiteracy. It bars them from receiving knowledge and information passing around the society. Therefore, cannot upgrade their skills and techniques to fight against the odds.

Economic activities around the area are very limited. Day labor, agricultural labor, live-

stock rearing, treading (shop keeping) are the most common economic activities. They usually follow traditional methods and techniques for cultivation and livestock rearing. Due to illiteracy, they cannot learn the innovative and scientific skills and techniques. That results low production from the same investment and effort. There are some professions like quakes, preacher, barber, etc. Those are not full time and many people are not elegible take those as profession.

2.2 Financial Status

In economics, Base of the Pyramid (BOP) is the largest but the poorest socioeconomic group. This group of people possesses the ability of spending less than $2.50 per day. Globally nearly 3.5 billion people fall into this group and all lives in the developing countries. This group comprises half of the world population and around two third of the population in the developing countries. Unfortunately, BOP people use to buy their necessities at a price higher than that of rich urban people. This incident is know as BOP penalty and caused by the presence of poor infrastructure, week governance, and very strong intermediaries [1]. Basically the poor people in the remote areas live on borrowings. Their regular earning is so little that they can never save for their rainy days. Therefore, they need to borrow from others to meet emergency need during treatment, paying school fees, funeral, and so on. Afterwards, on regular basis they need to service their debt from their daily earnings [13]. Their usual transaction amount falls into the range of 50 cents to few dollars.

Inadequate economic activity in the locality causes unemployment for the villagers in the remote rural areas. Day labor, agricultural labor, fishing, farming, livestock rearing, shop keeping, and so on are the economic activities generally available. Many of these activities are seasonal. Therefore, people remain unemployed during some period of time of the year. Mill-factories available in the area are also dependent of the agriculture produces. Therefore,

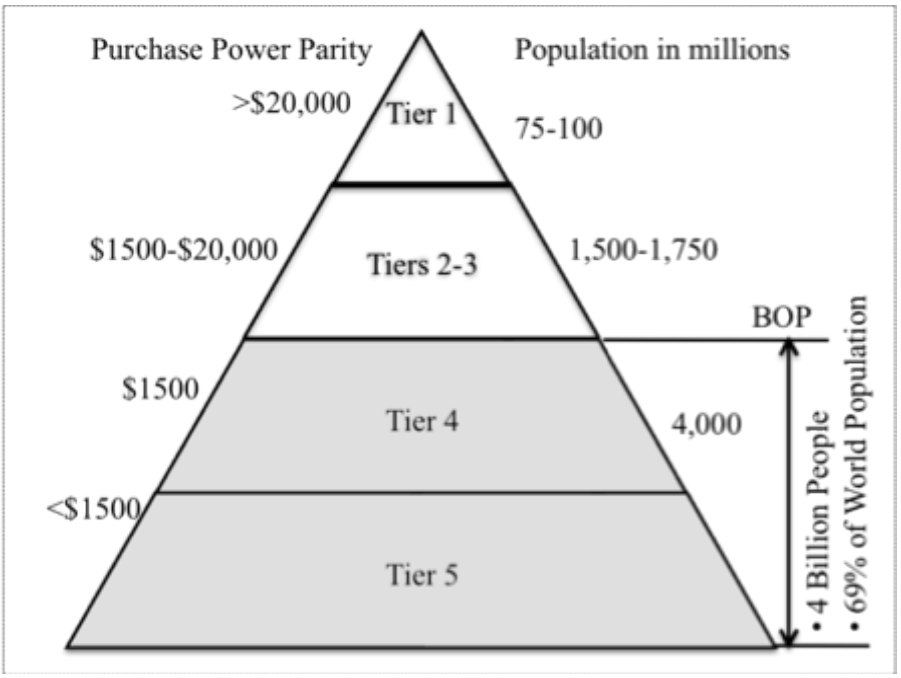

Figure. 2.1: Population distribution in economic pyramid.

employment is irregular. While remain unemployed, some people migrate to the near by towns or cities for employment. The rest of the people borrow money from moneylenders at high interest or sell their labor in advance.

In the last few decades, microfinance service is expanding very fast in the remote rural areas to provide financial services to the poor people. This helps them managing their financial activities better. Microfinance service providers offer savings and lending service to the poor people based on their need.

2.3 Infrastructure and Services

Physical infrastructure is in a very poor state in the remote part of the developing countries. In many places people never heard of telecommunication services. They need to travel hundred

miles to access a hospital facility. Unpaved roads are not suitable for running automobiles.

Illiteracy is a major problem in the developing countries. Globally 1 out of 4 children within age 6 to 17 do not enroll in school [14]. In countries like Djibouti, Niger, Mali 40% of the children within age 5 to 9 cannot access to primary school [15]. Children need to travel a long way to reach the school. In some places Schools does not have permanent structures. Children attend schools in huts or even under open sky. Figure 2.2 shows some examples of the situations of schools in developing countries. (A) and (B) show the classes arranged in Africa. (C) shows that Nepalese children travel one and a half hours to reach school through the mountain terrains. (D) shows the traveling path of Indonesian children.

Figure. 2.2: Schooling situation in some developing countries: (A) teaching in a hut, (B) teaching under open sky, (C) children going to school in Nepal, (D) children going to school in Indonesia.

Many people living in the remote villages of the developing countries never experienced traveling to any hospital. Some of them never meet a qualified Doctor. Until the disease

become acute, villagers used to see the quakes or take Herbal medicine or follow indigenous medication. When the disease becomes acute they travel few hours to go to the hospital. Various reasons works behind this behavior:

(1) Treatment in the hospital costs high. In most cases the cost is beyond their capacity.

(2) Visiting a hospital is always very troublesome for a seek person.

(3) Historically they are used to this culture.

Figure 2.3 shows some picture of rural healthcare practices in different developing countries. (A), (C) and (D) shows quakes are giving medication to villagers in India, Latin America, and Pakistan. These people do not have proper education on medicine. They do the treatment based on their experience. (B) shows an ambulance over a tricycle van without any emergency support equipment in Bangladesh. Automobiles cannot run on the village roads. Therefore, this type of vehicles is the only available option.

According to Wikipedia (www.wikipedia.org) per thousand square kilometer land area, road network size of including both paved and unpaved in Japan is 3,214 kilometers. Comparing to that the road network size per square kilometer land area in Bangladesh, Cambodia, Myanmar, Tajikistan, Kazakhstan is 233, 303, 51, 194, 36 kilometers respectively. This data clearly indicates the poor situation of road network in the developing countries. In most of these countries the size of unpaved road is more than that of paved road and in the remote areas unpaved road is more available than paved road. This poor road conditions does not allow comfortable transportation system to operate. The growth centers are connected through automobiles and the villages are connected to the growth centers by non-automobiles like 3 wheeler van, carts, etc. There is no scheduled transportation service available. Journey gets delayed by indefinite period of time due to unexpected events like accident, traffic jam. During the rainy season situation gets even worse. Sometimes unpaved roads become fully useless.

Figure. 2.3: Healthcare service delivery in rural areas of Developing countries: (A)Quake giving medication to a villager in the shade of a tree in India, (B) ambulance over a tricycle van without any emergency support equipment in Bangladesh, (C) and (D) situation similar to (A) in Latin America and Pakistan respectively.

Figure 2.4 shows the road conditions and vehicles run in the remote areas of some developing countries.

About half of the developing countries are out of electric power grid network. The national production capacity is not enough to cover the whole country. Average power consumption per capita in Japan is 774W.h/person. Whereas the same is 6W.h/person for Ethiopia, 28W.h/person for Bangladesh, and 101W.h/person for India [**?**]. As a general trend, electricity

Figure. 2.4: Road transportation situation in developing countries

is more available in the urban areas. Therefore, those areas are more industrialized and rural areas are not suitable for industrialization. Recent development in the solar electricity system increased the span of electricity usage. Presently the affluent families in the village use solar home system for lighting their house. However, due to high production cost, solar electricity is not suitable for industrial usage. In absence of electricity villagers uses kerosene lamps to light at night. The economic activities are run by old fashion machineries based on the muscle power of human or animals like cow, ox, horse, etc.

Until the cost of mobile phone service falls within the affordable range of the poor people in the developing countries, there was no telecommunication service available in the remote areas. Nowadays, mobile phone network has been expanded up to remote areas in many countries. However, absence of electricity causes a major problem to the villagers to charge the

handset and run the communication towers etc.

In absence of the physical infrastructure, the public service delivery points are also not available in the remote rural areas. People need to travel hundreds of miles to receive any public service. Like in India people needs to travel hundred miles to get a land record certificate. To register any birth or death, they need to travel similar distance. As there is no electricity, these records are maintained manual in papers. Therefore, is very vulnerable to lose or destruction.

In Bangladesh one post office is available for 12 villages. It is more than an hour distance on an average. Banking services are even scares. There is a bank in 20 to 30 villages. Therefore, villagers keep their money in their own disposal with the risk of theft or burglary. Absence of banking service also deprives them from borrowing facility during their need. However, microfinance service is available for small savings and borrowing. The microfinance model is suitable considering the financial ability of the poor people. Employees of the microfinance institution (MFI) visit the village homestead and meet the villagers in groups. They collect savings and loan installment on spot. The amount of savings collected from the villagers range from 10 cents to few dollars. The loan installment amount varies from 5 dollars to 25 dollars. The service is very convenient for the villagers. However, the service charge is very high compared to that of commercial banking services.

Chapter 3

Affordable Power solution for The Last Mile People

Availability of electricity in the remote areas is an essential precondition for introducing e-Services for the last mile people. Due to lack of financial and infrastructural capacity the governments of developing countries are unable to provide necessary electricity to the rural areas. Therefore, in case of necessity, different alternative approaches are adopted. To deliver e-Services, some projects used dedicated diesel electricity generators and some others used solar electricity solution to ensure electricity supply in the service delivery points. However, these solutions need large initial investment and higher operational and maintenance cost. Therefore, the cost of service delivery increases to a level that is not justified to the worth of the service to the last mile people. In 2012 we conducted an experiment that introduced an innovative distribution model of solar electricity. The goal of the experiment was to ensure optimized usage of the resources (like PV panel, charge controller, battery, etc.) in a shared solar electricity generation facility to reduce per unit cost of the electricity production. We considered using especially made appliances that run in DC, to reduce AC to DC and DC to AC conversion losses, use of DC nano-grid to distribute electricity in the vicinity. This chapter explains the activities of the experiment in derails. We found that the electricity consumption

cost for lighting is very close to the cost incurred by using kerosene lamps. We also used the electricity from this facility to operate e-Money service.

3.1 Introduction

Rural electrification means the availability of electricity for any purposes in rural areas. In this case any technology, source, and form can be considered to achieve the goal. Rural electrification offers direct financial benefit to rural households [16]. The governments in the developing countries are increasing the national electricity generation capacity continuously. However, in many cases, the growth of electricity generation is much slower than that of demand of electricity in the concerned countries. Therefore, the rural electrification is till far to achieve. Considering the capacities and priorities of the concerned governments, producing electricity and expanding grid network up to the remote areas would take long time.

Traditionally fossil fuel based electricity generators meet the demand in the remote areas. The important establishments are electrified in this manner. At the beginning of 21st century, availability of low cost solar electricity generation system showed new light to the solution of this problem. Governments in the developing countries are encouraging the use of solar electricity as an interim measure to meet the demand of electricity in the off grid areas. At a similar time, the cost of computers also reduced to the affordable range of general people in the developing countries. This encouraged the researchers to start developing innovative services that can influence the life of people living in the remote areas. Presently, many public and private service providers are offering services beneficial to the rural people. Many of those services have also become commercially self-sustainable. However, areas beyond the electric power grid network remain out of the scope of those services. Many people living in those areas cannot afford the additional cost to use electricity generated from diesel generator or solar electricity system. Therefore, we intended to devise a solution to drag down the cost of

electricity consumption within the affordable range of poor villagers.

3.2 Existing Scenario

In 2012 we conducted a survey in the Chordurlovpur village of Barishabo Union of Kapashia Upazila of Gazipur district in Bangladesh. The national electric power grid network is not available in the village. Therefore, villagers use alternative means for lighting. A business entity produces and supplies electricity in the evening for 4 hours in the local market using diesel generator. Some of the houses use solar home system (SHS) to produce electricity for domestic lighting purpose. The purpose of the survey was to find out:

(1) How the villagers meet their lighting demand at night? How long they need lighting?

(2) How much money they spend every month for lighting solution?

(3) How many houses use SHS? What is the socioeconomic background of those families? Are they happy with the solution?

(4) How much electricity they need for lighting? Is their any variation in their lighting demand?

(5) Is there any other activity in the village where electricity is required?

We visited individual houses in the villages to observe their activities, asked them questions to collect data regarding the aforementioned questions. Findings from the survey can be summarized as follows:

(1) In the village market area, a business entity supplies diesel generator based electricity. The electricity supply continues for 4 hours. Starting from 6 pm and continues until 10 pm. Each connection lights one 60W bulb. For the domestic use, villagers mostly

depend on kerosene lamp. Usually they light two lamps simultaneously. They move the lamps from one place to another as and when needed. The duration of lighting is 4 hours. Families having member who goes to high school need lighting for 6 hours. Therefore, the duration of lighting varies from 4 hours to 6 hours and one family needs two lamps on an average for two different purpose: lighting the room and reading. Some families use solar home system (SHS) in their home. Because of comparatively higher financial capacity, these families enjoy more flexibility for lighting.

(2) Shops and vendors in the market spends 10 dollars in a month for using electricity supplied from the Diesel generator. Families need 240 hours to 300 hours of lighting every month spend 20-30 dollars per month.

(3) Approximately 30% of the families use SHS. They are the affluent group in the village. They maintain larger homestead, and maintains secured and regular income. They use electricity for lighting and running other appliances like TV, refrigerator, etc. Experience of using SHS is mixed. In the first year, the experience is very good. It adds lot of comfort to their life. Maintenance people are not easily available in the village. Therefore, starts giving pain to the families when the devices become old. Within 3 years, most of the families purchase a new one.

(4) As mentioned earlier, most of the families need 4 to 6 hours lighting at night. The purpose is lighting the room and reading. A usual size of a room is approximately 10 square meters. And the reading table size is 150cm x 80cm. The SHS supply AC current. The villagers use 60W bulbs.

(5) In absence of electricity, the economic activities using electricity is not started. Electricity produced by the SHSs is too expensive to use in commercial activities. However, we planed to use electricity to run a computer, charge mobile phones, and e-Money R/W to operate our e-Money service in the locality.

3.3 The Smart Center

We observed that SHSs used in the individual houses are not being utilized to their capacity. As a part of safety factor, there is some extra capacity to meet the unexpected increased demand. Moreover, maintenance effort for small and large systems is mostly similar. Therefore, we can increase efficiency by generating electricity in a single place in bulk volume. We also considered using innovative technique to increase efficiency of electricity usage. Therefore, at the end we found that the cost of electricity consumption has been reduced down to an affordable level.

We considered establishing a powerhouse where large capacity solar electricity would be generated. Afterwards this electricity would be distributed among the villagers in different means. The center would also operate an e-Money system for the villagers. We named the establishment **Smart Center**.

3.3.1 Exsiting Solutions

We found some implementation of AC grids in different parts of the world to produce electricity in bulk in a single place to increase efficiency. The electricity later converted to AC and distributed through wires. The arrangement of such system can be described as shown in figure 3.1.

Solar array is the photovoltaic (PV) panel that produces the electricity. Charge controller is an electronic device that regulates the voltage and current coming from the solar panels going to the battery. Voltage output of a solar panel is not a consistent one. Therefore the battery might get damaged if not controlled properly. Usually an array of lead acid battery is used in a solar electricity system to store the current produced from the PV panel. An inverter's basic function is to invert the direct current (DC) output into alternating current (AC). AC is the standard used by all commercial appliances, which is why many view inverters as the gateway

between the photovoltaic (PV) system and the energy receiver.

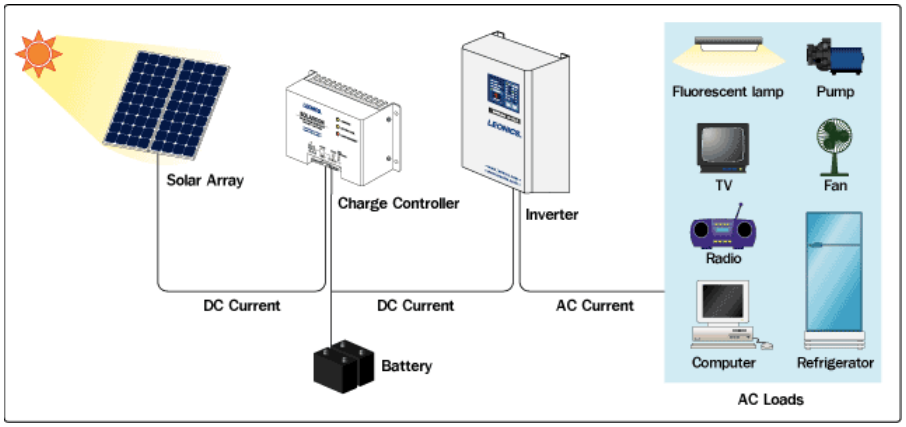

Figure. 3.1: schematic diagram of AC grid arrangement.

This arrangement has two advantages mentioned below:

(1) AC grid is the de facto standard method of electricity distribution. Therefore, all sorts of appliances are available to be used in AC.

(2) AC current can be transmitted up to any length.

However, the solar PV panel generates DC voltage and battery stores electricity in DC. Therefore, we need to convert the electricity two ways, which incur around 18% loss.

3.3.2 Proposed Solutions

In order to devise an appropriate solution, we studied appropriate technologies available. While designing the solution, our main concentration was to increase the usability of the electricity generated from the solar PV panel. We noticed on the following points regarding the technologies available:

(1) Solar PV panel produces DC electricity.

(2) Battery stores and delivers DC electricity.

(3) AC-DC conversion loss is around 9%.

(4) DC electricity cannot be transmitted more than 100 meters. It is recommended to limit the transmission within 50 meters.

(5) LED produces higher amount of light in low power consumption than traditional lighting bulbs.

(6) All electronic based appliances run on DC voltage internally. AC supply voltage is converted to DC internally before used by the devices.

Considering all advantages and disadvantages of different technologies and devices, we decided to develop the smart center completely DC based. The arrangement is depicted schematically in figure 3.2.

The solar panel is a large photovoltaic (PV) panel that produces electricity. We can add new panel to increase capacity when needed. The control panel is a purpose made device that controls the voltage and current generated in the PV panel and passes to the battery. It also controls the output from the battery. The control panel provides supply to charge LED lamps through USB ports within the smart center. It provides 15 V supply for a Laptop inside the smart center and 3 15 V supply to be used as DC grid. It calculates the amount of current supplied through each connection individually and stores in the internal memory. Later the computer uses this data for billing.

We designed and made specialized LED rechargeable lamps based on the requirement collected from the villagers during the aforementioned survey. We developed two types of lamps one for reading and the other for lighting a room. We also converted some appliances like computer, TV, DC fan to run directly from our supplied DC electricity.

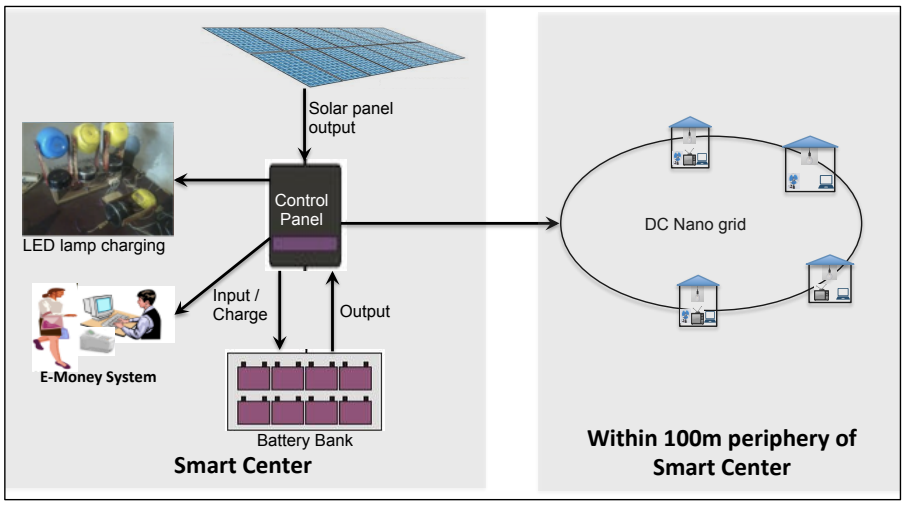

Figure. 3.2: schematic diagram of Smart Center.

The produced electricity is distributed among the villagers in two ways. The villagers may decide to use rechargeable LED lamps for lighting solution. In this case they will bring the lamps to the smart center in the morning for charging and take it back before evening. They may also use rechargeable DC fan in the similar fashion. Villagers have another option of using DC current from DC nano-grid system. The DC nano-grid system works within 100 meters periphery. Therefore, houses within that range can only use this DC grid facility to run computer, TV etc.

Our proposed solution has following advantages:

(1) Use of DC in every occasion saves 18% conversion loss.

(2) Use of DC to electronic based devices reduces use of inverters inside the devices therefore reduces e-waste.

(3) Creates business opportunity for new type of appliances.

3.3.3 LED Lamp Design

To maximize the use of resources we designed and made appliances for our use. We Designed lamps that use low power to illuminate required level of light (LUX) for a desired purpose. We arranged charging laptops directly from the DC supply, using computers to run from DC supply. All these efforts reduce the AC-DC conversion loss.

According to the ophthalmology during reading the object should be lit at minimum 100 LUX and a room should be lit at minimum 75 LUX to ensure visibility [18]. Based on this fact we designed one lamp for Reading purpose and one lamp for domestic use. We used high quality LEDs in perfect series register to create clear light in low power and having longer life of LEDs. To reduce the cost we made the lamp having compact plastic body with adjustable neck and reflector. The reading lamp is made 9 inch high so that the light get distributed throughout a table with 1.5 square meter top. We used Li-ion battery and low Voltage cutoff circuit inside the lamp to maintain the battery in its preferable depth of discharge level as 80% to 95%. The fast charging circuit is designed to charge at constant voltage and constant current phase for Li-ion battery with stable over charge protection. The light surface azimuth graph for both the lamps can be like Figure 3.3.

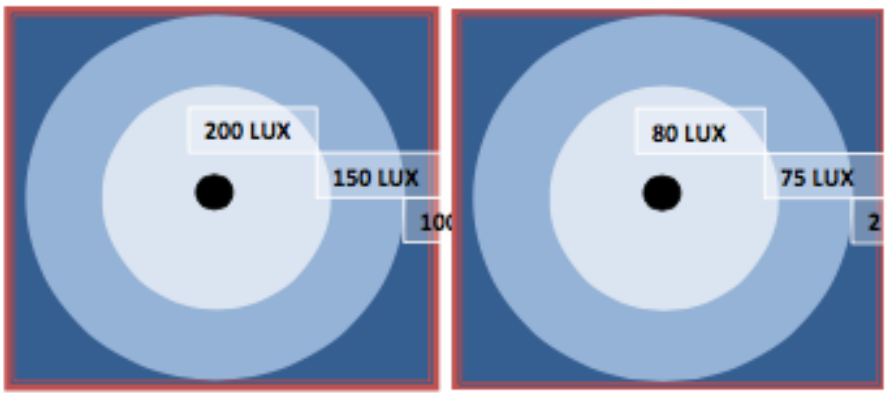

Figure. 3.3: Light surface azimuth graph for lamps. (Left: Approximate Illumines at 1.5 square meter tabletop; Right: Room of 10 square meter)

3.4 Business Model - Financial Affordability

In this work we wanted to use the existing equipment and devices available in the market as much as possible. Our intent was to introduce a suitable business model so that the ordinary villagers can afford the service and enjoy the benefits of clean lighting to boost their economic activities and live healthy. We also want to keep the technical aspects of the smart center very simple so that the local entrepreneurs can repeat the concept easily.

The target population is poor, illiterate, and possesses limited earning sources. The solution included designing appropriate appliances to ensure optimum use of electricity and developing a suitable business model. We considered the followings while developing the appliances as well as the business model:

(1) The ordinary poor villagers live from their tiny daily earnings. In many cases they cannot earn everyday. In case of emergency they borrow from the neighbor and returns back immediately. It is very obvious that the neighbors also are not able to lend large amount. Therefore, signup money to start using the service should be low, preferable zero.

(2) Duration of lighting requirement varies from family to family. For domestic use the need is daily 4 hours to 6 hours. But there are some business entities like restaurants, tailors, etc. who must work at night and need lighting for longer duration.

(3) We found in the survey that, they buy kerosene in small amount based on their affordability. There are situations when they don't buy kerosene because they don't have money. That night the family manages without light. Therefore, the users should be offered to use the service based on their daily affordability.

(4) Appliances, specially the LED lamps, are used in the night and remain unused during day time. Therefore charging time should not be longer than 8 hours. So that, the lamps can be collected from the houses, charged and returned back for use within 12 hours of

daytime. The working time after charge should be considerably long. So that villagers do not need to charge those frequently.

It is difficult for many poor villagers to arrange signup money to subscribe the service. Therefore, we engaged a Microfinance Institution (MFI) to pay the initial signup money for the users. Later the users pay back the money to the MFI based on a mutual contract. Here MFI is a type of financial institution that provides savings and lending service to the poor people throughout the developing countries. This is a very popular and widely used service in those regions. Their payment terms are very flexible and suites the affordability of the concerned people [17]. In Bangladesh branch offices of MFIs are available in every village.

Villagers who want to subscribe our service for lighting houses for domestic purpose, signup for using LED lamps. This service cost the least. We designed two types of lamps. One type of lamp is suitable to light the entire room and another type is suitable to use on the reading table. Lamps are designed in a way that after one full charge it can light for maximum 6 hours. So the users do not need to charge those everyday. When a user needs to charge, he leaves the lamp in the Smart Center in the morning. The Smart Center attendant charges the lamp for the whole day. In the evening the user comes back to take the charged lamp and pay the money for charging. If the user does not have money then he will not take the charged lamp from the center.

Villagers may signup for DC nano-grid connection if they want to use the lighting service for longer time. The connection is possible to light a bulb or run any appliance like computer, fan, etc. The appliances are modified to take DC inputs. Supply is available for 5v and 12v. The users pay in advance and keep adding up their balance when they have money. Supply is stopped when the balance is used up.

3.5 Evaluation of Financial Affordability

We used 1,200 Wp solar PV panel that produced 3175 W-hr electricity on an average per day. In this regard it can be mentioned that the production of electricity is subject to intensity of sunlight during different part of the day. From table 3.1 we can find that the initial installation cost of the production facility is 211,400 taka. Assuming the life of this facility 3 years. The cost of per unit electricity production becomes 0.061 taka. For the sake of calculation we used the cost of the items in Bangladesh market.

Table. 3.1: System cost calculation

Item	No. x Price	Taka
Solar Panel	1,200 Wp x Tk. 80	98,000
Battery	6 x Tk. 17,000	102,000
MPPT charge Controller	2 x Tk. 6,700	13,400
Total system price		211,000

Besides this we used a purpose made control panel. The project personnel in Japan built the device. The cost of which is undefined. We also used purpose made LED rechargeable lamps. The cost of each lamp is 400 Taka. Assuming a family would use 3 lamps. Assuming the life of each lamp is one year, the monthly expense for lamp for each family would be 100 taka.

In addition to the mentioned production costs, the owner of the smart center would add up the overhead cost and profit. We can reduce per unit (W-hr) cost to the consumers by increasing the production and usage capacity of smart center. Besides, adding other services in the smart center can also reduce the overhead cost. In our experiment, we delivered e-Money service, composing, printing services from the smart center.

3.6 Related Works

Electrification in the off-grid areas is considered as a priority for many developing countries. Different available technologies are being used in this regard. Fossil fuel based generation system is capital intensive and cannot be used considered as an option for poor people. In some countries mini grids are established and powered from fossil fuel or solar electricity. At a later point, these mini-grids would be connected to the national power grid. Therefore, need to be synchronized with the national grid expansion plan. Solar PV panel based power generation system is suitable for generating electricity in the off-grid localities in a country like Bangladesh. Despite different attempts for solar base micro grid projects, SHSs are the most popular option in Bangladesh. There are effective use of hydropower based micro grid systems in Sri Lanka and Nepal [19].

Regarding usage of the electricity both AC and DC grids are being used. As the mainstream of the grid system uses AC current, appliances of reliable quality for AC are available in affordable price. Solar PV system generates DC current. To operate AC based appliance a DC-AC conversion has to be performed. Most of the electronic devices internally operate in DC. So in AC grids loss in power because of conversion between AC and DC may incur 15% 40% of total energy. In case of DC grid, less number of appliances are available in the market also those suffers from quality. DC grids also have limitation on its span due to resistive loss in ware. Since in most of the cases common villagers require lighting at night, absence of suitable appliances does not affect much.

SHSs (Solar Home System) are the most popular solution for remote rural electrification in Bangladesh. The technology, maintenance infrastructure, as well as the financial model through the microfinance institutions all are supporting each other to deliver the service successfully. Till January 2013, 1,938,957 SHSs has been installed throughout Bangladesh by IDCOL through its partners. The purpose of SHSs are mostly lighting the village homestead. Here, IDCOL is a government owned company involved in financing renewal energy based

projects. They have adopted innovative financing model suitable for the people concerned.

3.7 Conclusion

Introducing descent lighting solution to the villagers influences their living quality. Use of kerosene lamps throughout the life cause them to suffer from different health related problems. Reading in low lights and inhaling carbon mono oxide from the infancy lead to vision and lungs related chronic diseases. With almost similar expenses this solution provides quality lighting, comfort and safety. Figure 3.4 shows the difference in lighting quality visually.

Figure. 3.4: Difference in quality of lighting. (Top-left: Intensity of light; Top-right: Lighting using DC grid; Bottom-left: Using reading lamp; Bottom-right: Reading using kerosene lamp;)

This experiment was conducted as a proof of concept for providing descent lighting to the

poor villagers who cannot invest large amount of money to buy SHSs. At the same time this facility also provide electricity to an e-Money service provider. The financial terms of the services are planned to suit the daily expenditure pattern on kerosene consumption by the poor villagers. The experiment was conducted in a remote village in Bangladesh for 2 years. 15 families (40 lamps) used electricity for domestic lighting and 200 people used the e-Money service. Financially the services were affordable to the villagers. One month domestic lighting using one lamp requires only 15 to 18 dollars (based on the lamp charging fees). The e-Money service required spending 100 dollars a month for electricity.

In future if other e-Services are introduced in the area, this facility can provide electricity. The capacity of this facility can be extended easily as and when required. The electricity supply service was not absolutely smooth one. During the rainy season, prolonged rain for few days reduced the electricity generation at a level, when it was not possible to continue the service. We assume a hybrid system with a diesel generator along with the solar system can be considered as a feasible solution. It is important to distribute the load between day and night to ensure better use of the resources.

Chapter 4

Electronic Payment System for The Last mile People

Electronic payment system is an integral part of e-Service delivery mechanism. The nature of the existing electronic money systems is not suitable for the last mile people. Their high operational and infrastructural cost do not justify small value transactions usually performed by the poor people. This chapter details the requirements of the payment system suitable for the last mile people. Then it lists the features of the electronic money system available in Bangladesh. It also elaborates our proposed model of e-Money system especially developed to meet the requirements of the poor people living in the remote rural areas of the developing countries. Finally it presents the results from a pilot project that implemented the service in a remote village in Bangladesh.

4.1 Introduction

Introduction of currency as an equivalent of the financial worth of an item can be traced back to the last one thousand years. During this time currency was in different forms. The modern banknotes are also in the system for few hundred years [20]. Electronic money (e-

Money) was first introduced in the early 20th century for the airlines reservation system. In the last 2 decades, in the advent of e-Services like e-Commerce, e-Business, and e-Payment to consume other services bought e-Money into prominence. However, physical cash is remained as pivotal to all sorts of financial transactions. Anonymity of physical cash acts as both advantage and disadvantages. However, in the context of lack of security in the remote areas of developing countries, physical cash might be robbed, lost, destroyed and stolen. On the contrary e-Money can be password protected that elevate the safety and security to a customized level. Again it's ability to be used electronically over internet increases flexibility. The most widely discussed advantages of e-Money from the users' perspective are:

(1) Security against theft and lost.

(2) Ease of use in transaction over internet and other electronic platform.

(3) Traceability against transaction.

These features are equally desirable to the both poor and rich people throughout the world. Currently, money transfer as an e-Money service is gaining enormous popularity in the remote part of the developing countries. Because the alternate option is to carry the money up to the destination, which involves time and money. However, the full potential of e-Money e.g. payment against purchase, savings, withdrawal, deposit, etc. services are yet to reach to the poor people for three major reasons:

(1) Ignorance of the demand of such services for the poor people. The requirement of such service for the poor people is largely different from that of rich people. Poor people perform limited number of irregular transactions. The transaction value is very small. We found in our experiment that the amount of transaction can be as low as 5 cents.

(2) Absence of poor people friendly value added services. The last mile people are deprived from banking services. Therefore, electronic payment services like credit card is not

applicable for them. Their life is centered with borrowing and saving but the definition provided by the regulators does not allow the service provider to offer similar services. The e-Money service providers need to join such service providers to incorporate these services to the platform as value added services.

(3) High operational and infrastructural cost. The credit card and debit card service is not applicable for the unbanked poor people. Other alternative services like mobile banking service, Post office banking service, etc. available in Bangladesh are designed in such a way that the service charge for the each transaction is too high compared to the amount poor people usually transact in their daily life. One of the reasons is that the service delivery is outsourced at the last end based on commission.

However, the nature of financial need of the poor people and that of rich or middle class people are different. Therefore, the popular e-Money system in the developed countries may not be equally useful to the last mile people. In this regard we conducted a survey in a remote village in Bangladesh to identify the requirement of the desired e-Money service. We also investigated the existing e-Money service and their use, and whether the last mile people need a new platform to fulfill their need.

4.2 Electronic Payment System

Banknotes are circulated and managed in a well-defined and internationally recognized process. Where each unit of the money has a specific worth which can be compared with the other currencies in the world. In case of e-Money the same process must be applied. The regulators (usually the central bank) ensure that the e-Money issuers are not issuing e-Money beyond their allocated range. Failing so will create inflation within the economy.

In one approach, e-Money service providers issue e-Money against equivalent amount of physical cash received. This type of service is also known as prepaid e-Money. In another

approach the central bank grants right to an e-Money issuer to issue some predefined amount of e-Money. In this case the central bank regulates the issuing process very carefully [21].

4.2.1 Type of e-Money

Electronic money can be defined as a prepaid service where a person buys e-Money in exchange of equivalent physical cash and stores the value on an IC card or magnetic card or in an electric form in a computer, which can be accessed through a specialized system in a computer network or mobile phone network. Regulatory authority around the world put almost similar requirements on the activities related to this new concept of money. The requirements can be listed as:

(1) It is stored electronically or magnetically in a card or in a computer system accessed by specialized software over internet or mobile phone network.

(2) Issued against some exact equivalent of physical cash. The equivalent physical cash either deposited by the user or granted to the issuer by the central bank. e-Money should be traceable by the regulator so that there is no unaccountable e-Money in the market.

(3) Issued for the purpose of payment against goods, service etc. or otherwise defined by the regulator.

(4) Accepted as a means of payment by persons or entities other than the issuer.

4.2.2 Basic components of e-Money

An e-Money system consists of the components as depicted in figure 4.1:

(1) **Issuer:** Issuer is the entity (a company, typically a bank) that owns the traditional money and liable for its redemption. So its financial condition is relevant for integrity of the value of e-Money.

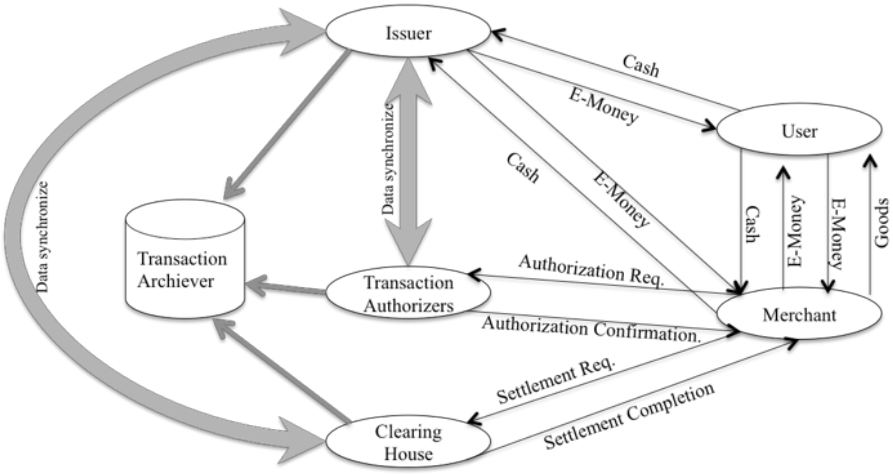

Figure. 4.1: Basic e-Money components.

(2) **Merchant:** In some schemes the issuer itself distributes the e-Money among the users but in most of the cases, the distributor appoints 3rd party entities to create a nationwide network of merchants for handling the customers. The merchants buy e-Money from the issuers in bulk and retails to the users. In some schemes, the merchants also allow redemption at their end.

(3) **Transaction Authorizer:** For some e-Money product no authorization is required but some need authorization. For the IC chip based systems authorization information is stored in the card itself. But for the mobile banking as well as magnetic strip based systems the transactions need to be authorized from a central server. Usually the issuer itself performs the task.

(4) **Clearinghouses:** e-Money systems are open systems in which the recipients of e-Money must have an efficient way to redeem it. In a society with well-placed banking network the redemption may take place over a secured telecommunication network. But in the developing countries, the clearing facilities are cascaded up to the remote part of the

country to facilitate smooth disposal of cash against the e-Money value.

(5) **Transaction Archive:** Depending on the scheme, transactions are archived at different phases. Eventually the transactions are archived in a central server for regulatory investigation, as well as analysis purpose. In case of lose and theft of the card the transaction archives are used to calculate the unused e-Money to be uploaded in to the new card.

(6) **User:** Users subscribe the service from a service provider. In general subscribing a service means buying a magnetic or IC card or opening a mobile banking account. The user may buy e-Money from the issuer itself or from the merchants. Later they use the e-Money for shopping etc.

4.3 Financial services for the last mile people

Many People living in the remote rural areas of developing countries are living with less than $2 earning a day. Nature of their financial activities largely differs from that of wealthy people living in the cities and suburbs. We conducted a questionnaire survey and also reviewed related documents to identify the requirement of financial services as well as the challenges to introduce those in the targeted community.

The survey was conducted among 100 villagers in a remote village in the Gazipur district in Bangladesh. The purpose of the survey was to find out:

(1) Their experiences regarding using physical cash during transaction.

(2) How much comfortable they are of using banking services available in the locality.

(3) What they feel about using card based e-Money service and the nature of the same service.

The data collected from the survey shows that 98% of the villagers feel insecure while carrying cash with them. 10% of them feel insecure even with cash equivalent to 3 dollars and none of them want to keep cash of worth more than 12.5 dollars with them. On an average they keep 5 dollars equivalent money with them in cash. 68% spend 50 cents to one dollar equivalent worth in each transaction. Although they have a bank within the village, still only 50% of the respondents maintain a bank account. Among them only 40% need to transacts beyond the scheduled transaction hour. On an average they keep 10 dollars equivalent cash in their possession at home. 50% of the respondents showed their interest to signup for card based e-Money service, if available. Survey data also showed that, the villagers are expected to maintain an average balance of 12 dollars worth of money. All the participants expressed their desire to pay directly from the card during shopping as well as wants to have an option to encash when needed. Average monthly transaction per user is estimated to 133 dollars equivalent of money.

Following comments can be made based on the survey findings and observations:

(1) The demand for e-Money is already created among the last mile people. It indicates that, the prevailing insecure situation due to risk of robbery, stilling by family members are pushing the villagers to convert the cash (an anonymous asset) into some identifiable form of resource which can easily be used at the time of necessity.

(2) The amount of money they transact is very small. Considering the overhead cost of traditional e-Money systems like credit card, debit card, mobile banking, etc. the transactions will not be justified. However, the villagers are interested in spending the e-Money directly for shopping and other purpose.

(3) The villagers have expressed their desire to put all available money into the e-Money system. This intention indicates that it is possible to incorporate all types of payment in the rural areas into the system. Most importantly they intend to see this new system as a

tool for performing all sorts of financial activities.

4.3.1 Financial activities

Financial life of poor people always circles around debt and repayment. They rarely earn enough money to have surplus. On the contrary, they need to borrow money from every possible source to meet emergency requirements like treatment, funeral. Servicing these borrowings need savings. They efficiently use many innovative savings tools throughout their life. Some of popular savings tools can be listed as follows:

(1) **Home savings:** They save money and put it in the piggybank, under the roof, inside the bamboo pillars etc. within their home. This is a very week tool for savings. Because sometimes they liquidate the saved money to meet their emergency need. Sometimes the neighbors or other family members misappropriate the money.

(2) **Peer savings:** In this scheme people save the money to some trusted person, usually their neighbor. The advantage of this scheme is that, this money is not readily available to them. But they can access the savings in short time when they need.

(3) **Savings club:** They organize peer group to save money together and use the same in some business. Usually they put small savings every day/week/month, as the members agree, in a common fund. One person within the group is assigned to keep the accounting of the group. When the amount of saved money grows to a considerable amount, they consider investment in any available means. This is a very old and effective tool as long as the group remains harmonic.

(4) **Savings on Assets:** This is possibly the oldest and most widely used tool for savings. They build their savings on different types of assets. Like they buy and rear chicken, goat, and cow, depending on their ability. Due to inability to accumulate large sum of

money together, they invest in chicken to build up large sum. For example ten chickens can be sold to buy a goat calf. They target some specific purpose against a specific asset. Like they target yearly children's educational fees with a goat, parent's funeral or a marriage with a cow or ox. Sometimes they sell out goats to buy a calf.

All the above instruments are vulnerable to different type of risk. Every family definitely incurred losses due to those risks at some point of their life. An intervention that eliminates the risk is highly desirable. Sometimes the savings are not readily usable. Like assets may not be sold instantly at market price.

In many cases, family members migrate to different places to work and earn for the family. For some family these migrations take place periodically at a particular time of every year. For some families few of their members work at a distant place on permanent basis. In both cases family members earning at a distant place sends money to the village. Again some families receive different allowances from government safety net programs. In all these instances the transfer are expensive and availability of access cash prompt some unproductive expenses.

People in the rural areas need to carry cash for their daily transactions and incur risk on a regular basis. Avoiding transaction of cash they prefer to use some sort of identified worth of asset like electronic money. At the same time the shops, which rarely maintains any book keeping can have a transactions details automatically. Which can be used as their official accounting. Most importantly they need to operate in a flexible time when the money is available to them.

Analyzing the above facts we find money transfer, customizable savings option, spending in shops, deposit, and withdrawal in the desirable service list.

The challenges to be addressed in an ideal e-Money system are:

(1) The transaction amount is very small. Sometimes cost of printing a receipt of the transaction is more than the transaction amount itself.

(2) Demand for long time service availability. Preferably round the clock.

(3) Requirement of using e-Money for different financial tools, like using e-Money for savings, remittance, bill payment, etc.

(4) Scarcity of necessary resources like electric power, data communication in the remote areas.

(5) The merchants as well as users are less exposed to the high-tech devices. Illiteracy is another factor as well. The system including the related devices should be suitable for their use.

(6) The merchants will try to reduce the time spent per transaction. This reduces the quality of service delivered.

4.3.2 Recomended features for the e-Money for the last mile people

Based on the feedbacks received from the survey and the findings from the document review we propose following common features for any e-Money platform to ensure participation from the poor people living in the remote villages in the developing countries:

(1) **Ease of use:** The prospective users are living in the remote areas of the developing countries. So they are expected to have less experience of using high tech gadgets and sophisticated system. All the user interfaces must be especially suitable for illiterate people. Audio confirmation can be used to replace printed receipts after a transaction is completed.

(2) **Infrastructural:** Unavailability of stable electricity supply is the most widely discussed constraint for expansion of technology-based services in the remote areas. The proposed service is also dependent of data communication network. Considering the above facts

it is recommended to build the system where the devices consume very low power so that can be operated long time from battery. Moreover the system should be capable to operate offline without being connected directly to the Issuer online and can update the Issuer periodically. The overhead cost of the system as well as the devices should also be low. So that it can be commercially justified with very low value transactions.

(3) **Functional:** Presently there is no formal financial service delivery channel in the remote areas. Informal financial services are being delivered by the MFIs, NGOs and moneylenders. Introducing a successful financial service delivery channel can achieve the purpose of branchless banking service as well. The system should have features that support the need of the target people. In this case the need includes wide range of financial services for example: deposit, withdrawal, savings, fixed deposit, term deposit, asset buildup scheme, account-to-account transfer, and so on. The need varies from family to family. So it is better to allow them to customize according to their need.

(4) **Self Service Kiosk:** Building branch offices or dedicated merchant network throughout the country is a very expensive proposition. Like mobile banking the remote operations are usually outsourced to third party merchants where the same merchants are engaged with some other activities. This concept reduces the overhead cost of the service delivery. But as a side affect, this invites the concern for low quality service. To overcome this problem we proposed a self-serviced kiosk where the users will ask for different services by themselves using a touch screen system. The user interface of the system would be especially suitable for the illiterate people. After finishing the service, the system will generates an SMS to the merchant and ask the user to complete the transaction by paying the merchant physically. This system will increase the level of financial education among the users.

4.4 Proposed e-Money System - Pilot implementation

The existing e-Money systems around the world are successful in a different operational environment than that we are considering. Rather than introducing a new e-Money system and justify its effectiveness as well as security, we proposed to use an established prepaid e-Money system that is already being used in Japan. The service is delivered using IC Card that can store data. We also used a multi service delivery platform to allow this card to deliver other services using the same platform. The system can work both online and offline mode. Data storing in the IC card, and service delivery process is developed according to the requirements of the end users. The proposed process shown in figure 4.2.

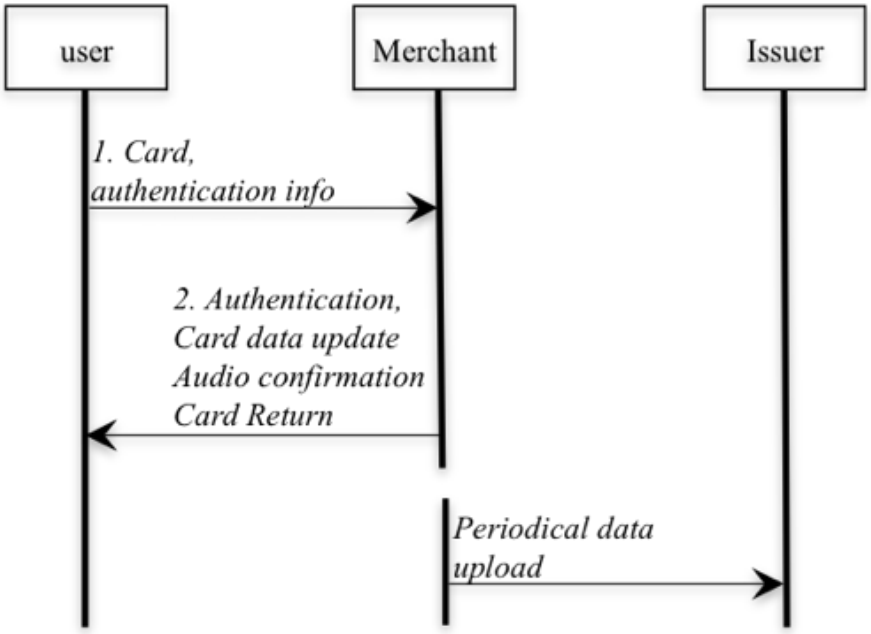

Figure. 4.2: e-Money service execution.

(1) The user will give the IC Card to the merchant. The user also specifies the required service. The merchant asks the user to enter the PIN for authentication. Then the merchant

will perform the transaction using the data available within the card and update the card data. The POS will also record the transaction within its own memory. Then the POS will confirm the transaction by relevant audio message. And ask for the money to the user.

(2) The merchant will perform the authentication process and execute the transaction as per the user 's requirement. Give money to the user if it is a withdrawal operation and receives money if it is a deposit or transfer operation. The POS will play an appropriate message to confirm user regarding the transaction. Finally the merchant will return the card to the user and finish the transaction.

(3) The merchant will upload the transaction data to the Issuer periodically to update the transactions. Since all necessary data are available in the card itself, it is not required to communicate the Issuer for completing the transaction.

Availability of value added service is the key factor to make the e-Money system successful for the last mile people. Insecurity, the biggest threat to physical cash, is applicable during carrying cash required for making a transaction, saving money to meet future emergencies and repayment of debts. e-Money is usable in all purposes where physical cash can be used. Therefore, any value added service that is applicable for traditional money is also applicable for e-Money. Among those, we propose a process to include savings service within our proposed service. In this case the e-Money company will come to an arrangement with a savings company. The user will deposit the savings on a specific account. This amount will be transferred to the savings company in exact amount as it was received from the user. The savings company will use the money according to the agreement between the user and the company. All the terms will also be programmed in the IC card so that the same amount can be calculated later. When the user wants to withdraw the savings deposit, can receive the service from the merchant. Merchant gives the money along with the interest applicable according to the

contract between the user and the savings company. When the data is uploaded in to the server of the Issuer, the e-Money company claims the amount from the savings company. Here introduction of the savings company in necessary to comply the regulators' requirement of issuance of e-Money exactly equivalent to the physical money. The savings process is shown in figure 4.3

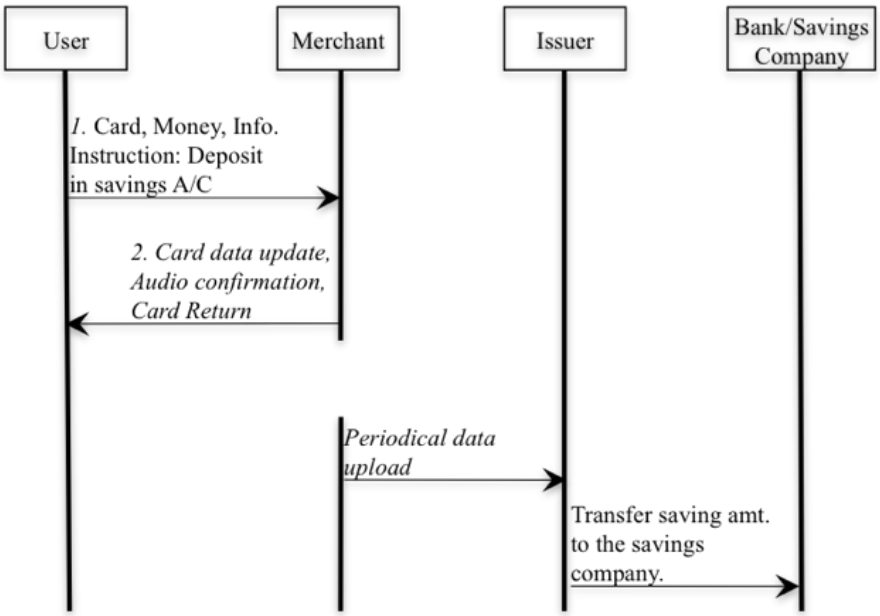

Figure. 4.3: Savings-deposit process.

In our proposed system we used multi-purpose IC card based on Kyushu university technology VRICS [22]. Where multiple services can be delivered from the same IC card. The service providers can access the data related to their own service only. We designed a custom made POS for this purpose which accommodate new features to fulfill the requirements mentioned earlier. But the cost of the card itself is slightly higher. The advanced feature of platform sharing can justify this additional cost. Due to its multipurpose use of the card along with the platform can be used to offer different public and private services to the last mile people which otherwise is impossible.

We implemented an e-Money system within ChorDurlovpur village of Gazipur district in Bangladesh. The objective was to verify the acceptance of the system with much extended features. Postal cash card and mobile banking service already introduced in Bangladesh are yet to reach the mentioned village.

We introduced limited purpose e-Money through Kyushu University's own technology VRICS based multipurpose IC Card management system. We developed suitable devices to operate the system. The system allows the users to convert physical cash into e-Money, withdraw cash from e-Money, purchase good using e-Money, and transfer e-Money from one account to other account.

The system was implemented in the village for 2 years and number of daily transactions was moderate. Since the service is available only in one village so transfer from one account to other was not relevant. Users regularly used the system for depositing e-Money, withdrawal, and purchasing goods from the shops using e-Money. Table 4.1 shows the summary of the observation during implementation. We have following observations:

Table. 4.1: Observation summery of e-Money service implementation

Period of evaluation	2 years
Number of regular users	200
Lowest amount of transaction	3 Taka (5 Cents)
Account status	Always active
Transaction cost to the users	None

(1) The amount of money transacted during one transaction is as low as the worth of 5 cents (3 taka). As we can see in traditional e-Money transaction system, if we want to print a receipt for this transaction, then the overhead cost becomes more than the transaction value itself. In our system, we confirmed the transaction related information in the

display screen. In our next version of the same system this transaction amount will be confirmed with an audio message. In case of any dispute the users can take transaction details from the office.

(2) Unlike mobile banking and postal cash card the accounts were never dormant, however the average balance is very low. Users deposit and spend on regular basis. The reason behind this attitude is that people in the rural areas live from daily income. So they avail small cash on regular interval and they deposit the same as and when cash is available to them and keep spending the deposited money to meet their daily necessities.

(3) Villagers are comfortable to use the service. Transaction without transaction receipt does not create much tension among the users. The transaction details available from the office can satisfy them. Since the deposit amount is small, they can calculate the balance amount orally after the transaction.

Figure. 4.4: IC Card reader-writer and e-Money card.

4.5 Related Works

Apart from the existing bank based e-Money services like debit card, credit card, there are some mobile banking services and postal cash card services available in Bangladesh for

the unbanked poor people. We investigated and analyzed three of such services presently available in Bangladesh. All these service providers offer deposit, withdrawal, and money transfer services to the clients. They receive service charge against every transaction and the every transaction amount must be higher than a predefined amount.

Table. 4.2: e-Money services in Bangladesh

		Deposit		Money Transfer		Withdrawal	
Service	Minimum Balance	Min. Amount	Charge	Min. Amount	Charge	Min. Amount	Charge
Postal Cash Card	10	200	10	200	10	200	10
DBBL Mobile Banking	50	100	1%	100	2%	100	2%
bKash	50	100	0	100	1.85%	100	1.85%

Table 4.2 shows that the clients need to deposit, withdraw or transfer a minimum amount which is high comparing to their regular transaction amount. The applied service charge also discourages them to transact frequently with small amounts. Absence of payment facility to the shops restricts them from buying goods using the system. So the poor people cannot avoid using cash from their daily life. Due to its reach up to the remote part of the developing countries, mobile banking service has the potential to fulfill the banking need of the last mile people. However, the unfavorable terms and conditions bar its growth up to its full potential. However, it has emerged as a very effective tool to remit money by the family members working far apart.

4.5.1 Card Based e-Money System (Postal Cash Card)

In card based e-Money systems, the users need to visit to a service delivery agent (Merchant) to access the service. The merchant possesses a POS to deliver the service. The process

can be explained below. Figure 4.5 shows the process.

(1) The user goes to the merchant. The user gives the card along with the money and necessary information to the merchant and expresses his desire regarding the type of transaction like withdrawal, deposit, transfer etc.

(2) The merchant swaps the card, takes the PIN and sends the information to the Issuer over internet for settlement and confirming the completion of the process.

(3) The issuer performs all the necessary tasks and sends the confirmation to the POS over internet.

(4) The merchant prints receipt. The merchant returns the card with the receipt to the user and the process ends.

4.5.2 Mobile Banking System (bKash & DBBL Mobile Banking)

The users need to visit to a mobile banking service agent (merchant) to receive the service from a mobile banking e-Money system. The merchant possesses a mobile phone and delivers the service using the phone. The process is explained below. Figure 4.6 shows the process.

(1) The user visits the merchant with his mobile phone and gives the mobile banking (MB) number along with the transaction request details.

(2) The merchant sends an SMS to the Issuer mentioning MB account number, transaction type and necessary details.

(3) The Issuer completes the transaction and updates necessary data.

(4) Then the Issuer sends an SMS to the user confirming the completion of the transaction. At this stage the Issuer also sends SMS to all relevant parties. Like if transaction is

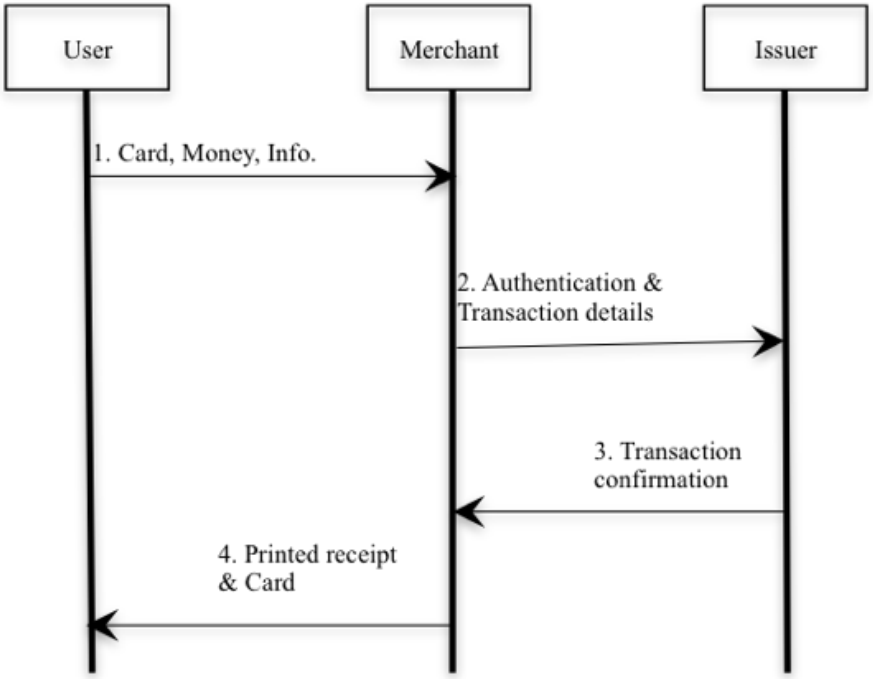

Figure. 4.5: Card based e-Money system

a fund transfer to another MB account, then the Issuer will also send an SMS to the relevant mobile of the recipient of the money as well as the remitter.

(5) The Issuer will send an SMS to the merchant confirming the completion of the process.

(6) The user gives the applicable money including service charge to the merchant and the process ends.

4.5.3 User Feedback and Observations

According to the feedback from both users and the services providers, it became clear that the service has become very popular for remittance but the use of e-Money for daily use is mostly ignored. In most of the cases the accounts remains dormant with zero or minimum

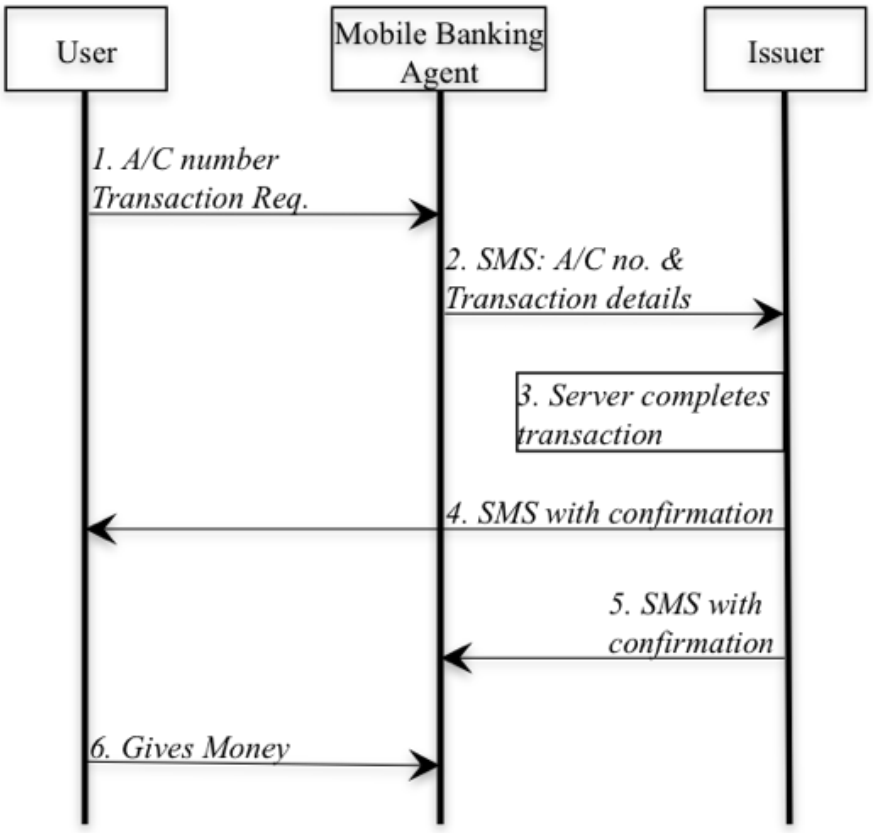

Figure. 4.6: Mobile phone based e-Money system.

allowable balance after remittance received and sent. Following list contains the facts those are challenging the service providers to expand these service as a general platform for transaction at the last mile:

(1) The service is being delivered by the merchants who are paid against number of transaction and amount of money transacted. So they are interested to make big transaction only.

(2) The whole operation is merchant based. So it takes long time for the merchant to compete a transaction.

(3) Lack of privacy. The user needs to give full details to the merchant for the operations. Most of time they don't feel comfortable.

(4) Due to high involvement of the merchant, the financial planning using different value added services are not taking place.

4.6 Conclusion

The need for e-Money already exists in the remote rural areas. e-Money services are already being offered in the rural areas and the poor villagers are using those. However, the services are not designed based on the actual demand of the target people, therefore, it is not being used as a complete solution to the required financial services. Still there is scope for adding new features to the e-Money solutions.

The experiment we conducted shows that, the last mile people use e-Money service for all sorts of financial activities provided the solution is developed based on their requirements. Introducing e-Money allow them to manage their financial life better. In this connection we should always keep in mind that, more services we would incorporate with the e-Money services more it would become popular and the cost of service would go down.

Chapter 5

Data Communication In Challenged Infrastructural Scenario

Data communication service is another essential precondition for delivering e-Services. The remote areas of the developing countries are deprived from reliable data communication service. Therefore, we proposed delay tolerant network (DTN) based data communication that can ensure bulk data transfer in the context of the existing challenged infrastructure scenario. DTN is a hop-by-hop store and forward data transfer protocol that can guarantee data transfer from the source node to a destination node, when both source and destination nodes are not online simultaneously. This chapter describes our proposed DTN based data communication arrangement suitable for the delivering e-Services for the last mile people. It also describes our proposed change in the bundle protocol to reduce end-to-end data transfer time.

5.1 Introduction

C.K. Prahalad in his book detailed about the social and business potential of the poor people mostly living in the rural areas of the developing countries [1]. It is also seen that availability of ICT based services empowers poor people and help to achieve financial self-sustainability

[23]. However, the existing telecommunication infrastructure in the developing countries is not in favor of introducing e-services for the last mile people. With more than 7 billion subscriber base, mobile phone network is the only available communication means in the remote areas. In the recent years the mobile phone operators are offering data communication service along with the voice service. Therefore, mobile phone network opens the door to offer e-Services to the last mile people.

We conducted a survey on the quality of mobile internet service in Bangladesh. The survey indicates that the upload and download bandwidth is similar to ideal performance of 56kbps dialup connection. However, network performance parameters were found to be very poor: TCP Request/Response per second varies from 1.0 to 2.0, TCP Connect/Close per second varies from 0.5 to 2.0, and TCP connect/Request/Response per second varies from 0 to 0.5. Needless to mention that it is not possible to make any service delivery plan over such instable network.

In this circumstance, we started thinking of using Delay Tolerant Network (DTN) to transport data between the cities and the rural areas [7]. DTN is a network designed to transfer data from a source node to a destination node while both of the nodes are not online simultaneously. DTN uses hop-by-hop store and forward data transfer methodology to transfer data from source to destination. The Bundle Protocol (BP) [8], responsible for transporting data from source to destination is a complete one, covering the data security and reliability. However, sending a data bundle and finally receiving the acknowledgement requires significant time in the context of a DTN created over the public transportation system operating in the rural areas of developing countries. In reality sometimes this total turnaround time becomes few days, which lead to repeated retransmission. Therefore, we proposed some changes in the DTN arrangement to improve performance.

5.2 Delay Tolerant Network (DTN)

The concept of DTN was first introduced to create interplanetary network (IPN) and was characterized as a network, which can tolerate high delay and frequently disrupted transmission and ensures guaranteed transmission of data bundles from source to destination where both the source and destination nodes are not simultaneously available to be connected. In short DTN is a network of regional networks. It works as an overlay on top of different regional networks including Internet. DTN supports interoperability of regional networks by accommodating long delay between and within regional networks. It also translates the varying characteristics of different regional networks among each other.

In figure 5.1 it is assumed that different networks are available in different planets. Within the DTN architecture if a node in a planet needs to communicate with a node in another planate then it uses the DTN communication facility through the DTN gateway in that planet. Two DTN gateways use BP to transfer data between them. Finally data is reached to the destination node. Within the path from source to destination, the bundle may be passed through many gateways to reach to the desired network. Due to long latency delay between the interplanetary gateways and possible disruption in communication, the acknowledgement may not reach within the lifetime of a bundle. So transfer of bundles and acknowledge is confirmed by hop-by-hop store and forward method. The acknowledgement bundle from the final destination to the source also travels the similar path as the data bundle and takes similar time.

5.3 Applicability DTN for Data Communication in Developing Countries

If we consider an isolated remote village as a network in a planet then the whole Bangladesh can be considered as a galaxy. Connecting the gateways nodes (computers with necessary DTN server software installed) may form an IPN. To reduce the cost of transportation from one planate (village) to another planate (village) we can use public transportation vehicles

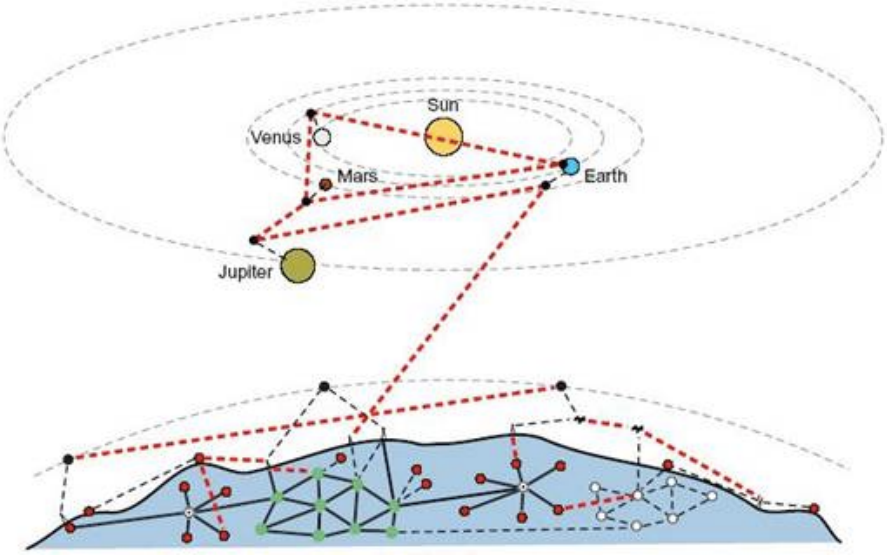

Figure. 5.1: DTN in interplanetary Network.

(bus) having a DTN box installed inside. The DTN box will have a Wi-Fi router and look for presence of any nearby Wi-Fi network opportunistically. If the detected network is a member of the same DTN, it establishes a connection. The DTN box maintains a routing table and identifies which bundles to be transferred in which DTN node or gateway. Immediately it sends the data relevant to this DTN box and receives any data sent from the node. After the bus moves out of the range of the Wi-Fi signal the connection terminates and it starts sorting the data to create stack of bundles for the nodes on the way. To elaborate our explanation we took Bangladesh as a representative of developing country and we explain a possible way of transferring data from a remote village to the capital city Dhaka over DTN network.

5.3.1 Existing Road Transportation Network in Bangladesh

Bangladesh is a centrally controlled, small and highly dense country. ICT infrastructure is not flourished beyond major cities. Road transportation system is also not improved uniformly. Road quality largely varies in different parts of the country. Therefore, similar vehicle cannot

operate as public transport all over the country. The public transportation network can be divided in the following categories:

(1) Divisional cities to District towns. Although some of the operators offer services up to some prominent Upazila (Sub district) towns, the operators usually use bus to transport passengers.

(2) District town to Upazila towns. The bus is used as a carrier also in this case. Besides buses, small vehicles (different types three wheelers) also operate in these routes.

(3) Besides the above two types routes, small vehicles operate throughout the country to access the people living in the last mile. In many cases, these vehicles are not automobiles.

While a vehicle travels in the first two types of routes, it also passes by many small localities. To cover all 90 thousand villages in Bangladesh we need to coordinate with vehicle operators at different levels. Since Bangladesh Post Office (BPO) transports mails in all 10 thousand post offices on a regular basis, keeping them in the consortium would make the process much easier [**?**].

5.3.2 A typical DTN topology to Link a DTN node in the village to the central server in Dhaka

Considering the above transportation network, possible data-traveling paths from village to Dhaka could be imagined as figure 5.2.

Three-wheeler, locally known as Tempu, operates between point A and point B. The DTN box in the vehicle receives and delivers data from the roadside DTN nodes. At point B the DTN node in the Tempu transfers the data received from other DTN node during this trip to the DTN gateway at point B. It also receives data for the DTN nodes along its route so that it can deliver the data to the corresponding nodes during its next trip. The DTN gateway at

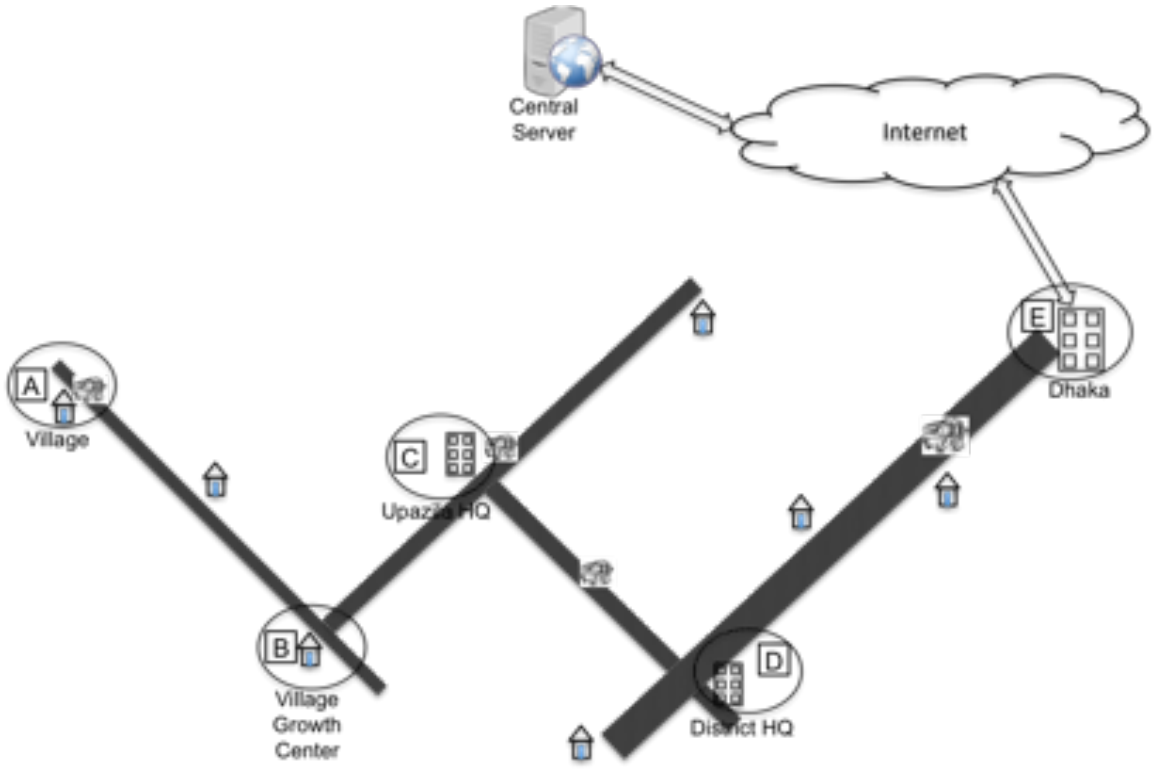

Figure. 5.2: Topology to connect DTN nodes in the villages and the cities.

Point B stores the received data to forward later. Bus or three-wheeler Tempu operates in the route between Point B and Point C. The DTN box in the vehicle receives and delivers data from the gateways as well as the roadside DTN nodes exist in the route. Similarly the vehicles travelling between point C and point D, and point D and point E receive and deliver the data to the corresponding gateways based on the routing algorithm. Finally the data received at point E is pushed to the Internet to reach the destination connected to Internet.

According to the above topology, a data bundle travelling from point A to Central server in Dhaka needs to pass through 4 hops (gateways). Similarly the received acknowledgement bundle would require another 4 hops to reach to point A from Dhaka. Considering the trans-

portation condition prevails in Bangladesh, any of these vehicles can be damaged permanently or delayed for unpredictable time. In that case the sender would be waiting for long time to receive the received acknowledgement from the destination (central server) and realize that the bundle is lost on the way and a re-transmission is required.

5.4 Existing mechanism for Bundle Transfer

Figure 5.3 shows how Bundle Protocol works to connect networks of different types to create a DTN. The Bundle protocol is implemented as an overlay to the transport layer and is common in all nodes throughout the DTN. While one application wants to transfer data to another application in a different network, it gives the data to the BP layer in its attached node. BP creates a bundle, finds the DTN ID of the destination node and also works on the routing of the bundle. Then the BP of the source node sends it to the next DTN Gateway through the underlying network layers. In this case the underlying network layers of both the nodes do not realize the presence of special arrangement of BP. In the next hop the bundle again moves to another DTN node. In this way the bundle changes nodes until reaches to the destination node.

The destination node generates an acknowledgement bundle for the source node, fix the routing path, and passes to the relevant node. The acknowledge bundle travels a similar path to reach the source node. After receiving the acknowledge bundle the source node confirms that the data bundle reaches the destination and discards the data bundle. If the source bundle does not receive the acknowledgement bundle within a predefined time, it retransmits the data bundle.

The above-mentioned scenario is an ideal one. In reality many unusual scenarios may arise. Some of the nodes between the source and destination may successfully receive the bundle but fail to transfer to the next node. Some nodes may receive the bundle successfully but fail to send the custody transfer acknowledgement to reach the sending node. Here, custody transfer

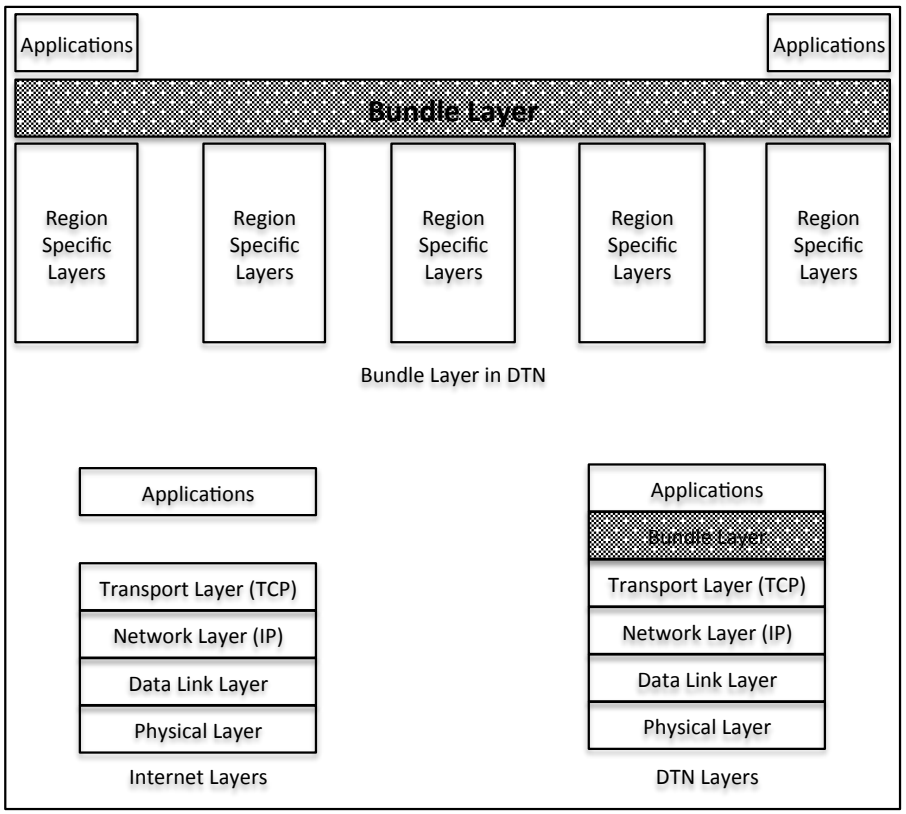

Figure. 5.3: Implementation of Bundle Protocol.

is a message that indicates that the new node has successfully finished all formalities of receiving the bundle and takes full responsibility of the bundle from the previous custody owner (DTN node). All these mentioned scenarios lead to unsuccessful transfer of the data bundle from the source to destination and the acknowledgement bundle from destination to source. Therefore, the final acknowledgement bundle does not reach the sender within predefined time frame. That leads to retransmit the bundle.

Since internet works on TCP/IP, we are discussing how DTN handles connection oriented data transfer in a network where source and destination is not online simultaneously to be connected. TCP needs end-to-end connection but both sender and receiver is not connected simultaneously. Therefore, both data and acknowledgement is delivered in hop-by-hop store

and forward method. BP layer transfers the bundle from one node to another then the new node takes over the custody of the bundle and acknowledges the custody control to the previous node. In this way the bundle reaches the destination. Then the destination sends the received acknowledgement and it passes through the similar path up to the sender. The process is depicted in figure 5.4.

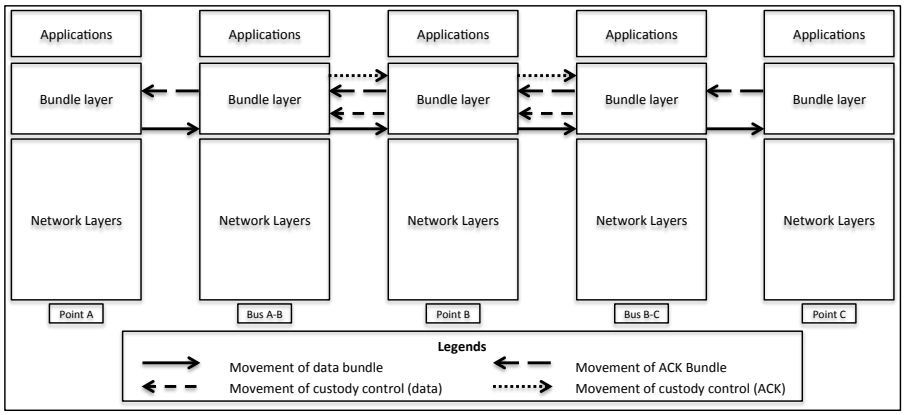

Figure. 5.4: Data transfer from point A to point C according to BP.

5.4.1 Performance calculation

The performance of BP can be calculated by the time required to receive the received-acknowledgement of a bundle sent by a node for the first time. During the lifetime of a bundle, situations might occur where one node might fail to transfer the custody of the bundle to the next node. In that case there will be some delay added to the total time required to receive the received acknowledgement by the source node from the destination node. If many nodes fails to transfer the custody control of the bundle to the next node then the ultimate time required to receive the received acknowledgement from the destination node will be extremely high. Again the failure of this custody transfer of the bundles depends on the bundle size, data transfer rate of network connection established, and duration of the connection established. All these parameters can be analyzed carefully to improve the performance of the network.

For simplicity of calculation to compared the performance of a DTN Network in a scenario where all nodes within the path could transfer the custody control of the bundle to the next node in one attempt. In that case the equation 5.1 can be developed to calculate the time for receiving the received acknowledgement from the destination node by the source node:

$$T = 2\left(\sum_{w \in nodes(P)} T_w + \sum_{s \in segments(P)} (T_{source(s),destination(s)} + 2t)\right) \tag{5.1}$$

Where,

P = Path on the transportation network,

nodes(P) = Set of points in the path P

segments(P) = Sequence of segments of paths from one node to the next

T_w = Average waiting time for the next bus to arrive at node w

$T_{a,b}$ = Transportation time from a to b

t = Time required to transport a bundle from the DTN node in the bus to the DTN node in the village

5.5 Proposed Change for Performance Improvement

Considering the communication infrastructure in Bangladesh and other developing countries, availability of reasonability acceptable data communication facility up to the last mile is beyond imagination. At the same time with over 6 billion-subscribers, mobile phone network is available almost anywhere in the world. In the developing countries including Bangladesh, mobile phone operators offer only text and voice service to the remote areas. We would like to reduce the time for receiving received acknowledgement bundle using SMS service. We proposed modification of part of the BP to send received acknowledgements.

5.5.1 Acknowledgement send-receive procedure in BP

Sending a bundle from source to destination (from point A to point E of figure 5.2) and receiving the acknowledgement from destination to source according to BP can be explained as below:

(1) Create the bundle according to the format of bundle block. Assign destination address and source address corresponding to Point E and point A. Assign the custodian address corresponding to point A. Remove "Dispatch Pending" retention constraint.

(2) When the Wi-Fi network connection is established between the bus and the VIC at point A, the data bundle is transferred to the DTN node in the bus. The DTN node in bus receives the custody of the bundle but does not send acknowledgement bundle because it is the source node. So the source node preserves the bundle with "Dispatch Pending" retention constraint and waits for the received acknowledgement bundle to receive.

(3) When the bus reaches within the range of Wi-Fi of the VIC at Point B, it transfers the bundle to point B. Point B sends the custody transfer acknowledgement to the bus DTN node. After Bus DTN node receive the custody transfer acknowledgement, it discards the bundle.

(4) Similarly the custody of the bundle is transferred to another bus operating in the route B-C and bus sends custody transfer acknowledgement to point B DTN node. Point B DTN node discards the bundle.

(5) Then the custody is again transferred from bus to the VIC in point C and the bus receives the custody transfer acknowledgement and discards the bundle.

(6) Similarly the bundle will moves up to its destination Point E. Point E DTN node would find itself to be the destination and therefor, would not send the custody transfer to the

DTN node in the bus. Point E will send the received acknowledgement bundle mentioning Point A as destination. The received acknowledgement bundle will go through similar process to reach point A. The return path might be reverse of the previous path or a completely new path depending on routing algorithm. After receiving the received acknowledgement from the destination node. DTN node at Point A discards the bundle.

Following assumptions were made while considering the above mentioned steps:

(1) The value of "lifetime" of the bundle is long enough to accommodate receiving the acknowledgement.

(2) The DTN overlay layer is capable of using TCP/IP for transmitting the bundle physically from one node to other and eventually release the bundle in the Internet to reach the actual destination.

(3) We have considered using SMTP to send/receive data from node to node. The DTN BP layer contains a control module, which implements a suitable routing module to transfer the bundle to the appropriate gateway among the available ones.

5.5.2 Areas of Improvement

Send-receive acknowledgement through the same communication channel makes the architecture more robust and controlled. However, it consumes enormous amount of time specially in case if the bus passes by the VIC fast and the DTN box in the VIC cannot send/receive all the data and send the corresponding acknowledgement in a single session. In that case a node need to wait some time to receive the acknowledgement or it will re-transmit many times.

Considering the availability of mobile phone network with text messaging service we can consider send/receive acknowledgement through SMS. In this regard we consider the following assumptions:

(1) Every node in the system will be registered beforehand along with a mobile phone number attached to the system.

(2) Router module in each DTN node will be dynamically updated about the topology of the nodes within the DTN. It will also preserve the mobile number of each node.

(3) Every node in the DTN will be identified by a DNS name. The domains will be created according to the national administrative divisions as described in [24] like chordurlovkhan.barishabo.kapasia.gazipur.dtn.bd.

5.5.3 Proposed change

We propose a new type of administrative bundle for acknowledgement within the scope of BP. These bundles will be transmitted over mobile phone network as SMS. The format of the bundle is given in table 5.1. Here we assume that the Source and destination ID scheme will be designed carefully so that those can be accommodated within the range 49 bytes. The third and forth fields are binary data. They will be converted to mime text before inserting into the SMS.

To reflect the proposed changes in BP equation 5.1 can be adjusted as equation 5.2.

$$T = \sum_{w \in nodes(P)} T_w + \sum_{s \in segments(P)} (T_{source(s),destination(s)} + 2t) + T_{SMS} \tag{5.2}$$

Where,

P = Path on the transportation network,

nodes(P) = Set of points in the path P

segments(P) = Sequence of segments of paths from one node to the next

T_w = Average waiting time for the next bus to arrive at node w

$T_{a,b}$ = Transportation time from a to b

t = Time required to transport a bundle from the DTN node in the bus to

Table. 5.1: SMS bundle format.

SN	Field Name	Bytes	Comments
1	Source ID	49	DNS name
2	Destination ID	49	DNS name
3	Bundle creation timestamp time	20	BP uses this fields for identification of a bundle
4	Bundle creation timestamp sequence number	20	BP uses this fields for identification of a bundle
5	Type of bundle	1	1: Ack

the DTN node in the village

T_{SMS} = Time required to receive an SMS by the destination mobile phone after sending it by the sending mobile phone

5.6 Performance Comparison

According to Bundle Protocol, a bundle transfer process from Point A to Point C can be explained by figure 5.5. Arrows in solid lines represent the movement of data bundle, arrows in dashed line represent the movement of custody control transfer acknowledgement of data bundle, arrows in long dashed line represent received acknowledgement bundle from the destination node, arrows in dotted line represent the movement of custody control transfer acknowledgement of received acknowledgement bundle.

According to our proposed modification, a bundle transfer process from Point A to Point C

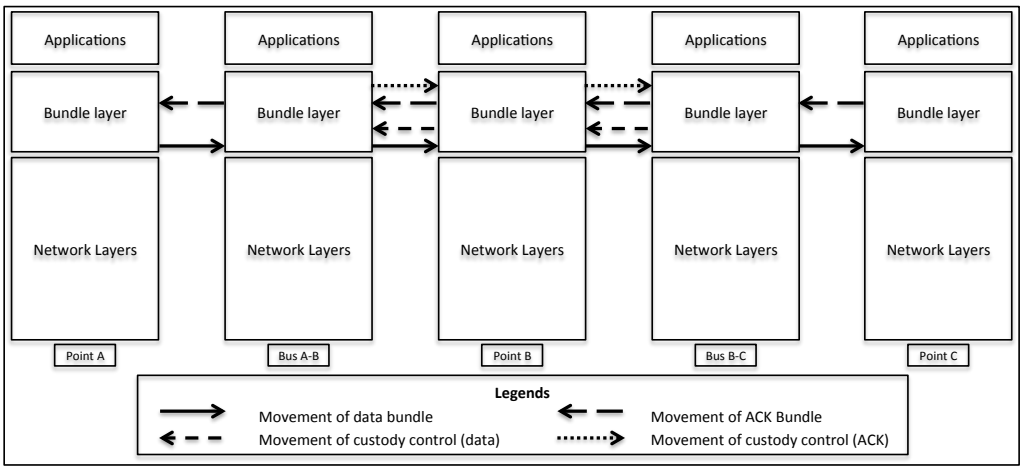

Figure. 5.5: Data transfer from Point A to Point C According to BP.

can be explained by figure 5.6. Arrows in solid lines represent the movement of data bundle, arrows in dashed line represent the movement of custody control transfer acknowledgement of data bundle, arrows in long dashed line represent received acknowledgement of the data bundle from destination node.

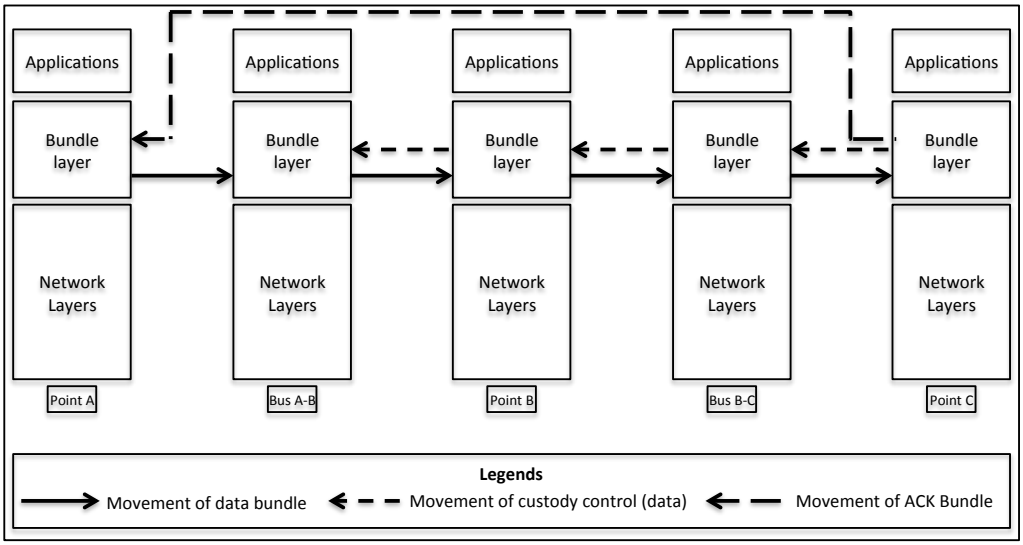

Figure. 5.6: Data transfer from Point A to Point C According to our proposed Modification.

For simplicity, in figure 5.5 and figure 5.6 we assumed the following:

(1) The data bundle and the acknowledge bundle travels the same path. In a real system spanned over a country this might not be true every time.

(2) Every node can transfer bundle in one attempt without any failure.

(3) $T_{source(s),destination(s)}$is same for every segment of paths ($T_{a,b}$).

(4) T_W is zero for all nodes, means there is no waiting time and the next bus is instantly available.

(5) T_{SMS} and t are negligible, therefore, assumed equal to zero.

Applying the above assumptions we can get the value of $T=8T_{a,b}$ from equation 5.1 and $T=4T_{a,b}$ from equation 5.2. Therefore, performance improvement with the proposed change in the BP is 50%.

5.7 Related Works

Researchers are working on developing efficient mechanism to transport data using DTN over vehicular network for the last decade. In this regard we can mention Daknet [25] as the first attempt. It successfully demonstrated the usability of DTN over vehicular network in India and Cambodia. Kiosknet is another implementation encouraged by Daknet was tested in some bigger extent in the laboratory [24]. In this regard, MotoPostTM, developed by Motorola Research Lab, Motorola India, can also be named [26]. All these mentioned projects were developed by implementing DTN architecture and BP (Bundle Protocol) developed by DTNRG. The systems achieved their goals to deliver data to its destination node and sending back acknowledgement to the source node. Due to their limited and laboratory implementation the practical delay and its implication to the commercial systems was not considered.

Systems developed till date to solve similar problems intended to see the applicability of DTN Architecture and BP. There is no trace of research to know how much delay is tolerable by the people living in the remote areas to purchase a service of necessity. Because of the pilot implementation, their performance was never the priority.

5.8 Conclusion

Reaching the people at the last mile was a dream to the researchers for many decades. With the overwhelming popularity of ICT in changing life of the people putting pressure to the governments of the developing countries to use of ICT to deliver the public service to the last mile people. In the last two decades mobile telecommunication services have reached till the last mile. People living in the concerned areas have adopted this technology. Presently most of the revenue of mobile phone communication industry is coming from poor people around the world. This fact forced to change the myth "poor people are not capable of using state-of-the-art technology based systems/products". Researchers around the world are realizing that it is rather a problem of inappropriate system that could not attract the people to use the system.

Introduction of DTN was seen as a light on the problem of delivering ICT based services up to the last mile at an affordable cost. The limited implementation of RFC 4838, and RFC 5050 could successfully proved the concepts. In this paper we put emphasize on the question on "How much delay is tolerable by the people for a commercial system?" Figure 5.2 shows the average scenario of a DTN node up to the last mile. Considering the vehicle frequency, speed, distance it would take around 2 days to receive the acknowledgement by a village node if there is no lose of bundle. So as an average case to deliver a residency certificate (for example) to a villager it will take around a week. The researchers of this paper desire to improve the delivery time.

It will be excellent to incorporate the mobile phone communication network within the

DTN architecture and Bundle Protocol. Here we need to consider the limitation of length of user data in SMS protocol.

Chapter 6

User Interface For Functionally Illiterate People

Half of the population living in the developing countries cannot read and write effectively. They never experienced using ICT access devices like computers, tabs, and smartphone. Therefore, the e-Services developed for them are designed to deliver the service with the help of a service delivery agent. The involvement of service delivery agent increases the cost of the services. The services that gives them direct financial benefit, can justify the additional cost incurred by the service delivery agent. However, services like e-Learning, messaging, bulletin board, etc. cannot justify the involvement of service delivery agent. Besides, there are some services that need to provide some personal information and the villagers do not feel comfortable to provide personal information to the service delivery agent to consume those services. Therefore, we intended to develop a user interface for the functionally illiterate people, so that, those people can use the e-Services independently without any help from others. This chapter elaborates our proposed standards and techniques to develop user interface for functionally illiterate people.

6.1 Introduction

In the recent days, different e-Services are introduced targeting the poor people of the developing countries. Services are related to e-Government, e-Business, messaging, and so on.

In this regard, we may mention services like e-Choupal and Bhoomi [27, 3]. e-Choupal is a service introduced by Indian conglomerate ITC Ltd. to purchase agricultural produces from the farmers directly, avoiding intermediaries. The service became very popular within a short time. The farmers can offer the price of their produces to the buyer directly. In the existing arrangement, the farmers sell the produces to the local intermediaries and the local intermediaries sell the same to the actual buyers. Therefore, e-Choupal offers benefits to both the farmers and the purchasers by eliminating the local intermediary. Bhoomi is an e-Government service introduced by Indian state of Karnataka. The service provides the land ownership related services to the citizens. This service also received huge response from the stakeholders. However the end-users need intervention of a service delivery agent of the service provider to consume the service.

Considering the amount of direct financial benefit the villagers get from the aforementioned services, the cost added for the service delivery agent is justified. However, there are services like e-Learning, messaging, information bulletin board, and so on, which do not provide any direct financial benefit to the users. Additional cost due to involvement of a service delivery agent cannot be justified for these services.

Besides the aforementioned services, there are various other types of service available for the people in the developed countries. Such services include e-Commerce, e-Learning and many more. Apart from additional cost, users do not feel comfortable to consume the services that involve providing sensitive personal information and financial transaction through an intermediary agent. Therefore, there is a need for a platform, which the end-users (mostly illiterate villagers) can use independently.

In order to empower the rural people with the necessary information and skills to improve their living we intended to develop an e-Learning system for the villagers. The e-Learning system would contain videos that demonstrates different skills and techniques related to improved farming techniques, preventive healthcare, domestic hygiene, information about latest

invention in the fields, and so on. These information and learning can improve the quality of life of the rural people. A service delivery agent must be there to help the users to consume this service. The villagers do not get any immediate financial benefit from this service. Therefore, they would be discouraged to spend additional money in this regard. We decided to develop the user interface of the e-Learning system to be suitable for the illiterate users as well. This chapter describes the design considerations behind the work, limitations of the existing proposals, necessary improvements, and effectiveness of the improvements.

6.2 Existing Design Considerations

User interface development for computerized systems is a topic of continuous research. In the early days of computing in 1950's, command line based user interface was the only option. Gradually developers used text, graphics, audio and video to create innovative user interface that encouraged common people using computers. From the beginning of 21st century, the cost of computers started to reduce and common people in the developing countries can afford to purchase computer with rich multimedia features. Since then, governments of the developing countries and the international development agencies are taking initiatives to introduce ICT based services for the rural people. However, illiteracy became the biggest challenge to ensure acceptable participation from the common villagers. Therefore, researchers are putting effort to develop user interface especially suitable for the illiterate people.

Different approaches have been attempted while developing user interfaces for the illiterate people. All the attempts can be categorized as:

(1) **Innovative use of text and numbers:** Developers who developed these type of user interfaces mainly emphasized the fact that people can remember numbers better than texts [28, 29]. The proposals falling into this category are more suitable for the systems developed in the early days of computing and mobile phones. In the present days, with

computers having rich multimedia features, these proposals fail to cater much interest.

(2) **Use of extensive graphics and minimum text:** A picture bears universal meaning [35, 36, 37]. A chicken would be written differently in different languages. Without knowing how to read the language a person would not understand. However, everybody would understand seeing a picture of a chicken. Researches fall into this category emphasized this fact while developing the user interface. However, it is not possible to eliminate text completely in a user interface. Therefore, the effort was to minimize the use of text.

(3) **Speech recognition based user interfaces:** Another group of researchers used speech recognition techniques to develop user interface [30, 31, 32, 33, 34]. However, for the languages having too many variant of dialects, it becomes very difficult to train a system to respond a set of command with acceptable size and works for a reasonable group of population. However, with limited set of commands the developed user interfaces work satisfactorily for limited number of people.

(4) **Use of audio in addition to text and graphics:** Using graphics instead of text proved to be efficient for the illiterate users. However, Some researchers used audio in addition to graphics to improve performance in some special cases [38, 39].

For our purpose of developing a computer based e-Learning system we gathered all the recommendations made by different researchers to develop user interface for illiterate users to use similar systems. Additionally we emphasized that the illiterate people would use our proposed system independently without any help from others. The recommendations are described in details as follows:

(1) **Minimizing the need for hierarchical navigation:** In case of hierarchical menu, the number of options increases geometrically with the level of hierarchy. The menu items to invoke a command should be arranged in such a way that user does not need to remember

too many options in deferent levels. A flat menu with only one option to be chosen for one command is the simplest one. Sometimes it is difficult to arrange commands in a flat menu for a real system. However, we may separate the command for illiterate users from and literate users and make the menu for the illiterate people a simple one.

(2) **Maintaining natural workflow:** The illiterate users are not habituated using technological gadgets. Only such gadget they used is a mobile phone that they use for voice call only. Considering this background, we should not expect them to learn new logical flow to persuade a task in computer. Additionally this might put them into technophobia. It is important the workflow involved is same as the natural one.

(3) **Use of graphics to invoke command:** As described earlier a photo bears universal meaning. Therefore, we should use photos where users need to select any command or give input. Like to select a category from a list fruit, flower, vegetable, animal, birds and fish, we can use photos as shown in figure 6.1. For an illiterate user this is the only way since the words do not bear any meaning to them.

Figure. 6.1: Photos representing categories fruit, flower, vegetable, animal, birds and fish

(4) **Using audio annotation in addition to graphics:** There are situations where it is very difficult to generate two distinct photos to represent two very similar subject. Like figure 6.2 shows two photos, one for category insect and another for pest. Apparently those are so similar that most of people would make mistake. In such situation some sort of audio annotation would help the user making the right choice.

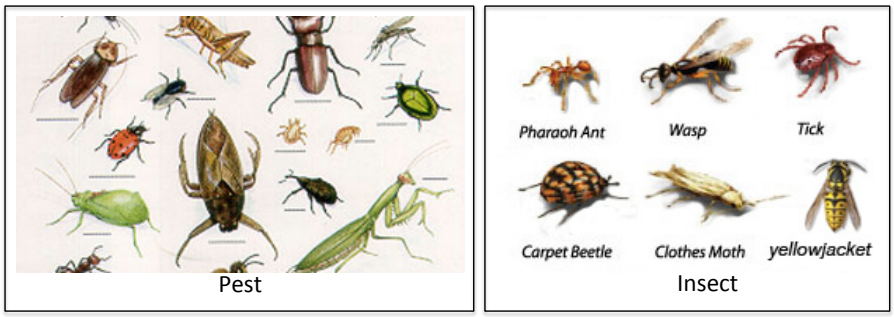

Figure. 6.2: Photos representing categories Insect and Pest

6.3 Primary Design of User Interface

In order to verify the usability of the existing design considerations in our intended application, we developed a user interface of the aforementioned e-Learning system following the aforementioned design considerations. The features of the e-Learning system include: User registration, Upload content, Edit content, Delete content, Search Content, Play content. The users of the system are of two categories: Registered users and anonymous users.

Registered users are administrators and content providers. They need authentication to perform their tasks. These users are literate and possesses high IT aptitude. Registered users perform the tasks of system administration and upload, edit and delete content. The anonymous users do not need authentication and can search and play video contents. The illiterate users are the anonymous users and the target group of our special user interface. Therefore,

henceforth we would discuss the user interface related to search content and play content task only.

6.3.1 User Interface using existing design considerations

We developed a user interface for the illiterate people following the aforementioned recommendations. Figure 6.3 shows the user interface for the search content feature. Details of the user interface is described below:

In the upper part of every page there is a header that contains 3 buttons. The middle button is to invoke search content feature. The rest two are for user registration and upload content. When the user specifies to search for content by clicking the search content button, the webpage shown in figure 8.3 (a) appears.

A literate user specifies the category, subcategory, language, and country from the related drop down list box and optionally enters full or part of the title of the content he/she wants to search. For the illiterate users all the texts are supplemented by audio annotation. If the user makes the cursor hover to any textbox or button, the purpose of the textbox or button is mentioned in voice.

This text-based webpage is not suitable for the illiterate users. Another version of this page, suitable for the illiterate users to use is also available. Users may invoke that by clicking the bottom right button of the webpage shown in figure 8.3 (a) and the webpage shown in figure 8.3 (b) appears.

This graphics based webpage is suitable for the illiterate users. This page is to select category. Different pictures are representing different categories. The user can select the desired category by clicking on the photo. For example, if the user wants to search video related to fruit, then he/she may click on the photo of fruit. The selected category would be marked with a black border. If the user cannot understand a category from the photo, then the user may hear the name of the category in voice by hovering the mouse on top of the photo for 2 seconds or

Figure. 6.3: User interface of Search Content feature: (a) user interface for literate users; (b) categories an illiterate user can select: fruits, flower, vegetable, etc.; (c) subcategories an illiterate user can select: mango, jack fruit, orange, strawberry, etc., which are the subcategories of the category fruit; (d) countries an illiterate user can select: Bangladesh, India, Sri Lanka, Indonesia, and Nigeria; (e) languages an illiterate user can select: Bengali, Hindi, Tamil, etc.; (f) list of contents match the criteria specified in the previous steps.

more. After selecting the category, the user may go to the next step to select subcategory or may ask to list all videos related to fruit. The user may abandon the search at the stage also. The user may select the correct button by listening to the purpose of each button by hovering on the button for 2 seconds or more.

Similarly the illiterate users can select subcategory, country, and language using the websites shown in Figures 8.3(c), 8.3(d), 8.3(e), respectively, which appears subsequently. At each

stage user has the option to abandon the search or start search with partial options. In the case of partial option, the system will list all the videos meeting the partial information.

At any stage, when the user clicks the start search button in the webpages, the system start searching the database for matching contents. Finally the results are shown as Figure 8.3(f). The list contains the videos that matches the options already selected (partially or full).

Then the user specifically identifies one video content that he/she wants to play. User can specify by clicking on the content image in Figure 8.3(f) and this invokes the play content feature and screen shown in figure 6.4 appears. Like the previously described webpages, all the textboxes and the buttons in this page are also supplemented by audio annotation. The user may hover the cursor on different textboxes or buttons to hear the purpose and use of the same in voice. Different textboxes mention the category, subcategory, language, and country. One textbox also contains a short description of the video.

Figure. 6.4: User interface for play content feature

6.3.2 Trial Evaluation

The design considerations used to develop user interface for illiterate people was derived based on the experience with different types computer based systems developed for the usage of illiterate people living in the urban areas and moderately experienced with using ICT gadgets. However, out system is planned to be deployed in a remote villages with users having less experience of using ICT gadgets. Moreover, the users will be using the system without any help from others. Therefore, we conducted a trial evaluation of the system in a simulated environment.

We used definition of illiteracy as inability of a person to read and understand the texts written in Bangla language. In Japan we arranged some Indonesian and Japanese students to take part in the evaluation process. In the original system the audio annotation was in Bangla language. However, for this evaluation purpose, we developed audio annotation in Japanese language for the Japanese student and in English language for the Indonesian students. Each participant was given some time to learn the system and later given a task to find a specific video content based on a description. The example of a task is "Find a video that describe how to raise a cow for milk production". The participants used the system independently and could find the desired video successfully. However, they often made mistakes to choose the right option.

6.3.3 Observations and Limitations

The observations from the trial evaluation are listed as follows:

(1) The participants possess high IT aptitude. They use computerized system everyday and very conversant to the user interface and workflow concepts. However, they cannot understand the text used in this user interface. Still it took long time for them to decide which button to choose at what stage.

(2) The users repeatedly listen to the audio annotation by hovering mouse cursor on different textboxes and buttons until they find their desired element. Sometimes they repeated listing for few rounds to confirm their selection.

(3) Sometimes users cannot concentrate on the audio descriptions because the number of buttons to choose is high. This leads the participants to make mistakes.

(4) The participants felt discouraged to go through all the buttons and textboxes if the number available in the page is too high.

After the trial evaluation, we talked to all the participants and noted their feedback. We analyzed the observations and feedbacks received from them and identified two limitations of the user interface design. The limitations are:

(1) If there are too many textboxes displaying information for the users and many buttons are available to choose action, the users gets confused and try to avoid listening to the audio annotation by making guess for the next action and get frustrated due to repeated wrong guess. Therefore, we need to devise some mechanism to restrict users to make choice from a short list of options.

(2) Sometimes users cannot recall from where to start. Since they are unable to read the text, they cannot make guess also. This situation especially arrives if the user uses the system after a while.

6.4 Proposed Improvements

To overcoming the aforementioned limitations of the user interface design, we implemented following improvements:

(1) In order to minimize the number of options to choose, we intended to guide the users to choose from a limited number of most probable options. In a specific situation there are some options most users choose. There are some which users rarely choose. Among the textboxes there are some, which contain information that is critical, and there are some textboxes, which contains information that users occasionally want to know. Those buttons with high probability and textboxes containing critical information are made blinking to indicate the users their importance.

(2) To help the users to recall the purpose of the page itself and its components, a proactive audio description is added to each page. The description is played after the page is loaded. If the user forgot the purpose of the page and its elements, he/she may listen to the description before start using the page.

The user interface after applying the aforementioned improvement looks like figure 6.5. Figure 6.5(a) shows the text based user interface to be used by the literate users, who does not need any special arrangement in the user interface. The illiterate users may either choose to move forward the search with photos or they may abandon the search. Therefore, the corresponding two buttons are made blinking. The users may listen to the purpose of each button by keeping the cursor hover on any of those. There are 13 elements including the dropdown list, textbox and buttons. In the previous arrangement, an illiterate users need to check with all these to select the right one. However, according to present arrangement, that shows that these 2 blinking buttons are the most probable to choose, allows the users to take decision after verifying only 2 buttons. Similarly some buttons and textboxes are made blinking in every page to indicate the most probable actions in that page.

Furthermore, as second improvement, we added a proactive audio description for each page. The description is played immediately after the page is loaded. The description includes the purpose of the page and blinking buttons and text boxes available in this page. Illiterate users can recall their previous experience after listening the description.

Figure. 6.5: User interface of Search Content feature after improvement. The figures are same as figure 6.4 (a)-(f) except in each page few buttons and text boxes are blinking.

Both the improvements are implemented in all pages. The new user interface for play content feature is shown in figure 6.6. The user may want to finish watching the video and go back to the previous list or start a new search. Therefore, corresponding two buttons are made blinking.

6.5 Evaluation

We intended to develop a user interface especially suitable for the illiterate people. We identified some limitations of the existing design considerations made by other researchers and proposed improvement to make the user interface more effective. Finally we compared

Figure. 6.6: User interface of Play Content feature after improvement.

the performance of the improved user interface with that of the old one.

6.5.1 Evaluation Process

The user interface developed based on the recommendations of the previous researchers are henceforth referred as UI-1 and the user interface developed along with our improvement proposal is henceforth referred as UI-2. 14 illiterate people from a remote village in Bangladesh evaluate UI-1 and 15 illiterate people from the same village evaluate UI-2. The participants of both the groups are selected randomly among the male villagers. The age of the participants are uniformly distributed among different age groups. Some of the participants can read and write a little, however, fall in the category of functionally illiterate. All the participants used mobile phone, some saw computers but none used any computer. The workflow of the evaluation process is as follows:

(1) At the beginning, every participant (user) is given a detailed description of the system. The user is briefly shown how to use the system. The purpose of the evaluation and the

role of the user are mentioned clearly. It was categorically mentioned that the purpose of the evaluation is to evaluate the performance of the user interface not the user. Personal data like name, age, educational qualification, etc. are also collected at this stage.

(2) The user is allowed to practice with the system for about an hour. This was the first time the user is using a computer. Therefore, the time was not enough for them to be master on it. However, it could make them little easy before the evaluation. The user was guided as and when needed during this practice session.

(3) The user is given a list of tasks to perform. The example of a task is "Find a video that describes the scientific process of raising a cow for meat production". The user performs the tasks and his activity during this period is recorded. Later we used the video clip to collected data regarding time to complete a task, mistakes during search, etc.

(4) Oral feedback about the system is collected from the user.

6.5.2 Results

The participants were given a list of task to complete during the evaluation. Example of a task can be "find a video that describes the scientific process of raising a cow for milk production". The successful completion of the aforementioned task means that the participant could find the correct video. While performing the task, a participant might find a wrong video or after repeated choice of wrong steps a participant may abandon the search and starts from the beginning.

Successful Completion

14 participants used "UI-1" and 15 participants used "UI-2". The performance of the participants of "UI-1" and "UI-2" are shown in table 6.1. The data shows that 8 out of 14 participants could complete the task using "UI-1". On the other hand, 13 out of 15 participants

could complete the task using "UI-2". Therefore, more people can use "UI-2" successfully than "UI-1".

Table. 6.1: Number of participants completed tasks using both the user interfaces.

	UI-1	UI-2
Total Participants	14	15
Failed to complete	6	2
Completed without hints	6	9
Completed with hints	2	4

Completion Time

The number of tasks attempted and completed by the participants is not same for all participants. The number of attempts depended on interest of the participant on the system and time spent on learning the system. Most of the participants could complete at least one task successfully. Time spent for the unsuccessful attempts is ignored during calculating the average completion time. For the participants who completed multiple tasks, we considered average time of completion as their completion time. Average time of completion for all participants using "UI-1" is 6:32 minutes whereas average time of completion for all participants using "UI-2" is 5:10 minutes. Therefore, it can be concluded from the data of this experiment that, in similar situation a participant can use "UI-2" 26% faster than "UI-1".

Age wise Performance

We know that younger people can respond to the new technology faster and older people suffer from technophobia, therefore, fails to use new technology. However, in this work

we found people from different age groups could use the system similarly. The participants were selected almost equally among different age groups. Table 6.2 shows the number of participants became successful and unsuccessful in different age groups. The data shows that combining all participants of "UI-1" and "UI-2" every age group has 2 unsuccessful persons.

Table. 6.2: Successful and unsuccessful participants in different age group.

Age group	Successful	Unsuccessful
Under 20	5	2
Under 30	5	2
Under 45	6	2
Rest	5	2

6.6 Discussion

We found in the experiment that,

(1) More people can use "UI-2" successfully than "UI-1".

(2) Users can find the desired video faster in "UI-2".

(3) The user interface is equally useful to all different age groups.

We found that the recommendations made by previous researchers for similar applications are also applicable in the present scenario. However, the proposed improvements affect significantly in the situation where the users need to use the system independently.

6.6.1 Recommendations

Based on the observations and data analysis, following design principals can be recommend for the user interface development for the functionally illiterate people:

(1) **Use of images and graphics instead of text:** People understand photos even if they cannot read. It is important that the photo emphasizes a specific message only. The background or other object present in the photo does not get prominence. It is found in the previous works that illiterate people can understand sketch better than photos. The background and other objects available in the photo drags their attraction that makes them confused sometimes. Although photos were used in this experiment, users were not confused. The photos used in the user interface are selected carefully to emphasize only one message.

(2) **Use of audio annotation:** In many cases it becomes very difficult to represent two very close subjects with two distinctly different graphics images. Therefore, it requires using audio annotation in addition to graphics representation. In our research, audio annotation during hover action found the most effective. Besides, it is not possible to eliminate text completely. Therefore, All the text elements must be supplemented by audio annotation.

(3) **Adding context sensitive suggestions to the users:** Guided and controlled users action reduces errors and mistakes. The illiterate users should always be guided to the possible actions for a specific situation. However, the designer should be careful to select most likely options for a specific situation. Too many suggestions may confuse the users.

(4) **Proactive briefing:** In this research, it is found that a proactive description of the features and possible use of different active elements is very effective for the users to select the correct button or option. Users with less orientation to the technology cannot remember all the steps accurately. Besides, due to lack of experience they cannot make good guess. Therefore, early briefing would help them to make fewer mistakes. We may avoid long verbal description by some graphics based animated description in order to make it interesting.

6.6.2 Observations

After completion of using the system the users were requested for their comments about the user interface and the system. This session was their first experience of using computers. Therefore, they could not articulate their opinion very clearly. We are listing the observations acquired through the whole activity:

(1) Orientation to computer usage is an essential part of using any computer-based system. Whatever smart user interface is developed, users cannot use it unless they learn basic computer usage. Therefore, the users need basic computer training for two weeks or more.

(2) Age was not a factor for learning and using the system. Appropriate use of graphics, audio annotation, and proactive and innovative guidance were the reasons behind the success.

(3) Schooling does not influence learning process. There are people who have gone higher classes in the school but cannot respond well. Some people who can read and write a little still failed to ensure good learning of the system.

(4) All participants could understand the audio instruction but it was difficult for a first time user to remember the workflow after listening the audio instruction.

(5) Audio annotation is essential during training period. However, it should be brief and to the point. Long description and repetition should be avoided. After the users get used to the system then long description of each page would be very annoying.

(6) Animated guidance used in “UI-2” is very effective.

6.7 Related Works

User interface for print illiterate people became a subject of interest for the researchers for quite a long time. Different approaches have already been tested to develop a user interface and improve its usability for the print illiterate people. All these attempts might be categorized as: i) innovative use of text and numbers; ii) Use of extensive graphics and minimum text; and iii) Use of audio in addition to text and graphics.

In the early days of computer application development, command line based user interface was the only means of man-machine interaction. Soon after the computers had more processing capabilities, text-based menu was introduced. Text-based menu was shortly replaced by graphics-based menu. During this time it was not considered that poor illiterate people living in the developing countries would use computers. In the early of 21st century, when the price of computers came within the range of common people in the developing countries, the governments and the international development agencies took initiatives to develop application for the people living in the rural areas of the developing countries. However, it was always remain as a challenge to make the rural illiterate and semi literate people using those. Ample of evidences were found where many potential software applications were abandoned because the target illiterate and semi literate users could not use those. This observation encouraged the researchers to work extensively to develop suitable user interface for the illiterate people.

Researches have shown that the illiterate people can remember numbers more easily than words. Therefore, some experiments used more numbers to make it easy for the illiterate users to use the applications [28, 29]. However, these recommendations based on usage of number against text are more relevant for mobile phone interface and other man-machine interface where high quality multimedia capabilities are not available.

Some other researchers used speech recognition techniques to solve the problem of illiteracy [30, 31, 32, 33, 34]. In these applications, the researchers used short word based commands

to activate tasks. In India, China, Bangladesh and some African countries, local dialects vary from district to district within the same state. It would be very difficult to train the speech recognition system to work for a considerably large segment of people. However, the systems work satisfactorily with very limited command set used by people from only small number of villages.

In the recent days, some researchers introduced new techniques using the recent improved hardware and software features [35, 36, 37, 38, 39]. Researchers have also tested the effect of different types of graphics like sketch, photo, animated cartoon and video. In different situation the result varies significantly. The researchers also recommended some guidelines for developing effective user interface for the illiterate users.

6.8 Conclusion

The developed user interface could encourage the governments of developing countries and international development agencies to introduce new services for the people living in the rural areas of the developing countries. Services like e-Learning, e-government could add significant value to the living quality of those people. More and more service would empower the poor people further towards financial self-sustainability.

This study was conducted for a computer-based system. However, the results and recommendations can also be used in other situations for man-machine interface. Consider a situation when a person is moved to other country where the local language is different. In that case that person becomes a newly illiterate person. While this person needs to use vending machines he faces the same difficulties like that of an illiterate person faces in the remote areas with a computer system. The recommendation can be used to develop a system that is easily usable.

This research put some recommendations that demand more resources to the system. For

advanced and complex systems the additional resources could become very exhaustive. In future we would like to use the user interface with the proposed e-Learning system for a considerable period of time. We would also extend the features of the e-Learning system to make it more useful to the users. This would allow us to study the performance of the proposed user interface more accurately. Finally the authors would like to come to a conclusion for the optimum level of details for the audio annotation, proactive guidance etc.

Chapter 7

Discussion

Challenges related to offering e-Services to the last mile people is a multifaceted one. It involves solutions related to data communication, information system, and electricity solution related technologies as well as social aspect. Therefore, the works related to this thesis is also multidisciplinary. This chapter describes how all these works coincide together to achieve the goal of offering e-Services to the last mile people. It also contains a proposed arrangement that would facilitate utilizing the results of the works together to achieve the social goal by eliminating existing challenges.

7.1 Introduction

We were very concerned about how the last mile people would access our services from the very early days of our work. In our first work we developed a prototype ePassbook, an electronic gadget to offer financial, e-health, e-money service for the microfinance borrowers and tested in a village in Bangladesh. Despite wide acceptance from the stakeholders: the microfinance Institution (MFI), the users, suppliers we could not introduce ePassbook and its related services due to absence of necessary infrastructural support. Therefore, we started working on the infrastructural issues so that we can facilitate the service providers to overcome

the infrastructural constrains.

While arranging the infrastructural facilities, affordability of the target population was our major concern. Poor people traditionally share resources. They allow other people to use their mobile phone. They install tube well in a place so that poor neighbors can access that. This culture of sharing resources encouraged us to develop business model to reduce the cost of service consumptions. We did detailed analysis of their requirements and devised the business model to utilize the resources most efficiently. The success of phone ladies inspired us to develop a shared facilities for all villagers to access the e-services [41]. We named the facility Village ICT-access Center (VIC).

7.2 Village ICT-access facility (VIC)

We considered VIC as a shared facility that would possess necessary resources to facilitate accessing ICT based services. Based on the area and population size of a village the number of VIC would vary. Historically public owned facilities demonstrate low efficiency in the developing countries. Therefore, we considered the facility to be a privately owned. In order to achieve financial self-sustainability we considered offering some services of high demand: electricity supply and basic e-Government service for the villagers. In Bangladesh, where we established the VIC, remote villages are out of grid electricity network. Besides, some e-Government services like birth and death registration service, residency certificate issuance are also mandatory for use. For the digital birth and death registration service, the service provider receives money from government and for residency certificate, the intended user spend money. It is found in our experiment, that a VIC can be made financially self-sustainable by these services.

Presently the poor villagers are using kerosene lamp for domestic lighting. Using the lighting solution we proposed would help them enjoying quality lighting and be relieved from

many chronic health problem. Access to internet from the village would allow them to get the residency certificate without traveling to the nearby town. Therefore, the villagers can save money and time. Presently the villagers cannot register birth and death instantly. This causes them facing difficulties during receiving other services like issuing passport, inheriting family property etc.

It is difficult for poor individuals to maintain an ICT access device. However, this shared facility can serve their purpose. Pay as you use business model justify the cost and the rural entrepreneur also get return from his investment. It creates a win-win situation for all the stakeholders. We propose some public subsidy at the initial stage to these VIC entrepreneurs until a reasonable number of services are introduced.

7.3 e-Services through VIC

We established a VIC to identify the challenges related to the operations management and financial self-sustainability. We operated the center for two years. Based on our experience, we propose the following services of a VIC in order to thrive for financial self-sustainability:

(1) **Solar electricity generation:** In Bangladesh all the remote villages are out of electric power grid network. Therefore, VIC can supply electricity to all villagers using the business model described in chapter 3. Besides, the VIC itself needs electricity to operate the ICT access devices. However, the electricity generation capacity should be designed module based. Spreading the service to all villagers would take some time. The VIC would also offer new services as and when available. The villagers are expected to introduce new business and services based on electricity gradually.

At the beginning, the entrepreneur should estimate the requirement and identify the possible growth over the first year. Based on this analysis, the initial capacity should be decided. Considering unavailability of sunlight during rainy season, the capacity should

be at a level of 1.5 times of the estimated demand. In the areas where the rainy days are extended for 2 to 3 days, a standby diesel generator might be arranged to support essential works during the rainy days.

(2) **LED lamp distribution and billing system:** Majority of the villagers are poor. They cannot afford to install solar home system in their home. Presently they use kerosene lamps for domestic lighting and do not afford to increase the expenditure for lighting. Therefore, appropriate LED lamp should be designed to consume minimum power for their purpose. It is understandable that, design and manufacture lamps is not justified for an individual entrepreneur. However, we are considering VICs as a standard facility established throughout the country. Lamp manufacturers might be interested in that case. Another important point is billing for LED lamp charging. Billing and payment must be accurate and transparent.

(3) **DC nano-grid and billing system:** There are some affluent families and business units that need constant power supply. Supplying electricity through DC nano-grid would be more meaningful in these occasions. Like LED lamp service, accurate and transparent billing and payment system is also necessary in this case. It is recommended to apply prepaid billing system. The users would pay in advance and the supply would be disconnected when the paid money will be finished.

(4) **e-Money management system:** e-Money service is an essential precondition for consuming e-Services. Therefore, a suitable e-Money service must be available. Existing e-Money services uses banks to convert physical cash to e-Money. Traditionally the poor people in the remote areas of the developing countries are unbanked. In our e-Money system, described in chapter 4, we assumed an entity to convert physical cash to e-Money. It is also assumed that the villagers would use this e-Money in the local market to purchase goods, transferring money from one user to another, and so on. The

local merchants also need receive cash in exchange of e-Money. The owner of the VIC would act as an agent for this service as well.

(5) **Networking and internet service:** All the computers in the VIC would be connected to the internet through a local area network. Internet service is not available in many of the remote villages. If internet service is available, the owner would subscribe that. If internet service is not available then the owner would connect the VIC to a DTN for internet service. The DTN arrangement is described in chapter 5.

(6) **Self-service kiosk:** It is assumed that one VIC would be established in one village. On an average, 700 families live in a village. It is important to reduce the workload of the person serving the villagers in the service delivery process. This would help reducing the cost of service delivery. Therefore, we considered self operated kiosks. The villagers would be helped, trained and later encouraged to use the kiosk independently. Apart from cost reduction, there are some services that need personal information to process. Villagers can conceal their personal information while consuming the service.

(7) **Scanning and printing facility:** This is an essential service for such facility. Besides it might help the owner to earn from an additional source.

The aforementioned services can be introduced from the first day of the VIC. Our experience from the pilot implementation of the VIC shows that the VIC becomes almost financially self-sustainable from the earning of these services. However, there should be an active support from the government to make the entrepreneur successful. A well-coordinated effort from the development organization, NGOs, and government can add more and more services useful for the poor people. Adding more services to the VICs would increase its self-sustainability. At the same time villagers would be able to enjoy easy and improved living.

In our work we demonstrated success of some e-Services with practical implementation. There are many more examples available among the research community. All these services

can be customized to apply in the concerned country. The already demonstrated successful services can make the VIC financially self-sustainable. We hope many more innovative services to be offered by private service providers and VICs would get more money.

7.4 Conclusion

The works described in this thesis intended to devise a complete end to end solution to deliver e-Services to the last mile people of the developing countries. We moved forward keeping our main focus unchanged. First we identified challenges to achieve the goal then devised appropriate solutions. Later based on the availability of fund, we implemented the solutions in Bangladesh through pilot projects. Pilot implementations gave us feedback from the real users directly.

We coordinated with the Government of Bangladesh and ASA, a large Bangladeshi NGO while implementing our pilot projects. Our works were highly appreciated by the concerned organizations. The government has already started establishing VIC. Although VICs established by the government is slightly different from our proposed VICs. Bangladesh government is introducing e-Government services gradually. In future we need to encourage corporates to introduce other services like e-Money.

Chapter 8

Conclusion

e-Services largely influence our daily life. Endless opportunities are being created for both the service providers and consumers. Service providers can serve more people with greater efficiency in lower cost. They can easily breach their physical boundaries by reaching large number of clients virtually. e-Services also allow the last mile people accessing the services on their doorstep without traveling hundreds of miles. The time and money saved can easily justify the additional cost of service consumption. In short they are consuming a better service in comparatively lower cost and shorter time.

In this thesis, we discussed socioeconomic condition of the last mile people in details. The experiments we conducted indicate that the demand for e-Services has already been created and it is possible to operate e-Services commercially. We also explained how e-Services could make the difference in the life of the last mile people. However, making the e-Services available to the last mile people still remains as a challenge. We wanted to address the challenges in 3 areas:

(1) Improving the existing technologies to provide infrastructural support to introduce e-Services.

(2) Identifying feasibility of introducing e-Services. In this regard we implemented some

essential e-Service in remote areas as a pilot project.

(3) Developing a suitable user interface for the majority of the last mile people (illiterate people) so that the services can be used by the users independently without the help of an intermediary.

8.1 Summery of contribution

Summery of contributions listed below.

8.1.1 Improving infrastructural support

e-Services are ICT based services. Users need ICT access devices like computer, smart phone etc. to consume the services. The last mile people cannot afford to buy personal ICT access devices for this purpose. It is more convenient for them to visit some shared ICT service access facility to consume the service. Whatever the case is, the ICT service access facility needs power supply to run the devices. In the present context of the developing countries, the remote villages are out of national electric power grid network. In absence of grid electricity, villagers depend on the alternate power sources from diesel electricity generator or solar electricity generation systems. However, using dedicated power sources for the ICT service access facility would increase the operating cost to a level beyond the affordability of the poor people.

In this regard our contribution was to introduce an innovative model for electricity distribution and usage. It also demonstrated a business model suitable for the target population. It was also found during pilot implementation period that it is possible to distribute electricity to the people at an affordable cost. For lighting the electricity cost was very close to that of kerosene lamp.

Another essential infrastructural facility required for e-Service delivery is data communication facility. Only option prevails in the remote areas is mobile phone internet service. We

conducted a survey in Bangladesh that indicates that the mobile phone internet service is not suitable for accessing online services. Besides, the data communication service networks do not cover most part of the remote areas in the developing countries. We proposed to use delay tolerant network (DTN) over vehicular network to transport data among the remote villages and the cities.

The public transportation system in the developing countries is not reliable. The public transportation vehicles rarely maintain any schedule. Therefore, data transportation over this vehicular network is also very unpredictable. Our contribution in this regard is to improve the data received acknowledge mechanism of the DTN bundle protocol using SMS service over GSM network.

8.1.2 Socioeconomical feasibility of e-Services

From the early days of the 21st century, when the cost of computers came down to the reach of common people in the developing countries, concerned governments and the international development agencies are working to introduce e-Services for the rural people. Some e-Government and e-Business services became successful to reach the critical mass. However, those services could not reach the last mile people mainly because of absence of infrastructural support and higher rate of illiteracy. Additionally last mile people also suffer from less ICT aptitude and exposure to the technological gadgets. Therefore, we intended to conduct some experiment with some e-Services for the last mile people to find out the feasibility of introducing e-Services for that target population.

Availability of e-Money system is an essential precondition to introduce e-Services among the target population. In general situation we use bankcards (credit/debit cards) to pay the cost of the service. The poor people living in the remote areas of the developing countries are unbanked. In many cases, their financial worth does not allows banks to offer financial services to them. Therefore, the existing e-Money systems are unable to incorporate the poor people

within their network.

The main contribution in this regard is to develop an e-Money service platform especially suitable for the poor people living in the developing countries. The service was designed based on the requirements collected from the target population. The service offers a number of financial services required by the poor people. Therefore, the infrastructural overhead is divided among all the services to reduce the ultimate cost of individual service delivery.

8.1.3 Suitable user interface for illiterate people

Existing e-Services offered to the last mile people are designed in such a way that the end users would receive the service via a service delivery agent. For instance, to use mobile banking service, the users need to give all necessary information to an agent. The agent would do the formalities on behalf of the user. Finally the user would receive a confirmation SMS. The main reason behind this is the belief that the illiterate people (many of the poor people are functionally illiterate) will not be able to use the service properly. This is true because the systems developed are not friendly enough for the poor illiterate people.

Involving a service delivery agent increase the cost of service delivery. Additionally the users feel uncomfortable to share confidential and private information with the service delivery agent. Therefore, only very generic services can be offered in this process. The services like e-Learning, bulletin board, etc. which does not carry any direct financial benefit, can not justify the cost of service delivery agent. Therefore, we intended to develop a user interface that the illiterate people can use successfully. In this regard, our main contribution is adding some innovative improvements of the proposals already made by previous researchers, that makes to the user interface perform distinctly better.

8.2 Social impact

Successful implementation of the research findings of our works would change the lives of the last mile people in some aspects. People would be able to acquire knowledge using internet and use the same to improve their farming techniques, cultivate diversified crops and plant to increase their earning, getting better price for their produces, and many more. Possible social impact of each of the research is mentioned below:

(1) **Power Solution:** The proposed business model and usage demonstrated in our work can allow the poor villagers to use quality lighting in their home at night with spending the same amount of money. Kerosene lamps generate carbon dust and carbon-mono-oxide. Living in a closed room with a lighting kerosene lamp from the infancy cause people suffering from chronic lungs disease and reading in insufficient light create vision problem. Therefor the findings would help last mile people save money and live healthy.

(2) **e-Money system:** We found the proposed e-Money solution works in a remote village in Bangladesh. It would eliminate the risk of carrying physical cash. Last mile people would be able to manage their financial life better. It would help governments to include the unbanked people within the banking network. Using this system, the villagers would be able pay service charges needed to consume different e-Services offered for them.

(3) **Data Communication:** Some e-Services become very popular. These services are adding real values to the users. e-Government service Boomi introduced by Indian state of Karnataka, e-Commerce service e-Choupal introduced by Indian conglomerate ITC Limited are some appropriate examples in this regard . However, these services are not being able to extend up to the last mile just because of unavailability of suitable data communication infrastructure. Our proposed DTN based arrangement may solve the problem and allow the service provider to reach the last mile people.

(4) **e-Learning system:** Availability of quality doctor in the remote areas is a challenge for the whole world. The developed e-Learning system and the guidance about the user interface would facilitate creating systems related to primary and preventive healthcare. Additionally the e-Learning system can be used to deliver knowledge and information to the last mile people and empower them. The information would allow them to look for alternative earning sources, learning how to raise a child, necessity of balanced healthy food and how to arrange that within their limited earning, and many more.

8.3 Future works

The data communication facility is not tested through any pilot implementation. Therefore, the feedback from the actual uses could not be received. It is necessary to implement the concept to identify the challenges.

It is necessary to have Village ICT-access Center (VIC), a shared ICT service access facility, throughout the country to get the benefits from our works. Presently Bangladesh government is working to create public facilities in this regard. We need to convince the government to encourage private entrepreneurs to establish such facilities to run on commercial basis. Privatization of such facilities would create competition and encourage innovation. Additionally government owned facilities are less flexible to respond to dynamically changed situations and lacks from innovative initiatives of diversification.

Getting full benefit from our works depends on introduction of new e-services in regular basis. Availability of more services would share the cost of infrastructural overhead and therefore, reduce the ultimate cost of service consumption. e-Money service remains at the core of all services. The e-Money service that we proposed in our work is a prepaid e-Money applicable within a predefined closed network. For most of the countries this type of e-Money does not need any regulatory control. In this system, e-Money is issued against equivalent amount

of physical cash. The situation might be different in some countries though. These regulatory issues are not considered in our works. In future the regulatory issues need to be taken care of before implementation of the concepts and findings.

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Dedication

I dedicate this thesis to my mother, Ms. Ferdous Ara Rahman, (1937-2012). It was her desire and inspiration that drove me to enroll for my doctoral degree. I feel proud to fulfill her last desire to me.

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