

Feasibility Analysis of 4G Wireless Technology in Ubiquitous m-Health System in Bangladesh

N. Sultana, M. A. Islam, and N. Ullah

Abstract—In this paper current 2G m-health system and its services and limitations in Bangladesh have been studied. Then the feasibility of the adaptation of newly emerged technology 4G especially WiMAX has been studied. Most of the population of Bangladesh is live in country side and aging problem becomes prominent day by day. 85% lands are affected with flood in frequent years. Still now the communication system is also very poor in rural remote area. The survey and study show that most of the medical facilities are urban concentrated. By expanding WiMAX services with video conferencing helps people to contact with experts in a moment but mental satisfaction not so good. Also the cost for compatible mobile phone set is high and to operate it with lacking of IT knowledge also faces difficulties. So, we find a near Pharmacy and Mobile charging point solution which shows cost effective and better IT expert solution.

Index Terms—Aged people, flood, lack of IT knowledge, m-health, per capita income, WiMAX.

I. INTRODUCTION

The central focus was the information infrastructure and ongoing use of ICT in the health sector of Bangladesh. Bangladesh is one of such overpopulated countries in the world; where the physician patient ratio is 1:4719. Population is over 150 million, Rural population is 77%, Population density – 881 square kilometers (340 sq mi), People below poverty line – 60%, Population doubling rate – 25–30 years, Per capita GDP – Tk. 18,896.

No. of Various types of district level hospitals 80, Government medical college hospitals are 13, Postgraduate hospitals are 6, specialized hospitals are 25, Doctor to population ratio is 1:4,719, Nurse to population ratio is 1:8,226 and No. of Hospital beds – 40,773 (over 29,000 in GOB) [1].

The above statistics shows that even though the population of Bangladesh is concentrated in the villages and small towns, the medical services in those areas are far from sufficient. To consult a specialist doctor, the people of rural areas have no choice but to travel to large cities, spend money and crucial time on transportation. Many times due to poor conditions of roads and traffic the patients are unable to meet the concerned doctor on the day of appointment.

On the other hand, during severe floods the affected area may exceed 75% of the country, as was seen in 1998. This volume is 95% of the total annual inflow. The floods have caused devastation in Bangladesh throughout history, especially during the years 1966, 1987, 1988 and 1998. The 2007 South Asian floods also affected a large portion of Bangladesh. Therefore, m-health seems to be the best option for providing best health care facilities using maximum utilization of limited resource.

II. LITURATURE SURVEY

A. Bangladesh

TRCL (Telemedicine Reference Center Ltd.) demonstrated successful medical call center system using mobile phone infrastructure and text messaging systems in 2005. After that one of the pioneer mobile phone operator, Grameenphone Ltd., launched Health line - the first medical call center manned by licensed physician jointly with Grameenphone GSM Network. In 2009, TRCL has celebrated successful completion of 1st decade in Telemedicine, e-Health and m-health businesses. At the end of the year 2009, TRCL launched chronic disease management system under "AMCARE" brand in Bangladesh. In first phase, TRCL Diabetes Patient Management System (DPMS) and Mobile Applications were introduced. In following years, TRCL launched pilot scheme in collaboration with ICDDRB and JHSPH funded by DFID (UK) to include village (traditional) doctors under medical call center system of TRCL. TRCL also launched medical call center service in Singapore for Bangladeshi expatriates [2].

B. Abroad

The authors in [3] give a snapshot of recent developments in these areas and address some of the challenges and future implementation issues from the m-health perspective. They defined m-health as “mobile computing, medical sensor, and communications technologies for health-care.” This emerging concept represents the evolution of e-health systems from traditional desktop “Telemedicine” platforms to wireless and mobile configurations. In [4], they demonstrate a Teletrauma system which enables the virtual presence of Trauma specialist to remote area to ensure prehospital care by getting the required patient’s video, medical images and ECG through commercially available 3G mobile data service. To overcome the bandwidth constraint they applied data priority, application level quantization control, media transformation etc. An e-emergency systems, including the wireless technologies used, as well as the data transmitted (electronic

Manuscript received December 12, 2014; revised March 20, 2015.

F. N. Sultana and S. M. A. Islam are with the Electronics & Telecommunication Engineering, Daffodil International University, Bangladesh (e-mail: apesnajnin@daffodilvarsity.edu.bd, md.tanin@gmail.com).

T. N Ullah is with the Higher Education Department Khyber Pakhtunkhwa, Pakistan (e-mail: niamatnaz@gmail.com).

patient record, bio-signals, medical images and video, subject video, and other) [5]. Many researches are made on the driving force for the advancement of m-health solutions [6]. The research method is based on literature research, market scan and analysis. The paper concluded in suggesting the most critical factor for the success of m-health. Recently a m-Health solution with 3G Technology has been present in [7]. In our another paper, we have made an feasibility analysis of 3G Technology in m-Health in a developing lower income country like Bangladesh [8].

C. Our Work Plan

In Bangladesh, WiMAX data services have been launched in 2011. So, we propose a modified infrastructure with WiMAX mobile technology for m-health system. At first in Sections III and IV we make study on m-health scenario and the existing technology used in m-health system in Bangladesh and the limitations of these technologies. Section V describes the features of WiMAX Mobile Technology. In Section VI, we propose our own m-health infrastructure model. The feasibility test of this new higher data rate service, WiMAX system in the present m-health infrastructure has been made. Also a thorough analysis on per capita income and IT expertise of general people of developing country like Bangladesh has been studied. Section VII shows some experimental results. Finally, Section VIII concludes the paper.

III. M-HEALTH

The m-health field has emerged as a sub-segment of e-health, the use of information and communication technology (ICT), such as computers, mobile phones, communications satellite, patient monitors, etc., for health services and information. A concept is shown in Fig.1.

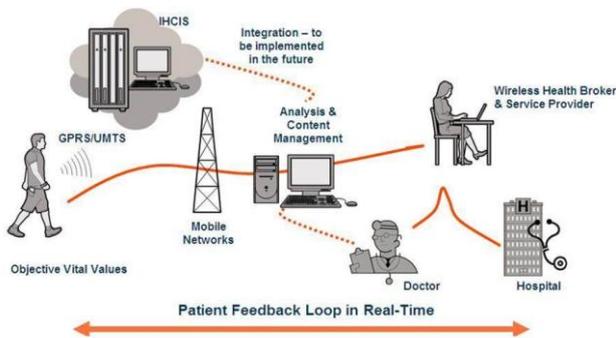


Fig. 1. M-health system.

M-health offers the ability of remote individuals to participate in the health care value matrix, which may not have been possible in the past. In many cases remote users are valuable contributors to gather data regarding disease and public health concerns such as outdoor pollution, drugs and violence.

The motivations behind the development of the m-Health field are twofold. The first one is many constraints faced by healthcare systems of developing nations. These constraints include dense population, a high burden of disease prevalence, urban concentrated low health care system, and large numbers

of rural inhabitants, and limited financial resources to support healthcare infrastructure and health information systems. Second one is the recent rapid rise in mobile phone penetration in developing countries [9]. With greater access to mobile phones to all segments of a country, including rural areas, the potential of lowering information and transaction costs in order to deliver healthcare improves. Previously, GPRS with 171 kbps, EDGE of 384 kbps [10], and also GPS systems are used in m-health system in many developed countries. M-health services are ensured with Video Conferencing, Phone Call, SMS, Web-based Database etc.

IV. SURVEY REPORT

At first we study the Health Policy of Bangladesh from the official Website of Health Ministry of Bangladesh. According to the Policy report, Government has already taken steps about e-Health service for 1030 health complex in Bangladesh [3]. But in practice, when 2nd author has visited few health complexes and union health community clinics in various districts, and taken interviews of the medical in charge of those hospitals, the real scenario has found different. Due to lack of awareness the project work is slowing down, no e-Health services or telemedicine infrastructures are available in those hospitals or health complexes. Only 2.7G m-health is the existing service. There is only one emergency number or help line for every health complex. The Government provides this service by using existing GSM mobile Networks of Grameenphone operator. Here we would like to describe our visiting report:

We visited 8 upazilla hospitals (Shibpur, Belabo, Palash, Gouripur, Gazipur, Mymensing) and 6 union community clinics in different districts of Narshingdi, Gazipur, Comilla, Manikgonj, Barisal, and Maymensing. The visited unions are Shibpur (Chakrada, Masimpur), Monohordi (Bilsoron), Daudkandi (Maligoan, Solpo), Aricha(Aiubpur). From Barisal and Manikgonj, we collected the information about m-health service over phone through our friends.

Summary of The Findings

Table I summarizes the findings.

V. WiMAX DATA SERVICES

The IEEE standard for WiMAX is 802.16. Data Rate is from 500kbps to 2 Mbps. It has both Fixed and mobile broadband wireless access system, it uses OFDM, OFDMA, Single Carrier, Mesh Topology, ARQ, operating frequency range is 2-11 GHz (NLOS), 10-66 GHz (LOS), IP-based service [11].

WiMAX offers different kinds of services for health system: VoIP – consultancy with expertise, Real-time video stream – ECG, EEG, video conferencing, File Transfer – Patient Database, Disease History, Web Traffic – Hospital Info, Booking facilities, Doctor Appointment, Online Consultancy through modem internet etc.

The Prerequisites for WiMAX are a cellular architecture similar to that of mobile phone systems with a central base station and controlling downlink/uplink traffic.

In Bangladesh, 3.5 GHz band is used for WiMAX. At first two operators launched it, one is Banglalion which has 84,000 subscribers, has got LTE (4G) permission in 2013, another one is Qubee, has 31,000 subscribers, also have got LTE (4G) permission in 2013 [12], [13]. Later on another company ‘Wolo’ launched WiMAX.

TABLE I: SURVEY REPORT ON 2G M-HEALTH SYSTEM

Existing Services	Service Provided	Mobile Generation	Call Number	Service Duration
m-Health	<ul style="list-style-type: none"> • Patient communicates with doctor by mobile phone. • Every health complexes or community clinic has a call number through which patients contact with doctors. • Only voice call service exists, no video call or video conferencing exist there. 	7G GSM Network, Grameen phone	Shibpur Upazila Health Complex(01 730324538)	24 hours
Limitations: This service is not useful for patient. Because <ul style="list-style-type: none"> • Doctor don't be able to serve proper treatment or can't give any advice about the therapy or medicine without eye/direct observation of the situation of patient. • No video call service or video conferencing facilities with 2G wireless system. • In rural area the network connection condition (availability) is too poor. So, to get proper treatment, patients must come in the hospital. • The patient can't describe his/her situation properly due to lack of knowledge. 				
Health Line	<ul style="list-style-type: none"> • Interactive teleconference between a Grameenphone mobile user and a licensed physician, available round the clock • Only remote voice emergency counseling service exists, no other kind of health services like as text service, fax services, video conferencing and so on are available 	2.7G GSM Network, Grameen phone	on emergency, non-emergency or regular medical situation by just dialing "789".	24 Hours
Limitations: <ul style="list-style-type: none"> • Only available to Grameenphone mobile phone subscribers, which number about 20 million in Bangladesh. • The call charge is so high (about \$0.21/ Tk 15 per call (call duration = 3 min fixed)). • Only one GP call center is assigned for this service which is placed in Dhaka. 				

VI. PROPOSED MODEL

The latest high speed mobile phone service, WiMAX, offers us a ubiquitous opportunity to upgrade the m-health

systems in Bangladesh. Recent years the whole Bangladesh telecommunication core infrastructures e.g. backbones are upgraded with high speed optical fiber E1 and STM 4 services through SEA-ME-WE-4. In 2016, Bangladesh will connect with SEA-ME-WE-5 which provides 1400Gbytes data speed [14]. So, we propose the entire arrangement of m-health infrastructure of Bangladesh as in Fig. 2.

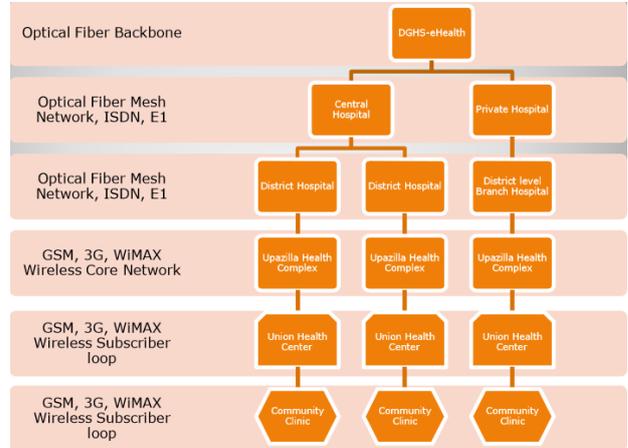


Fig. 2. Proposed block diagram of m-health system in Bangladesh.

The total m-health service frameworks can be described as in Fig. 3.



Fig. 3. Proposed service framework in m-health system.

We need to create central database of the disease history and drug history of patient during conversation between doctor and patients over phone. It will be helpful for future reference of this patient. For that we can use National ID No. for tracking. And to get a smooth service again we need higher bandwidth which can be provided by WiMAX technology.

A. Coverage Area

In Bangladesh, there are thirty thousand tours exist in total of all operators like 3G, WiMAX, T&T etc.

Comparison of WiMAX coverage area in Bangladesh between Banglalion and Qubee, Banglalion WiMAX coverage area is better than Qubee. Banglalion has already covered all metropolitan area of every division and in the district level, they covered 40 plus districts. On the other hand, Qubee could not reach in every division of Bangladesh. Fig. 4 shows the scenario.

Using WiMAX services, we can make video conferencing experts from different hospitals about any crucial situation of any patients through Skype or VoIP. Again, doctor can check

the physical conditions of the patients through video. He can record the patient's case history, age, and location etc. in central Hospital database against the National ID No. of the patient and also against mobile no. for future reference. Also, He can suggest drugs by observing the situation of the patients. In other side, the remote rural patient can also buy drugs by ordering to the Pharmacy over phone, or by sending the prescription through FAX or e-mail or MMS and pay money by mobile banking (e.g Dutch-Bangla Mobile Banking), or through service like that BKash, MCash, UCash. The total proposed service categories are shown in Fig. 2. In addition, the information about expert doctors, medical facilities, drugs and pharmacies, and also information on diagnostics, test reports can be found through MMS.

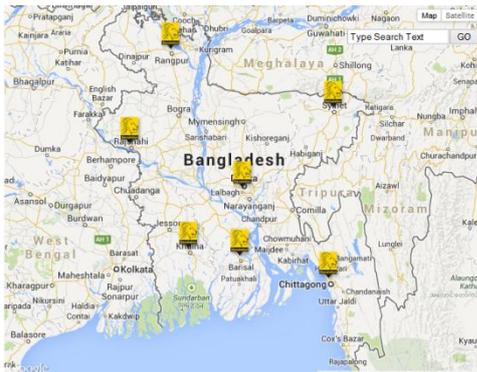


Fig. 4. Banglalion coverage area in Bangladesh.

B. Cost Analysis

It is well known that with increasing data rates and facilities, the price of technology is also increased. So, we need to test feasibility of these new technologies while the per capita income of peoples of Bangladesh not so high.

Tables II, III show different costs for WiMAX modems and services.

TABLE II: COST OF MODEM OF WiMAX

Operator	Prepaid cost	Postpaid cost
Banglalion	Tk 2499	Tk 1999
Qubee	Tk 2500	Tk 2000

TABLE III: WiMAX PACKAGE COST

Operator	Speed	Cost	Data Limit	Validity
Banglalion	512Kbps Or 1Mbps	Tk 150	600MB	10 Days
		Tk 400	2.5GB	30 Days
		Tk 699	5GB	30 Days
Qubee	512Kbps 1Mbps	Tk 1000	10GB	30Days
		Tk 500	2GB	
		Tk 1000	4GB	

C. Per Capita Income in Bangladesh

From the report of Bangladesh Bureau of Statistics, in September 2013 the per capita income of Bangladesh reached up to 1044\$ that means 81,432 Tk. But the crucial truth is that, for villagers this amount is far less than 1044\$. Now this is the main considerable point whether these kinds of High data rate services of WiMAX and advanced featured mobile phones with high cost is feasible for the rural remote people or not. Because for individual people, illness or disaster case is not

frequently occur. So, for the whole year they don't need this kind of High Tech Mobile set. So, it's not a cost effective solution. By spent of money only a small portion of rich villagers can get facilities of m-health services or they can stay with only 2G m-health services.

VII. EXPERIMENTAL RESULTS

Banglalion has more than 2 Lakh subscribers in urban areas while the total wireless mobile subscribers in our country are about 115 million. So, there is a big opportunity to enhance the m-health system in our country by using this 4G technology. The coverage area will be increased day by day. The main problem is cost. To get the high data rate audio, video services we need to change our mobile phone set. The price of such mobile set starts from 7,000 Tk upto 60,000 Tk (iPhone5, Samsung S5). Price depends on available features and manufacturing quality of mobile set. Again, the cost of WiMAX modem starts from 2,000 Tk for postpaid and 2,500 Tk for prepaid connection which is shown in Table III. It doesn't depend on company. All kinds of modem from all service provider companies have same qualities and performances.

Using WiMAX services, we can make video conferencing experts from different hospitals about any crucial situation of any patients through Skype or VoIP. Again, doctor can check the physical conditions of the patients through video. He can record the patient's case history, age, and location etc. in central Hospital database against the National ID No. of the patient and also against mobile no. for future reference. Also, He can suggest drugs by observing the situation of the patients. In other side, the remote rural patient can also buy drugs by ordering to the Pharmacy over phone, or by sending the prescription through FAX or e-mail or MMS and pay money by mobile banking (e.g Dutch-Bangla Mobile Banking), or through service like that BKash, MCash, UCash. The total proposed service categories are shown in Table II. In addition, the information about expert doctors, medical facilities, drugs and pharmacies, and also information on diagnostics, test reports can be found through MMS. The cost of WiMAX is very reasonable. The minimum monthly data package of 512 kbps or 1 Mbps is 400 Tk excluding VAT.

Now, we would like to compare the performance of WiMAX with 2.7G during image and video transmission.

A. Analysis of Upload Speeds of 2.7G and WiMAX for 2 MB File Size Image

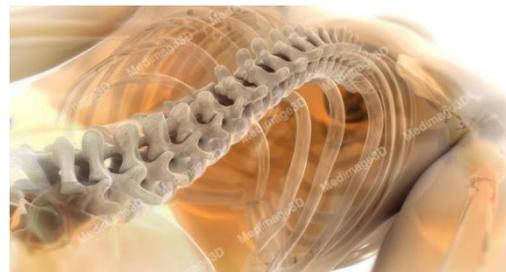


Fig. 5. Example image of human chest.

In our country network operator like Banglalion WiMAX provides shared bandwidth which is very limited for smooth

voice call transmission. Sometimes the assigned bandwidth goes to below standard and it also varies in different zones like urban area and rural area. So, for smooth voice and also video transmission, the performance may be worse.

We took an example image of 2 MB file size.

We have observed that the required transmission time for a patient's E.C.G. or X-ray report image file of 2 MB is about 2s for 3G, 1s for WiMAX while 2.7G needs 7s (Table IV).

TABLE IV: IMAGE ANALYSIS BY 2.7G AND 4G TECHNOLOGY

Generation	Data Speed	Average upload speed	Uploading Time for 2MB Image file
2.7G	320Kbps	30KB	7s
4G	1024Kbps	110KB	2s

Due to shared Bandwidth, although 2.7G has GPRS, EDGE services but it can't be used in community clinics. In addition, the special m-health voice call rate is fixed of 15Tk/3 min. But the normal 2.7G voice call rate is around 1 Tk/ min. So, this emergency service is too much costly for the inhabitants of rural areas with lower income.

B. Analysis of Transmission Speeds of 2.7G and WiMAX for Videoconferencing

For experiment, we took picture of patient comes to near Pharmacy to get proposed m-health service. For video performance analysis of 2.7G, and 4G WiMAX, we recorded two videos of 2 minutes duration using internet connection of two modems of two different generations of mobile technology. Fig. 6 and Fig. 7 show the visual quality of those videos.

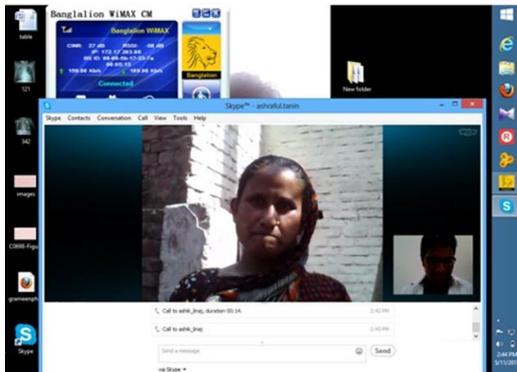


Fig. 6. Patient communicates with doctor through Skype by Wi-MAX modem.



Fig. 7. Patient communicates with doctor through Skype by Citycell 2.7G modem.

By using 2.7G modem, it was very difficult to establish a video call because the Bandwidth and data rate of 2.7G Network is very low. And also the network was disconnected

many times during the conversation. And also due to slower data streaming, it takes much time to buffering, so the video stream was stopped for few moments.

With WiMAX modem, the video streaming was very fast and clear, but to make a near connection we need to try two to three times. After successful connection once, there was no interruption during conversation of 2 minutes. In addition, during video call over WiMAX for far distance (Bogra to Dhaka), the connection was interrupted for one time.

A patient can use Skype or VoIP through smart phone. But in doctor's end it is good to see the full screen image of patient. If we use USB PC connection for mobile image or video, the full screen image seems to be faded due to lower resolution. But with modem, doctors can get clearer image of patient.

But at the end of all discussion is that in terms of individual users especially for villagers, this kind of high-cost mobile phone set and high cost infrequent services are not feasible. Again, for the uneducated or less educated rural people, it is difficult to handle such kind of high-Tech devices and operations. So, Mobile Recharge Service Points and/or the Local Pharmacy can be best alternate for providing these services of video call, FAX, emailing, MMS as their extra business, then it will be more helpful and efficient service for the rural poor people. Before that, we need to train up those remote service providers properly by every hospital or community clinics in cooperation with mobile operators.

VIII. CONCLUSION

2.7G is now in every district, Upazila, Thana etc. Bangladesh is going to be connected with higher data rate services of 1400Gbps. But after observing the present coverage area and different prices of 2G, and WiMAX modem; different WiMAX data packages, long distance network connection quality, we can conclude that for individual rural people it is not feasible to take the advanced m-health service. Although the per capita income of Bangladesh crosses the 1000\$, exactly 1044\$ or 81432 Tk but the real income of rural people is much less than that. So, if Government and mobile operators take proper initiative through Mobile Recharge Point and/or Local Pharmacy and with the help of mobile banking for payment then it is not so far when a patient in remote places will consult the doctors through m-health system. Especially in disaster case, it would become a very prominent health consultancy medium for remote victim patients.

REFERENCES

- [1] D. Wright, "Telemedicine and developing countries, A report of study group 2 of the ITU development sector," *J Telemedicine Telecare*, no. 4, pp. 1-85, 1998.
- [2] R. S. H. Istepanian and Jovanov, "Guest editorial introduction to the special section on m-health: Beyond seamless mobility and global wireless health-care connectivity," *IEEE Transactions on Information Technology in Biomedicine*, vol. 8, issue 4, pp. 405-415, December 2004.
- [3] Y. Chu and A. Ganz, "A mobile teletrauma system using 3G networks," *IEEE Transactions on Information Technology in Biomedicine*, vol. 8, issue 4, pp- 456-462, December 2004.
- [4] E Kyriacou, "M-health e-emergency systems: Current status and future directions [Wireless corner]," *IEEE Antennas and Propagation Magazine*, vol. 49, issue 1, pp. 216-231, 2007.

- [5] P. Yu and H. Yu, "The challenges for the adoption of m-health," *IEEE International Conference on Service Operations and Logistics, and Informatics*, pp. 181-186, 2006.
- [6] M. A. Islam and M. N. Sultana, "Ubiquitous future m-health system including wireless 3G technologies in Bangladesh," presented at International Conference on Applications and Innovations in Mobile Computing (AIMoC), February, 2015.
- [7] A. Nessa, M. A. Ameen, and S. Ullah, "Applicability of telemedicine in Bangladesh: current status and future prospects," in *Proc. Third International Conference on Convergence and Hybrid Information Technology*, pp. 948-953, 2008.
- [8] N. Ullah, P. Khan, N. Sultana, and K. S. Kwak, "A telemedicine network model for health applications in Pakistan: Current status and future prospects," *International Journal of Digital Content Technology and Its Applications*, vol. 3, no. 3, pp. 149-155, September 2009.
- [9] WHO, *The Global Burden of Disease 2004 Update*, 2008.
- [10] A. K. Mogal, "Wireless mobile communication - A study of 3G," *Int. J. Advanced Networking and Applications Technology*, vol. 3, issue 5, pp. 1-6, 2012.
- [11] K. Etemad and M. Y. Lai, "WiMAX technology and network evolution," *WiMAX Standards*, Wiley-IEEE Press, 2011, ch. 1.
- [12] Banglalion WiMAX Package. (2014). [Online]. Available: <https://www.facebook.com/BanglalionWiMAX.bd>
- [13] Qubee WiMAX Package. (2014). [Online]. Available: <http://www.qubee.com.bd/our-solutions/monthly-package/>
- [14] SEA-ME-WE. (2012-2013). Annual report. *Bangladesh Submarine Cable Company Limited*. [Online]. Available: <http://www.bscc.com/>



M. N. Sultana is from Bangladesh. She completed her B.Sc. (4 years Hons') and her MS in applied physics and electronics from University of Dhaka, Bangladesh. Now, she is doing her Ph.D., majoring in IT & telecommunication engineering at Inha University, South Korea under the supervision of professor Kyung Sup Kwak.

She got Government Scholarship from the very beginning of the Elementary School upto MS due to her excellent academic results. She also got Talent Pull Scholarship in Eight Class, Board Scholarship for S.S.C. and H.S.C Examinations' results and University

Talent pull Scholarship for Hons' Scholarship. In addition, she got Jungseok Memory Scholarship for Ph.D. Program, sponsored by Inha University. Very recently she has got Fellowship under Polish National Commission for UNESCO for attending one month fellowship program including UCTE 2014. She is also an assistant professor in Electronics and Telecommunication Engineering Department of Daffodil International University, Bangladesh. She has three journals and three international conference publications and one book chapter. The book name is "Modeling, Simulation and Identifications", and chapter name is "Network and System Simulation Tools for Next Generation Networks". Her research interest is vehicular wireless communications, energy saving LTE-MIMO feedback, smart eTax, eVAT system, telemedicine, m-health etc.



M. A. Islam is from Bangladesh. He completed his B.Sc. in electronics and telecommunication engineering from Daffodil International University. He did thesis work under the supervision of Mst. Najnin Sultana. Now he is doing job in an ISP provider company.



N. Ullah is from Pakistan. He received his B.Sc. in mathematics in 1994 from Peshawar University and his master in computer sciences in 1996 from Quaid-e-Azam University Islamabad, Pakistan. He then joined the Higher Education Department Khyber Pakhtunkhwa as a lecturer.

Recently, he got Ph.D. degree from Graduate School of IT and Telecommunications at Inha University, Incheon, South Korea. His research area includes wireless ad Hoc networks, directional and smart antenna, wireless sensor networks, and MAC protocol for wireless body area networks.