Ubiquitous future M-Health system including wireless 3G technologies in Bangladesh

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Abstract—The study is based on 3G feasibility in the M-Healthcare system. It also addresses the aging problem, which becomes severe day by day. At first, a survey was conducted by visiting eight upazilla hospitals and six union community clinics in different districts of Bangladesh to observe the real scenario of the m-Health system and used technologies. Both remote monitoring and interactive service mode of the m-Health system were examined there. In addition, by interviewing the patients who already got services through the 2G m-Health system, we found out the practical lacking and limitations of the present infrastructures. After that, we proposed a modified health infrastructure using 3G in remote and Optical Fiber in the backbone side with a wide range of services like video conferencing through VoIP and Skype, M.M.S. diagnostic reports, drug prescriptions, mobile purchase, and home delivery, etc. Analysis shows that 3G needs less transmission time than 4s for medical image upload and transmit. The interactive video visual quality is also better than the existing m-Health service based on 2.7G, monitoring vital signals like E.C.G. signal, heart rate, bone fracture, etc. The feasibility test shows that huge initial costs and poor I.C.T. healthcare professionals make a barrier to a ubiquitous m-Health system. Moreover, the handling of the Hi-tech devices comfortably by villagers also puts a barrier to the smooth running of the system.

ongoing use of I.C.T. in the health sector of Bangladesh. In 2009, TRCL (Telemedicine Reference Center Ltd.) has

I.   INTRODUCTION

Bangladesh is one of the overpopulated countries in the world; where the physician-patient ratio is 1:4719. This study explores the condition of information infrastructures, current situation of Telemedicine and future opportunities of Telemedicine in Bangladesh. The central focus was the information infrastructure and

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celebrated successful completion of 1st decade in Telemedicine, e-Health and m-Health businesses [1].

The distribution of health infrastructures in Bangladesh can be divided into different tiers, viz, National, Divisional, District, Upazila (sub-district), Union, Ward and Village levels. In each district, there is a district hospital. There is a 31 to 50- bed hospital in every upazila (sub-district) level. At the union level, one of the three kinds of health facilities may exist. In the union health

facility, there is a post of medical doctor. All union facilities possess medical assistants to provide health service tothe people. At the ward level, community clinics (CC), one for every 6,000 people, are being established. Rural population in Bangladesh is 77%, population density–881 square kilometers (340 sq mi), people below poverty line–60%, population doubling rate–25–30 years, per capita G.D.P.–Tk. 18,896,no. of various types of district level hospitals is 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 is 40,773 (over 29,000 in G.O.B.) [2]. The above statistics show that even though the population of Bangladesh is concentrated in the villages and small towns, the medical services in those areas are far from being 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. Most of the time due to poor conditions of roads and traffic, the patients are unable to meet the concerned doctor on the day of appointment. During emergencies, it is more difficult to communicate with towns. So, Bangladesh made a step towards m-Health system.

Our existing 2G based m-Health system is not so popular. Because of lower data rate, even with EDGE technology, the users are unable to send clear image of diagnosis report, and to get prescription through SMS/MMS from doctor. Our survey shows that only voice call is the available service of m-Health system. Again we, the authors of this paper, try to video call and have video conference with doctors. But, with the 2G connection, due to bandwidth limitations video call is disconnected many times because of a weak network and we are unable to have video conference.

So, only by listening to some points from the patient, it is not possible to prescribe appropriate drugs to the patient. [4] also analyzed the resolution problem of network camera while observing the micro-expressions through camera by a psychologist claim. So, we tried to switch from 2G to 3G mobile Networks to get smoother connection and higher data rate for clear picture of diagnostics reports. From [4], the weak digital signals from cellular phone may not be able to reach cell tower. This difficulty is pronounced at higher frequency in 2G system. Again, digital delay curve is a steppy one. So, under good conditions, digital signal sounds better than analog, but for worst situation, the digital has occasional dropout.

In Bangladesh, 3G was launched in 2013. So, we propose a modified infrastructure with higher generation wireless mobile technology for m-Health system. At first we studied literatures about m-Health in section II. Then we developed anotherstudy on m-Health scenario in section III. Then in section IV we described 3G higher data rates schemes. A survey was made in V to observe the existing technology used in m-Health system and the limitations of these technologies. Our modified infrastructure model is shown in section VI. Finally, a thorough analysis on ability of general people of developing country like Bangladesh to handle the Hi-Tech Health facility is studied in section VII. Section VIII concludes the paper.

II.   LITERATURE REVIEW

The authors [5] 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. [6] demonstrate a Teletrauma system which applies data priority, quantization control to enable the smooth virtual presence of Trauma specialist in theremote areas by getting the required patient's video and medical images through 3G mobile data service. An e-emergency system, includesthe wireless technologies used as well as the data transmitted (electronic patient record, bio-signals, medical images and video [7].

III.   M-HEALTH

A.   Motivation of M-Health

The motivation behind the development of the m-Health field arises from two factors. The first factor concerns the myriad constraints felt by healthcare systems of developing nations. These constraints include high population growth, a high burden of disease prevalence, low health care workforce, large numbers of rural inhabitants, and limited financial resources to support healthcare infrastructure and health information systems. The second factor is the recent rapid rise in mobile phone penetration in developing countries to large segments of the healthcare workforce as well as the population of a country as a whole. With greater access to mobile phones for all segments of a country, including rural areas, the potential of lowering information and transaction costs in order to deliver healthcare has improved [8]. Technique;

MIMO antennas, enhanced multimedia service (M.M.S.); Security Enhancement, WLAN/WWAN internetworking, Broadcast/ Multicast services; Enhanced I.M.S., I.P. emergency Call, Many more management features [9].
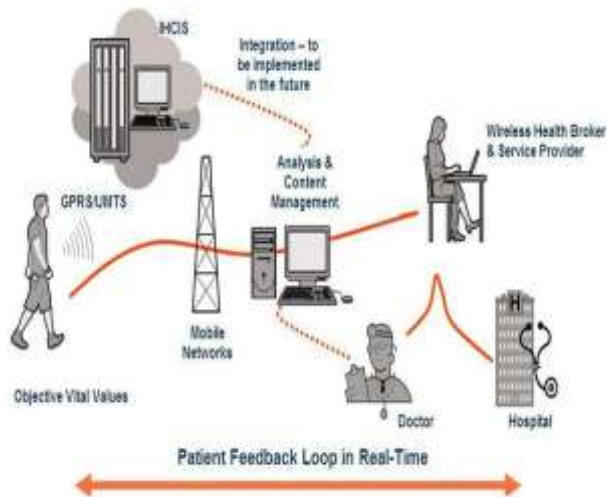

Fig. 1: m-Health.

B. *Previously Used Technology*

- E-mail, FAX, ISDN, GSM with GPRS, EDGE, SMS, Satellite
- Geographical Information System (G.I.S.) using G.P.S.
- Data rate up to 171 kbps with GPRS
- Data Rate up to 384 kbps with EDGE, starts with I.P. based service
- Video Conferencing, Phone Call, SMS, Web-based Database

C. *3G Wireless Mobile System*

In 1992, I.T.U. defined 230 MHz B.W. in 2 GHz for I.M.T. 2000 System – universal coverage enabling terminals to have seamless roaming across multiple networks.
Technology developed by 3GPP for 3G are Smooth Migration from GSM, Service Area overlays with existing 2G System, Ingrates IP-based multimedia services (I.M.S.) by using S.I.P. protocol. Two services are there:
IMTDS: WCDMA based UMTS Terrestrial Radio Access Network (UTRAN); connected to GSM-UMTS core Network using multi-vendor Interface.
HSDPA: High Speed Downlink Packet Access, Data Rate – 8 to 10 Mbps; using Adaptive Multi-rate Coding (A.M.R.)

D. *Launching 3G Mobile System in Bangladesh*

There are several mobile operators in Bangladesh.
Grameenphone Ltd. launched 3.9G (HSPA +), Data Rate Packages upto 512 kbps and 1 Mbps, around 46 million subscribers, to enable the users get access to the 1600 service points that cover almost all upazila with 94 Grameenphone Centers operating over there. Banglalink Digital Communication Ltd. launched 3G, HSPA+, around 28 million subscribers, 27 Customer Care centers, call centers and service points in every Thana for user support. Robi Axiata Ltd launched 3.5G HSPA with available Date Rate Package of 1- 3 Mbps around 25 million subscribers, 19 Customer Care Centers, 200 + touch points for user support. Teletalk BD Ltd. launched 3G, more variety of Data Rate Packages of 256 kbps, 512 kbps, 1 Mbps, 2 Mbps, 4 Mbps around 2 million subscribers over there, 40 Customer Care Centers and Call Centers for technical help.

E. *Characteristics of 3G Mobile System*

The important features of 3G Mobile System are higher capacity and noiseless voice coummunication, high-speed internet and wireless application protocol, video calling, mobile T.V., mobile music, enhanced video and audio streaming, video conferencing, M-commerce, localization-based services, messaging services, convergence, universal roaming and all sorts of multimedia services.

The prerequisites for 3G Mobile System are possession of a mobile device with 3G capability (smart phone), a3G network subscription plan and subscriber must be within 3G coverage area.

IV.   SURVEY AND RESULTS

In this study we chose the upazila level of Bangladesh. According to theNational Health Policy, Bangladeshhas already taken step about e-Health service by planning 1030 health complexes to be established in Bangladesh [Istepanian, 2004]. But in practice, scenario has something different. Here we would like to describe our visiting report:

V.   SUMMARY OF THE FINDINGS

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 were 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. Table I summarizes the findings.

VI.   PROPOSED SOLUTION

In section I, we already have mentioned that 3G wireless mobile technologies have been deployed in Bangladesh. The features of 3G one can be found in Wiki. These latest high speed mobile phone services offer us with a ubiquitous opportunity to upgrade the m-health systems in Bangladesh. Recently,the entire Bangladesh telecommunication core infrastructures i.e. backbones are upgraded with high speed optical fiber E1 and S.T.M. 4 services through SEA-ME-WE-4. Then we can propose the entire m-health infrastructure of Bangladesh in such a way as shown in Fig. 2.
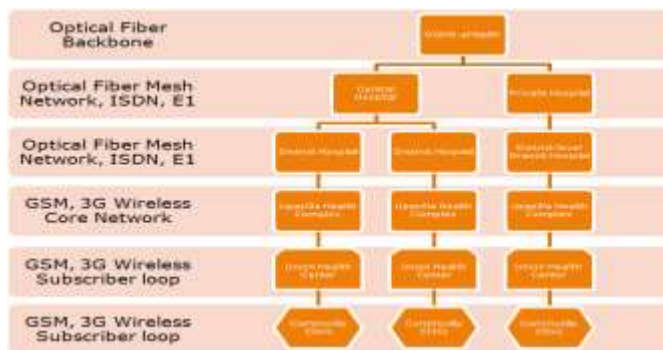
Fig. 2. Proposed block diagram of m-health system in Bangladesh.

TABLE I
SURVEY REPORT ON 2G M-HEALTH SYTEM

Existing Services	Service Provided	Mobile Generation	Call Number	Service Duration
m-Health	• Patient communicates with doctor by mobile phone. • Every health complex or community clinic has a call number through which patients contact with doctors. • Only voice call service exists, no video call or video conferencing exists there.	7G GSM Network, Grameenphone	Shibpur Upazila Health Complex (01730324538)	24 hours

Limitations:
This service is not useful for patients because

- Doctors are not able to offer proper treatment or can't give any advice about the therapy or medicine without direct observation of the situation of patient.
- No video call service or video conferencing facilities with 2G wireless system.
- In rural areas, the network connection condition (availability) is too poor. So, to get proper treatment, patients must come to the hospital.
- The patient cannot describe his/her situation properly due to lack of knowledge.

| Health Line | • 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 text service, fax services, video conferencing and so on are available | 2.7G GSM Network, Grameenphone | on emergency, non-emergency or regular medical situation by just dialing "789". | 24 Hours |

Limitations:
- 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 G.P. call center is assigned for this service which is placed in Dhaka.

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.

This ubiquitous program can extend the primary healthcare to the common people by providing: Information on Doctor and Medical Facilities, Information on Drugs or Pharmacies, Information on Laboratory Test Report, Medical Advice/ Consultation from Doctor, and Help and advice during Medical Emergency.

To verify our proposal we would like to explain the overall wireless connectivity scenario of Bangladesh. Here, we would only consider 3G system and exclude the discussion about countrywide optical fiber backbone because of well known features.

In Bangladesh, Grameenphone network gives better network coverage than others by twelve thousand Base Transmission tours where thirty thousand tours is existing for all operators like 3G, T&T etc. Also Grameenphone covers 95% area of entire Bangladesh but with 2.7G. They are gradually upgrading their networks to3G [Table II, Appendix A].

F.   Cost and Benefits of the Proposed Solution

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 people of Bangladesh remaining on a moderate level.

Table III shows the comparison between two 3G-enabled mobile phone sets made in China.

TABLE 2
PRICE COMPARISON BETWEEN TWO 3G FEATURED PHONE SETS

Features	• Operating System: Android 4.1 Jelly • 4.5" Capacitive Full Touch • 1.2 GHz Processor (Quad Core) • RAM 1 GB & ROM 4 GB • 3GNetworks,	• Operating System: Android 4.1 Jellybean • 4.5" T.F.T. Capacitive Full Touch • FWVGA Display, Camera: 5MP+1.3 M.P. • GHz

	EDGE, Wi-Fi, GPS	Processor (Dual core), RAM 512 MB & R.O.M. 4 G.B., 3G, EDGE, GPRS, WiFi, G.P.S., G-sensor, Proximity
Price	TK: 7,990	TK: 12,000

It is mentioned that according to 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$. For individual people, illness or disaster case does not frequently occur. So, for the whole year they don't need this kind of High Tech Mobile set.

Now from Appendix A, we found that in Chittagong, Robi Axiata has best 3G coverage than all other operators but its video call rate is somehow high. It is mentionable that the 2G and 3G voice call rates are same for all operators. Only in video calls, there are some differences among all.

Table 3 shows the call rates of different operators. Using 3G mobile data services, we can make video conferencing attempts from different hospitals about any crucial situation of any patient through Skype or VoIP. Again, doctor can check the physical conditions and also micro-expression of the patients through video. He can record the

TABLE 3
COMPARION OF CALL RATE AMONG DIFFERENT OPERATORS

Operator	Video Call rate of 3G		Cost/Pulse
Grammen Phone	1.20 Tk/min		20 paisa/10 sec.
Teletalk	54	paisa/ min	4.5 paisa/5 sec.
Airtel	1 Tk /min		0.1917paisa/1 0 sec.
Banglalink	1.20 Tk /min		20 Paisa/10 sec.

*Video call only available for intra operator(GP-GP, Robi-Robi)

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.

On theother side, the remote rural patient can also buy drugs by sending the prescription through FAX, e-mail or M.M.S. and pay money by mobile banking (e.g Dutch-Bangla Mobile Banking), or through services like BKash, MCash, UCash. The total proposed service categories are shown in Fig. 3.

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

VII.   RESULT ANALYSIS

In spite of all limitations we can rearrange our total health network in a hierarchical system with Optical fiber backbone in core networks and with wireless system at remote user end (Fig. 2). The Grameenphone has the largest amount of subscribers i.e.about 48 million both in urban and rural. 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 3G technologies. The coverage area will be increased day by day. The main problem is cost. To get the high data rate audio and video services we need to change our mobile phone set. Some prices are shown in Table III.

Table IV shows that Teletalk has lowest call rate for 3G video call of 54 paisa/min (4.5 paisa/5 second pulse). So, if Government will make a contract with Teletalk within its better coverage of 3G in Metropolitan areas, then the health complexes situated in those areas can provide the m-Health service with lower price including both voice and video calls.

It is mentionable that the 2G and 3G voice call rates are same for all operators. Only in video calls, there are some differences among all.

Now, we would like to compare the performance of 3G with 2.7G during image and video transmission.

Image Uploading Time for 2G and 3G

In our country network operators like Grameenphone, Banglalink, Citycell etc. provide shared bandwidth which is very limited for smooth voice call transmission. Sometimes the assigned bandwidth fails to meet the required standard and it also varies in different zones like urban area and rural area. So, for smooth voice as well as video transmission, the performance may be worse.

We took an example image of 2 M.B. file size.

Fig. 4. Example image of human chest.

TABLE 4
IMAGE UPLOAD TIME BY 2G, AND 3G TECHNOLOGY

Generation	Data Speed	Average upload speed	Uploading Time for 2 M.B. Image file
2G	320Kbps	30KB	7s
3G	512Kbps	55KB	4s

We have observed that the required transmission time for a patient's E.C.G. or X-ray report image file of 2 M.B. is about 4s for 3G, while 2G needs 7s [Table V]. So, it saves 3s. Result would be more significant with 3G if file size is much more than that, like that of the M.R.I. report. Although 2.7G has GPRS, EDGE services over the shared bandwidth 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.

Video Performance Analysis of 2G and 3G Technology

For experiment, we recorded video of a patient who visited the near by pharmacy forgetting proposed m-Health service. For video performance analysis of 2G and 3G we recorded two videos of 2 minutes duration using internet connection of two modems with two different generations of mobile technology. Fig. 5 and 6 show the visual quality of those videos.
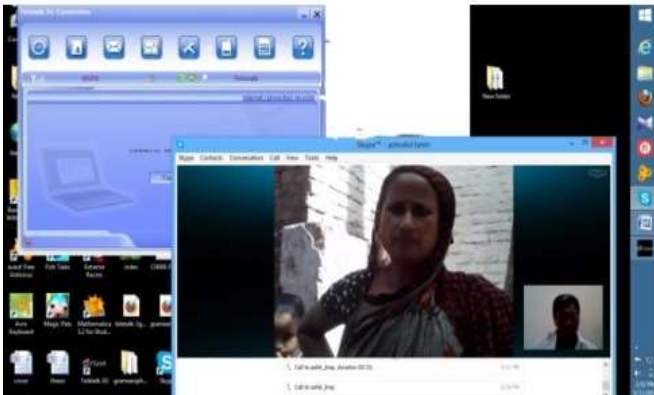

Fig. 5. Patient communicates with doctor through skype by teletalk 3G modem.
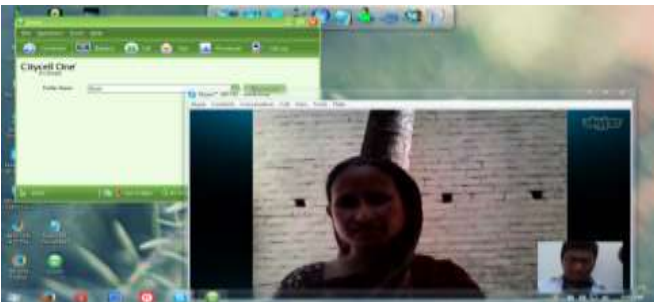

Fig. 6. Patient communicates with doctor through skype by citycell 2G modem.

By using 2G modem, it was very difficult to establish a video call because the Bandwidth and data rate of 2G network wasvery low and also the network was disconnected many times during the conversation. Due to slower data streaming, it took much time to buffer, so the video stream was stopped for few moments.

On the other hand, with 3G Teletalk modem, the video streaming was very fast and clear, but the connection was interrupted during conversation of 2 minutes. In addition,

during video call using3G phones over long distance (Bogra to Dhaka), the connection was interrupted two times.

VIII. CONCLUSION

In 2016, Bangladesh will be connected with optical fiber submarine cable SEA-ME-WE-5 of 1400 Gbps Bandwidth. 3G Voice and Internet facility is almost available in every district of Bangladesh. Emergency medical image uploading time is less, video transmission is faster and visual quality is higher in proposed 3G system. But from higher prices of 3G mobile sets, higher 3G call

rates and data packages, we can conclude that for the rural people it is not feasible to take the advanced 3G m-Health service. Although the per capita income of Bangladesh crosses the $1000, exactly $1044or 81432Tk but the real income of rural people is much less than that. So, we need to find a proper solution so that a nearly uneducated or less educated patient in remote places can consult the doctors through m-health system in a comfortable way.

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APPENDIX A
TABLE 2
COMPARISON OF COVERAGE AREAS AMONG DIFFERENT OPERATORS

Division	Grameen Phone	Banglalink	Teletalk	Robi	Airtel
Dhaka	Dhaka, Faridpur, Gazipur, Gopalgonj, Jamalpur,Kishorgonj, Madaripur, Manikgonj, Munshigonj Narayanganj, Narsingdi Netrakona, Rajbari, Shariatpur, Sherpur, Tangail	Dhaka metropolitan area by 89 BTS, Narayanganj metropolitan area by 6 BTS, Gazipur metropolitan area by 21 BTS	Dhaka metropolitan area, Narayangonj, Maymansing, Gopalgonj, Narsingdi, Faridpur, Manikgonj	Coverage only Dhaka metropolitan area	Coverage only Dhaka metropolitan area
Chitta-gong	Bandarban, Brahmanbaria Chandpur, Chittagong Comilla, Cox's Bazar Feni, Khagrachhri, Lakshmipur, Noakhali Rangamati	Coverage Chittagong metropolitan area by 56 B.T.S.	Chittagong metropolitan area, Comilla, Feni Cox's Bazar	Bandarban, Brahmanbaria, Chandpur, Chittagong, Comilla Cox's Bazar, Feni Khagrachhri, Laksh- mipur, Noakhali, Rangamati	
Rajshahi	Bogra, Chapainabab ganj Joypurhat, Pabna, Naogaon, Natore, Rajshahi, Sirajgonj		Rajshahi metropolitan area		
Khulna	Bagerhat, Chuadanga Jhenaidah, Khulna Kushtia, Magura, Meherpur, Narail, Satkhira	Coverage Khulna metropolitan area by eleven BTS	Khulna Jessore		
Sylhet	Habigonj, Maulvibazar Sunamgonj, Sylhet	Sylhet metropolitan area by 4 BTS	Sylhet Metropolitan area		
Barishal	Barguna, Barisal, Bhola Jhalokati, Patuakhali, Pirojpur		Barishal metropolitan area		

| Rangpur | Dinajpur, Gaibandha Kurigram, Lalmonirhat Nilphamari, Panchagarm Rangpur, Thakurgoan | Rangpur, Dinajpur |