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A Case Study of Telemedicine for Disaster Management in Underdeveloped Remote Districts of Balochistan, Pakistan

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Abstract

Balochistan (South West province of Pakistan) strategically lies at the border of Afghanistan and Iran. It is the largest but overlooked and least developed in human development index in Pakistan. Universal Service Fund (USF) has recently started several telecom projects for broadband delivery, telemedicine and distant learning to uplift and streamline the underprivileged class population of remote areas of Balochistan (Pakistan). Unfortunately, the ongoing and existing development projects are highly vulnerable to floods due to mountainous geography. This paper reports the breakdown analysis of telecom infrastructure through unstructured interviews, blogs, newspapers and organizational reports. An overview of existing information and communication system shortcomings and its remedies are discussed and alternative technological options for network resilience are highlighted through literature review and case studies. Two resilient designs for broadband and narrowband networks are proposed. The proposed modifications will shoulder in sustainability of telecommunication network, which is very vital during disaster mitigation, recovery and rehabilitation processes. The proposed models can be used to design better resilient telecommunication networks & disaster communication systems for under developed mountainous regions in the world for sustainable development.

Key Words: Disaster management, Information and communication systems, Telecom infrastructure, Balochistan, Floods, Telemedicine

1 Introduction

Balochistan is the largest province located at the South-West (220N to 320N, 660E to 700E) , covering 347190 square Km, an area equal to the size of Finland, it comprises of 44% of country's total area but has the least population density, comprising only 5% of country's population. According to 1998 census, its population is 6.6 million. Geographically 80 % of Balochistan is inter-mountainous, only 20% are flood plains, deserts and coastal areas (WB & ADB, 2008).Amongst all provinces, Balochistan has the highest poverty, lowest social indicators, and weakest institutions (MDTF World Bank, 2012). Besides its geography and climate features, Balochistan witnessed natural calamities and disasters including the Cyclone Yemyin 2007, Ziarat Quake 2008, Floods 2010, Flash flood in 2012, Awaran quakes 2013.

Balochistan is largely under privileged/ underserved in terms of basic health and education infrastructure. In 2009-2013 the Universal Service Fund (USF) started optical fiber projects in Balochistan for delivery of broadband services to un-served areas (USF (Pak), 2009); as well as various projects for distant education and telemedicine were launched through this infrastructure for uplift of local residents of the area. During the 2005 – 2012 flash floods, the optical fiber network infrastructure suffered many blows. The communication's blackout caused extreme difficulties in relief and coordination activities.

This paper attempts to critically analyze the existing &ongoing telecom projects in Balochistan in terms of its survivability against natural disasters and utility of telemedicine for disaster management in one of the most disaster prone areas of the world. The paper at the outset introduces telemedicine projects in Pakistan. The core component of telemedicine services i.e. Telecommunication networks and its breakdown causes during disasters are analyzed. Alternate technological options are searched from literature review. These technologies are applied for designing a robust telecommunication network for Balochistan for effective mitigation of disasters. A disaster information management plan is provided to overcome the shortcomings in current plans. The paper concludes with future directions & conclusions.

2. Telemedicine projects in Pakistan

Pakistan is the sixth largest population in the world, and ranked 122 of 190 countries in healthcare. More than three quarters of the population live in hinterlands, and quarter of the population comes below the poverty line. Infections and communicable diseases are very common due to unavailability of safe drinking water and accounts for more than 40% of total burden of diseases. Only basic healthcare services are available in rural areas with acute skilled human resource shortages. Specialty and tertiary care centers are located in large cities only, therefore in general the rural populations have to travel a fairly long distances making considerable expenditures for treatment in big cities (Akram & Khan, 2007; Shaikh & Hatcher, 2005; WHO, 2007). Thus telemedicine presents a viable solution for bridging the healthcare gaps between the large cities and the rural areas with affordable expenditures.

A number of telemedicine projects have been launched in Pakistan since 1998. A consolidated list of most significant telemedicine projects in Pakistan is given in Table 1. Telemedicine was introduced in country in 1998 by Exilir Technologies USA, for consultation services from Holy Family Hospital (HFH) Rawalpindi, the pioneer and most innovative hospital in terms of telemedicine in Pakistan.

The recent USF Telemedicine pilot project started in 2010; is an expansion project of **Health Net 2007**, which utilizes the national backbone optical fiber network. This comprises of 2 established health centers Jinnah Post Graduate Medical College (JPMC) Karachi & Holy Family Hospital Rawalpindi. A new tele-health center was also established at Nishtar Medical College Multan. Each Tertiary care hospital is connected to 4 District Head Quarters (DHQ) hospitals. 2Mbps connection with teleconference/telemedicine equipment is installed at Tertiary hospital and DHQ hospitals are provided with 1Mbps connection and teleconference / telemedicine equipment. Tele-centers in teaching hospitals are providing consultation services on (a) General (b) Cardiology (c) ENT (d) Skin (e) Radiology and (f) Gynecology to DHQ hospitals(USF (Pak), 2010).

Unfortunately, telemedicine has never been tried in Balochistan, which has the overall worst human resource shortages throughout the provinces. Recent 2009-2013 broadband optical fiber projects in Balochistan provided opportunity to bridge the gap of digital divide and provision of telemedicine services to the least developed districts of Pakistan. This paper discusses one of the most important issues in launching of “Balochistan Telemedicine Projects” i.e. model of a telecommunication network that can survive during disasters and can be used for livelihood development of underprivileged remote rural areas.

3. Baluchistan communication networks and causes of its failure

The telecommunication networks either land line or wireless are interconnection of distributed but interdependent networks, various stations are located at separate geographical location, these stations interact through national backbone links, for which optical fibers are the predominant medium. For example for delivery of ADSL internet services to the customer premises via twisted pair copper wire Digital Subscriber Line Access Multiplexer (DSLAM) is located at local exchange’s building. DSLAM is backhauled through optical fiber network to connect to Broadband Remote Access Server (BRAS) in Karachi for delivery of internet from Pakistan Internet Exchange (PIE). Similarly for mobile communications, the mobile towers communicate with the Base Service Station (BSC) located in the cities like Karachi for processing of voice & data calls. Therefore, in case of failure of backbone optical fiber network, telecommunication services are badly interrupted. Other causes of breakdown of communication are Water ingress in copper wire distribution network or telecommunication equipment, Congestion & network overloading, Power depletion/ outages and mobile tower damages (Townsend & Moss, 2005).

Table 1: The Prominent Telemedicine Projects of Pakistan (1998-2013)

Project Name & Year	Area of Project	Telecom Infrastructure	Usage
Telemedpak **1998**	Resource Center RC- Holy Family Hospital HFH Rawalpindi Remote Station RS- Taxila, Gilgit	Dial up modem internet connection	Store and Forward
COMSATS **2002 & 2005**	RC- Comsats Islamabad RS – Gujar Khan & Gilgit	Internet via landline / VSAT (dial up)	Store and forward
Health Net **Suparco & MoIT** **2007-2010**	3 Tertiary care hospitals with 12 RS Mayo Hospital Lahore with Gujrat, Jhang , Rajanpur, Sahiwal HFH Rawalpindi with Attock, , D.G Khan, Khushab, Pindi-Gheb & JPMC Karachi with Ghambat, Jacobabad , Mirpurkhas , Shikarpur	Paksat-1 satellite 500 Kbps Up/Down link connection	Tele-conferencing facility.
Pakistan Telemedicine Project 2007	US DoD Telemedicine & advanced technology Research center USA, HFH Rawalpindi and RS-District Headquarters hospital Attock attached in hub and spoke configuration.	Gigabit Ethernet connection at HFH, Wimax at Attock	Virtual grand round, distant training and health care facilities.
Multitasking of e-Health training center HFH 2008	Virtual training lab at HFH. Provided distant training to nurses & other medical personal from HFH to the RS. Earthquake's paraplegics training & healthcare facilities in Kashmir.	Paksat-1 satellite add connectivity to three more sites in AJK	Advanced training, healthcare and rehabilitation facilities.
Aga Khan Health Services 2007-2013	Various programs tele-radiology between AKUH-Karachi French Medical Institute of Child Health FMIC-Kabul Afghanistan. Lady Health Workers LHW training program via mobile phone. Distant lecture facility at AKUH Karachi to / from other institutes..	Gigabit Ethernet at AKUH Karachi. 2Mbps link with Kabul.	Various facilities online & offline.
Jaroka Tele health care 2006	From Mardan KPK mobile phones are used by LHW to send MMS, SMS based medical records/images to server at NUST-Islamabad, which is forwarded to consultant in USA.	EDGE mobile internet and VSAT server connection.	Store and forward
Sources : (Dodani, 2012; Farooq & Hassan, 2012; Hussain, 2008; Janjua, 2012; Keyani, 2009; Khan & Hayee, 2009; Mirza, 2009; National Academy of Sciences USA, 2006; Sherwani, 2009; Telemedpak, 1998)			

Prior to launch of "**USF Balochistan optical fiber projects**" the only major telecom operator i.e. Pakistan Telecommunication Company Limited PTCL, many areas were on microwave connectivity and had no broadband internet access. In 2009-2013 USF a private-public partnership started optical fiber projects for Balochistan underserved & un-served areas. USF is providing subsidies to the operators for operating in the economically unfeasible areas. Wateen and PTCL have won the optical fiber deployment projects and by 2014, it

is expected that broadband internet service will be available to every district in Pakistan(PTA(Pak), 2007; USF (Pak), 2009).

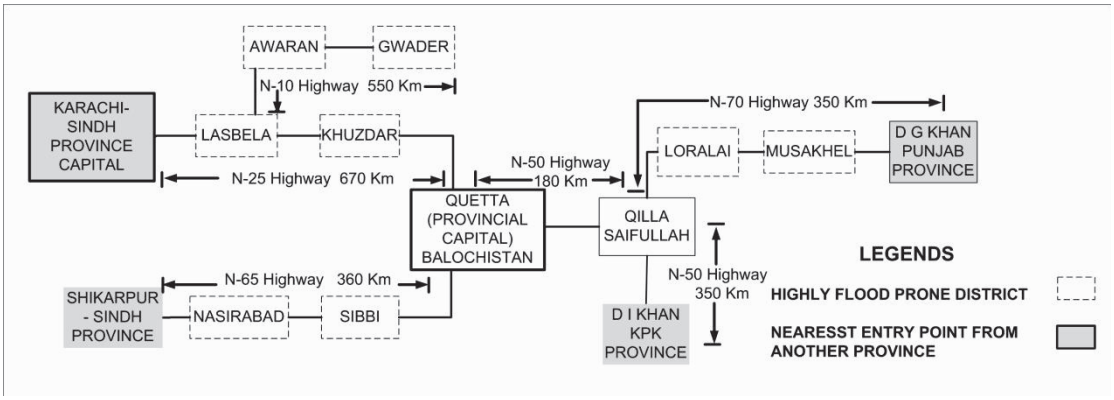

Figure 1: Simplified diagram of National backbone optical fiber connectivity of Balochistan to other provinces

Wire-line (Land line) networks are connected via underground or overhead wires i.e. optical fibers or copper cables. For Balochistan long distance network, these national optical fibers links are laid at the side of National Highways for easy access & maintenance. Therefore topography & detail description of road network is very necessary to analyze the failure of optical fiber networks. The national connectivity of Balochistan is given in figure 1. The five entry points of Balochistan as follows (Naeem, 2012; NHA(Pak), 2012).

1) Karachi Sindh province to Lasbela district via N-25 highway.
2) Shikarpur Sindh province to Nasirabad district via N-65 highway.
3) DG Khan Punjab province to Barkhan to Musakhel to Loralai district via N-70 highway.
4) DI Khan KPK province to Sherani to Zhob district via N-50 highway.
5) Rato-Dero to Qambar Shahdadkot Sindh province to Khuzdar district via unfinished national highway M-8, delayed since 2004 due to law & order situation. So, national Optical fiber network is not deployed on this route.

Most of the Balochistan landscape is composed of hill torrents. Several streams flow into seasonal rivers out of the hills. This goes through intense flash flooding during the rainy season that washes away anything comes in its way. The rains are caused by (i) monsoon depression originated at Bay of Bengal in summer (ii) Mediterranean Sea westerly waves in winter and (iii) Arabian Sea cyclones(Tariq & van de Giesen, 2012). The connecting highways to other provinces are blocked due to land sliding and cut away of roads, thus optical fiber laid in these roads is damaged, since this phenomenon usually occurs simultaneously at three or more connecting highways at different locations; thus Balochistan whose access is limited to only five routes results in blackout of communication in large areas during the disasters, and restoration may take many days.

Table 2: Prolonged telecom network outages during floods > 1 day (2005 – 2012)

Year	North Balochistan N-65, N-70 & N-50 Highways	South Balochistan N-10 & N-25 Highways	Remarks
2005		Gwadar & Awaran (on N-10 Highway)	Shadikor Dam busted.
2007		Awaran, Kech, Khuzdar, Lasbela, Gwader. (on N-10 & N-25 Highways)	Cyclone Yemyin caused widespread rains in Balochistan.
2010	Barkhan, Sibi, Kohlo, Bolan and Naseerabad (on N-65 & N-70 Highways)		Quetta was up from Karachi – Lasbela side. (from N-25 Highway)
2012	Almost all telecom networks were down, due to multiple optical fiber cuts. (on N-50, N-65 &N-70 Highways)	Khuzdar (Wadh) cable washed away. (on N-25 Highway)	Road cuts in 1. Zhob to DI Khan 2. Loralai to DG Khan. 3. Nuttal road Nasirabad district and cable washed away on N-25 Highway.
Sources: (ADRC 2005, ADB & WB 2007, P& D(Balochistan) 2011, Naeem 2012, PDMA (Balochistan) 2012, PDMA (Balochistan) 2012, PDMA (Balochistan) 2012, PDMA (Balochistan) 2012) & personal interviews			

4 Disasters' worst case scenarios analysis for telecom networks

The analysis of weak portions of national communication links and disaster profile were collected from unstructured interviews of optical fiber maintenance staff, cross validation was done from UNDP prepared Baluchistan's district disaster profiles & districts risk atlases, reports from government and other agencies, blogs and newspapers. The worst case scenario was identified from the compilation of fault analysis. The table-2 presents the region blackout caused by floods from 2005 to 2012.

The fault analysis indicates that year 2012 was the worst case for North Balochistan; when three routes on N-50, N-65 & N-70 highways were broken; only available route to Quetta was on N-25 highway. Just after Lasbela district another Optical fiber cable was washed away at Wadh Khuzdar. So all optical fiber links went down and majority of the province was blacked out (Naeem, 2012; OnePakistan News, 2012). The provincial capital Quetta is far located, therefore in future such events can reoccur and communication restoration can take several hours.

The worst case for South Balochistan is 2007 floods caused by cyclone Yemyin; heavy concentrated rains caused flash floods, majority of provincial / national roads were damaged or cut away at various sections of South Balochistan (M-8, N-10, N-25 & N-85 highways). The telecommunication sector sustained heavy damages due to ingress of rain water in exchange buildings and mobile tower damages, restoration took several days(ADB &

WB, 2007).

5 Technologies for breakdown of terrestrial communication

There are have been number of publications on resilient optical fiber network design through traffic routing, but the geography & disaster profile of Balochistan requires to handle the disaster situation by telecom management best practices and disaster resilient hybrid technology designs, since multiple optical fiber cuts causes huge regions cut off from the rest of country, and no alternate communication links are available. Satellite communication is sometimes the only solution in case of disasters(Kose, 2012). But high terminal and per minute costs can afford only few users. Majority of the disaster victims can only be benefited if terrestrial/mobile network were intact. Following is detail of disaster survivable telecom technologies. The proposed network models will be a hybrid model of these technologies.

5.1 Telecommunication Satellites

Telecommunication satellites are the most rapid & easy configuration solution on aftermath of disasters, when all terrestrial communications are collapsed. The disadvantages of satellite communication compared to terrestrial communication are its high terminal equipment costs, limited bandwidth, less flexible capacity and high usage charges. Satellite communication requires Line of Sight LOS communication, which is sometimes not possible at disasters' areas(Kose, 2012).

The first ever Satellite system in Pakistan are Intelsat ground earth stations deployed at Karachi & Islamabad for international connectivity by PTCL in 1992. Three domestic earth satellite systems Intelsat Domsat stations were established at Skardu, Gilgit (in Northern Areas) and Gwader (Balochistan). Intelsat Very Small Aperture Terminal VSAT services are available to corporate users with brand name "Skylink PTCL" in bandwidth of 64 Kbps to 2Mbps(PTCL, 2013).

Inmarsat Satellite systems are the most popular satellite services that have been utilized extensively during disasters in Asia & other continents. Inmarsat user terminals can support voice & data services at the highest rate of 512 Kbps, it has two types of user terminals, Broadband Global Area Network BGAN attache case terminals & handheld satellite phones(Sadiq, 2006).

Thuraya and Iridium satellite communication terminals and handsets support only low data rate voice & data services(Navein & O'Neill, 2009). Pakistan owned satellite Paksat-1R, is a geostationary satellite, which support VSAT & fixed satellite services in both Ku & C band. The Paksat-1R is providing backhaul services to Health Net project already mentioned in section 3. It is running commercial services for more than 45 clients(Paksat, 2011).

5.2 Wimax

Wimax Interoperability for Microwave Access or Wimax is licensed broadband wireless technology that can support higher bandwidths that were previously only possible with land line technologies like DSL & Cable Modem. It has been widely used for disaster management and emergency telemedicine support in the world(Chorbev & Mihajlov, 2009; Terry, 2009). The Wimax standard accommodates two separate frequency spectrum blocks for short range communication (non-line of sight) and long range backhaul communication (line of sight) technologies(Tipmongkolsilp, 2011). In Pakistan only short range technology is allowed by Pakistan Telecommunication Authority PTA. At this moment four Wimax operators are offering broadband wireless communication and short distance point to point Metro-Lan services in large cities (Asif, 2007). The allocation of long range frequency band for backhaul and rural customers is proposed, which will be used to design a resilient wireless broadband network for disaster mitigation.

5.3 Terrestrial Trunked Radio (Tetra)

Terrestrial Trunked Radio or Tetra is a mobile technology for professional / national agencies. It is intended for

professional organizations requiring fail free robust communication features which are not available in other technologies during emergencies & disasters.

Tetra support two additional modes of call setup besides call setup from the base station, (a) unit to unit & unit to multiunit communication. (b) In case of collapse of infrastructure, Tetra unit uses other tetra unit as relay for making call to the destination unit.

The technology lacks high data transfer rates of modern mobile technologies but superior in terms of security & encryption features demanded by government enforcement agencies, large commercial enterprises with mobile fleet, transportation services such as railway network, medical and emergency service provider such as Fire Brigade & Rescue 911 etc.(BakariC, 2005).

Tetra systems are deployed for Police force in Pakistan in 2008(TIG, 2012). Many developed and developing countries are using Tetra system for emergency & disaster management. Pakistan also needs to focus on to employ Tetra for voice communication during disasters when all other terrestrial communications have failed, as this technology can survive the worst disaster events.

5.4 Vehicle Communication Network

The MOBSAT & other projects utilized News Van vehicles linked up with satellite communication to provide high speed communication in disaster area. (Chen, 2012; Gayrard & Blanc, 2004; Iapichino, 2008; Patricelli, 2009). Mobile telemedicine vans have been in Pakistan during Swat Valley crises 2009, Floods 2010 & 2011(Malik, 2011; NDMA, 2011).

6 Proposed plans of Resilient Communications for Disaster Management & Sustainable Development

The disaster emergency communication network and e-development goals can be achieved by developing two telecommunication networks. (a) Wimax based broadband wireless network, which is comparatively very resilient than existing broadband networks for the provision of distant learning, e-government and tele-medicine services for rural population and (b) hybrid technology based resilient narrow-band voice and data communication platform for effective disaster management. Therefore two separate network plans for narrowband and broadband communication are provided. This paper also discusses the shortcomings in existing disaster information & communication system and remedial strategies to cut down the heavy human and economic losses.

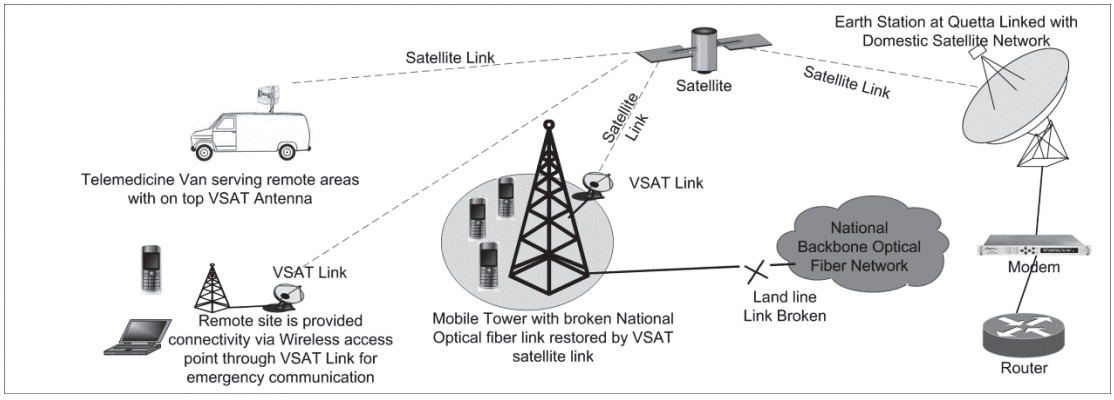

Figure 2: Theoretical model of emergency communication for Balochistan Province

6.1 Proposed plan for survival of narrow band voice and data communication systems.

Keeping in view of the topology of the deployed communication network and scarce of emergency communication resources in event of disasters, following points are proposed for better disaster management. A theoretical model for emergency communication is given in figure 2.

1) A satellite earth control station is proposed at Quetta, being located on central land locked location, survivability of network will be greatly enhanced.
2) Terrestrial Trunked Radio or TETRA technology should be employed for disaster relief operation as primary communication medium between the disaster management agencies. This pilot project should support Tetra Release 2 so that data rates beyond basic rates of 2.4 & 7.2 Kbps will be possible(Yarali, Ahsant, & Rahman, 2009).
3) Another lacking key area in communication support for relief activities is "development of mobile bag for disasters". Many countries have developed devices and application software to deal with the disaster situation(Sadiq, 2006). Typical mobile package/bag for disaster consists of Inmarsat BGAN sets, interfaced with telemedicine equipment. These mobile telemedicine kits are easy to use and operational within 20 to 30 minutes on disaster site. (Kose, 2012; Sutjiredjeki, 2009).
4) Setup of VSAT fixed terminals is complicated, as it requires 2 to 3 days to setup fixed satellite VSAT terminals. VSAT fixed terminals are used as backhaul to restore mobile communication in affected area(NDMA(India), 2012). After restoration of mobile communication, SMS based disease surveillance system can be used to epidemics in the area. (Yang, 2009). If Toll free are used for medical consultation, healthcare problems of affected population can be greatly served.(NDMA, 2011).
5) For delivery of healthcare to outreach areas telemedicine vans should be utilized.

6.2 Proposed plan for disaster resilient Wimax broadband telecommunication platform for sustainable development

The ongoing USF optical fiber projects in Balochistan and existing optical fiber infrastructure cannot survive due to terrain & technology constraints for laying optical fibers on routes which are highly flood prone; to overcome this complication an overlay of Wimax broadband infrastructure over optical fiber infrastructure is proposed. Due to usage of non-wire-line media, mobile towers can be erected on less disaster prone locations i.e. mountains or flood reinforced buildings. For the implementation of this proposal, Wimax backhaul frequency needs to be allocated by PTA.

The Wimax base station will serve rural / semi-urban customers in range of 5-15 Kms utilizing non line of sight communication at 3.5 GHz Band. The backhaul of base stations will be on Wimax backhaul technology that can work within 50 Km range using directional antennas (point to point communication). In case of event of breakdown of optical fiber, the alternate Wimax backhaul will be available; by utilizing mesh networking the robustness of the wimax broadband infrastructure is further enhanced(Karanasios, 2011; Mujyambere, 2012).

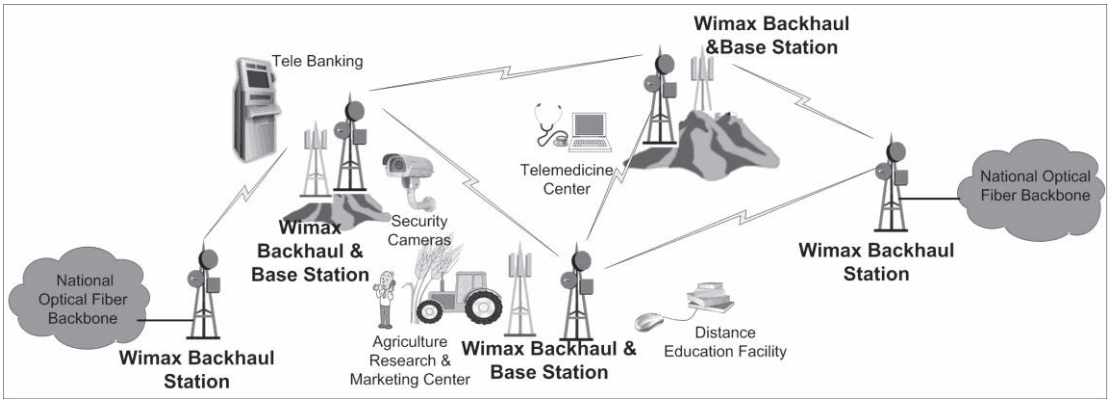

Figure 3: Wimax mesh Based **e-services** delivery infrastructure overlaid on existing optical fiber network

Since population in Balochistan is dispersed far and wide, the proposed Wimax broadband service platform will not only be cost efficient but also disaster resilient than ongoing deployments based on other technologies. Beside telemedicine & distant learning project, security cameras at important places will help controlling the sabotage activities by militant elements. A Wimax Based e-services delivery infrastructure overlaid on existing optical fiber network is given in figure 3 for Balochistan.

6.3 Disaster information & communication system shortcomings and its improvements

Twenty of 30 districts in Balochistan are highly vulnerable to seasonal floods(PDMA (Balochistan), 2012e). Unfortunately no concrete effort has been made to control high causality rates and economic losses. The improvements in disaster information & communication system will help reducing these losses and betterment in livelihood conditions due to the availability of modern technologies for education, timely dissemination of information, better health care facilities etc. The proposed disaster management plan is prepared from compilation of personal observation, NGO reports, literature review, and international disaster agencies guidelines. It is composed of three phases i.e. pre, during and post disaster management phases

6.3.1 Pre disaster planning

The disaster management arrangements are inadequate & ad-hoc. So far no early warning system is implemented in Balochistan hill torrents & rivers. Disaster preparedness arrangements lack human and other necessary resources, and awareness is required to be created at all levels for effective response. Following is mention of loop holes in existing disaster planning.

1) The vital databases of disaster affected population, detailed statistics of relief activities, land usage, live-stock and medical records are not maintained, incomplete or manual. Census, since 1998 has not been carried out . For the first step computerization of databases with secured access should be carried out for disaster management decision support system.
2) Balochistan Rivers and hill torrents should be provided with Doppler radars & remote sensing technologies and linked up to the National flood forecasting department for monitoring and mitigation strategies.
3) The weakest area of province is lack of GIS based planning and development. Necessary steps should be taken to build capacity of national development agencies in GIS databases for future projects.
4) Solar panels should be installed at telecommunication sites to avoid power depletion problems during disasters.
5) Human resources quality & quantity should be enriched through trainings and other resources.

6.3.2 During Disasters Management

During the disaster the damages are minimized using a well-coordinated strategy among the stakeholders. Information sharing with the disaster prone community on timings and intensity of disaster enable them to minimize their losses. Timely & justly distribution of relief & medical supplies lessen the suffering of vulnerable groups. Following arrangements are found lacking in existing disaster management plans.

1) The whole disaster situation need to be monitored on 24/7 basis, and for coordination and relief activities availability of communication facilities is very necessary. This paper provided suggestion for survival of narrow and broadband communication, which will be highly beneficial for disaster management.
2) Majority of relief goods & aids are provided through non-government channels and international donors, which does not reach the most deserving and hard to reach places. For transparency all the coordinating government and non-government agencies need to be linked with a common communication platform & database.
3) Due to worst law & order situation, shelters management, goods dispatch and disease monitoring need to be under strict surveillance system.

6.3.3 Post disasters rehabilitation and recovery process

On lapse of disaster event, the disaster struck community return to their homes. They are desperately in need of

financial aid to reconstruct their houses, properties and plough agriculture fields etc. They are provided remuneration according to the damage assessment. The availability of databases gathered during pre-disaster & during disaster phase will greatly smooth line the damage assessment process. Bunds & other safety civil structures are checked and repaired before second disaster. Through resilient communication infrastructure reconstruction process can be performed more efficiently, since more data can be transferred for decision making in less time. Due to deteriorated water & sanitary conditions diseases are on the spread. Awareness campaign from electronic media & healthcare support from telemedicine can cater for healthcare needs of affected population. In short all these activities will be run in an iterative process for improvement in disaster information & communication system, for achieving goals of a better disaster management in future.

7 Future directions

Pakistan ICT sector has not made efforts to enroll itself for partnership in disaster management. The paper due to space limitation focused on utilization of telecom infrastructure for effective disaster management. Other segments of ICT sector have enormous potential in streamlining the disaster activities for example Educational & Research institutes can help developing hand held devices and mobile applications to help communities in maintaining community based disaster management system. The disaster management authorities & government should focus on tapping out the potential of ICT sector and include this important industry in streamlining the disaster risk reduction measures.

8 Conclusions

This paper analyze a case study for provision of telemedicine & other e-services using telecom infrastructure for sustainable development in one of the most disaster prone and neglected region of the Balochistan, Pakistan. The ongoing and existing telecom projects does not incorporate disaster risk reduction measures, one of the most progressive sectors in Pakistan i.e. Telecom sector has yet to play it's part to curtail the disaster's risk through availability of resilient communication. The paper rectifies the shortcomings in broadband and narrowband telecommunication infrastructure by employing disaster resilient technologies, due to the hybrid design the presented model is not only cost effective but also optimal in terms of performance. Furthermore the proposed satellite earth station at Quetta will reduce the province's network outages during disasters. Last but not the least the paper discusses loopholes in existing disaster information & communication system, and its remedies. The changes recommended in the paper, provide a proposition for better information and communication infrastructure which can be employed at lower cost for bridging the digital divide of underprivileged population. The resulting rugged and fault tolerant telecom infrastructure will help in Disaster mitigation, Rehabilitation and Recovery processes.

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