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GSM Technology over Satellite for Disaster Management in Myanmar

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Abstract — **Telecommunication systems play an ever-increasing and important role in ensuring timely and effective responses to emergency services. The rescue phase in which the promptness of action can save many lives during and after disaster. Disasters often come along with the destruction of the local telecommunication infrastructure causing severe problems for rescue operations. Satellite communications is then the only communication means for the rescue teams. This paper emphasizes on GSM link over satellite medium. Appropriate interface of GSM is to be chosen, which is most vulnerable to destruction. The most vulnerable interface disruption occurs to Abis interface which is defined between Base Station Transceiver (BTS) and Base Station Controller (BSC). Also Abis interface is chosen here because it can be routed over the satellite to provide cost effective communication in developing countries with poor terrestrial communication infrastructure. In this paper, the suitable protocol architecture for Abis interface over satellite medium is chosen for disaster management applications. This paper proposed a system and its implementation plan to incorporate the existing GSM system to deploy over satellite by establishing a pico BTS with a few kilometres coverage around disaster site to connect to disaster safe site for immediate relief operations.**

Keywords— **Abis over satellite protocol architecture, BSC, BTS, GSM BTS-SAT terminal, GSM over satellite**

I. Introduction

The first victim of natural disaster is “Terrestrial based communication system” including Cellular communication. First and foremost, resource required for disaster recovery is “Communication”. Global System for Mobile communication (GSM) is the most popular means for voice and data communication having more than 2 billion subscribers all over the world. In a typical GSM network, there is a single MSC, a few BSCs and many BTSs. There are different interfaces between various components of GSM. The satellite link may be used to support any of these interfaces. The suitable interface should be chosen through the satellite for maximum mobility, interoperability and flexibility in the disaster communication scenario. After the disaster, the most vulnerable interface destruction occurs to the Abis interface, which is defined between BTS and BSC. Abis interface was originally designed for more reliable wire line communication links, hence to establish Abis interface over Satellite, signaling architecture of the interface and its protocol stack should be re-designed.

The IP based Pico BTS terminal introduced in this paper is intended to use while normal BTS link is broken in case of a disaster. Many IP based stand alone system solutions exist but are not interoperable to existing BSC/MSCs. The Pico BTS is an IP-based, software-radio solution that provides both efficiency and flexibility supporting all four GSM bands (850, 900, 1800 and 1900 MHz) enabling to build multi band BTS sites easily and efficiently. Interoperability with both traditional TDM-based MSCs and newer IP-based MSCs is provided.

Myanmar, by its geographical and geological nature, is prone to various types of natural disasters. After the occurrence of a disaster, emergency communication to rescue authorities is urgency requirement for the victims at the affected regions. To replace the existing over-head fiber cable connection used for long distance communication with underground cable network and to continue to use the existing over-head links as back-up is under arrangement for disaster communication in Myanmar. Both the over head and underground cable is most vulnerable to damage during disaster, a wireless medium of communication is necessary for the disaster management communication. The GSM communication is more popular for Myanmar having more than 50 percent of the cellular communication. There are around 250 BTSs covering 85 towns in Myanmar GSM network and the most vulnerable disruption occurs to BTS. So GSM technology over satellite is most viable and quick mechanism for the communication restoration which is proposed for disaster application.

II. Overview of the System

A typical GSM network is shown in Fig. 1. There are various interfaces such as E, A, Abis, Um (Air) interface between different components [3]. Fig. 2 shows a diagram of different interfaces between the stations. Each interface presents a particular and normalized format. The air or Um interface standard is used for signaling exchanges between the mobile equipment (ME) and the BTS [4]. The Abis interface links the BSC and the BTS [5]. The Abis interface links the BSC and the BTS [5]. The ‘A’ interface is used to provide communication between the BSC and the MSC [6]. The E interface is used between the MSC and the PSTN, or between two MSCs.

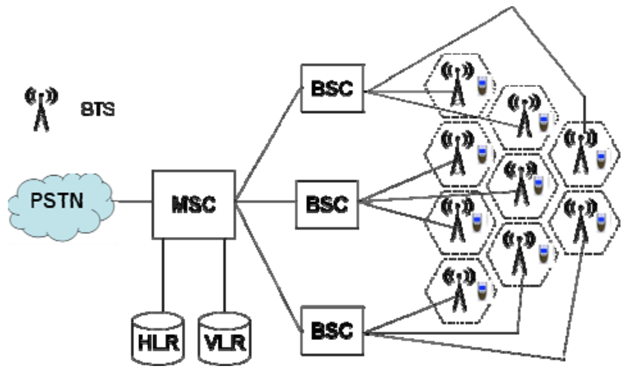

Fig. 1 A typical GSM architecture

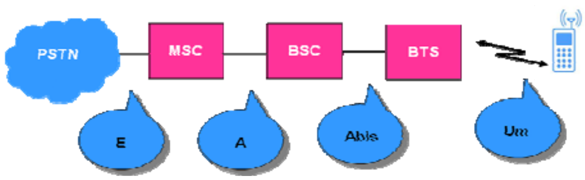

Fig. 2 Various interfaces of GSM network

III. Proposed System for Abis Interface over Satellite Architecture

A. *Overview of the Abis Interface*

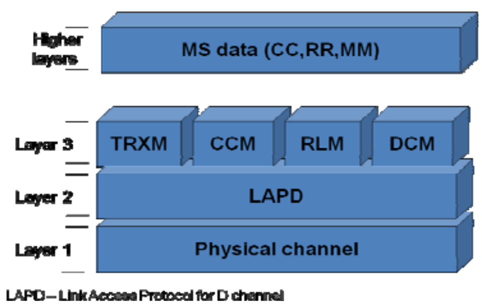

Fig. 3 Conventional protocol stack on the Abis interface

Abis interface comprising of signaling and traffic messages, is carried on El bearer channel. Signaling messages on Abis interface are defined as Transparent and Non Transparent. Higher layer on Abis interface consist of user data such as Call Control (CC), Radio Resource (RR) management, Mobility Management (MM). Messages related to higher layer are transferred transparently through BTS to mobile station (MS). Non-Transparent messages which comprise Layer 3 messages are defined as Transceiver Management (TRXM), Common Channel Management (CCM), Radio Link Management (RLM), and Dedicated Channel Management (DCM). Transparent and non-transparent messages which require acknowledgment are transferred in Information frames (I frames) between BTS and BSC [1]. The transmission rate is 2.048 Mbps, which is partitioned into 32 channels of 64 Kbps each. The compression technique that GSM utilizes packs up to 8 GSM traffic channels into a single 64-Kbps channel. Conventional protocol stack on Abis interface is depicted in Fig. 3.

B. *Proposed Protocol Architecture for Abis Interface over Satellite*

The block diagram of Abis interface over satellite is shown in Fig. 4, where the proposed protocol architecture lies between the BTS and BSC. The protocol architecture which is derived from [10] is proposed to provide necessary transparency and the architecture utilizes the transport protocol stack which is popularly used for the data networks in the satellite communication, while keeping maximum interoperability with the other telecom equipments. The traditional E1 link is replaced with IP transport mechanism. Logically the Frames on Abis interface are separated into TRAU and Signaling frames. The signaling frames are formatted over UDP/IP and encapsulated over satellite channel. The function of LAPD in conventional Abis interface will be take care by UDP/IP packet. The excessive delay encountered by the signaling in the satellite environment is sorted out by adjusting the appropriate timers in the stack. To provide voice compatibility between the BTS and BSC, the traffic in TRAU frames is encapsulated over the RTP/UDP/IP stack over satellite channel. The overall achievement is seamless conversion of circuit switched to packet switched network. The schematic representation of proposed Abis interface over satellite link is depicted in Fig. 5.

1. Signaling Messages management: In the forward link i.e. from BSC to BTS, these messages describe the link establishment and release information and its acknowledgment to all its BTSs. The messages with added UDP and IP header, Base Band (BB), FEC and Physical Layer (PL) headers are added and modulated before given to the RF channel. Each BTS will be identified by its IP address for the signaling. Similarly in the Return link i.e. from BTS to BSC each BTS is assigned with a fixed number of time slots in a Multi Frequency Time Division Multiple Access (MFTDMA) frame having burst lengths of fixed symbols. Number of slots assigned on a MFTDMA frame to each BTS depends upon the traffic volume of each BTS.

2. Traffic Management: TRAU frames which carry voice are encapsulated into Real Time Protocol (RTP) packets with time stamp of playback to prevent jitter while receiving, then encapsulated into UDP packets. Resulting UDP packets are IP encapsulated and transmit over the satellite channel. Similarly in the return link the IP packets access the Satellite using the MFTDMA with CRA type assignment.

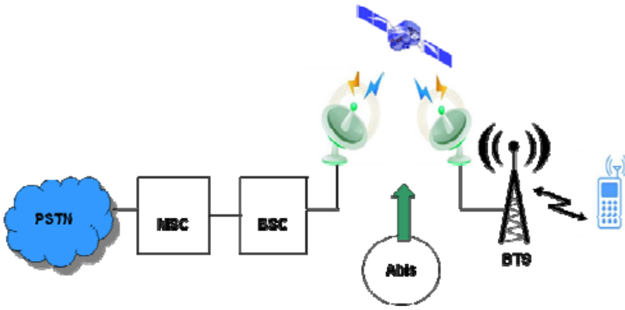

Fig. 4 Block diagram of Abis interface over satellite

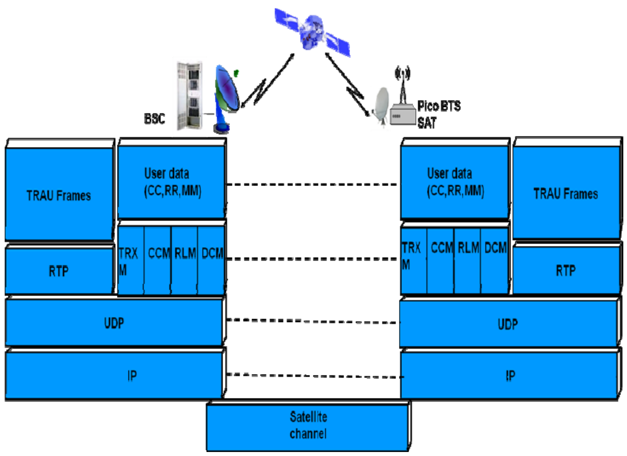

Fig. 5 Schematic representation of proposed Abis interface over satellite link

C. GSM BTS SAT Terminal

The chosen technology for the GSM BTS-SAT (IP based Pico BTS integrated with Satellite ground terminal) is IP access pico BTS. It provides coverage of a few kilometers with full power in open space. This BTS can be adapted to different deployment scenarios depending on the coverage and capacity needed. Due to its small size, the BTS can be carried and deployed anywhere, providing GSM coverage to practically any place on earth, as long as there is satellite connectivity. Satellite and/or terrestrial backhaul links are supported using the Internet Protocol (IP) with built-in support for IP routing.

D. Proposed Abis over Satellite System for Disaster Scenario

The existing mobile network can be restored by installing Pico BTS towers that can be installed atop the VSAT terminal itself.

The system setup for Abis interface over Satellite is shown in Fig. 6. There are two segments namely disaster site and disaster safe site. On disaster site, in transmit chain MS connects with GSM BTS-SAT terminal via air interface. IP interface from GSM BTS-SAT will go to satellite modem. Block up converter (BUC) converts L band (950 to 1,450 MHz) IF input to Ku Band (14.0 to 14.5 GHz) RF output and amplifies the RF output. RF output will be transmitted to satellite via 90 cm antenna.

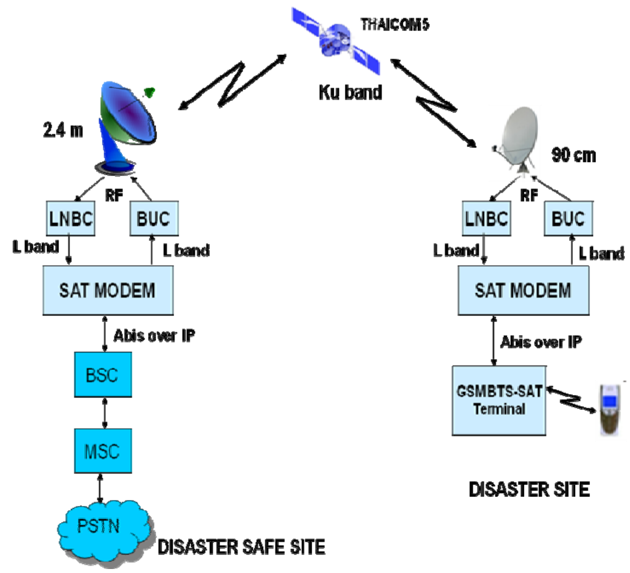

Fig. 6 Proposed Abis over satellite for disaster case

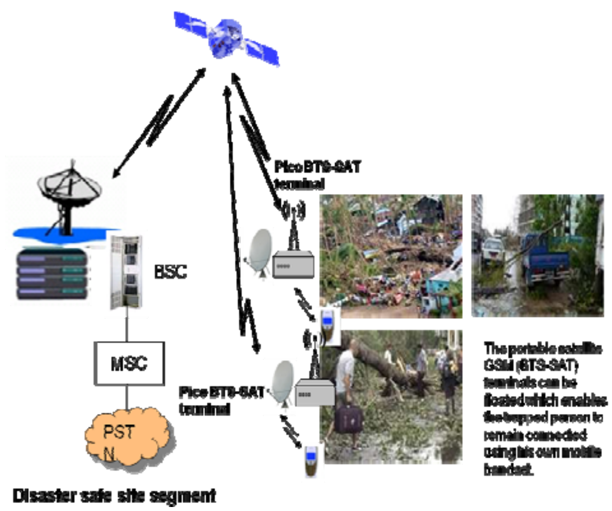

Fig. 7 Typical usage scenarios of the GSM pico BTS SAT terminal

In disaster safe site, 2.4 meter antenna will receive RF signal from satellite and feed to LNBC. L band output from LNBC will go to modem. The IP interface of the modem will be connected to the existing system of BSC. Appropriate interfacing software has to be included for non IP based BSCs. Normal operational procedure takes place from BSC to MSC. BSC routes the call to PSTN via MSC. From disaster safe site, the command response will take normal operation from MSC to BSC. BSC to satellite modem is connected by IP interface. The modem will convert the signal to L band and feed to the block up converter (BUC). The BUC convert the L band to Ku band and transmit to the satellite. At the disaster site, the antenna will receive the signal and feed to the low noise amplifier and convert from RF frequency (11.45 to 11.7 GHz) to L band. L band signal will be given to satellite modem. The IP interface of the modem is connected to the GSM BTS-SAT terminal. Typical usage scenarios of the GSM pico BTS SAT terminal is shown in Fig. 7.

E. Link Budget Results of Proposed System

Link budget is done based on Thaicom5 [8] Ku band transponder parameters. Link budget calculation result is shown in Table I, II, III, IV and V.

TABLE I
CALCULATED RESULTS FOR SATELLITE INTERFACE UPLINK PARAMETERS

Parameters	BTS to BSC	BSC to BTS	Unit
Uplink frequency	14.25	14.35	GHz
Uplink antenna diameter	0.9	2.4	m
Uplink antenna aperture efficiency	0.65	0.65	
Uplink antenna transmit gain	40.69	59.27	dBi
Uplink antenna, power at the feed	1	10	W
Uplink EIRP	40.69	59.27	dBW
Range	36000	36000	km
Uplink path loss	206.65	206.71	dB
Uplink pfd at satellite	-121.43	-102.85	dBW/m^2
Bandwidth	111000	1777000	Hz
Satellite G/T	0	0	dB/K
Uplink C/N0	62.63	81.15	dBHz

TABLE II
CALCULATED RESULTS FOR SATELLITE INTERFACE DOWNLINK PARAMETERS

Parameters	BTS to BSC	BSC to BTS	Unit
Downlink frequency	11.25	11.67	GHz
Downlink receive antenna diameter	2.4	0.9	m
Downlink receive antenna aperture efficiency	0.65	0.65	
Downlink system noise temperature (antenna + LNA)	100	100	K
Downlink receive antenna gain	47.15	38.95	dBi
Downlink receive antenna G/T	27.15	18.95	dB/K
Downlink satellite EIRP	15	33	dBW
Downlink path loss	204.59	204.9	dB
Downlink C/N0	66.15	75.63	dBHz

TABLE III
CALCULATED RESULTS FOR LINK MARGIN

Parameters	BTS to BSC	BSC to BTS	Unit
Uplink C/interference	28	28	dB
Uplink C/N0	62.63	81.15	dBHz
Satellite C/intermod	21	21	dB
Downlink C/N0	66.15	75.63	dBHz
Downlink C/interference	28	28	dBHz
Total link C/N0	60.45	73.84	dBHz
Required C/N0	58.07	70.11	dBHz
Link margin	2.38	3.73	dB

TABLE IV
CELL INTERFACE LINK CHARACTERISTICS

Transmitter characteristic	**Downlink**	**Uplink**	**Unit**
Transmitted power	6	2	W
TX antenna gain	17.42531	0	dBi
losses	-2	-1	dB
Transmitter EIRP	53.20682	32.0103	dBm
Receiver characteristics			
RX antenna gain	0	17.42531	dBi
RX sensitivity	102	104	dBm
losses	-2	-2	dB
Diversity gain	0	3	dB
Total receiver gain	101	122.4253	dB
System gain	154.2068	154.4356	dB
Margins			
Coverage probability (cell edge)	0.9	0.9	dB
Shadow fading std deviation	6	6	dB
Shadow Fading Margin	7.5	7.5	dB
Total margin	7.5	7.5	dB
Allowed propagation loss	141.7068	143.9356	dB

TABLE V
CALCULATED RANGE (OKUMURA-HATA PATH LOSS MODEL)[11]

Parameter	Value	Unit
Carrier frequency	900	MHz
BTS antenna height	10	m
MS antenna height	1.5	m
Cell range	1.418101	km

F. *Major specifications of the proposed System*

BTS site

Satellite interface specifications:

Parameter	Modem	BUC	LNBC
Output frequency	950 to 1450 MHz	14.0 to 14.5 GHz	10.95 to12.75 GHz
IF frequency		950 to 1450 MHz	950 to 1450 MHz
Data rate	128 kbps		
Modulation	8PSK		
Coding	Convolution/RS		
Output power		6 Watts	
Network interface	V.11/V.35/V.24/ G.703/IP		

Cell interface specifications:

Parameter	Value	Unit
Transmitted power	6	W
Cell range	1.418101	km
height	10	m

BSC site

Satellite interface specifications:

Parameter	Modem	BUC	LNBC
Output frequency	950 to 1450 MHz	14.0 to 14.5 GHz	10.95-12.75 GHz
IF frequency		950 to 1450 MHz	950 to 1450 MHz
Data rate	10 Mbps		
Modulation	8PSK		
Coding	QPSK/OQPSK Rates 1/2, 3/4, 7/8, k=7 RS coding		
Output power		50 W	
Network interface	RS232, G.703, Ethernet IP		

BSC interface specifications:

Parameter	Value	Unit
Data interface	IP	
Interface port	RJ45	
Data rate	10	Mbps

IV. CONCLUSIONS AND FUTURE WORK

The different interfaces in GSM network were studied and suitable interface for satellite link was selected. A suitable GSM BTS-SAT terminal was proposed for the disaster applications. Literature survey of Abis protocol stack is done and suitable protocol stack for Abis interface over satellite is proposed for disaster scenario in Myanmar. The architecture retains maximum interoperability with the existing telecom hardware. Link margin is calculated at both cellular interface and satellite Interface. The design parameters are proof by getting sufficient link margin (2.38 dB for BTS to BSC and 3.73 dB for BSC to BTS), which is acceptable. Implementation specifications were provided. As the future work, the study can be extended to provide coverage over the satellite for other cellular standards like CDMA, UMTS, Wimax etc.

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