Development of Integrated and Transportable Communication Terminal Using GSM and WiFi over Satellite for Emergency Communications

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This paper presents the development of a compact, ruggedized satellite terminal, to be used for communications in emergency situation. The terminal provides GSM coverage in disaster area, where existing communication infrastructure is destroyed or overloaded. It uses GSM backhauling over satellite to transport GSM signalling and data traffic to the core GSM network infrastructure in the disaster-safe area. Additionally, basic data services such as HTTP web browsing and email are also provided via WiFi access.

Nomenclature

BGAN = Broadband Global Access Network
WAT = WISECOM Access Terminal
WLAN = Wireless Local Area Network
TSGS = Terminal Side GSM Server
NSGS = Network Side GSM Server
MOGIS = Mobile GSM Infrastructure

I. Introduction

Disasters often come along with the destruction of the local telecommunication infrastructure (provided that this infrastructure existed beforehand) causing severe problems for rescue operations. Satellite communications is then the only communication means for the rescue teams.

Today costly satellite telephones with low data rates are used in the early disaster phase (usually several hours after the disaster). In order to quickly restore the local mobile communication networks (GSM or 3G) with higher data rates, more complex satellite communication terminals (up to container size with several hundred kilograms) are available, which connect local base stations via satellite to the core network. Transportation and installation of these satellite terminals take usually up to several days.

The WISECOM (Wireless Infrastructure over Satellite for Emergency Communications) project[1], co-funded by the European Commission under the 6th Framework Program, aims at the development and first demonstration of a rapidly deployable lightweight, satellite-based communication infrastructure, which can be easily transported by one person and can be installed within minutes. The communication infrastructure consists of small, rapidly deployable, terrestrial base stations (GSM, WLAN, WiMAX), which are connected to the public telephone network and to the Internet via satellite.

The system supports voice and data communications for the rescue teams and it also provides a local GSM or 3G communication infrastructure for the victims in the disaster area. The WISECOM system is available in two versions which use two different satellite technologies: one for early deployments (with Inmarsat BGAN) and another one for the disaster recovery phase (with DVB-RCS).

The paper will be structured as follows. An overview of the WISECOM project has been shortly given in this section. Description of the architecture and the design of the communication terminal to be developed will be given in Section II and Section III for GSM and WiFi respectively. Design-related issues will be discussed, in particular the ones related to the choice of system components that can satisfy certain QoS requirements with stringent limitations on size, weight, available capacity and power. It will be followed in Section IV by a discussion of the integration of the GSM and the WiFi. The overall system shall be integrated into a compact, lightweight form, fit into one rucksack, and very simple to install and operate.

Some tests will be performed on the realized system based on the outlined procedure given within the framework of WISECOM, which include configuration, basic service, performance, and load tests. The test procedures and results are presented in Section V. Section VI concludes the paper.

II. GSM over BGAN Development

To provide voice and basic data services such as SMS or GPRS, WISECOM considers the use of GSM over BGAN technology to be implemented in the WAT. The global system architecture is depicted in the picture below:

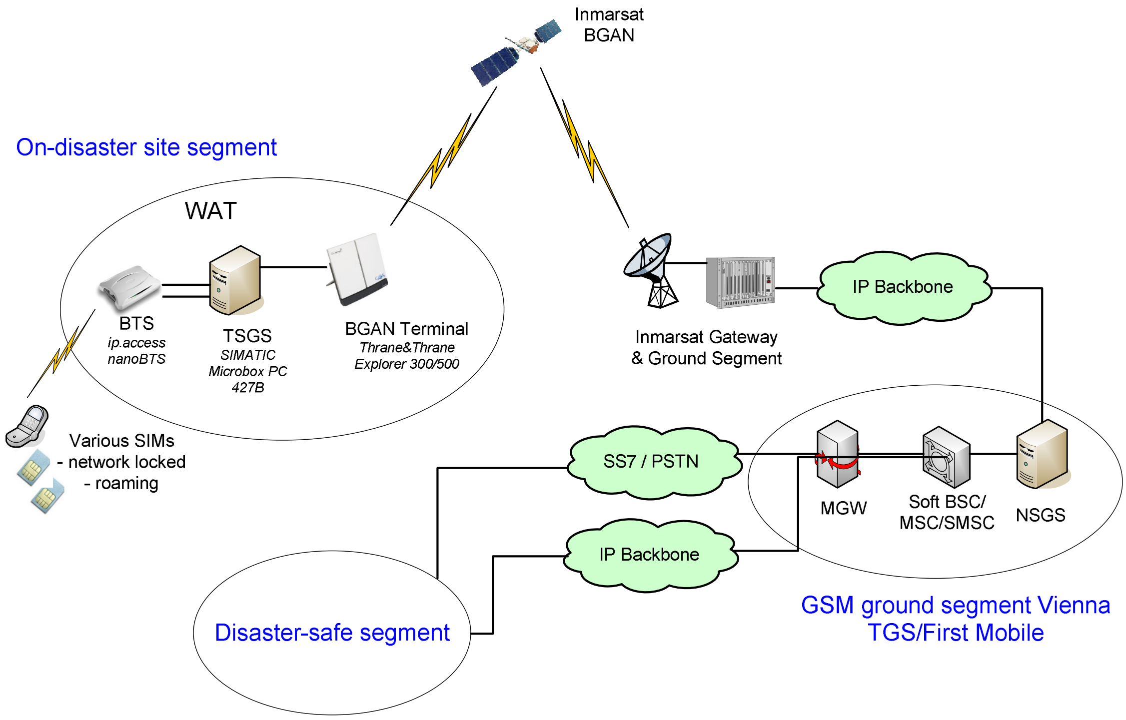

Figure 1. GSM over BGAN system architecture

The concept was first developed within the WirelessCabin project[4] and has been further developed into a mature product by TriaGnoSys, so far commercially implemented in the aeronautical domain. The idea is to breakdown the signaling and the data communication between the GSM BTS (Base Transceiver Station) and the BSC (Base Station Controller). The BTS performs encapsulation of GSM packets (signaling and data) into IP packets. The GSM packets are later recovered by the NSGS (Network Side GSM Server), forwarded to the BSC, and switched to the core network elements.

The TSGS is basically a ruggedized industrial computer running TriaGnoSys' Mobile GSM Infrastructure (MOGIS) software which performs the following functions:

- Satellite bandwidth on demand: the software requests dynamically the required bandwidth in the satellite modem, and when there is no more resource available, the incoming call will be blocked.
- BSC signaling suppression: TSGS and NSGS suppress most GSM signaling messages which are sent periodically to minimize the satellite usage and required bandwidth.
- Codec selection and IP compression: To efficiently utilize the scarce satellite resource, the TSGS supports different types of voice codecs to reduce the size of the voice packets. Both GSM full-rate and Adaptive Multirate narrow band (AMR-NB) with rate as low as 4.75 kbps are supported. Further decrease in the transmission bit rate is achieved by robust IP/UDP/RTP header compression.

Other functions such as Quality of Service (QoS) support, GSM BTS automatic control functions, GSM service selection, and network management are also supported.

One of the WISECOM user requirements[2] states that the WISECOM Access Terminal (WAT) should be light and reduced in dimensions / volume. The requirement puts a stringent limitation on the choice of the subsystems to be put in the WAT.

The chosen technology for the BTS is ip.access nanoBTS[5]. It provides coverage of approximately 350 meters with full power in open space. 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.

The foreseen satellite solution to be used is the Inmarsat BGAN (Broadband Global Area Network) technology. BGAN provides data and voice services globally via its 3 satellites. As of 2007, there are two operating satellites, with the coverage shown in Figure 2 (the two satellites in the middle). The third satellite is scheduled to launch in 2008[6]. For the WAT, only data service is of particular interest.

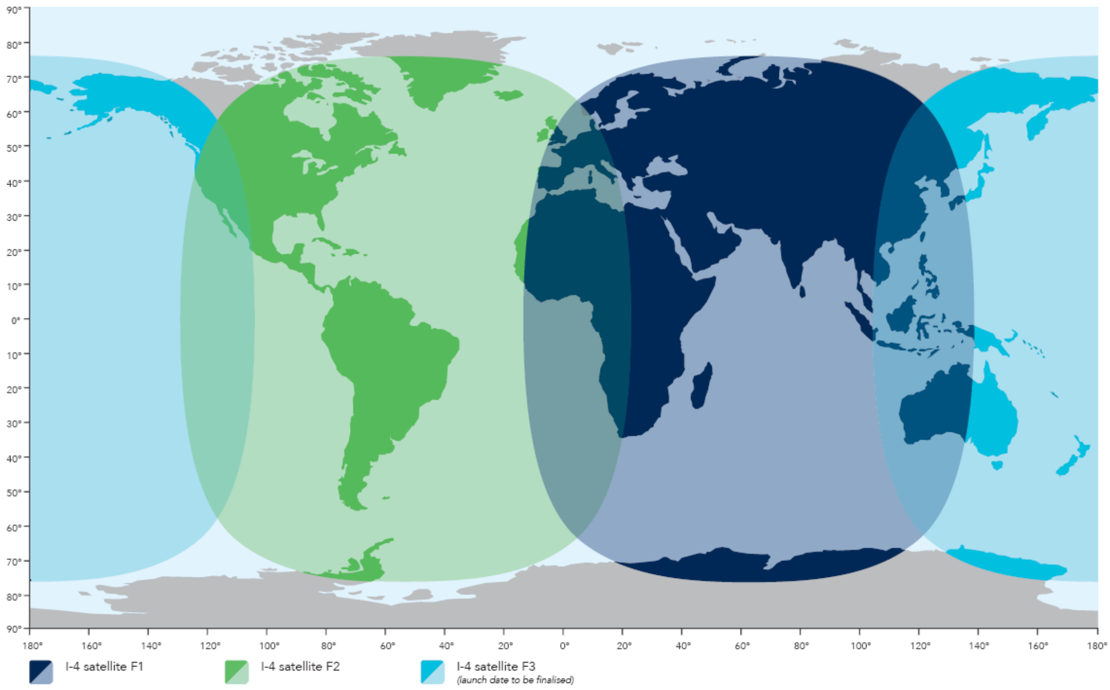

Figure 2. Inmarsat I-4 coverage

There exist different types of terminal to access the satellites[7]. The Thrane & Thrane Explorer 300 and Explorer 500 are the ones found to have reasonable trade-off between performance and dimension (size and weight). The small size of the satellite terminal limits the maximum data rates that can be achieved in the satellite link. The usage of the scarce bandwidth resource is managed through the usage of traffic classes. There are two types of class that could be opened for data communication: streaming and background class. The streaming class gets higher priority and ensures that constant data rate is available to the user. The Explorer 500 terminal is capable of providing streaming class connections up to 128 kbps. Users are charged based on the time spent on the connection. The rest of the satellite channel capacity is assigned to the background class. Here the available bit rate may vary, and the user is charged based on the volume of data transferred on the satellite link. Figure 3 displays the three main components of the WAT, namely the GSM base station, the industrial PC, and the satellite modem. The displayed scale serves only to show approximate dimension. The three components weigh approximately 5 kg.

Figure 3. GSM over BGAN subsystems: GSM nanoBTS, ruggedized PC, and BGAN terminal/modem

III. Provision of Data Services via WiFi

Figure 4 displays the general overview of the WiFi over BGAN system architecture developed in the framework of the WISECOM project.

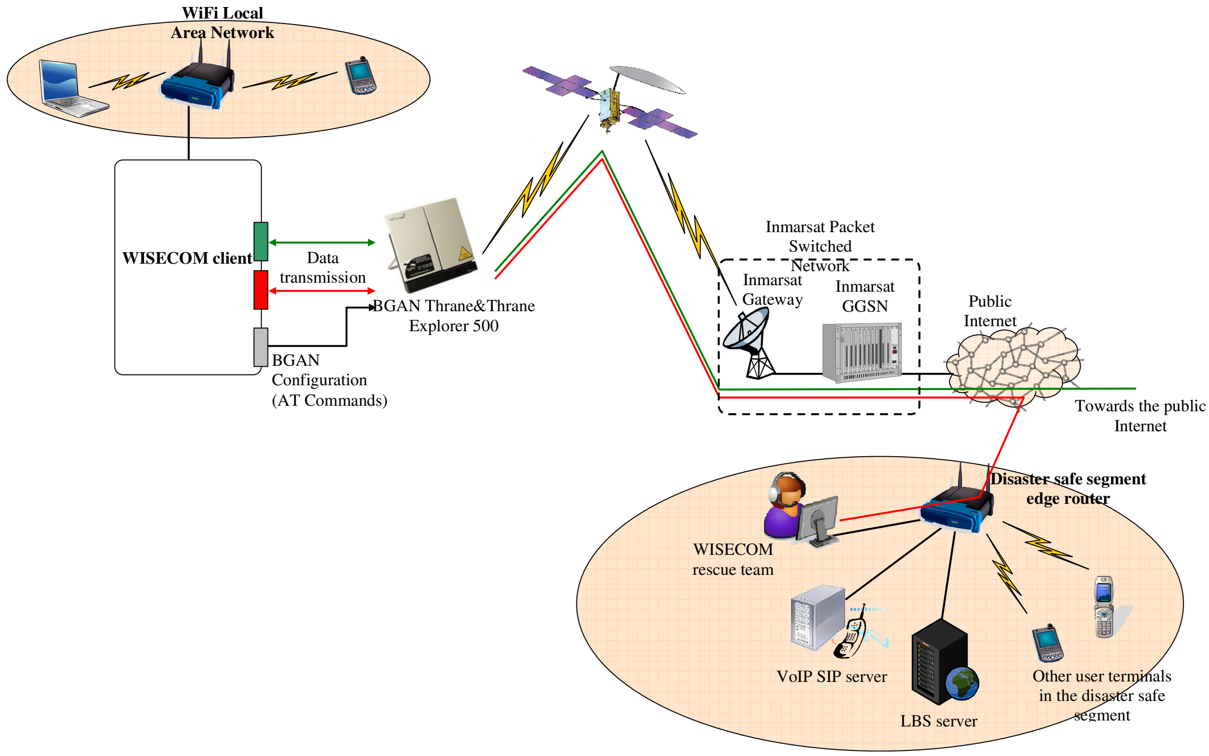

Figure 4. WiFi over BGAN system architecture

The architecture is composed of the WISECOM Access Terminal (WAT), encompassing mainly the WiFi router (Linksys WRT54GL with DD-WRT firmware), the WISECOM client and the BGAN terminal.

At the interface between the WISECOM client (WC) and the BGAN terminal, several virtual interfaces (potentially using the same physical interface), can be supported for data transmission. These virtual interfaces will be associated with IP tunnels carrying IP datagrams from the WAT to the Control Center in the disaster-safe segment, or directly to the public IP networks.

Authentication and authorization of users is done via a RADIUS server. It provides the rescue team members having specific credentials (username, password) with unlimited access to all IP services, and limits access by all other authenticated users only to HTTP service, including a specific web page giving all information relevant to the ongoing disaster.

The WISECOM client also supports traffic management and prioritization thanks to built-in tools (Linux tc command) performing traffic classification, traffic shaping, and implementing different queuing, dropping, and scheduling strategies

In addition, the WC performs cache and proxy for optimal use of the limited satellite link bandwidth, dynamically manages the satellite connection (using the satellite modem's AT commands) according to the amount of traffic to carry over the satellite link, supports different HTTP proxy servers managing the WISECOM emergency web page, accessed by default by the different users in the WiFi public domain and prior to login, the database of users allowed to connect to the system, and the state of the VoIP connections running over the system.

Finally, VoIP functionalities like voice over IP calls, voicemail, and voice conference are provided using Asterisk VoIP server[8].

IV. Integration of GSM and WiFi into the WAT

One important challenge in the integration between the GSM and the WiFi component of the WAT is the software integration. The main focus is on the QoS and network management since other features like security and data compression can be implemented separately in each module without interfering one another. The GSM and the WiFi module each has its own mechanism to guarantee QoS, namely via the MOGIS software in the GSM part, and via internal Linux tool in the WiFi part. The WiFi traffic management tool may alter the way the traffic is routed between the GSM base station and the satellite modem. However this should not produce much impact as long as the highest priority is still given to the GSM traffic.

Another issue is the mechanical integration. This includes the packaging of all the aforementioned system components into a compact and ruggedized case that can be carried by one person. All WAT devices except the BGAN terminal can be mounted permanently inside a housing case. The BGAN terminal with integrated satellite antenna must be operated outside and directed to the satellite. For example, clamps could be provided on the top of the WAT box where the BGAN terminal can be snapped in. Several alternatives of ruggedized case are shown in Figure 5.

Flat suitcase Plastic box Custom made box

Figure 5. Alternatives for mechanical packaging

NiMh rechargeable batteries are used as the power source for the WAT. 20 cylindrical cells, 1,2V 15Ah each, will be assembled to a 24V 15Ah battery with a weight of 5kg. The weight of a comparable set of Lead-Acid batteries is at least 75% higher.

Assuming that the Wireless Communication devices (BGAN terminal, WiFi access point, GSM BTS) will not work in transmit mode all the time, an average DC current of less than 4,5A drawn from a 24V battery can be expected. Under these assumptions, the selected battery pack will enable up to 3 hours of service time.

V. System Test Procedures and Results

The test can be classified into several groups: configuration and network functionalities, basic service, performance, and load tests. Configuration tests are carried out to simply confirm that all configurations in different network entities are correctly set. Basic service tests include the tests to check that the WAT is able to perform the services it offers, including GSM and voice over IP call tests, SMS, web browsing, and restrict the access to the network for authorized users only. Performance and load tests are done to check the quality of service the system provides in normal and loaded operations respectively.

Concerning the GSM component, all basic functionalities - voice, GPRS data, SMS - have been successfully tested in the particular configuration of the emergency WAT. As the GSM component is largely based on TriaGnoSys' MOGIS software/product that is already commercially used, basic test procedures are not further discussed herein. However it should be stated that a number of tests have been performed to verify in particular the performance and quality of voice calls over the particular BGAN modem, and to verify the support of several concurrent voice calls, depending on the GSM codec used. According to the MOGIS specifications, both native AMR and FR (the latter via transcoding into AMR) codecs allow to have concurrent calls.

In the WiFi part, all network functionalities and services presented in Section III have been successfully implemented and tested. VoIP calls from users connected to the WAT (via WiFi) to users connected to the control center or users in the PSTN have been carried on. One bi-directional voice calls used roughly 64 to 80 kbits per second of bandwidth over the satellite link, with silence detection.

In addition, Location Based Services (LBS) developed by partners in the WISECOM project for the tracking of members of rescue teams on the disaster area and the localization and triage of victims have also been successfully tested over the WiFi over BGAN telecommunication platform set up for the WISECOM demonstration.

Finally, Figure 6 illustrates how the WAT is able to reserve bandwidth over the satellite link according to the characteristics of the different traffic flows and to support Quality of Service (QoS).

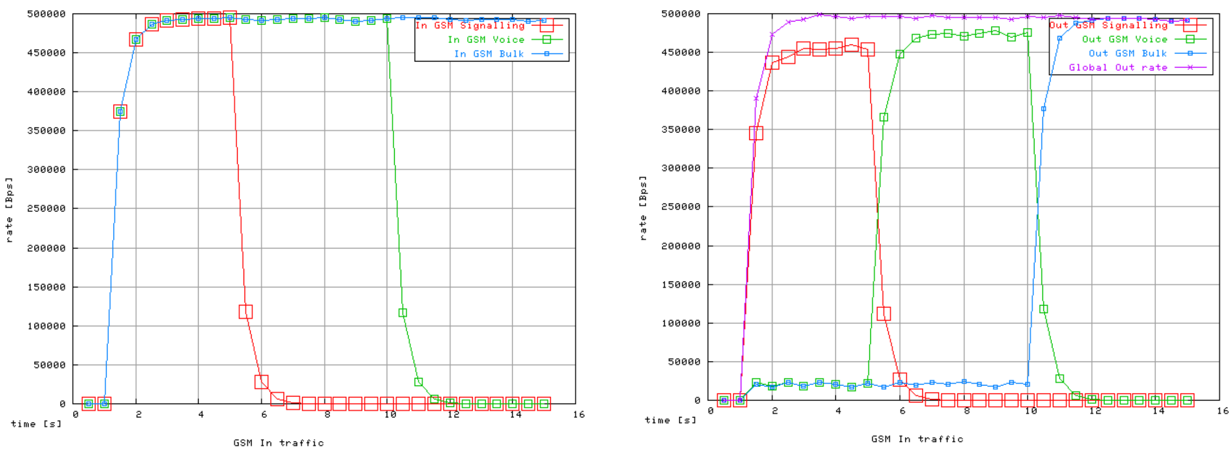

Figure 6. Test input (left) and output (right) traffic for QoS support

The left figure shows the rates of the different types of traffic arriving from the local access domain to the WAT whereas the right figure displays the rate of the traffic transferred over the satellite interface.

Initially, the WC receives signaling traffic, voice traffic and data traffic at the same rate, 500 kbps. The QoS ensures the 4% of the bandwidth at the output of the WAT is reserved for each category of traffic. The rest of the bandwidth is allocated using priorities. As the signaling traffic has the highest priority, it takes the entire remaining bandwidth. At time t = 6s, signaling traffic disappears, and then the GSM voice traffic takes the remaining bandwidth. Data traffic continues at the ensured rate (4% of the bandwidth available over the satellite link), since it has the lowest priority. Finally, at time t = 10s, GSM voice traffic decreases and data traffic uses all the available bandwidth over the satellite link.

VI. Conclusion

The design and development of the WISECOM access terminal (WAT) have been presented. The test results from both the individual GSM and WiFi system have shown the capability of the WAT to provide voice and data services over satellite backhaul link.

The WISECOM project is now approaching its end, and a demonstration which involves disaster simulation in the area around DLR facility in Germany has been planned on the 28th of May 2008. The demonstration will show a first prototype of the WISECOM system. In the demonstration, which is supported by the regional authorities for civil protection, fire brigades and emergency physician will use and test the demonstrator for the first time in realistic disaster training.

References

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