Broadband Services and Applications through Integrated Wireless Networks

Massimo Celidonio
Fondazione Ugo Bordoni
Rome Italy

and

Giovanni Nicolai
Aersat SpA
Rome Italy

ABSTRACT

Telecommunication systems based on wireless technology (Wi-Fi, WiMax, Sat DVB-RCS, etc.), in particular circumstances, offer more than others systems, the opportunity to provide a wide range of broadband services and applications. Two kinds of applications where these systems are of particular interest are: for communication restoration during emergency and catastrophic events and in rural suburban areas typically affected by “digital divide”.
In this context, this paper, presents an unique integrated wireless network system, mainly based on TCP-IP protocol, which provides a wide range of applications like voice, video, internet browsing, data access, etc.

1. COMMUNICATION NETWORK ARCHITECTURE

The main characteristics of an integrated satellite and terrestrial communication network (see figure 1), capable to provide broadband emergency services for fixed and mobile users with high availability are:

- The system shall interoperate with existing terrestrial wireless networks (2G, 3G, WiFi/WiMax, Tetra, IP, etc.)
- The entire system shall allow coexistence of star/mesh satellite networks operating with transparent or re-generative transponders based on hub gateways interconnected with terrestrial networks.

Wireless and Satellite Network integration

The Integration of Wireless and Satellite Technologies offers the opportunity to fill the gap as far as the following circumstances are concerned:

- Network Restoration due to Emergency and Catastrophic Events
- Digital Divide Reduction for Rural Suburban Areas

To this aim and to guarantee the possibility, for large communities of users, to access to IP applications and services on broadband networks, the Wireless Network Architecture shown in figure 2 has been considered. The main blocks of this architecture are:

- Wireless Access and Distribution Network (WADN)
- Satellite and Wireless User Terminals (SWUT)
- Satellite Network Access Point (SNAP)
- Mobile Integrated Station (MIS)
- Service Centre (SC)

A detailed description of these blocks will be given in the next paragraphs.

2. APPLICATIONS AND SERVICES FOR THE EMERGENCIES

As far as the catastrophic events are concerned they are managed according to the following phases:

Phase 1) - during event: human and technical resources engaged for first aid;
Phase 2) - after event: communication resources restoration and management.

In phase 2, the restoration of the communication interoperability between involved areas is a primary objective. A multi purpose wireless IP network is able to guarantee a wide range of services, exactly where they are essential, in very short times. Typical applications are:

- IP Audio/Video communications by satellite via a mobile terminal between emergency areas and a central telecommunication gateway;
- IP Audio/Video communication in the emergency areas via WiFi/WiMax access points integrated in the mobile terminal and/or via TETRA and GSM networks;
- Localization and positioning management (closed and open loop). Maps transfer service performed by the mobile terminal;
- Human Health Monitoring HHM (life parameters) involved in hazard operations;
- Internet browsing, database access, file transfer and file sharing;
- Hospital Receptivity Information (HRI)

Security Aspects

Security parameters of each service have to be carefully designed. An optimal compromise between network performance and exchanged information security level must be found to increase the network availability and usability.
Emergency and security operating procedures, developed and standardized in national and international contests, will be implemented in this multi purpose network, to allow high multi-systems interoperability grade.

3. APPLICATIONS AND SERVICES TO REDUCE THE DIGITAL DIVIDE

The digital divide is still present in industrialized countries where the regional topography (rural and mountain areas) does not allow fast communication infrastructures such as fibre optic or ADSL technologies, capable to provide broadband services. In these cases the broadband service demand can be granted by the use of wireless technologies which do not require large investment cost and long times for the implementation.

The following wireless technologies could be applicable for the above mentioned cases:

- DVB RCS satellite technologies constituting the network backbone between rural areas and the tlc gateway;
- Wireless Local Loop, WiFi, HiperLan and WiMax technologies for the broadband service local distribution;
- Terrestrial Digital TV for downlink channel distribution

The DVB RCS satellite terminals can provide data access up to 38 Mbps in download and up to 4 Mbps in upload.

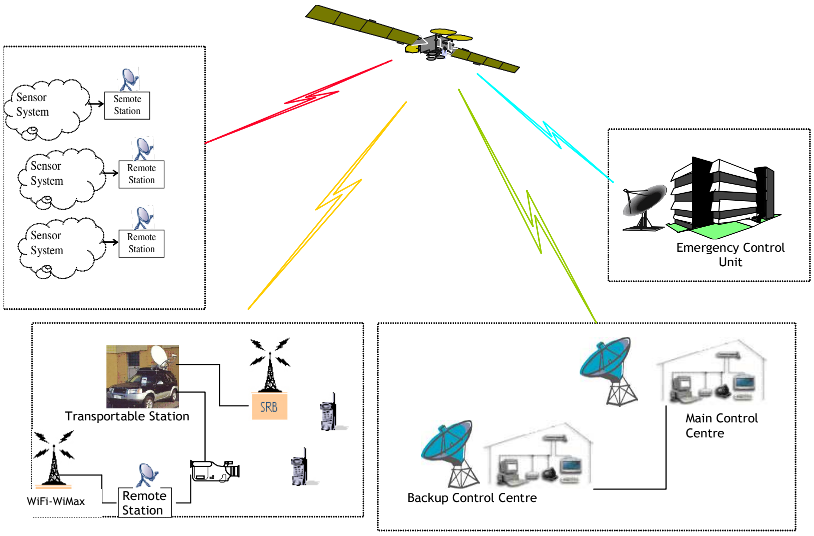

Figure 1 Communication Network Block Diagram

this data rate capability can allow the implementation of the following services:

- Administrative Management Services
- Emergency Services
- Service distribution to the user demand via WiFi-WiMax technologies

The applicable technologies and standards to be utilized are:

- Satellite Technology - DVB-RCS Standard
- Wireless WiFi, HiperLan Technologies - (802.11b,g,h a 2,4 GHz; 802.11a, HiperLan a 5GHz) Standard
- Wireless WiMax Technology - 802.16-2004 Standard
- Terrestrial Digital TV - DVB-T Standard

The broadband data services shall be based on a unique standard protocol TCP/IP and the useful data rate should be: 50 Mbps for Base Station and 10 Mbps for User Terminal .

4. WIRELESS NETWORK ELEMENTS

The Main Wireless Network Elements of a Broadband Telecommunication Network for disaster events and digital divide reduction are the following:

- Satellite Network Access Point (SNAP)
- Wireless Access and Distribution Network (WADN)
- Satellite and Wireless User Terminals (SWUT)

The functions of these Wireless Network Elements are described in the following.

Satellite Network Access Point (SNAP)

An emergency or rural satellite network shall be a mixed of different architecture/technologies in order to be flexible during the deployment to the different situations. Transparent and/or re-generative satellite could be used jointly with star and/or mesh network technologies for ground/user terminals.
The main criteria are:

- The star network shall provide connections between user terminals and Hub station via a single satellite hop. The Hub Station shall be co-located with the telecommunication gateway and interconnected to the terrestrial network;
- The mesh network shall interoperates with terrestrial networks with a single satellite hop between user terminals, each one interconnected with the terrestrial network;
- The satellite network shall be designed to be interconnected to the existing Telco infrastructures which will grant broadband connectivity with Telco gateways.

The main satellite networks elements of a SNAP will be:

- Satellite Network Control Centre (SNCC);
- Satellite Network Traffic Station (SNTS) usually named Hub Station;
- Telco Network Gateways (TNG) co-located with the SNTS.

The SNCC and the SNTS are normally co-located in the Satellite Operator Centres and provide three main functions:

- The Satellite Network Control
- The Traffic Management
- The connections between the User Terminals (UT) and the Telco Network Gateways (TNG).

The SNCC and SNTS do not need to be allocated in the Recovery areas but these are existing facilities providing a fast access to the TLC Network via the Service Network Elements (SWUT, MIS and SC).
The standardized technology for SNCC-SNTS stations is the DVB RCS providing a DVB IP download channels bit rate of 38 Mbps and an upload return channels max bit rate of 4 Mbps. The DVB IP channel is a TDM carrier while the RCS access is performed in TDMA in order to allow the connection to the SNCC-SNTS Station for hundreds of User Terminals.

Wireless Access and Distribution Network (WADN)

The WADN is the access and distribution network we propose, as far as the very attractive solutions of WiFi and WiMax technologies are concerned. It will be detailed in the following sections.

Using WiMax technology - While many technologies currently available for fixed broadband wireless can only provide line of sight (LOS) coverage or, alternatively, have good building penetration performance but small coverage area, the technology behind WiMax has been optimized to provide excellent, large, non line of sight (NLOS) coverage. WiMax's advanced technology, just following the preliminary technical features declared by manufacturing companies, provides the best performances in any of the above mentioned link conditions – large coverage distances of up to 50 kilometres under LOS conditions and typical cell radii of up to 5 miles/8 km under NLOS conditions.

Network Elements The standard BS will be equipped with:

- Basic WiMax implementation;
- Standard RF output power for a lower cost BS.

<u>The full featured BS will be equipped with:</u>

-Higher RF output power than standard BS;

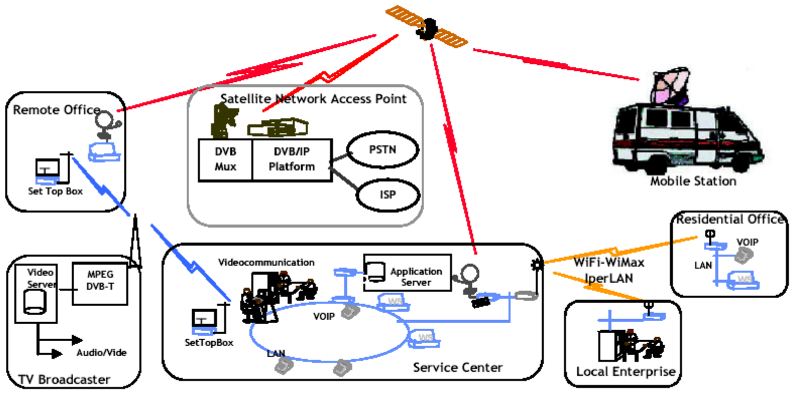

Figure 2 – Satellite and Wireless Network Architecture

- Tx/Rx diversity combined with space-time coding and MRC reception;
- Sub-channelling;
- ARQ.

Both the standard and full-featured base stations can be WiMax compliant, however the performance that can be achieved by each is quite different.
Table 1 shows the amount of differentiation between the two different types, for a reference system configuration.

Assumptions		Frequency: 3.5 GHz Bandwidth: 3.5 MHz Per 60^0 sector	Full featured		Standard	
			From	To	From	To
Cell radius (km)	LOS		30	50	10	16
	NLOS(Erceg-Flat)		4	9	1	2
	Indoor self-install CPE		1	2	0.3	0.5
Maximum throughput per sector (Mbps)		Downlink	11.3	8	11.3	8
		Uplink	11.3	8	11.3	8
Maximum throughput per CPE at cell edge (Mbps)		Downlink	11.3	2.8	11.3	2.8
		Uplink	0.7	0.175*	11.3	2.8
Maximum number of subscribers			More		Less	

Table 1 – Standard and Full featured BS performances

It is important to understand that there are a number of options within WiMax that give operators and vendors the ability to build networks that best fit their application and business case.

WiMax/WiFi network connection module with gateway capabilities - WiFi hot spots are being installed worldwide at a rapid pace. One of the obstacles for continued hot spot growth however, is the availability of high capacity, cost-effective backhaul solutions. This application can also be addressed with the WiMax technology. And with nomadic capability, WiMax can also fill in the coverage gaps between WiFi hot spot coverage areas.
WiMax offers a useful throughput better than 60 megabytes per second (Mbps) in a 20-MHz channel. This is more efficient if compared with the 25 Mbps available in the standards 802.11 a or g. The quality of service of WiMax is also superior, thanks notably to more sophisticated control over transmission, which guarantees a good level for the services offered. Thus, there will be limited latency delays, which prove to be essential, for example, in transmitting Voice over IP. It also provides better security levels as, the final equipment, must be identified before being connected to the network.
However an aspect where WiMax excels is in its transmission capacity over a very large area of territory (a range of about 10 kilometres in rural zones). This feature clearly meets the needs of zones that are too far away and that cannot be connected to a fixed DSL network.
Moreover, the coverage offered is flexible. WiMax may be used to cover a remote zone in point to point or in an even more extended framework such as meshing.
These differences in performance must not incite us to jump to the conclusion that WiMax will replace WiFi. These two technologies should cohabit and complete each other. Additionally, the 802.16 standard will make it possible to interconnect WiFi hot spots.
We can add that WiMax technology should be substantially less costly than the one proposed today under proprietary systems. This is explained by the type of equipment used, as well as the competition among suppliers once the standard has been adopted.

WiFi ground signal distribution point - The WiFi (802.11b/g) radio signal is mainly a line-of-sight signal, meaning it doesn't bounce off things like walls, ceilings, or even the atmosphere, as some radio signals do. But it can get through some opaque objects like walls, ceilings, and floors under certain conditions.
Those certain conditions depend on how electrically dense the barriers are. A typical drywall wall between offices isn't normally a problem, but conduit, plumbing, or steel studs can increase the density. Going through several of these walls can defeat the signal quickly.
Radio power is measured in decibels (dBm), and a typical WiFi access point emits about 20dBm EIRP. Starting from this value it is possible to make a rough estimate of the area you can cover with an access point by simply adding up the value of the obstacles between the access point and the computer. The average office wall absorbs about 30dB and an average human soaks up to 15dB. If you add a reinforced stairwell or elevator shaft, you can see that the 20dBm EIRP doesn't last long.
A site survey is a requirement for any large WiFi installation where coverage is critical, because the improper placement of access points is expensive. For the typical small office, there is no need for fancy gear, or even special software. What you're trying to accomplish is to discover those areas that don't get a signal, and then try to position your access point to provide a signal to the "blind" spots.

5. SERVICE NETWORK ELEMENTS

The Main Service Network Elements of a Broadband Telecommunication Network for Disaster and Digital Divide Recovery are the following:

- Satellite and Wireless User Terminal (SWUT)
- Mobile Integrated Station (MIS)
- Service Centre (SC)

The functions of these Service Network Elements are described here below.

Satellite and Wireless User Terminals (SWUT)

The Satellite and Wireless User Terminal is shown in
Figure 3. This figure underlines the structure of the satellite terminal (Outdoor Unit -ODU- and Indoor Unit – IDU) and the IP interface (in this case a wireless device). The satellite terminal is a two way, bandwidth-on-demand broadband VSAT. The forward channel provides a total capacity of 60 Mbps, while return channel to the hub can transmit up to 4Mbps. For increase return channel throughput and reduce the satellite bandwidth employed to transmit, it use DVB-RCS system.

The feature of satellite terminal is showed in the Table 2.

Mobile Integrated Station (MIS)

The concept of a Mobile Integrated Station MIS is to bring communication broadband services in the Recovery areas either for emergency or telemedicine applications. A typical Mobile Integrated Station is shown in Figure 4. The MIS station is normally equipped with:

- Satellite Access to the SNCC-SNTS Station and to the TNG
- Wireless Access for Service Distribution for local users
- Audio/Video Recording and Encoding equipment
- VoIP gateway

Return Channel	
Format : MF-TDMA	
Symbol Rate: 156, 312, 625 Ksps, 1,25 , 2,5 Msps	
Turbo coding : DVB-RCS compliant	
Modulation: QPSK	
Forward channel	
Format: DVB/MPEG-2 TS, DVB-MPE for IP data	
Symbol rates: 2,5 to 36 Msps	
FEC: DVB compliant R/S and Convolutional	
Modulation QPSK	
Performance	
Protocols: TCP/IP,UDP/IP, IGMP, RIP, 1&2, IP QoS support	
TCP accelerator	

Table 2 Satellite and Wireless Terminal feature

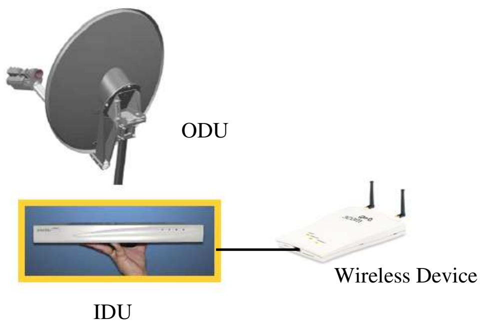

Figure 3 - Satellite and Wireless Terminal Layout

Typical offered applications are:

- Voice over IP VoIP
- Audio/Video Communications
- Emergency and Telemedicine Services
- News Distribution for Emergency

Figure 4 – Mobile Integrated Station Layout

Service Centre (SC)

The Service Centre (see Figure 5) is normally co-located in the Service Coordination Centres and allows the Access to standard DVB IP platforms capable to provide a wide range of applications. Typical offered applications are:

- Voice over IP VoIP
- Web TV e Business Television
- Distant Learning
- Emergency Services for Telemedicine
- Web Hosting
- Application Hosting
- News Distribution

Furthermore the Service Centre could include a Regia Centre (figure 6) where the Live Events Contributions via SNG Mobile Station can be collected and provided to local Broadcaster for Information Dissemination.

6. CONCLUSION

The architectures for satellite and wireless recovery networks capable to carry out broadband applications are day by day evolving due to three main factors:

- The service convergence to IP protocols
- The wireless evolution of WiMax technologies
- The satellite evolution of DVB RCS technologies

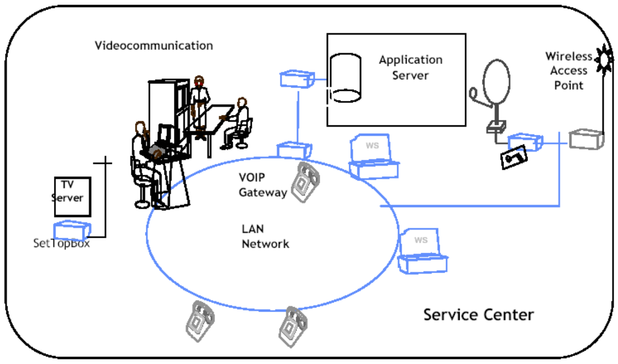

Figure 5 – Service Centre

There are a lot of examples of pilot networks already implementing the architecture and services described in this paper and for this reason the possibility to plan Recovery Networks for Emergency Communications and Digital Divide Reduction is nowadays a reality allowed by the wireless technology convergence and it could be carried out in short time and without large investment costs.

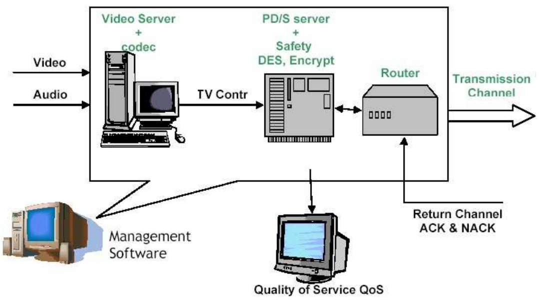

Figure 6 – RegiaCentre

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