Satellite Digital Multimedia Broadcasting (SDMB) system presentation

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Abstract
This paper presents an overview of the Satellite Digital Multimedia Broadcasting (SDMB) system, as studied within the European IST integrated project MAESTRO. The SDMB takes advantage of the satellite inherent capability to provide broadcast services over global coverage, to constitute an efficient way to serve mobile multimedia contents to a potentially unlimited audience.

The paper includes an introduction to mobile multimedia markets and explains how the broadcast will help the mobile operators to serve the mass market.

The main part of the paper is devoted to SDMB system description: services and delivery methods are first presented; then an example coverage for an European system is described. The key point of the low cost impact on the 3G mobile phone is justified, as well as the way the SDMB system interfaces with the mobile terrestrial networks. Later on, techniques to enhance the distribution reliability and capacity are pointed out. At the end, services personalisation, security aspects and the power saving management are underlined. The advantages regarding radio exposure aspects are outlined in conclusion.

Keywords
Satellite Mobile Multimedia Broadcasting 3GPP SDMB handset

I. INTRODUCTION

The introduction of multimedia services in mobile systems is of key importance for mobile operators to maintain the Average Revenue Per User (ARPU) in the coming years, since voice service revenues are expected to decrease over the next decade. 3G deployment is slower than expected, but the multimedia usage will push for 3G mobile phone generalisation. The effective development of the mobile multimedia market is nevertheless closely linked to critical conditions:

a) Interest of the mobile operators themselves, related to:

- Ability to control the services distribution
- Capability to differentiate their 3G service offer from the competitors, for both handset and vehicular market
- Compatibility of the new terrestrial infrastructure, if any, with the existing one
- Significant ARPU raise Vs investment

b) Multimedia services acceptance by end users, related to:

- Low traffic fees ideally comparable to Internet levels, which means roughly going from one Euro per minute to one Euro per hour, allowing to offer unlimited usage for a monthly subscription fee
- Service continuity over nation wide coverage in line with today's coverage for mobile voice communications
- Tailored content, adapted to mobile usage constraints and screen size

c) Media operators interest and willingness to produce and aggregate appealing multimedia services, linked to:

- Cost effective content delivery and nation wide coverage to maximise audience
- Protection against unauthorised content sharing
- Acceptable services revenues sharing agreement with the mobile operators
- Flexible billing system that includes subscription, bundle, pay per usage, etc.

Mobile Broadcast/Multicast technologies are clearly well positioned to meet some of the above challenges, since the one-to-many distribution mode is the most efficient way in terms of radio/network resources usage and cost to deliver data to a large audience [1]. Therefore, these techniques [2] are seen as an effective way to significantly increase the mobile system content delivery capacity. To complement other mobile Broadcast/Multicast solutions, the MAESTRO integrated project [3] is focusing on an architecture based on a satellite broadcast layer to enhance 3G and beyond 3G systems in the delivery of mobile multimedia broadcast services. The resulting hybrid architecture makes the most out of satellite and terrestrial technologies efficiency.

MAESTRO builds on several preliminary studies carried out under European Space Agency (ESA), European Commission (EC/IST) and French Space Agency (CNES) funding. It aims at defining the business model with representative partners acting in the multimedia business chain and to validate the system performances and implementation through engineering and trials [4] with major players from the mobile and satellite industry.

II. SYSTEM OVERVIEW

The purpose of the Satellite Digital Multimedia Broadcasting system (referred as SDMB in the rest of the document) is to

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provide a delivery capacity for several mobile operators to deliver cost effective streaming and data download services directly to mobile handsets. This is done over nation wide umbrella cells in both outdoor and indoor environments.

The system is designed to prevent introduction of constraints on the 3G cellular mobile phone or operational constraints to the consumer itself. In other words, it shall be as transparent as possible to 3G handsets with respect to cost, autonomy, form factor, aesthetics to maximise market penetration. These mobile phones will be equipped with extensive storage that allows the consumption of previously cached content at an opportune time. SDMB also aims to offer live content streaming as well as emergency notifications, e.g. for disaster alert purposes.

The SDMB system is compatible with Multimedia Broadcast/Multicast Service (MBMS), and as such open to the end-to-end framework defined by the Open Mobile Alliance (OMA).

It is assumed that at the time of deployment of the SDMB system, most mobile mobile phones will be able to operate on both 2G and 3G types of networks. Conversely, the 3G mobile networks will most likely be limited to urban areas. The SDMB system is compatible of both 2G and 3G networks to be able to offer its services everywhere.

The system relies on a hybrid satellite & terrestrial repeaters infra structure operating in the IMT2000 core frequency band allocated to Mobile Satellite Systems, as shown in next figure:

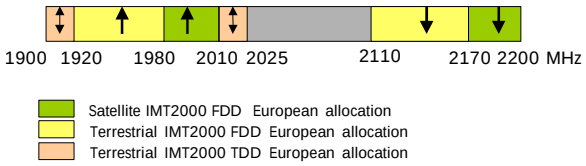

Figure 1: Satellite band adjacent to terrestrial band for IMT2000 systems

It makes use of the UTRA FDD WCDMA waveform in full compliance with the relevant 3GPP standard to allow a very low cost impact on the 3G handset bill of material. The system relies on very high power geo-stationary satellites able to overcome indoor penetration constraints in rural areas.

III. USER EXPECTATIONS & SERVICES

In the scope of MAESTRO, the University College of London has conducted focus groups to interview people about what they like or dislike in their mobile phone, and what they expect from it in a near future.

The result shows that more than anything mobile consumption of multimedia content has to be inexpensive as people are already wary of the cost of their mobile communication. It is crucial that it must not interfere with people's communication needs and patterns in order to be a success. Also, battery life is a key concern to people on the move.

Overall, the participants were very interested in following multimedia content on their mobile phones especially content that would be comparably short. This matches findings of a study conducted in Finland [5] where participants were usually using mobile television services for less than 10 minutes.

In terms of services news is wanted more than anything else. News fits with the concept of mobility because of its brevity, appeal to peoples' desire of being up-to-date, and its relevance to being mobile in the form of traffic news.

Users are also very interested in being notified about disasters that can affect them, based on their own location.

MTV services are also popular options especially among the young people.

Note that live sports are not as appealing to people as one might expect because people prefer to share emotion behind large TV set screens.

IV. DELIVERY METHODS

The multimedia content is conveyed to the 3G handset through a direct satellite distribution link using 3GPP standard technology using IMT2000 mobile satellite band. Service management and interactivity use mobile network point-to-point capability. Local cache can be used to store the content procuring the user with a look-and-feel of quasi-on-demand service.

Basically, two delivery methods are implemented: download and streaming.

Download services optimise the bandwidth usage over the whole day duration and maximise the satellite broadcast content delivery capacity: local storage can be filled at any time of day and regularly updated with cache management techniques providing mobile operators with an increased content delivery capacity. In each mobile phone, only those contents with a potential interest for the user are processed at physical level and stored to be available upon user's request.

Streaming services are delivered using also the satellite link by pre-empting the capacity allocated to download services.

Service interactivity is achieved at two levels:

- The local storage enables immediate interactivity and contributes to decrease the access time resulting in an enhanced perceived Quality of Service; the local storage can provide time-shifting service according to mobile phone capabilities.
- The terrestrial mobile network point-to-point capability provides service interactivity with the distant service centre, when local interactivity cannot serve the user's requests.

V. NATION WIDE COVERAGE

The European S-DMB system is designed to cover Europe with nation wide spot beams (~0.9° aperture). A spot beam corresponds to about 700 - 1000 km diameter cell and a European linguistic area. This gives the advantage to integrate a wide and scattered audience and significantly reduces the retail service fee.

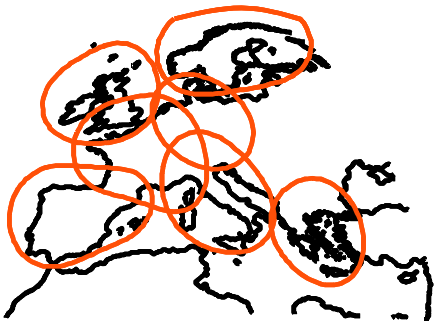

Figure 2: Example of European coverage

The system infrastructure will typically aim at an average availability greater than 95% in outdoor over the umbrella cell to address the 3G handset mass market. SDMB aims at achieving in building penetration through the use of a combination of several techniques operating at different layers of the air interface:

- Use of high power satellites, with large deployable antennas: depending on selected on-board configuration (from two to six spots), the range of EIRP per spot should be in the range 60-72 dBW.
- Specific reliable transport layer based on Forward Error Correction, interleaving and carousel techniques [6]. These will boost the error correction performance of physical layer coding scheme to overcome limited duration impairments.
- Terrestrial repeaters may be deployed to overcome some shadowed areas in dense urban areas. The system preserves the environment since the terrestrial repeaters are designed to be co-sited with 2G and 3G base stations.
- And optionally, selective retransmission using the 3G system point-to-point capability. User equipment powered-off, content not selected for local storage may justify the need for selective retransmission.

Even though a SDMB umbrella cell may cover several countries, the capacity can be shared by several national mobile operators and it is possible to support different language/cultural multimedia services on the same carrier.

As an evolution, it is envisaged to enhance the SDMB architecture to provide direct satellite return link for mobile phone in line of sight conditions, hence achieving the true anywhere and anytime challenge with a dependable infrastructure offering point to point service capability via satellite over permanent or temporary zones not covered by the terrestrial networks [7]. This would allow to support voice and messaging capabilities for security-related applications.

VI. LOW IMPACT ON 3G USER EQUIPMENT

Two designs are considered for introduction of SDMB features in a 3G mobile phone:

- The basic 3G mobile phone activates SDMB features as a background task in order to allow terrestrial mobile network operations without requiring an additional WCDMA reception chain. In this mode, the ability to receive paging messages, SMS or to set-up a connection is preserved, while the discontinuous satellite signal reception results in a compound signal blockage taken into account in reliable transport layer dimensioning.
- The enhanced 3G mobile phone includes a dedicated WCDMA reception chain for SDMB and then ensures continuous reception of the SDMB flow, whatever the 3G activity.

The SDMB features to be implemented on the MBMS compliant mobile phone are then basically limited to:

- Extension of the frequency agility to the IMT2000 satellite downlink frequency band enabling reception of the dedicated SDMB downlink carriers.
- Possible augmentation of the number of rake fingers to ensure optimum reception.
- Configuration of the UMTS/MBMS protocol stack to take into account the uni-directional nature of the satellite link.

VII. ARCHITECTURE

The SDMB system inter-works with the terrestrial mobile networks as depicted in the figure below.

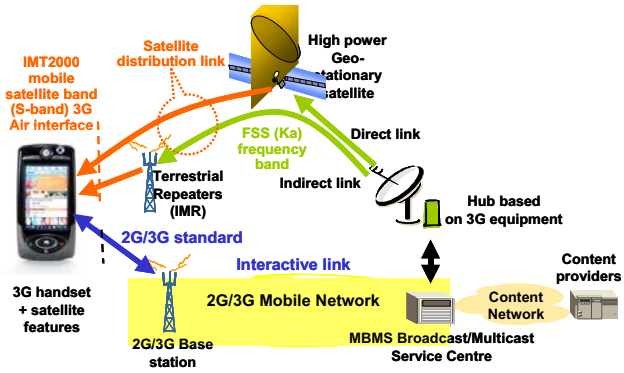

Figure 3: SDMB architecture

The Service Center is basically a 3GPP MBMS Broadcast/Multicast Service Centre (BM-SC), which needs to be configured to take into account the broadcast nature of the SDMB system. Multicast, as defined in MBMS, is not used by SDMB. The BM-SC implements the security features (user authorisation, channel protection) in relation with mobile operator(s) user database. It also includes the mechanisms ensuring reliability of distribution.

The 2G/3G mobile network is used to exchange security and billing data, as well as to support the point-to-point selective retransmission. The SDMB architecture is compatible with MBMS or non MBMS mobile networks.

The hub includes 3G radio access network equipment and 3G core network functions. It takes as input the incoming multimedia services from the BM-SC via the Gmb interface. Further mapped on the Iub interface, this information stream is fed to a Node B modem to build the SDMB WCDMA downlink carrier which is modulated with a specific Radio

frequency sub-system onto two Fixed Satellite System (FSS) frequency band (Ka or Ku band) 5 MHz carriers: one for direct satellite path (Hub-satellite-handset), and the other one for the indirect satellite path (Hub-satellite-terrestrial repeater-handset).

The SDMB satellite is transparent, therefore open to waveform enhancements along its 15 years lifetime. The satellite down-converts the direct carrier to IMT2000 Mobile Satellite System (MSS) frequency band and transmits it directly to the SDMB enabled 3G mobile phones in the umbrella cell. It also down-converts the indirect carrier for further frequency change and amplification by terrestrial repeaters in dense urban areas.

The terrestrial repeaters down-convert the satellite WCDMA signal in the same IMT2000 MSS frequency band as the one generated by the satellite, and amplify it to ensure outdoor/indoor reception in urban areas.

The SDMB enabled 3G mobile phone can then combine these identical signals possibly received from the satellite and/or different terrestrial repeaters with its rake receiver provided that the system ensures that the satellite and the terrestrial repeaters signals are seen as echoes and received within the appropriate time window.

More details on impacts of SDMB on MBMS architecture and protocols can be found in [8].

VIII. RELIABILITY OF DISTRIBUTION

The physical layer implemented in SDMB is compliant to 3GPP. As such, SDMB takes benefit from standard correction mechanisms. The propagation impairments in SDMB system are quite specific due to the mobile satellite propagation channel and in particular in building environment. Under 3G coverage, SDMB reception is also subject to periodical losses due to SDMB/3G system interworking mode. A reliable transport layer has then been designed to boost the SDMB physical layer correction performances.

Applied to the multimedia service information, this reliable transport layer relies on forward error coding algorithms over blocks of bytes resulting in redundant data. Moreover, function of the delivery method (streaming or download), it encompasses judicious long interleaving in order to take as much as possible advantage of the good reception states, thanks to the local storage in the mobile phone. The physical layer allows several multimedia services multiplexed on the same carrier to be protected differently.

With a limited overhead, this scheme rebuilds losses due to SDMB/3G system interworking issue and propagation impairments, increasing overall link availability and limiting terrestrial repeaters deployment.

The download delivery method reliability is also extended by a combination of carousel feature and selective retransmission scheme relying on the terrestrial mobile network point-to-point capability. This allows to overcome any severe loss such as mobile phone powered off or deep indoor environment conditions.

The reliable transport can be implemented with software in a 3GPP standard mobile phone at application level. Particular attention has been paid to limit CPU consumption and buffer size for decoding purpose in the mobile phone.

IX. CAPACITY

The system is designed to fully re-use the allocated spectrum in each spot beam. Assuming a 15 MHz spectrum, the system can then offer a capacity of 3 WCDMA carrier per spot beams. The baseline space segment for Europe includes up to three satellites, each of them covering six spots. Each satellite may provide three times 384 kbps per spot, hence a gross capacity of 3*6*3*384kbps=20.8 Mbps for the whole system. The capacity available to the end users is 3.46 Mbit/s at any location.

This allows to end user to benefit from 9 video channels with 128 kbit/s encoding rate as soon as a single satellite is available, then to get up to 27 video channels with the full space segment deployment. This 128 kbit/s data rate is based on a user acceptability ratio consistent with the handsets screen size.

The evolution towards higher capacity in a second stage is under study.

X. SERVICE PERSONALISATION

The download delivery method allows for service personalisation. The mobile phone automatically selects for local storage the most pertinent multimedia services distributed by the SDMB system taking into account the user preference profile. The profile includes a set of preference criteria and weighted content classification which are matched against the multimedia descriptor or metadata as part of the multimedia service information stream. Once the multimedia service is stockpiled in the local cache, it can be accessed locally.

This automatic scheme is also used to renew the multimedia content in the limited size local cache and maximise local interactivity in front of distant interactivity via the 3G system resources.

XI. SECURITY

The main security function is the user authorisation which prevents content use by unauthorised users: the authorisation function allows to perform an efficient billing for a broadcast service. Among possible mechanisms, the following ones may apply:

- Protection at channel level, defined in the scope of 3GPP/MBMS: this allows to protect the service based on either a subscription mechanism or pay per view, i.e. all users requesting the SDMB service have subscribed to a given service, therefore the mobile phone has the relevant key and is able to decipher the encrypted data.
- Protection at application/content level, based on the OMA defined digital right management (DRM) security

method, i.e. every user receives the encrypted data but only the user who buys the rights will be able to have the service. This technique is used to control the content sharing practices.

XII. POWER SAVING MANAGEMENT

The SDMB system inherits from two standardised MBMS procedures mechanisms dedicated to power saving, which are defined in 3GPP: the Service Announcement and the MBMS notification.

A. Service announcement

In SDMB, service announcement is the distribution to users of detailed information about the service - parameters required for service activation (e.g. IP multicast address), and detailed information about what will be sent over the service. This Content Descriptor is stored by the mobile phone, then used by the end user to select the most relevant multimedia services. This information is distributed to the mobile phones via a specific MBMS channel.

B. MBMS notification

When a session starts or is modified, for example when the BM-SC needs to broadcast a new multimedia service, it sends a message containing a multimedia service reference. This reference is included in an MBMS notification transmitted by the Hub to ensure the reception by all the UEs.

In download delivery method, the mobile phone decodes the MBMS notification and checks if the reference belongs to the selected multimedia services which description was included in the previous Service Announcement. If it is the case, it starts to receive data on the MBMS traffic channel. If not, it stays in idle mode and wakes up regularly to listen to the MBMS notification channel.

XIII. RADIO FREQUENCY EXPOSURE

Radio exposure is far higher for mobile phone users than for those living near cellular base stations [9]. As far as SDMB is concerned, there is no signal sent by the mobile phone to the satellite, due to the broadcast nature of the service.

Moreover, the signal power of terrestrial repeaters is lower than the one sent by 3G base stations. Consequently the levels to which the public are exposed are extremely low, even if they live nearby.

XIV. CONCLUSIONS

The paper provided an overview of the SDMB system implementing the broadcast mode of 3GPP also known as MBMS. The proposed system minimises cost impacts on the 3G mobile phone by relying on 3GPP standards, provides nation wide umbrella cells able to integrate a large scattered audience, permits a significant service fee reduction enabling subscription based multimedia services for the end user and allows profitable business case for the system stakeholders. These are key enablers to address the 3G mass market with high quality multimedia services.

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