Application Note:

Paradise Datacom connecting GSM networks via Satellite

Presented by Paradise Datacom Limited

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Proprietary and Confidential

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Acknowledgements

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1. Introduction

The worldwide popularity of GSM has encouraged operators to deploy services in most cities and, increasingly into remote areas. In parts of the world where the terrestrial infrastructure is non-existent, GSM has enabled telecom services for the first time. The only practical way to extend GSM services into these remote locations has been via satellite.

For a GSM operator the task of designing and rolling out a new network is considerable. The satellite link (or links) is only one consideration. Fortunately GSM is inherently satellite friendly so the inclusion of the satellite link (or links) is relatively simple. Satellite operators are providing an increasing amount of applications support to the GSM operator, particularly with minimising the space segment required for GSM traffic transmission. Satellite ground segment equipment manufacturers are also providing increased functionality in their equipment to best utilise bandwidth and minimise operating costs. Paradise Datacom provides a one-stop shop for the system integrator or GSM operator that needs ground segment equipment to connect via satellite. We have designed compatible modem and RF products that make the task of integrating a satellite link into a GSM network simple. Paradise Datacom designs and manufactures the satcom equipment needed at both hub and remote sites. In the following paragraphs we consider;

i) Where satellite links fit in GSM networks

ii) The features of Paradise Datacom modems and RF products that have made these products a de facto standard in GSM over satellite links around the world.

2. GSM Architecture and Satellite links

Figure 1 is a simplified version of a GSM network showing only the components relevant to the transmission of voice and signalling information. For our purposes, the GSM network can be viewed as consisting of three major parts: the Mobile Switching Centre (MSC), the Base Station Controller (BSC) and the Base Transceiver Station (BTS). The Home and Visitor Location Registers (HLR and VLR) and other "back office" sub-systems are considered to be part of the MSC since these links would not normally be routed via satellite

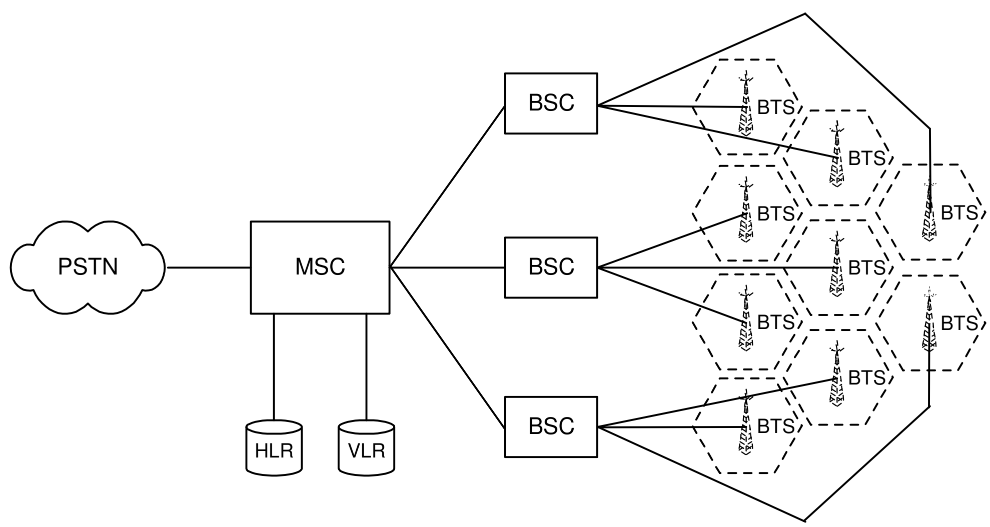


Figure 1 - GSM Architecture

In a typical network, there is a single MSC, a few BSCs and many BTSs. The equipment cost decreases from MSC to BSC to BTS. This distribution is important when considering where to put the satellite link.

The main functions for the major network components are:

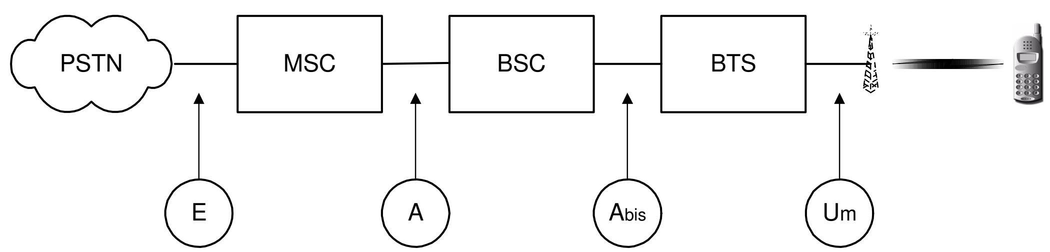
- Mobile Switching Center (MSC) - Controls the call setup for incoming and outgoing calls. Interfaces to the PSTN and other mobile networks. Usually there is one in a network or possibly one in each major city. All calls must go through the MSC.

- Base Station Controller (BSC) - Allocates radio channels to individual calls. Performs hand-offs between BTSs located with the same BSC. The BSC subsystem also normally performs the GSM specific voice compression. A single BSC can support many BTSs for coverage of a large geographical area.

- Base Transceiver Station (BTS) - Performs the actual transmission over the air to the mobile subscribers. The BTSs are located at the cellular towers throughout the coverage area. The BTS can contain one or more GSM radios, each of which supports eight GSM voice calls

The most frequent scenario is to locate a single BTS in the remote location. As the user population grows and traffic increases, multiple BTS can be deployed either with or without a BSC

All of the interfaces between the various components are carried using standard E1 bearer trunks to allow easier transmission over microwave fibre or satellite. Figure 2 shows a diagram of the different interfaces



The satellite link may be used to support any of these interfaces. While each of these interfaces is carried over a physical E1 link, the format of the data varies for each of the interface types. The selection of each of these interfaces for the satellite link provides different advantages and disadvantages. Since each of these interfaces are compatible with satellite transmission, the exercise then becomes one of how efficiently the traffic can be transmitted via satellite in order to minimize the space segment required for transmission, and hence achieve operational cost savings. The two most common bandwidth reduction techniques used to achieve this aim are voice compression and time slot elimination. In the following paragraphs we consider how Paradise Datacom modems are used to improve space segment efficiency and how Paradise Datacom modems and RF equipment bring unique benefits to GSM over satellite links.

3. Paradise Datacom P300 and Evolution series satellite modems (PD10, PD25 & PD55) improve space segment efficiency

3.1 Drop & Insert for N=1 to 31 (all values)

A feature included in Paradise Datacom satellite modem called "Drop & Insert" is used to extract only the revenue earning terrestrial timeslots, and transmit these over satellite thus improving link efficiency.

Drop & Insert is used to extract data from a PCM bearer, send it over satellite, and then re-insert it into a 2M PCM bearer (probably a blank bearer generated in the modem) at the distant end. During this process it is critical that the `identity` of each data Time Slot (TS) is maintained.

`Time Slot Identity Maintenance` enables;

i) Individual 64kbps channels to be inserted back into 64kbps Time Slots at the distant end

ii) The 64kbps traffic within those channels to be identified and maintained.

Time Slot Identity Maintenance enables each individual 64kbps transmit channel to be inserted back into the correct 64kbps Time Slot at the distant (receiving) end, with the individual 64kbps traffic content of each channel being identified and maintained across the satellite hop. Without `Time Slot Identity Maintenance` the multiple (N) 64kbps channels from the drop mux turn into a single homologous N x 64k stream, and at the distant end the stream cannot be processed back into the correct timeslots. Where Time Slot identity is not maintained, the resulting terrestrial Time Slots at the receiving end may be misaligned or shifted along and data from single Time Slots may be split across two timeslots. Not only this but the alignment will be different after each traffic break.

Normally time slot identity maintenance is provided by the IBS/SMS overhead in the signal passing over satellite. It uses the IBS/SMS frame to tag the first timeslot, which accompanies the data through the modem and satellite link, allowing the timeslots not only to be kept as separate 64kbps channels, but also each individual 64kbps channel to be inserted into a specific time slot at the distant end. However the IBS/SMS overhead only works for certain values of N, where N will `fit into` the four IBS frames. Four IBS satellite frames provide 240 satellite data timeslots, and so if 240/N is not an integer, this means that standard IBS/SMS cannot provide TS Identity Maintenance.

The values of N for which this IBS/SMS scheme does not work are collectively called the `odd values of N`.

TS Identity Maintained: N=1, 2, 3, 4, 5, 6, 8, 10, 12, 15, 16, 20, 24, 30

TS Identity NOT Maintained: N=7, 9, 11, 13, 14, 17, 18, 19, 21, 22, 23, 25, 26, 27, 28, 29, 31 (`Odd values of N`)

This poses a problem. Consider what happens if you have a 6 x 64kbps IBS/SMS satellite circuit, and want to upgrade to 7 x 64kbps. Equipment which implements only the minimum feature requirements for IBS/SMS cannot provide this. However the Paradise Datacom the P300 series satellite modem can!

If one configures Drop/Insert on a modem, and selects an `odd value of N`, the modem asks "Do you want to maintain TS identity?" If the answer is "Yes" then the modem switches to a special mode and provides time slot identity maintenance within the normal 6.7% overhead. This is not a proprietary mode, it uses the CAS multiframe scheme defined in the IBS/SMS specifications for handling CAS signalling, but the modem applies this to data without signalling. The result is you can vary the user data rate from 64kbps to 2048kbps in 64kbps steps without equipment changes, and the operator needs no complex knowledge of the schemes used over satellite.

3.2 Minimum Overhead mode

IBS/SMS is fine, especially with the ability to support all values of N=1 to 32, however do you really want to waste 6.7% overhead just to provide TS identity maintenance? Probably not.

For that reason the P300 & Evolution Series modems implement a fully variable overhead mode. This was primarily implemented to allow the user to provide a fully variable Async ESC resource between stations, but if the ESC is not used then the overhead reduces to the minimum of about 0.5% (`about` half a percent, as it varies very slightly as the frame length is adjusted to provide TS ID maintenance). On the P300 this is called `Closed Net plus ESC`, but on the Evolution Series it has been renamed to "Minimum Overhead Mode" (`Min OH`) to better explain what it provides. In practice the overhead is closer to 1/256 (0.4%), but if you allow 0.5% then this will allow for any variation as it changes slightly to accommodate any value of `N` within the payload space.

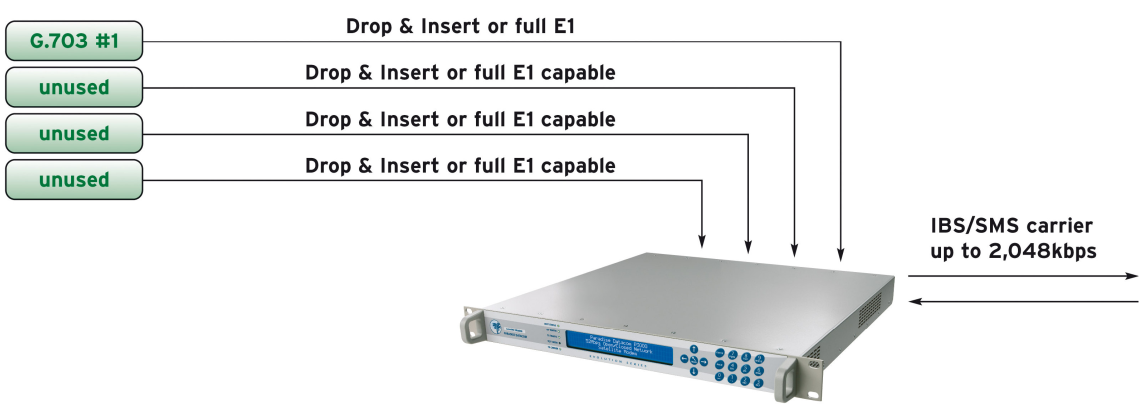
Again this is not a truly proprietary system, it just uses an adaptation of the IBS/SMS framing structure, and varies the `payload` space between the overhead bytes to provide TS Identity maintenance with a high enough overhead to provide whatever ESC may be required.

4. Evolution series modems (PD10, PD25 & PD55) with Quad E1 card

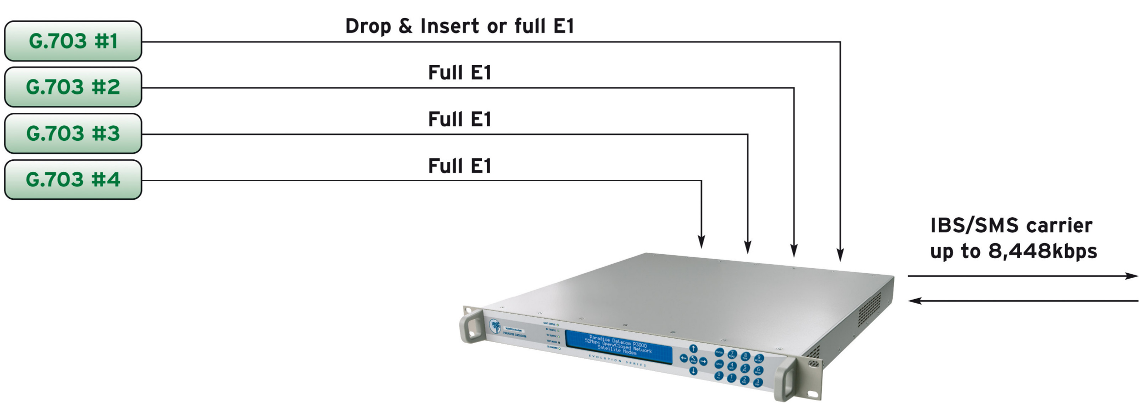
GSM systems often expand rapidly with an increased demand for more traffic bandwidth on installed links to the point where the partial E1 (drop & insert) delivery system becomes fully loaded, that is, a full E1 pipe. Additional traffic bandwidth over satellite is historically provided by adding further E1 links over satellite by means of adding more satellite modems. This is both expensive (capital outlay for multiple modems) and time consuming, as new modem hardware must be purchased, shipped, installed and commissioned.

With this application in mind, the Evolution series modem is available with a Quad E1 traffic interface. Initially, the Quad E1 card can be purchased cheaply with a single E1 port activated. This allows drop & insert (partial E1) operation, or full E1. The Quad E1 interface is easily upgraded by means of a software activated feature code, with no change of hardware, to activate ports 2, 3 and 4 as required. The modem carries all four E1 traffic channels on the same carrier signal over satellite by multiplexing the E1 traffic channels appearing at the modem input. Similarly, the modem extracts and demultiplexes the signal off satellite to reconstruct the four separate E1 channels.

Example of an initial install with a single E1 bearer for a phase 1 GSM system



Example of a final install with three full E1 bearers plus either a full or partial E1



Drop & insert is always available on the first E1 port, and additional E1 ports can progressively be enabled with drop & insert always available on any active port. In this way, the Quad E1 card caters for multiple (N) 64kbps E1 bearer timeslots for all values of N from N=1 to N=128, distributed across 4 x E1 bearers, **concentrated into one carrier signal**.

The Evolution series modem equipped with Quad E1 card therefore provides an expandable solution which is:

- Lowest cost at all stages
- Simple to implement with no modem hardware changes
- Fast to expand by means of software code
- A minimal hardware solution – one modem caters for up to four E1 channels
- Using Drop & Insert or full E1 on any port(s)
- Bandwidth efficient over satellite
- Convenient and worry free

For further information and pricing on the Evolution modem with Quad E1 card, contact your local Paradise Datacom representative or your nearest Paradise Datacom sales office.

5. L-band Modems plus Paradise RF equipment provide additional system functionality

The P300 series and Evolution series satellite modems include an L-band variant. These L-band modems have the same modem functions as the IF version, but with L-band interfaces to RF equipment. L-band equipment allows a more simplified system architecture in which the modem can supply dc power to the transmit low/medium power block upconverter (BUC) plus dc power to a low noise block-downconverter (LNB). This eliminates the need for expensive upconverter and downconverter equipment. Furthermore, the transmit L-band interface allows monitor and control of the BUC from the modem using Frequency Shift Keying (FSK) signalling providing a more functionally integrated system.

FSK provides monitoring of the BUC status with detailed alarm visibility, plus BUC output power measurement, BUC attenuation control and programming of the BUC to give additional compensation efficiency. Modem remote monitor and control is therefore extended to include the BUC, and when the modem+BUC (and LNB) combination is located at a remote site, both the modem and BUC may be monitored and controlled via the satellite link using the ESC channel as the conduit for M&C messaging. This clearly has tremendous advantages in geographically remote areas where stations or terminals are unmanned and access is difficult.

As mentioned earlier, the satellite-framing overhead carrying the ESC channel need only be the order of 0.5%, so the impact on space segment costs is minimal and in most cases negligible.

The L-band modem + BUC combination may also be operated in “Terminal mode” whereby the BUC output power is stabilised by closed loop feedback with the modem. Excessive remote site power variation is therefore eliminated when in “Terminal mode” – particularly useful where extremes of temperature are seen.

6. Summary

Paradise Datacom satellite modems and BUCs are ideally suited for GSM over satellite systems. Increased bandwidth (space segment) efficiency and better system functionality are the key benefits of using these products for GSM over satellite links. For detailed datasheets on Paradise Datacom products, please visit www.paradisedata.com, or contact sales@paradise.co.uk, or sales@paradisedata.com.