GSM Network Architecture

There are many excellent textbooks on GSM network architecture, find details of some of these at: https://2g-gsm.co.uk/books-references - many of these along with hard and soft copies of training course notes are available and will likely survive as artefacts of this period. Therefore, the objective here is to provide a short summary of the GSM network architecture during the launch period and pre-GPRS (General Packet Radio Service) era.

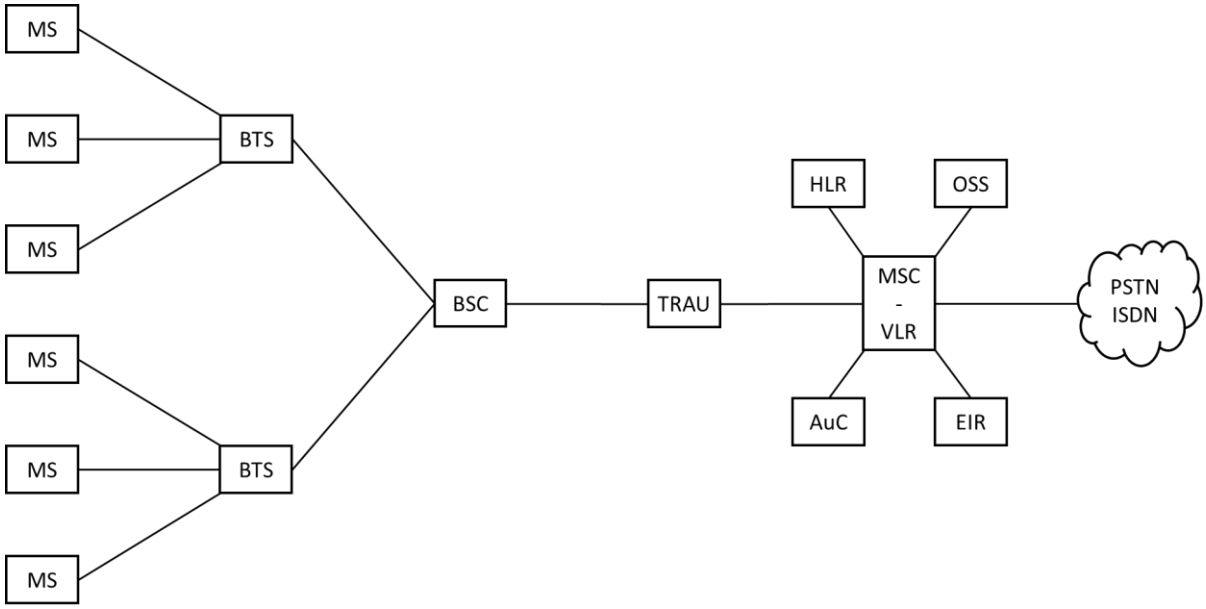
GSM network architecture can be considered in several ways; firstly, what did the standards specify? Secondly, how were the standards interpreted and implemented by the equipment vendors. And thirdly, how was this implemented by network operators who had to also consider the underlying transmission network which connected the various GSM network elements together and provided external interconnects to the PSTN (Public Switched Telecommunications Network).

GSM specifications were influenced by the latest developments in fixed telecommunications networks, at the time this was the ISDN (Integrated Services Digital Network) however the level of complexity was much higher given the need for radio access and the ability to manage the mobility of subscribers. The objective of the original GSM specifications was to support telephony via a traditional Circuit Switching (CS) core network, data services were limited and based on CS.

GSM network architecture consisted of several sub-systems as follows:

1. The Mobile Station (MS)
2. The Base Station Sub-System (BSS)
3. The Network and Switching Sub-System (NSS)
4. The Operation Support Sub-System (OSS)

You'll find many slight variations on how the GSM network architecture is presented; the diagram below illustrates the major components as defined in the specifications. There is more complexity when one considers the practical implementation of the network, in example, how MSCs are used within a core hierarchy; from facing the access network to transit switches between core sites and gateway MSCs to external networks. Additional components evolved to support the significant growth in the SMS (Short Message Service), commonly known as text messaging.



High-level GSM network architecture as per initial specifications

The MS consists of the physical device, typically a mobile phone and a SIM (Subscriber Identification Module) card. The BSS consists of a number of radio base stations known as a BTS (Base Transceiver Station), a BSC (Base Station Controller) and TRAU (Transcoder and Rate Adaptation Unit). The NSS consists of MSC (Mobile Switching Centre), VLR (Visitor Location Register), HLR (Home Location Register), AuC (Authentication Centre) and EIR (Equipment Identity Register). The OSS connects to BSS and NSS network elements for the purposes of network operations and management.

There are defined reference points, often called interfaces, between each network element within the GSM architecture. These are as follows:

- MS to BTS - Um interface, also known as the radio interface
- BTS to BSC - Abis interface
- BSC to TRAU - Ater interface
- TRAU to MSC - A interface
- MSC to VLR - B interface
- Gateway MSC to HLR - C interface
- VLR to HLR - D interface
- MSC to Gateway MSC - E interface
- MSC to EIR - F interface
- VLR to VLR - G interface
- HLR to AuC - H interface

All interfaces were initially designed to operate over E1 TDM interfaces. E1 is the European designation for a 2.048Mbps circuit which had been in use for many years as a digital transmission bearer based on PCM (Pulse Code Modulation) techniques. The utilisation of the E1 frame between TRAU and MSC, inter-MSC, MSC to G-MSC and G-MSC to OLO (Other Licensed Operator) interconnects, such as those to the PSTN, is based on the 32 channel PCM format (32 x 64kbps timeslots (TS)) with frame alignment in TS 0, signalling in TS16 and voice traffic in the remaining 30 channels. The voice traffic is PCM encoded using the standardised A-law and based on an audio input frequency range of 300 Hz to 3.4 kHz.

The GSM vocoder is optimised for the radio access network and rather than the traditional 64kbps PCM output it produces a data rate of 13kbps, this maps to 2 bits within an E1 frame, therefore occupying a 16kbps circuit. The structure of the Abis E1 interface varied according to BSS vendor.

The GSM radio interface is based on a TDMA (Time Division Multiple Access) frame structure implemented on an FDMA (Frequency Division Multiple Access) channel plan. A BTS has a number of TRX (transceivers) which occupy a nominal 200 kHz of radio spectrum, the GMSK (Gaussian Minimum Shift Keying) signal is actually wider than the 200 kHz and as such adjacent channels cannot be used on the same site or a neighbouring site, there are advanced radio network planning techniques to manage this.

Each mobile network operator has a number of GSM channels available in the 900 MHz and/or 1800 MHz frequency bands. These radio channels are referred to by an ARFCN (Absolute Radio Frequency Channel Number).