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# Strategy of Mobile Station and Base Station System in GSM Network

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## ABSTRACT

A Mobile Station that selects one of a plurality of base stations according to electric field strengths of signals transmitted on control channels corresponding to the plurality of Base Stations, and establishes first a link and then a call connection with the selected base station on a traffic channel that is assigned via a control channel corresponding to the selected base station, the mobile station including: a measuring unit for measuring an electric field strength of a signal on the traffic channel when a link operation is performed to establish the link for the traffic channel; and a judging unit for judging whether the link operation should be continued according to the measured electric field strength.

**Keywords:** GSM, Mobile Station, Base Station, ME, IMSI, SIM, 2G, BTS, Base Station Controller.

## I. INTRODUCTION

The Mobile Station (MS) in Global System for Mobile Communications (GSM) is really two distinct entities. The actual hardware is the Mobile Equipment (ME), which is anonymous. The subscriber information, which includes a unique identifier called the International Mobile Subscriber Identity (IMSI), is stored in the Subscriber Identity Module (SIM), implemented as a smart card. By inserting the Subscriber Identity Module (SIM) card in any GSM mobile equipment, the user is able to make and receive other subscriber services [1]. Most of what goes on in a mobile phone is fully automatic and so is not noticed by the user. The user is spared the complications of all the elaborate procedures and can operate his mobile like a phone connected by a copper network. [2].

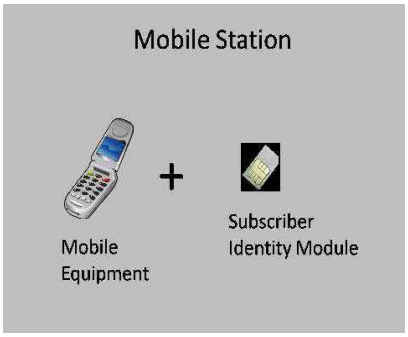


**Figure 1:** Mobile Station

A mobile station comprises all user equipment and software needed for communication with a mobile network. The term refers to the global system connected to the mobile network that is a mobile phone connected using a mobile broadband adapter. This is the terminology of Second Generation (2G) systems like Global System for Mobile Communication (GSM) [3].

A Base Station serves a multiplicity of single-antenna terminals over the same time-frequency interval. Time-division duplex operation combined with reverse-link pilots enables the base station to estimate the reciprocal forward and reverse-link channels [4]. Base stations are deployed for two reasons – coverage and capacity. Without coverage, terminals will not have any service. If there is insufficient capacity, then at busy times due to congestion, users may need to make several call attempts before being able to make a call or their incoming calls may not be delivered [5].

**Figure 2 :** A base station; right: two of the three masts with an antenna at the top; foreground: the equipment cabinet; left: Base station tower with antennas.

## II. METHODS AND MATERIAL

### A. Mobile Station (MS) consists of two main elements

1) The Mobile Equipment (ME) or Terminal.
**2)** The Subscriber Identity Module (SIM) [6].

### B. The Mobile Equipment (ME) or Terminal

The mobile equipment is uniquely identified by the International Mobile Equipment Identity (IMEI). The SIM card contains the International Mobile Subscriber Identity (IMSI) used to identify the subscriber to the system, a secret key for authentication, and other information. The IMEI and the IMSI are independent, thereby allowing personal mobility [7].

There are different types of terminals distinguished principally by their power and application:

1) The 'fixed' terminals are the ones installed in cars. Their maximum allowed output power is 20 W.
2) The GSM portable terminals can also be installed in vehicles. Their maximum allowed output power is 8W.
3) The handhelds terminals have experienced the biggest success thanks to the weight and volume, which are continuously decreasing. These terminals can emit up to 2W. The evolution of technologies allows to decrease the maximum allowed power to 0.8W [6].

### C. Types of Mobile Station

The different types of Mobile Stations such as vehicle mounted, hand-held and transportable stations.

1) Vehicle -Mounted Mobile Station

In this standard, a vehicular mounted mobile station is a mobile station where the used antenna is physically mounted to the outside of a vehicle. Vehicles include, for example, trucks, buses, trains and ships.

**Figure 3:** Vehicle-mounted mobile station.

2) Hand-Held Mobile Station

In this standard, a handheld station is an mobile station where the used antenna is directly attached to the portion of the equipment containing the acoustic transducers for speech (this condition applies only to speech MSs) [8].

**Figure 4:** Hand-held mobile station.

3) Transportable Mobile Station

In a transportable mobile station the antenna is not attached to the hand-set. These mobile stations support all power levels required in the system and can either be vehicle-mounted or hand-carried. They usually consist of a portable plug-in unit and a vehicle-mounted adapter [9].

**Figure 5:** Transportable mobile station.

### D. Mobile Station (MS) Access

The mobile station access procedure is comprised of the initial actions the user has to take before calls can be established or received, this procedure insertion of

subscriber-card and entering the PIN-code. As there exist different types of mobile station and as requirement in other GSM recommendations allow different option the mobile station access procedure may differ between mobile stations. The method for describing the mobile station access procedures is by using a Mealy-graph.

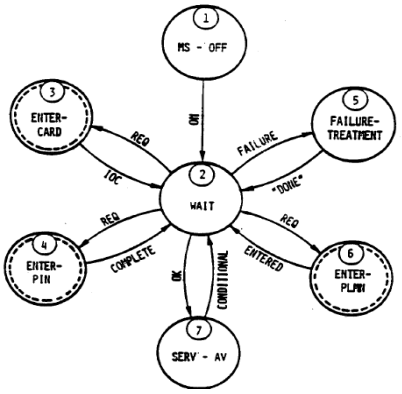


**Figure 6:** Mealy-Graph for the MS access procedure.

The graph shows the mobile station access for simple mobile station hand-held and they may be different for more complex station [10].

### E. Mobile Station Service Access Configuration

Service access configuration must suit the requirements of the customer and will depend on the combination of Tele-, bearer and supplementary services to be used. The actual configuration will depend on the manufacturers' implementation and may comprise a single unit or a mobile termination unit with additional Terminal Equipment or Terminal Adaptors.

### F. Mobile Station Access Capability

The mobile station access capability is defined in GSM Channels Structures and Access Capability, and describes the limitation put on the simultaneous provision at a given time of Tele- or bearer services [8].

### G. Mobile Station Frequency Bands in GSM

For the GSM Mobile Stations, three frequency bands are defined:

1) Standard GSM Band: 890-915 MHz Uplink and 935- 960 MHz downlink.
2) Extended GSM Band: 880-915 MHz Uplink and 925-960 MHz downlink.
3) GSM 1800 Band: 1710-1785 MHz Uplink and 1805-1880 MHz downlink.
4) GSM 1900 Band: 1850-1910MHz Uplink and 1930-1990 MHz Downlink.

The Mobile Station may be capable of supporting one or more of these bands. However, a procedure to select GSM 1800 operation must be provided internally in the MS if it is capable of handling both. Simultaneous use of GSM 1800 modes is not supported [11].

### H. Mobile Station Locating in GSM

The exact location of the mobile station is not currently known in the GSM network. During a call the serving Base Transceiver Station (BTS) is known within an accuracy of one cell. The locating procedure must therefore be flexible to allow implementation of different service.

The criteria of different location methods can be compared and evaluated. Also the usability of the selected method must be assessed using these requirements.

1) Minor changes to existing network and terminal. Ideally the existing terminals could use the locating service without modifications in practice software modifications may be necessary.
2) Large, predictable coverage area. The coverage area for the locating service should be large, ideally the same as the coverage area for calls. It should also be possible to predict the coverage area in advance.
3) Accurate locating. The locating accuracy requirements are somewhat flexible.in this case of emergency calls, even a rough estimate is an improvement. It should be possible o know exactly the maximum possible error of the location estimate.
4) Light-weight protocol. The protocol used should be light-weight without an unbearable increase of the signalling traffic. This is especially critical for the air-interface. The requirement depends on the generally of the application and the obtained value of the location.
5) Usability. The locating service should be able to locate both a stationary and a moving MS. The user should be able to make calls without disturbance when the location service is on. With the commercial services the network operator should be

able to charge the users of the positioning service based on real use [12].

### I. Mobile Station Units

The mobile station consists of 3 major functional units:

1) Transceiver unit (including circuit for duplex operation)
2) Operational controls unit.
3) Logic and control unit.

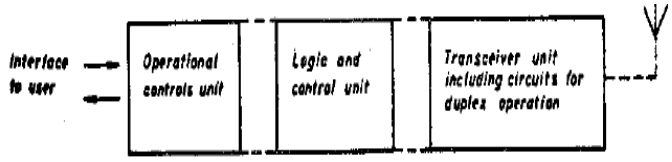


**Figure 7:** Mobile Station Unit.

In the physical realization of the equipment, the different functional units may be integrated into single packages [13].

### J. Mobile Station Modes

The measurements made by a mobile station are used in making decisions about signal strength and handovers. Measurements are taken in both active and idle mode. When mobile station in Active Mode, during a call, the mobile continuously a report via Slow Associated Control Channel (SACCH) to the system how strong the received signal strength is from Base Transceiver Station (BTS). Both signal strength and quality are measured on the mobile station's "own" base transceiver station. These measurements are used by the Base Station Controller (BSC) to make fast decisions about target cells when a handover is required.

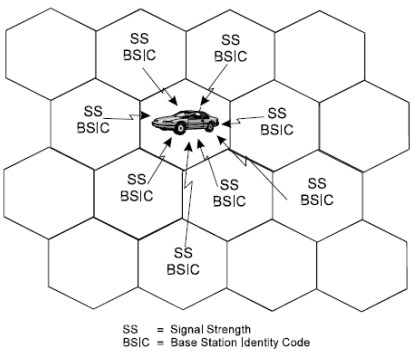


**Figure 8:** Monitoring Broadcast Control Channel carriers.

Measurements on neighboring cells during a call take place when the mobile is idle, that is when it is not transmitting or receiving [9].

While the mobile station is in idle mode, it will continuously make measurements on the Broadcast

Control Channel (BCCH) carriers of serving and neighboring cells to decide on which cell to camp on. It will also, if necessary, register its presence in the location area of the chosen cell by performing a location updating. The purpose of camping on a cell is threefold:

1) It enables the mobile station to receive system information from the network.
2) The mobile station can initiate a call by accessing the network on the Random Access Channel (RACH) of the cell on which it is camped.
3) The network will know the location area of the cell in which the mobile station is camped (unless the MS has entered a limited service state and can therefore page the MS when an incoming call is received).

The idle mode task can be subdivided into four processes:

- Public Land Mobile Network (PLMN) selection.
- Cell selection.
- Cell reselection.
- Location updating.

The relationship between these processes is illustrated [14].

### K. Mobile Station Output Power

GSM mobile stations are separated into classes according to their maximum output power follows in table 1:

**Table 1:** mobile station output power in GSM

| Classes | GSM 900 | GSM 1800 | GSM 1900 |
|---|---|---|---|
| Class1 | - | 1 Watt | 1 Watt |
| Class 2 | 8 Watt | 0.25 Watt | 0.25 Watts |
| Class 3 | 5 Watt | 4 Watt | - |
| Class 4 | 2 Watt | - | - |
| Class 5 | 0.8 Watt | - | - |

In GSM, vehicle and transportable mobile station may be of GSM 900 classes 2, GSM 1800 and GSM 1900 mobile stations can be both class 1 and 2. A GSM handheld mobile station may be of GSM 900 classes 4 and 5 and GSM 1800 handheld MSs can be both class 1 and class 2. Both GSM 900 and GSM 1800 Mobile Stations must be capable of reducing transmitter output power when instructed by the network to do so. [9,11].

**L. Subscriber Identity Module (SIM)**

A Subscriber Identity Module (SIM) is the physically secured module which contains the International Mobile Subscriber Identity (IMSI) an authentication algorithm, the authentication key and other (security related) information and functions. The basic function of the Subscriber Identity Module (SIM) is to authenticate the subscriber identity in order to prevent misuse of the Mobile Station (MS) and the network [15]. Basically, a mobile station can be divided into two parts. The first part contains the hardware and software to support radio and human interface functions. The second part contains terminal/user-specific data in the form of a smart card, which can effectively be considered a sort of logical terminal. The SIM card plugs into the first part of the MS and remains in for the duration of use. Without the SIM card, the MS is not associated with any user and cannot make or receive calls (except possibly an emergency call if the network allows). The SIM card is issued by the mobile service provider after subscription, while the first part of the MS would be available at retail shops to buy or rent. This type of SIM card mobility is analogous to terminal mobility, but provides a personal-mobility-like service within the GSM mobile network [16].


**Figure 9**: SIM Card

**M. SIM Card Structure and Types**

SIM card is a smart card with a microprocessor and it consists of the following modules:

- CPU
- Program memory (ROM)
- Working memory (RAM)
- Data memory (EPROM or E2PROM)
- Serial communication module.

These five modules must be integrated into an Integrated Circuit (IC), otherwise their safety would be threatened. This is because the chip connections may become illegal access and misappropriation of SIM cards important clues.

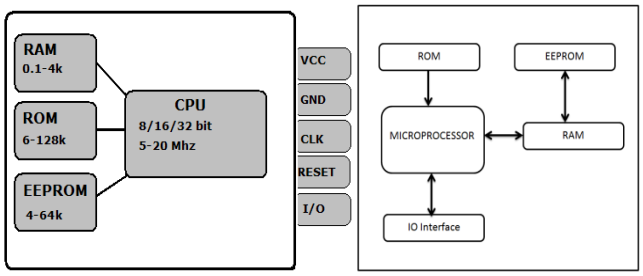


**Figure 10:** SIM Card structure [17].

Two physical types of SIMs are specified. These are the ID-1 "SIM" and the "Plug-in SIM". The logical and electrical interfaces are identical for both types of SIM.

1) ID-1 SIM: The format and layout of the ID-1 SIM comply with International Organization for Standardization (ISO) standards for Integrated Circuit (IC) cards.


**Figure 11:** ID-1 SIM card.

2) Plug-in SIM: The plug-in SIM is smaller than the ID-1 SIM. It is intended for semi-permanent installation in the Mobile Equipment (ME).

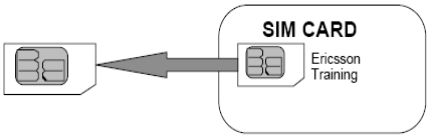


**Figure 12:**.Plug-in SIM card [9].

**N. Logical Model of the SIM Card**

1) Master File (MF) - the root of the file system that contains dedicated and elementary files.
2) Dedicated File (DF) - a subordinate directory to the master file that contains dedicated and elementary files.
3) Elementary File (EF) - a file that contains various types of formatted data, structures as either a sequence of data bytes, a sequence of fixed size records, or a fixed set of fixed size records used cyclically.

In spite of SIM file systems are highly standardized, the standards allow flexibility such that their content can vary among network operators and service providers. For example, a network operator might not use an optional file system element, might create an additional element on the SIM for use in its operations, or might install a built-in function to provide a specialized service.

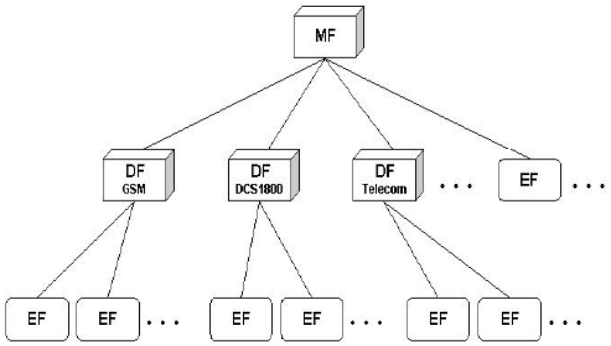


**Figure 13:** SIM Logical Model [17].

**O. SIM Card Generations**

Each generation of card implements a new set of Java Card and application development features as described below. They also define the new network configurations and applications related to the revision of the network associated with the SIM card type.

**Table 2:** SIM cards types [18].

| SIM Card type and release | Specifications and features for on-board application development. |
|---|---|
| SIM Card R99 | Open Platform 2.0.1, Java Card 2.1.1. First SIM version that has Java Card on-board. |
| SIM Card R5 | Java Card 2.1. |
| USIM Card R5 | Java Card 2.2.1, Advanced phonebook, higher serial communication speeds. |
| USIM Card R6 | Global Platform 2.1.1 (2003) and Java Card 2.2.1, ISIM application. |
| R-UIM Card | Global Platform 2.1 and Java Card 2.2.1. |
| (LTE/3G Cards) | Global Platform 3.x and Java Card 3.x |
| (LTE/4G Cards) | Global Platform v2.3, ITU-R (IMT-Advanced), 3GPP LTE and IEEE 802.16m (resent) [19]. |

**P. Subscriber Identity Module (SIM) Card Security Features**

This clause defines the security attributes to be supported by the SIM, which are:

- Authentication algorithm (A3);
- Subscriber authentication key (Ki);
- Cipher key generation algorithm (A8);
- Cipher key (Kc);
- Control of access to data stored, and functions performed, in the SIM.

An algorithm A38 may perform the combined functions of A3 and A8 [17].

**Q. Base Station System (BSS)**

In GSM, the Base Station or Base Station Subsystem (BSS) is a term given to a Base Station Controller (BSC) and the Base Transceiver Station (BTS) associated with it. The number of Base Transceiver Station (BTS) associated with it [20]. The system of base station equipment (transceivers, controllers, etc.) which is viewed by the Mobile services Switching Center (MSC) through a single interface as defined by the GSM series of recommendations, as being the entity responsible for communicating with mobile stations in a certain area. The radio equipment of a base station system may cover one or more cells. A base station system may consist of one or more base stations. If an internal interface according to the GSM series at recommendations is implemented, then the base station system shall consist of one Base Station Controller (BSC) and several Base Transceiver Stations (BTSs) [21]. In GSM, the base station monitors the received signal strength from the terminals in its coverage and provides instructions to the terminal on which power level it should transmit. During handover between base stations, the terminal communicates at the maximum

power control level permitted by the target base station, often at full terminal power. Where there is a high density of small cells or for indoor installations it is quite likely that the terminal power will be limited to be below maximum even for handover.

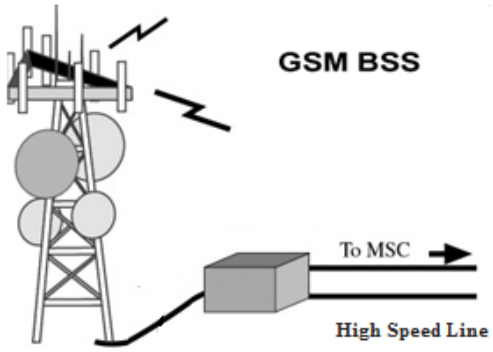


**Figure 14:** GSM Base Station system.

The base station commands the terminal to transmit the optimum Radio Frequency (RF) power to give an adequate received signal at the base station. Indoor and micro base stations enable lower terminal powers in areas of high use [5].

**R. Base Transceiver Station (BTS)**

A Base Transceiver Station (BTS) is a system in a mobile communication network that houses radio receivers and is used for wireless communication between users and network providers that is under the control of Base Switching Controller (BSC) and then the exchange. A base transceiver station also referred to as the Radio Base Station (RBS) in Third Generation (3G) Networks. Simply, the Base Station (BS) or evolved node in Long Term Evolution (LTE) standard is a system that has the radio transceivers which define a cell and provides wireless communication between users like mobile phone, computers or WLL phones and a network service provider. A base transceiver station is controlled by a Base Station Controller (BSC). A base transceiver station is usually placed in the centre of a cell whose transmitting power defines the size of a cell. Each base transceiver station has between 1 to 16 transceivers, depending on the density of users in the cell. Each base transceiver station serves as a single cell. A base transceiver station has four main parts namely power element, a power source (engine/alternator), a base transceiver station machine and towers & antenna [22]. The Base Transceiver Station houses the radio transceivers that define a cell and handles the radio-link protocols with the mobile station. In a large urban area, there will potentially be a large number of base transceiver stations deployed, thus the requirements for a base transceiver station are ruggedness, reliability, portability, and minimum cost [7].

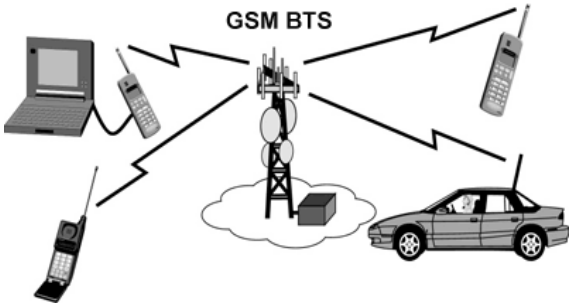


**Figure 15:** GSM Base transceiver Station.

The Base Transceiver Station (BTS) used in a GSM network comprises the radio transmitter receivers. The defining element for each cell. Base transceiver station communicates with the mobiles and the interface between the two is known as the radio interface (Um) with its associated protocols [23].

**S. Architecture of Base Transceiver Station (BTS)**

The general architecture of Base Transceiver Station (BTS) system reveals the following parts:

1) Power Cards: A power card is used to provide fixed current and voltage levels to circuit components. A base transceiver station usually uses -48V power whose positive is grounded to reduce noise.
2) Baseband receiver Unit (BB2F): A BB2F is used for digital signal processing and frequency hopping. It connects the BOIA card to Transceiver (TRx).
3) Transceiver (TRx)/ Data Receiver (DRx): Transceivers handles the user calls. Usually there are 12 Transceiver (TRx) in a Base Transceiver Station (BTS) and can handle 8 calls/sec.
4) Base Operation and Interface Unit (BOIA): It processes the baseband signals received from the BB2F and interfaces the processed signal with transmission cards such as RRI, E1/T1 etc. Also base transceiver station initialization, power amplification, O&M signaling, clock functions, timing functions, etc. So it is considered as the brain of the Base Transceiver Station.
5) Radio Receiver Card (RRI): It provides E1 connectivity to the base transceiver station. Also it

creates the microwave link between base transceiver station & base station controller.

6) Multi-couplers and Duplexers: Multi-couplers are used to connect different Transceivers also into the duplexer.
7) Alarm Extension System: It monitors and collects the working state of various units of base transceiver station and then extends to the O&M monitoring station.

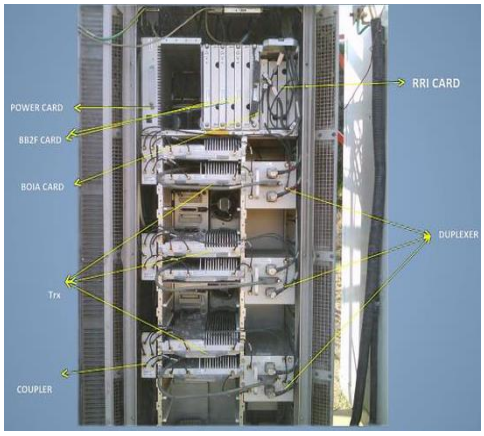


**Figure 16:** Architecture of Base Transceiver Station [22].

**T. The Base Station Controller (BSC)**

The Base Station Controller (BSC) controls a major part of the radio network. Its most important task is to ensure the highest possible utilization of the radio resources [9]. The base station controller controls a group of base transceiver station and manages their radio resources. A base station controller is principally in charge of handovers, frequency hopping, exchange functions and control of the radio frequency power levels of the base transceiver stations [6]. The Base station controller manages the radio resources for one or more base transceiver stations. It handles radio-channel setup, frequency hopping, and handovers, as described below. The Base station controller is the connection between the mobile station and the Mobile Service Switching Center (MSC) [7].

**Figure 17:** Base Station Controller

**U. Mobile services Switching Centre (MSC)**

It is the central component of the Network Switching Subsystem (NSS). The mobile services switching centre performs the switching functions of the network. It also provides connection to other networks [24]. The main element within the core network area of the overall GSM network architecture is the Mobile switching Services Centre (MSC). It provides registration, authentication, call location, inter- MSC handovers and call routing to a mobile subscriber. It also provides an interface to the Public Switched Telephone Network (PSTN) so that calls can be routed from the mobile network to a phone connected to a landline. Interfaces to other MSCs are provided to enable calls to be made to mobiles on different networks.

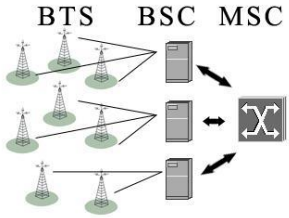


**Figure 18:** Network Design [23].

## III. RESULTS AND DISCUSSION

**A. Call set-up**

**1)** Call to Mobile Station: Calls to mobile stations are transmitted simultaneous from all base station in the traffic area which the mobile station is operating. When a mobile station has received a calling signal containing its identification, it returns a acknowledgement on this return frequency of the calling channel, where upon Mobile Transceiver (MTX) allocates a traffic channel at the base station

where the mobile station has answered the call. The mobile station then switches to the allocated channel. The calling cannel, on which all other mobile stations remain, is immediately available for the next call to a mobile station.

2) Call from Mobile Station: When an ordinary mobile subscriber initiates a call, the mobile traffic channel, on which all signals are exchanged and the conversion takes place [13].

**B. Between Base Transceiver Station (BTS) and Mobile Station (MS)**

In the GSM system the mobile station sends constantly Measurement Report Messages on Slow Associated Control Channel (SACCH). The massage contains the result of the measurements gather from the serving and neighbor Base Transceiver Station (BTS). It is Possible to exploit the measurement report massage transferring the location data from the mobile station to the serving base transceiver station. There are a lot of advantages in using that massage:

1) The measurement report massage is sent frequently, the maximum rate is one message in each 480ms. The frequent sending of the measurement result helps the Location Service Centre (LSC) to locate the moving mobile station accurately.
2) No extra load on the air interface is generated, because the existing measurement report message is used. There will thus be no degrading of the transmission quality.
3) Using only the least important part of the message in transferring the location information, only a little harm is done to the handover and power control processes using the measurement information.
4) The mobile station can easily dynamically or according to the orders by the network. The sending can take place when the user is making a call.

**C. Delay time between Base Transceiver Station (BTS) and Mobile Station (MS)**

The time delay between the mobile station and the serving base transceiver station must be known to avoid overlapping time slots. This is called Timing Advance (TA) in the GSM. If we want know TA also to other base transceiver station, the mobile station must communicate also with the neighbour base transceiver station. When timing advance to at least three base transceiver stations is known, the location of the mobile station can be calculated.

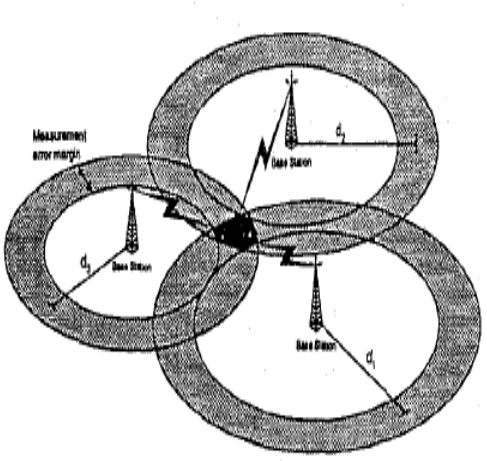


**Figure 19:** The location estimate of the mobile station based on timing advanced

The mobile station location can be found in the intersection of the circles drawn around at least 3 base transceiver stations. The radius of the circle is obtaining from timing advance. The width of the circle depends on the measurement accuracy of ting advance [12].

**D. Base Transceiver Station (BTS) and Base Station Controller (BSC)**

Tasks of Base Station System (BSS) are distributed over Base Station Controller (BSC) and Base Transceiver Station (BTS).

- Base transceiver station comprises radio specific functions.
- Base station controller is the switching centre for radio channels.

**Table 3:** Tasks of a BSS are distributed over BSC and BTS [25].

| Functions | BTS | BSC |
|---|---|---|
| Management of radio channels | | X |
| Frequency hopping (FH) | X | X |
| Management of terrestrial channels | | X |
| Mapping of terrestrial onto radio channels | | X |
| Channel coding and decoding | X | |
| Rate adaptation | X | |
| Encryption and decryption | X | X |
| Paging | X | X |
| Uplink signal measurements | X | |
| Traffic measurement | | X |
| Authentication | | X |
| Location registry, location update | | X |
| Handover management | | X |

## IV. CONCLUSION

This paper describes the mobile station and base stations are typically related to each other via different media in GSM network. GSM is a very complex standard. Access or call connection process from mobile station to base station belonging to a very large system in GSM network. On subscriber side, each subscriber can make there calling process in GSM network by this method and materials. Whereas systems stability, reliability, sustainability must be ensured.

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