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Second-Generation Digital Mobile Telephone Standard using a Variation of Time Division Multiple Access (TDMA)

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Abstract: ***Traditional mobile service was structured similar to television broadcasting: One very powerful transmitter located at the highest spot in an area would broadcast in a radius of up to fifty kilometers. The Cellular concept structured the mobile telephone network in a different way. Instead of using one powerful transmitter many low-powered transmitter were placed throughout a coverage area. For example, by dividing metropolitan region into one hundred different areas (cells) with low power transmitters using twelve conversations (channels) each, the system capacity could theoretically be increased from twelve conversations using one hundred low power transmitters.***

1. Introduction

Wireless Communication is the fastest growing and most vibrant technological areas in the communication field. Wireless Communication is a method of transmitting information from one point to other, without using any connection like wires, cables or any physical medium.

Generally, in a communication system, information is transmitted from transmitter to receiver that are placed over a limited distance. With the help of Wireless Communication, the transmitter and receiver can be placed anywhere between few meters (like a T.V. Remote Control) to few thousand kilometres (Satellite Communication).

We live in a World of communication and Wireless Communication, in particular is a key part of our lives. Some of the commonly used Wireless Communication Systems in our day – to – day life are: Mobile Phones, GPS Receivers, Remote Controls, Bluetooth Audio and Wi-Fi etc.

Objective: Time-division multiple access (TDMA) is a channel access method for shared-medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots. The users transmit in rapid succession, one after the other, each using its own time slot. This allows multiple stations to share the same transmission medium (e.g. radio frequency channel) while using only a part of its channel capacity. TDMA is used in the digital 2G cellular systems such as Global System for Mobile Communications (GSM), IS-136, Personal Digital Cellular (PDC) and iDEN, and in the Digital Enhanced Cordless Telecommunications (DECT) standard for portable phones. TDMA was first used in satellite communication systems by Western Union in its Westar 3 communications satellite in 1979. It is now used extensively in satellite communications, combat-net radio systems, and passive optical network (PON) networks for upstream traffic from premises to the operator.

2. Existing and Proposed System

2.1 Existing system

The brief history of development of mobile communications is given below:
1876 - Alexander Graham Bell invented telephone
1887 - Heinrich hertz discovered “Hertzian waves” (radio waves)
1896 - Marconi started first radio transmission (Trans Atlantic Radio Transmission in 1901)
From the beginning of the 20th century, police in Europe & North America have been equipped to communicate with patrol vehicles
In early 1950s Bell Telephone Company in USA introduced radio telephones to customers
1964 - Shared Resources Concept introduced
1977 - PHS in Japan
1978 – AMPS in USA by Bell
1982 - USA has stadardised the AMPS
1982 - ETSI has setup GSM
1986 - Field test of GSM
1987 – TDMA selected for GSM
1989 - Validation of GSM
1990 - Pre-operational system (gsm)
1991 - Commercial system start up
1992 - Capital cities & airports
1993 - Coverage of main roads
1994 - Coverage of countryside
2001- 3G Services launched in Japan

2.2 Mobile Generation

1G - Analog (Cellular revolution)- Only Mobile Voice Services
2G - Digital (Breaking Digital Barrier)- Mostly Voice services & Data delivery made Possible
3G - Voice & Data (Breaking Data Barrier)- Mainly for data services where voice services will also be possible
4G – Voice & Data at still higher speed

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3. Proposed System: GSM Architecture

A GSM system is basically designed as a combination of three major subsystems: the Network Subsystem (NSS), the Base Station subsystem (BSS), and the Operation and maintenance Support Subsystem (OSS). In order to ensure that network operators will have several sources of cellular infrastructure equipment, GSM decided to specify not only the air interface, but also the main interfaces that identify different parts. There are three dominant interfaces, namely, A interface between MSC and BSC, Abis interface between BSC and BTS and an Um interface between the BTS and MS.

Applications for GSM:
Digital Communication such GPS, Cell Phones, Laptops

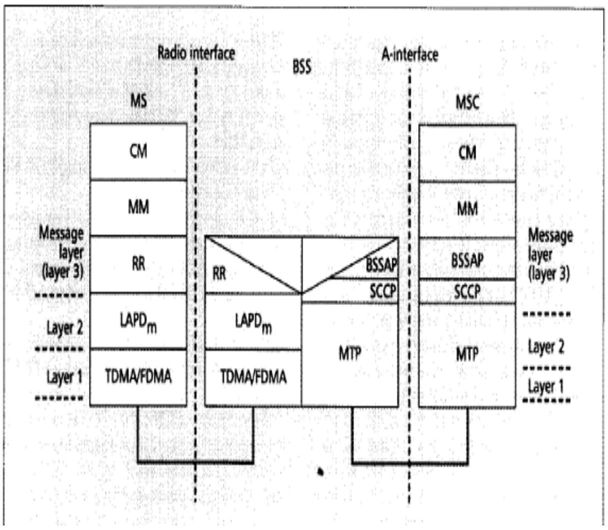

Figure 1: GSM Architecture

4. Call Processing

In this we discuss the call processing aspect and look into specifics case of a mobile originated (MO) call and a mobile terminated (MT) call.

4.1 Mobile originated (MO) call

There are four distinct phase of a mobile originated call-
1) Setup phase.
2) Ringing phase.
3) Conversation phase.
4) Release phase.

Out of these phases the setup phase is the most important phase and includes authentication of the subscriber, Ciphering of data over radio interface, validation of mobile equipment, validation of subscriber data at VLR for requests service and assignment of a voice channel on A-interface by MSC. Whenever MS wants to initiate on outgoing call or want to send an SMS it requested for a channel to BSS over RACH. On receiving request from MS, BSS assigns a stand-alone dedicated control channel (SDCCH) to MS over access grant channel (AGCH). Once a SDCCH has been allocated to MS all the call set up information flow takes place over SDCCH.

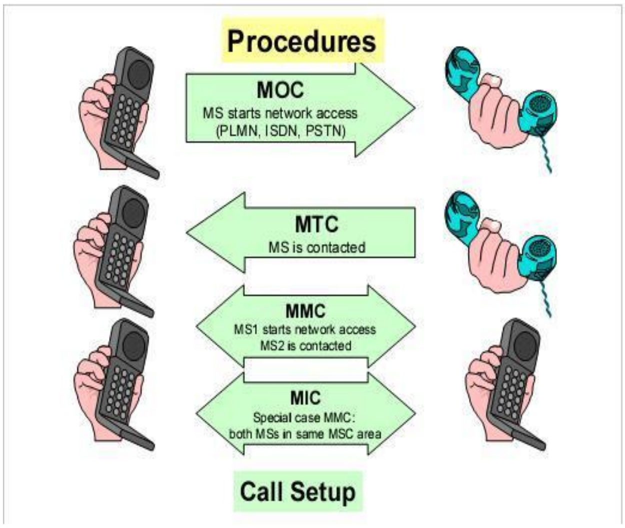

Figure 2: Call setup

A connection management (CM) entity initiates a CM Service Request message to the network. Network tries to establish an MM connections between the MS and the network and upon successful establishment of MM connection a CM Service Accept message is received by MS from the network. MS now sends a Call Set up Request to the network which contains the dialed digits (DD) of the called party. As the call setup message is received at the MSC/VLR certain check are performed at MSC/VLR like-whether the requested service is provisioned for the subscriber or not, whether the dialed digits are sufficient or not, any operator determined barring (ODB) does not allow call to proceed further etc. As these checks are performed at MSC/VLR a Call Proceeding Message is sent from the network towards the MS. After all the checks are successfully passed MSC sends Assignment command to the BSS which contains a free voice channel on A-interface On getting this message BSS allocates a free TCH to the MS and informs the MS to attach to it. MS on attaching to this TCH informs the BSS about it. On receiving a response from the BSS, MSC switches the speech path toward the calling MS. Thus at the end of Assignment the speech path is through from MS to MSC. It is important to note that at this stage mobile has not connected user connection as yet. MS at this stage does not listen anything.

After assignment MSC sends a network set-up message to the PSTN requesting that a call be set up. Included in the message are the MS dialed digits (DD) and details specifying which trunk should be used for the call. The PSTN may involve several switching exchanges before finally reaching the final local exchange responsible for applying the ringing tone to the destination phone. The local exchange will generate the ringing tone over the trunk, or series of trunk (if several intermediate switching exchange are involved), to the MSC. At this point in time MS will hear ringing tone. The PSTN notifies the MSC with a network-alerting message when this event occurs. MSC informs the MS that the destination number is being alerted. It is important to note that this is primarily a status message to the MS. The MS hears the ringing tone from the destination local exchange through the established voice path.

When the destination party goes off hook, PSTN informs the MSC of this event. At this point, MS is connected to the destination party and billing is started. MSC informs the MS that connection has been established and MS acknowledges the receipts of the connect message.

Under normal condition, the termination of a call is MS initiated or network initiated. In this scenario, we have assumed that MS initiates the release of the call by pressing "end" button and MS send a disconnect message to the MSC. The PSTN party is notified of the termination of the call by a release message from the MSC. The end- to- end connection is terminated. When MSC is left with no side task (e.g. charging indication etc.) to complete a release message is sent to the MS. MS acknowledges with a release complete message. All the resources between MSC and the MS are released completely.

4.2 Mobile Terminated (MT) call

The different phases of a mobile terminated call are
1) Routing analysis
2) Paging
3) Call setup
4) Call release

The phases of mobile terminated (MT) call are similar to a mobile originated (MO) call except routing analysis and paging phase. Call to a mobile subscriber in a PLMN first comes to gateway MSC (GMSC). GMSC is the MSC, which is the capable of querying HLR for subscriber routing information. GMSC need not to be part of home PLMN, though it is normal practice to have GMSC as part of PLMN in commercially deployed networks.

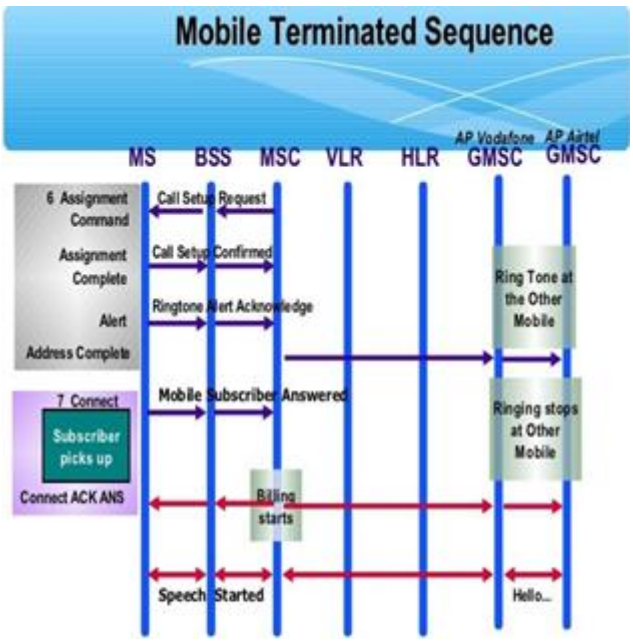

Figure 3: Call termination

GMSC opens a MAP (Mobile Application Part) dialogue towards HLR and Send / Routing / Info-Request (SRI request) specific service message is sent to HLR. SRI request contains MSISDN of the subscriber. HLR based on location information of this subscriber in its database, opens a MAP dialogue towards VLR and sends Provide / Roaming / Number-request (PRN request)to the VLR. VLR responds to PRN request with PRN response message, which carries an MSRN (mobile subscriber roaming number), which can be used for routing toward visiting MSC in the network. HLR returns MSRN to GMSC (MSC that queried HLR) in SRI response message. On getting MSRN the GMSC routes the call towards VMSC The purpose of this entire exercise is to locate where the terminating mobile subscriber is.

The MSRN received at GMSC is in international format (Country Code + Area Code + subscriber number). Normally, based on the routing info at GMSC, the call may be routed out of the GMSC towards VMSC of the terminating subscriber, in which case appropriate signaling protocol (MF or ISUP) depending on the nature of connecting of GMSC with subsequent exchange along the route will apply. If at VMSC the terminating mobile subscriber is found to be free (idle), paging is initiated for terminating mobile subscriber. MSC uses the LAI provided by the VLR to determine which BSS's should page the MS. MSC transmit a message to each of these BSS requesting that a page be performed. Included in the message is the TMSI of the MS. Each of the BSS's broadcasts the TMSI of the mobile in a page message on paging channel (PCH).

When MS detects its TMSI broadcast on the paging channel, it responds with a channel request message over Random Access Channel (RACH). Once BSS receives a channel request message, it allocates a stand –alone Dedicated Control Channel (SDCCH) and forwards this channel assignment information to the MS over Access Grant Channel (AGCH). It is over this SDCCH that the MS communicates with the BSS and MSC until a traffic channel assigned to the MS. MS transmits paging response message to the BSS over the SDCCH. Included in this message is MS TMSI and LAI. BSS forwards this paging response message to the MSC. Now Authentication and Ciphering phases are performed to check the authenticity of MS and encrypt data over radio interface.

On the network side after paging is initiated, while waiting for paging response, a defensive timer called, "Early ACM" timer is run at MSC to avoid network timeouts. On successfully getting paging response, a setup message is constructed to be sent towards terminating MS. In case paging fails due to authentication failure or when the subscriber is out of radio-coverage, the call is cleared.

In case CLIP is not subscribed by the terminating mobile subscriber, calling number is not included in set-up message. In case CLIP is subscribed and PI value in calling number parameter indicates "presentation allowed" the number is included in the set-up message. In case CLIP is subscribed but PI received in calling number parameter indicates "presentation restricted" then number is included only if CLIRO is also subscribed to.

MS on receiving the set-up message performs compatibility Checking before responding to the set-up message – it is possible that MS might be incompatible for certain types of call set-ups. Assuming that MS passes compatibility checking, it acknowledges the call setup with set-up confirm message. After getting set-up confirm message from the MS, MSC performs assignment phase (similar to one discussed in MO call) and a voice path is established from MSC to the MS. MS begins altering the user after it receives the traffic channel assignment. MS send alerting message to the MSC .MSC upon receiving the alerting indication from the MS, begins generating an audible ringing tone to the calling party and sends a network alerting via GMSC to the PSTN. Prior to this the calling party heard silence.

At this point in the call, MS is alerting the called party by generating on audible tone. One of the three events can occur-calling party hangs-up, mobile subscriber answers the phone, or the MSC times out waiting for the mobile subscriber to the answer the call. Since radio traffic channel is a valuable resource, GSM does not allow a MS to ring forever.

In the present scenario we have assumed that the mobile subscriber answers the phone. The MS in response to this action stops alerting and sends a connect message to the MSC. MSC removes the audible tone to the PSTN and connects the PSTN trunk to BSS trunk (terrestrial channel) and sends a connect message via GMSC to the PSTN. The caller and the called party now have a complete talk path. This event typically marks the beginning of the call for billing purposes. MSC sends connect acknowledge message to the MS.

The release triggered by the land user is done in similar way as the release triggered by mobile user. MSC receives a release message from the network to terminate end-to-end connection. PSTN stops billing the calling landline subscriber. MSC sends a disconnect message towards the MS and MS responds by a Release message. MSC release the connection to the PSTN and acknowledges by sending a Release Complete message to PSTN. Now the voice trunk between MSC and BSS is cleared, traffic channel (TCH) is released and the resources are completely released.

The mobile-to-mobile call scenario is a combination of phases encountered in mobile originated (MO) and mobile terminated (MT) call.

5. Conclusions and Future Work

There are many different wireless standards and protocols depending the methods of transferring information (with laser, with infrared beams, with radio frequencies); depending the power consumption; depending the speed of transferring of the information; depending the environment (for example harsh industrial environment, agriculture, medicine, etc.); depending the type of transferred information (voice, data, video, etc.). According the needs, conditions and environment everyone can pick the suitable technology. Based on literary analysis have emerged several groups of technologies in terms of their area of application. It is noteworthy that the best results are obtained by combining several technologies such as in agriculture ZigBee, GSM, SMS and GPS. It was created as a table summarizing the characteristics, advantages and disadvantages of wireless technologies. Our future work is to select the most appropriate technology or combination of technologies to implement in our further research in wireless sensor networks. In the analog communication systems the voice quality was poor and in the GSM networks we find good voice quality and the frequency range is also increased. The transformation has been going and the third generation networks are being used and it has higher frequency ranges and data rates.

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