Call Processing in GSM

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. We also look into short message (SMS) and voice mail service (VMS) as implemented IMPCS pilot project.

RF channel overview:

RF channel play important role in call processing case. These are basically three types of RF control channel.

1. Broadcast control channel:

The broadcast channels are points to multi-point channel, which are defined only for down-link direction (BTS to mobile station). They are divided into:

BCCH (Broad cast control channel):
BCCH acts as a beacon. It informs the mobile about system configuration parameters (e.g. LAI, CELL IDENTITY, NEIGHBOURING CELL). Using this information MS choose the best cell to attach to.

BCCH is always transmitted on full power and it is never frequency hopped.

FCCH frequency correction channel:
MS must tune to FCCH to listen to BCCH. FCCH transmits a constant frequency shift of the radio carrier that is used by the MS for frequency correction.

SCH (synchronization channel):
SCH is used to synchronize the MS in time .SCH carries TDMA frame number and BSIC (Base Station Identity Code)

2. Common control channels :

Common control channels are specified as point to multi-point, which operate only in one direction either in up-link or down-link direction.

PCH (Paging Channel):
PCH is used in down-link direction for sending paging message to MS whenever there is incoming call.

RACH (Random Access Channel) :
RACH is used by the MS to request allocation of a specific dedicated control channel (SDCCH) either in response to a paging message or for call origination /registration from the MS. this is an up-link channel and operate in point to point mode.

AGCH (Access Grant Channel):
AGCH is a logical control channel which is used to allocated a specific dedicated control channel (SDCCH) to MS when MS request for a channel over RACH. AGCH is used in downlink direction.

3. Dedicated Control Channel :

Dedicated control channel are full duplex, point to point channel. They are used for signalling between the BTS and certain MS. They are divided into: -

SACCH (Slow Associated Control Channel):
the SACCH is a duplex channel, which is always allocated to TCH or SDCCH. The SACCH is used for

- Radio link supervision measurements.
- Power control.
- Timing advance information.

In 26 frame traffic multi-frame 13th frame (frame no .12) is used for SACCH.SACCH is used only for non-urgent procedures.

FACCH (Fast Associated Control Channel):
FACCH is requested in case the requirement of signaling is urgent and signaling requirement can not be met by SACCH. This is the case when hand-over is required during conversation phase. During the call FACCH data is transmitted over allocated TCH instead of traffic data. This is marked by a flag known as stealing flag.

SDCCH (Stand Alone Dedicated Control Channel):
The SDCCH is a duplex, point to point channel which is used for signaling in higher layer. It carries all the signaling between BTS & MS when no TCH is allocated to MS. The SDCCH is used for service request, location updates,

subscriber authentication, ciphering. equipment validation and assignment of a TCH.

Mobile originated (MO) call:

There are four distinct phase of a mobile originated call-

-Setup phase.
-Ringing phase.
-Conversation phase.
-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.

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.

Mobile Terminated (MT) call:

The different phases of a mobile terminated call are

- Routing analysis
- Paging.
- Call setup.
- 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.

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 a 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.

Short Message Service (SMS)

SMS is a simple bearer service and acts as a bi-directional alphanumeric paging service, which allows value added service provision as well as management services provision such as advice of charge. A short message can carry at most 160 characters (it can be less depending upon the type of characters and their coding scheme). The SMS could be either in broadcast mode (via CBCH channel) or in a point-to-point mode (via either SDCCH channel if mobile is in idle state, or SACCH if the mobile is in dedicated mode).

SMS allows to provide many values added service to individual/ corporate clients. Individuals may be interested in messaging (transmitting messages in compact way) or leisure services (weather forecast, road traffic, restaurant booking, movies, TV programs etc.). Business users may be interested in corporate information (company performance, stock value), e-commerce etc.

SMS involves specific entities in the GSM network: first is the SMS Service Centre (SMS-SC simply SMSC) which can be connected to several networks and many MSC's (SMS- GMSC's or SMS-IWMSC's) within the same PLMN and which is addressed by a mobile using a E.164 number of the numbering plan of the PLMN. SMSC is capable of following functionality's:

- Transmission of short message towards a mobile, retaining the responsibility of the message until reception of acknowledgement or expiration of the validity period.

- Reception of the short messages from MS and transmission of acknowledgement to the PLMN.

- Transferring messages received from Internet to mobile.

The second entity involved by the SMS is the SME (short message entity), which is responsible for producing or receiving a short message. The SME can be connected to the SMSC via a data network such as X.25 or IP.

A short message is characterized by its parameters the most significant are the validity period, the service center time stamp which indicates the SM arrival time at the SC, etc.

In IMPCS (pilot project), the SMS architecture has been implemented by C-DoT. The hardware architecture of SMSC is similar to HLR and is located on same physical platform. It services as an inter-working and relaying function of the message transfer between two MS. The service provided are-

(i) Mobile Originated short message - Enables MS to send an SMS (up-to 140 bytes) to another MS via SMSC.

(ii) Mobile terminated short message - Enables delivery of an SMS to a particular MS.

(iii) Operator initiated SMS - This facility enables fixed network subscriber to send an SMS to a mobile subscriber through an operator at SMSC.

(iv) SMS Newsletter Service - A group of mobile subscriber can subscribe to SMSC for receiving periodic news regarding sports, weather, traffic etc. The subscription is done through on operator at SMSC. The operator feeds the news segments, which are transferred, to the subscriber periodically.

Voice Mail System (VMS)

VMS offers function of call answering device in the system. It provides personal voice mailbox to the subscribers. VMS redirects/forwards voice calls of a temporarily in accessible subscriber (busy or no reply) to a personal mailbox of the subscriber connected to the MSC. Whenever a call is redirected to VMS, it first greets the caller with a personalized greeting message and prompts the caller to

leave the message in the mailbox. Later on the called party (mobile subscriber) can access the VMS from PLMN/PSTN phone by means of access code.

VMS interfaces with MSC on E1 lines using R2 MF/CCS#7 signaling protocol. In IMPCS network the VMS consists of Pentium PC equipped with Dialogic card loaded with Windows NT 4.0. Dialogic card provides telephony network interface, voice recording, compression and play. The disk capacity requirement of the PC is totally application dependent. For 10,000 subscribers, if each subscriber stores 10 minutes of voice data then disk storage for subscriber voice information is around 20 GB.

References: 1. The GSM system for mobile communication-Michel Mouly & Marie- Bernadette Pautet.

2. GSM system Engineering-Asha Mehrotra (Artech House Publisher).

3. ETSI standard ETS 300303 July 1994 on ISDN, ISDN-GSM, PLMN signalling interface.