Mobility Management

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Outlines

⌘ Introduction

⌘ Handoff

⌘ Roaming Management

⌘ Roaming Management through SS7

⌘ Summary

Introduction

✤ In the PCS system, the mobile service area is covered by a set of BSs which are responsible for relaying the calls to/from the MSs.

✤ The BSs are connected to MSCs by land links.

✤ MSC interfaces the MSs (via BSs) with the PSTN.

✤ Two types of databases are used for roaming management.

  ❑ **Home Location Register (HLR)**

  ❑ **Visitor Location Register (VLR)**

✤ Examples of the protocols to support mobility management

  ❑ **EIA/TIA Interim Standard 41 (IS-41 or ANSI-41)**

  ❑ **GSM Mobile Application Part (MAP)**

Two Aspects of Mobility in a PCS network

⌘ Handoff (link transfer, or handover).

❑ **When a mobile user is engaged in conversation, the MS is connected to a BS via a radio link.**

❑ **If the mobile user moves to the coverage area of another BS, the radio link to the old BS is disconnected, and a radio link to the new BS should be established to continue the conversation.**

⌘ Roaming.

❑ **When a mobile user moves from one PCS system (e.g., the system in Taipei) to another (e.g., the system in Tainan), the system should be informed of the current location of the user.**

Three Strategies for Handoff Detection

⌘ Mobile-Controlled Handoff (MCHO).

- ❑ MCHO is used in DECT and PACS.
- ❑ Part I. The MS continuously monitors the signals of the surrounding BSs.
- ❑ Part II. The MS initiates the handoff process when some handoff criteria are met.

⌘ Network-Controlled Handoff (NCHO).

- ❑ NCHO is used in CT-2 plus and AMPS.
- ❑ Part I. The surrounding BSs measure the signal from the MS.
- ❑ Part II. The network initiates the handoff process when some handoff criteria are met.

⌘ Mobile-Assisted Handoff (MAHO).

- ❑ MAHO is used in GSM and IS-95.
- ❑ Part I. The network asks the MS to measure the signal from the surrounding BSs.
- ❑ Part II. The network the handoff decision based on the reports from the MS.

Inter-BS Handoff (1/3)

✼ The new and old BSs are connected to the same MSC. Assume that MCHO is adopted here.

✼ **Step 1.** The MS momentarily suspends conversation and initiates the handoff procedure by signaling on an idle channel in the new BS. Then it resumes the conversation on the old BS.

✼ **Step 2.** Upon receipt of the signal, the MSC transfers the encryption information to the selected idle channel of the new BS and sets up the new conversation path to the MS through that channel. The switch bridges the new path with the old path and informs the MS to transfer from the old channel to the new channel.

Inter-BS Handoff (2/3)

⌘**Step 3.** After the MS has been transferred to the new BS, it signals the network, and resumes conversation using the new channel.

⌘**Step 4.** Upon receipt of the handoff completion signal, the network removes the bridge from the path and releases resources associated with the old channel

Inter-BS Handoff (3/3)

⌘ For NCHO, all handoff signaling messages are exchanged between the MS and the old BS through the failing link. Thus, the whole process must be completed as quickly as possible.

⌘ If the new BS does not have an idle channel, the handoff call may be dropped (forced to terminate).

⌘ Forced termination of an ongoing call is considered less desirable than blocking a new call attempt.

ISSUE 1: Channel Assignment Schemes for Handoff Calls (1/3)

⌘ Nonprioritized Scheme.

- ❑ **The networks handle a handoff in the same manner as a new call attempt.**

⌘ Reserved Channel Scheme.

- ❑ **Similar to the nonprioritized scheme, except that some channels in each BS are reserved for handoff calls.**

Channel Assignment Schemes for Handoff Calls (2/3)

⌘ Queuing Priority Scheme.

❑ **There is a considerable area where a call can be handled by either BS, which is called the *handoff area*.**

❑ **If no new channel is available in the new BS during handoff, the new BS buffers the handoff request in a *waiting queue*.**

❑ **The MS continues to use the channel with the old BS until either a channel in the new BS becomes available.**

Channel Assignment Schemes for Handoff Calls (3/3)

⌘ Subrating Scheme.

- ❑ **The new BS creates a new channel for a handoff call by sharing resources with an exiting call if no free channel is available.**

- ❑ **Subrating means an occupied full-rate channel is temporarily divided into two channels at half the original rate.**

- ❑ **One half-rate channel is to serve the exiting call, and the other half-rate channel is to serve the handoff request.**

- ❑ **When occupied channels are released, the subrated channels are immediately switched back to full rate channels.**

Intersystem Handoff (2/3)

⌘ Step 1.

- ❑ **Part I.** MSC A requests MSC B to perform handoff measurements on the call in progress.

- ❑ **Part II.** MSC then selects a candidate BS "BS 2", and interrogates BS 2 for signal quality parameters.

- ❑ **Part III.** MSC B returns the signal quality parameters, along with other relevant information, to MSC A.

⌘ Step 2.

- ❑ **Part I.** MSC A checks if the MS has made too many handoffs recently (e.g., to avoid that MS is moving within overlapped area) or if intersystem trunks are not available.

- ❑ **Part II.** If so, MSC A exits the procedure.

- ❑ **Part III.** Otherwise, MSC A asks MSC B to set up a voice channel.

Intersystem Handoff (3/3)

❖ **Step 3.**

❑ **Part I.** MSC A sends the MS a handoff order.

❑ **Part II.** The MS synchronizes to BS 2.

❑ **Part III.** After the MS is connected to BS 2, MSC B informs MSC A that the handoff is successful.

❑ **Part IV.** MSC A then connects the call path (trunk) to MSC B.

❖ MSC A is referred to as the *anchor MSC*, and is always in the call path before and after the handoff.

Anchor Approach (2/2)

- ⌘ If the MS moves back to MSC A again, the connection between MSC A and MSC B is removed.

- ⌘ If the MS moves to the third MSC C, then MSC B will be in the call path.

- ⌘ **Path Minimization.** When the MS moves to the third MSC, the second MSC may be removed from the call path. The link between MSC A and MSC B is disconnected, and MSC MSC C is connected MSC A directly.

Roaming Management

- Two basic operations in roaming management are

  - **Registration (or Location Update):** the process whereby an MS informs the system of its current location

  - **Location Tracking:** the process during which the system locates the MS (this process is required when the network attempts to deliver a call to the mobile user)

- The roaming management schemes proposed in IS-41 and GSM MAP are two-level strategies

- They use a two-tier system of home and visited databases that are

  - **Home Location Register (HLR), and**

  - **Visited Location Register (VLR).**

15

Home Location Register (HLR)

✡ When a user subscribes to the services of a PCS network, a record is created in the system's database,

✡ which is referred as to the home system of the mobile user.

✡ HLR is a network database that stores and manages all subscriptions of a specific operator.

✡ The information contained in HLR includes

- ❑ *MS Identity,*
- ❑ *directory number,*
- ❑ *profile information,*
- ❑ *current location,*
- ❑ *validation period.*

Visitor Location Register (VLR)

- ⌘ When the mobile user visits a PCS network other than the home system, a temporary record for the mobile user is created in the visitor location register (VLR) of the visited system.

- ⌘ The VLR temporarily stores subscription information for the visiting subscribers.

- ⌘ Thus, the MSC (corresponding with the VLR) can provide service to the mobile user.

- ⌘ The VLR is the "other" location register used to retrieve information for handling calls to/from a visiting mobile user.

MS Registration Process (2/3)

⌘ Step 1.

❏ **Suppose that the home system of a mobile user is in Morristown. When the mobile user moves from one visited system (e.g., New York City) to another (e.g., Los Angeles), it must register in the VLR of the new visited system.**

⌘ Step 2.

❏ **Part I.** **The new VLR informs the mobile user's HLR of the person's current location-the address of the new VLR.**

❏ **Part II.** **The The HLR sends an acknowledgement, which includes the MS's profile, to the new VLR.**

MS Registration Process (3/3)

⌘ Step 3.

❑ **The new VLR informs the MS of the successful registration.**

⌘ Step 4.

❑ **After Step 2, the HLR also sends a deregistration message to cancel the obsolete location record of the MS in the old VLR.**

❑ **The old VLR acknowledges the deregistration.**

Call Origination Procedure

⌘ To originate a call, the MS executes the following steps.

❑ **Step 1.** MS contacts the MSC in the visited PCS network.

❑ **Step 2.** The call request is forwarded to the VLR for approval.

❑ **Step 3.** If the call is accepted, the MSC sets up the call to the called party following the standard PSTN call setup procedure.

Call Delivery (Call Termination/Location Tracking) (2/3)

⌘ Step 1.

- ❑ **Part I.** If a wireline phone attempts to call a mobile subscriber, the call is forwarded to a switch, called the **originating switch** in the PSTN.

- ❑ **Part II.** The originating switch queries the HLR to find the current VLR of the MS.

- ❑ **Part III.** The HLR queries the VLR in the which the MS resides to get a routable address.

- ❑ **Note that** if the originating switch is not capable of querying the HLR (i.e., it is not equipped to support mobility), the call is routed through the PSTN to the subscriber's **Gateway MSC**, which queries the HLR to determine the current VLR serving the MS.

Call Delivery (Call Termination/Location Tracking) (3/3)

⌘**Step 2.** The VLR returns the routable address to the originating switch through HLR.

⌘**Step 3.** Based on the routable address, a trunk (voice circuit) is set up from the originating switch to the MS through the visited MSC.

Roaming Management under SS7

- ⌘ How is mobile roaming managed by the PSTN signaling? By using SS7.

- ⌘ *Signaling System No. 7 (SS7)* is a Common Channel Signaling (CCS) system.

- ⌘ SS7 is developed to satisfy the telephone operating companies' requirements for an improvement to the earlier signaling systems, which is lacked the sophistication required to deliver much more than plain old telephone service (POTS).

- ⌘ Signaling between a PCS network and the PSTN are typically achieved by the SS7 network.

Common Channel Signaling (CCS)

✽ CCS is a out-of-band signaling network that provides control and management functions in the telephone network.

✽ CCS consists of

❑ **Supervisory functions,**

❑ **Addressing, and**

❑ **Call Information Provisioning.**

✽ Functions provided by CCS are

❑ **To convey messages to initiate and terminate calls,**

❑ **To determine the status of some part of the network, and**

❑ **To control the amount of traffic allowed.**

Three Distinct Components of SS7 (1/2)

⌘ Service Switching Point (SSP).

- ❑ **A telephone switch interconnected by SS7 links.**
- ❑ **The SSPs performs call processing on calls that originate, tandom, or terminate at that nodes.**
- ❑ **A local SSP in the PSTN can be central or end office (EO).**
- ❑ **An SSP in a PCS network is called a mobile switching center (MSC).**

⌘ Signal Transfer Point (STP).

- ❑ **A switch that relays SS7 messages between network switches and databases.**
- ❑ **Based on the address fields of the SS7 messages, the STPs route the messages to the correct out-going signaling links.**
- ❑ **For the reliability requirements, STPs are provisioned in mated pairs.**

Three Distinct Components of SS7 (2/2)

⌘ Service Control Point (SCP).

❑ **SCP contains databases for providing enhanced services.**

❑ **An SCP accepts queries from an SSP and returns the requested information to the SSP.**

❑ **In mobile applications, an SCP may contains an HLR or VLR.**

⌘ In SS7 network, the *trunks* connects SCPs to STPs, and STPs to SSPs.

⌘ The SSPs and SCPs are connected indirectly through STPs.

Registration through SS7 (2/3)

⌘ **Step 1.** The MS enters the area controlled by MSC2. MSC2 lunches a registration query to its VLR through STP2, assuming that VLR2 and MSC2 are not co-located.

⌘ **Step 2.**

❑ **Part I.** VLR2 sends a registration message to the MS's HLR (HLR4).

❑ **Part II.** VLR2 may not know the actual address of HLR. Instead, VLR2 sends the message containing the MS identity, called *Mobile Identification Number (MIN)*, to an STP (STP3) that can translate the MIN into the HLR address.

Registration through SS7 (3/3)

❖ **Step 3.** The MIN-to-HLR address translation is performed at STP3 by a table-lookup technique called *Global Title Translation (GTT)*. STP3 then forwards the registration message to HLR.

❖ **Step 4.** After the registration, HLR sends an acknowledgement back to VLR2. Since the address of VLR2 is known, the acknowledgement may be sent to VLR2 using a shortcut, without passing through STP3.

❖ **Step 5.** After Step 3, HLR sends a deregistration message to VLR1 to cancel the obsolete record. VLR1 then acknowledges the cancellation.

ISSUE 3: Reducing the "Cost" of Deregistration (1/2)

⌘ Approach 1: Implicit Deregistration.

❑ **Part I.** Obsolete VLR records are not deleted until the database is full.

❑ **Part II.** If the database is full when an MS arrives, a record is deleted, freeing storage space to accommodate the newly arrived MS.

❑ **Part III.** A replacement policy is required to select a record for replacement. (Note that a valid record is replaced, and the information is lost).

❑ **Advantage.** No deregistration messages are sent among the SS7 network elements.

Reducing the "Cost" of Deregistration (2/2)

⌘ Approach 2: Periodic Re-registration.

- ❑ **Part I.** The MS periodically re-registers to the VLR.

- ❑ **Part II.** If the VLR does not receive the re-registration message within a timeout period, the record is deleted.

- ❑ **Advantage 1.** This approach only creates local message traffic between the MSC and the VLR.

- ❑ **Advantage 2.** No SS7 messages are generated if the VLR is co-located with the MSC.

Reducing the Registration Traffic－Pointer Forwarding Scheme (2/2)

✤ Move Operation (registration).

- ❑ When an MS moves from one VLR to another, a pointer is created from the old VLR to the new VLR.

- ❑ No registration to the HLR is required.

✤ Find Operation (call delivery).

- ❑ When the HLR attempts to locate the MS for call delivery, the pointer chain is traced.

- ❑ After the find operation, the HLR points directly to the destination VLR.

Call Delivery through SS7 (2/2)

⌘ Similar to the registration process, visited to several STPs, and a GTT maybe required to access the HLR in call delivery.

⌘ Several STPs may be visited to obtain the routable address from the VLR.

⌘ To reduce the call delivery traffic, a *cache scheme* was proposed.

ISSUE5: Cache Scheme (1/3)

⌘ Two possible positions for the cache.

❑ **Method 1.** The cache is maintained in the originating SSPs.

❑ **Method 2.** The cache is maintained in the STP that performs GTTs.

⌘ A cache entry consists of two fields:

❑ **The MIN of an MS, and**

❑ **The current visited VLR of the MS.**

⌘ The cache contains entries for MSs recently accessed from the SSP.

Cache Scheme (3/3)

⌘ When the calling party originates a call to an MS, the SSP first checks if the cache entry for the MS exists. Three possibilities are

❑ **Case 1: The cache entry does not exist.** The call delivery is processed following the normal procedure.

❑ **Case 2: The cache entry exists and is current.** The VLR is directly accessed.

❑ **Case 3: The cache entry exists but is obsolete.** The procedure detects that the cache entry is obsolete if the queried VLR's response is negative. The normal procedure is executed.

Summary

- ⌘ Handoff

  - ❑ **Handoff Channel Assignment Schemes**

  - ❑ **Intersystem Handoff Procedures (Anchor Approach)**

- ⌘ Roaming Management

- ⌘ Roaming Management through SS7

  - ❑ **Reducing the "Cost" of Deregistration－ Implicit Deregistration, and Periodic Re-registration**

  - ❑ **Reducing the Registration Traffic－Pointer Forwarding Scheme**

  - ❑ **Reducing the Call Delivery Traffic－cache scheme**