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International Roaming for GSM

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Introduction

- GSM supports roaming services that allow a subscriber in a GSM network to receive service when the user visits a different GSM network.
- If the networks are located in different countries, the current GSM implementation for call delivery to the roamer can be very expensive.
- In current GSM international roaming implementations, call delivery to a GSM roamer results in one or two international calls.

Three Scenarios for GSM International Call Delivery (1/2)

- Suppose that a GSM user from Taiwan (named John) roams to Singapore.
- **Scenario 1.**
  - **If a person in Taiwan calls John, the result is a local call + an international call.**
  - **The caller is charged for a local GSM call.**
  - **John is charged for an international call from Taiwan to Singapore.**

Three Scenarios for GSM International Call Delivery (2/2)

- **Scenario 2.**
  - If the caller is from a third country (e.g., Hong Kong), the call delivery to John results in two international calls.
  - The caller is charged for an international call from Hong Kong to Taiwan.
  - John is charged for an international call from Taiwan to Singapore.
- **Scenario 3.**
  - If the caller is in Singapore, the call delivery results in two international calls, even though both caller and callee are in Singapore.
  - This scenario is in fact a special case of Scenario 2, and is referred to as Tromboning.

International GSM Call Setup (1/4)

- The call delivery procedure to a GSM roamer is basically the similar to the GSM basic call setup procedure.
- Two **International Switch Centers (ISCs)** are involved in the voice path.
  - All countries have a national network, which is connected to an international network.
  - ISCs offer inter-working functions between the national networks and the international network.

International GSM Call Setup (2/4)

- The call path of every international call is composed of three segments:
  - One in the origination country,
  - Another in the international network, and
  - The third in the destination country.
- These circuit segments are interconnected by two ISCs.
  - One ISC in the origination country and
  - The other ISC in the destination country.

International GSM Call Setup (3/4)

- Consider the previous example where Jenny (in Singapore) places a call to John (who has roamed from Taiwan to Singapore).
- **Step 1.**
  - John's GSM home system is in Taiwan, so Jenny first dials the International Switch Center Access Code (ISCA) + the Country Code (CC) + John's MSISDN.
  - MSISDN = National Destination Code (NDC) + 6-digit Subscriber Number (SN)
  - Step 1.1. When Switch A interprets the ISCA, it identifies the call as an international call, then sets up the call to Singapore's ISC B.
  - Step 1.2. Based on the CC, ISC B routes the call to Taiwan ISC C.
  - Step 1.3. ISC C interprets the prefix of the remaining digits, and sets up the voice trunk to GMSC D.

International GSM Call Setup (4/4)

- **Step 2**. **GMSC D** queries **HLR E** to obtain **the MSRN**.
- **Steps 3 and 4. HLR E** queries **VLR F**.
  - **Note that these message travel between Taiwan and Singapore (see Steps 3.1, 3.2, 3.3, 4.1, 4.2 and 4.3).**
- **Step 5. The MSRN** is returned to **GMSC D**.
- **Step 6.** Based on the MSRN, **GMSC D** sets up the trunk to MSC G.
- The voice path is

  (1) -> (1.1) -> (1.2) -> (1.3) -> (6.1) -> (6.2) -> (6.3)

Reducing The International Call Delivery Cost (1/2)

- To avoid unnecessary international, an **IAM** message should not travel across country before the destination is known.
- Four solutions are proposed following this guideline.
  - **A basic restriction is that we should not introduce any new types to the GSM MAP.**

Reducing The International Call Delivery Cost (2/2)

- In the first three solutions, we utilize the concept of **roamer location cache (RLC)** .
  - **The RLC in a visited system maintains a database containing the records of all international roamers who are presently in that visited system.**
  - **From the perspective of a VLR, RLC functions as the HLR of a roamer.**
- In Solution 4, **a special dialing code** that leads the call to the **GMSC** of the visited system.
  - **It can perform routing translations to access the HLR of the roamer and route the call to the destination MSC directly.**

Solution 1 (Location Update) (1/3)

- **The RLC** is co-located with the **ISC in the visited system.**
- **Step 1.** The MS registers to the VLR.
- **Step 2.** The **VLR** sends **MAP_UPDATE_LOCATION** to the roamer's HLR.
- **Step 3. ISC B** interrupts the message, identifying it as a roamer registration operation.
- **Step 4.**
  - **At the same time, ISC B duplicates the message and forwards it the RLC.**
  - **RLC creates a record to store the IMSI and VLR/MSC address.**

Solution 1 (Location Update) (2/3)

- **Step 5.**
  - After the registration operation has been completed, the RLC does not have the MSISDN of the roamer (Only IMSI is delivered in the standard GSM location update operations).
  - Without the MSISDN information, the RLC cannot handle call delivery to the roamer.
  - The RLC requests this information from the HLR using the MAP_RESTORE_DATA message.
  - The MSISDN will be returned from the HLR to the RLC through the MAP_INSERT_SUBSCRIBER_DATA.

Solution 1 (Location Update) (3/3)

- If the roamer leaves the visited system, the VLR will receive a **MAP_CANCEL_LOCATION** message.
- After removing the obsolete VLR record of the roamer, the VLR will forward the cancellation message to RLC to cancel the obsolete location record in the RLC.

Call Delivery for Scenario 3 under Solution 1 (1/3)

- **Step 1.**
  - Jenny first dials the ISCA code, the CC code, then John's MSISDN, as before.
  - When Switch A interprets the first portion of the dialed digits (i.e., ISCA + CC), it identifies the call as an international call, then routes the trunk to ISC B.
- **Step 2.**
  - Based on the CC code and the prefix of the remaining digits, ISC B recognizes that the called party is a potential roamer.
  - ISC B searches RLC using the MSISDN provided by the IAM message.
  - If there is no such entry, the call delivery is for Scenario 2, and ISC B forwards the IAM message to Taiwan.

Call Delivery for Scenario 3 under Solution 1 (2/3)

- **Step 3.** If an entry for John is found, **RLC** serves as John's HLR to obtain the **MSRN**.
- **Step 4.** By using the **MSRN**, **ISC B** routes the **IAM** message to John, and the two international circuits are avoided.

The Advantages and Disadvantages for Solution 1

- **The Advantages.**
  - Only ISC B needs to be modified.
  - Other network elements (e.g., VLR and HLR) remain the same.
- **The Disadvantages.**
  - Most ISCs are not equipped with the GSM MAP protocol, and thus may not be able to interrupt the GSM MAP message in Step 2.
  - ISCs typically belong to an international agreement may have to be made between the two service providers.
  - The transfer of charging and billing information is also more difficult.

Solution 2 (Location Update)

- The GSM service provider may want to build its own RLC **without involving an ISC**.
- In this case, call delivery to a foreign GSM user should **not be forwarded to the ISC**.
- Instead, the caller would dial into a switch (colocated with the RLC) in the local GSM system for call forwarding.

Solution 2 (Location Update)

- **Step 1.** The MS registers to the **VLR**.
- **Step 2.**
  - **The VLR recognizes that the registration is for an international roamer.**
  - **The VLR sends the MAP_UPDATE_LOCATION message to the RLC.**
  - **The RLC crates a record to store the IMSI and the VLR/MSC address.**
- **Step 3.** The RLC sends the MAP_UPDATE_LOCATION message to the roamer's HLR through the ISCs.
- **Step 4.** After the registration operation has been completed, RLC obtains the **MSISDN** of the roamer using the **MAP_RESOTRE_DATA** message.

Solution 2 (Call Delivery)

- The steps are the same as those for Solution 1, except that **Jenny dials the number of Switch D instead of the country code**.
- After Switch D is connected, **Jenny will be asked to dial John's MSISDN**.
- If the MSISDN is not found in the RLC (Scenario 2 applies to this call delivery), and Switch D routes the call to the ISC.
- If the MSISDN is found in the RLC (it is a Scenario 3 call delivery), and the call is processed locally.

Disadvantages and Advantages for Solution 2

- **The Advantage.**
  - The modifications are made only within the GSM network.
  - They do not involve an international carrier.
- **The Disadvantages.**
  - The extra modifications to the VLR.
  - The caller must dial the number of Switch D, then the MSISDN.
  - The dialing process is different from the ordinary international call dialing procedure with which users are already familiar.
  - Sophisticated billing procedures are also required (since the calling party can be charged either with a GSM or with an international call.

Solution 3

- Solution 2 may not be attractive because the VLR must be modified.
- An alternative is to introduce an **extractor**.
  - **The extractor** monitors (but does not modify) the messages passing through the signaling links of the VLR and
  - takes action **when a location update message is sent to the HLR in the foreign country**.

Registration and Call Delivery for Solution 3

Registration.

- when the MAP_UPDATE_LOCATION message is delivered from the VLR to the ISC B at step 2, the extractor will send a registration message to the RLC.
- RLC will create a roamer record as illustrated in Solution 2.
- Then the RLC obtains the roamer's MSISDN from the HLR.

Call Delivery.

- The same as that for Solution 2.

The Advantages and Disadvantages for Solution 3

The Advantages.

- Solution 3 is transparent to VLR (which is disadvantages of Solution 2).

The Disadvantages.

- A new network component (i.e., the extractor) is introduced.

Solution 3 can be deployed based on **Lucent Technologies' 5ESS MSC 2000 system**.

The extractor can be an HP E4250 ACCESS7.

- This system is an innovative platform for collecting and analyzing the SS7 data in the network in real time.

The RLC/Switch D can be WinComm's Jupiter PBX.

Solution 4

- The registration procedure is the same as the GSM basic registration procedure.
- The basic idea of this solution is
  - **To divert the mobile call termination (incoming call to the mobile) into the visited GSM system before it reaches the ISC.**
- The operator of the visited GSM system reserves an ***International Roamer Access Code (IRAC)*** in its numbering plan, and announces to the public that it is a cheaper way to call visiting roamers.

Solution 4 (Call Delivery) (1/2)

- To make a call to a visiting GSM roamer, one should dial

NDC1 + IRAC + CC + NDC2 + SN

  - **NDC1: the NDC or mobile network access code to the visited GSM system.**
  - **IRAC: the international roamer access code.**
  - **CC: the country code of the home country.**
  - **NDC2: is the NDC of the home GSM system.**
  - **SN: the subscriber number for the roamer (given by the home GSM system).**

Solution 4 (Call Delivery) (2/2)

- According to **NDC1**, the PSTN routes the call to a GMSC of the visited GSM system.
- From **IRAC**, the GSM recognizes it as an international roaming call.
  - **Instead of querying the HLR of the visited system, the GMSC translates CC + NDC2 + SN into MSISDN and uses it as the address to reach roamer's HLR.**
  - **If there is a bi-directional signaling path between the GMSC and the roamer's HLR, the call would follow the normal GSM call delivery procedure (i.e., the GMSC in the visited system would query the HLR of roamer's home system to obtain the MSRN).**
  - **Since the roamer registered to a VLR in the visited system, the MSRN would route the call to the MSC.**

Discussion for Solution 4 (1/2)

- In this scheme, we assume that a signaling path between the **GMSC in the visited system** and the **HLR in the home system** already exists.
- **Implementation Issue.**
  - **the fulfillment of the signaling relationship (Since the GMSC and the HLR are located in different countries).**
  - **If an international STP does not exits, every node involved in the roaming process must have a *Point Code (PC)* in the International SS7 Signaling Network.**

Discussion for Solution 4 (2/2)

- To fulfill this implementation, the GMSC must
  - (1) Be able to connect to more than one SS7 Signaling Network;
  - (2) Be equipped with the Global Title Translation (GTT) that translates MSISDNs into Network Indicator (Point Code) and Subsystem Number for all HLRs with roaming agreement.
  - (3) Be able to route an international MSRN into the national network.

Advantages and Disadvantages for Solution 4

- The Advantages.
  - The GSM call delivery procedure (and thus the VLR software) is not modified, and
  - No new network elements are required.
  - The implementation is cost-effective because no new network elements (e.g., RLC) are introduced.
  - If GMSC is implemented by a general-purpose switching system (e.g., 5ESS), the cost is reasonable.
- The Disadvantages.
  - A potential limitation is that many MSCs may not have the required functionality to implement this solution.

Summary

- The Cost for International Roaming of GSM
- International GSM Call Setup
- Reducing the International Call Delivery Cost
  - **Solution 1**
  - **Solution 2**
  - **Solution 3**
  - **Solution 4**