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E9-1-1 Crankback routing on the INdigital E9-1-1 network

**a whitepaper guide to the SS7 Crankback feature
for routing legacy E9-1-1 calls in a
transitional NG9-1-1 environment**

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Enhanced SS7 / IUSP trunking configurations in an E9-1-1 to NG9-1-1 transition environment

Overview:

This paper sets out and creates the distinguishing characteristics between two algorithms an originating switch (called switch "OS") can use to perform trunk group selection for an outbound call.

The common use of "alternate" or "overflow" trunk translations in switch OS work as follows: Once switch OS selects a route to the destination, it scans its route table for the first trunk group with an idle outbound member. This routing behavior is common to in-band signaled trunks (CAMA/MF) or out of band (SS7 based trunks.) Note that the enhanced service described in this document addresses only SS7 based facilities.

If the all trunks in the first trunk group are busy, blocked, or unavailable for some reason, the switch picks the next trunk group (alternate) for the route, and continues its scan for an idle member. If no idle member for the route can be found after all available trunk groups have been checked, then the switch gives the caller a reorder or "all circuits are busy" intercept.

If an idle member is found, the switch places the call on the selected outbound trunk. The key point for this discussion is that for the common alternate routing is that **once the trunk has been selected, switch OS considers its call route processing complete.**

A subsequent rejection on the selected trunk by the next switch, or additional switches "N+1" (a common notation for subsequent downstream switches) would result in switch OS providing a re-order or "unable to complete your call" type of signal/message reflected back toward the call originator.

However, a second trunk selection algorithm is available. In most modern class 4 / class 5 switches, this is algorithm is called Crankback. Some switch manufacturers refer this feature as **Automatic** Re-Route capability, which is **not** the same as the **Alternate** Re-Routing described in this paper.

Using the Crankback feature, Switch OS will select another trunk group for a route if the first trunk selection "fails" given these conditions:

- 1) Switch OS chooses the first idle trunk group/member in the routing table. This trunk group connects to the primary or preferred intermediate or final N+1 switch in the direction of the call's destination, that is, the downstream switch or tandem.
- 2) Switch OS issues SS7 ISUP "IAM" (Initial Address Message) for the trunk member to switch N+1.
- 3) Switch N+1 responds to the IAM message with a ISUP/Q.931 "Release" message with one of these cause codes:

Release Cause = 34 (No Circuit/Channel Available)

Release Cause = 38 (Network Out of Order)

Release Cause = 41 (Temporary Failure)

Release Cause = 42 (Switching Equipment Congestion)

Release Cause = 47 (Resource Unavailable/Unspecified)

- 4) Switch OS, using the Crankback feature, then selects a member of the next trunk group in the route table. It is expected that this second trunk group connects to an alternative intermediate or destination switch or trunk group route.

This feature was first implemented by AT&T in their long distance network in the mid 1980s to provide more robust routing in the event a downstream switch blocked a call due to congestion, trunk failures, etc.

This sort of alternate re-routing, or Crankback is useful in providing E9-1-1 service in a transitional environment, or where full telephone number based selective routing is unneeded or would be duplicative and unnecessary in a SS7 switching environment.

ARR or Crankback is available only on SS7 trunks, since MF trunks can't return "cause" codes.

References:

- 1) John G. van Bosse, "Signaling in Telecommunication Networks," John Wiley and Sons, 1998, Section 1.3.4.
- 2) Siemens EWSD Release 20, March 2004 (EDDS Issue L3) Book 0625, Document 03010, Issue G3, Feature 70-88-0200-0200.
- 3) ATIS document T1.TRQ.9-2003

This network service is available throughout the INdigital E9-1-1 network, and is called Crankback 9-1-1 trunk routing, or simply Crankback. INdigital has implemented Crankback as part of an overall E9-1-1 transition plan from legacy networks to NG9-1-1 networks.

Typically, Crankback is implemented in an originating local exchange switch where the serving area of the switch is in multiple public safety agency (9-1-1 authority) or local governmental jurisdictions. Crankback allows the legacy E9-1-1 network to be unaffected by the addition of an additional 911 service provider using a different type of technology than the legacy network provider(s).

Crankback is also useful in providing failsafe E9-1-1 service in jurisdictions that use 'call boxes' as a safeguard for 9-1-1 service. In these instances, the call box is the last and final route for 9-1-1 calls from the originating switch (switch OS), and allow the 9-1-1 call to be routed to a call box phone in the event of a critical network failure or other incident.

Technical requirements for 9-1-1 Crankback trunking

In order for Crankback service - which is a type of routing by rejection scheme - to work, INdigital sends a ISUP release message in response to an ISUP IAM message. In other words, the sequence of events is as follows:

- 5) IAM from originating switch (OS) is received by INdigital.
- 6) The SS7 Intelligent Network trigger launches a signaling control point (SCP) query to the INdigital selective routing database (SCP based SRDB).
- 7) The SCP-SRDB responds, and then:
 - 8) The INdigital SCP "accepts" the call, and the call is processed normally, that is the ISUP signaling selects a trunk group member and sets up the call, returning an ACM (address complete message) to the OS, or
 - 9) The INdigital SCP "rejects" the call, returning an ISUP REL to the OS, with a reject cause code as set out in item 3 on page 3.

In situation 8, if the call is accepted by the INdigital 9-1-1 network for delivery, the INdigital N+1 switch sends an ACM, providing a positive

indication it has "accepted" the call, and will then terminate the 9-1-1 call to the appropriate 9-1-1 agency, or provide announcements or alternate routes as required within the INdigital network.

In situation 9, the OS will receive the ISUP REL in direct response to the IAM. That is, the normal response ACM (address complete) in response to the IAM **will not be sent** by INdigital.

In this way, the call is "released" back to the originating switch, which then uses the switch Crankback feature to do further call processing, the recommended action to be the selection of an alternate route from its switch translations.

Summary

Thru the implementation of this signaling protocol, E9-1-1 calls can transition from legacy network environments to NG9-1-1 call processing platforms without disruption of public safety agencies that continue to be served by legacy E9-1-1 network providers.

INdigital contacts

Parties needing additional information about IN911 Crankback service or other inquiries regarding 9-1-1 trunking are invited to write or call:

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Supporting documentation:

1.0 Acronyms & Abbreviations

ARR Alternate Re-Routing
ANSI American National Standard Institute
BICC Bearer Independent Call Control
IAM Initial Address Message
ISDN Integrated Services Digital Network
ISUP ISDN User Part
SN Switching Node
SS7 Signaling System 7
SCP Signaling Control Point
STP Signaling Transfer Point
TDM Time Division Multiplexing
TG Trunk Group
TS Terminating Switch

2.0 Definitions

- 2.0.1. Alternate Re-Routing parameter: Information sent in either direction giving information about Crankback of a call.
- 2.0.2. End-User: A user of telecommunication services. Examples of types of end users are the general public who initiate an emergency 91-1- call. These could include business, residential, coin, hotel/motel, or other subscribers, or suspended lines that can originate an emergency call.
- 2.0.3. Intermediate Switch: An intermediate switch through which a call passes. Not the originating or terminating switch.
- 2.0.4. Originating Switch: The switch serving the calling party.
- 2.0.5. Terminating Switch: The switch serving the called party.
- 2.0.8. Trunk Group: A set of trunks between two switches with common characteristics.

3.0 Normative References

For non-ANSI documents, only specific sections referenced in the body of this technical requirement are considered normative. The remaining sections of those documents are considered informative.

American National Standards Institute (ANSI):

T1.111-2001, Signaling System No.7, Message Transfer Part

T1.113-2000, Signaling System No. 7 (SS7) Integrated Service Digital Network (ISDN) User Part

T1.673-2002, Bearer Independent Call Control (BICC) capability set

ITU E.351-3/2000, Routing of Multimedia Connections Across TDM-, ATM- and IP-based Networks.

ITU Q.2961-2964-2000, B-ISDN User Part

4.0 User Perspective

4.1 End User Perspective (Human Interface) - The operation of this network capability does not change end user procedures. The application of this capability can help reduce call blocking, improve reliability and accuracy by the proper routing of E9-1-1 calls, and provide failure resiliency.

Insignificant post dial delay will be experienced when an alternate routing after Crankback is performed in a properly configured network.

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4.2 Service Provider Perspective - The following operational function needs to be facilitated: When a particular egress route is not primary, or blocked, control over alternate routing can be accomplished through the provisioning of alternate trunk group treatment as a configuration characteristic. Proper provisioning is needed in both the invoking node and the re-routing node so that alternate re-routing can be invoked.

5.0 Functional block diagrams and illustration narratives

This section includes these illustrative examples:

5.1 and 5.2 – an environment involving the legacy provider’s originating switch, a second legacy provider and (INdigital) as a new market entrant E9-1-1 provider.

5.3 and 5.4 – an environment involving the legacy provider’s originating switch and INdigital as a new market entrant provider. In this illustration, both providers are using SS7 protocol. There is no third provider in this illustration.

5.5 and 5.6 – an environment involving the legacy provider’s originating switch, a second legacy provider and INdigital as a new market entrant provider. In these illustrations, legacy provider 1 and INdigital are using SS7 protocol. Other legacy E911 service providers are not using SS7, and rely on in-band CAMA/MF trunking.

All examples: The conditions in the following examples show the existence of a multiple governmental jurisdictions with a single PSAP within the local exchange service provider’s rate center(s).

These examples could be expanded to include multiple PSAPs served by these providers.

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5.1 - Figure 1 illustrates an example of a network where Crankback capability **would be used between two legacy providers and a new market entrant**. In this example, the providers are using Bearer Independent Call Control (BICC), [another term for SS7 signalling.] The Alternate Re-Routing (ARR) parameter associated with Crankback service is illustrated in this example.

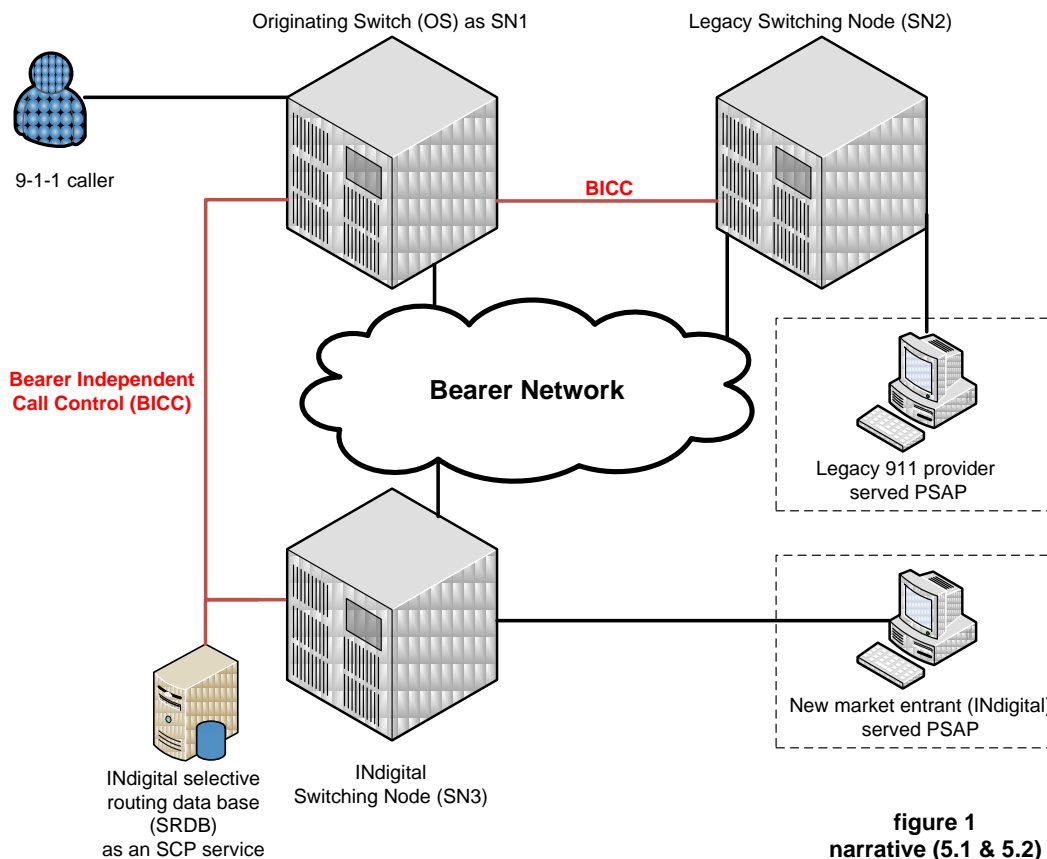


figure 1
narrative (5.1 & 5.2)

5.1.1 A call originates at Switching Node 1 (SN1), from a telephone exchange that may be served by INdigital (as a new market entrant) requiring a transitional network configuration. In this scenario, the E9-1-1 call may require routing to a terminating switch outside the legacy providers' existing network.

5.1.2 The trunk group in SN1 is routed toward Switching Node 3 (SN3) [a terminating switch]. Both switches SN1 and SN3 have been provisioned to facilitate Crankback. Switching Node 2 (SN2) is operated by a second legacy E9-1-1 service provider, and does not require Crankback provisioning.

5.1.3 Successful route selection is based on the switch translations at SN1, which indicate that a BICC Initial Address Message (IAM) should be sent to SN3.

5.1.4 When SN3 receives the IAM, it queries its associated Selective Router Data Base (SRDB). If the subscriber record is **not present** in the SRDB, SN3 responds to SN1 with a release cause value generated by SN3.

This release message consists of an ARR Crankback indication, and is sent back to SN1 over the BICC signaling network.

5.1.5 SN1 receives the Crankback message and continues routing the call to SN2 as if the route to SN3 had not been available. The original route to SN2 that previously existed is provisioned in the route list used by SN1.

5.1.6 SN1 sends an ISUP IAM message to the SN2 terminating switch. SN2 then replies to SN1 with an Address Complete Message (ACM) acknowledgment. The Bearer voice channel between SN1 and SN2 is then set up using a bearer channel protocol, and the call is complete.

5.2 To further illustrate the possible conditions of call routing in this environment, this is the narrative for a scenario where the E9-1-1 call requires routing to a terminating switch outside the legacy providers' existing network, resulting in a successful call between SN1 and SN3.

5.2.1 A BICC IAM message is sent from SN1 to SN3. SN1 has an available TDM bearer trunk to SN3 as a terminating switch.

5.2.2 When SN3 receives the IAM, it queries its associated Selective Router Data Base (SRDB). The subscriber record is present in the SRDB.

5.2.3 SN3 responds to SN1 with an ISUP ACM acknowledgement.

5.2.4 A voice bearer channel between SN3 and SN1 is set up using a bearer protocol. The call is complete.

SN2 is not involved in this message processing transaction.

5.3 - Figure 2 illustrates an example of a network where the Crankback capability is **used between a single legacy provider and a new market entrant**. In this example, the use of the Bearer Independent Call Control (BICC) Alternate Re-Routing (ARR) parameter is illustrated:

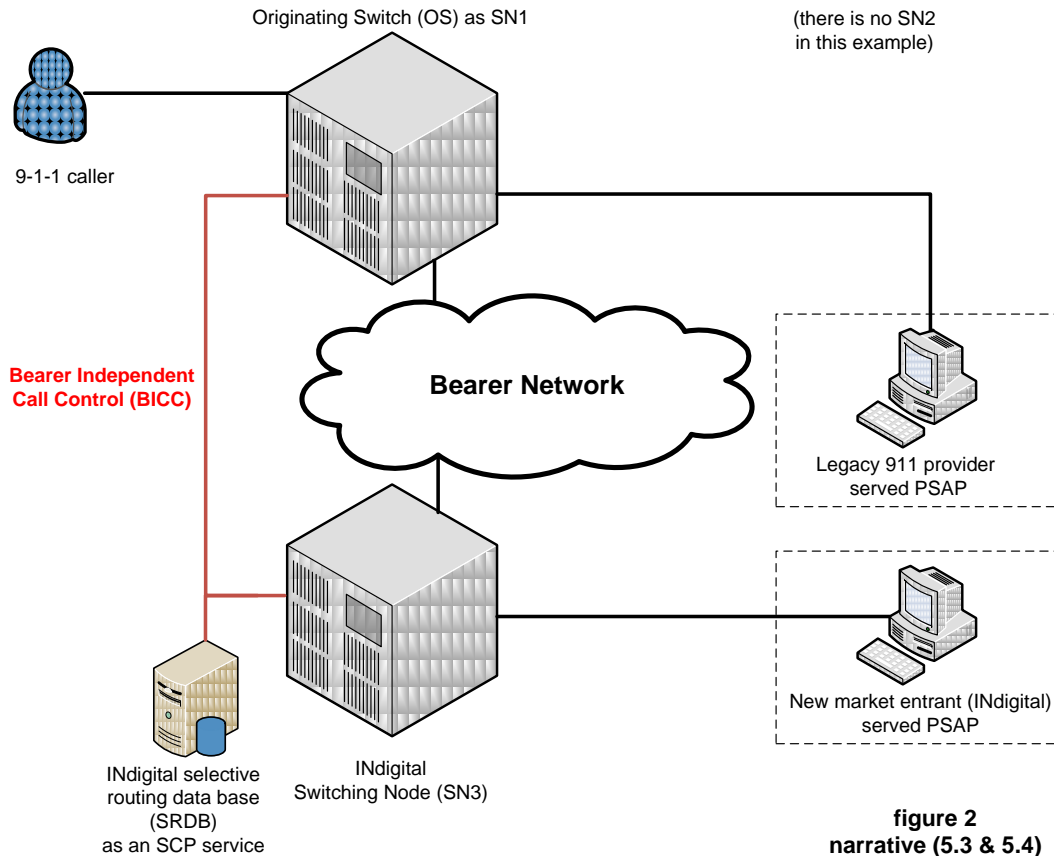


figure 2
narrative (5.3 & 5.4)

5.3.1 A call originates at Switching Node 1 (SN1) from a telephone exchange that may be served by INdigital (as a new market entrant) requiring a transitional network configuration. In this scenario, the E9-1-1 call may require routing to a terminating switch outside the legacy provider's existing network.

5.3.2 The trunk group in SN1 is routed toward Switching Node 3 (SN3) [a terminating switch]. Both switches SN1 and SN3 have been provisioned to facilitate Crankback. [In this scenario, there is no Switching Node 2 (SN2)].

5.3.3 Successful route selection is based on the switch translations at SN1, which indicate that a BICC Initial Address Message (IAM) should be sent to SN3.

5.3.4 When SN3 receives the IAM, it queries its associated Selective Router Data Base (SRDB). If the subscriber record is **not present** in the SRDB, SN3 responds to SN1 with a release cause value generated by SN3.

This release message consists of an ARR Crankback indication, and is sent back to SN1 over the BICC signaling network.

5.3.5 SN1 receives the Crankback message and continues routing the call as if SN3 had not been available. The original route within SN1 is used for the routing and termination of the E9-1-1 call.

5.4 To further illustrate the possible conditions of call routing in this environment, this is the narrative for successful call setup between SN1 and SN3.

5.4.1 A BICC IAM message is sent from SN1 to SN3. SN1 has an available TDM bearer trunk to SN3 as a terminating switch.

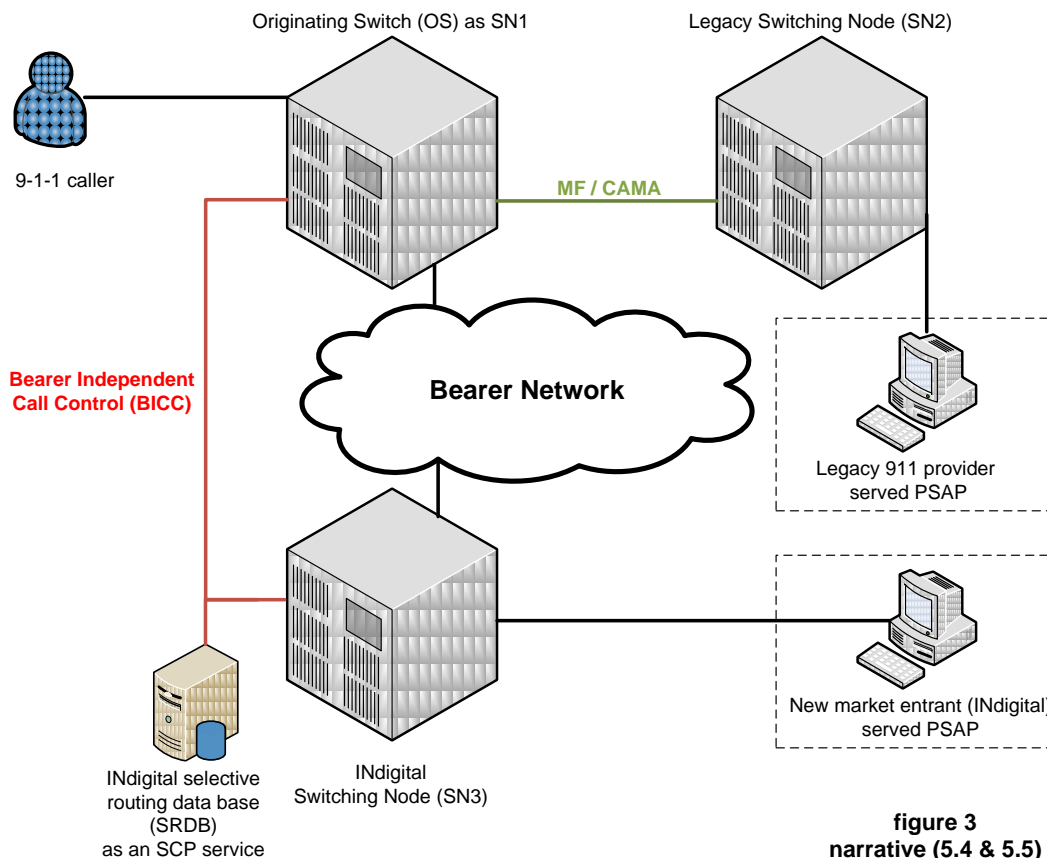
5.4.2 When SN3 receives the IAM, it queries its associated Selective Router Data Base (SRDB). The subscriber record is **present** in the SRDB.

5.4.3 SN3 responds to SN1 with an ISUP ACM acknowledgement.

5.4.4 A voice bearer channel between SN3 and SN1 is set up using a bearer protocol. The call is completed.

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5.5 - Figure 3 illustrates an example of a network where the Crankback capability is **used between two legacy providers, (with one using in-band MF/CAMA trunking) and a new market entrant**. In this example, the use of the Bearer Independent Call Control (BICC) Alternate Re-Routing (ARR) parameter **only with the new market entrant** is illustrated:



5.5.1 A call originates at Switching Node 1 (SN1), from a telephone exchange that may be served by INdigital (as a new market entrant) requiring a transitional network configuration. In this scenario, the E9-1-1 call may require routing to a terminating switch outside either of the legacy providers' existing networks.

5.5.2 The trunk group in SN1 is routed toward Switching Node 3 (SN3) [a terminating switch]. Both switches SN1 and SN3 have been provisioned to facilitate Crankback. Switching Node 2 (SN2) is operated by a second legacy E9-1-1 service provider, and does not require Crankback provisioning.

5.5.3 Successful route selection is based on the switch translations at SN1, which indicate that a BICC Initial Address Message (IAM) should be sent to SN3.

5.5.4 When SN3 receives the IAM, it queries its associated Selective Router Data Base (SRDB). If the subscriber record is **not present** in the SRDB, SN3 responds to SN1 with a release cause value generated by SN3.

5.5.5 This release message consists of an ARR Crankback indication, and is sent back to SN1 over the BICC signaling network.

5.5.6 SN1 receives the Crankback message and continues routing the call to SN2 as if the route to SN3 had not been available. The original route to SN2 that previously existed is provisioned in the route list used by SN1.

5.5.7 SN1 has an available TDM trunk to SN2, the terminating switch. The TDM voice channel between SN1 and SN2 is then established using legacy protocol. In-band signaling occurs, and the call is completed.

5.6 To further illustrate the possible conditions of call routing in this environment, this is the narrative for a scenario where the E9-1-1 call requires routing to a terminating switch outside the legacy providers' existing network, resulting in a successful call between SN1 and SN3.

5.6.1 A BICC IAM message is sent from SN1 to SN3. SN1 has an available TDM bearer trunk to SN3 as a terminating switch.

5.6.2 When SN3 receives the IAM, it queries its associated Selective Router Data Base (SRDB). The subscriber record is present in the SRDB.

5.6.3 SN3 responds to SN1 with an ISUP ACM acknowledgement.

5.6.4 A voice bearer channel between SN3 and SN1 is set up using a bearer protocol. The call is complete.

5.6.5 SN2 is not involved in this message processing transaction.