Handover Protocol for FPLMTS*

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abstract

FPLMTS is the third generation mobile communication system which can provide various and seamless services to mobile users. To provide multimedia services for FPLMTS users, it is widely accepted that integration of FPLMTS with ATM network is indispensible. For the integration of ATM network, there is a need of adaptation both in FPLMTS and in ATM network. In this paper we have investigated the adaptation of ATM network signaling for handover. Q.2931 is the current call control protocol at user-network interface in ATM network. As Q.2931 is designed for the fixed network, it is required that Q.2931 protocol be extended for handover. We analyze the current standardization works on FPLMTS related to handover and present reference model which reflects the physical configuration of FPLMTS. Based on our reference model, we extend Q.2931 by adding messages for the indication of start and end of handover and messages for the change of bearer path of the call.

1 Introduction

The rapid introduction of wireless telecommunication systems resulted in many incompatible services and technologies, each working over a different radio environment and with different terminal type. The concept of FPLMTS(Future Public Land Mobile Telecommunication System)[1] was introduced to ensure seamless wireless access in a widely varying radio environments from indoor to macro-level region.

One of the main purpose of FPLMTS is to provide multimedia services to users. Therefore, it is indispensible for FPLMTS to be integrated with ATM network. Current ATM network considers only for fixed network, so there is a need of adaptation in ATM network[3]. For user mobility, the existing ATM network should adapt itself to support location management, authentication, handover and so on. In this paper, we focus on the signaling aspect at the user-network interface for handover.

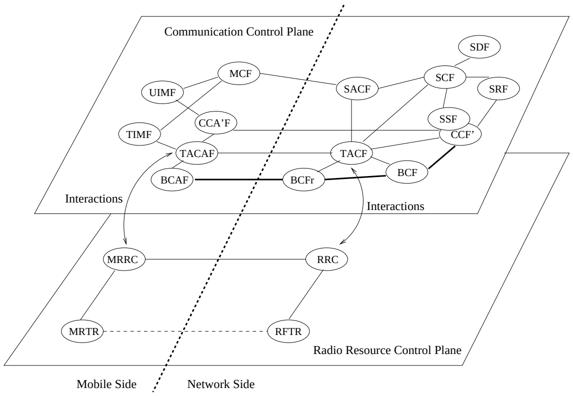

Figure 1. Functional Architecture of FPLMTS

ITU has been actively working on a set of recommendations for FPLMTS, which will operate with the help of IN(Intelligent Network)[5]. Especially ITU-T SG11 works on the signaling aspect for FPLMTS and produced two recommendations : Q.FNA and Q.FIF. Q.FNA[8] document describes the functional network architecture of FPLMTS, as depicted in Figure 1. Functional entities(FE) related to call control and handover are as follows.

- CCF(Call Control Function) : This FE provides call/connection control with $CCAF$.

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- $TACF$(Terminal Access Control Function) : This FE provides overall control of the access and connection between a mobile terminal and network.

- BCF(Bearer Control Function) : This FE controls the interconnection of bearers.

- BCF_r(radio Bearer Control Function) : This FE controls the interconection and adaptation of a radio bearer to the corresponding fixed line bearer.

- RRC(Radio Resource Control Function) : This FE handles the overall control of the radio resource, such as handover decision.

- $CCAF$(Call Control Agent Function) : This FE manages the call/control with CCF.

- $TACAF$(Terminal Access Control Agent Function) : This FE provides access for the mobile terminal.

- $BCAF$(Bearer Control Agent Function) : This FE controls the interconnection of radio bearer to the mobile terminal.

Control information flow for call control and for handover of FPLMTS is described in Q.FIF[9]. We will discuss the control information flow about handover later.

As the conventional ITU recommendations only define signaling protocols for wired networks(Q.2931[10] is the typical case), new protocols are needed. The specific functions to be provided by the newly developed protocols mostly concern registration, location management, and handover. Authentication should be correctly handled too. Since many network elements are concerned at different levels, several protocols can be added (i.e. handover protocol, location management protocol, authentication protocol, registration protocol etc.).

This paper addresses the problem of handover protocol in FPLMTS. In Section 2 the reference model is formulated based on the physical configuration of FPLMTS access network. In Section 3 the architectural requirements and information flows defined in Q.FNA[8] and Q.FIF[9] are investigated to derive the protocol specification for handover. The proposed handover protocol, an extension of Q.2931[10], is described in Section 4. Other functions(authentication, location management etc.) are not discussed in this paper. Then Section 5 will highlight the remaining issues ; NNI signaling for example. Finally we will conclude this paper in Section 6.

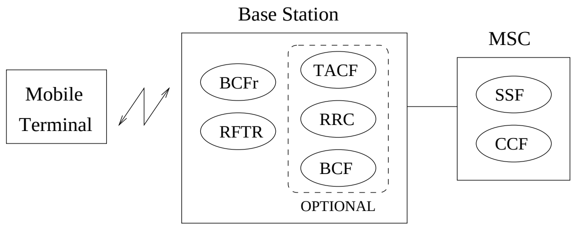

Figure 2. FPLMTS Reference Model

2 Reference Model of FPLMTS

Most of the mobile networks consist of mobile terminals(MT), base stations(BS), mobile switching center(MSC), and IN-related entities(SCP, SDP, etc). Therefore, there can be many possible groupings of FEs in Figure 1 into physical configuration for FPLMTS. A typical configuration of mobile cellular network is assumed here to investigate the signaling for handover on that model. When designing the physical configuration, the key issue is how to distribute the FEs in Figure 1 between BS and MSC.

$TACF$, RRC, BCF are FEs deeply related to the signaling of handover. In [7] the above-mentioned FEs are located in MSC. In that case, MSC has to monitor the radio transmission between all MTs and BSs. Also MSC should be engaged in the bearer control of all MTs(bearer is the communication path between two adjacent nodes[8]). However, handover is usually initiated by BS and/or MT. So it would be better to locate RRC and $TACF$ in BS because these functions are engaged in handover decision. BCF is also located in BS because bearer control is needed in case of handover. In short, BS-oriented approach is adopted. Our reference model of FPLMTS is shown in Figure 2 which contains FEs related to handover. Based on our model, we define handover related messages at user-network interface(UNI) between BS and MSC. These messages will be described later.

In case when some of the above-mentioned FEs are physically located in MSC, some signaling messages are tranmitted within MSC. But we believe that there is no problem although some UNI messages about handover is exchanged between FEs within MSC. This assumption can be also applied to the case when the FEs in BS are distributed into two subsystem : base tranceiver subsystem(BTS) and base station controller(BSC).

3 Handover in FPLMTS

Handover enables MT to change network access areas/points within a network or to an other network, primarily due to the movement of mobile users. It is

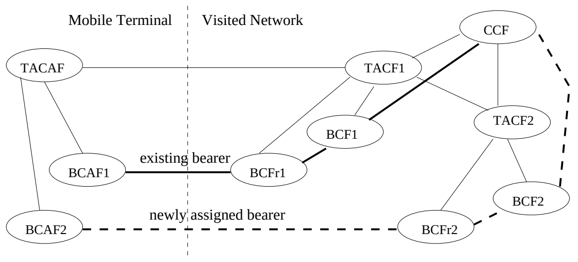

Figure 3. Functional Model of Handover Scenario 1

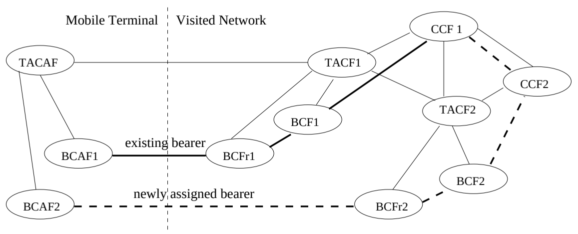

Figure 4. Functional Model of Handover Scenario 2

a capability by which the radio channels and, in some cases, terrestrial channels between an MT and the network are changed while maintaining the state of the calls. Both soft and hard handover[2] are allowed in FPLMTS.

MT may enter a new cell served by the same BS for the previous cell. This is handover scenario 0. When crossing the border between areas served by different BSs, handover of scenario 1(Figure 3) is performed between BSs at the same MSC. Scenario 2(Figure 4) handover is the case where an MT moves into a cell served by different MSC than the previous one. The ITU-T document Q.FIF specifies one more scenario, which is integrated in scenario 1 in our reference model.

The usual handover follows four successive steps : (1) handover initiation triggering, (2) radio resource reservation for handover, (3) establishment of new bearer connection for handover, and (4) detection of handover completion and release of old connection. Figure 5 is the signaling flow of handover in scenario 1.

4 Q.2931 Extensions

In this section, we discuss the signaling messages that are related to handover in FPLMTS. It is generally agreed that Q.2931[10], current ATM UNI signaling protocol for B-ISDN should be extended to support handover and other mobility menagement in FPLMTS[3, 5].

Originally Q.2931 defines the messages to establish, maintain, and release the call/connection between end terminal and fixed ATM network. As Q.2931 is not designed for mobile network, Q.2931 is needed to be extended for user's mobility. The network transactions related to user mobility are registration, location update, authentication, handover and so on. In this paper, we focus on the extension of Q.2931 for handover in FPLMTS.

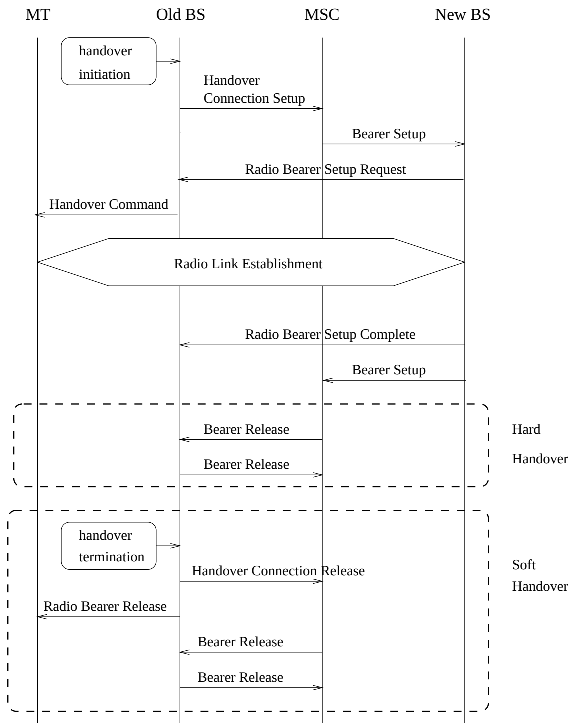

Figure 5. Signaling Flows for Handover in Q.FIF

The call-related signaling messages in Q.2931 are composed of SETUP, CALL PROCEEDING, CONNECT, CONNECT ACKNOWLEDGE, RELEASE, RELEASE COMPLETE messages. These signaling messages' flow is shown in Figure 6. For the information elements for each message, refer to the Q.2931.

For the messages in Figure 5, we assume that mes-

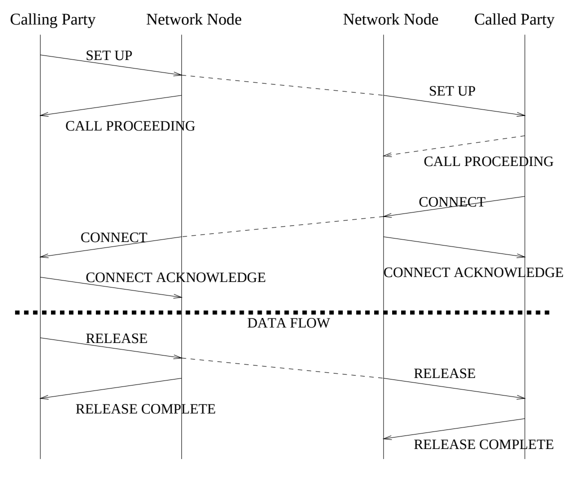

Figure 6. Call Control Message Flows in Q.2931

Signal Message	Functions	Information Elements
HANDOVER CONNECTION SETUP	Request MSC to perform the handover	CCF-TACF relationship ID, Base station ID, Target TACF instance ID, Radio frequency info., Reverse link info., Power control info., Handover mode
BEARER SETUP	Request TACF to set up the bearer connection	CCF-TACF relationship ID, Call ID, Base station ID, Target TACF instance ID, Bearer ID
HANDOVER CONNECTION RELEASE	Request MSC to perform the handover release in the Soft-handover	CCF-TACF relationship ID, Call ID, Released bearer ID
BEARER RELEASE	Request TACF to release the bearer connection	CCF-TACF relationship ID, Cause

Figure 7. Signaling Messages for Handover

sages between MT and BS is handled by the wireless control protocol and that the messages between old BS and new BS is transmitted via the permanent virtual connection(PVC) as in [4]. These messages are, therefore, not considered in Q.2931 extensions. We regard the messages between BS and MSC as the ones that should be added to the current Q.2931 protocol.

According to the information flow for handover in Figure 5 and our reference model, between $TACF$ in BS and CCF in MSC additional messages should be included to Q.2931. The messages and information elements for each message are described in Figure 7, based on Q.FIF.

In Figure 7, **HANDOVER CONNECTION SETUP**, **HANDOVER CONNECTION RELEASE** messages are to indicate the start and end of handover respectively. **BEARER SETUP**, **BEARER RELEASE** messages are used to change the bearer path of the handovered call. The information flow of the above-mentioned messages are depicted in Figure 8. Though **HANDOVER CONNECTION RELEASE** messages is used only in soft handover case, it would be better to include this one because CDMA technology is the most promising candidate for physical layer protocol in FPLMTS.

5 Further Issues

We have investigated the messages for handover at UNI in FPLMTS. The four messages in Section 4, which are suggested to be added into Q.2931, are minimal for the required handover function. If we consider lossless handover, other messages may be needed for the integrity of data flow during handover[11].

In the handover scenario 2, in which multiple MSCs are involved, the NNI(Network Node Interface) messages for handover are needed between MSCs. **SUBSEQUENT HANDOVER** message in Q.FIF, which is used in case when another handover is invoked during one handover, can be added to the message list, although not essential.

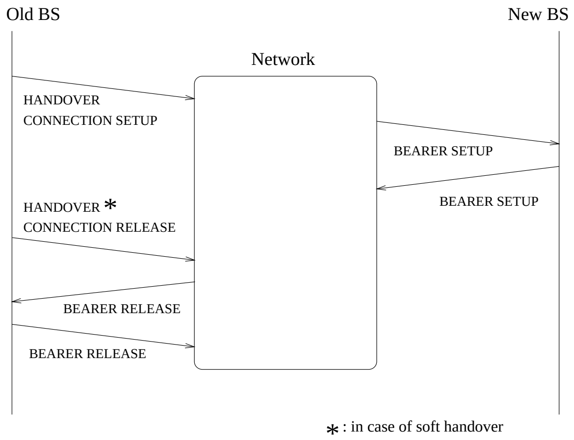

Figure 8: Handover Message Flow in Q.2931 extension

Other necessary functions such as registration, authentication, and location management should be handled at UNI signaling protocol. There can be two different approaches[12] to support these mobility management functions. We can invent separate messages and thereby protocol entities for each functional category. The other approach is the use of a common information element which contains Remote Operation Service Element(ROSE) application protocol data unit(APDU). ROSE is one of application service elements in Common Application Service Element(CASE) layer in the famous OSI 7 layer protocols[13].

6 Conclusions

In this paper, we introduced an overview of ITU standardization of FPLMTS in signaling aspect. Functional architecture and signaling information flow for FPLMTS are described in Q.FNA and Q.FIF respectively.

Functional entities in FPLMTS are specified in a very general and flexible way that we propose our reference model considering physical configuration which consists of MT, BS, and MSC. Our model is BS-oriented approach in that $TCAF$, RRC, BCF are located not in MSC but in BS. Because these functions are closely related to handover processes, our model can process handover efficiently and rapidly.

Based on the model, we analyzed the signaling information flow for handover in Q.FIF and defined the signaling messages to be added to Q.2931. We found that at least four messages were needed for minimal handover function. The messages are **HANDOVER CONNECTION SETUP**, **HANDOVER CONNECTION RELEASE**, **BEARER SETUP**, **BEARER RELEASE** to indicate the start and end of handover and to establish new connection and to release old connection between BS and MSC.

How to embody these messages according to the context of Q.2931 is for further study. For example, the name of **BEARER SETUP**, **BEARER RELEASE** can be renamed as **HANDOVER SEGMENT SETUP**, **HANDOVER SEGMENT RELEASE** respectively or the name of abovementioned messages can be integrated into other UNI signaling messages as in the form of information element.

When multiple MSCs are involved during handover(scenario 2), we should consider the NNI messages between MSCs. It is also required that new NNI messages be created for re-routing. In this case, connection path may be changed for optimal path and there may be a need to exchange NNI messages between switchs.

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