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cdma2000 Femtocell Network: Overview

Revision History

Revision	Description of Changes	Date
Rev. 0 v1.0	Initial Publication	January 2010
Rev. A v1.0	Updated Publication	December 2011

cdma2000 Femtocell Network: Overview

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FOREWORD

(This foreword is not part of this specification.)

This document was prepared by the Third Generation Partnership Project 2 (3GPP2) TSG-X Working Group. This document is a new specification.

This document is part of a multi-part document. The multiple parts together specify the cdma2000®[1] Femtocell Network.

This document is subject to change following formal approval procedures. Should this document be modified in the future, it will be re-released with a change-of-release date and an identifying change in version number as follows:

X.S0059-000-X-n

where:

- X: a numerical or uppercase alphabetic character [A, B, C, …] that indicates the revision level;
- n: a numeric string [1, 2, 3, …] that indicates the point release level.

[1] cdma2000 is the trademark for the technical nomenclature for certain specifications and standards of the Organizational Partners (OPs) of 3GPP2. Geographically (and as of the date of publication), cdma2000 is a registered trademark of the Telecommunications Industry Association (TIA-USA) in the United States.

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1 Introduction

This document provides an overview of the series of documents that specify the HRPD, eHRPD, and cdma2000 1x Femtocell network.

1.1 Scope

This series of documents defines an architecture model and set of specifications for an HRPD, eHRPD, and cdma2000 1x Femtocell network that can support existing services provided by HRPD, eHRPD, and cdma2000 1x.

1.2 Document Conventions

"Shall" and "shall not" identify requirements to be followed strictly to conform to this document and from which no deviation is permitted. "Should" and "should not" indicate that one of several possibilities is recommended as particularly suitable, without mentioning or excluding others, that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is discouraged but not prohibited. "May" and "need not" indicate a course of action permissible within the limits of the document. "Can" and "cannot" are used for statements of possibility and capability, whether material, physical or causal.

2 References

2.1 Normative References

This section provides references to other specifications and standards that are necessary to implement this document.

References are either specific (identified by date of publication, revision identifier, and version number) or non-specific.

- For a specific reference, subsequent revisions may not apply.
- For a non-specific reference, the latest revision applies.

[X.S0002] 3GPP2: X.S0002-0 v2.0, "MAP Location Services Enhancements"*;* June 2006.

[X.S0024] 3GPP2: X.S0024-0 v1.0, "IP-Based Location Services"; November 2005.

[C.S0022] 3GPP2: C.S0022-B v1.0, "Position Determination Service for cdma2000 Spread Spectrum Systems"; April 2009.

[J-STD-036] Joint ATIS/TIA: J-STD-036-C, "Enhanced Wireless 9-1-1 Phase II"; January 2009.

[TS23.002] 3GPP: TS 23.002 v9.1.0, "Network Architecture (Release 9)"; September 2009.

[X.S0011] 3GPP2: X.S0011-E v1.0, "cdma2000 Wireless IP Network Standard"*;* November 2009.

[A.S0024] 3GPP2: A.S0024-A v1.0, "Interoperability Specification (IOS) for Femtocell Access Points"; April, 2011.

[A.S0012] 3GPP2: A.S0012-C v3.0, "Interoperability Specification (IOS) for cdma2000 Access Network Interfaces – Part 2 Transport"; September 2010.

[A.S0014] 3GPP2: A.S0014-C v3.0, "Interoperability Specification (IOS) for cdma2000 Access Network Interfaces – Part 4 (A1, A1p, A2, and A5 Interfaces)"; September 2010.

[A.S0022] 3GPP2: A.S0022-A v1.0, "Interoperability Specification (IOS) for Evolved High Rate Packet Data (eHRPD) Radio Access Network Interfaces and Interworking with Enhanced Universal Terrestrial Radio Access Network (E-UTRAN)"; February 2011.

[X.S0057] 3GPP2: X.S0057, "E-UTRAN – eHRPD Connectivity and Interworking: Core Network Aspects".

[X.S0059-100] 3GPP2: X.S0059-100-A, "cdma2000 Femtocell Network: Packet Data Network Aspects".

[X.S0059-200] 3GPP2: X.S0059-200-A, "cdma2000 Femtocell Network: 1x and IMS Network Aspects".

[X.S0059-400] 3GPP2: X.S0059-400-0, "cdma2000 Femtocell Network: Overview".

3 Definitions and Abbreviations

This section provides definitions, symbols and abbreviations that are used throughout the document.

3.1 Definitions

For the purposes of this document, the following definitions apply.

Femtocell Access Point (FAP)

A Femtocell Access Point (FAP) provides cdma2000 coverage in a small area, usually a private residence or a small office, and connects the MS to an operator's network via a broadband IP connection (e.g., DSL, cable). The FAP may operate in cdma2000 1x mode, HRPD mode, eHRPD mode, or any combination thereof. The FAP, when operating in eHRPD mode, is referred to as an eFAP.

Femtocell Access Control

This function allows any MS that is part of the Access Control List (ACL) for a FAP to access services through that FAP. The types of Femtocell access control include open association, restricted association, and signaling association.

Open Association

Any MS can register with the FAP and access the services provided by cdma2000 1x, HRPD, and eHRPD.

Restricted Association

Only an MS in the ACL for a given FAP is allowed to register and access the services provided by cdma2000 1x, HRPD, and eHRPD.

Signaling Association

Any MS can register with the FAP, but during a service access, the MS may be redirected to a macro base station if that MS is not included in the FAP ACL (i.e., the MS is not authorized to access service through the FAP).

3.2 Abbreviations

3GPP2	3rd Generation Partnership Project 2
AAA	Authentication, Authorization and Accounting
AC	Authentication Center
ACL	Access Control List
ACS	Auto-Configuration Server
AKA	Authentication and Key Agreement
AN	Access Network
BS	Base Station
BSC	Base Station Controller

DSL	Digital Subscriber Line
eAN	Evolved Access Network
eFAP	Evolved Femtocell Access Point
eHRPD	Evolved High Rate Packet Data
EPC	Evolved Packet Core
FA	Foreign Agent
FAP	Femtocell Access Point
FCP	Femtocell Control Protocol
FCPCP	Femtocell Control Protocol Convergence Protocol
FCS	Femtocell Convergence Server
FIAP	Femtocell IOS Application Protocol
FMS	Femtocell Management System
HA	Home Agent
HLR	Home Location Register
HRPD	High Rate Packet Data
HSGW	HRPD Serving Gateway
IKE	Internet Key Exchange
IMS	IP Multimedia Subsystem
IOS	Interoperability Specification
IP	Internet Protocol
IPsec	IP Security
ISC	IP Multimedia Service Control
L1	Layer 1
L2	Layer 2
L3	Layer 3
LAC	Link Access Control
LIIWF	LMSD-IMS Interworking Function
LIPA	Local IP Access
LMA	Local Mobility Anchor
LMSD	Legacy MS Domain
MAC	Media Access Control
MAG	Mobile Access Gateway
MAP	Mobile Application Part
MC	Message Center
MGCF	Media Gateway Control Function
MGW	Media Gateway
MIP	Mobile IP
MS	Mobile Station
MSC	Mobile Switching Center
PCF	Packet Control Function
PCRF	Policy and Charging Rules Function
PMIP	Proxy Mobile IP

PDSN	Packet Data Service Node
PDST	Packet Data Service Termination
PSAP	Public Safety Answering Point
QoS	Quality of Service
SCTP	Stream Control Transmission Protocol
TCAP	Transaction Capabilities Application Part
RIPA	Remote IP Access
RPC	Remote Procedure Call
RTP	Real-Time Transport Protocol
SeGW	Security Gateway
SIP	Session Initiation Protocol
SMS	Short Message Service
TCP	Transmission Control Protocol
UA	User Agent
UDP	User Datagram Protocol
URL	Uniform Resource Locator
VoIP	Voice over IP
WAN	Wide Area Network

4 List of Parts

The Parts that comprise of this document are shown in Table 1. Each document in the series is numbered as a Part. Each Part represents an area of focus within the series of documents.

Table 1 List of Parts

Part	Title
000-A	cdma2000 Femtocell Network: Overview
100-A	cdma2000 Femtocell Network: Packet Data Network Aspects
200-A	cdma2000 Femtocell Network: 1x and IMS Network Aspects
400-0	cdma2000 Femtocell Network: 1x Supplementary Service Aspects

5 Architectural Model and Reference Points

5.1 Femtocell cdma2000 1x Circuit Service Architecture

This section describes cdma2000 1x circuit service Femtocell network architectures.

5.1.1 IMS-based Femtocell cdma2000 1x Circuit Service Architecture with MSC

The figure below shows the access network reference architecture for cdma2000 1x circuit service access from a Femtocell base station. This figure represents the IMS-based architecture used with an MSC.

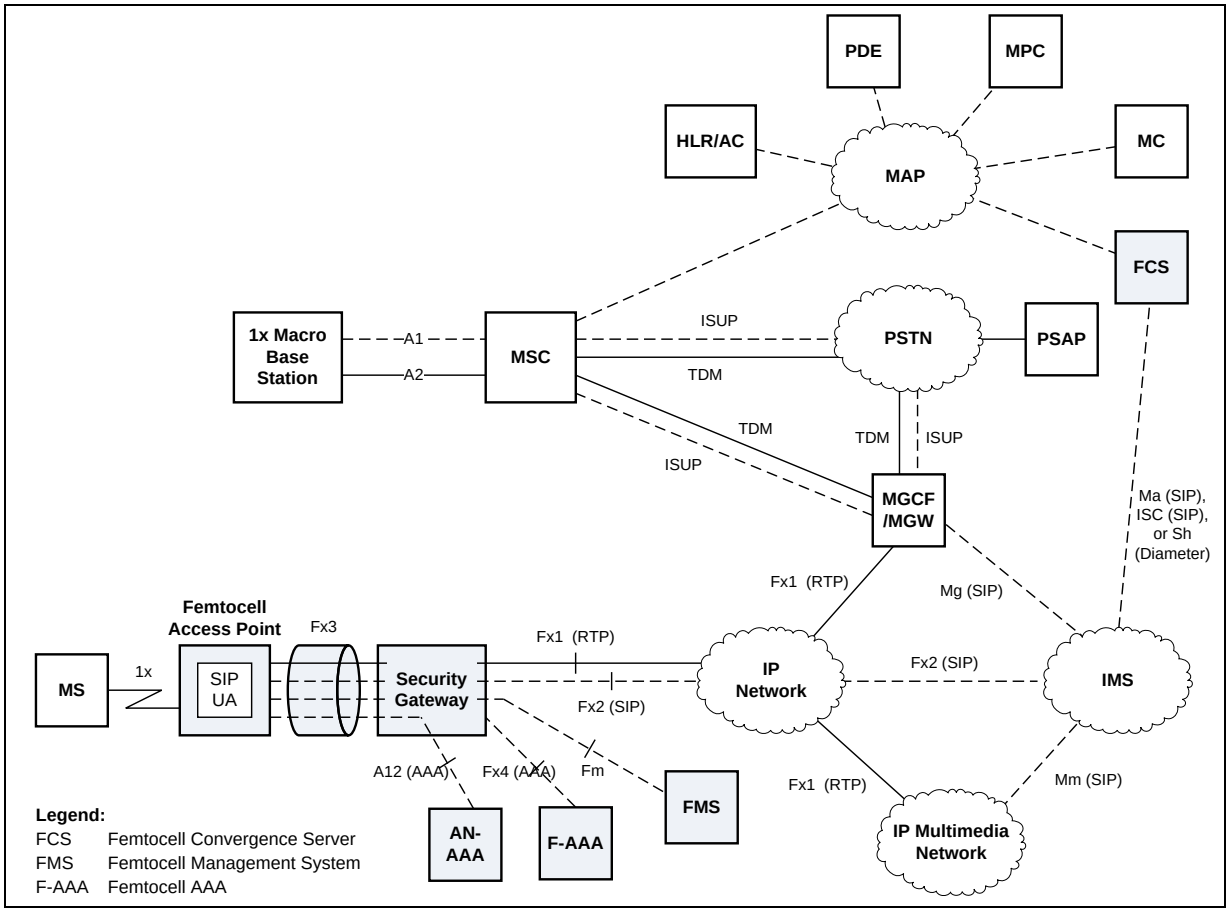

Figure 1 IMS-based cdma2000 1x Circuit Service Femtocell Network Architecture with MSC

Notes:

1. Location Based Services are supported using [X.S0002], [X.S0024], and [C.S0022]. Emergency services calls are supported using [J-STD-036].
2. The Ma, Mg, Mm, Sh and ISC reference points are as defined in [TS23.002].

5.1.2 IMS-based Femtocell cdma2000 1x Circuit Service Architecture with MSCe

The figure below shows the access network reference architecture for cdma2000 1x circuit service access from a Femtocell base station. This figure represents the IMS-based architecture used with an MSCe in support of LMSD.

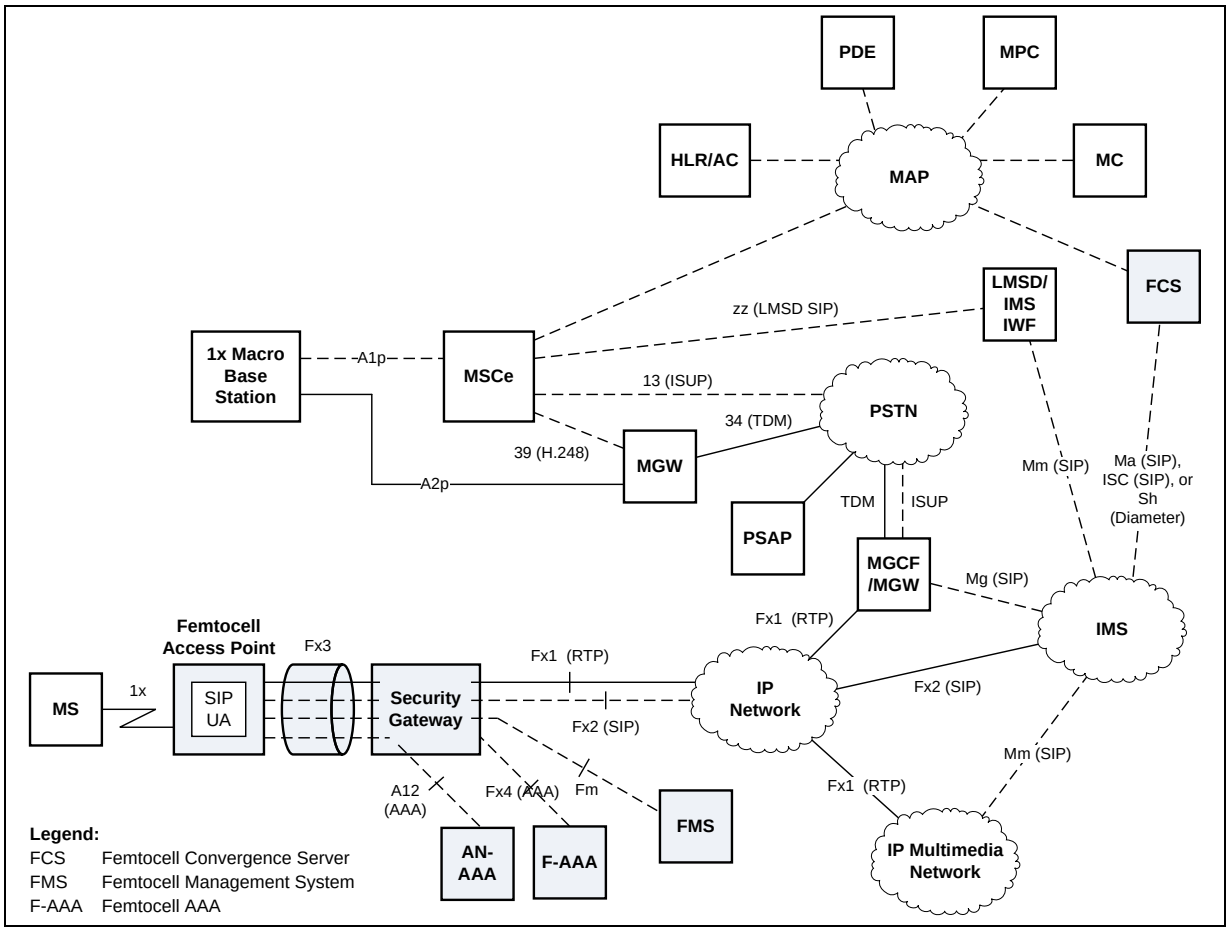

Figure 2 IMS-based cdma2000 1x Circuit Service Femtocell Network Architecture with MSCe

Notes:

1. The LMSD-IMS Interworking Function (LIIWF) provides interworking between the MSCe [X.S0025] and IMS by interworking LMSD SIP and IMS SIP. This function is outside of the scope of this document.

2. The Ma, Mg, Mm, Sh and ISC reference points are as defined in [TS23.002].

5.1.3 IOS-based Femtocell cdma2000 1x Circuit Service Architecture with MSC

The figure below shows the access network reference architecture for cdma2000 1x circuit service access from a Femtocell base station. This figure represents the IOS-based architecture used with an MSC.

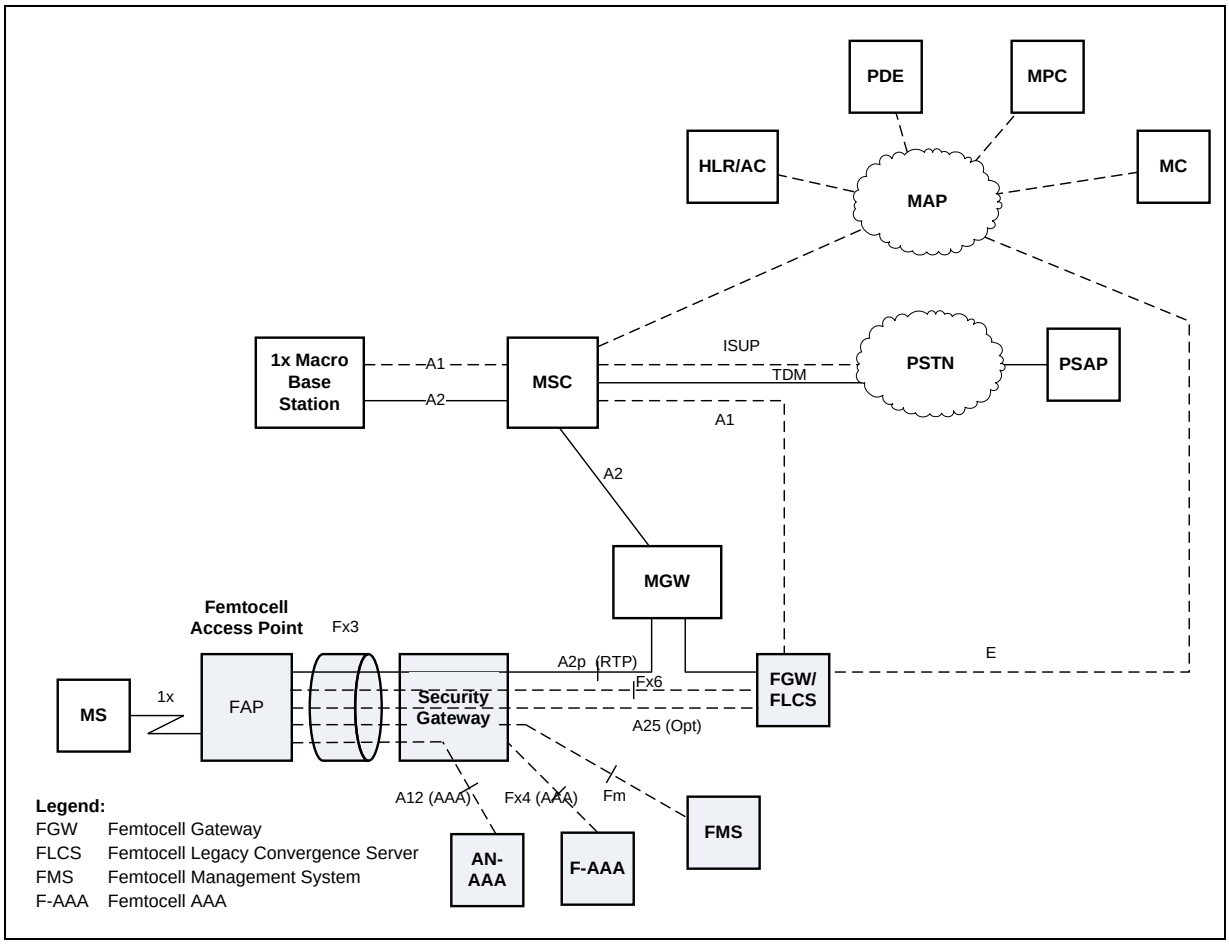

Figure 3 IOS-based cdma2000 1x Circuit Service Femtocell Network Architecture with MSC

Notes:

1. Location Based Services are supported using [X.S0002], [X.S0024], and [C.S0022]. Emergency services calls are supported using [J-STD-036].
2. Either A1/A2 interface to MSC or E interface to the MAP network is used.
3. The interface between the MGW and FGW is outside the scope of this document.

5.1.4 IOS-based Femtocell cdma2000 1x Circuit Service Architecture with MSCe

The figure below shows the access network reference architecture for cdma2000 1x circuit service access from a Femtocell base station. This figure represents the IOS-based architecture used with an MSCe.

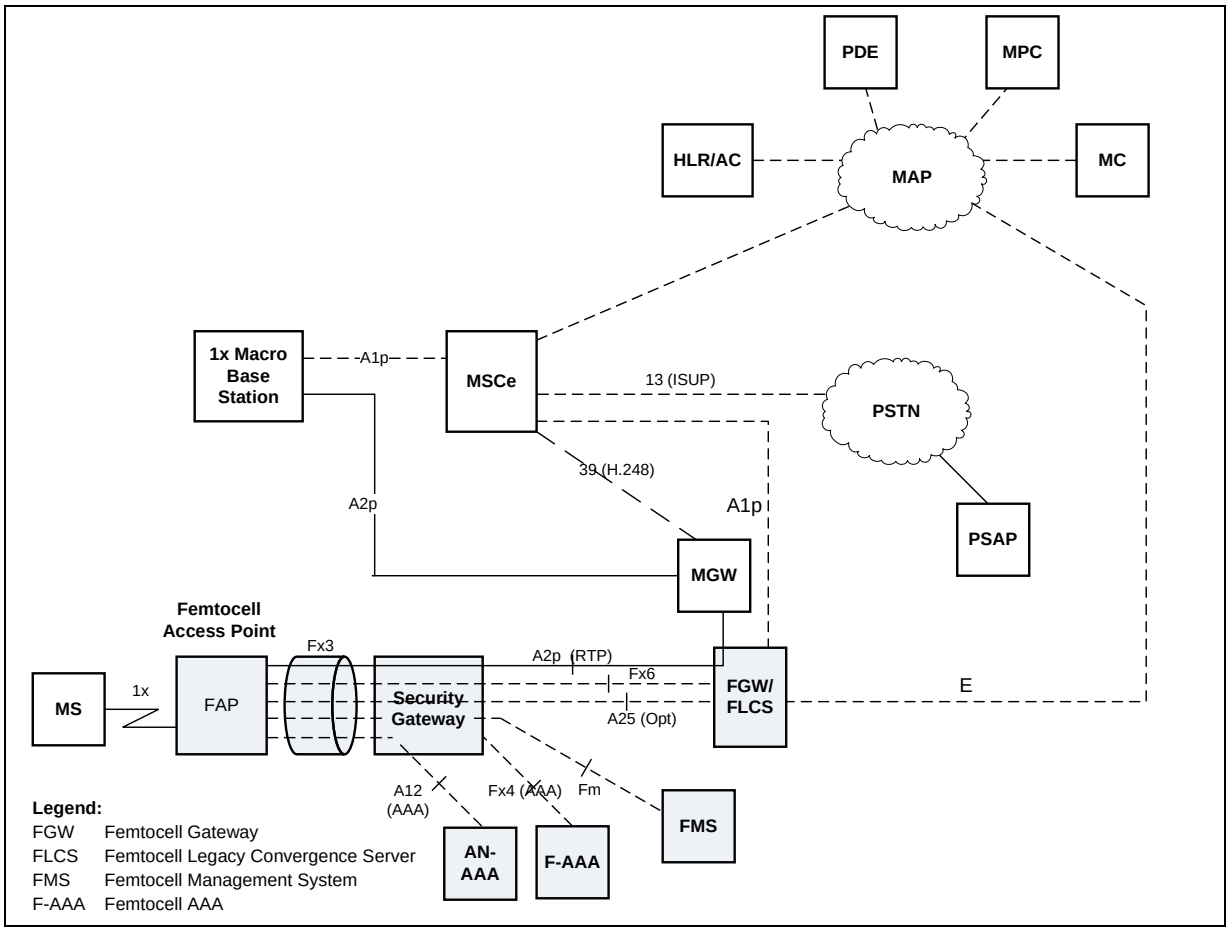

Figure 4 IOS-based cdma2000 1x Circuit Service Femtocell Network Architecture with MSCe

Notes:

1. Location Based Services are supported using [X.S0002], [X.S0024], and [C.S0022]. Emergency services calls are supported using [J-STD-036].
2. Either A1p/A2p interface or E interface to the MAP network is used.
3. The A2p interface between the FAP and MGW may go directly between the FAP and the MGW without going through the FGW.

5.1.5 Network Entities

This document defines the following network entities:

- Femtocell Access Point (FAP);
- Security Gateway (SeGW);
- Femtocell AAA;
- Femtocell Management System (FMS);
- Access Network AAA (AN-AAA);
- Femtocell Convergence Server (FCS); and

- Femtocell Gateway (FGW).

Femtocell Access Point

The FAP provides access for cdma2000 1x MS devices to support cdma2000 1x circuit services. This entity also provides a Femtocell access control function.

Security Gateway

The Security Gateway (SeGW) provides security functions for FAP access to the cdma2000 core network. It supports: secure tunnel management procedures between itself and the FAP, including establishment and release of the tunnel; allocation of an IP address to the FAP from the serving cdma2000 network; and encapsulation and de-capsulation of packets to and from the FAP. Through the interface to the Femtocell AAA, the SeGW supports Femtocell level authentication and transfer of authorization policy information.

Femtocell AAA

The Femtocell AAA provides a FAP authorization function. It sends authorization policy information to the SeGW.

Femtocell Convergence Server

The Femtocell Convergence Server (FCS) is an IMS Application Server that provides interworking among: the FAP that is supporting the cdma2000 1x mobile; the SIP environment of IMS; and the appropriate MAP network elements (e.g., HLR, MC, MPC, cdma2000 1x MSC).

AN-AAA

The AN-AAA provides authorization function for Femtocell access control.

Femtocell Gateway/Femtocell Legacy Convergence Server

The Femtocell Gateway (FGW) is a network entity that resides in an operator's network and provides gateway convergence functions between either an MSC (over the A1/A2 IOS interfaces), an MSCe (over the A1p/A2p IOS interfaces), or the MAP network (over the E interface) and the FAP (over the Fx6 interface). The FGW provides aggregation, proxy, and signal routing functions for the FAPs to access services within the system operator's core network.

Femtocell Management System

The Femtocell Management System (FMS) is a network entity that resides in an operator's network and aids in the auto-configuration of the FAP before the MS can access services through the FAP.

5.1.6 Reference Points

The following reference points are introduced:

Fx1 The RTP bearer interface between the FAP and the Media Gateway (MGW) that carries the RTP payloads.

Fx2 The signaling interface that carries user SIP signaling between the FAP and the IMS core network.

Fx3 The IPsec tunnel between the FAP and the SeGW.

Fx4 The signaling interface between the Security Gateway and the Femtocell AAA.

Fx6 The signaling interface that carries application layer protocols on behalf of the MS between the FAP and the FGW.

A25 The signaling interface that carries control protocols between the FAP and the FGW. A25 is optional and is used only when SIP is not being used to provide transport of Fx6.

Fm The interface between the FAP and the FMS for auto-configuration.

5.1.7 Protocol Descriptions

The protocol stacks for the Femtocell 1x control plane provide six general functions:

1. Femtocell IOS Application Protocol (FIAP) – conveys 1x circuit core network related information elements using a subset of IOS Application Layer messages;
2. FIAP Convergence Protocol (FIAPCP) -- representation and encapsulation of the FIAP messages;
3. Femtocell Control Protocol (FCP) – control protocol between the FGW and the FAP to provide Femtocell-specific control functions (e.g., FAP registration, MS binding for MSs that are being served by the FAP, paging control and optimization);
4. FCP Convergence Protocol (FCPCP) – representation and encapsulation of the FCP messages;
5. FIAP/FIAPCP transport protocols; and
6. FCP/FCPCP transport protocols.

5.1.7.1 FIAP (Femtocell IOS Application Protocol)

The FIAP is comprised of a subset of IOS Application Layer messages (as defined in [A.S0014] and [A.S0024]) that are used between:

- the FAP and the FGW, or
- the FAP and the FCS, when SIP/IMS are used with an FCS (see Section 5.1.1. and 5.1.2).

5.1.7.2 FIAPCP (FIAP Convergence Protocol)

There are two optional protocols for FIAPCP:

1. The A1 application layer message encapsulation and representation protocol as defined in [X.S0059-200]. This encapsulation and representation protocol is used when the FIAP messages are transported using SIP.
2. SUA as defined in [A.S0012]. This encapsulation and representation protocol is used when the FIAP messages are transported using the A1p SCTP protocol stack.

5.1.7.3 FCP (Femtocell Control Protocol)

There are two optional protocols for FCP:

1. SIP – SIP is used to transport FIAP messages to provide FAP registration, MS binding (for MSs that are being served by the FAP), paging control and optimization functions, etc., according to [X.S0059] and [A.S0024]. In this case, basic SIP procedures (e.g., SIP Registration) are used along with a minimal set of extensions (e.g., carried with SIP MESSAGE or SIP INFO requests).
2. A25 – A25 is used when FIAP messages are transported using the protocol stack as specified in [A.S0024] to provide FAP registration, MS binding (for MSs that are being served by the FAP), paging control and optimization functions, etc. A25 is optional and is not used when SIP is being used to transport FIAP messages.

5.1.7.4 FCPCP (FCP Convergence Protocol)

There are two optional protocols for FCPCP:

1. SIP with Femtocell-specific extensions as defined in [X.S0059] and [A.S0024].
2. A25 representation as defined in [A.S0024]. FCPCP is assumed to be null in this case.

5.1.7.5 FIAP/FIAPCP Transport Protocols

There are two optional protocol stacks for FIAP/FIAPCP transport:

1. SIP transported over TCP, UDP, or SCTP according to [X.S0059] and [A.S0024].
2. SCTP/IP.

5.1.7.6 FCP/FCPCP Transport Protocols

There are two optional protocol stacks for FCP/FCPCP transport:

1. SIP transported over TCP, UDP, or SCTP according to [X.S0059] and [A.S0024] when SIP is being used to transport FIAP messages.
2. SCTP when A25 is being used as the FCP.

5.1.8 cdma2000 1x Circuit Protocol Stack

5.1.8.1 IMS-based Femtocell Architecture

5.1.8.1.1 Control Plane between MS and FCS for Voice/SMS

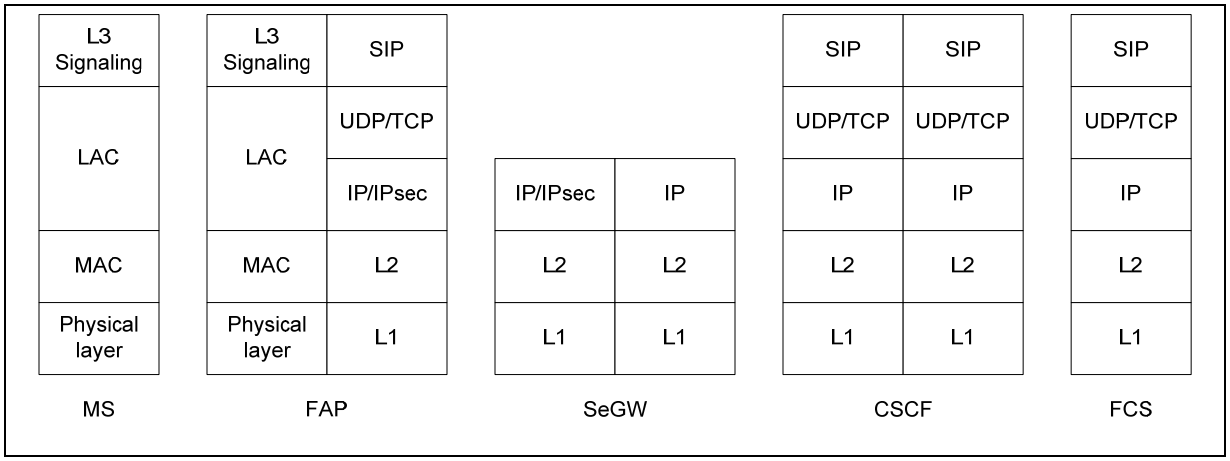

Figure 5 Control Plane between MS and FCS for Voice/SMS

5.1.8.1.2 User Plane between MS and MGW for Voice

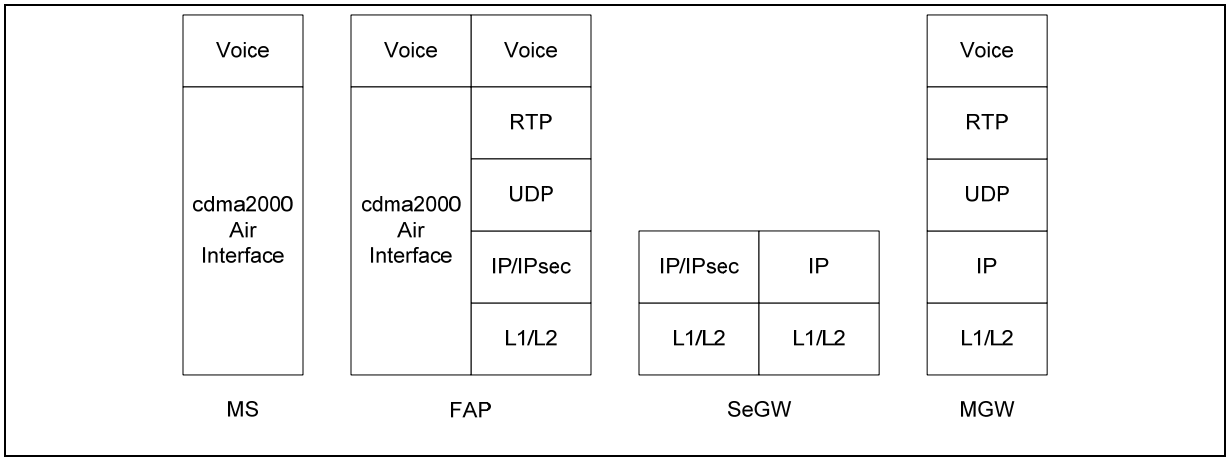

Figure 6 User Plane between MS and MGW for Voice

5.1.8.2 IOS-based Femtocell Architecture

5.1.8.2.1 Control Plane Protocol Stacks when the FGW Uses A1p to the MSCe

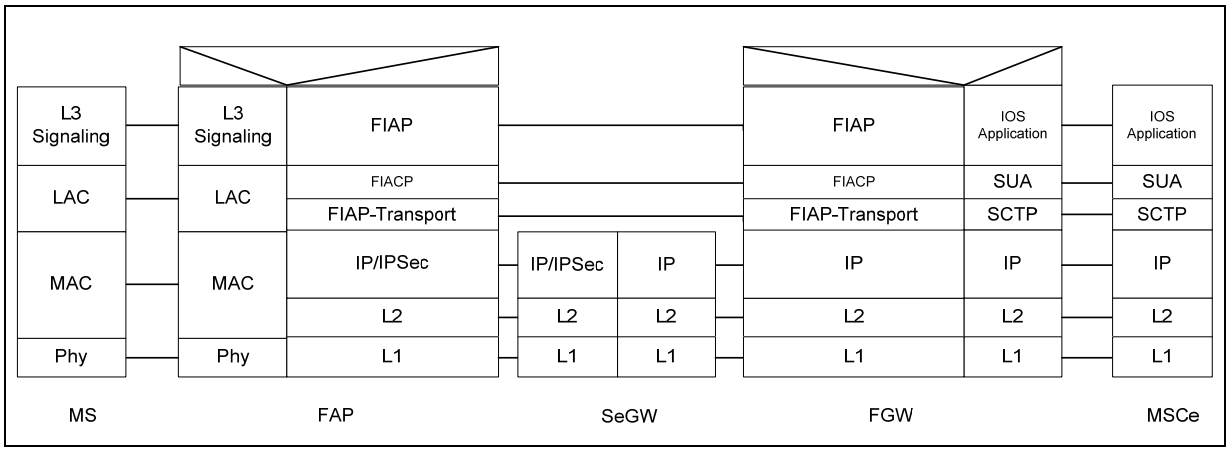

Figure 7 Control Plane Protocol Stacks when the FGW Uses A1p to the MSCe

5.1.8.2.2 User Plane Protocol Stacks when the FGW Uses A1p to the MSCe

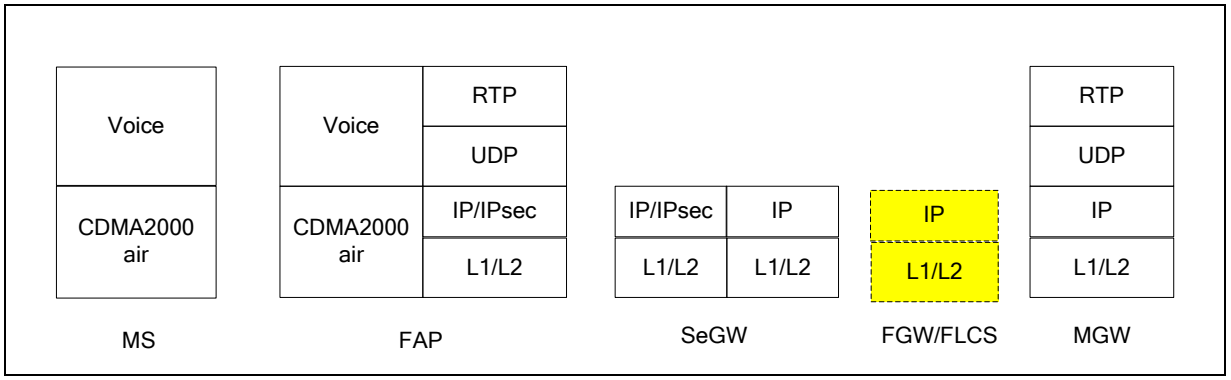

Figure 8 User Plane Protocol Stacks when the FGW Uses A1p to the MSCe

Note: FGW is optional in the bearer plane for RTP traffic.

5.1.8.2.3 Control Plane Protocol Stacks when the FGW Uses A1 to the MSC

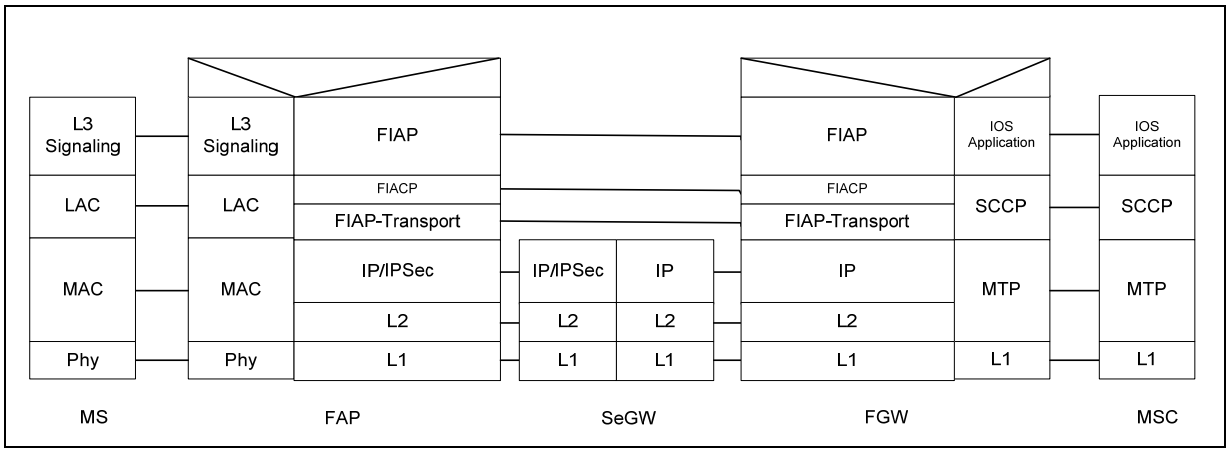

Figure 9 Control Plane Protocol Stacks when the FGW Uses A1 to the MSC

5.1.8.2.4 User Plane Protocol Stacks when the FGW Uses A1 to the MSC

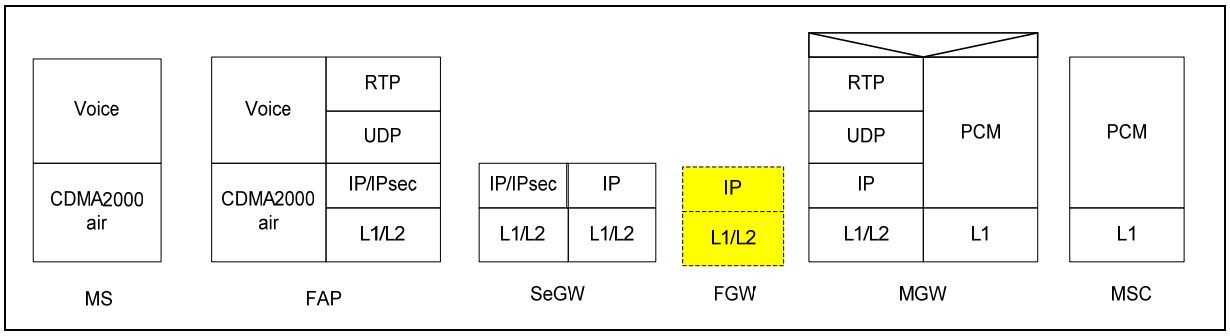

Figure 10 User Plane Protocol Stacks when the FGW Uses A1 to the MSC

5.1.8.2.5 Protocol Stacks for FCP (FCP and FCP/FCPCP Transport)

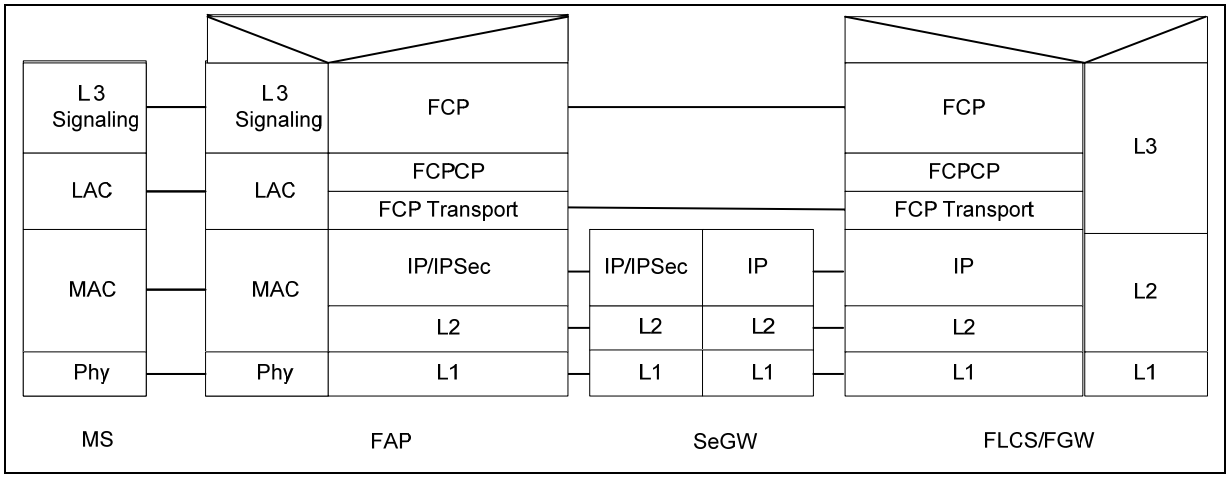

Figure 11 Protocol Stacks for FCP (FCP and FCP/FCPCP Transport)

5.2 HRPD/cdma2000 1x Packet Data Femtocell Architecture

The following figures show the HRPD or cdma2000 1x Packet Data Femtocell network architecture.

In these figures, the only new interfaces introduced (see [X.S0011] and [TS23.002]) are: the interface between Femtocell Access Point and Security Gateway; the interface between Femtocell Access Point and Femtocell Management System; the interface between the Security Gateway and Femtocell AAA; and the interface between the Security Gateway and AAA.

The HRPD Femtocell network architecture also supports Local IP Access (LIPA) which allows an MS to access either local IP networks or the internet through the local interface.

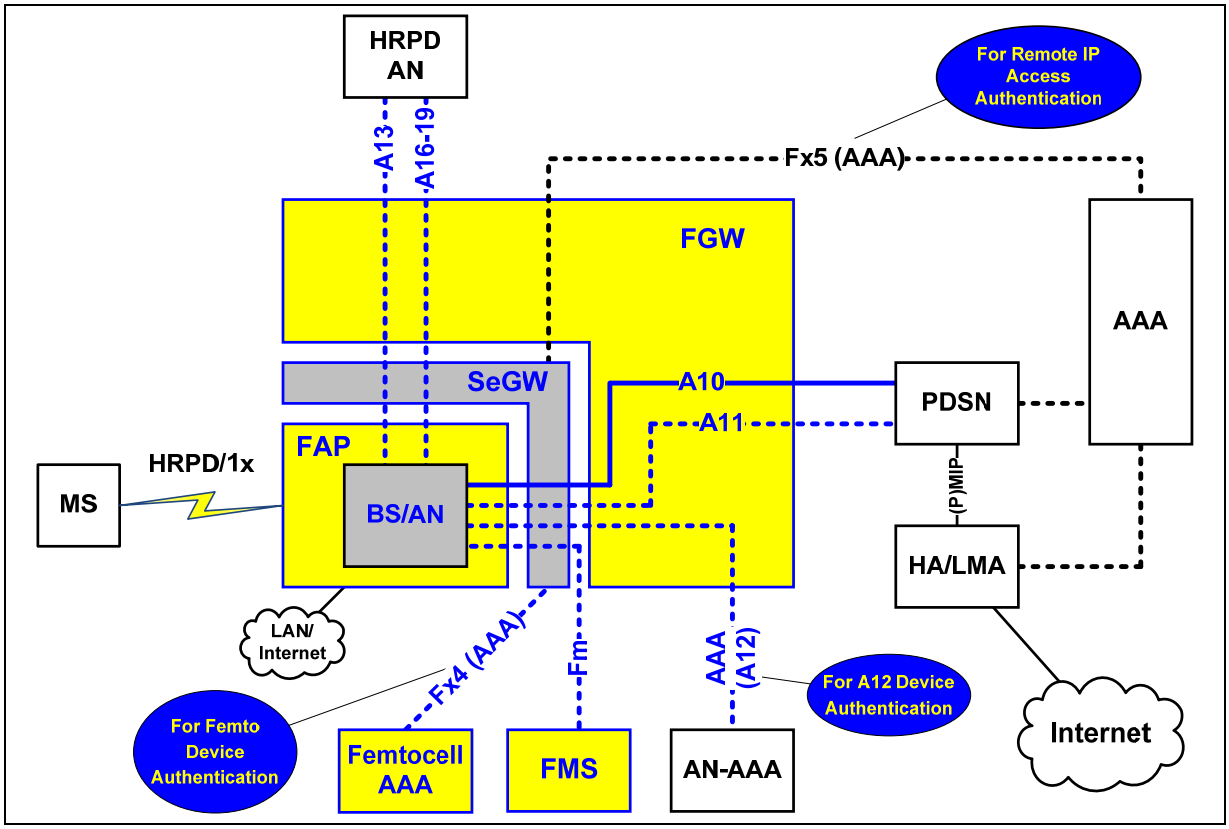

Figure 12 HRPD/cdma2000 1x Packet Femtocell Network Architecture

Note: All interfaces that pass through the SeGW entity are transported within a secure tunnel between the FAP and the SeGW. The Fx3 interface between FAP and SeGW is not shown in the figure.

5.2.1 Network Entities

A description of new network entities and entities with new functions is provided below.

Femtocell Access Point

The FAP provides access for cdma2000 1x and HRPD devices to support cdma2000 1x packet data and HRPD services. This entity also provides a Femtocell access control function.

Security Gateway

The Security Gateway (SeGW) is a network entity that resides in an operator's network and provides secure access for the Femtocell Access Point to access services within the system operator's network.

Femtocell Gateway

The Femtocell Gateway (FGW) is a network entity that resides in an operator's network and provides aggregation and proxy functions for the Femtocell Access Point to access services within the system operator's network.

Femtocell AAA

The Femtocell AAA provides a FAP authorization function. It sends authorization policy information to the SeGW.

Femtocell Management System

The Femtocell Management System (FMS) is a network entity that resides in an operator's network and aids in the auto-configuration of the FAP before the MS can access services through the FAP.

AN-AAA

In addition to the function described in [C.S0022] and [J-STD-036], the AN-AAA also provides a Femtocell access control function and LIPA authorization function. For LIPA authorization, the AN-AAA may access the Home AAA for authorization information, but this interface is outside the scope of this Specification.

5.2.2 Reference Points

The following new reference points make use of existing protocols and interfaces that are specified by 3GPP2 TSG-A, TSG-X, and IETF:

- A12 for HRPD access authentication between the AN function in the FAP and the AN-AAA.
- A13 for HRPD idle session handoff between the AN function in the FAP and another HRPD AN (AN). Identical to the HRPD A13 interface between two ANs.
- A16-19 for HRPD active session handoff between the AN function in the FAP and another HRPD AN. Identical to the HRPD A16-19 interface(s) between two ANs.
- A10/A11 interface between the AN/PCF function in the FAP and the PDSN.
- MIP/Proxy MIP between the FA/MAG function in the FGW and the HA/LMA.

The architecture contains the following new reference points:

Femtocell Access Point – Security Gateway (Fx3)

The interface provides IPsec tunnel between Femtocell Access Point and Security Gateway.

Security Gateway – Femtocell AAA (Fx4)

The interface provides authorization to the Femtocell Access Point.

Femtocell Access Point – Femtocell Management System (Fm)

The Fm interface enables auto-configuration of the FAP by the FMS.

SeGW – AAA (Fx5)

The Fx5 interface enables the AAA to authorize the MS for Remote IP Access (RIPA) to the FAP.

5.2.3 Protocol Stack

5.2.3.1 Control Plane

5.2.3.1.1 Control Plane between FAP and SeGW

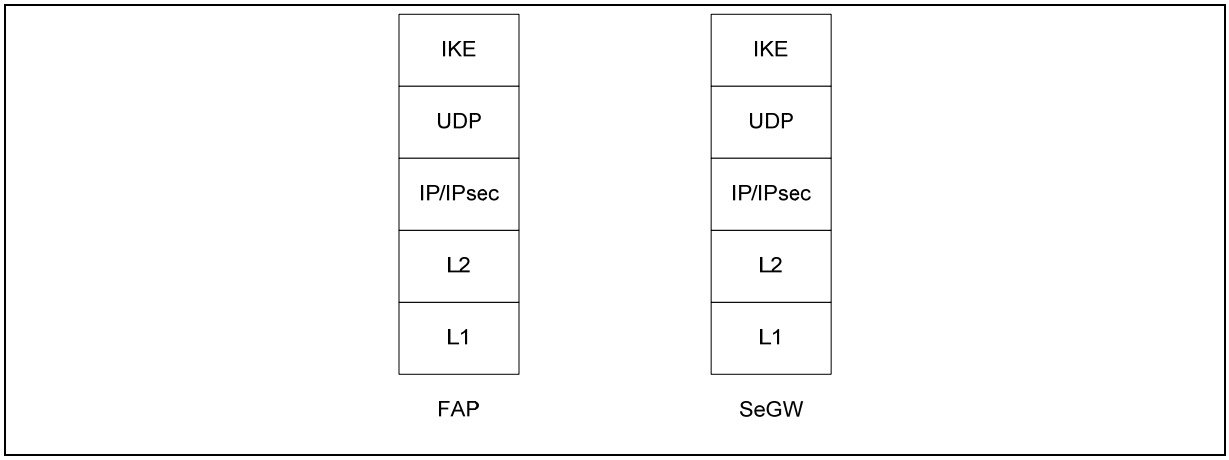

Figure 13 Control Plane between FAP and SeGW

5.2.3.1.2 Control Plane Between FAP, FGW, and PDSN

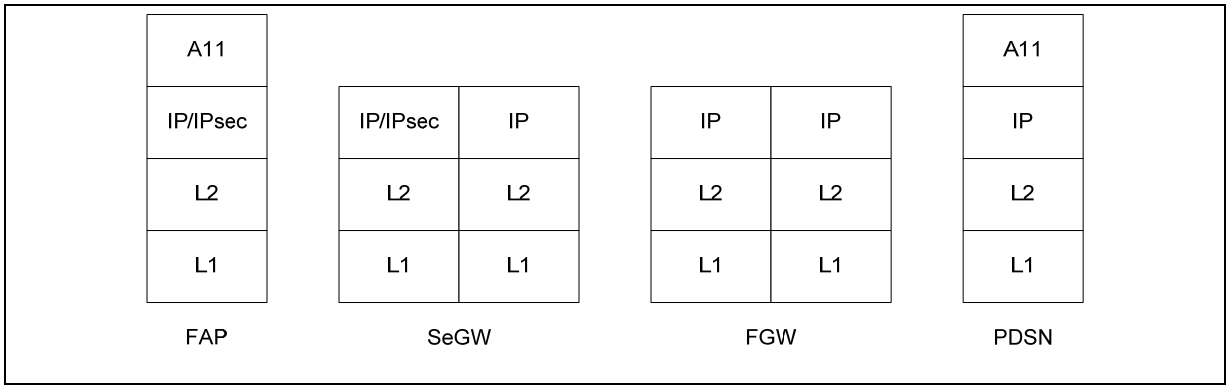

Figure 14 Control Plane Between FAP, FGW, and PDSN

5.2.3.1.3 Control Plane Between MS and PDSN

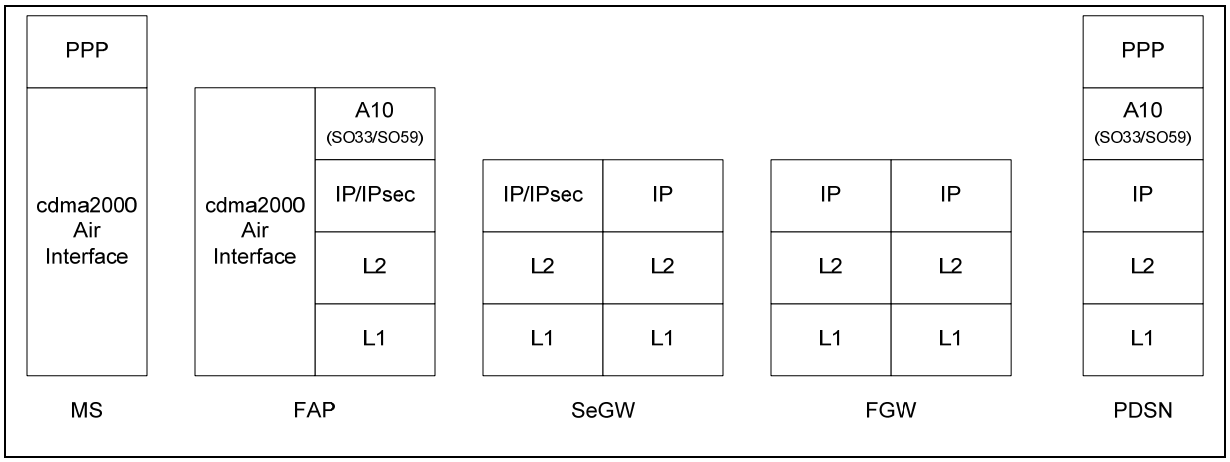

Figure 15 Control Plane Between MS and PDSN

5.2.3.2 User Plane

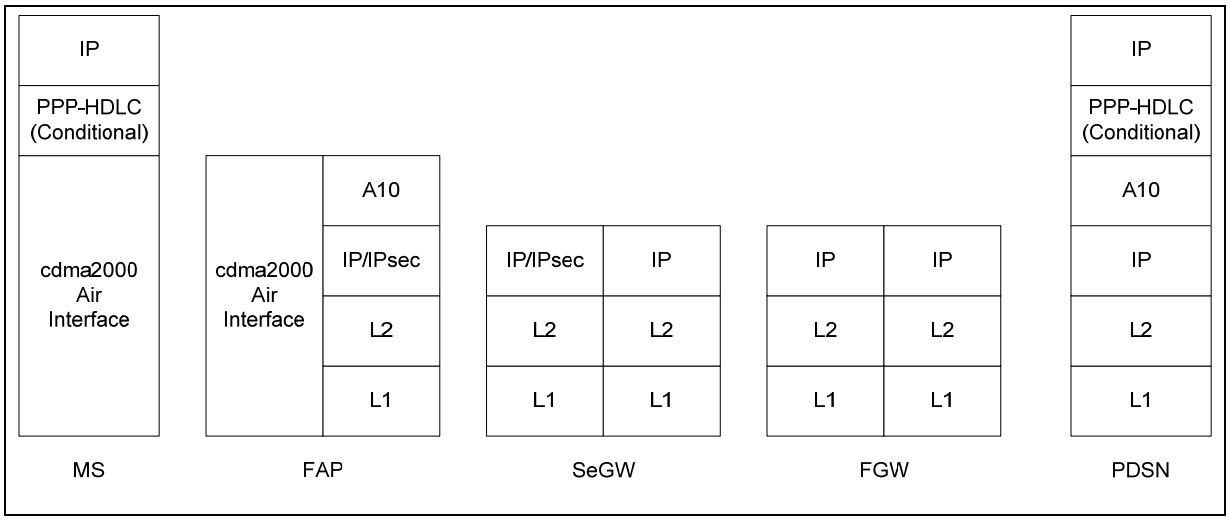

Figure 16 User Plane

5.3 eHRPD Femtocell Architecture

The following figure shows the eHRPD Femtocell network architecture. The architecture shown in Figure 20 does not support optimized handoff between E-UTRA and eHRPD.

The eHRPD Femtocell network architecture also supports Local IP Access (LIPA) and remote IP Address (RIPA) as defined in section 5.2 of this document.

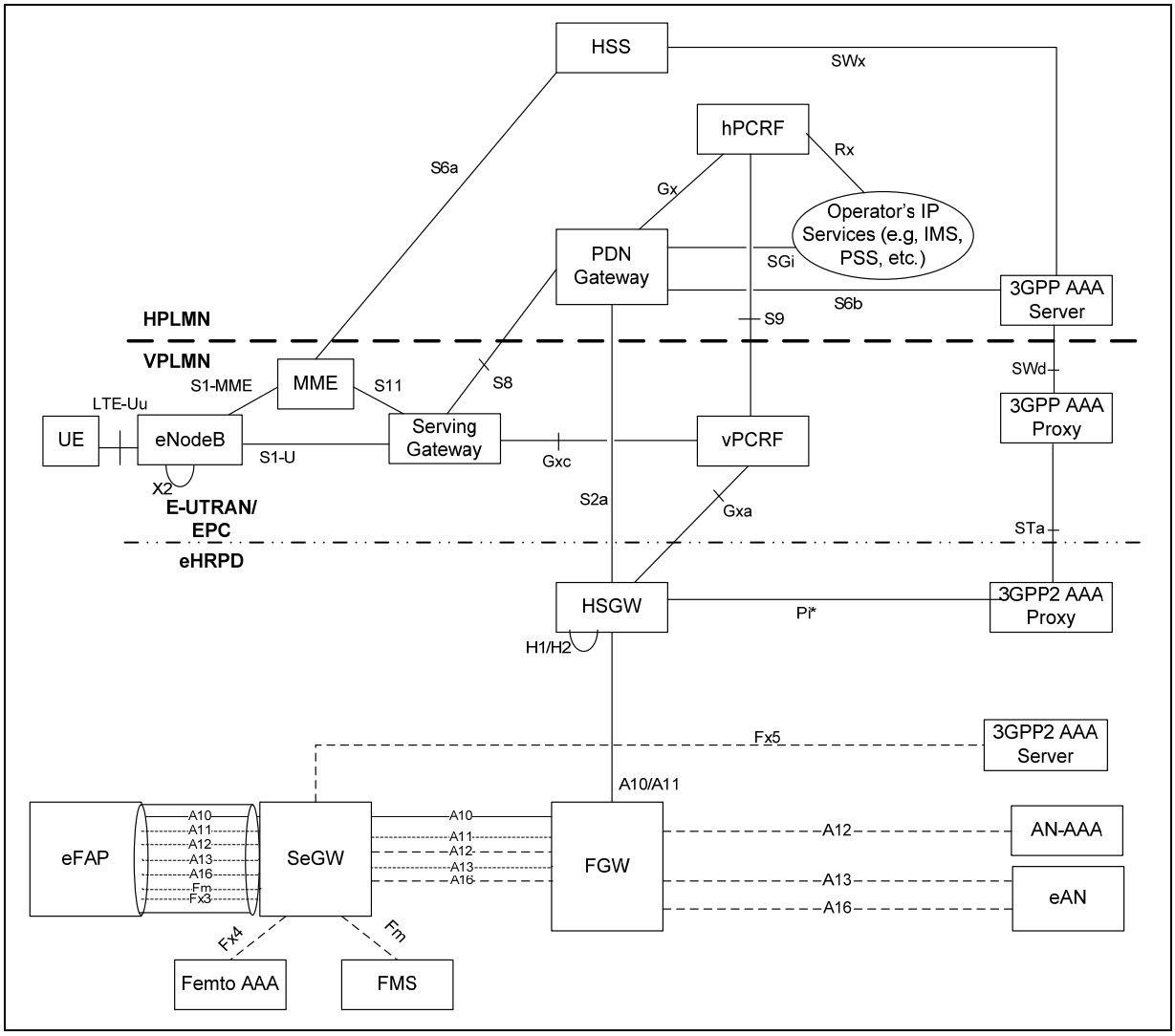

Figure 17 eHRPD Femtocell Network Architecture

5.3.1 Network Entities

Refer to section 5.2.1, [A.S0022], and [X.S0057] for description of network entities, except for the following.

Evolved Femtocell Access Point (eFAP)

The eFAP is a cdma2000 wireless access point that provides coverage in a small area, usually a private residence or a small office, and connects the UE to the EPC (Evolved Packet core) of an operator's network via a broadband connection (e.g., DSL, cable). This entity also provides a Femtocell access control function.

5.3.2 Reference Points

Refer to section 5.2.2 of this document and [X.S0057] for description of reference points with the exception PDSN is replaced with HSGW.

5.3.3 Protocol Stack

Refer to section 5.2.3 of this document for description of protocol stack with the exception PDSN is replaced with HSGW.