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10 **System Requirements for Femto Cell**
11 **Systems**

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Table of Contents

1		
2		
3	Table of Contents	iii
4	List of Tables.....	iv
5	List of Figures	v
6	1 INTRODUCTION AND SCOPE	1
7	1.1 Phasing	1
8	1.2 Terminology	1
9	2 REFERENCES	2
10	3 DEFINITIONS AND ABBREVIATIONS.....	2
11	4 GENERAL FEATURE DESCRIPTION	3
12	4.1 Benefits	4
13	4.2 Use Cases (Informative).....	5
14	5 DETAILED REQUIREMENTS	6
15	5.1 System Requirements	6
16	5.2 Radio Requirements.....	6
17	5.3 Mobility Requirements	7
18	5.4 Security Requirements	8
19	5.5 Operation, Administration, Maintenance and Provisioning	
20	Requirements	9
21	5.6 Regulatory Requirements	10
22	5.7 Performance Requirements	11
23	5.8 Accounting Requirements	11
24	6 SYSTEM DESIGN GOALS	11
25		
26		

List of Tables

- 1
- 2 None.
- 3

List of Figures

1
2 Figure 1 Concept of Femto Cell..... 4
3
4
5

1 **1 INTRODUCTION AND SCOPE**

2 This document specifies the requirements for and operations of femto
3 cells within cdma2000^{®1} networks from the perspective of the user(s)
4 and/or the system operator.

5 The objective is to define and to standardize the functionality of femto
6 cells that can be incorporated into the operations of cdma2000 based
7 wireless telecommunications networks.

8 **1.1 Phasing**

9 This document supports the ability to rollout femto cell capabilities in an
10 incremental manner by means of phased femto cell deployments.

11 This initial effort is to be mindful of the continued development in
12 subsequent phases. At a minimum, the following two phases in the
13 development of femto cell capabilities are envisioned:

14 Phase 1: Development of basic femto cell functionality intended for
15 residential use, for support of legacy mobiles and limited femto-macro
16 mobility when both macro and femto operate the same radio interface
17 (e.g., both are cdma2000-1x).

18 Phase 2: Enhancements for more comprehensive mobility, including
19 femto-femto handoffs, mobility between dissimilar radio interfaces, etc.
20 Phase 2 may additionally include enhancements that can facilitate
21 denser femto cell deployments.

22 **1.2 Terminology**

23 In this document, the phrase “it shall be possible to support ...” implies
24 that the 3GPP2 specifications shall include appropriate procedures for
25 the specified feature. This phrase further implies that an operator is not
26 required to deploy the feature in their network.

27 In this document, requirements on “femto cell systems” indicate that the
28 functionality is to be included in 3GPP2 specifications related to femto
29 cell support. This phrase further implies that an operator is not required
30 to deploy the specific feature defined by the requirement in their
31 network.

32

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1 **2 REFERENCES**

2 The document references which are applicable to this specification
3 include the following:

- 4 [1] 3GPP2 C.S0024-B *cdma2000 High Rate Packet Data Air Interface*
5 *Specification*
- 6 [2] 3GPP2 C.S0001~0006 *Radio Interface Specifications for cdma2000*
7 *Spread Spectrum System*
- 8 [3] 3GPP2 X.S0013-003 *All-IP Core Network Multimedia Domain; IP*
9 *Multimedia Session (IMS) Handling; IP Multimedia (IM) Call Model*
- 10 [4] 3GPP2 S.R0108 *HRPD-cdma2000-1x Interoperability for Voice and*
11 *Data*
- 12 [5] 3GPP2 S.R0087-A *cdma2000 – WLAN Interworking*
- 13 [6] 3GPP2 X.S0013-000-A *All-IP Core Network Multimedia Domain*
- 14 [7] 3GPP2 C.S0010-C v2.0 *Recommended Minimum Performance*
15 *Standards for cdma2000 Spread Spectrum Base Stations*
- 16 [8] 3GPP2 C.S0032-A v2.0 *Recommended Minimum Performance*
17 *Standards for cdma2000 High Rate Packet Data Access Network*
- 18 [9] 3GPP2 C.S0057-B v1.0 *Band Class Specification for cdma2000*
19 *Spread Spectrum Systems*

20 **3 DEFINITIONS AND ABBREVIATIONS**

21 The terms and abbreviations which are used within this specification are
22 defined as follows:

23

Active handoff	A handoff performed by the terminal while active on the radio channel. This includes hard and soft handoff for cdma2000-1x and connected state handoff for HRPD.
AT	Access Terminal
BS	Base Station
DSL	Digital Subscriber Line
Femto cell	A radio access network element that supports one or more of the cdma2000 family of radio interfaces, operates in a limited geographic area in licensed spectrum, may operate over the public internet, and supports a limited number of simultaneous users in a home environment.
Femto cell system	A set of one or more femto cells and a set of

	core network elements to manage and support the use of those femto cells in accessing network services.
GPS	Global Positioning System
Hand-in	Handoff from the macro cellular network to the femto cell
Hand-out	Handoff from the femto cell to the macro cellular network
HRPD	High Rate Packet Data
LAN	Local Area Network
Legacy mobile	An MS/AT that has not been enhanced in any way to support femto cell operation
MS	Mobile Station
OAM&P	Operation, Administration, Maintenance, and Provisioning
OAM&P System	The Network Management System (NMS), Element Management System (EMS), and the network management functions within the components of the femto cell system that jointly provide OAM&P functions
QoS	Quality of Service
WLAN	Wireless Local Area Network

1 **4 GENERAL FEATURE DESCRIPTION**

2 The function of a femto cell from a user perspective is similar to that of a
3 Wireless LAN (Local Area Network). Its principal functions are for
4 coverage extension and for offloading users from the cellular network.

5 This makes possible support of existing cdma2000 MS/AT without
6 modification, while preserving a high level of integration with the existing
7 macro cellular network.

8 The concept of femto cells is illustrated in Figure 1. A low power base
9 station (BS) transceiver is installed indoors (home or office), and
10 connected to the Internet via cable, DSL, on-premise fiber optic link, or a
11 similar IP backhaul technology. This connection is used to integrate the
12 femto cell with the wireless operator's core network.

13 The purpose of this document is to enable support of cdma2000/UMB
14 mobiles on femto cells, and to set out requirements for operation of femto
15 cells in licensed spectrum. Any potential deployment in unlicensed
16 bands is outside the scope of this document.
17

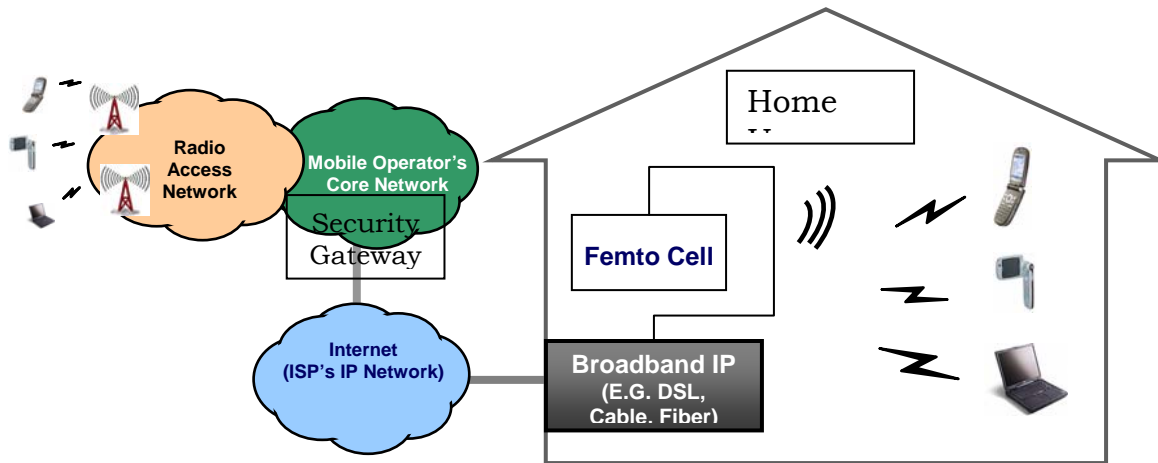


Figure 1 Concept of Femto Cell

4.1 Benefits

According to some estimates, the proportion of calls originating from residences is in the range of 30% to 60%, and has an upward trend, as wireless calling becomes more affordable, and often a replacement for landline calls. At the same time, percentage of homes with a broadband Internet connection is also rapidly increasing.

Under these circumstances, femto cells have the following benefits:

Improvement of Coverage and Capacity: Cellular operators can improve indoor coverage of wireless services, and enhance performance and QoS of wireless data services delivered in the home or in the office. By offloading some traffic to the femto cells, operators can increase system capacity. Improved coverage in locations such as home and office, where subscribers spend much of their time, reduces churn.

Backhaul: Wireless operators can take advantage of existing home broadband connectivity for backhauling traffic whenever the subscriber is in the vicinity of a femto cell (e.g. at home).

New Service Offering: Femto Cells offer the operator a possibility to develop new service offerings at home, e.g., home zone subscription plan.

Acceleration of Fixed/Mobile Convergence: Unlike in the case of WLAN use for fixed installation, femto cells do not require dual mode handsets. By enabling any wireless handset to use femto cells, fixed and mobile service convergence would occur at an accelerated pace.

Other Operational Efficiency: Femto cells can additionally help reduce churn and can be used as a platform on which operators can effectively deliver triple- and quadruple-play services (Internet, TV, fixed/mobile telephony).

1 **4.2 Use Cases (Informative)**

2 This section includes some use cases that provide insight into the
3 requirements included in this document.

4 Synchronization:

5 It might be necessary in some deployments to synchronize the
6 femto cell transmission timing with the macro cellular network
7 transmission timing without reliance on GPS in the femto cell, e.g.,
8 when GPS satellite signals are not available to the femto cell.

9 Access Control:

10 Terminals will be able to find femto cells based on the radio
11 interface specifications. Not all of those terminals will be allowed
12 to access all of the femto cells that they find. Determination of
13 access will be based on:

- 14 • Femto access policy of the terminal;
- 15 • Access exclusion/inclusion policy associated with the
16 femto cell;
- 17 • Adequacy of QoS on the backhaul;
- 18 • Interference conditions; or
- 19 • Emergency nature of the call/session attempt.

20 If the femto cell system is unable to grant an access request on the
21 femto cell, it is possible the system will provide the requested
22 services on the macro cellular network.

23

1 **5 DETAILED REQUIREMENTS**

2 The requirements contained in this section may be implemented in a
3 phased manner during the development of the stage 2 and stage 3
4 specifications.

5 **5.1 System Requirements**

6 FC-SYS-01: It should be possible for femto cell systems to support all the
7 features and services supported by systems based on the
8 cdma2000 family of specifications.

9 FC-SYS-02: It shall be possible to determine the location of an MS/AT that
10 is being served by a femto cell system according to all relevant
11 cdma2000 location service specifications. It should be possible
12 to substitute the reliably determined geographic location of the
13 serving femto cell device in place of the location of the MS/AT,
14 subject to local regulatory requirements and system operator
15 policy.

16 FC-SYS-03: A femto cell shall have a globally unique identifier.

17 FC-SYS-04: The femto cell system shall be able to determine reliably the
18 geographic location of each individual femto cell.

19 FC-SYS-05: Femto cell systems should be capable of operating using
20 existing broadband networks (e.g., DSL, cable) for backhaul
21 connections.

22 **5.2 Radio Requirements**

23 FC-RAD-01: Femto cell systems shall include mechanisms to control and
24 minimize interference with the macro cellular system.

25 FC-RAD-02: Femto cell systems shall include mechanisms to control and
26 minimize interference between femto cell devices.

27 FC-RAD-03: Femto cell systems shall support one or more of the family of
28 cdma2000 air interfaces.

29 FC-RAD-04: Femto cell systems shall support existing MSs/ATs that
30 employ any radio interface supported by the femto cell. For
31 example, if the femto cell supports cdma2000 1x technology, it
32 shall support existing cdma2000 1x MSs.

33 FC-RAD-05: It shall be possible for a femto cell to support concurrent
34 operation on multiple cdma2000 radio technologies and
35 multiple concurrent frequency assignments (e.g. one carrier
36 with HRPD, one for cdma2000-1X, and one for UMB).

S.R0126-0 v1.0 System Requirements for Femto Cell Systems

1 FC-RAD-06: Femto cell systems shall be capable of operating and co-
2 existing with the macro cellular system in the same radio
3 frequency channel.

4 FC-RAD-07: Femto cell systems shall be capable of operating and co-
5 existing with the macro cellular system when the macro
6 cellular system is operating in different radio frequency
7 channels or bands than the femto cell system.

8 FC-RAD-08: Legacy MSs shall continue to operate in Phase 1 and Phase 2
9 femto cell networks without any modifications.

10 Notes:

11 Phase 2 femto cell system (designed to work with femto-aware
12 MSs) shall be backward compatible with Phase 1 femto cell
13 system (designed to support legacy MSs), i.e:

- 14 • Legacy mobiles that are not subscribed to femto cells
15 shall continue to operate unaffected as Phase 1 and
16 Phase 2 femto cell system is deployed.
- 17 • Legacy mobiles subscribed to Phase 1 femto cells shall
18 continue to operate with phase 1 femto cells upon
19 deployment of phase 2 femto cell systems
- 20 • Femto-aware mobiles subscribed to femto cells shall be
21 able to operate in Phase 1 and Phase 2 femto cell
22 systems
- 23 • Initially deployed femto-aware MSs shall continue to
24 operate in the future-deployed Phase 1, Phase 2, and
25 beyond femto cell networks

26

27 **5.3 Mobility Requirements**

28 The requirements contained in this section are applicable only to low
29 speed (e.g. pedestrian) mobility.

30 FC-MOB-01: It shall be possible to support idle handoff to the macro cellular
31 system from the femto cell (idle hand-out).

32 FC-MOB-02: It shall be possible to support idle handoff from the macro
33 cellular system to the femto cell (idle hand-in) and acquire
34 service in a timely manner.

35 FC-MOB-03: It shall be possible to support hard handoff out to the macro
36 cellular system (hard hand-out) when the femto cell and the
37 macro cellular system are operating the same cdma2000 radio
38 interface.

S.R0126-0 v1.0 System Requirements for Femto Cell Systems

1 FC-MOB-04: It shall be possible to support hard handoff from the macro
2 cellular system to the femto cell (hard hand-in) when the femto
3 cell and the macro cellular system are operating the same
4 cdma2000 radio interface.

5 FC-MOB-05: It shall be possible to support active handoff into the macro
6 cellular system when the femto cell is operating the HRPD
7 radio interface and the macro cellular system is operating the
8 cdma2000 1x radio interface.

9 5.4 Security Requirements

10 FC-SEC-01: Femto cell systems shall be capable of communicating securely
11 between the femto cell device and the operator's network.

12 FC-SEC-02: It shall be possible for femto cell devices and the operator's
13 network to communicate in a manner that is mutually
14 authenticated.

15 FC-SEC-03: It shall be possible to communicate in a secure and
16 authenticated manner between the OAM&P system and the
17 femto cell device.

18 FC-SEC-04: It shall be possible for a femto cell system to support a means
19 to admit or deny admission to an MS/AT based on operator
20 policy.

21 FC-SEC-05: Femto cell systems shall protect the users and the access/core
22 network from security threats arising from unauthorized
23 access to the backhaul link.

24 FC-SEC-06: Femto cell systems shall provide communications integrity and
25 confidentiality between the femto cell and the operator's core
26 network.

27 FC-SEC-07: Femto cell systems shall provide communications integrity and
28 confidentiality protection of OAM&P traffic between the femto
29 cell and the OAM&P system(s).

30 FC-SEC-08: It shall be possible to allow only authorized users to perform
31 OAM&P functions on the femto cell.

32 FC-SEC-09: Femto cell systems in conjunction with the operator's core
33 network shall authenticate and authorize MS/AT access to the
34 operator network services by utilizing already existing MS/AT
35 credentials.

36 FC-SEC-10: It shall be possible to support over-the-air security for femto
37 systems that is at least equal to over-the-air security provided
38 by the equivalent macro cellular specifications.

1 **5.5 Operation, Administration, Maintenance and Provisioning**
2 **Requirements**

3 The OAM&P requirements contained in this specification envision a
4 common femto cell OAM&P server that can support all femto cells
5 deployed in one or all regions of an operator's network, regardless of the
6 manufacturer of each femto cell. In that respect, the OAM&P interface
7 must be fully specified to allow full interoperability and standardization
8 of all OAM&P features necessary for successful deployment, automatic
9 configuration, and ongoing customer support for femto cells.

10 FC-OAM&P-01: Femto cell systems shall support radio frequency assignments
11 for each supported radio technology (e.g., cdma2000 1x and
12 HRPD) via the OAM&P interface. See [9]

13 FC-OAM&P-02: Femto cell systems that support concurrent operation on
14 multiple 3GPP2 radio technologies and multiple concurrent
15 frequency assignments shall support the ability to be
16 configured to a particular 3GPP2 radio technology (e.g., HRPD
17 or cdma2000 1x) for a particular frequency assignment via the
18 OAM&P interface.

19 FC-OAM&P-03: It shall be possible for the femto cell system to optimize
20 operating frequency, PN assignment, and other system
21 parameters, and to assign those parameters to the femto cell
22 via the OAM&P interface.

23 FC-OAM&P-04: Femto cell systems shall be capable of optimizing the RF
24 coverage of a normal home environment while minimizing the
25 impact on the RF environment of the macro cellular system
26 and other femto cells.

27 FC-OAM&P-05: Femto cell systems shall be able to report their capabilities to
28 the OAM&P system, e.g., radio interface variant, supported
29 band classes, protocol revision.

30 FC-OAM&P-06: Femto cell systems shall support collecting and reporting
31 status, configuration information, alarms and clearing-alarms,
32 statistics, and error logs to the OAM&P system.

33 FC-OAM&P-07: Femto cell systems shall support diagnostics and reset
34 operations from the OAM&P system.

35 FC-OAM&P-08: Femto cell systems shall support a standard set of managed
36 objects and functions on those objects by the OAM&P system.

37 FC-OAM&P-09: Femto cell systems shall support automatic configuration by
38 the OAM&P system, i.e., it is possible to place a femto cell into
39 operation in a "plug and play" manner.

S.R0126-0 v1.0 System Requirements for Femto Cell Systems

1

2 FC-OAM&P-10: Femto cell systems shall support the ability to configure radio
3 transmission power levels and other radio technology
4 operational parameters via the OAM&P system.

5 FC-OAM&P-11: Femto cell systems shall support the ability to enable or
6 disable the femto cell radio transmitter at any time via the
7 OAM&P system.

8 FC-OAM&P-12: Femto cell systems shall be able to configure radio parameter
9 information (e.g., neighbor cell information) via the OAM&P
10 system.

11 FC-OAM&P-13: Femto cell systems shall be able to download and install
12 firmware and software updates via the OAM&P system.

13 FC-OAM&P-14: Femto cell systems shall be capable of supporting logging,
14 reporting, and auditing of security events, e.g., unauthorized
15 attempts to modify settings on the femto cell.

16 FC-OAM&P-15: It shall be possible for the OAM&P system to determine the
17 geographic location of a femto cell device.

18 FC-OAM&P-16: Femto cell systems shall not operate in any geographic location
19 unless it is authorized to do so by the OAM&P system.

20
21 NOTE: The authenticated OAM&P system is responsible for
22 using the geographic location information supplied by the
23 femto cell to determine whether the operator is licensed to
24 operate in that location. For example, it is a requirement that
25 femto cell devices are not enabled in a geographic location for
26 which the carrier does not have a license to operate in the
27 assigned radio frequency.

28 FC-OAM&P-17: The OAM&P system for management of femto cell systems
29 should provide a means to automatically reconfigure and
30 update the femto cell device when a change in the surrounding
31 radio environment occurs.

32 FC-OAM&P-18: It shall be possible for the OAM&P system to control the
33 amount of data sent to it from the femto cell system, e.g., for
34 purposes of avoiding overloading the OAM&P system.

35 **5.6 Regulatory Requirements**

36 FC-REG-01: It shall be possible for femto cell systems in conjunction with
37 the operator's core network to support lawful intercept.

1 FC-REG-02: It shall be possible for femto cell systems in conjunction with
2 the operator's core network to support emergency calls.

3 **5.7 Performance Requirements**

4 FC-PERF-01: It shall be possible for femto cell systems in conjunction with
5 the operator's core network to scale to support millions of
6 femto cells.

7 FC-PERF-02: Femto cell devices shall meet minimum performance
8 specifications modeled after [7] and [8].

9 **5.8 Accounting Requirements**

10 FC-ACCT-01: In conjunction with the operator's core network, it shall be
11 possible for femto cell systems to provide accounting
12 information comparable to that provided for the macro cellular
13 system, including information that the services were provided
14 on the femto cell system.

15 **6 SYSTEM DESIGN GOALS**

16 The following design goals shall be pursued diligently during the
17 development of stage 2 and stage 3 work. The design goals in this
18 section are not considered normative.

19 FC-GOALS-01: Femto cell systems should not increase the complexity of the
20 macro cellular system.

21 FC-GOALS-02: Femto cell systems when interoperating with the macro cellular
22 system should use the interfaces standardized for that system.

23 FC-GOALS-03: It should be possible to configure the femto cell system, the
24 macro cellular system, and the MS/AT in such a way that the
25 MS/AT, when in radio coverage of a femto cell where it is
26 authorized to receive service, will preferably use that femto cell.

27 FC-GOALS-04: It is a design goal that femto cell systems should store,
28 maintain, and process the credentials (e.g., keys) securely.

29 FC-GOALS-05: It is a design goal that any compromise of security in femto cell
30 systems should not lead to compromise in other parts of the
31 operator's core network.

32 FC-GOALS-06: The OAM&P system for management of femto cell systems
33 should be able to be integrated securely into the network
34 operator's existing macro cellular OAM&P system.

S.R0126-0 v1.0 System Requirements for Femto Cell Systems

- 1 FC-GOALS-07: Femto cell systems, in conjunction with the operator's core
2 network, should be capable of supporting any required handoff
3 (see section 5.3) at comparable performance as the same
4 handoff in the macro cellular system. Performance goals
5 should address metrics visible to the user as well as critical
6 system performance metrics:
- 7 • Examples of user-perceptible handoff performance
8 include: call drop rate caused by handoff failures and
9 short term voice frame erasure rate.
 - 10 • Examples of critical system performance metrics
11 include handoff delay and any critical effects on
12 system level interference that may result in notable
13 loss of system capacity.
- 14 FC-GOALS-08: In conjunction with the operator's core network, femto cell
15 systems should be capable of supporting comparable voice
16 quality as that of the macro cellular system.
- 17 FC-GOALS-09: In conjunction with the operator's core network, femto cell
18 systems should be capable of supporting comparable packet
19 data service quality as that of the macro cellular system.
- 20 FC-GOALS-10: Femto cell systems should not degrade the signaling efficiency
21 of the macro cellular system.
- 22 FC-GOALS-11: Femto cell systems should provide for efficient transport of
23 signaling and bearer data between the femto cell and the core
24 network elements.
- 25
26