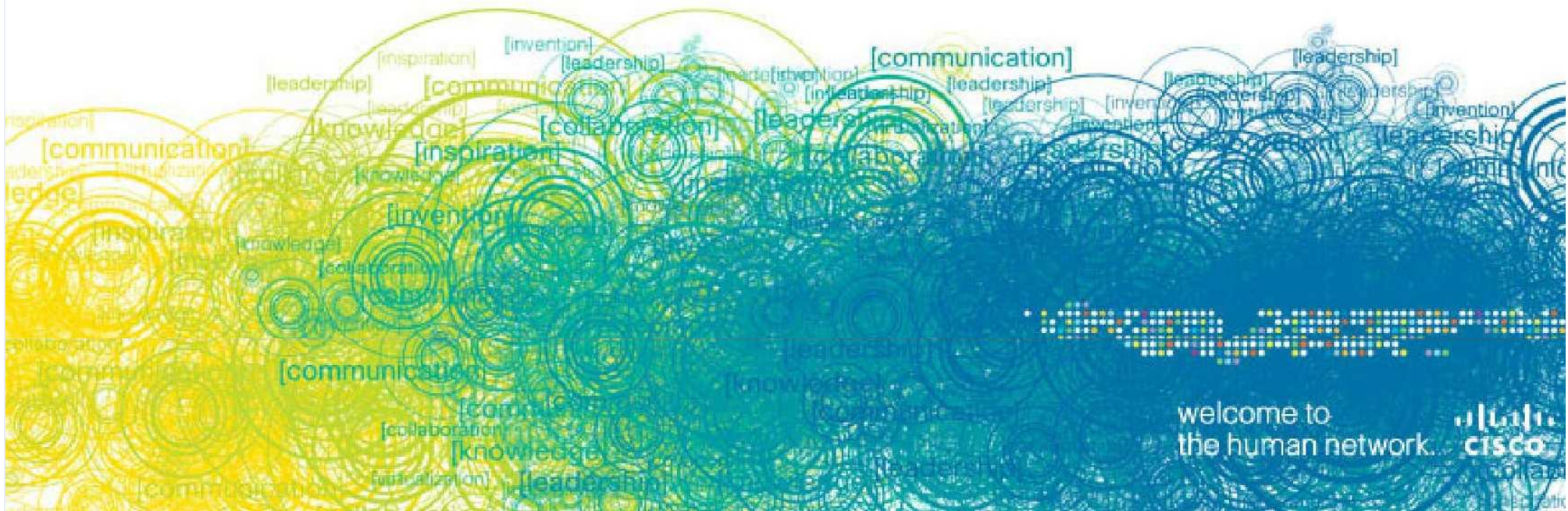# 3G UMTS Femtocell Architecture and Design
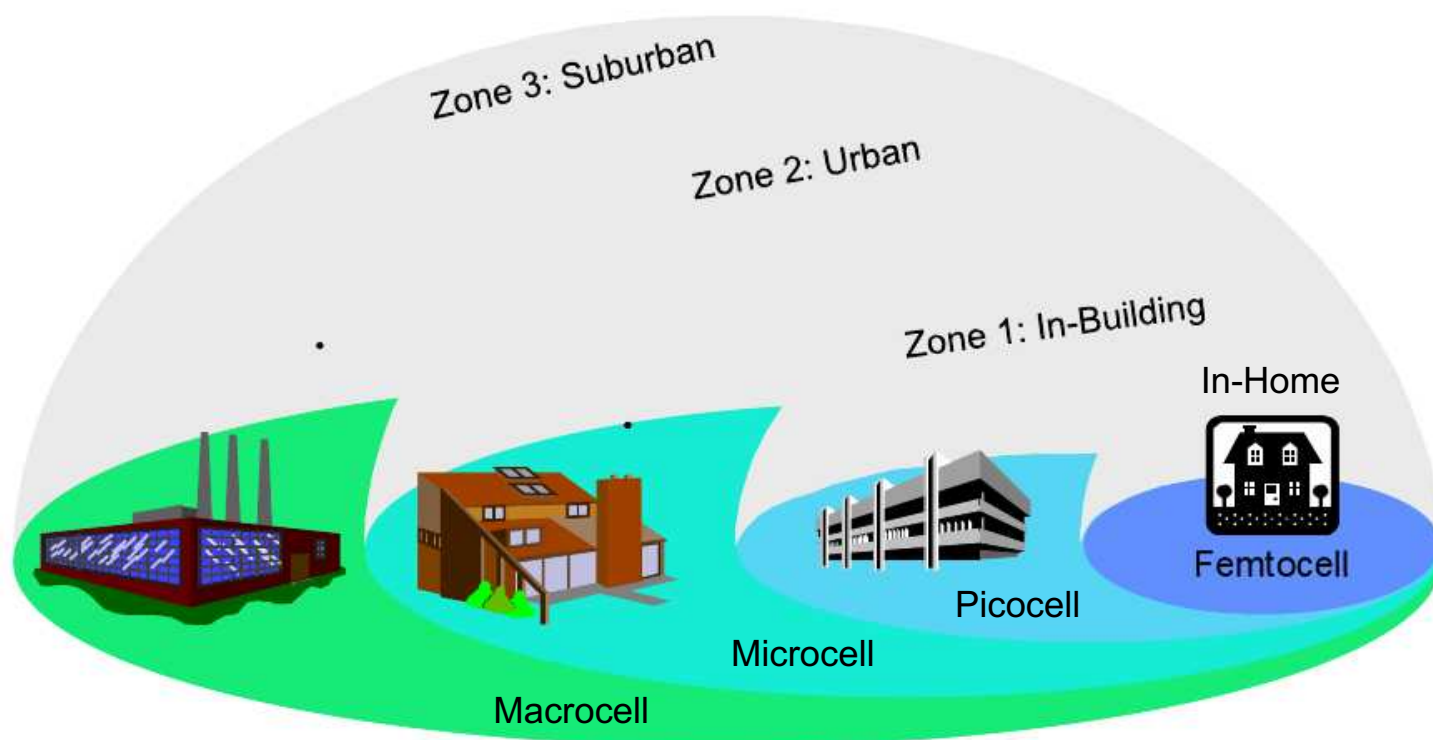
BRKAGG-2002

Agenda

- Introduction to Femtocell

- Market Drivers

- Femtocell Architecture

- Key Femto Features

- Femto Call Flows

- Standards Update

- Cisco Solution Components

- Femto Integration

- Summary

Introduction to Femtocell

What Is a Femtocell?

Zone 3: Suburban

Zone 2: Urban
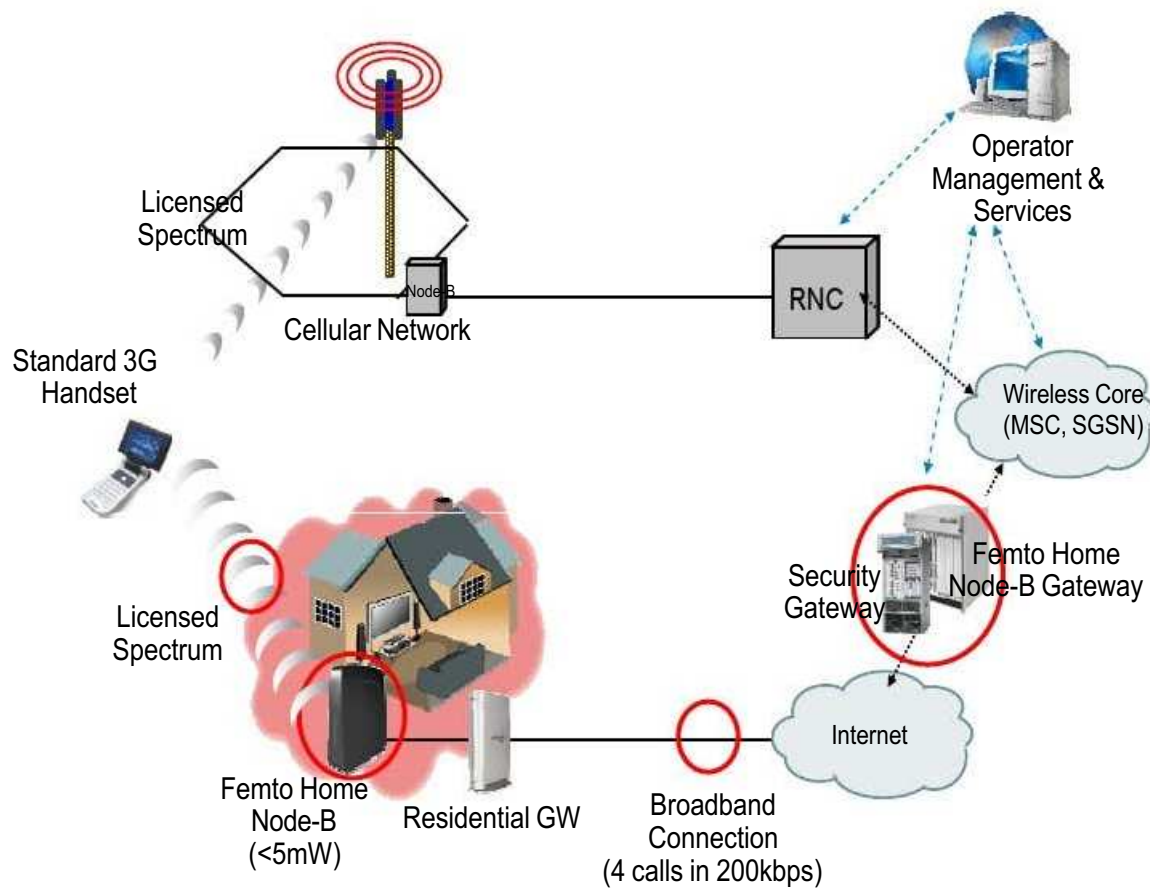
Zone 1: In-Building

In-Home

Femtocell

Picocell

Microcell

Macrocell

- Focus of this topic is Femtocell

  In-house coverage

- Compare and contrast with Macrocell, Microcell or Picocell

  Femto provides in fill for Macro, Micro and Pico

What Is a Femtocell?
Contrast With Macro

Licensed Spectrum

Node-B

Cellular Network

Standard 3G Handset

Operator Management & Services

RNC

Wireless Core (MSC, SGSN)

Licensed Spectrum

Security Gateway

Femto Home Node-B Gateway

Internet

Femto Home Node-B (<5mW)

Residential GW

Broadband Connection (4 calls in 200kbps)

Femto Cellular Network

Tiny 3G Home Access Point

- Gives 3G signal inside the home

- Very low RF power.

- Standalone or integrated into home gateway.

- Works with all standard handsets.
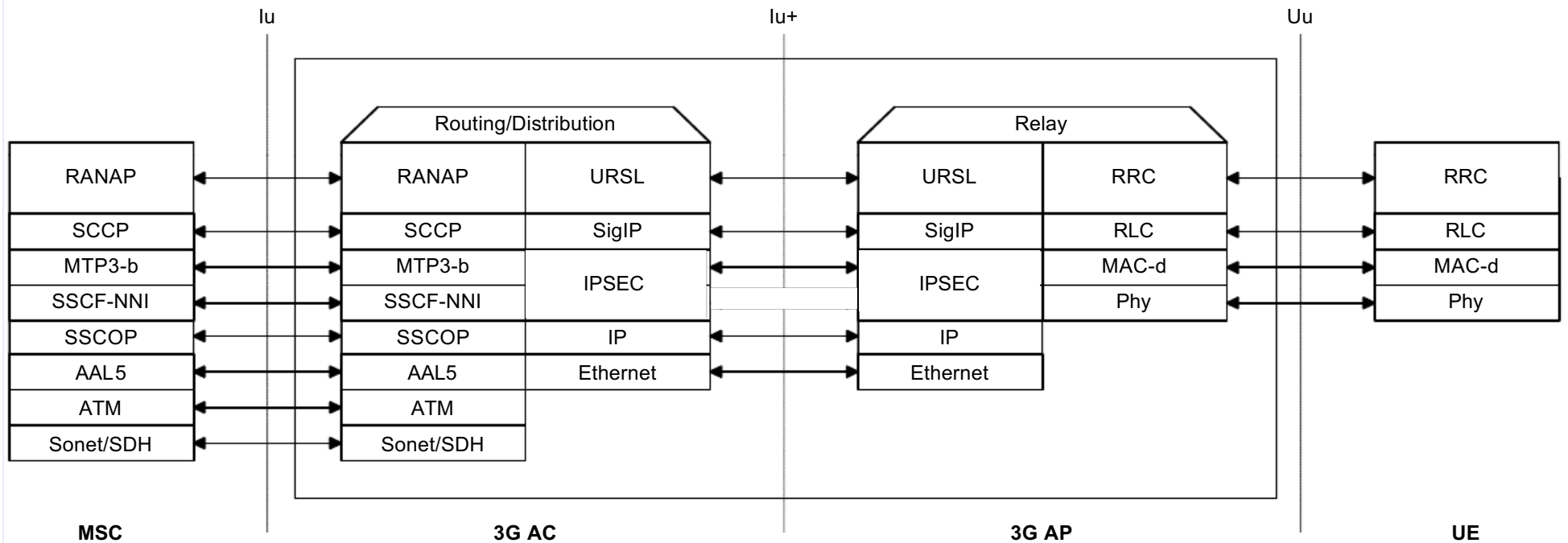
Connects to the Core Network via the Internet

- Uses home broadband connection for backhaul (contrast: Dedicated backhaul)

- Requires Wireless Security Gateway for protection

Standard Connectivity to Core

- Connectivity from Femto network to Core similar to Macro network

Market Drivers

Cisco Solution Protocol Stack
Iu+ Control Plane

Iu	Iu+	Uu

Routing/Distribution

Relay

MSC		3G AC			3G AP			UE

| RANAP | | RANAP | URSL | | URSL | RRC | | RRC |
SCCP		SCCP	SigIP		SigIP	RLC		RLC
MTP3-b		MTP3-b	IPSEC		IPSEC	MAC-d		MAC-d
SSCF-NNI		SSCF-NNI				Phy		Phy
SSCOP		SSCOP	IP		IP			
AAL5		AAL5	Ethernet		Ethernet			
ATM		ATM						
Sonet/SDH		Sonet/SDH						

- 3GAP and 3GAC use IP based stack (instead of legacy stack)
  Encapsulate within IPSEC

- Functionality moved from RNC to Home Node-B

- Regular RANAP stack towards MSC

- AP and AC have a persistent URSL connection

- URSL is an enhanced RANAP including HNB management procedures

*Pre-version of Iuh Protocol stack

Cisco Solution Protocol Stack
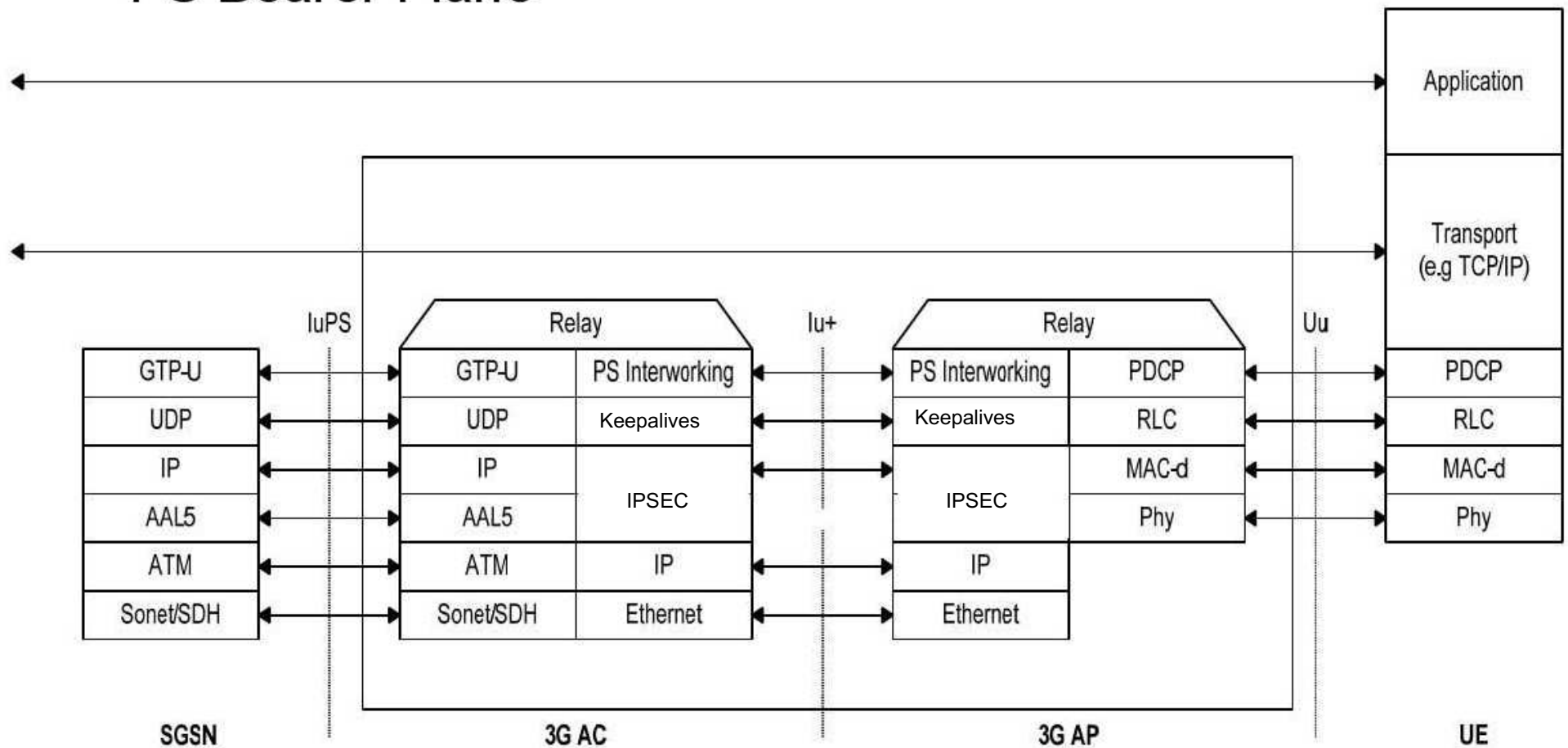## CS Bearer Plane
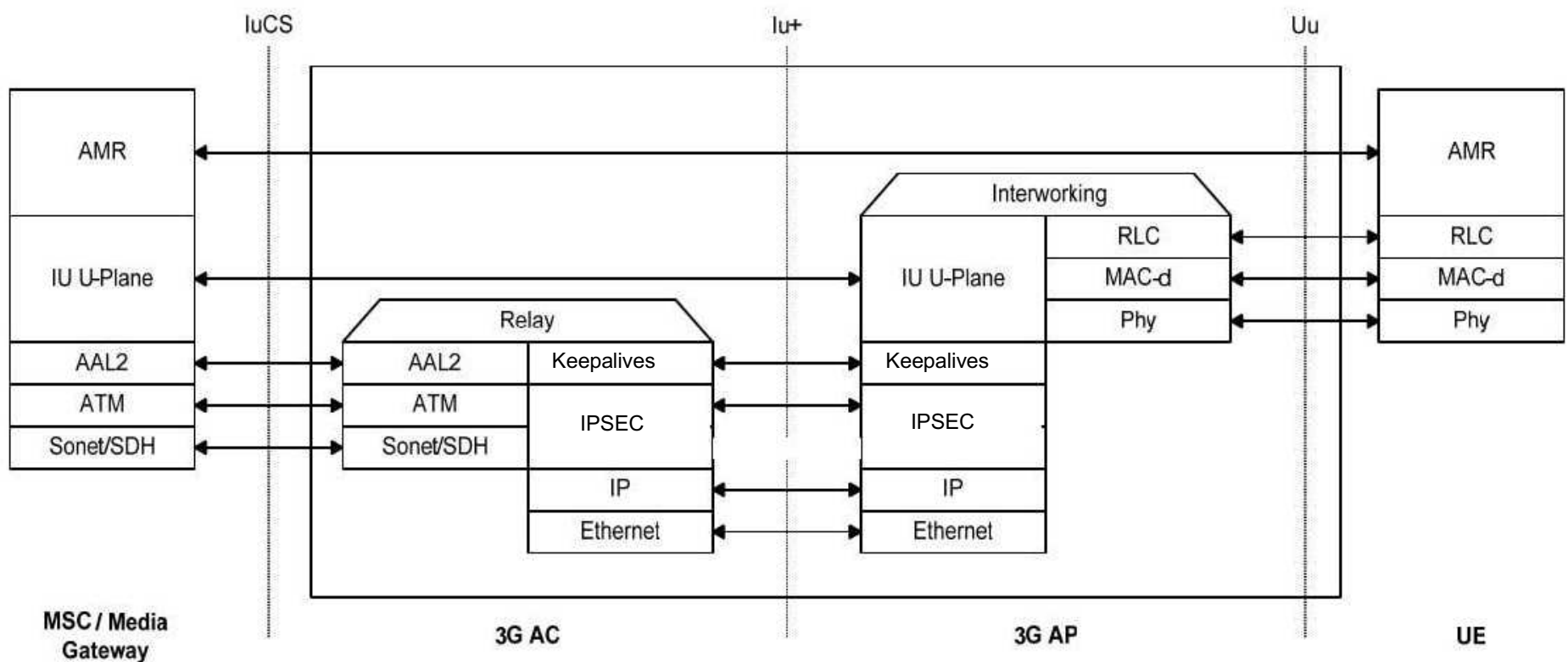
- 3GAP and 3GAC use IP based stack (instead of legacy stack)
  - Encapsulate within IPSEC
- Regular Iu-CS stack towards MSC
- "Keepalives" layer is similar to session layer ensuring the IPSEC remains up all the time

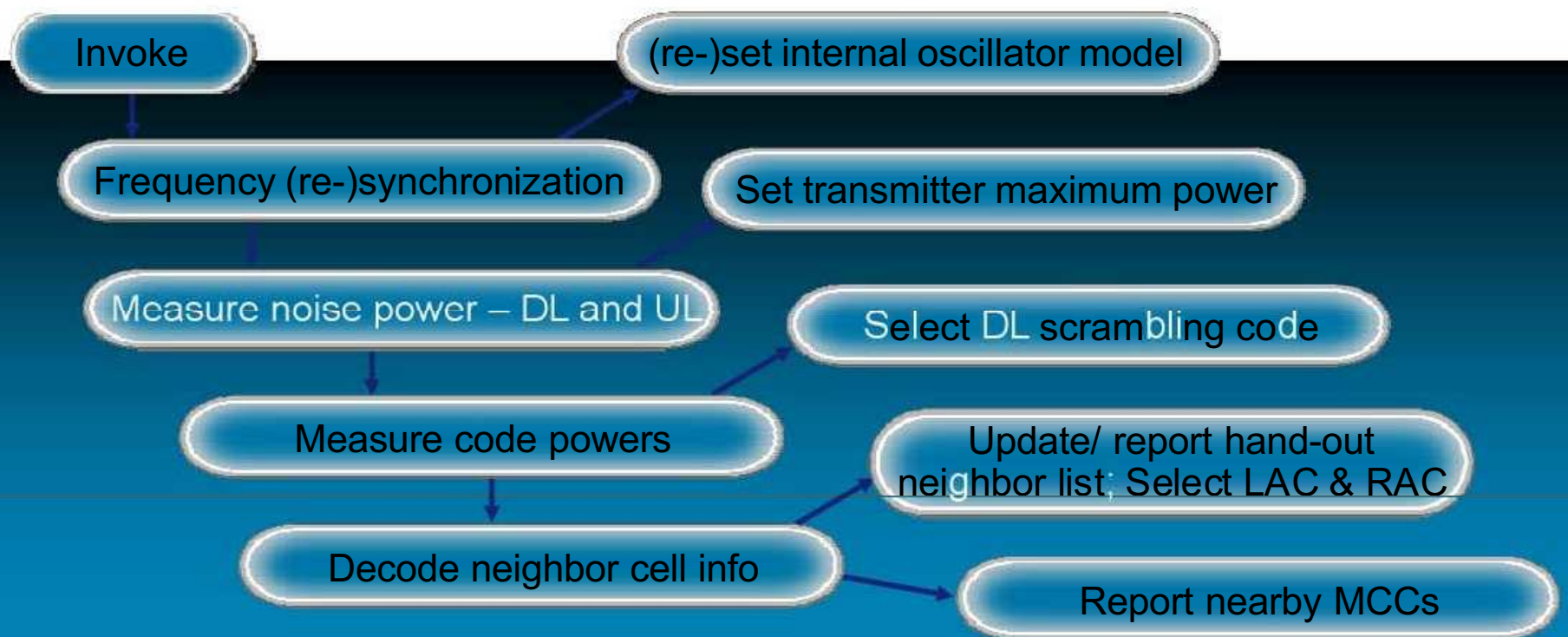# Cisco Solution Protocol Stack
PS Bearer Plane

- 3GAP and 3GAC use IP based stack (instead of legacy stack)
  - Encapsulate within IPSEC
- Regular Iu-PS stack towards SGSN
- Standards seem to incline towards GTP-U encapsulation to start at AP

Network Listen

- Network listen is a scan of radio environment by HNB which detects neighbor cells, their frequencies and transmit power levels.

- Network listen procedure allows the HNB to monitor surrounding 2G and 3G macrocell and femtocell layer.

- Results are used to select and adjust the access related parameters (frequency, power, scrambling code, neighbour list).

```
Invoke                                    (re-)set internal oscillator model

    Frequency (re-)synchronization        Set transmitter maximum power

        Measure noise power – DL and UL        Select DL scrambling code

            Measure code powers              Update/ report hand-out
                                             neighbor list; Select LAC & RAC

                Decode neighbor cell info        Report nearby MCCs
```

Network Listen

- Network Listen feature on the Home Node-B uses both 3G and 2G downlink receivers and signal processing chains for:

  Fast synchronize the internal Home Node-B clock with any nearby macro cell frequency.

  Validate the Mobile Country Code (MCC) used by nearby cells to help in verification of the territory of operation.

  Check Interference levels on uplink & downlink for each operational permitted frequency.

  Decode the System Information of nearby Home Node-Bs as the basis for selecting LAC.

  Detect the scrambling codes used by nearby Home Node-Bs to help choose an optimal scrambling code for the location.

  Decode the System Information of nearby macro cells as the basis for constructing neighbor lists in the Home Node-B.

  Estimate the noise power in the band, to set the Home Node-B transmit power.

- Network Listen feature is a mode of the device – i.e. when in NWL mode, Home Node-B is not providing service. Intelligent scheduling algorithms used to minimize service interruption.

 Cisco Public
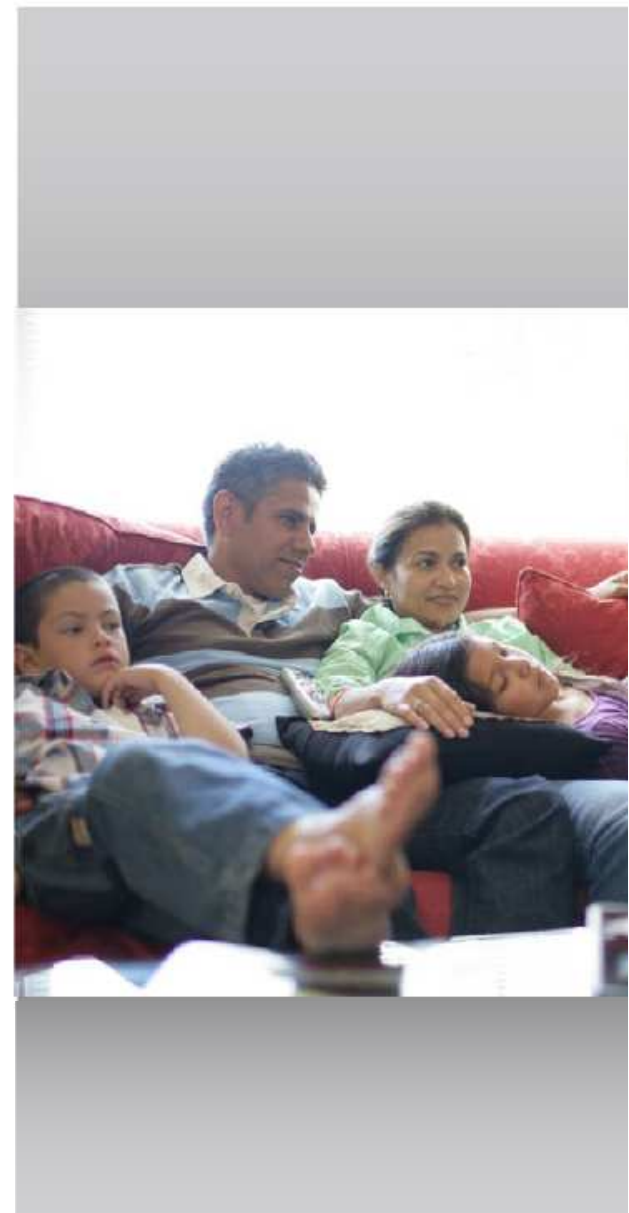
GPS

- GPS chipset within HNB is authority for location verification.

- Since the GPS test can potentially take minutes to complete, NWL is preferred first.

- GPS results are passed back from HNB to Provisioning System for comparison against Expected Lat/Long based on a tolerance value set.

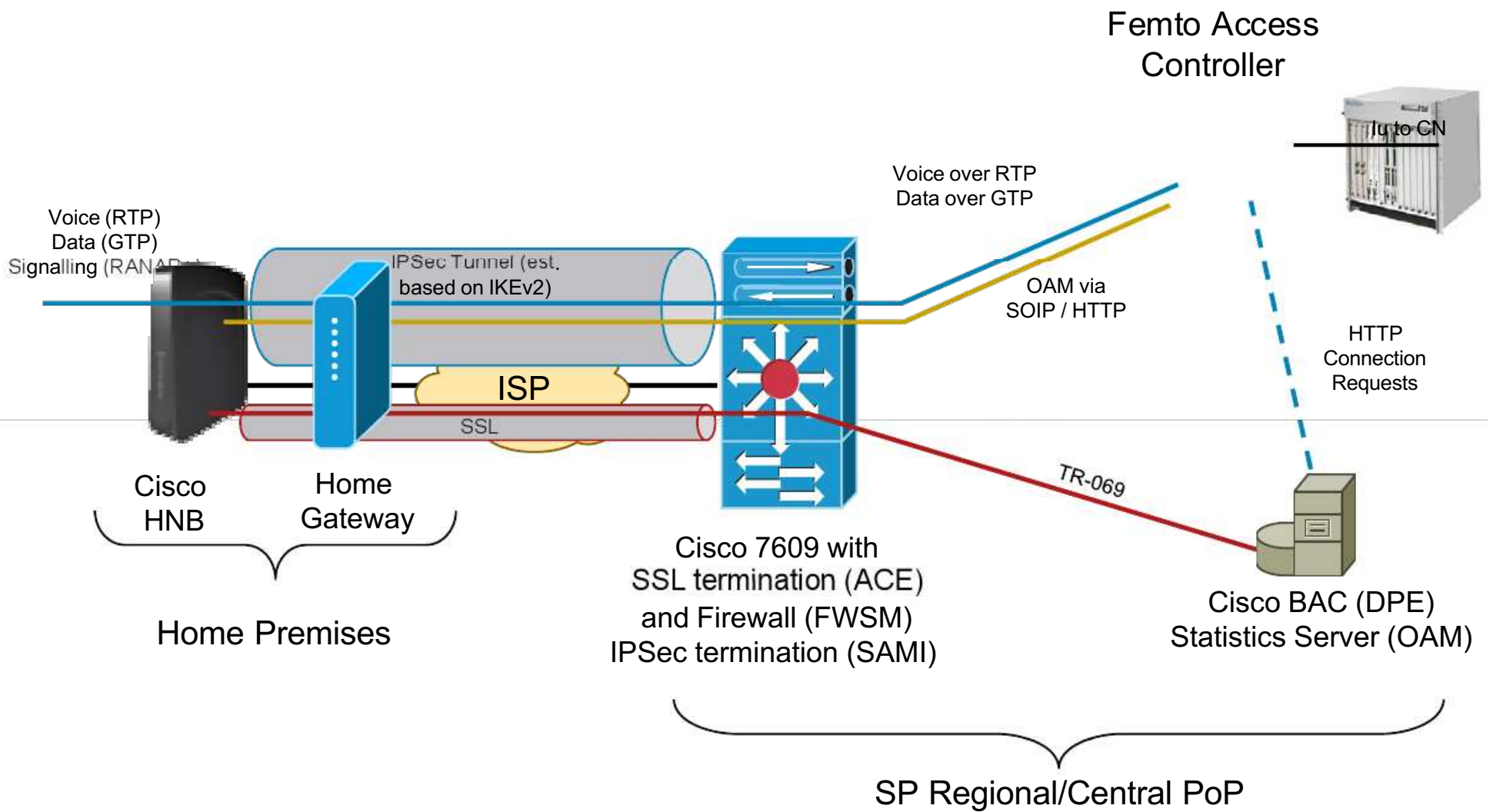- Restrictions: direct line of sight requirements to the sky.
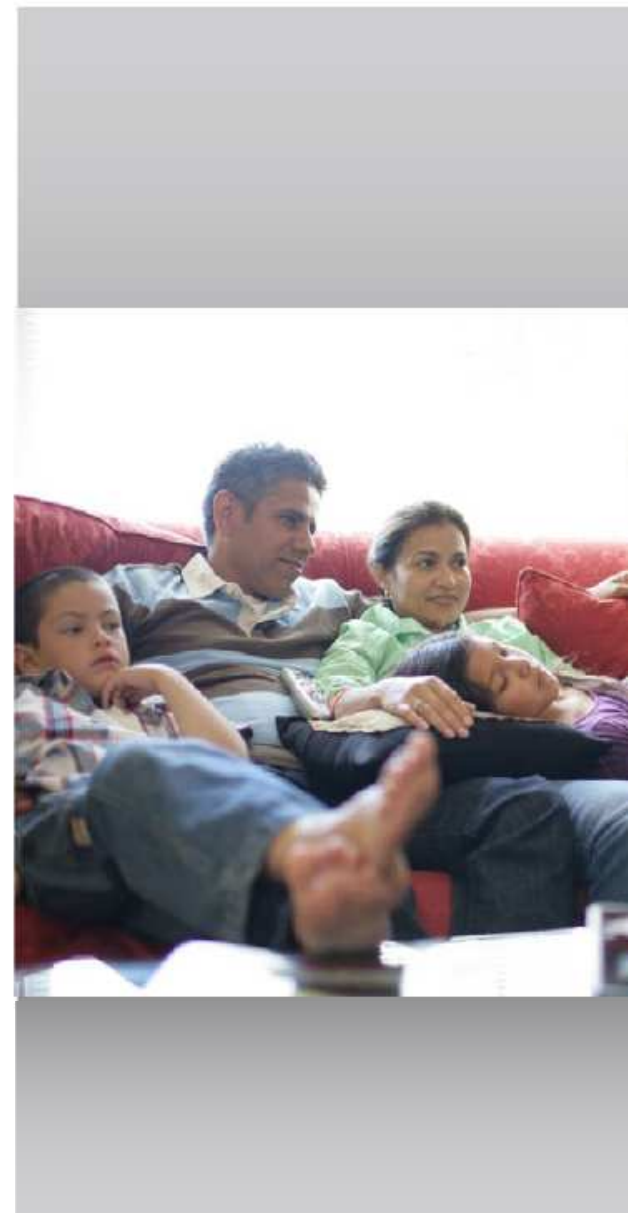
Femto End-to-End Security

- **HNB related security**

    Mutual authentication with network based on X.509 certificates

    Private Key Protection and Certification Revocation list

    Tamper resistance

    HNB Secure tunnel for data/control and management traffic

- **Core Network protection (Traffic Encryption)**

    Signaling and Bearer Plane

    > IPsec per 3GPP with SeGW

    Management traffic

    > TR-069 over SSL

    > Statistics/Alarms file upload with HTTPS

- **Additional network security capabilities**

    > ACLs, Firewalling, Intrusion Detection

Femto Secure Connectivity

Femto Access
Controller

Iu to CN

Voice (RTP)
Data (GTP)
Signalling (RANAP)

IPSec Tunnel (est.
based on IKEv2)

Voice over RTP
Data over GTP

OAM via
SOIP / HTTP

HTTP
Connection
Requests

ISP

SSL

TR-069

Cisco
HNB

Home
Gateway

Cisco 7609 with
SSL termination (ACE)
and Firewall (FWSM)
IPSec termination (SAMI)

Cisco BAC (DPE)
Statistics Server (OAM)

Home Premises

SP Regional/Central PoP

Femto Zero-Touch Provisioning

- True zero-touch provisioning for Femto to scale

- Standards-based solution

  Based on an extended TR-069 interface

  Actively contribute to O&M standards (FemtoForum & 3GPP)

- Plug-n-Play installation

  Automatic discovery of the provisioning system

  Activation procedure requiring strong integration work prior to deployment

  No macro network reconfiguration at new HNB activation

- Specific Workflows defined for Femtocell allowing for:

  Location verification

  Use of information gathered through Network Listen

  Software download and auto-configuration

  Femto user IMSI-based ACL management

- Future proof solution reusable for:

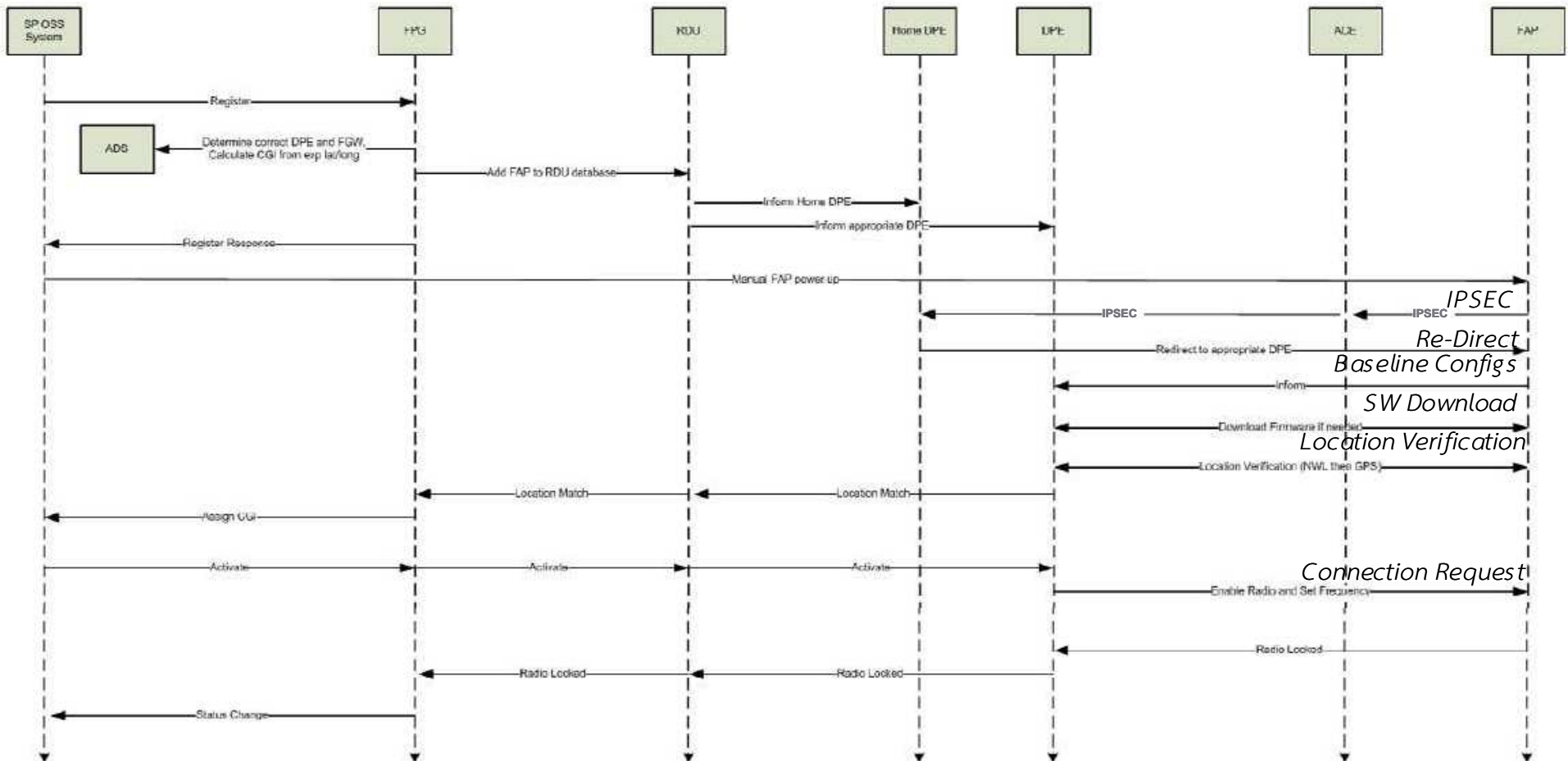 Connected Home (Broadband Gateways, Set-Top-Boxes)

  Macro network (LTE)

Femto Call Flows

HNB Register/Activate

HNB Initial Provisioning

Note: within the above flow, if the location verification process failed to match within a specified tolerance, a ToleranceFailure message would be sent. At that point, the provisioning process would require intervention from Ops to determine whether to Activate the HNB.
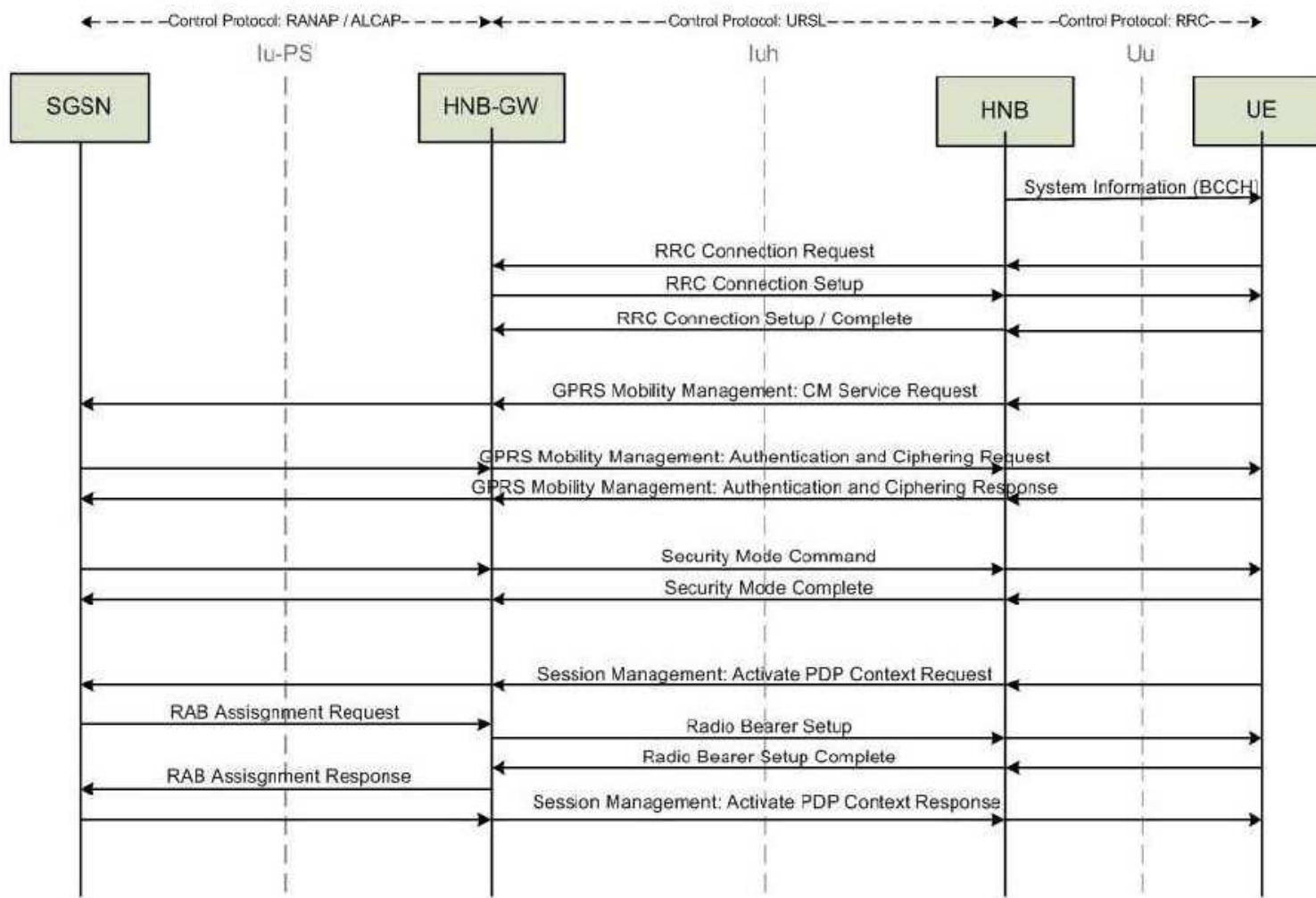
Femto Call Flow – Voice

Femto – Logical Voice Call Flow (Mobile Originated)

- **Resembles closely with Macro**

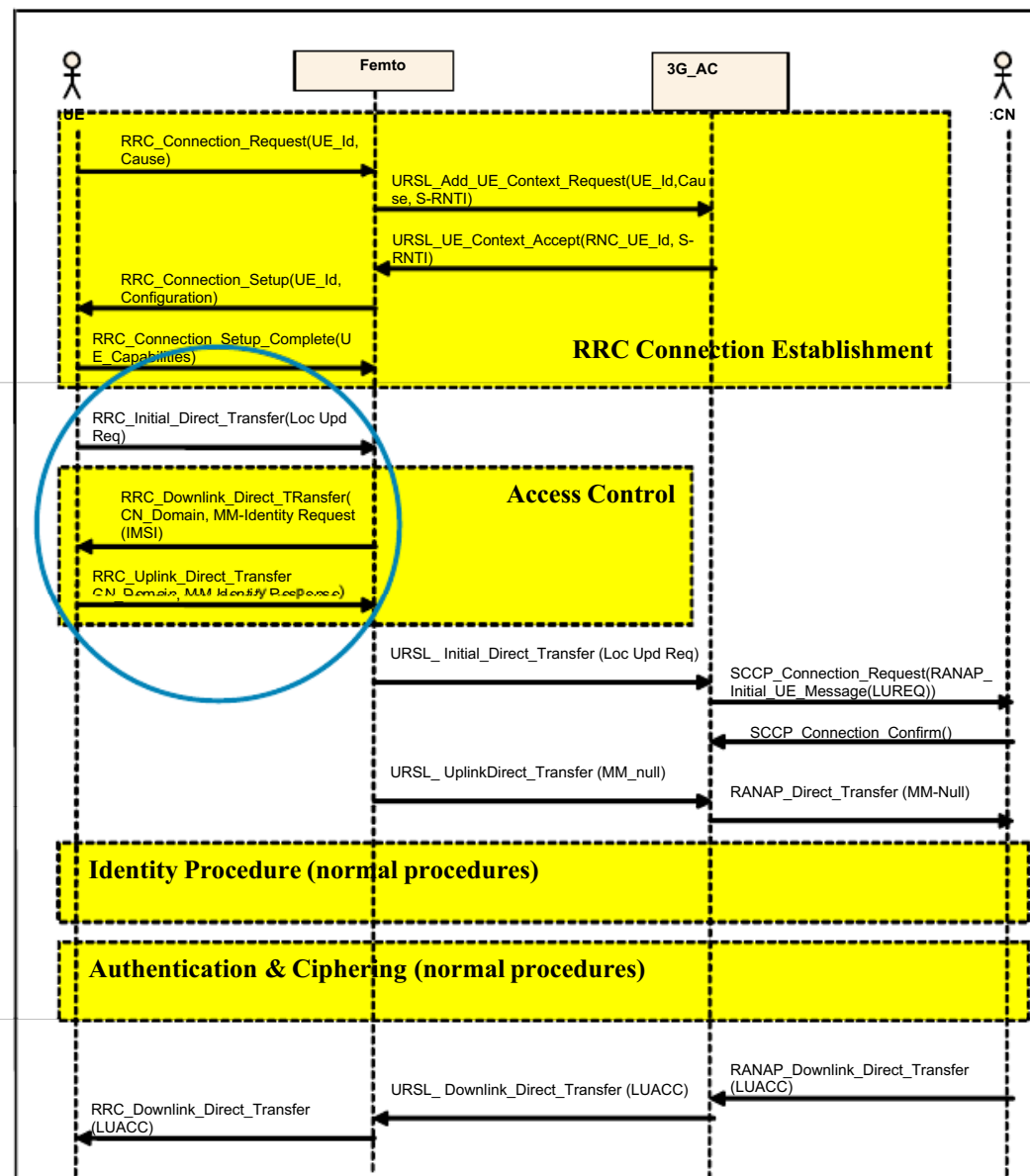- **Mobile Terminated includes Paging**
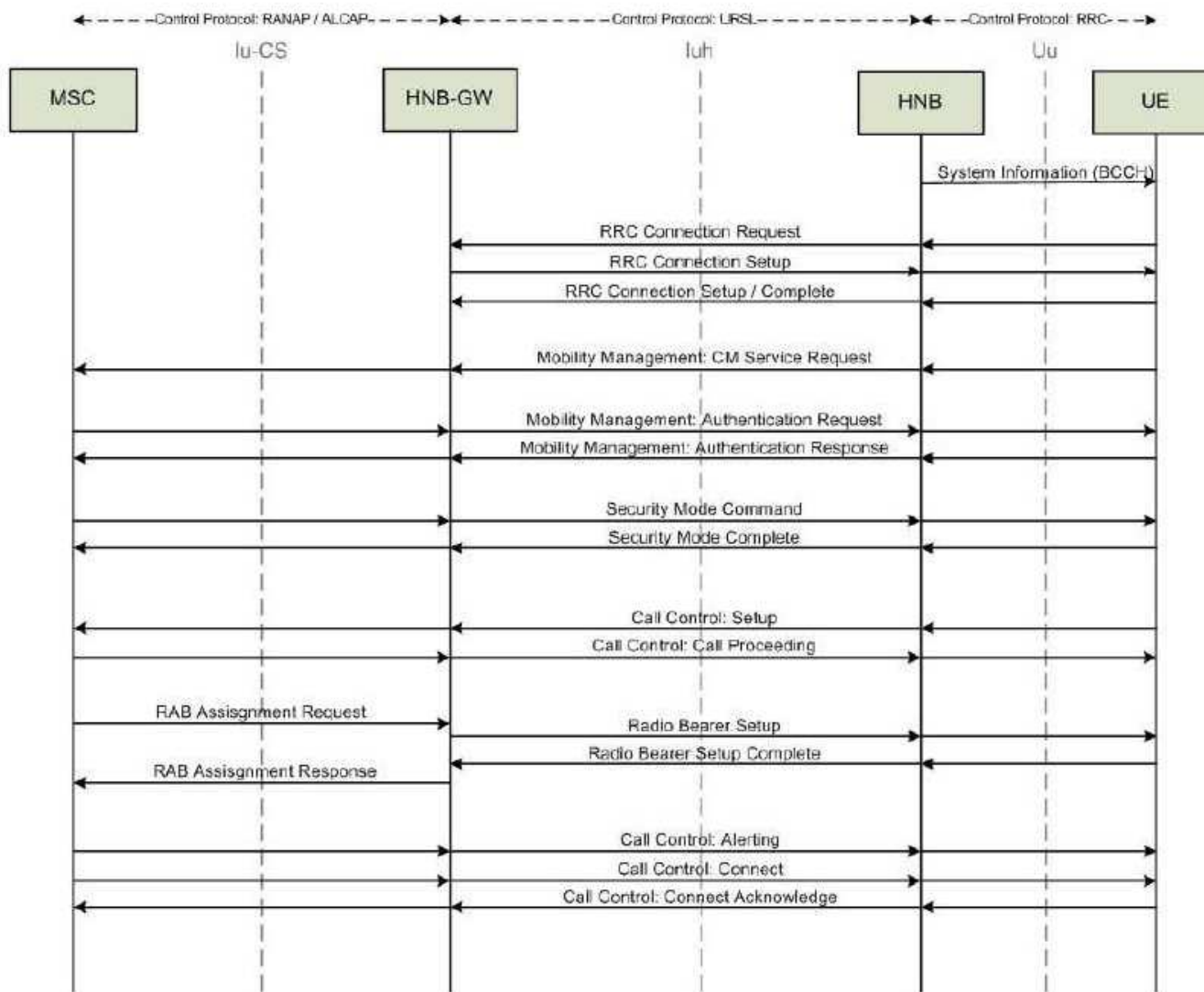
Femto Call Flow – Data
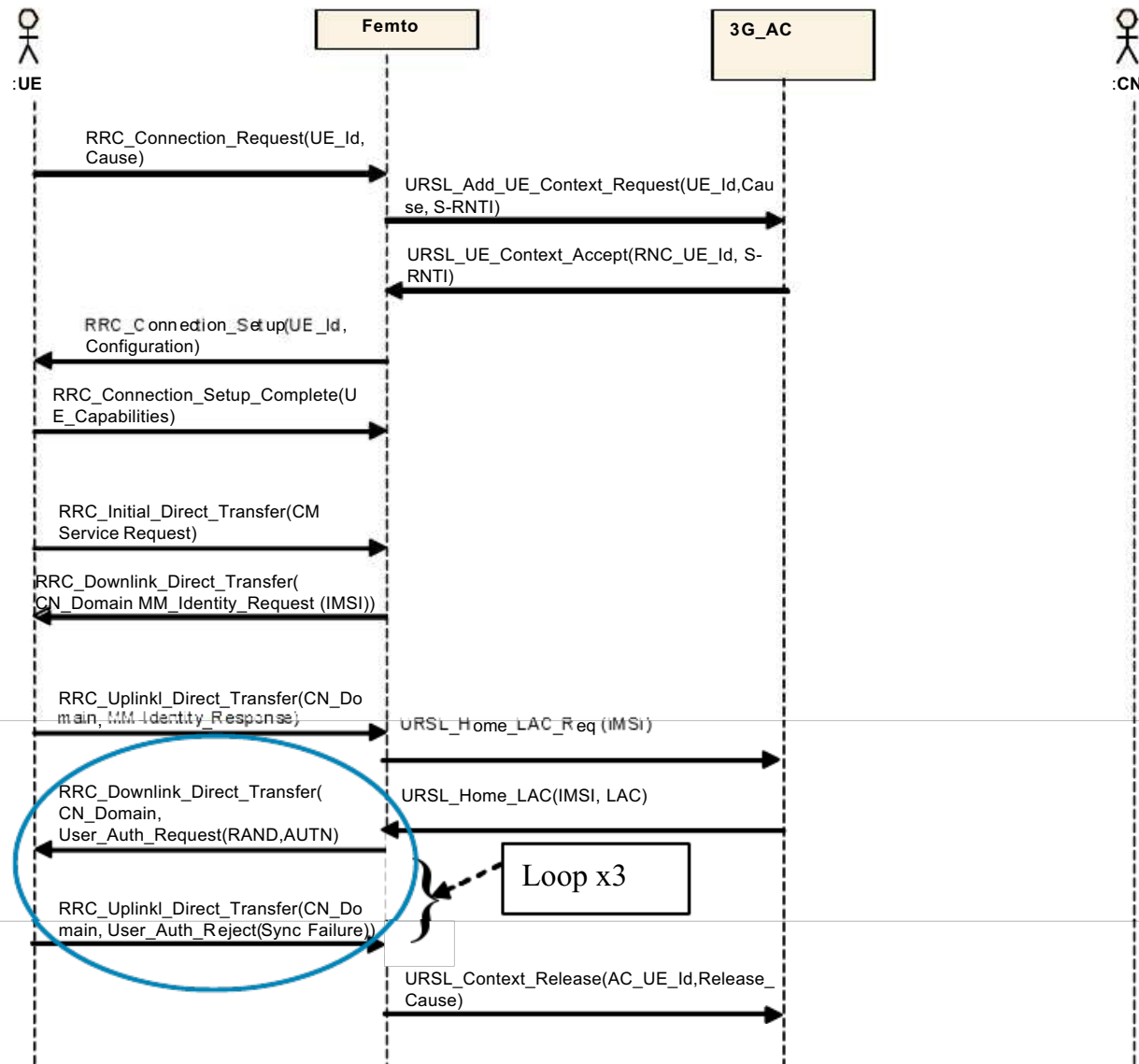
Femto – Logical Data Call Flow (Mobile Originated)

- Resembles closely with Macro

- Mobile Terminated includes Paging

Access Control – Registration Accepted

RRC Connection Establishment

- RRC_Connection_Request(UE_Id, Cause)
- URSL_Add_UE_Context_Request(UE_Id,Cause, S-RNTI)
- URSL_UE_Context_Accept(RNC_UE_Id, S-RNTI)
- RRC_Connection_Setup(UE_Id, Configuration)
- RRC_Connection_Setup_Complete(UE_Capabilities)

Access Control

- RRC_Initial_Direct_Transfer(Loc Upd Req)
- RRC_Downlink_Direct_TRansfer(CN_Domain, MM-Identity Request (IMSI)
- RRC_Uplink_Direct_Transfer CN_Domain, MM Identity Response)
- URSL_ Initial_Direct_Transfer (Loc Upd Req)
- SCCP_Connection_Request(RANAP_ Initial_UE_Message(LUREQ))
- SCCP_Connection_Confirm()
- URSL_ UplinkDirect_Transfer (MM_null)
- RANAP_Direct_Transfer (MM-Null)

Identity Procedure (normal procedures)

Authentication & Ciphering (normal procedures)

- RANAP_Downlink_Direct_Transfer (LUACC)
- URSL_ Downlink_Direct_Transfer (LUACC)
- RRC_Downlink_Direct_Transfer (LUACC)

Registration Rejected:
Authentication Failure

Femto Integration

Iuh Integration

Routing & Switching	Internet Routing (BGP) with Internet Provider
	Aggregation Router for the site
	VRF-Lite for Internet Routing and OAM
	QoS / CoS Management
Security	Stateful firewall
	Intrusion Prevention (optional)
IPSEC	Tunnel termination
	CA Server, Certificates, Certificate Verification, CRL
	DSCP Marking of tunnel traffic
Load Balancing	Load-balancing of servers, SeGW farm
	SSL Offload for server traffic
Management Security	Control Plane Policing

 Cisco Public

Core Network Integration

Iu-CS:

ATM	RANAP / ALCAP / Bearer VCs
	Class of Service and Parameters
	AESA Addresses of Media Gateways and Femto Gateway (for Voice Bearer only)
SS7	RANAP / ALCAP Point Codes for MSC/Media-Gateway
	Point Code for Femto Gateway
RAN	MCC, MNC
	RAC, LAC, SAC
	RNC-ID

Iu-PS:

ATM	RANAP / ALCAP / Bearer VCs
	Class of Service and Parameters
SS7	RANAP / ALCAP Point Codes for SGSN
	Point Code for Femto Gateway
RAN	MCC, MNC
	RAC, LAC
	RNC-ID
IP Addressing	Transport IP Addressing for Bearer VCs
	GTP-U IP Addressing

OSS Integration

Coverage	Hexagonal maps of county/market
RAN	LAC, RAC for Femto
	LAC, RAC for Macro
Provisioning	New AP addition, deletion
	User MSISDN, MSID changes
	Friend's list
E911	Location Identification

Summary

Summary

Operators looking to offload/complement their Macro with Femto to provide Mobile Internet to indoor users

Standard bodies, 3GPP and Femto Forum, have churned major interest. RAN-Gateway approach by 3GPP makes it easier to integrate with Macro.

Femto Success = Seamless Integration with Macro + Auto-Provisioning / Self Optimizing

Femto trend continues with LTE Femto and Super Femto interests.

References

- 3GPP Standards http://www.3gpp.org

- 3GPP Standards http://www.3gpp.org/femto

- TR-069 with CPE WAN Management Protocol proposed as a framework http://www.broadband-forum.org/technical/download/TR-069Amendment2.pdf

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