# *IMS in Next Generation Networks*
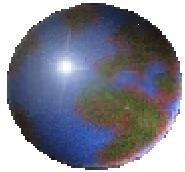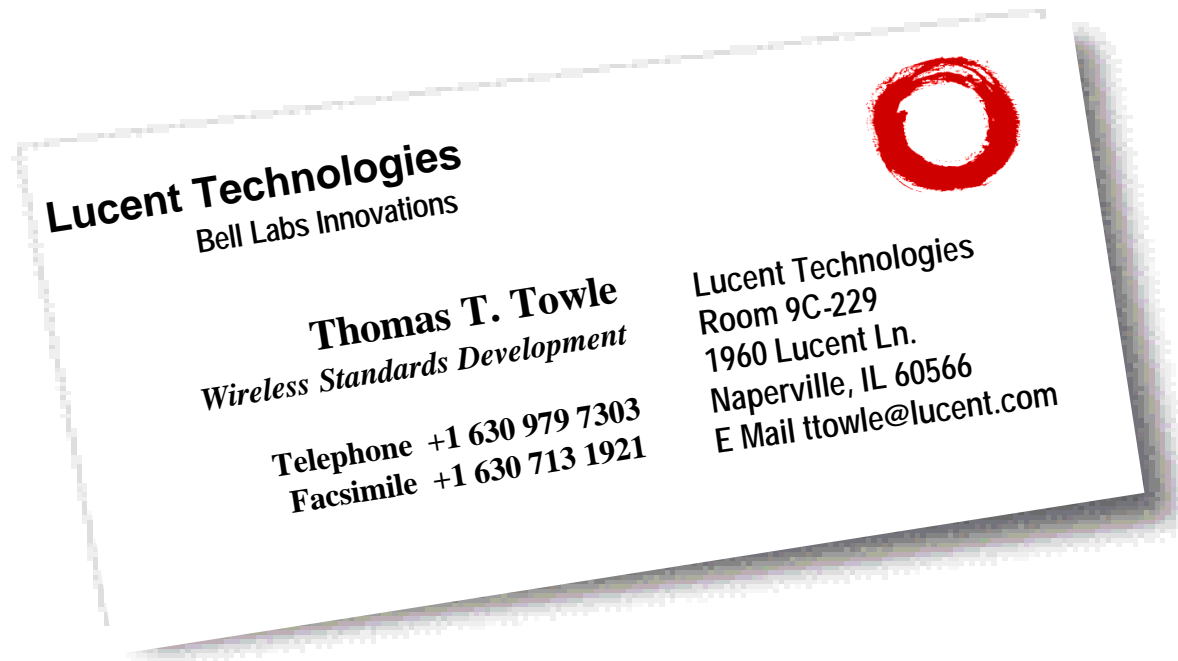
The IP Multimedia Subsystem
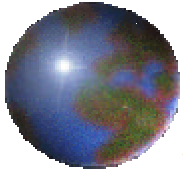
# IMS in Next Generation Networks

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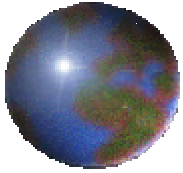Naperville, IL 60566
E Mail ttowle@lucent.com
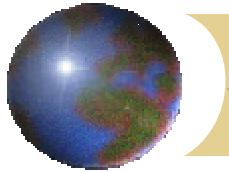
# IMS In Next Generation Networks

- What we will cover.
  - Description of what is IMS
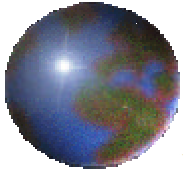  - IMS Architecture
  - IMS Operation

# *What is IMS*

- IP Multimedia Subsystem.
  - A set of core network functional entities to support access to operator provided SIP based services.
- IMS builds on IETF protocols, to create a robust and complete multi-media system.
  - Based on SIP, SDP, DIAMETER.
  - Enhancements and operational profiles provide support for operator control, charging and billing, and security.
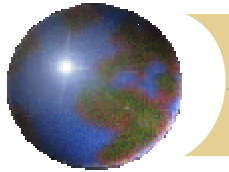
# *What is IMS*

- Supports vertical interfaces between IMS and transport level to provide:
  - ❑ Coordinated and ensured QoS (session layer negotiation matched with resources granted at transport layer, per operator policy).
  - ❑ Media gating under operator control.
  - ❑ Correlated Accounting/Charging among service, session and transport layers.

# *What is IMS*

- Coordinated network interfaces provide:
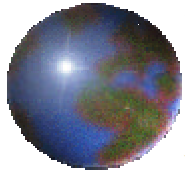  - ❑ Improved security and single authorization point for user.
  - ❑ Better user experience for obtaining services.
    - QoS, accounting, single sign-on, subscription.
  - ❑ Common interfaces to Application Servers for.
    - Accounting/Charging, Security, Subscriber data.
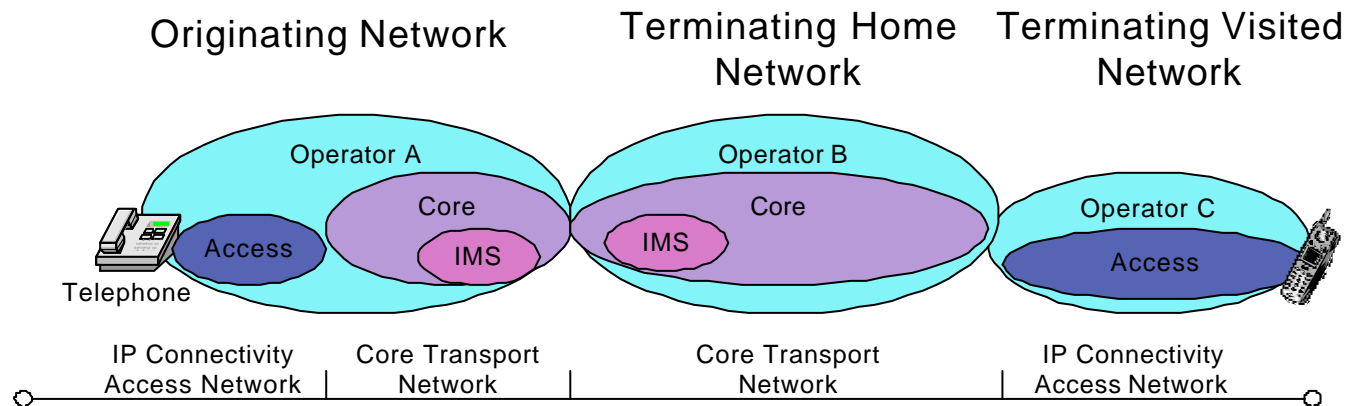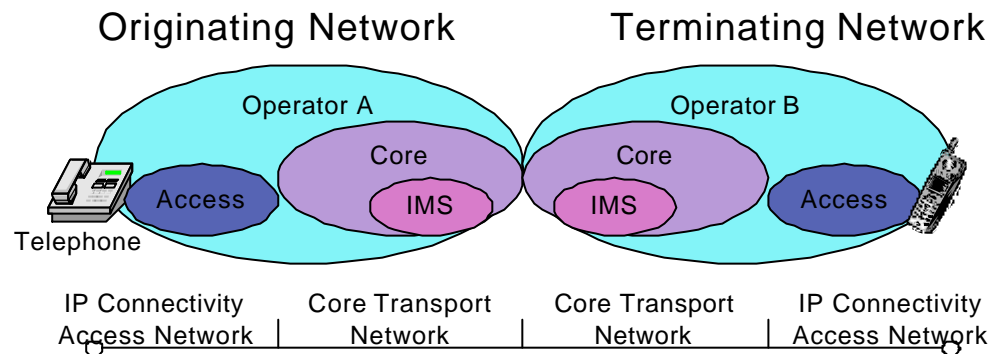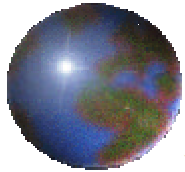    - Service building blocks (e.g. presence and location).

# *IMS in NGN*

IMS Architecture Overview

# IMS in NGN configurations

Originating Network          Terminating Network

Operator A                   Operator B

Core          Core

Access    IMS      IMS    Access

Telephone

IP Connectivity | Core Transport | Core Transport | IP Connectivity
Access Network  | Network        | Network        | Access Network

Originating Network    Terminating Home    Terminating Visited
                       Network             Network

Operator A                 Operator B

Core                   Core              Operator C

Access    IMS      IMS          Access

Telephone

IP Connectivity | Core Transport | Core Transport | IP Connectivity
Access Network  | Network        | Network        | Access Network

# *Harmonized IMS Functional Architecture*
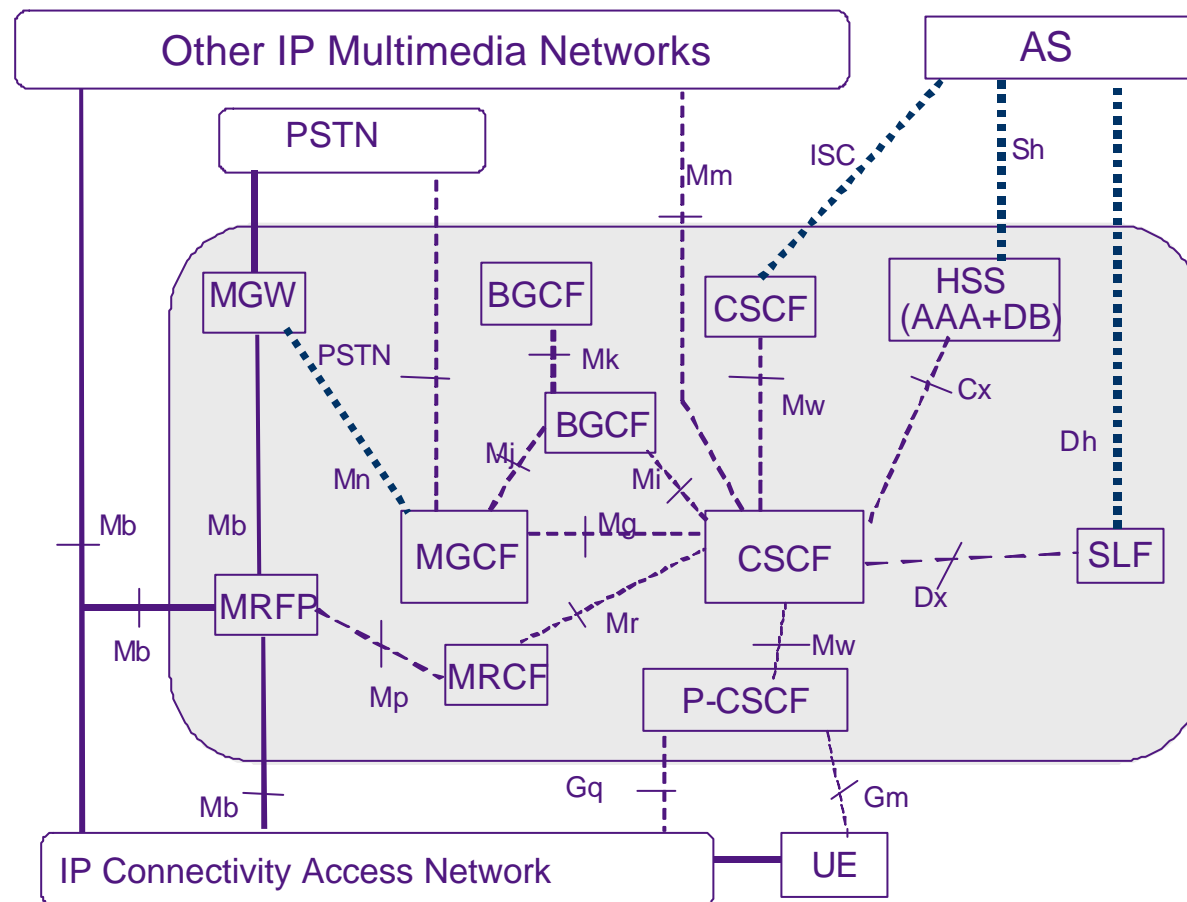
# *Location of session control entities*

Home or Visited Network | Home Network Only

```
+-------------+      +-------------+            +---------------+      +-------------+
| IP          |  Gm  | (Proxy)     |     Mw     | (Interrogating)|  Mw | (Serving)   |
| Multimedia  |------| Session     |------------| Session        |-----| Session     |
| Client      |      | Control     |            | Control        |     | Control     |
|             |      | Manager     |            | Manager        |     | Manager     |
+-------------+      +-------------+            +---------------+      +-------------+
```
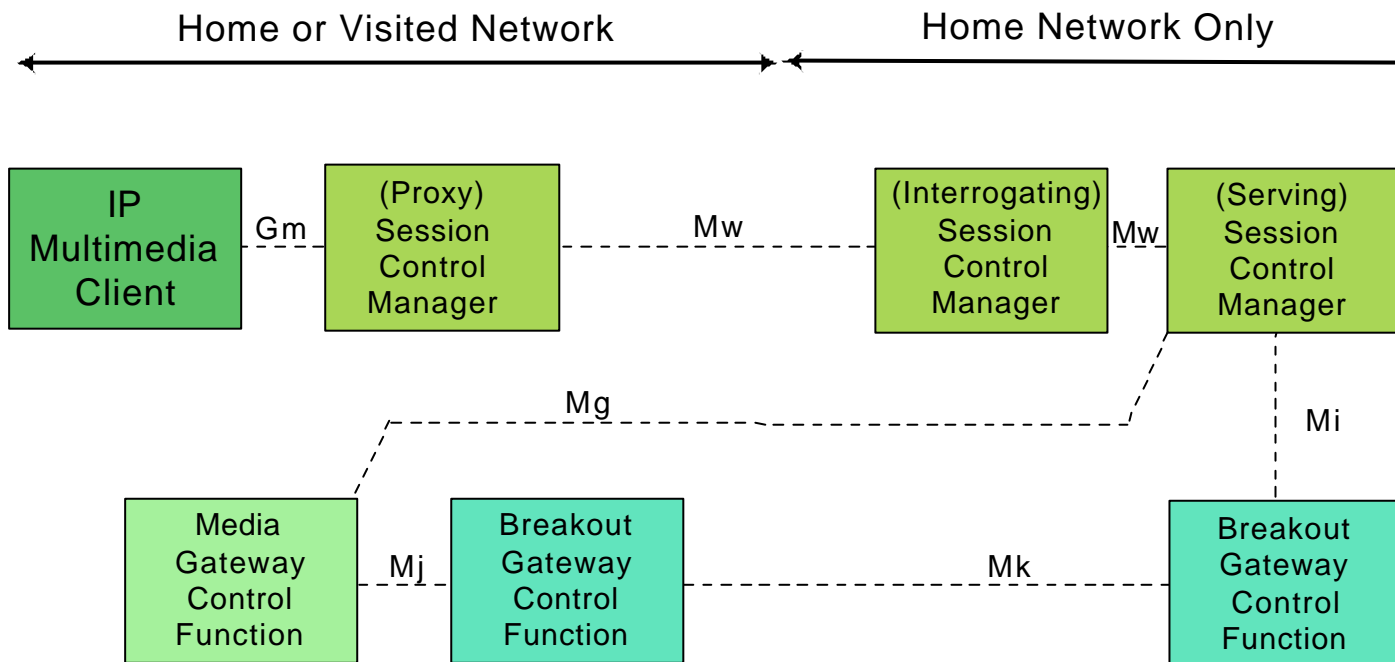
Mg

Mi

```
+-------------+      +-------------+            +-------------+
| Media       |  Mj  | Breakout    |     Mk     | Breakout    |
| Gateway     |------| Gateway     |------------| Gateway     |
| Control     |      | Control     |            | Control     |
| Function    |      | Function    |            | Function    |
+-------------+      +-------------+            +-------------+
```
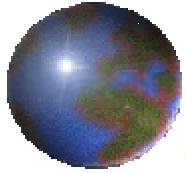
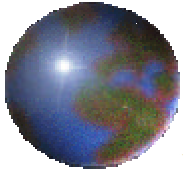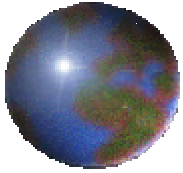# *Application Server (AS)*

- The Application Server provides service control for IMS.

- May be directly connected to S-CSCF or via OSA Gateway for 3rd party security.

- Interacts with the HSS to obtain subscriber profile information.

- May support applications such as presence, conference control, online charging, etc.
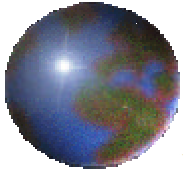
# *Home Subscriber Server (AAA+DB)*

- The HSS supports IMS level Authentication, and Authorization.
- Holds IMS subscriber profile(s).
- Keeps track of currently assigned S-CSCF.
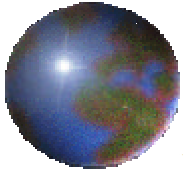- Supports CSCF and AS access.

# *Call Session Control Function (CSCF)*

- CSCF Manages SIP Sessions.
  - Coordinates with other network elements for session control, feature/service control and resource allocation.
- A CSCF may perform one or more of the following rolls:
  - Serving CSCF (S-CSCF) – session control point for UE as an originator and terminator (home network).
  - Interrogating CSCF (I-CSCF) – the contact point into the UE's home network for other networks.
  - Proxy CSCF (P-CSCF) – the contact point into the IMS for the UE (home or visited network).
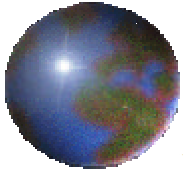
# *Serving CSCF (S-CSCF)*

- S-CSCF performs the following functions:
  - Acts like a Registrar defined in [IETF RFC 3261].
    - In other words, it accepts SIP REGISTER requests and creates a binding of the public user ID and terminal location.
  - The Serving CSCF retrieves the subscriber profile from the HSS including AS filter criteria.
  - Provides session control for the registered endpoint's sessions (service logic is performed by an Application Server, not the S-CSCF).
  - Ensures that media indicated by SDP for a session are within boundaries of subscriber's profile.
  - Interacts with Application Services platforms for the support of services.

# *Interaction of S-CSCF and AS*

- S-CSCF uses Initial Filter Criteria to involve AS(s) as needed to provide services and features.
  - The S-CSCF forwards messages to each AS in the order indicated by the Filter Criteria received from the HSS in the subscriber's service profile. After the last AS is contacted, then the message is sent on towards the intended destination.
- IMS defines Service Point Triggers (SPTs), points in the SIP signaling on which Initial Filter Criteria can be set:
  - any initial known or unknown SIP method (e.g. REGISTER, INVITE, SUBSCRIBE, MESSAGE).
  - presence or absence of any header or content of any header.
  - direction of the request with respect to the served user.
    - MO or MT to registered user or MT to unregistered user.
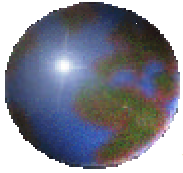  - session description information (i.e. SDP).

# *Serving CSCF Routing Behaviors*

- **On behalf of an originating endpoint:**
  - ❑ Obtain from DNS the address of the I-CSCF (or other IP endpoint) for the network operator serving the destination subscriber using the destination name of the terminating subscriber (e.g. dialed E.164 phone number or SIP URL). Send the SIP request or responses to the indicated I-CSCF.
  - ❑ If the destination name of the terminating subscriber is determined by DNS to be a PSTN address, then send the SIP request to the BGCF within the operator's network.
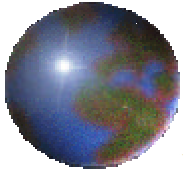
- **On behalf of a destination endpoint:**
  - ❑ Send the SIP request to a P-CSCF based on the registered location for registered subscribers.
  - ❑ Send or redirect the SIP request to an alternate endpoint for unregistered subscribers with call forwarding or similar services.

# *Interrogating CSCF (I-CSCF)*

● I-CSCF performs the following functions:
- ❑ Serves as the initial point of contact from other networks.
- ❑ Performs a stateless SIP proxy function.
- ❑ Selects a S-CSCF for a user performing SIP registration.
- ❑ Routes SIP requests received from another network to the S-CSCF.
  - Query HSS for the address of the S-CSCF.
  - If no S-CSCF is currently assigned (e.g., unregistered subscriber), then assign S-CSCF to handle the SIP request.
- ❑ Send a SIP request or response to:
  - S-CSCF in another operator's network.
  - MGCF for mobile termination call after processing INVITE.
  - I-CSCF in another operator's network (network hiding case).
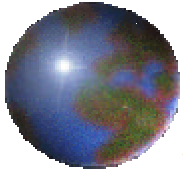- ❑ Provide Topology Hiding Inter-network Gateway (THIG) function.

# *Proxy CSCF (P-CSCF)*

- Proxy-CSCF (P-CSCF) performs the following functions:
  - ❑ Serves as the initial point of contact for user terminal to network.
  - ❑ Performs a stateful SIP proxy function.
  - ❑ Send the SIP REGISTER request received from the UE to an I-CSCF determined using the home domain name, as provided by the UE.
  - ❑ Send all subsequent SIP messages received from the UE to the S-CSCF, whose name the P-CSCF has received as a result of the registration procedure.
  - ❑ Insert public user identity for UE initiated requests.
  - ❑ Perform SIP message compression to reduce the amount of data sent over the radio interface.
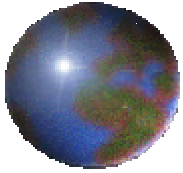  - ❑ Enforce the bearer resources as negotiated in the SDP when Service Based Policy is used.
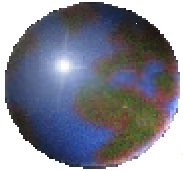
# *Breakout Gateway Control Function (BGCF)*

- Breakout Gateway Control Function (BGCF) performs the following functions:
  - ❑ Selects the network in which PSTN breakout is to occur.
  - ❑ Selects local MGCF or peer BGCF.
  - ❑ Provides security through authorization of peer networks.
- IMS standards do not specify the criteria for the BGCF to use when selecting the PSTN/PLMN access point.  Some possible factors include the following:
  - ❑ Current location of the calling UE.
  - ❑ Location of the PSTN/PLMN address.
  - ❑ Local policies and business agreements between the visited and home network (e.g. Minimize path distance, Least cost path).

# *Media Gateway Control Function (MGCF)*

- MGCF performs the following functions:
  - ❑ Controls the parts of the call state that pertain to connection control for media channels in a MGW.
  - ❑ Communicates with the S-CSCF.
  - ❑ Communicates with the I-CSCF and BGCF.
  - ❑ Performs protocol conversion between ISUP and SIP.
  - ❑ Out of band information received in MGCF and may be forwarded to the CSCF/MGW.
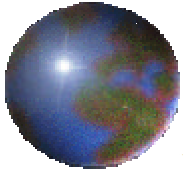
# *Media Gateway (MGW)*

- MGW performs the following functions:
  - ❑ Interacts with the MGCF for resource control.
  - ❑ Terminates bearer channels from circuit switched network and media streams from packet network (e.g. RTP streams in an IP network).
  - ❑ Supports media conversion, bearer control, and payload processing (e.g. codec, echo canceller, conference bridge).
  - ❑ Detects events (i.e. bearer loss, DTMF digits, etc.) and notifies the MGCF.
  - ❑ May perform DiffServ Code Point (DSCP) markings on the IP packets sent towards the UE.
  - ❑ Supports conversion between RFC 2833 DTMF packets and G.711.
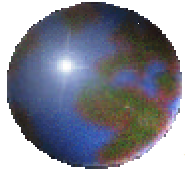
# *Media Resource Function Controller (MRFC)*

- MRFC performs the following functions:
  - ❑ Controls the media streams resources in the MRFP.
  - ❑ Interprets information coming from an AS via the S-CSCF (using SIP) and controls the MRFP accordingly.
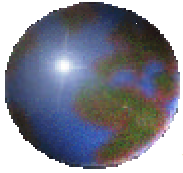  - ❑ May be co-located with an AS to provide capabilities such as conference services.

# *Media Resource Function Processor (MRFP)*

- MRFP performs the following functions:
  - ❑ Provides resources to be controlled by the MRFC.
  - ❑ Mixes incoming media streams (e.g. for multiple parties).
  - ❑ Sources media streams (for multimedia announcements).
    - ▪ Text, files, within the bearer path, etc. with various options (language, customize, etc.).
  - ❑ Processes media streams (e.g. audio transcoding, media analysis).
  - ❑ Provide tones and supports DTMF within the bearer path.
  - ❑ Notifies the MRFC when an event has occurred.
    - ▪ For example: AS/CSCF may have directed it to collect DTMF digits.
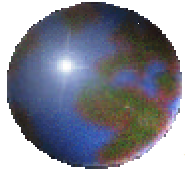
# *How IMS uses SIP*

- IMS defines extensions to headers and parameters to address specific needs.
  - New auth-param parameter defined for WWW-authenticate header, which is used to pass the Integrity Key and Cipher Key during the registration process that sets up the integrity protected relationship between the UE and P-CSCF.
  - New tokenized-by parameter, which is used to carry encrypt/decrypt strings within the SIP headers to implement the I-CSCF THIG function.
  - New icn-charging-info parameter defined for P-Charging-Vector header, which is used to include IP Connectivity Network charging information.
  - New parameter defined for P-Access-Network-Info, which provides information on the access network serving the UE.

# *P-Headers used by IMS*

- IMS introduced several Private Headers (P-Headers) into IETF to meet telephony needs.  P-Headers are optional extensions to SIP.
  - P-Asserted-Identity
    - Allows the network (e.g. P-CSCF) to assert a public user identity for identifying the calling user.
  - P-Called-Party-ID
    - Allows the terminating UE to learn dialed public user identity that triggered the call.
  - P-Access-Network-Info
    - Allows the UE to provide information related to the access network it is using (e.g. cell ID).
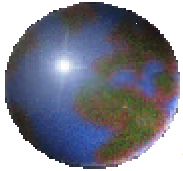
# *P-Headers used by IMS*

🔴 Additional IMS introduced Private Headers

- ❏ **P-Visited-Network-ID**
  - ▪ Allows the home network to discover, via registration, the identities of other networks utilized by the user.
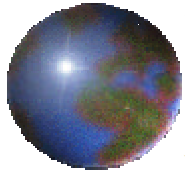
- ❏ **P-Associated-URI**
  - ▪ Allows the home network (e.g. S-CSCF) to return a set of URIs associated with the public user identity under registration.

- ❏ **P-Charging-Function-Addresses**
  - ▪ Allows for distributing addresses of charging function entities.

- ❏ **P-Charging-Vector**
  - ▪ Allows for sharing of charging correlation information (e.g. ICID).

# *How IMS uses SDP*

- IMS bans encryption of SDP payloads.
  - The operator network is able to read the SDP and can enforce QoS and policies when processing INVITE requests.
- For an initial INVITE, IMS requires:
  - SDP payload shall include terminal capabilities, with codecs listed in priority order.
  - SDP payload shall indicate that local QoS is mandated (preconditions).
  - For video and audio media types, the proposed bandwidth for each media stream shall be included in the SDP payload.
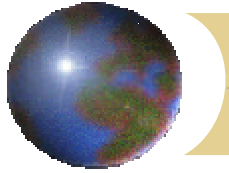
# *IMS in NGN*

IMS Operation Overview
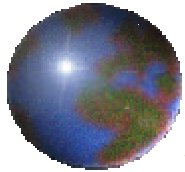
# *SIP Registration / Re-Registration*

① **Initiate SIP Registration**

② **Query DNS to obtain routing information**

③ **Forward SIP REGISTER to Home Network**

④ **Retrieve information needed for S-CSCF Selection**

⑤ **Forward SIP REGISTER to S-CSCF**

⑥ **Retrieve and select Authentication Vector**

⑦ **Reject with Authentication Data**

⑧ **Re-initiate SIP Registration (steps 1 – 5)**

⑨ **Store S-CSCF Name**

⑩ **Retrieve Subscriber Profile and Filter Criteria**

⑪ **Register with AS(s) based on Filter Criteria**

⑫ **AS(s) retrieve Subscriber profile (if needed)**

⑬ **P-CSCF SUBSCRIBE, for de-registration**
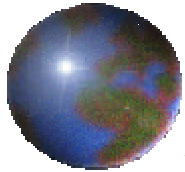
⑭ **UE SUBSCRIBE, for de-registration**
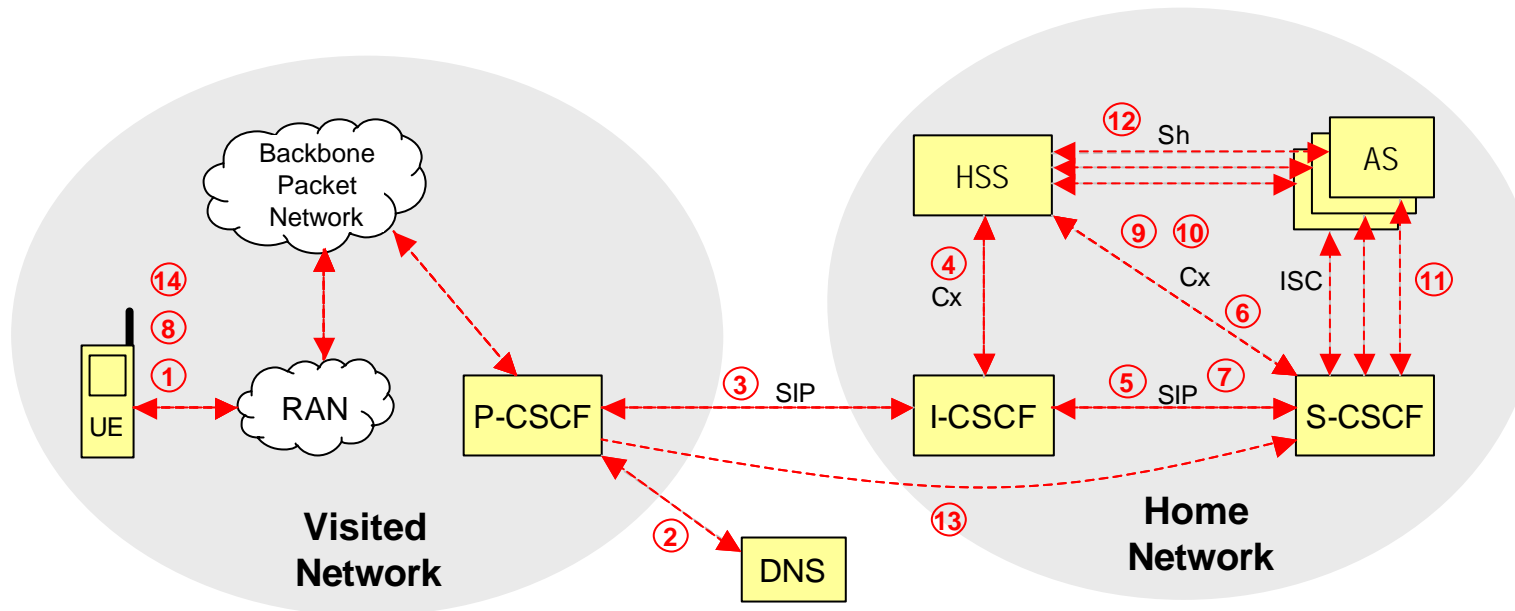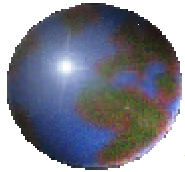
# *IMS Origination to IMS Subscriber*
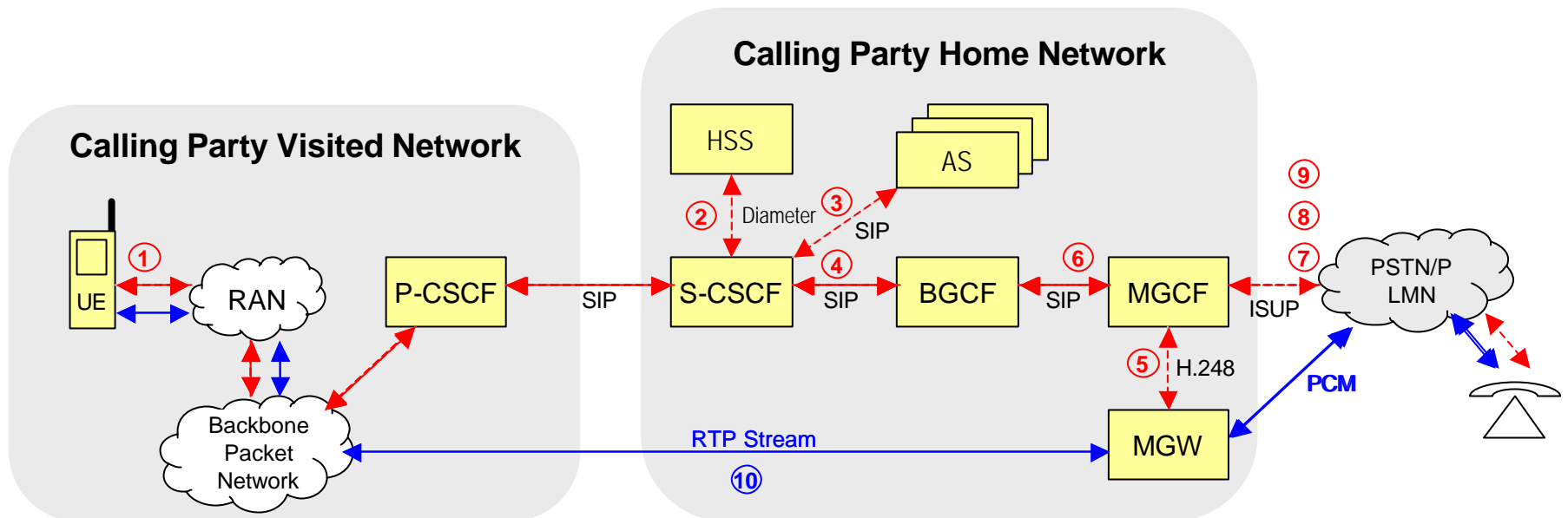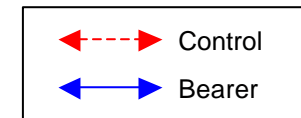
① Initiate SIP Invitation

② Retrieve Subscriber Profile (if needed)

③ Apply Service Logic

④ Retrieve Address of CLD Party Home Network and Forward INVITE.

⑤ Identify Registrar of CLD Party and Forward INVITE.

⑥ Retrieve Subscriber Profile (if needed)

⑦ Apply Service Logic

⑧ Forward INVITE to CLD Party

⑨ SDP Negotiation / Resource Reservation Control

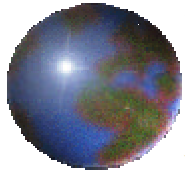⑩ Ringing / Alerting

⑪ Answer / Connect

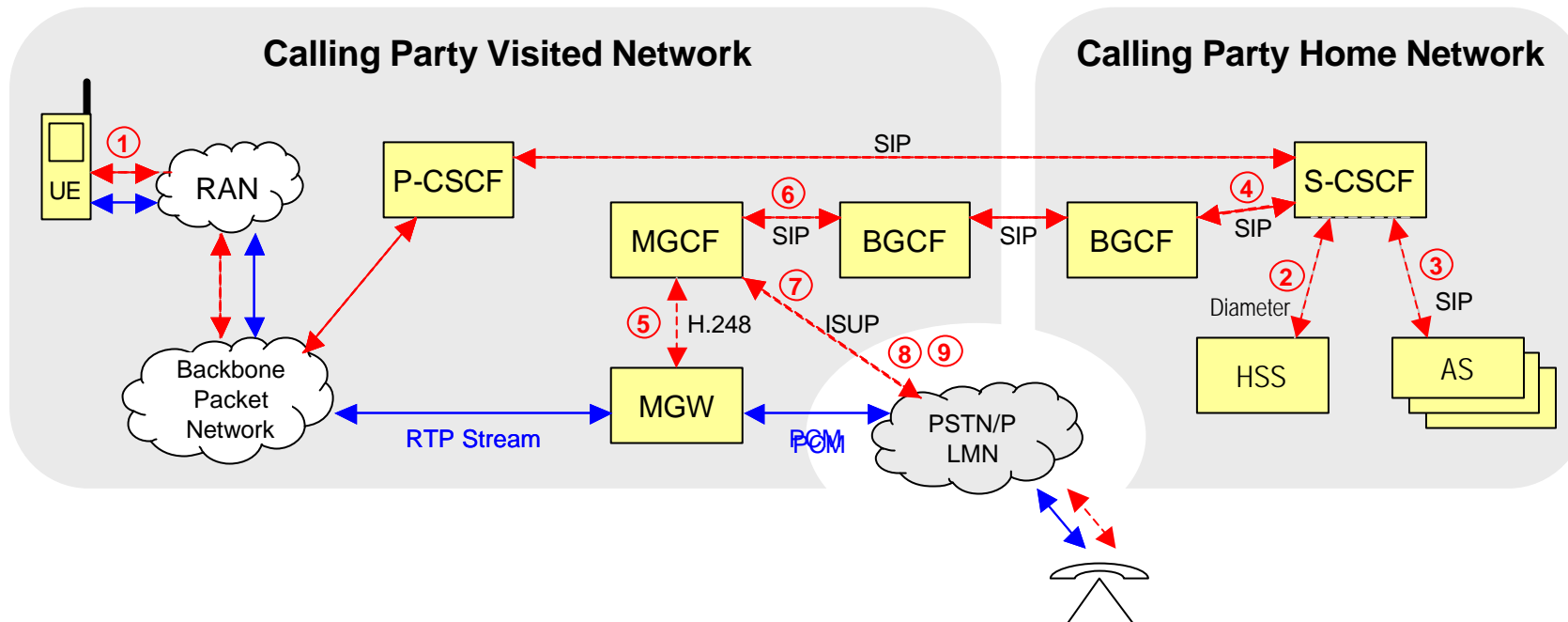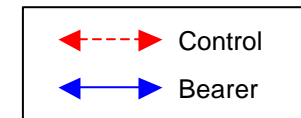⑫ Session Active
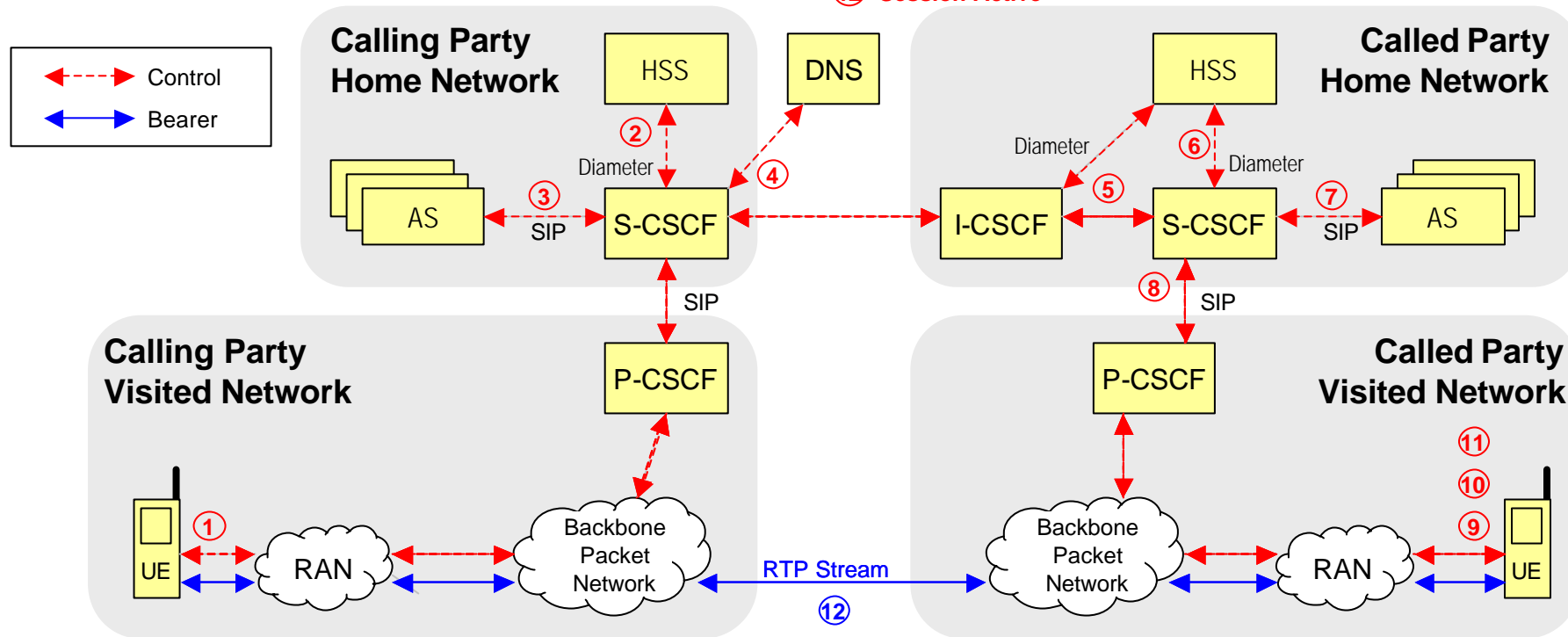
# *IMS Origination to PSTN/PLMN (option 1)*

① Initiate SIP Invitation

② Retrieve Subscriber Profile (if needed)

③ Apply Service Logic

④ Select network to access PSTN, and select MGCF

⑤ Seize trunk / determine media capabilities of MGW

⑥ SDP Negotiation / Resource Reservation Control

⑦ ISUP IAM

⑧ Ringing / Alerting

⑨ Answer / Connect

⑩ Session Active

◄----► Control
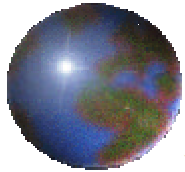
◄——► Bearer

**Calling Party Home Network**

**Calling Party Visited Network**

HSS

AS

⑨
⑧
⑦

② Diameter ③ SIP

UE ①

RAN

P-CSCF

SIP

S-CSCF ④ SIP

BGCF ⑥ SIP

MGCF

ISUP

PSTN/P LMN

⑤ H.248

PCM

Backbone Packet Network

RTP Stream ⑩
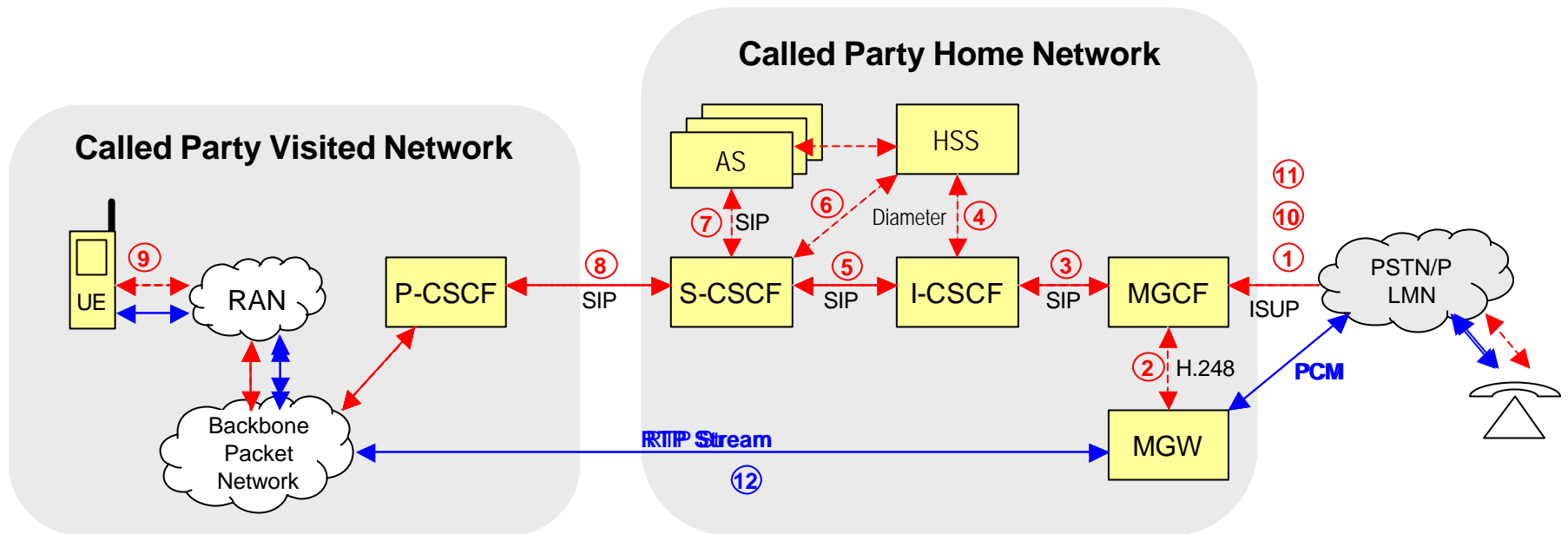
MGW

# *IMS Origination to PSTN/PLMN (option 2)*

① **Initiate SIP Invitation**

② **Retrieve Subscriber Profile (if needed)**

③ **Apply Service Logic**

④ **Select network to access PSTN, and select MGCF**

⑤ **Seize trunk / determine media capabilities of MGW**

⑥ **SDP Negotiation / Resource Reservation Control**

⑦ **ISUP IAM**

⑧ **Ringing / Alerting**

⑨ **Answer / Connect**

⑩ **Session Active**

- ◀┅┅▶ Control
- ◀──▶ Bearer



**Calling Party Visited Network**

**Calling Party Home Network**

UE — ① — RAN — P-CSCF

SIP — S-CSCF

MGCF — ⑥ — BGCF — SIP — BGCF — SIP

SIP

④

② Diameter   ③ SIP

⑤ H.248   ⑦ ISUP   ⑧ ⑨

Backbone Packet Network

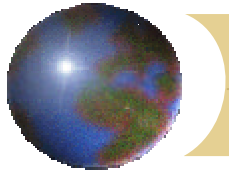MGW — RTP Stream — PCM — PSTN/PLMN

HSS   AS

# *PSTN to IMS UE (initial contact is MGCF)*

① **Incoming Call (ISUP IAM)**

② **Seize Trunk and IP Port**

③ **Initiate SIP Invitation**

④ **Determine where the Subscriber is Registered**

⑤ **Forward SIP INVITE to S-CSCF**

⑥ **Retrieve Subscriber Profile (optional)**

⑦ **Service Logic (if needed)**

⑧ **Forward SIP INVITE to Called Party UE**

⑨ **SDP Negotiation / Resource Reservation Control**

⑩ **Alerting / Ringing**

⑪ **Connect / Answer**

⑫ **Session Active**

# *IMS in NGN*

Questions?