IPv6 Services in Cellular Networks

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Outline

- Cellular Networks
- GSM/GPRS
- 3G Networks and IMS
- Transition Scenarios
- IPv6 MS Implementation Issues
- Standards

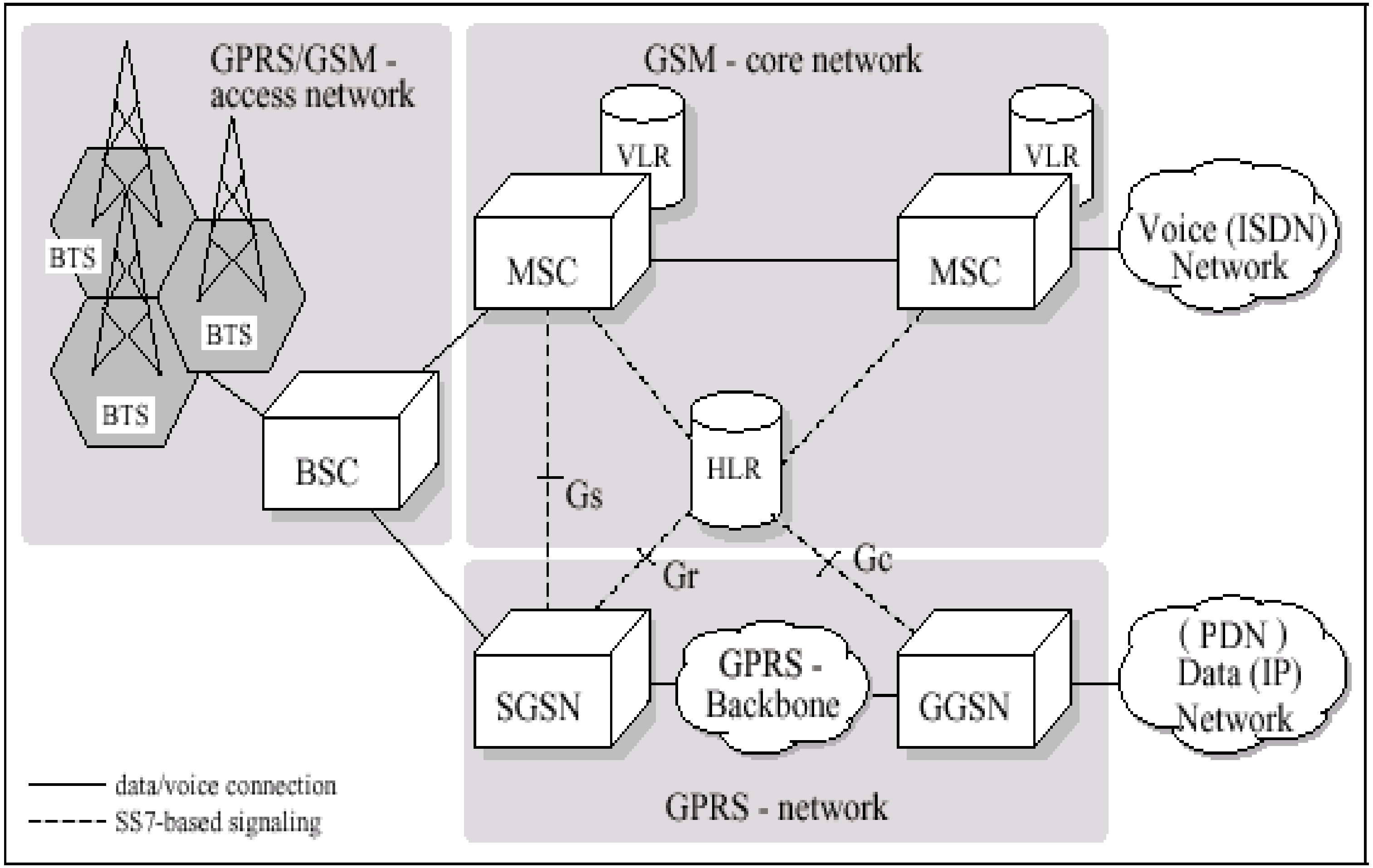
Cellular Networks

- 2G cellular network: *Circuit-switched* network optimised to transport voice and video
  - GPRS allowed packet switching services over 2G networks
- 3G cellular network: *Circuit/packet-switched* network optimised for voice, multimedia and data transport

European 2G cellular Network

- Global System for Mobile (GSM) is the European digital cellular standard published by ETSI
- General Packet Radio Service (GPRS) enhancement allows packet-switching services in 2G networks
  - Always-on connections are feasible for mobile terminals

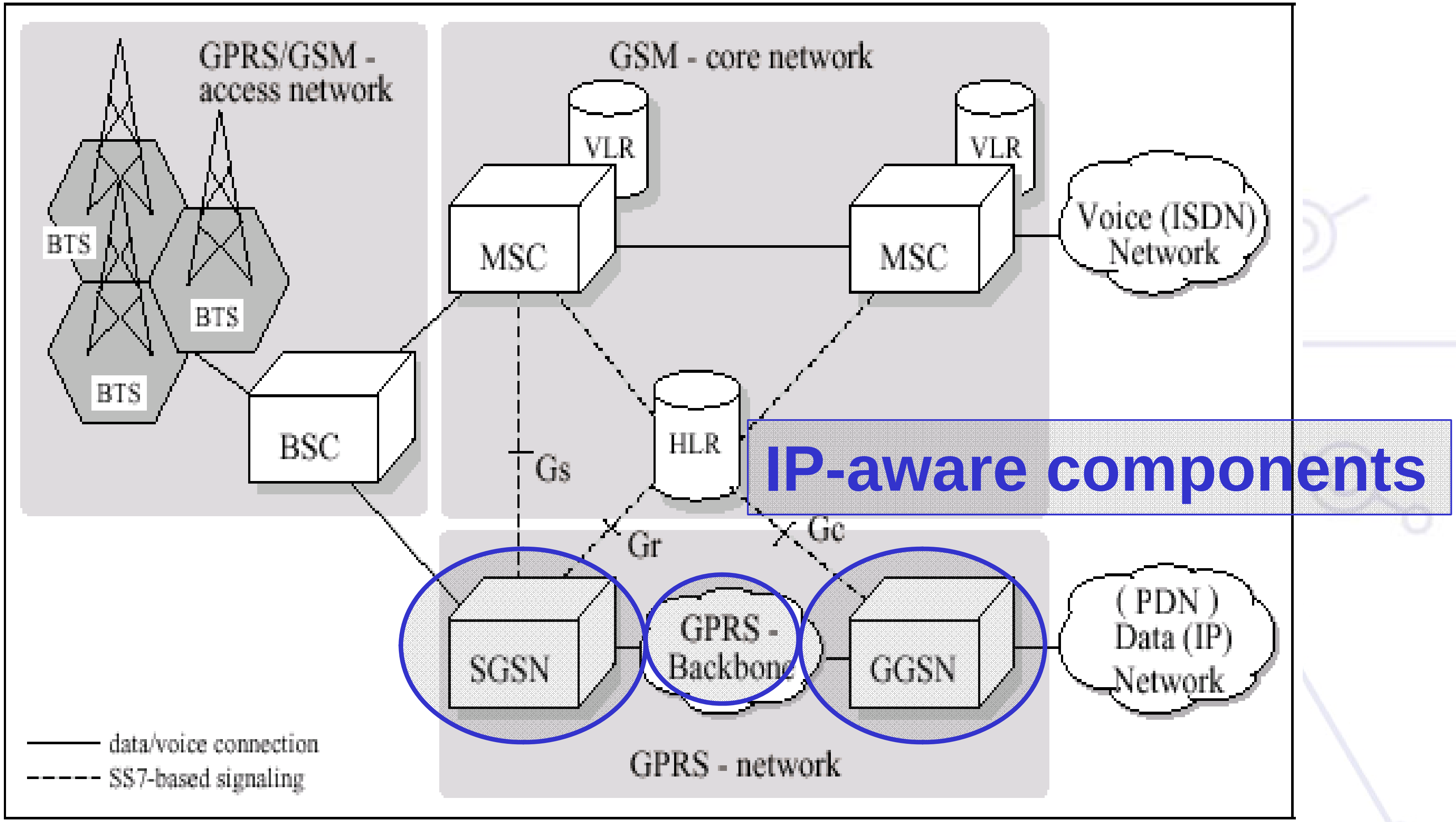
GSM/GPRS Architecture



Components

- **MS** (Mobile Station)
- **BSS** (Base Station Subsystem)
  - **BTS** (Base Transceiver Station) and **BSC** (Base Station Controller)
- **NSS** (Network Subsystem)
  - **MSC** (Mobile Switching Centre)
  - **HLR** (Home Location Register) and **VLR** (Visitor Location Register)
- **SGSN** (Serving GPRS Support Node) and **GGSN** (Gateway GPRS Support Node)

GSM/GPRS Architecture



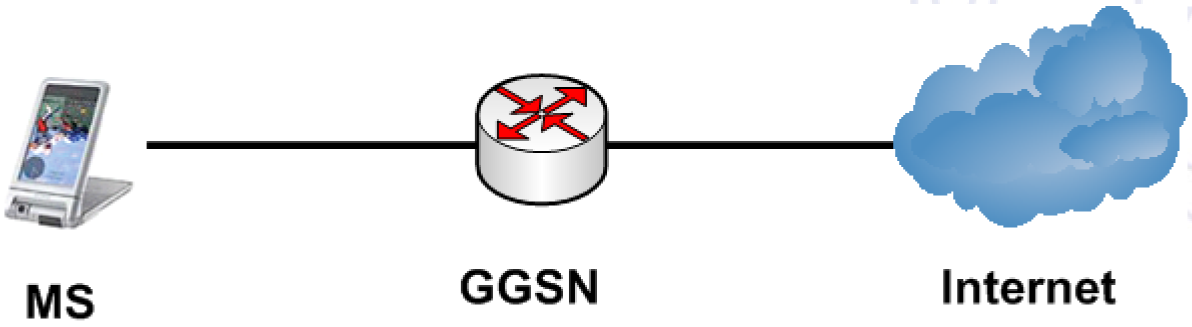
GPRS Components - Details

- Serving GPRS Support Node – **SGSN**
  - Delivery of data packets from/ to the MS within its geographical service area.
  - Main functions include authentication, authorization, mobility management, and collection of billing information.
  - Keeps track of the location of an individual MS, performs security functions and access control.
  - Connects to the SS7 network and through that, to the *Home Location Register (HLR)*, so that it can perform user profile handling, authentication, and authorization.

GPRS Components - Details

- Gateway GPRS Support Node - **GGSN**
  - Provides interworking with packet data networks, e.g. Internet
  - Operates as a gateway between the GPRS network and the external networks
  - Gathers charging information about the connections.
  - In many ways, the GGSN is similar to a *Network Access Server (NAS)*

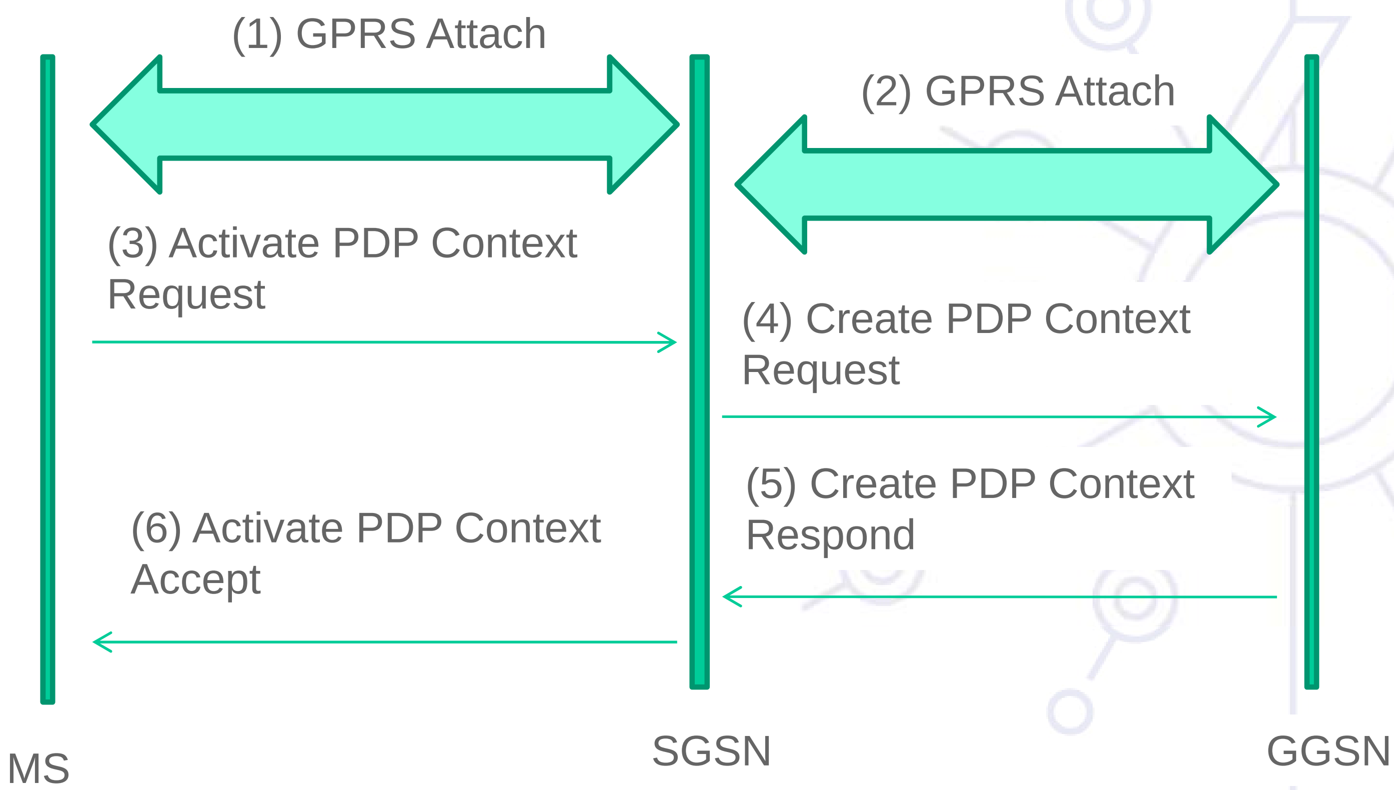
GPRS Logical Topology



A ***PDP context*** is a connection between the MS and the GGSN, over which the user packets are transferred.

User data is transferred transparently between the SGGN and GGSN using tunnelling, aka *GPRS Tunnelling Protocol*.

Getting IP(v4) connectivity in GPRS



3G networks and IP Multimedia Subsystem

- Key element in 3G architecture that makes possible to provide cellular access to all services that the Internet provides
  - Web browsing, voice, videoconference, VoD, etc

The following slides are based on 3GPP specifications Release 5 and above.

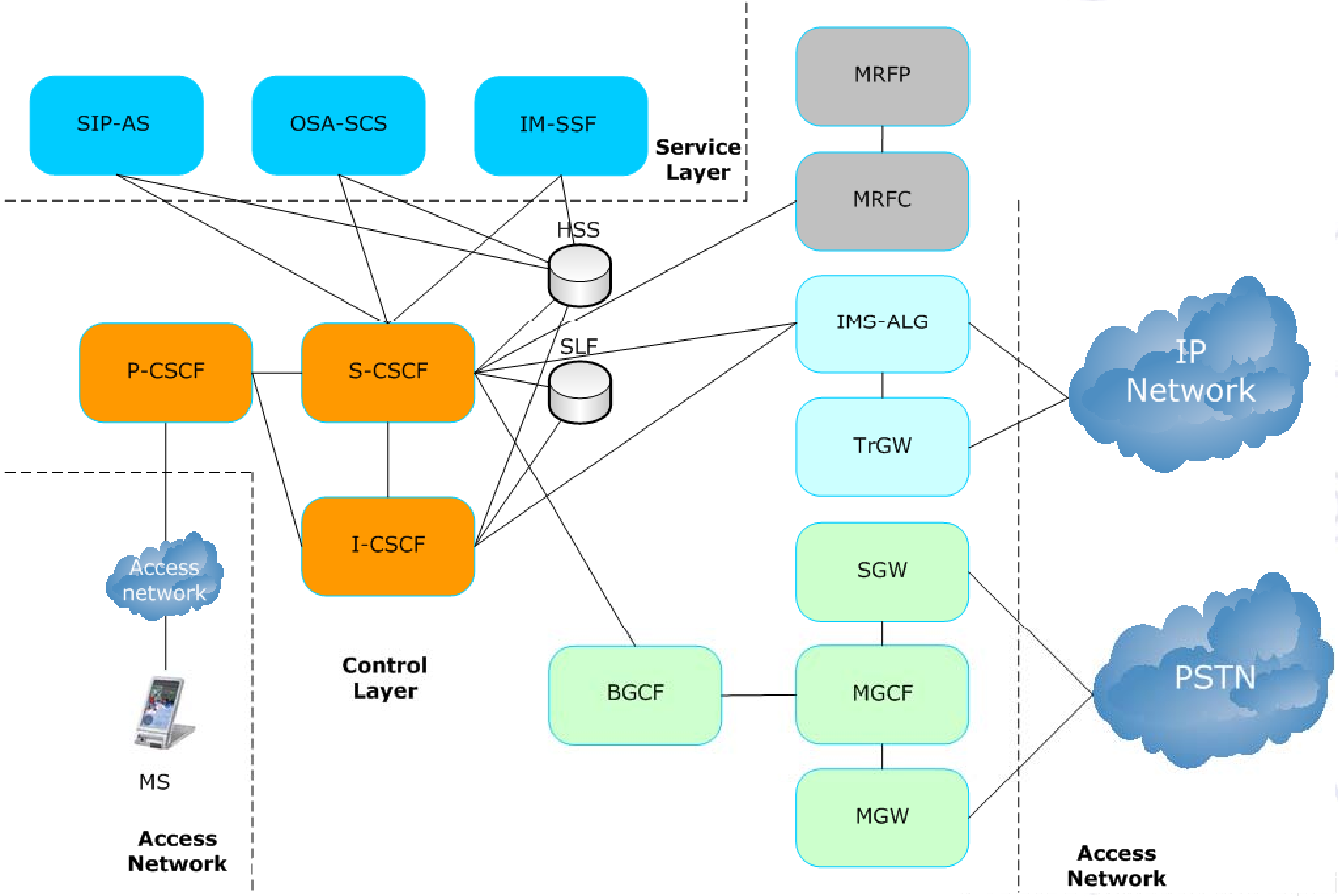
Requirements of IMS

- Support the establishment of multimedia services
- Support mechanisms to negotiate QoS
- Internetworking with Internet
- Allow control of services provided to users - Policies
- Support roaming
- Support fast service deployment without prerequisite standardization
- Support different access technologies

Some history …

- 3GPP selected IPv6 as the only allowed version of IP for IMS communications
  - When 3GPP designed IMS, IPv6 was already been standardized by IETF. It was envisaged that by the time IMS implementations would go into operation, IPv6 would be widely available in the Internet
  - SIP and associated protocols suffered when traversing NATs
- 3GPP allowed IPv4 for early IMS implementations
  - The first IMS products had been released
  - IPv6 was not widely deployed but NAT gateways
  - SIP and associated protocols could traverse NATs

3GPP IMS Architecture Overview



IMS Components - Overview

- **HSS**s (Home Subscriber Servers) and **SLF**s (Subscription Locator Functions)
- **CSCF** (Call/Session Control Function)
  - **P-CSCF** (Proxy CSCF), **S-CSCF** Serving CSCF), **I-CSCF**(Interrogating CSCF)
- **AS** (Application Server)
  - **SIP AS**, **IM-SSF** (IP Multimedia Service Switching Function), **OSA-SCS** (Open Service Access-Service Capability Server),
- **MRF** (Media Resource Function)
  - **MRFC** (MRF Controller), **MRFP** (MRF Processor)

IMS Components - Overview

- **IMS-ALG** (IMS Application Layer Gateway) and **TrGW** (Transition Gateway)
  - Facilitate interworking between IPv4 and IPv6
- **BGCF** (Breakout Gateway Control Function)
- **SGW** (Signalling Gateway), **MGCF** (Media Gateway Control Function) and **MGW** (Media Gateway)

IMS Components (Backup slide)

- **HSS**: Central repository for user related information, such as location information, security information, user profiles, etc.
- **SLF**: Repository that maps users' addresses to a single HSS, provided that there are more that one HSSs.

- **P-CSCF**: The first point of contact for an IMS terminal and the IMS network. It does not change for the duration of the registration.
  - It forwards SIP messages, establish IPsec security associations (authentication), corrects and (de)compress SIP messages, etc
- **S-CSCF**: Central node of the signaling plane
  - SIP registrar, inspects all SIP messages to/from IMS terminal, SIP message routing, translates DNS and E.164 numbers
- **I-CSCF**: SIP proxy located at the edge of an administrative domain responsible to forward messages to S-CSCF

IMS Components (Backup slide)

- **SIP AS**: Hosts and implements IP Multimedia Services based on SIP
- **IM-SSF**: Application server that allows to reuse *CAMEL (Customised Applications for Mobile network Enhanced Logic)* services developed in GSM
- **OSA-SCS**: Application server that provides interface to *OSA Application Server*

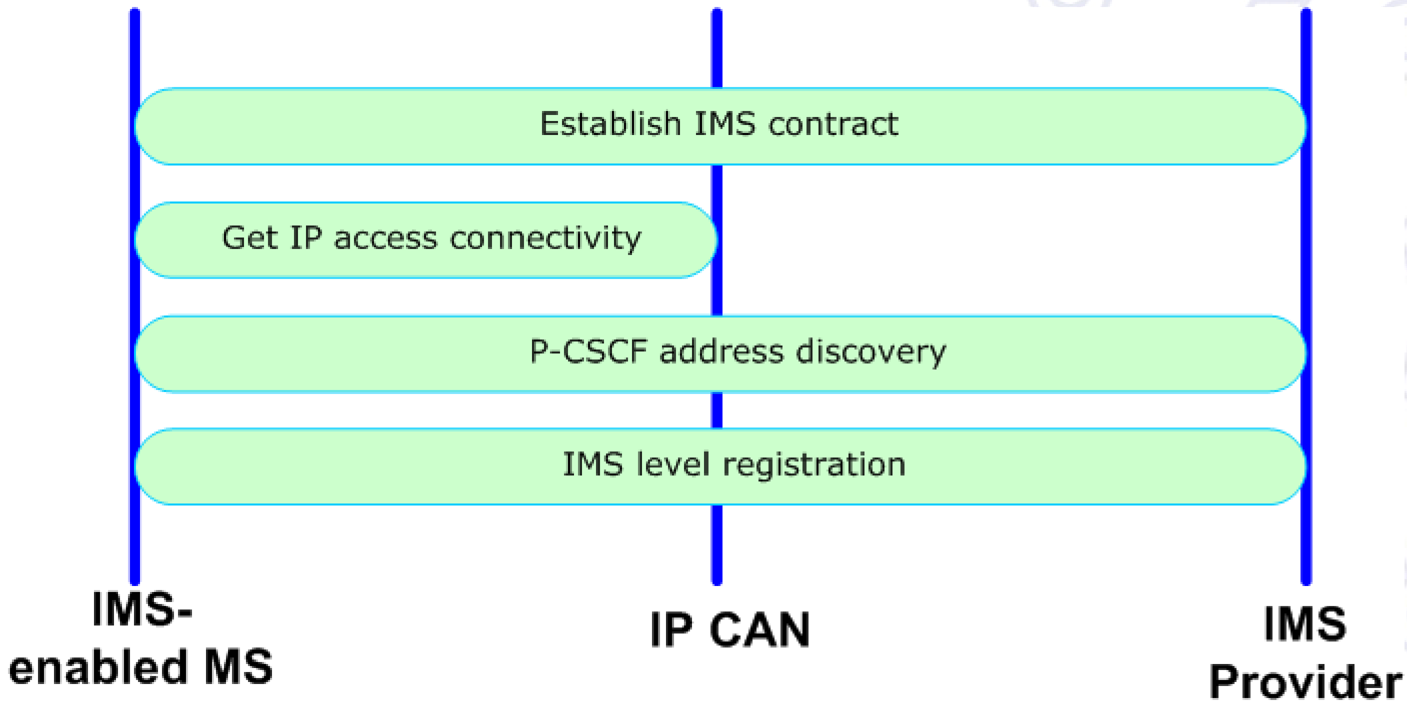
IMS Components (Backup slide)

- **IMS-ALG (Application Layer Gateway)**: Process control plane signalling, such as SIP and SDP messages
  - Required in dual stack implementations for SIP interworking
- **TrGW**: Its effectively a NAT-PT/NAPT-PT server processing media traffic, e.g. RTP, RTCP
  - Required in dual stack implementations for RTP/RTCP interworking
- **MRFC**: A SIP User Agent towards S-CSCF
- **MRFP**: Implements media-related functions, e.g. mixing media in multiparty video-conference

IMS Components (Backup slide)

- **BGCF**: SIP server responsible for routing sessions to circuit-switched networks, e.g. PSTN
- **MGCF (Media Gateway Control Function)**: Central node controlling interconnection with circuit switched network, e.g. PSTN
- **SGW (Signalling Gateway)**: Interface with circuit switched network
- **MGW (Media Gateway)**: Interface the media plane with circuit switched network

Prerequisites for using IMS services



Prerequisites for using IMS services

- Establish IMS contract
  - The provider has to authorise the end-user
- Get IP access connectivity
  - The IMS terminal has to get access to *the IP-CAN (IP Connectivity Access Network)*, such as GPRS
  - Get a valid IPv4/6 address
- P-CSCF address discovery
  - Discover the IP address of the incoming/outgoing SIP proxy server
- IMS level registration
  - The IMS terminal registers to SIP application servers

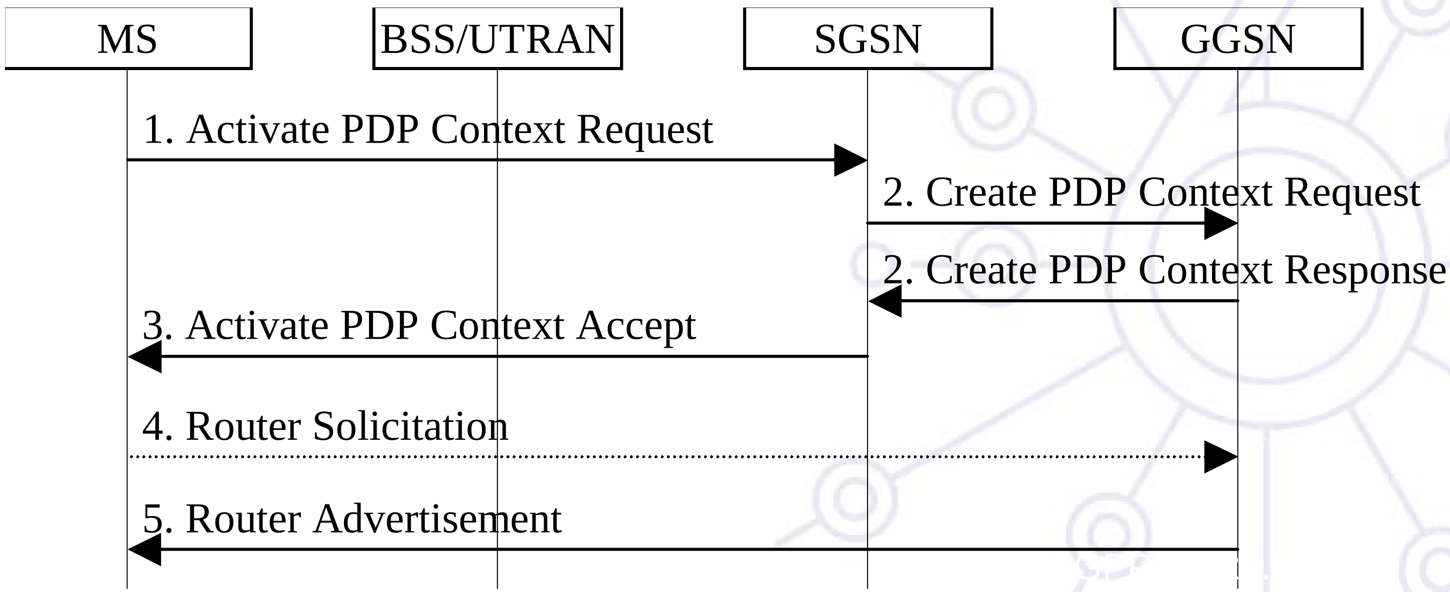
IPv6 Address allocation using GPRS

- Stateful and stateless autoconfiguration are both supported
- Getting IPv6 address requires MS to send a separate *PDP context request* (in addition to IPv4 request)
  - GGSN responds to a *PDP context request* attaching an IPv6 address. GGSN has already selected an interface identifier for the MS, as the latter lacks one (and thus avoids any collision with the link local address of GGSN)
  - GGSN assigns a unique /64 to /128 prefix for each PDP context
  - If necessary, the MS sends a *Route Solicitation* message to the GGSN

IPv6 Address allocation using GPRS

- MS uses the Route Solicitation messages to form a unicast IPv6 address, not necessarily attaching the interface identifier selected by the GGSN

IPv6 address allocation

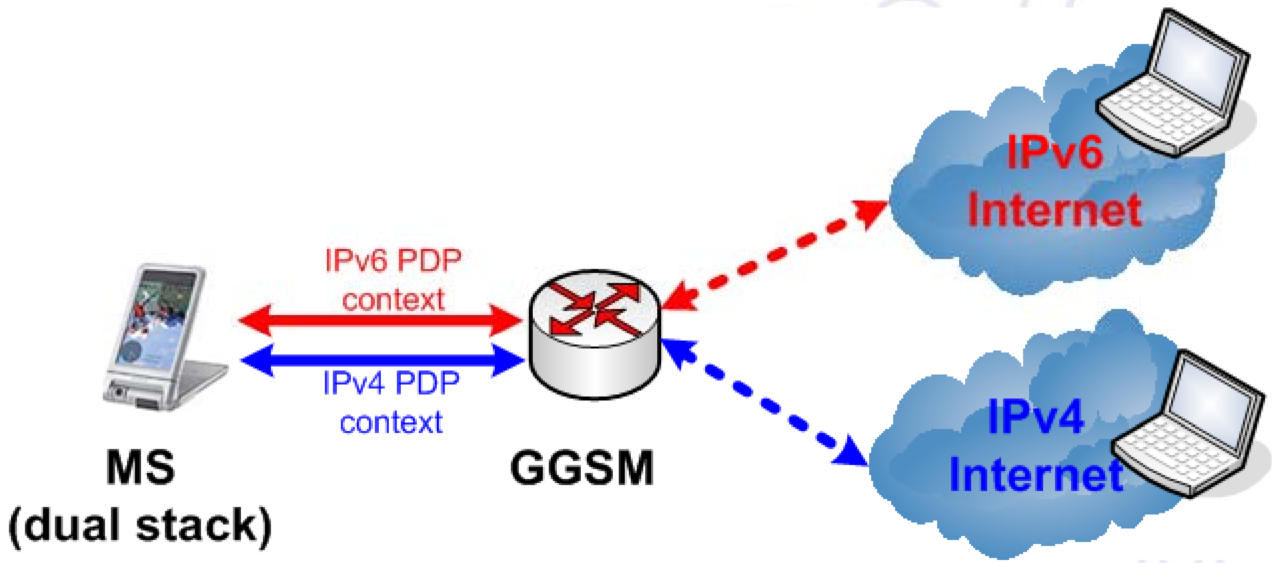


P-CSCF discovery

- *P-CSCF discovery* is the procedure by which the MS obtains the address of P-CSCF
- The MS can find P-CSCF address either via *PDP Context Requests* or via DHCPv6

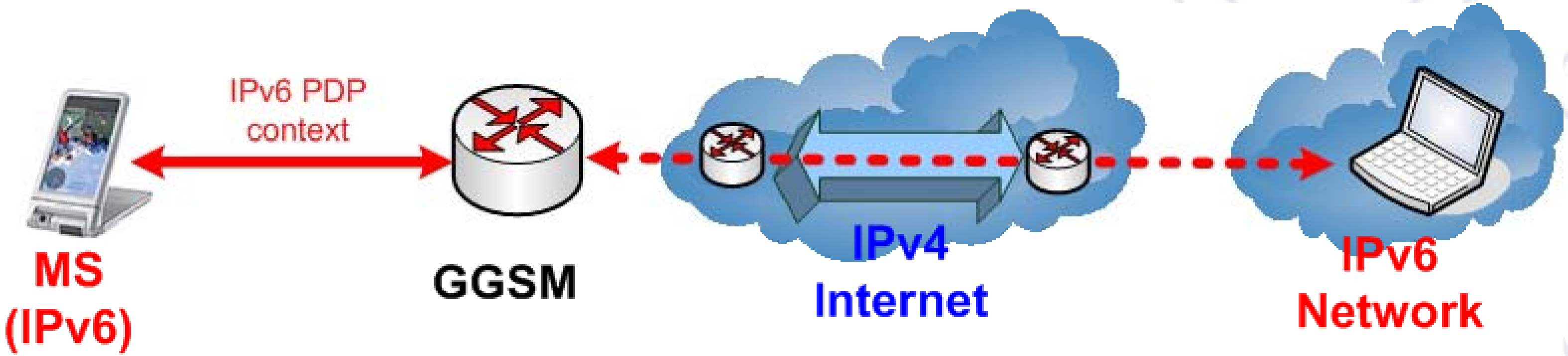
Transitioning scenarios related to MS

- Dual Stack MS connecting to IPv4 and IPv6 nodes
  - MS may have simultaneously IPv4 and IPv6 connections
  - Managing IPv4 address space and passing through NAT can be challenging



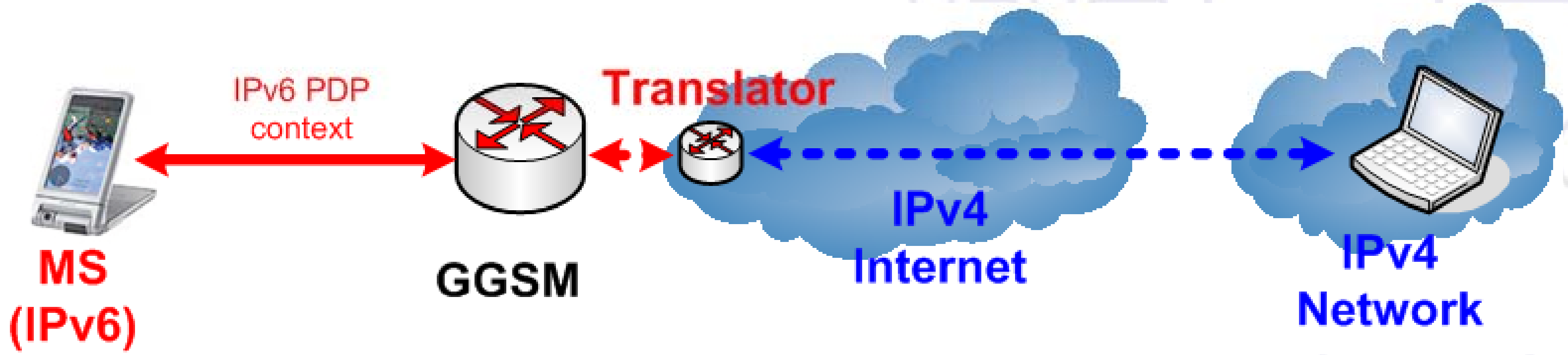
Transitioning scenarios related to MS

- IPv6 MS connecting to an IPv6 node through an IPv4 network
  - Tunneling is required but no other challenges
- IPv4 MS connecting to an IPv4 node through an IPv6 network



Transitioning scenarios related to MS

- IPv6 MS connecting to an IPv4 node
- IPv4 MS connecting to an IPv6 node

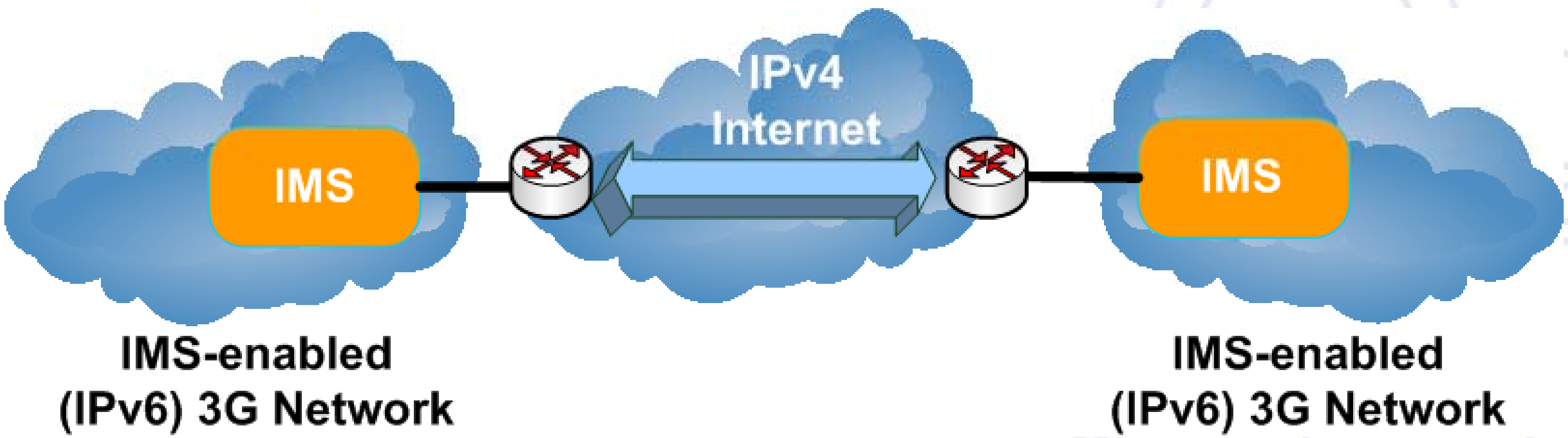


Transitioning Scenarios related to IMS

- MS connecting to a node in an IPv4 network through IMS
  - IPv6 MS needs to exchange both signaling and media with IPv4 nodes
  - IMS ALG process control plane signaling, e.g. SIP, SDP
    - Acts as back-to-back User Agent towards two networks supporting different IP versions
    - Rewrite SDP messages (IP addresses and ports) so as media traffic to be routed to TrGW
  - TrGW operates as NAT-PT/NAPT-PT
    - Performs translation of IPv4 and IPv6 at the media level, e.g. RTP, RTCP

Transitioning Scenarios related to IMS

- IPv6 IMS connected via an IPv4 network
  - IPv6 over IPv4 tunneling is required
  - No other challenges



IPv6 MS implementation issues (1/3)

- Some neighbor discovery messages are unnecessary as GPRS / UMTS links resemble a point-to-point link
  - The only MS neighbor is the default router, known through Router Discovery.
  - The cellular host must support neighbor unreachability detection
- Duplicate address detection is not necessary for a MS as GGSN allocates the addresses in the PDP context

IPv6 MS implementation issues (2/3)

- MS should not generate network solicitation messages
  - If NS message is sent, the GGSN silently discard it
  - There are no link layer addresses
- MLD reports may be unnecessary
  - Point-to-point connection exist between MS and default router (GGSN), aka two devices exist per link
  - No attempt is made to suppress the forwarding of multicast traffic
  - MLD is needed for multicast group knowledge that is not link-local

IPv6 MS implementation issues (3/3)

- Privacy extensions for SAA should be supported
  - May not be necessary if IPv6 addresses are short-lived.
- DNS should be supported.
  - Both the iterative and the recursive approach should be supported.
  - A MS can perform DNS requests in the recursive mode, to limit signaling over the air interface.
- DHCPv6 may be used
  - DHCPv6 is not required when IPv6 SAA is used.
  - DHCPv6 may be useful for other configuration set-up

3GPP Standards

- 3GPP TS 23.060: GPRS Service description
- 3GPP TS 23.228: IMS
- 3GPP TR 23.981: Interworking aspects and migration scenarios for IPv4-based IMS implementations
- 3GPP TR 23.981: Interworking aspects and migration scenarios for IPv4 based IMS Implementations
- 3GPP TS 29.061: Interworking between the PLMN supporting packet based services and PDN
- 3GPP TS 29.062:Interworking between the IP Multimedia (IM) Core Network (CN) subsystem and Circuit Switched (CS) networks

IETF RFCs

- RFC 3314: Recommendations for IPv6 in Third Generation Partnership Project (3GPP) Standards
- RFC 3316: Internet Protocol Version 6 (IPv6) for Some Second and Third Generation Cellular Hosts
- RFC 3574: Transition Scenarios for 3GPP Networks
- RFC 4215 - Analysis on IPv6 Transition in Third Generation Partnership Project (3GPP) Networks
- RFC 2473 - Generic Packet Tunneling in IPv6

IPv6 Protocols for Cellular Hosts

- RFC1981 - Path MTU Discovery for IP Version 6
  - Cellular hosts with a link MTU larger than the minimum IPv6 link MTU can use Path MTU Discovery in order to discover the real path MTU.
- RFC2460 - Internet Protocol Version 6
  - By definition, a cellular host acts as a host, not as a router. Consequently, the cellular host must implement all non-router packet receive processing as described in RFC 2460.
- RFC4861 - Neighbor Discovery for IPv6
  - A cellular host must support NS and NA messages.
  - Some NDP messages can be unnecessary in certain cases in GPRS and UMTS networks. GPRS and UMTS links resemble a P-P link; … There are no link layer addresses. Therefore, address resolution and next-hop determination are not needed.
  - The cellular host must support neighbor unreachability detection.

IPv6 Protocols for Cellular Hosts

- RFC4862 - IPv6 Stateless Address Autoconfiguration (SAA)
  - Hosts in 3GPP networks can set DupAddrDetectTransmits equal to zero, as each delegated prefix is unique within its scope when allocated using the 3GPP IPv6 SAA.
  - In addition, the default router (GGSN) will not configure or assign to its interfaces, any addresses based on prefixes delegated to IPv6 hosts. Thus, the host is not required to perform Duplicate Address Detection on the cellular interface
- RFC4941 - Privacy Extensions for SAA
  - Should be supported. Cellular hosts may use the temporary addresses as described in RFC 4941. However, the use of the Privacy Extension in an environment where IPv6 addresses are short-lived may not be necessary.

Questions?