BME/TMIT
Budapesti Műszaki és Gazdaságtudományi Egyetem (BME)
Távközlési és Médiainformatikai Tanszék (TMIT)

IMS – IP MULTIMEDIA SUBSYSTEM

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Introduction

- What is Your preferred tool for phone calls?
  - landline phone (PSTN)
  - mobile phone
  - VoIP phone
  - Skype
  - other

Changing Trends

- Competitive environment
  - widened capabilities of service providers and services
    - landline, mobile, satellite…
    - voice, data, video…
  - new entrants
    - using a network infrastructure without investment costs
    - VoIP, Skype, etc.
  - network access does not restrict the provided services any more
  - requirements for service providers
    - outstanding service provisioning
    - continuous development and renewal

Evolution of Mobile Telephony

- Increasing number of services and multimedia content available
- Personalization of services
- Internet services (e-mail, web browsing, instant messaging, multimedia call, presence, etc.) available on mobile too
- Internet as a new broadcasting media
- Demand for Internet services on mobile devices with "telecom grade" quality
  - Reliability
  - Quality of Service
  - Safe communication

IMS – Short Overview

- Provisioning of IP multimedia services (Rich communication services) with uniform management
  - web
  - email
  - instant messaging
  - presence
  - videoconference
- Ubiquitous service over a variety of access and transport network technologies
  - fixed-mobile convergence (FMC)
- Using Internet standards (IETF protocols)
  - Session Initiation Protocol – SIP: a key signaling protocol
    - creating, modifying and terminating sessions consisting of media streams
- High quality telecom services over packet switched network
- Operators keep the control over the services
  - „operator friendly" ☺

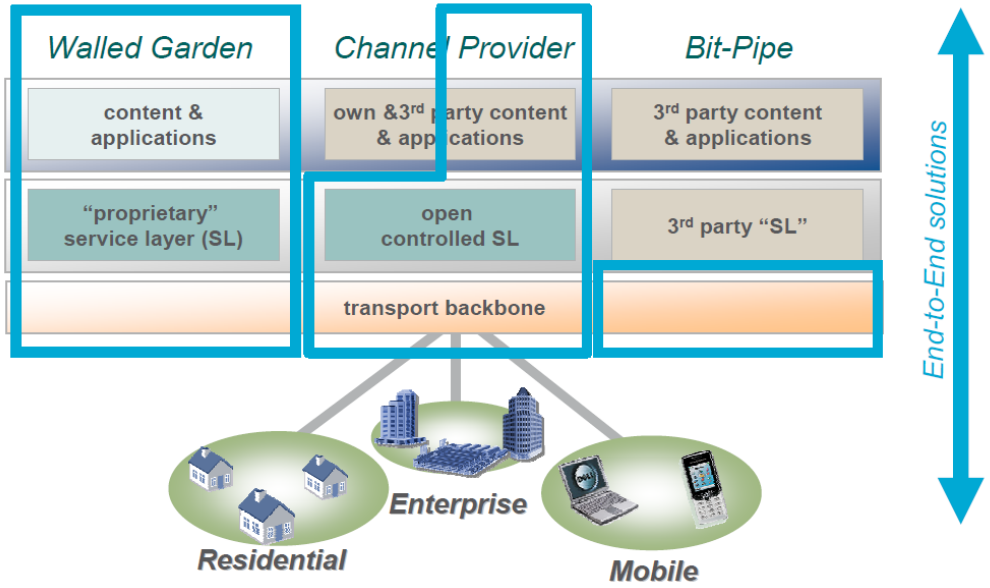
IMS advantages

- Any…
  - kind of access network (fixed, mobile, wireless) – independent of core network
  - kind of media, or combinations of them (voice, text, image, video)
  - kind of device (IMS terminals)
- open, standardized interfaces
- support for legacy systems through gateways (e.g. PSTN)
- support for roaming
- uniformity
  - unified subscriber database
  - one subscriber profile
  - Single Sign-On
- isolation of application and session control layers
  - several applications, or combination of them (service blending) can be active at the same time

History of IMS

- Original goal: Provisioning "Internet services" over GPRS (General Packet Radio Service) networks
  - 3GPP (3rd Generation Partnership Project)
    - telecommunications standard development organization union
  - Rel-5, 2002 /Rel = release/ (latest: Rel-13)
- Extending to other networks in later releases – access with any terminal
  - 3GPP, 3GPP2, ETSI TISPAN (European Telecommunications Standards Institute Telecommunications and Internet converged Services and Protocols for Advanced Networking – main goal is the specification of NGN)
- 2010. GSMA (GSM Association) VoLTE (Voice /and SMS/ over LTE) initiative – based on IMS
  - advances the usage of IMS

Business Models

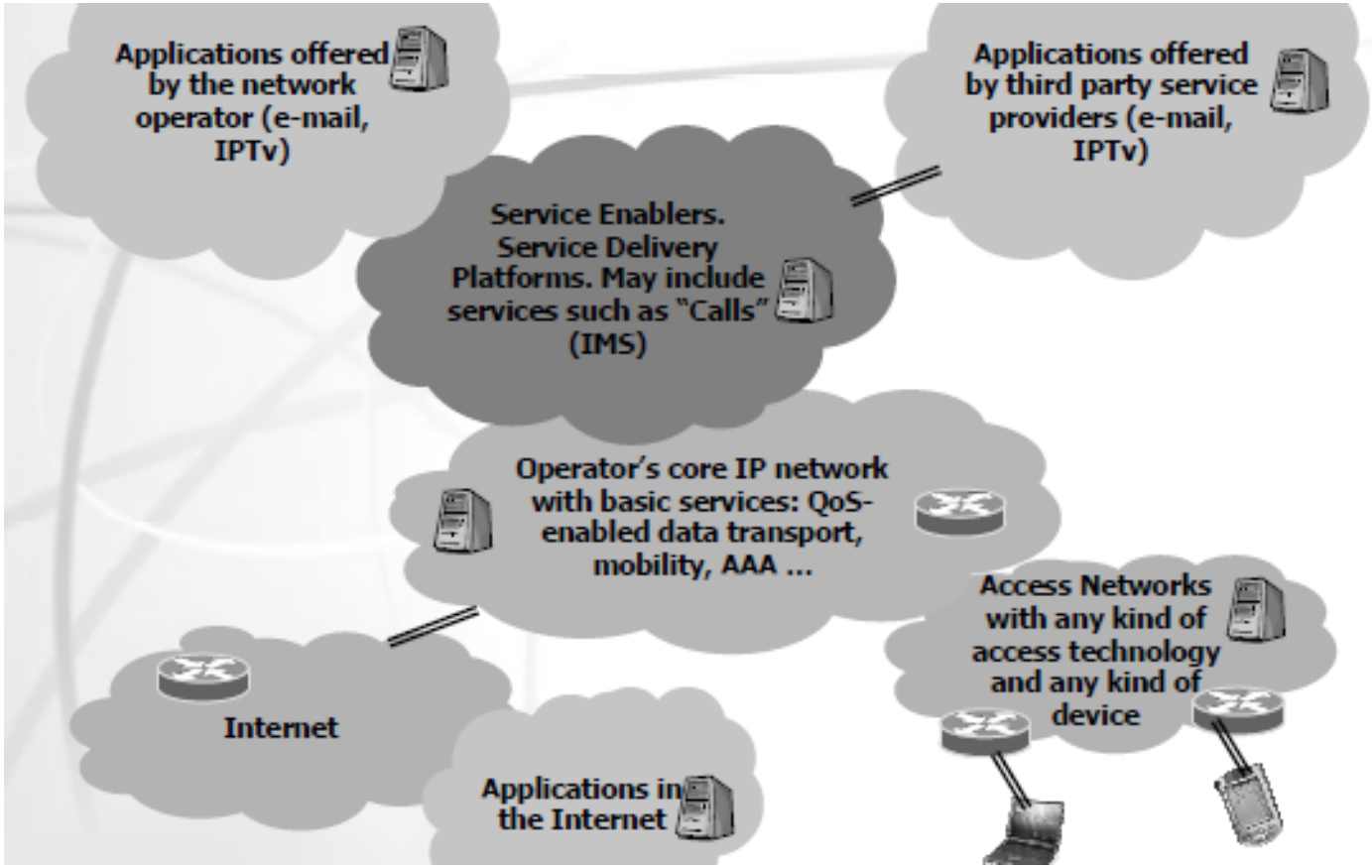


- Two different "worlds"
  - Telco operators
    - monolithic and closed
  - Internet
    - shared and open
    - standalone applications
- Result: semi walled garden
- Interests
  - Network providers
    - universal packet switched network for everything (minimizing operational expenditures)
    - do not want to be omitted form the value chain by transmitting only bits (avoid being bit pipes)
    - provisioning services is the profitable part
  - Service providers
    - Internet modell is suitable
    - finding new pay services

Business Models

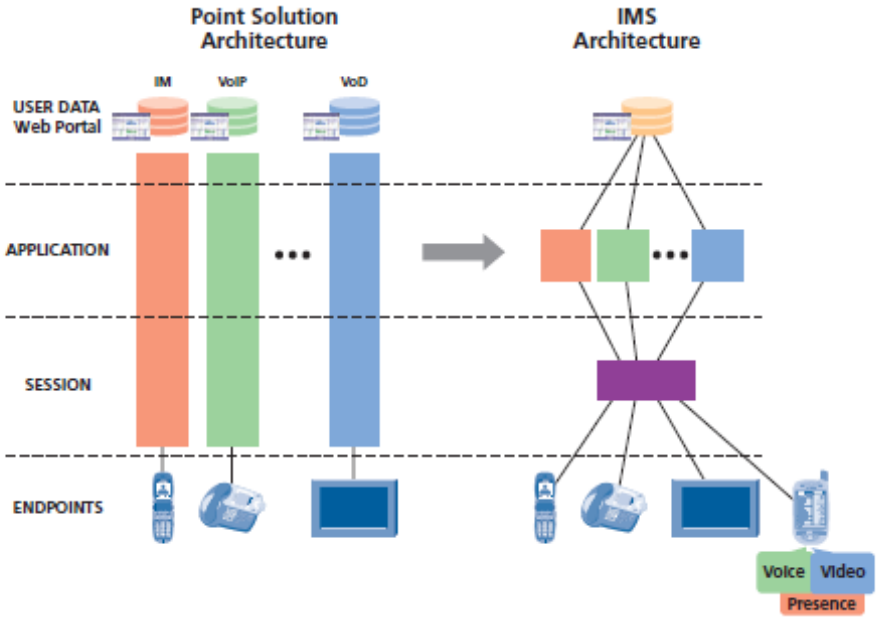
- Internet
  - network provider is only transferring bits (bit pipe)
  - all kinds of services/applications can be provisioned over it
  - for a each service separate
    - login
    - payment data
    - invoice
- Telecom
  - network and service provider
  - limited services
  - third party is not allowed to provide services
  - single login, invoice, payment data
- Converged business model (semi walled garden)
  - network provider is a service broker
  - third party services are also available: broader service selection
  - invoicing by network provider, keeping certain percentage; remaining amount transmitted to third party service provider
  - single login, invoice, payment data
  - ⇨ service platforms

Service Platforms

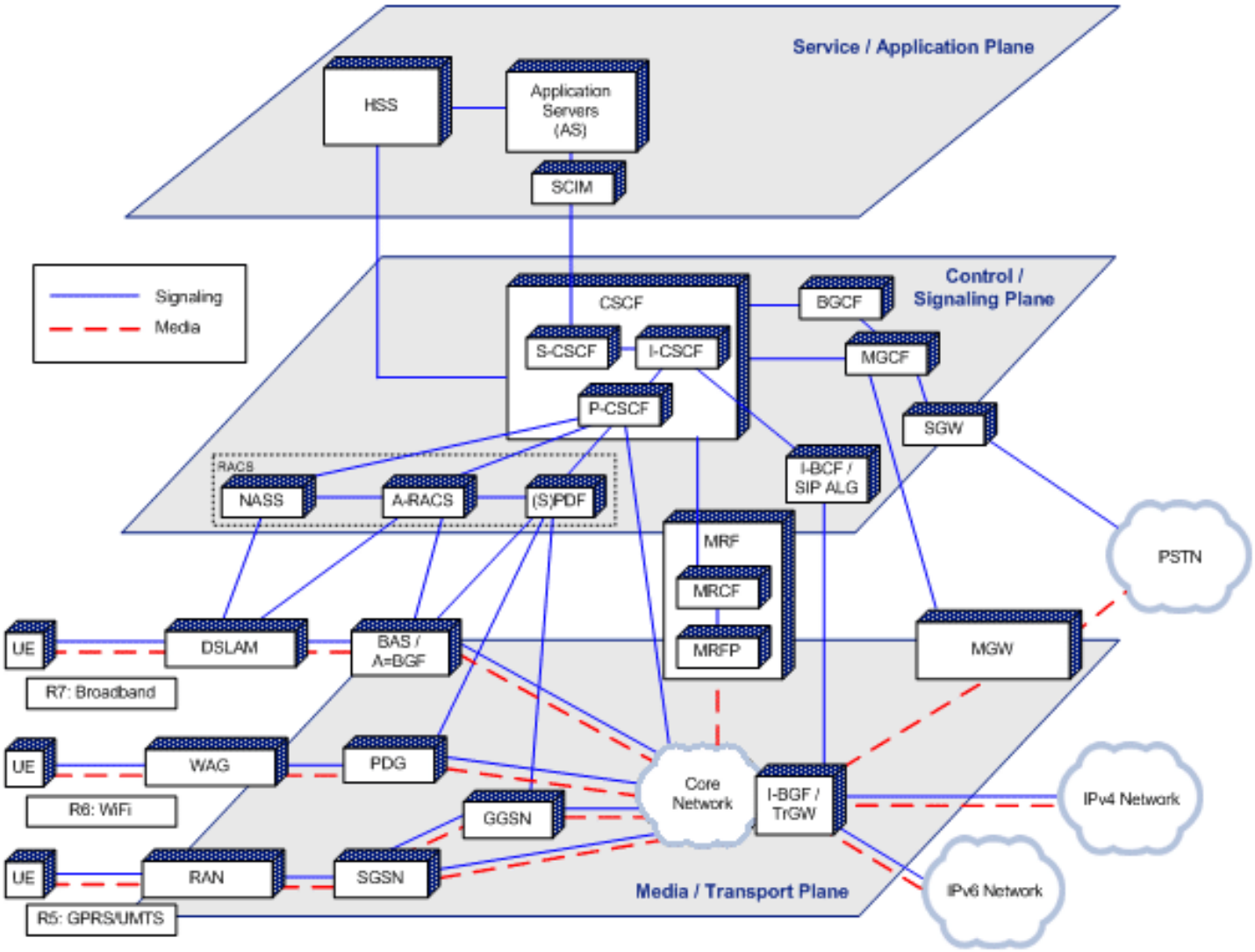


NGN – IMS

- Unified transport core network for all kinds of services
  - multi protocol
  - multi access
  - substantially simpler network operation and management



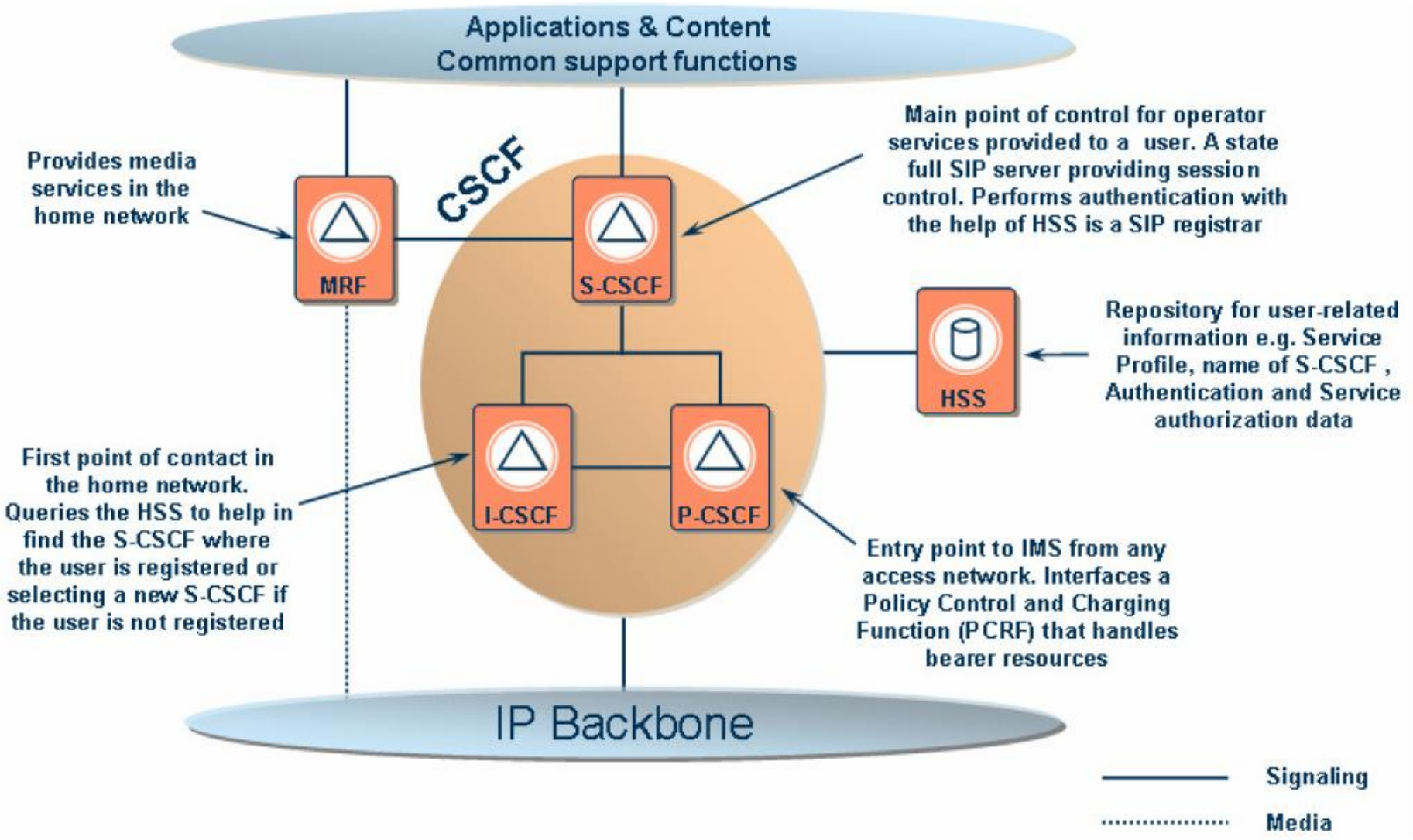
IMS functional architecture



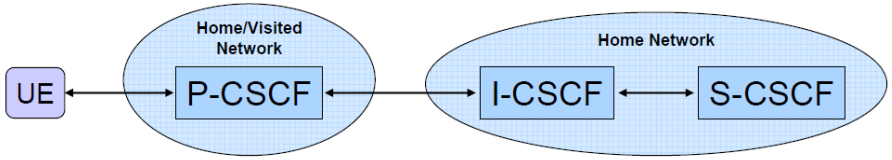
IEC (International Engineering Consortium) Newsletter, www.iec.org

HSS – Home Subscriber Server
PDF – Policy Decision Function
SCIM – Service Capability Interaction Manager
PDG – Public Data Gateway
BGCF – Border Gateway Control Function
MRF – Media Resource Function
MGCF – Media Gateway Control Function
MRFP – Media Resource Function Processor
SGW – Signalling Gateway
MRFC – Media Resource Function Controller
RACS – Resource and Admission Control Subsystem
MGW – Media Gateway
IBCF – Interconnection Border Gateway Function
TrGW – Translation Gateway
BAS – Broadband Access Server
WAG – WLAN Access Gateway

IMS core network architecture



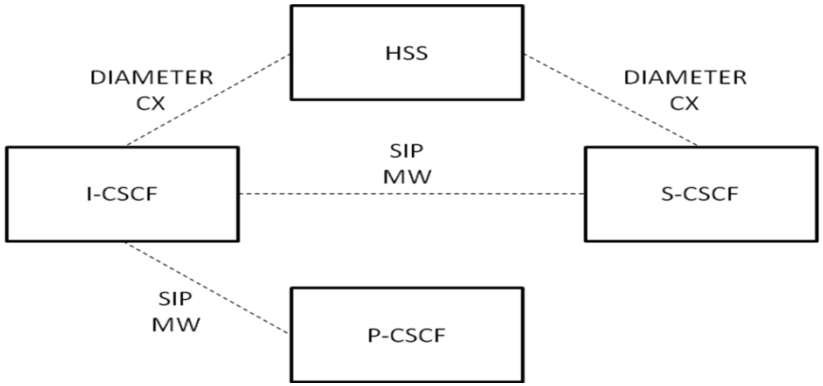
IMS core network



- CSCF functions provided by SIP proxies
  - P-CSCF (Proxy - Call Session Control Function)
    - first signaling point of contact for the UE
    - SIP message handling
      - compress and decompress
      - may establish secure channel to UE
      - checking correctness of messages
  - S-CSCF (Serving - Call Session Control Function)
    - session control for services
    - SIP registrar function: handles registrations
    - SIP proxy function: routing of signaling messages
  - I-CSCF (Interrogating - Call Session Control Function)
    - gateway to the network at the border of the administrative domain
    - inter-domain SIP signaling
      - its address is published in the DNS of the domain, therefore remote nodes can reach it and use it as a forwarding point
      - it queries the HSS to retrieve the address of the S-CSCF that will be assigned as a serving S-CSCF for the user

Home Subscriber Server– HSS

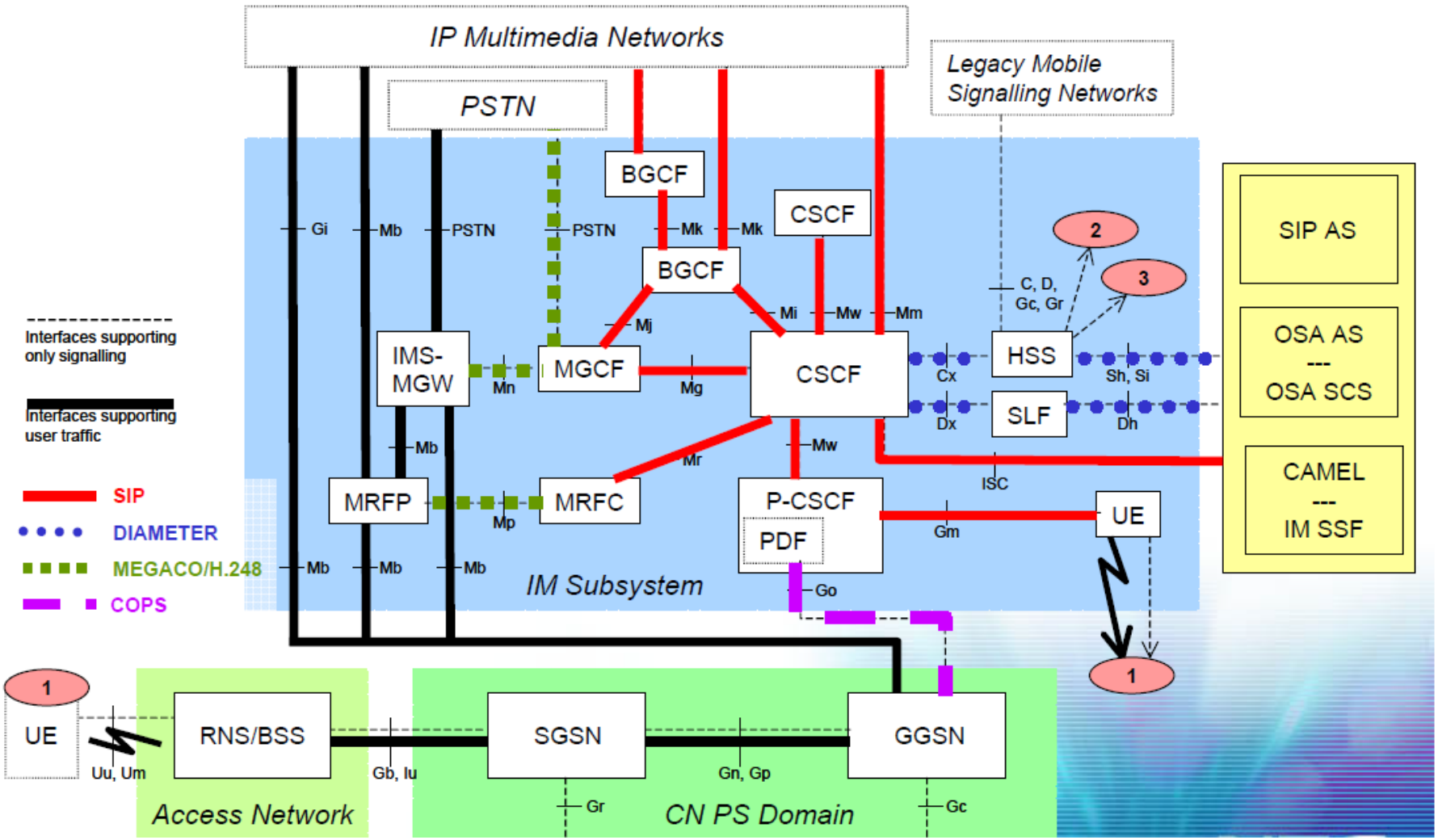
- Contents
  - user identities, subscriber data
  - subscriber profiles, enabled services
  - call state, location information
- Subscription Locator Function (SLF) is required when multiple HSSs are used



Media resources and gateway control

- Media resources
  - Multimedia Resource Function Processor (MRFP)
    - media plane node
    - provides resources of the bearer packet switched network to control by MRFC
    - handles media streams
      - mixing
      - processing, transcoding
  - Multimedia Resource Function Controller (MRFC)
    - signaling plane node: controls the media resources of MRFP node
    - interprets messages coming from S-CSCF and Application Servers
- Gateways
  - Breakout Gateway Control Function (BGCF)
    - routing based on telephone numbers
    - in case of call termination in circuit switched (CS) network (e.g. PSTN, PLMN)
  - Media Gateway (MGW)
    - interfaces with the media plane of the CS network by converting/transcoding media streams
  - Signalling Gateway (SGW)
    - lower level protocol conversion
  - Media Gateway Control Function (MGCF)
    - control of SGW and MGW

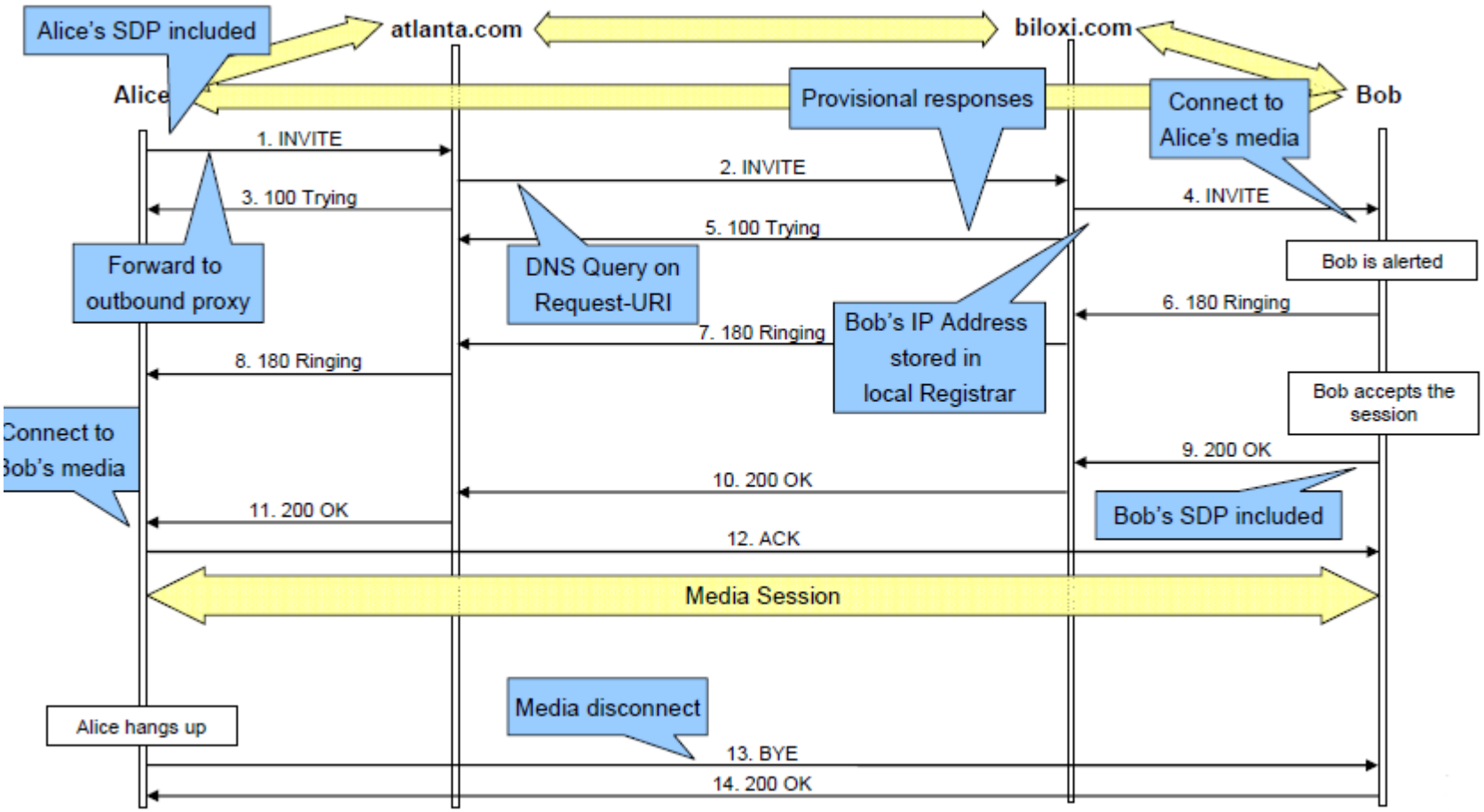
IMS protocol suite



Session Initiation Protocol (RFC3261)

- signaling protocol
  - text based
  - extensible
  - media transfer is not part of SIP
- session – interactive information interchange, conversation
  - creating, modifying and terminating
  - codec negotiation
- SIP registrar
  - location service by linking IP addresses and SIP URI
  - processing REGISTER requests
- SIP proxy
  - intermediary entity
  - can provide registrar function
  - routes requests
  - handles only signaling, media stream is not forwarded
- NAT traversal problems

SIP session handling



IMS and „plain” SIP (RFC3261) comparison

- IMS added functions
  - managing subscribers, controlling services, single sign on
  - QoS/media authorization and resource control, charging
  - roaming, interworking between different networks, conference call, etc.
- Most of these functions are defined by IETF extensions
  - Update (RFC331), Preconditions (RFC3312), PRACK (RFC3262), Offer/Answer (RFC 3264),
  - QoS/Media Authorization (RFC 3313), Event Notification (RFC 3265),
  - Tel-URIs (RFC 2806), 3GPP P-Headers (RFC3455), Service-Route (RFC3608),
  - Asserted ID (RFC3325), DNS-Support (RFC 3263), SigComp (RFC3320, RFC3485, RFC 3486),
  - ENUM (RFC2916, RFC2915), SIP Refer (RFC3515), Digest AKA (RFC 3310),
  - Path-Header (RFC 3327), Security-Mechanism-Agreement (RFC3329), etc.

DIAMETER protocol functions

- DIAMAETER is the evolved version of RADIUS (Remote Authentication Dial In User Service) (IETF)
  - binary client-server protocol
  - base protocol + extensions
  - better security and easier extensibility
  - better scalability and notification of errors
- Authentication: identifying a user, and granting access to the network
- Authorization: determining what types or qualities of activities, resources, or services a user is permitted to use
- Accounting: measures the resources a user consumes during access; collecting, storing and forwarding traffic usage data
- An AAA server collects and stores the data sent by their clients, and sends back statistics by the request of the clients
  - user login timestamp
  - service time counter
  - number of sent/received packets, etc.
- Advantages
  - services controlled by the operator
  - end-to-end provider responsibility
  - anonymous or unauthorized user is not allowed to enter the network

User identities

- one or more public id: IP Multimedia Public Identitity - IMPU
  - used to route SIP messages
  - either SIP URI (Uniform Resource Identifier) (RFC 3261), e.g.: sip:name@domain.com
  - or TEL URI (RFC 3966), e.g.: tel:+15551234567
  - In the HSS all IMPUs, in the mobile device holding an IP Multimedia Services Identity Module (ISIM) at least one is stored
  - can be portable
- exactly one private id: IP Multimedia Private Identitity - IMPI
  - permanently allocated global id, assigned by the home network operator
  - In NAI form (Network Access Identifier, RFC 2486), e.g.: name@domain.com
  - used only for registration and AAA
  - stored in the HSS and on the ISIM within the mobile device

Service identities

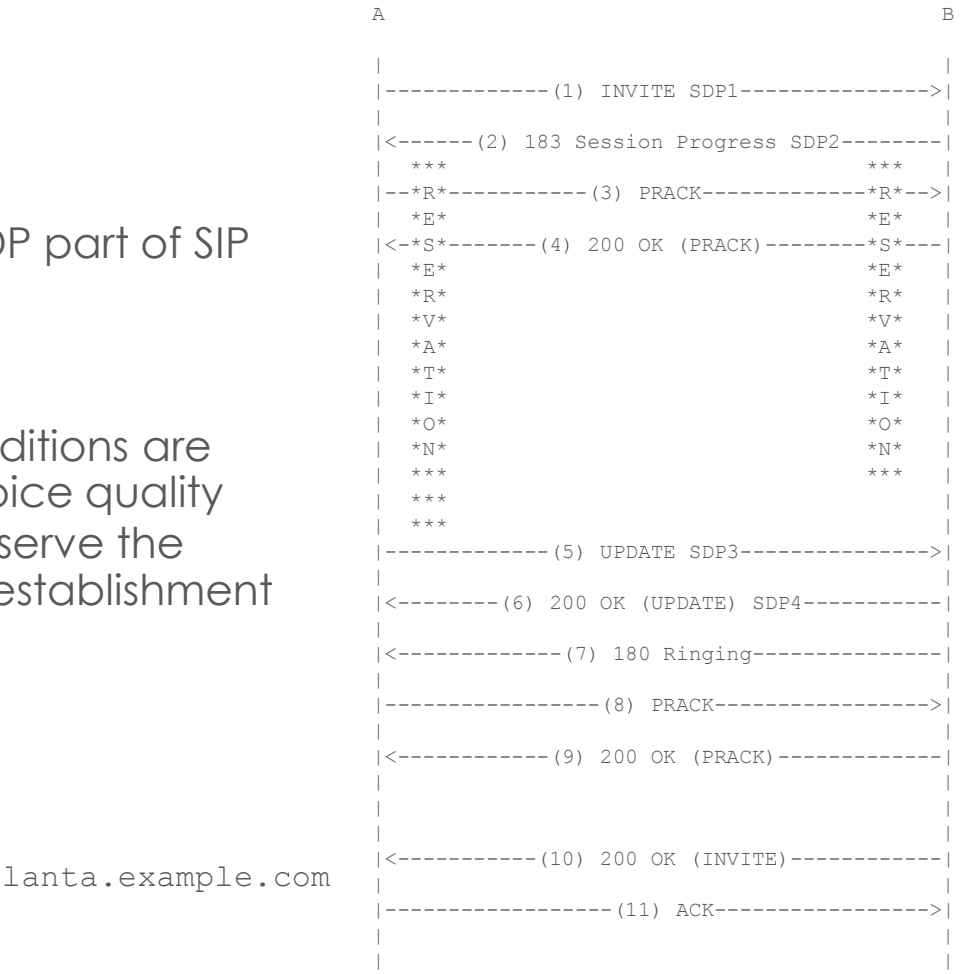
- Public Service Identitity - PSI
  - used for routing of SIP requests
  - not applicable for AAA, no private id is associated
  - either SIP URI (Uniform Resource Identifier) (RFC 3261), e.g.: sip:presence@domain.com
  - or TEL URI (RFC 3966), e.g.: tel:+15551122335

IMS and QoS

- Network layer provides QoS for services
  - access network, e.g. UMTS
  - packet switched core network (e.g. with Intserv, DiffServ, etc.)
- Four QoS classes in UMTS
  - conversational
  - streaming
  - interactive
  - background
- PDP (Packet Data Protocol) context
  - data structure stored in SGSN and GGSN if subscriber is active
  - includes subscriber's IP address, IMSI, etc. and QoS parameters, including the QoS class
  - it is activated at first attachment of IMS terminal
- How it is used with IMS?
  - SCSF extracts QoS parameters of connection from the SIP signaling (e.g. codec, bandwidth)
  - no direct control over the media stream and bearer network
  - ⇨ intermediate function is required: Policy Decision Function
- Policy Decision Function
  - Mediation between the QoS level defined at application layer (IMS) and the access bearer network (data plane)
  - Placed between P-CSCF and BAS/PDG/GGSN in the architecture

IMS and QoS

- PDP context activation
  - which codec is negotiated in SDP part of SIP INVITE and 200 OK
  - success of PDP activation
- Preconditions
  - client can declare what preconditions are required to create a call, e.g. voice quality
  - if bearer service is not able to reserve the required resources then session establishment does not take place
  - SIP/SDP extension: RFC 3312




```
SDP offer example (audio+video):

v=0
o=alice 2890844526 2890844526 IN IP4 host.atlanta.example.com
s=
c=IN IP4 host.atlanta.example.com
t=0 0
m=audio 49170 RTP/AVP 0 8 97
a=rtpmap:0 PCMU/8000
a=rtpmap:8 PCMA/8000
a=rtpmap:97 iLBC/8000
m=video 51372 RTP/AVP 31 32
a=rtpmap:31 H261/90000
a=rtpmap:32 MPV/90000
```

v= protocol version
o=<username> <session id> <version> <network type> <address type> <address>
s= session name
c=<network type> <address type> <connection address>
t= time the session is active
m=<media> <port> <transport> <format list>
a=<attribute>
a=rtpmap:<payload type> <encoding name>/<clock rate> [/<encoding parameters>]

Charging

- Accounting (collecting and sending usage data)
  - Control plane (IMS): parties, start time of session, session duration, etc.
  - Data plane – usage of resources: sent/received bytes, PDP context, etc.
- Correlation between the planes
  - unified charging
- Accounting data
  - home/visited network: usage of network resources
  - home network: charging, billing
- IMS charging archiecture
  - Offline charging (postpaid)
    - All SIP signaling entity (P-CSCF, I-CSCF, S-CSCF, BGCF, MRFC, MGCF, AS) sends accounting information to the CDF (Charging Data Function) of the domain
  - Online charging (prepaid, or real-time controlled postpaid)
    - Interconnection between S-CSCF and Session Charging Function (SCF)
    - if no credit remains, SCF notifies S-CSCF, which terminates the call

Scalability

- Signaling
  - size and rate of messages
  - passing many intermediate nodes (proxy based arch.)
  - message multiplication (e.g. NOTIFY)
  - CPU processing time
- Architecture
  - planned for high number of subscribers
  - modular design
  - multiple CSCFs, HSSs
- Load balancing
  - by resolving CSCF and AS addresses with DNS
  - Multiple HSSs: Service Locator Function
  - In S-CFCS: iFC (initial Filter Criteria) –according to user profiles (static)
  - Application Servers (AS)
    - cost of SIP communication
    - difficult coordination among distributed and stateful App. Servers

IMS Call Flows

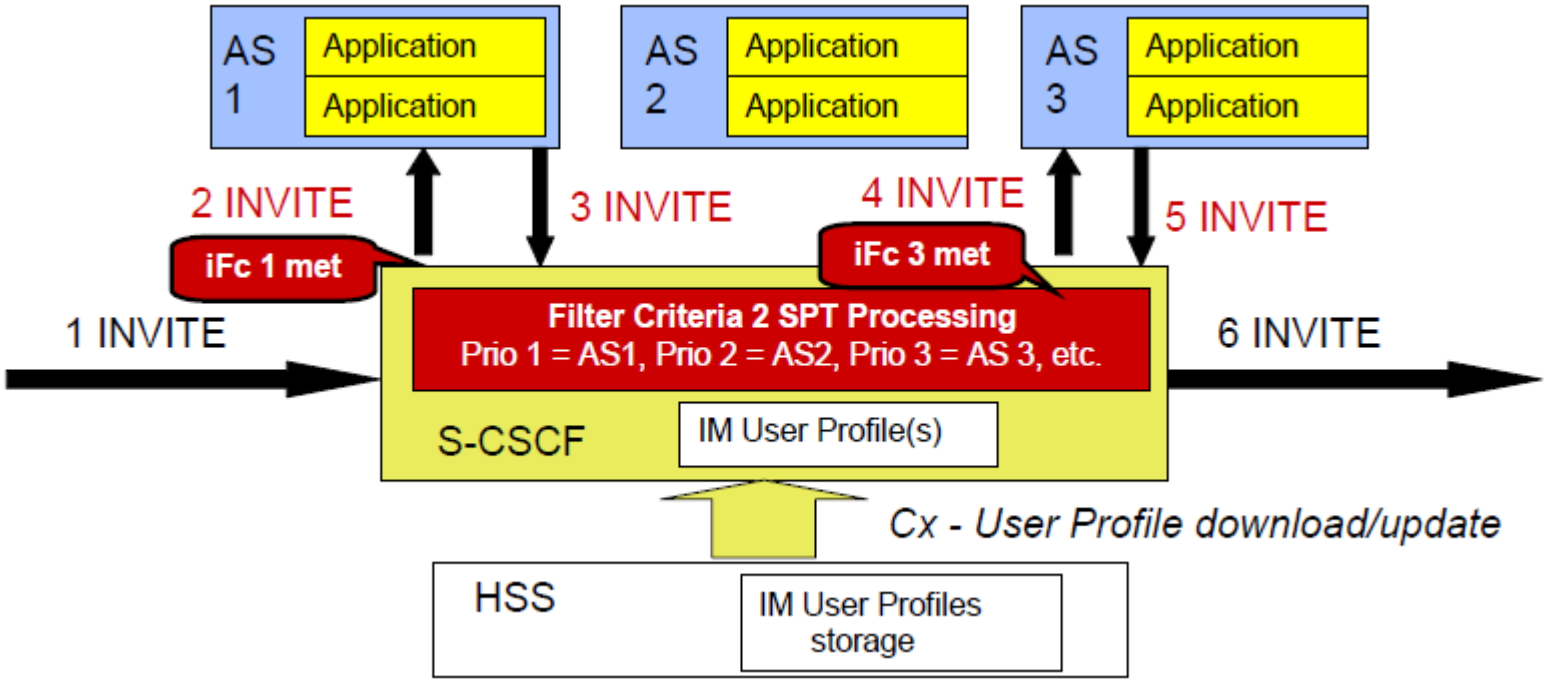
- http://www.eventhelix.com/ims
- Routing related headers in SIP messages
  - Via: proxies add a Via header field value containing their address
  - Route:
    - used to force routing for a request through the listed set of proxies
    - initial request:
      - UE: received values of Service-Route header from P-CSCF
      - CSCF: next hop or the received Path header value
    - subsequent requests:
      - Record-Route headers
  - Record-Route: stays in the signaling path for subsequent signaling messages
  - Service-Route: UE (or P-CSCF) receives and saves the address of S-CSCF at registration
  - Path: P-CSCF inserts its address at registration, S-CSCF saves it, UE receives all messages through this proxy address

Service profiles

- Dynamic profile based application server selection
- Service profile
  - list of iFCs with assigned priorities
- Filtering and routing by S-CSCF
  - Initial Filter Criteria (iFC)
    - stored in HSS as part of user profile
    - list of subscribed services
    - contains:
      - SIP URI of AS to which the request should be routed
      - Trigger Point: logical expression (AND, OR NOT) related to SIP requests
        - set of Service Point Triggers
          - » Request-URI *equals* <value>
          - » SIP Method *equals* <value>
          - » SIP Header *matches* <regular expression>
          - » Session Case *is one of* [originating, terminating, terminating to unregistered user]
          - » SDP Line [<line name>] *matches* <regular expression>
        - if Trigger Point is true send request to AS
        - only initial request is matched
      - a *Default Handling* element

Initial Filter Criteria

- An example:



Application Servers (AS)

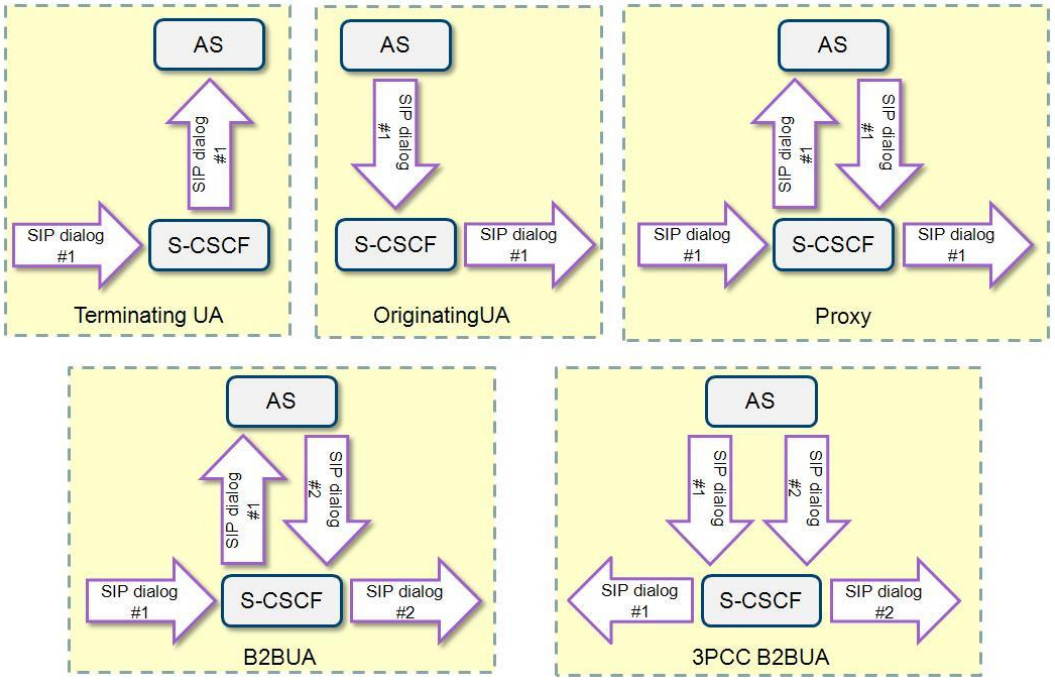
- IMS gives an architectural framework for service provisioning
- Services are implemented by Application Servers, not by IMS
- Application Servers
  - are owned by operators or third parties
  - can exploit IMS provided functions
  - can interact with S-CSCF and HSS
- Services
  - Calling Line Identification presentation/restriction
  - Call Hold, Waiting, Forwarding, etc.
  - Conference call
  - SMS, MMS
  - Voicemail
  - Location Based Services – LBS
  - Presence information
  - Instant messaging
  - etc.

Application Servers

- Types
  - SIP AS
    - native IMS
    - based on Internet technologies
    - simple service composition
  - OSA (Open Service Access)
    - via OSA-SCS (Service Capability Server) gateway
    - to make use of network functionality
    - Parlay API
  - CAMEL (Customized Applications for Mobile network Enhanced Logic) AS
    - via IM-SSF (Service Switching Function) gateway
    - existing intelligent services in 2G/3G networks

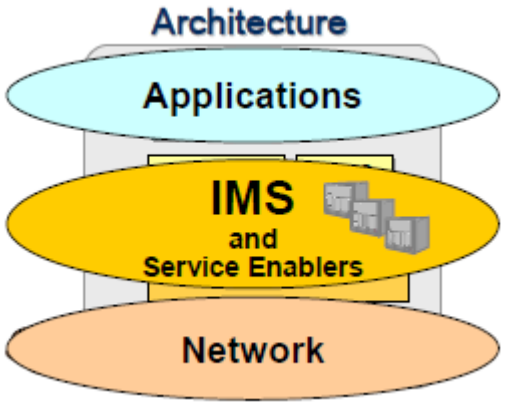
Application Servers

- Operating modes
  - SIP User Agent, as endpoint
    - e.g. terminating: voice mail
    - e.g. originating: messaging
  - SIP proxy server (without service)
  - SIP redirect server
  - SIP B2BUA mode (Back to Back User Agent, concatenation of 2 UAs)
    - full control over SIP dialogs
    - functions
      - Telephony AS (TAS):call management (call routing, forwarding; call waiting, usage data collection, conference call, etc.)
      - Non-telephony AS: presence, IM, etc.
  - 3rd party call control (3PCC) B2BUA
    - e.g. click to dial

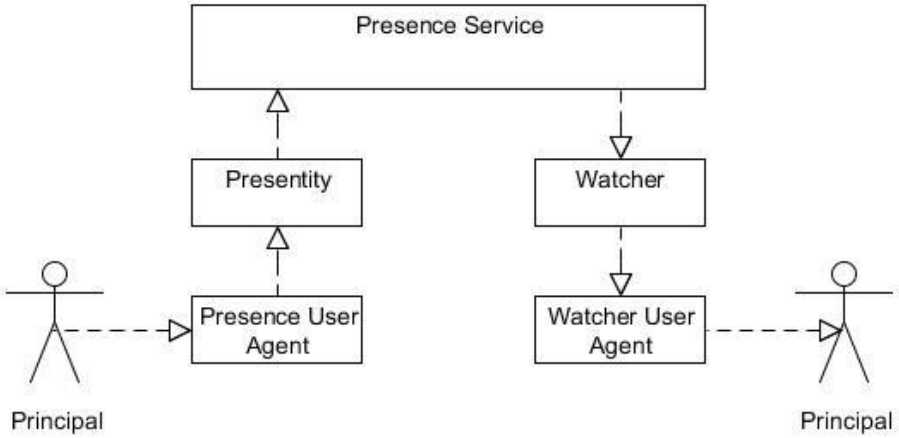


Service enablers and unified functions

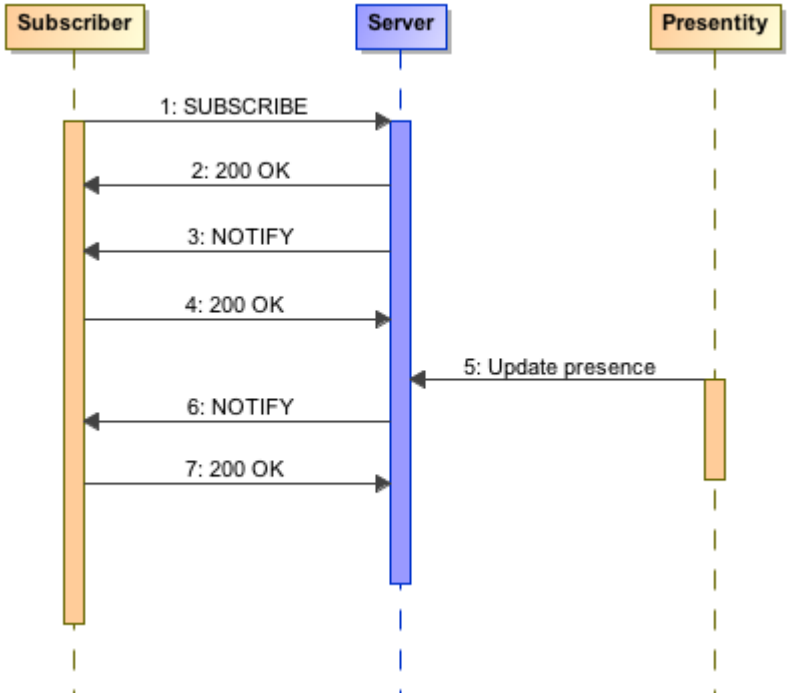
- Reusable building blocks for different services/applications
- Special Application Servers with general function
- Service enablers:
  - presence: status information
    - storing and distributing status information
    - handling subscriptions
  - group/list management
    - list of contacts
    - list of blocked contacts
    - chat groups
  - location based information
  - instant messaging
- Unified functions
  - provisioning
  - management
  - billing



Presence service model



- RFC 2778
- Presentity = presence + entity
  - register
  - publish
- Watcher
  - fetch, poll
  - subscribe



Services 1.

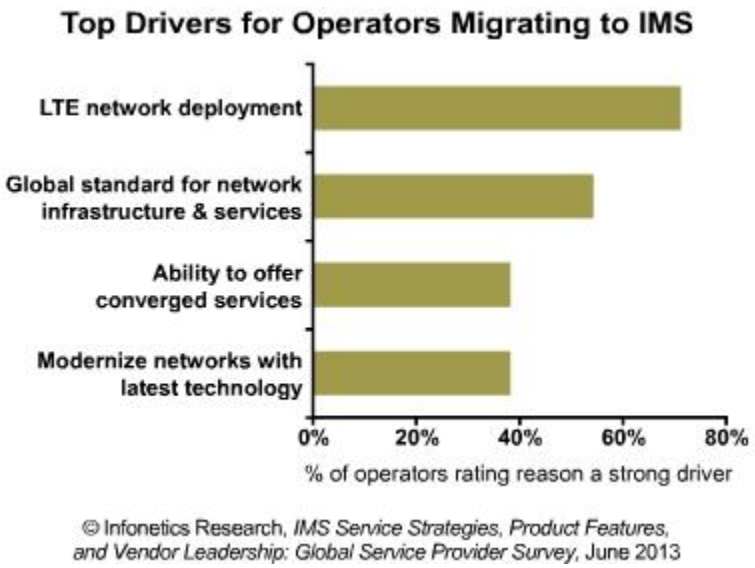
- Presence
  - active phone book: online/offline + details:
    - busy, out of office, do not disturb, etc.
    - location, how to contact, etc.
    - watcher is notified at status changes, e.g. principal goes online
  - what kind of media types can be sent/received
  - not only for humans, but for services and devices too, e.g.
    - result of sport event
    - home surveillance system
- Instant Messaging – IM
  - real-time
  - can be sent/received by devices, application servers too (e.g. control of a device, receiving notification)
  - combined with presence service

Services 2.

- Group messaging
  - ad-hoc groups
  - many-to-many communication
- Multimedia conference call
  - voice, video, file sharing
- Push to Talk (PTT) over Cellular (PoC)
  - Open Mobile Alliance (OMA)
  - half-duplex communication, i.e. walkie-talkie
  - might be a1-to-1 person comm., but usually a 1-to-many synchronous comm.
  - integrated with group management and (optionally) presence services
  - e.g. a group of people travelling with several cars
  - the PoC server handles the signaling and the media too, which is a bit confusing
- Home Control, Interactive games, etc.

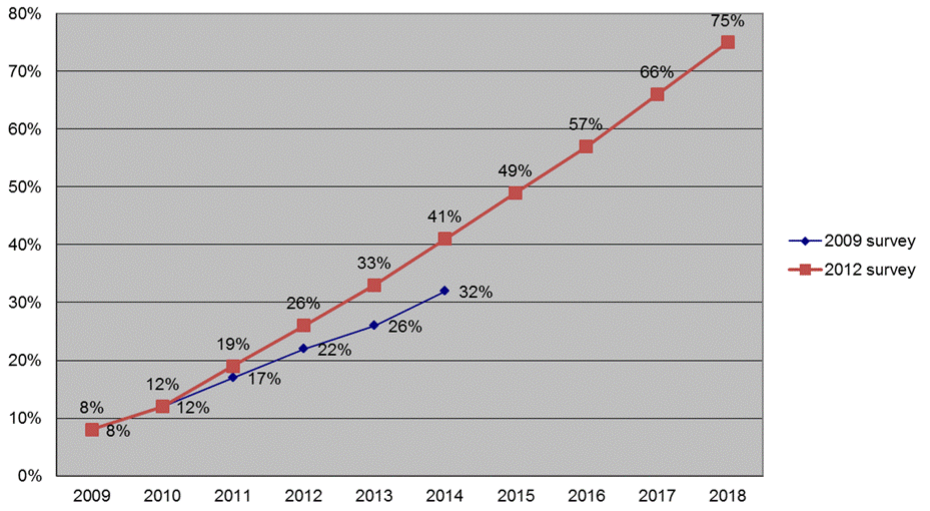
IMS deployment

- IMS core network vendors: Ericsson, Alcatel Lucent, Nokia Siemens (NSN), Huawei, etc.
- Hungary
  - Hungarian Telecom and T-Mobile: 7/2006, Comverse + Huawei, FMC
- Survey shows operators plan to deploy VoLTE in earnest by 2015
  - major deployments in the U.S., China, and Japan, where the mobile markets are large and operators are competitive



© Infonetics Research, *IMS Service Strategies, Product Features, and Vendor Leadership: Global Service Provider Survey*, June 2013

Cumulative Percentage of Operators by year they anticipate starting IMS Deployment, 2009 and 2012



IMS critics

- cynical name resolution: Internet Monetarizing System
- IMS promotes rapid app. development
  - but where are the new, income generating applications?
  - alternatives: web applications (over the top /OTT/ of the network)
    - do users demand controlled QoS, safe communication, mobility, interworking between operators?
- most deployed systems are limited in functions
- exotic blended services are not emerging, e.g. that combine presence, location and user preferences
- from business perspective it is ideal for new entrants, but not necessarily means immediate cost reduction for legacy operators
- not enough IMS-capable terminals?
- too complicated system (but in return provides value added services)

IMS and Internet applications

- IMS: Rich Communication Services
  - operator services: video and voice call, SMS, MMS, chat, group messaging, file transfer, even combined
  - brand name: joyn (GSMA): talk, chat, share videos, photos and files (2012)
    - operators: Deutsche Telekom, Movistar Spain, Orange Spain, Vodafone Germany, Vodafone Spain, MetroPCS (USA), Korean operators
    - slow expansion
  - What are the main advantages compared to Internet applications?
    - provisioned by the network operator
    - interoperability: operators, devices
    - without app download, install and user registration
  - Critic
    - same services as the Internet apps
    - slow preparation of standards and recommendations
    - all operators provision the same services (no differentiation)
    - rather a fallback service
- Internet:
  - pl. Skype, Viber, Google Talk, Facebook messenger, WhatsApp Messenger, Twitter, etc.
  - quicker reactions to changes
    - pl. Google Wave, Buzz, Google+ : just launch and analyze usage statistics, if not successful then discontinue the service