

IP Multimedia Subsystem (IMS)

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Background and Research Problems

- Users demand for multimedia services is rising, dialing & talking is a narrow subset of networking
- Until now network operators develop the services often lacking of new, innovate ideas based on using the traditional network capabilities
- Merging the Internet with the cellular worlds
 - CS domain
 - PS domain
 - QoS, charging and integration of different services are not available for 3G users through the PS domain
- How can we provide end users new, exciting services to satisfy the subscribers' demands
 - IP multimedia subsystem is ideally placed to fill the gap
 - IMS is used to offer Internet services everywhere and at any time using cellular technologies

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A scenario supported by IMS

What is IMS?

Anna → Call to Bob for business → Bob

Bob → Accept the call → Anna

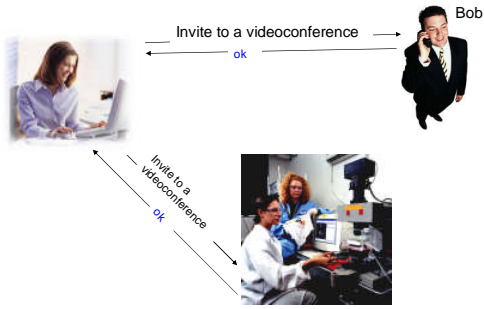
Bob → Activate the video mode → Anna

Bus icon → Answer → Anna

Meeting room → Initiate a push to talk group session → Anna

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A scenario supported by IMS (Cont'd)



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Main advantages to network and users

- Deliver person-to-person real-time IP-based multimedia communications as well as person-to-machine communications
- IMS enables applications in mobile devices to establish P2P connections
- Quality of Service (QoS) provides some type of guaranteed level transmission
- Easy user setup of multiple services in a single session or multiple simultaneous synchronized sessions

1. Take a picture.
2. Send it (Email, MMS).
3. Call and ask to retrieve.
4. Talk about it.



1. Call.
2. Take a picture.
3. Send it while talking.
4. Talk about it.



1. Call.
2. Take a picture.
3. Send it while talking.
4. Talk about what you point at.



Increasing technical support

Degree of Input Coordination

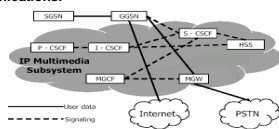
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What is IMS?

- IP Multimedia Subsystem is a Session Initiation Protocol (SIP)-based IP Multimedia infrastructure that provides a complete architecture and framework for **real-time and non-real-time IP multimedia services** on the top of Packet Switched (PS) core while still preserving the Circuit Switched (CS) telephony services.
- IMS provides the necessary IMS Capabilities: **service control, security functions (e.g. authentication, authorization), routing, registration, SIP compression and QoS support, charging.**
- IMS is also expected to bring the strengths of wireless and fixed-line worlds together. In 3GPP's words: **The IMS should enable the convergence of, and access to, voice, video, messaging, data and web-based technologies for the wireless user, and combine the growth of the Internet with the growth in mobile communications.**



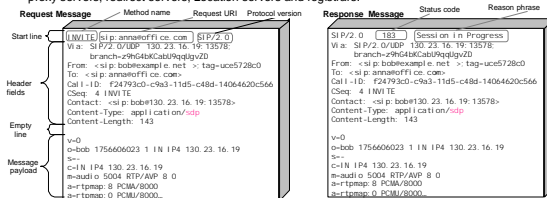
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Session Initiation Protocol (SIP)

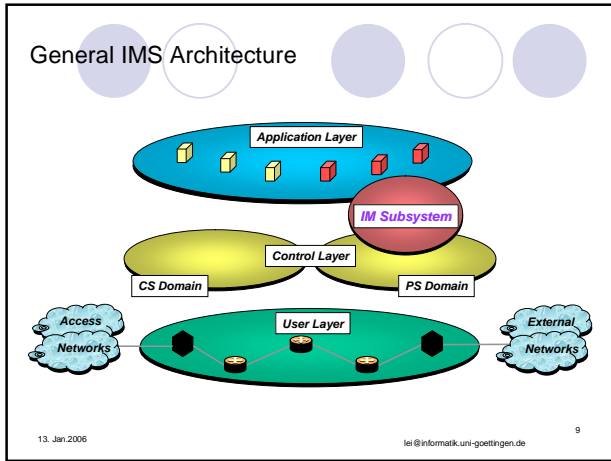
- 3GPP has chosen SIP for signaling between UE and the IMS as well as between the components of IMS in order to facilitate maximum interoperability with existing (fixed and mobile) Internet systems, devices (user equipment), and protocols
- SIP is **application-layer control protocol** based on **request-response** paradigm for creating, modifying and terminating multimedia sessions with one or more participants
- Defined in IETF **RFC 3261** with numerous extension RFCs for e.g. Presence, Push-To-Talk (PTT) and Instant Messaging
- Works over UDP and TCP
- Basically there are five types of logical entities in a SIP network, namely User Agents (UAs), proxy servers, redirect servers, Location servers and registrars.



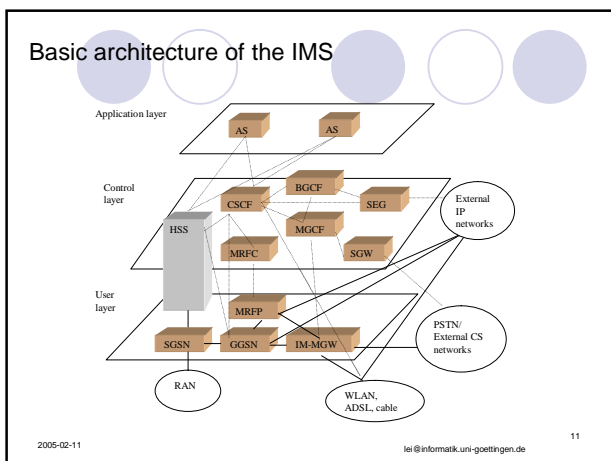
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- ### IMS-related Entities and Functionalities
- **CSCF** – Call Session Control Function
Provide control and routing functions for SIP sessions
 - **HSS** – Home Subscriber Server, **SLF** – Service Location Function
Master database for a given user, contain the subscription-related information
 - **Interworking elements**
Enable communications between IMS users and other Domain users
 - **Service related elements**
Performs SIP application-related functions
 - **Charging architecture**
Related to charging due to different charging types
 - **GPRS** (General Packet Radio Service)
Provide IP-connectivity
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- ### Application Server (AS)
- ASs are not the pure IMS entities. ASs provide (value-added) multimedia services in the IMS. ASs reside in the user's home network or in a third-party location.*
- The main functions:**
- Originating SIP requests
 - Processing and impacting an incoming SIP session received from the IMS
 - Sending accounting information
- AS** has three different types:
- ❖ SIP AS
 - ❖ Open Service Access – Service Capability Server (OSA-SCS)
 - ❖ IP Multimedia Service Switching Function (IM-SSF)
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User Databases

IMS-related Entities and Functionalities

- **HSS (Home Subscriber Server)**
the main data storage for all subscribers and service-related data of the IMS

HSS stores the data including: user identities, registration information, access parameters and service-triggering information.

```

    graph LR
      UI[User identity] --> PUI[Private User identity]
      UI --> PUU[Public User identity]
      PUI --- PUI_desc[Assigned by the home network operator and used only for authentication purpose such as registration and authorization]
      PUU --- PUU_desc[Other users can use for requesting communication with the end user]
  
```

- **SLF (Service Location Function)**
used as a resolution mechanism that enables CSCFs to get the address of HSS.

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CSCF (Call Session Control Function)

IMS-related Entities and Functionalities

- **Functions**
 - session management
 - routing family
- **Types**
 - **P-CSCF (Proxy CSCF)**
i.e. interpret and rewrite the signaling from or to UE
Provide integrity protection of SIP signaling and maintain a security Association(SA) between the UE and P-CSCF
detect and support emergency calls
 - **I-CSCF (Interrogating CSCF)**
i.e. determine how to route terminated calls and to assign a S-CSCF during registration
 - **S-CSCF (Serving CSCF)**
i.e. interacts with the application platform and the HSS for obtaining subscriber data and for application service provision

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Services-related elements

IMS-related Entities and Functionalities

- **Media Resource Function Controller**
MRFC is used to control the resources.
- **Media Resource Function Processor**
MRFP provides user-layer resources that are requested and instructed by MRFC.

```

    graph LR
      SC[S-CSCF] -- SIP signalling --> MRFC[MRFC]
      MRFC -- SIP signalling --> MRFP[MRFP]
      MRFP --> MEGACO[MEGACO (Media Gateway Control Protocol)]
  
```

MRFP functions:

- ❖ Mixing of incoming media streams
- ❖ Media stream source & processing

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Interworking Elements

IMS-related Entities and Functionalities

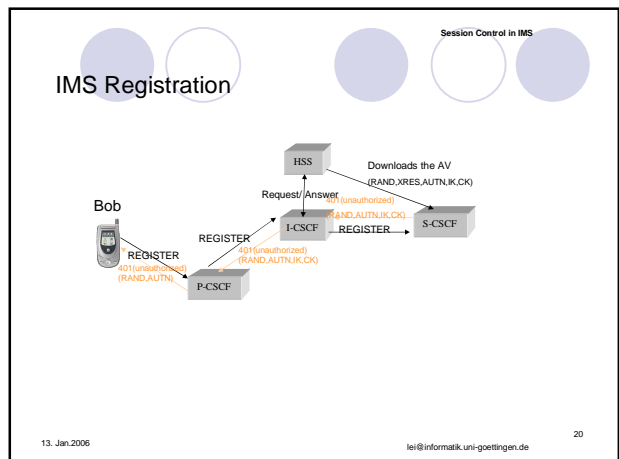
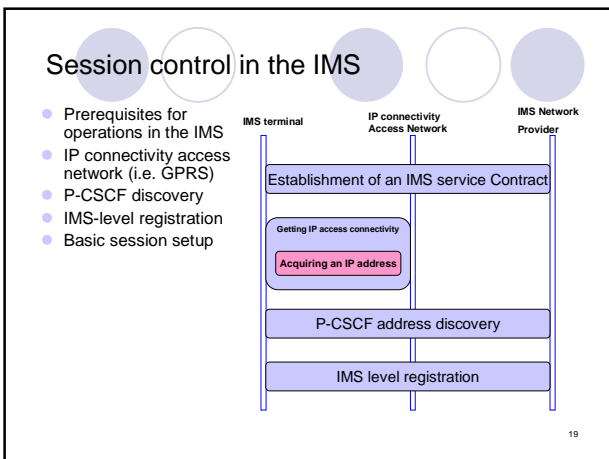
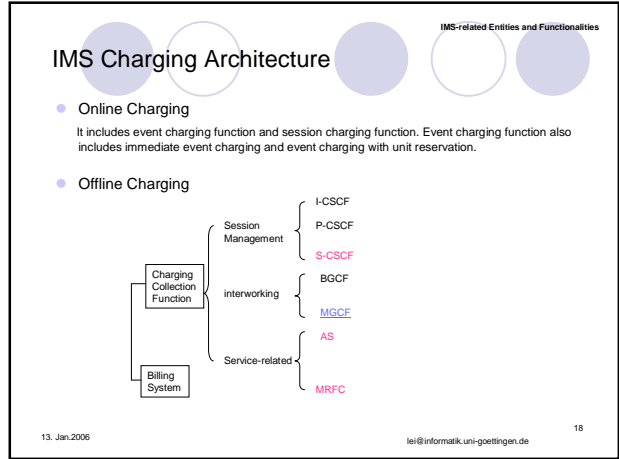
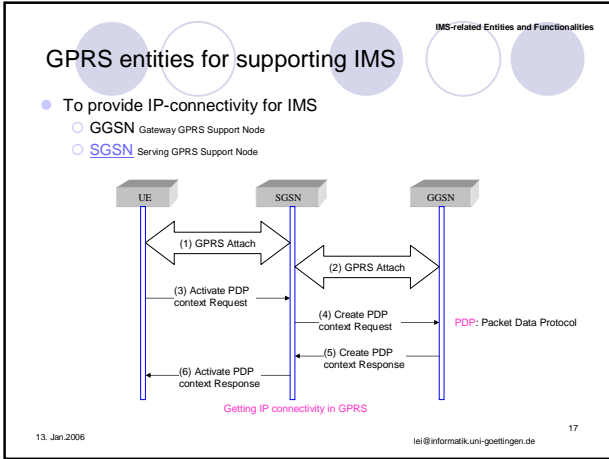
- **Media Gateway Control Function (MGCF)** is the gateway that enables communications between IMS and CS users.

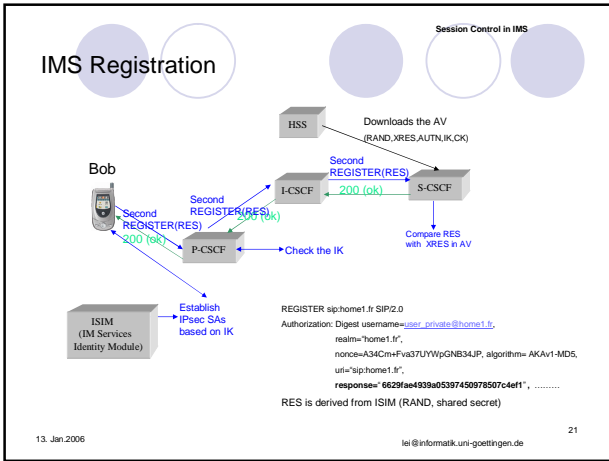
```

    graph LR
      CS[CS users] -- Sessions --> MGCF[MGCF]
      MGCF -- Sessions --> IMS[IMS users]
      MGCF -- "Charging related information" --> CCF[Charging Collection Function]
  
```

- **IM-MGW --- IP multimedia Media Gateway**
 - Interface the media plane of CS networks
- **SGW ---- Signaling Gateway**
 - Lower layer protocol conversion

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IMS Session Establishment Call Flow

Session Control in IMS

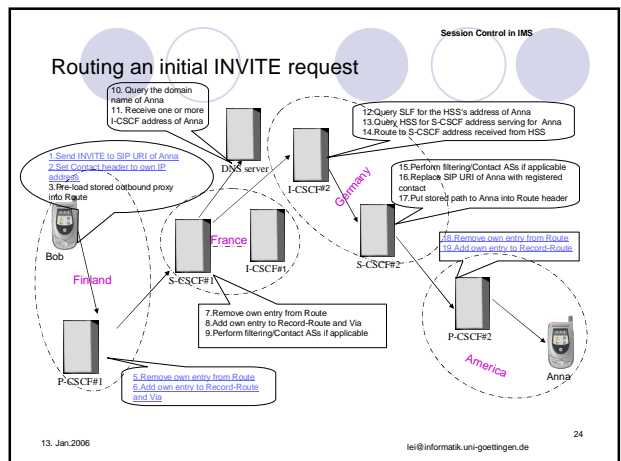
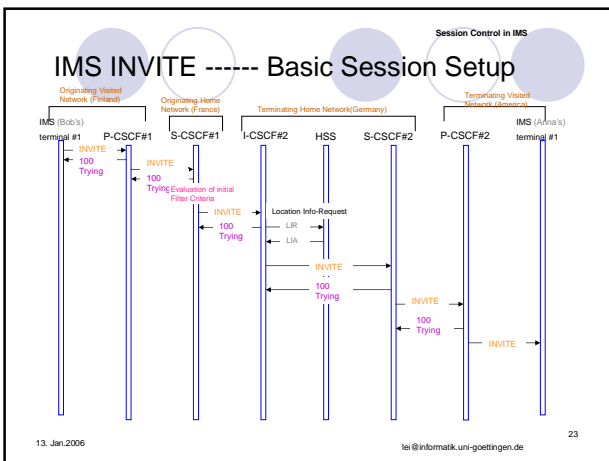
Supposed:

Bob is a student in France and now visiting Finland. He calls to his sister Anna. Anna is working in Germany and currently on a business trip to America. Choose **GPRS** as an example for IP connectivity access network.

So Bob's mobile phone is registered at France and now is roaming at Finland.

Anna's mobile phone is registered at Germany and now is roaming at America.

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Session Control in IMS

INVITE request from UE1 to P-CSCF1

```

INVITE sip:anna@home2.de SIP/2.0
Via: SIP/2.0/UDP [1080::1:2:3:4]:1357; comp=sigcomp; branch=z9hG4bK9h9ab
Max-Forwards: 70
Route: <sip:pcscf1.visited1.fi;5080;lr;comp=sigcomp>,
      <sip:origin@scscf1.home1.fr;lr>
P-Preferred-Identity: "Bob Smith" <sip:bob@home1.fr> ← User may have multiple public user identities
Privacy: none
P-Access-Network-Info: 3GPP-UTRAN-TDD;
                      utran-cell-id-3gpp=C359A3913B20E
From: <sip:bob@home1.fr>; tag=ty20s
To: <sip:anna@home2.de>
Call-ID: 3s09cs03
CSeq: 112 INVITE
Require: precondition, sec-agree
Proxy-Require: sec-agree
Supported: 100rel
Security-Verify: ipsec-3gpp; q=0.1;
                alg=hmac-sha-1-96;
                spi=c=98765432; spi-s=909786;
                port-c=5057; port-s=5058
Contact: <sip:[1080::1:2:3:4]:1357; comp=sigcomp>
Allow: INVITE, ACK, CANCEL, BYE, PRACK, UPDATE, REFER, MESSAGE
Content-Type: application/sdp
Content-Length: 590
..... (message body)

```

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Session Control in IMS

INVITE request from P-CSCF1 to S-CSCF1

```

INVITE sip:anna@home2.de SIP/2.0
Via: SIP/2.0/UDP pcscf1.visited1.fi; branch=z9hG4bKoh2qrz
Via: SIP/2.0/UDP [1080::1:2:2:4]:1357; branch=z9hG4bK9h9ab
Max-Forwards: 69
Route: <sip:origin@scscf1.home1.fr;lr> → Send to next trusted hop
Record-Route: <sip:pcscf1.visited1.fi;lr>
P-Asserted-Identity: "Bob Smith" <sip:bob@home1.fr>
Privacy: none
P-Access-Network-Info: 3GPP-UTRAN-TDD;
                      utran-cell-id-3gpp=C359A3913B20E
P-Charging-Vector: icid-value="W34hd6dIg"
From: <sip:bob@home1.fr>; tag=ty20s
To: <sip:anna@home2.de>
Call-ID: 3s09cs03
CSeq: 112 INVITE
Require: precondition
Supported: 100rel
Contact: <sip:[1080::1:2:3:4]:1357; comp=sigcomp>
Allow: INVITE, ACK, CANCEL, BYE, PRACK, UPDATE, REFER, MESSAGE
Content-Type: application/sdp
Content-Length: 590
..... (message body)

```

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Session Control in IMS

INVITE request from S-CSCF1 to I-CSCF2

```

INVITE sip:anna@home2.de SIP/2.0
Via: SIP/2.0/UDP scscf1.home1.fr; branch=z9hG4Kpl8jgk
Via: SIP/2.0/UDP pcscf1.visited1.fi; branch=z9hG4bKoh2qrz
Via: SIP/2.0/UDP [1080::1:2:3:4]:1357; branch=z9hG4bK9h9ab
Max-Forwards: 68
Route: <sip:icscf2.home2.de>
Record-Route: <sip:scscf1.home1.fr;lr>,
              <sip:pcscf1.visited1.fi;lr>
P-Asserted-Identity: "Bob Smith" <sip:bob@home1.fr>;
                  <tel:+1-121-586-1234>
Privacy: none
P-Charging-Vector: icid-value="W34hd6dIg"; orig-oi=home1.fr
From: <sip:bob@home1.fr>; tag=ty20s
To: <sip:anna@home2.de>
Call-ID: 3s09cs03
CSeq: 112 INVITE
Require: precondition
Supported: 100rel
Contact: <sip:[1080::1:2:3:4]:1357; comp=sigcomp>
Allow: INVITE, ACK, CANCEL, BYE, PRACK, UPDATE, REFER, MESSAGE
Content-Type: application/sdp
Content-Length: 590
..... (message body)

```

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Session Control in IMS

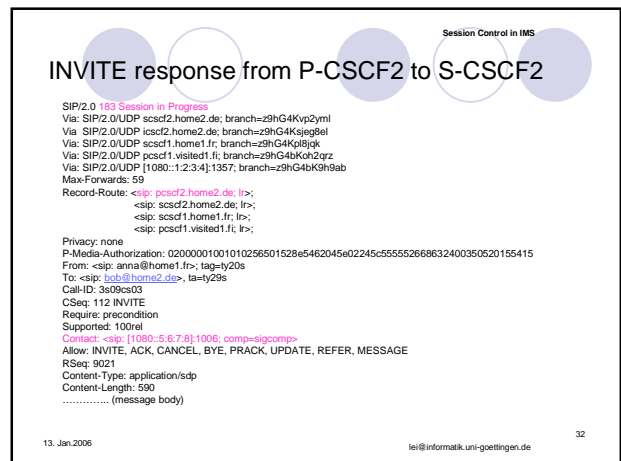
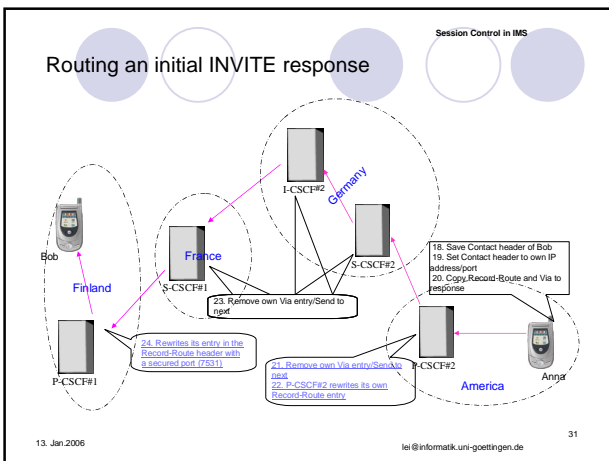
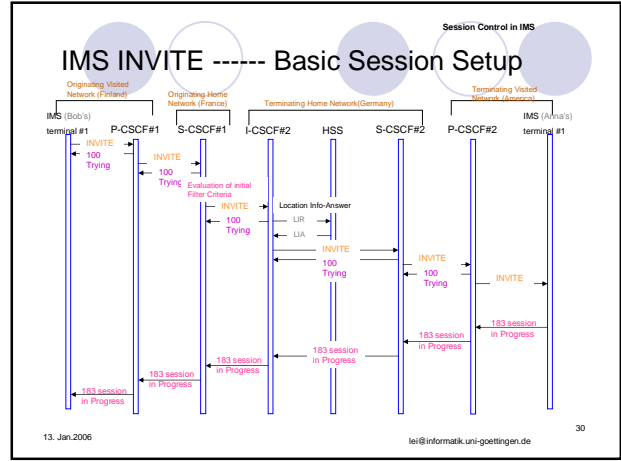
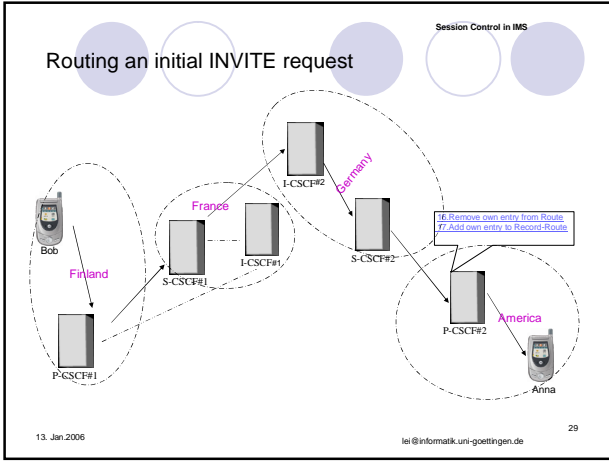
INVITE request from P-CSCF2 to UE2

```

INVITE sip:[1080::5:6:7:8]:1006; comp=sigcomp SIP/2.0
Via: SIP/2.0/UDP pcscf2.visited2.com;5091; comp=sigcomp; branch=z9hG4Kpl8jgk
Via: SIP/2.0/UDP scscf2.home2.de; branch=z9hG4Kvp2ymI
Via: SIP/2.0/UDP icscf2.home2.de; branch=z9hG4Ksje98l
Via: SIP/2.0/UDP scscf1.home1.fr; branch=z9hG4Kpl8jgk
Via: SIP/2.0/UDP pcscf1.visited1.fi; branch=z9hG4bKoh2qrz
Via: SIP/2.0/UDP [1080::1:2:3:4]:1357; branch=z9hG4bK9h9ab
Max-Forwards: 64
Record-Route: <sip:pcscf2.visited2.com;lr>,
              <sip:scscf2.home2.de;lr>,
              <sip:scscf1.home1.fr;lr>,
              <sip:pcscf1.visited1.fi;lr>
P-Asserted-Identity: "Bob Smith" <sip:bob@home1.fr>; <tel:+1-121-586-1234>
Privacy: none
P-Media-Authorization: 02000001001010256501528e5462045e02245c55552668632400350520155415
From: <sip:bob@home1.fr>; tag=ty20s
To: <sip:anna@home2.de>
Call-ID: 3s09cs03
CSeq: 112 INVITE
Require: precondition
Supported: 100rel
Contact: <sip:[1080::1:2:3:4]:1357; comp=sigcomp>
Allow: INVITE, ACK, CANCEL, BYE, PRACK, UPDATE, REFER, MESSAGE
Content-Type: application/sdp
Content-Length: 590
..... (message body)

```

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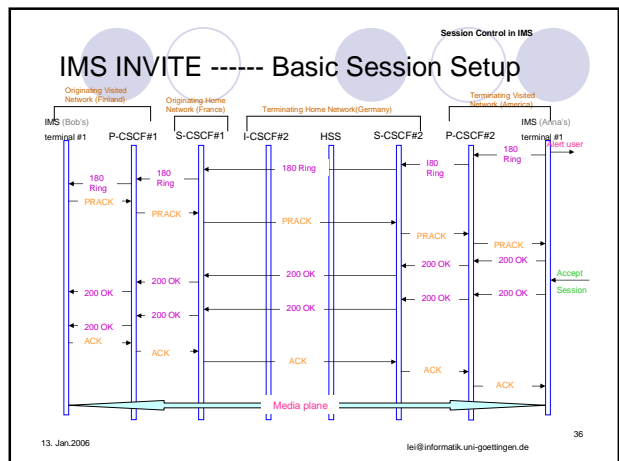
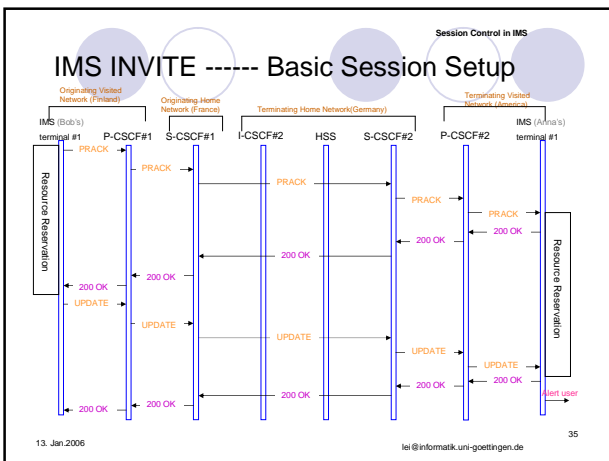
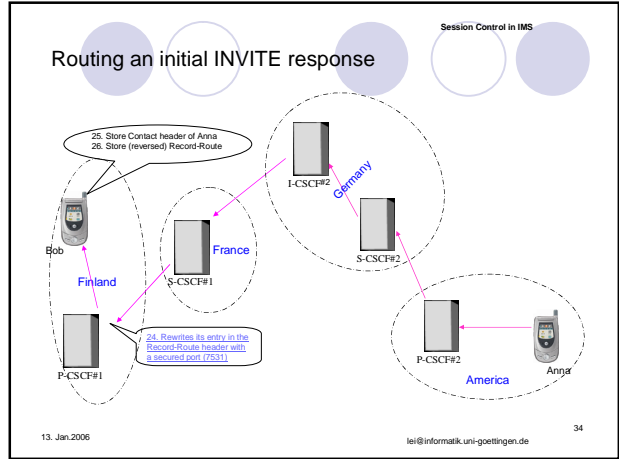
Session Control in IMS

INVITE response from P-CSCF1 to UE1

```

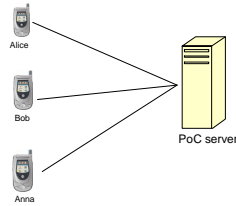
SIP/2.0 183 Session in Progress
Via: SIP/2.0/UDP [1080::1:2:3:4]:1357; comp=sigcomp; branch=z9hG4bK9h9ab
Max-Forwards: 59
Record-Route: <sip: pscsf2.home2.de; lr>;
                <sip: scscf2.home2.de; lr>;
                <sip: scscf1.home1.fr; lr>;
                <sip: pscsf1.visited1.fr;7531; lr>
P-Asserted-Identity: "Bob Smith" <sip: bob@home1.fr>; <tel: +1-121-586-1234>
Privacy: none
P-Media-Authorization:
02000001001010256501528e5462045e02245c555552668632400350520155415
From: <sip: anna@home1.fr>; tag=ty20s
To: <sip: bob@home2.de>; tag=tyese
Call-ID: 3s09cs03
CSeq: 112 INVITE
Require: precondition
Supported: 100rel
Contact: <sip: [1080::5:6:7:8]:1006; comp=sigcomp>
Allow: INVITE, ACK, CANCEL, BYE, PRACK, UPDATE, REFER, MESSAGE
RSeq: 9021
Content-Type: application/sdp
Content-Length: 590
..... (message body)
  
```

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IMS Enabled Services

- > **Presence**
Making my status available to others
The statuses of others available to me
- > **Push-to-talk**
Push-to-talk over Cellular --- PoC
- > **Conferencing**
Loosely coupled conference
Fully distributed multiparty conference
Tightly coupled conference
- > **IMS messaging**
Immediate messaging
Session-based messaging
Deferred delivery messaging



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Conclusions and topics for future studies

- Concepts and key components of the IMS
- Basic functionalities of important elements in IMS
- Registration and authentication procedure
- IMS basic session setup

- Future study could concentrate on finding the mapping of Presence to SIP and SIP with Mobility enhancement
- The SIP-based 3rd party service provisioning solution should be studied from the perspective of security
- Some detailed mechanisms used within IMS domain, i.e. how to store the user-related information in HSS, which way is the most sufficient, effective?

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Appendix -- IMS Session Establishment Call Flow

Session Control in IMS

Supposed: Bob is a student in France and now visiting Finland. He calls to his sister Anna. Anna is working in Germany and currently on a business trip to America. Choose GPRS as an example.

1. Bob constructs an **INVITE** request that includes a registered public user Identity of Anna in order to reach her.
2. All messages are sent via the established IP Security (**IPsec**) security associations (**SAs**) between the UE and their P-CSCFs.
3. All SIP messages are sent **compressed** between the UE and their P-CSCFs.
4. All SIP messages must traverse the P-CSCFs and the S-CSCFs of both users.
5. Two items of UE agree on the media streams that they will exchange, and agree on a **single codec** for every media stream that they will exchange.
6. The network will authorize the media for the session.
7. Both items of UE perform **resource reservation** (e.g. set up secondary PDP contexts over the media streams).
8. Bob's UE will not get any indication before the resources for the media streams have been reserved on both sides.
9. The network elements will exchange charging information, so that media sessions can be billed correctly.
10. The S-CSCFs will initiate advanced services for their served users.
11. Anna's UE will finally start to ring and Bob will accept the session.

Then the session is completely established between Bob and Anna.

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Thank you for all of your attentions!