

# Chapter 3: IP Multimedia Subsystems and Application-Level Signaling

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IP-Based Next-Generation Wireless Networks  
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## Outline

- 3.1 Signaling in IP Networks
- 3.2 3GPP IP Multimedia Subsystem (IMS)
- 3.3 3GPP2 IP Multimedia Subsystem (IMS)

## 3.1 Signaling in IP Networks

- ◆ 3.1.1 Session Initiation Protocol (SIP)
- ◆ 3.1.2 Session Description Protocol (SDP)

## 3.1.1 Session Initiation Protocol (SIP)

- ◆ SIP is an application-layer protocol that can establish, modify and terminate multimedia sessions (conferences) over the Internet.
- ◆ SIP messages could contain session descriptions such that participants can negotiate with media types and other parameters of the session.
- ◆ SIP provides its own mechanisms for reliability and can run on top of several different transport protocols such as TCP, UDP and SCTP (Stream Control Transmission Protocol).

## SIP Capabilities

- ◆ Determine destination user's current location
- ◆ Determine whether a user is willing to participate in a session
- ◆ Determine the capabilities of a user's terminal.
- ◆ Set up a session
- ◆ Manage a session. This includes modifying the parameters of a session, invoking service functions to provide services to a session, and terminating of a session.

## SIP Components

- ◆ SIP user agent (UA)
  - user agent client (UAC)
  - user agent server (UAS)
- ◆ SIP redirect server: UAS
- ◆ SIP proxy server: UAC and UAS
- ◆ SIP registrar: UAS
  - Location service

## SIP

- ◆ 3.1.1.1 Naming and Addressing
- ◆ 3.1.1.2 Messages
- ◆ 3.1.1.3 Location Registration
- ◆ 3.1.1.4 Session Establishment and Termination

## 3.1.1.1 Naming and Addressing

### ◆ SIP Uniform Resource Identifier (URI)

- sip:tao@research.telcordia.com
- sips:tao@research.telcordia.com
- sip:user:password@host:port;uri-parameters?headers
- sip:+886-3-574-2961:1234@cs.nthu.edu.tw;user=phone
- sip:jcchen@cs.nthu.edu.tw?subject=Wiley%20Book&priority=urgent
- sip:wire.cs.nthu.edu.tw

## URI Parameters

- ◆ parameter-name=parameter-value
- ◆ transport: UDP, TCP, SCTP, TLS, etc.
  - transport=udp is equivalent to Transport=UDP
- ◆ maddr: indicate a proxy that must be traversed to the destination
  - maddr=140.114.79.60
- ◆ ttl: used only when the maddr is a multicast address and the transport protocol is UDP
- ◆ user: distinguish a real telephone number from a user name that resembles a telephone number
- ◆ method: specifies the method of the SIP URI request
- ◆ lr: used when a specific SIP routing mechanism is implemented (will not discuss further)

## 3.1.1.2 Messages

- ◆ **INVITE:** Used by a user to invite another user to establish a SIP session
- ◆ **ACK:** Used to confirm final response
- ◆ **BYE:** Used to terminate a session
- ◆ **CANCEL:** Used to cancel a SIP request
- ◆ **OPTIONS:** Used to query servers about their capabilities
- ◆ **REGISTER:** Used by a user to register information with a server
- ◆ **INFO:** Used to carry session related control information
- ◆ **SUBSCRIBE:** Used to request current state and state updates from a remote node
- ◆ **NOTIFY:** Used to notify a SIP node that an event which has been requested by an earlier SUBSCRIBE method has occurred
- ◆ **PRACK:** Used to provide a reliable Provisional Response ACKnowledgement
- ◆ **UPDATE:** Used to update parameters of a session
- ◆ **MESSAGE:** Used to transfer Instant Messages (IM)
- ◆ **REFER:** Used to direct a recipient to other resource by using the contact information provided in the REFER request

## Message Format

- ◆ A start-line
  - Request-Line
  - Status-Line
- ◆ One or more header fields
- ◆ An empty line indicating the end of the header fields
- ◆ An optional message body

## Table 3.1 Structure of a SIP message

<b>Start-line</b>	INVITE sip:tao@research.telcordia.com SIP/2.0
<b>Header Field(s)</b>	Via: SIP/2.0/UDP fly.cs.nthu.edu.tw:5060;branch=z9hG4bK776asdhds Max-Forwards: 70 To: Tao <sip:tao@research.telcordia.com> From: Jyh-Cheng <sip:jcchen@cs.nthu.edu.tw>;tag=1928301774 Call-ID: a84b4c76e66710@fly.cs.nthu.edu.tw CSeq: 123456 INVITE Contact: <sip:jcchen@fly.cs.nthu.edu.tw> Content-Type: application/sdp Content-Length: 132
<b>Empty Line</b>	
<b>Message Body</b> (Optional)	v=0 t=2873397496 2873404696 m=audio 49170 RTP/AVP 0 .....

## Status-Line

### ◆ Status-Code

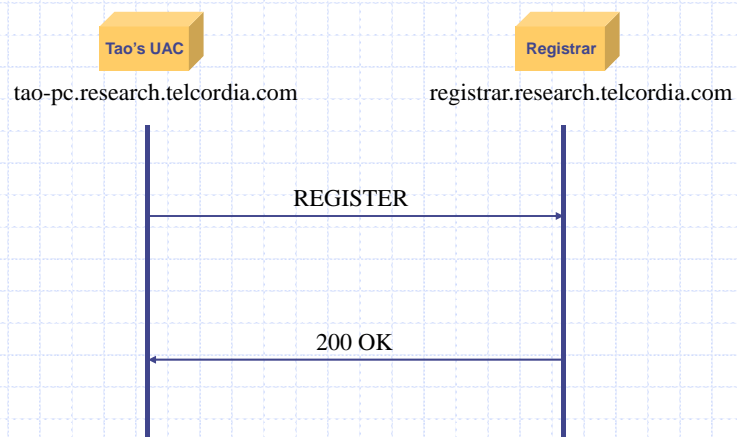
- 1xx: Provisional – indicate a request is received and is being processed.
- 2xx: Success – indicate the method invoked by a request is successfully accepted.
  - ◆ E.g. SIP/2.0 200 OK
- 3xx: Redirection – further action needs to be taken by the sender of the corresponding sender in order to complete the request.
- 4xx: Client error – the request contains syntax error or cannot fulfilled at this server.
- 5xx: Server error – the server failed to fulfill an apparently valid request.
- 6xx: Global failure – the request cannot be fulfilled at any server.

### 3.1.1.3 Location Registration

- ◆ Address of the registrar

- Preconfigured
- address-of-record
  - ◆ *sip:tao@research.telcordia.com* will send REGISTER to *sip:research.telcordia.com*
- Multicast address
  - ◆ In IPv4, 224.0.1.75 has been allocated to sip.mcast.net

### Fig. 3.1 SIP registration





## Example of REGISTER

```
REGISTER sip:registrar.research.telcordia.com SIP/2.0
Via: SIP/2.0/UDP tao-pc.research.telcordia.com:5060;
    branch=z9hG4bKnashds7
Max-Forwards: 70
To: Tao <sip:tao@research.telcordia.com>
From: Tao <sip:tao@research.telcordia.com>
Call-ID: 843817638423076@989sddhas09
CSeq: 2660 REGISTER
Contact: <sip:tao@128.96.60.187>
Expires: 3600
Content-Length: 0
```

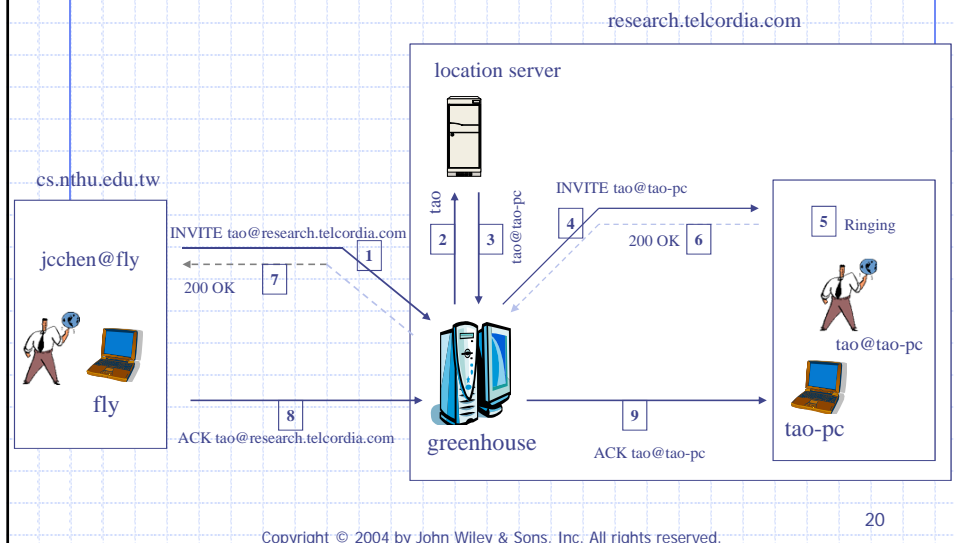
## Example of OK

```
SIP/2.0 200 OK
Via: SIP/2.0/UDP tao-pc.research.telcordia.com:5060;
    branch=z9hG4bKnashds7;received=128.96.60.187
To: Tao <sip:tao@research.telcordia.com>
From: Tao <sip:tao@research.telcordia.com>
Call-ID: 843817638423076@989sddhas09
CSeq: 2660 REGISTER
Contact: <sip:tao@128.96.60.187>
Expires: 3600
Content-Length: 0
```

### 3.1.1.4 Session Establishment and Termination

- ◆ Peer-to-peer mode
  - a caller establishes a call to a callee directly without going through any SIP server
- ◆ Server mode
  - Proxy server
    - ◆ forward the received SIP request toward its final destination on behalf of the originator
    - ◆ may rewrite specific parts of the message before forwarding it
  - Redirect server
    - ◆ respond to a request with the callee's contact information to indicate where the caller should contact next

### Fig. 3.2 SIP in proxy mode



## INVITE

INVITE sip:tao@research.telcordia.com SIP/2.0  
Via: SIP/2.0/UDP  
fly.cs.nthu.edu.tw:5060;branch=z9hG4bK776asdhd  
Max-Forwards: 70  
To: Tao <sip:tao@research.telcordia.com>  
From: Jyh-Cheng <sip:jcchen@cs.nthu.edu.tw>;tag=1928301774  
Call-ID: a84b4c76e66710@fly.cs.nthu.edu.tw  
CSeq: 123456 INVITE  
Contact: <sip:jcchen@fly.cs.nthu.edu.tw>  
Content-Type: application/sdp  
Content-Length: 132

## 200 OK

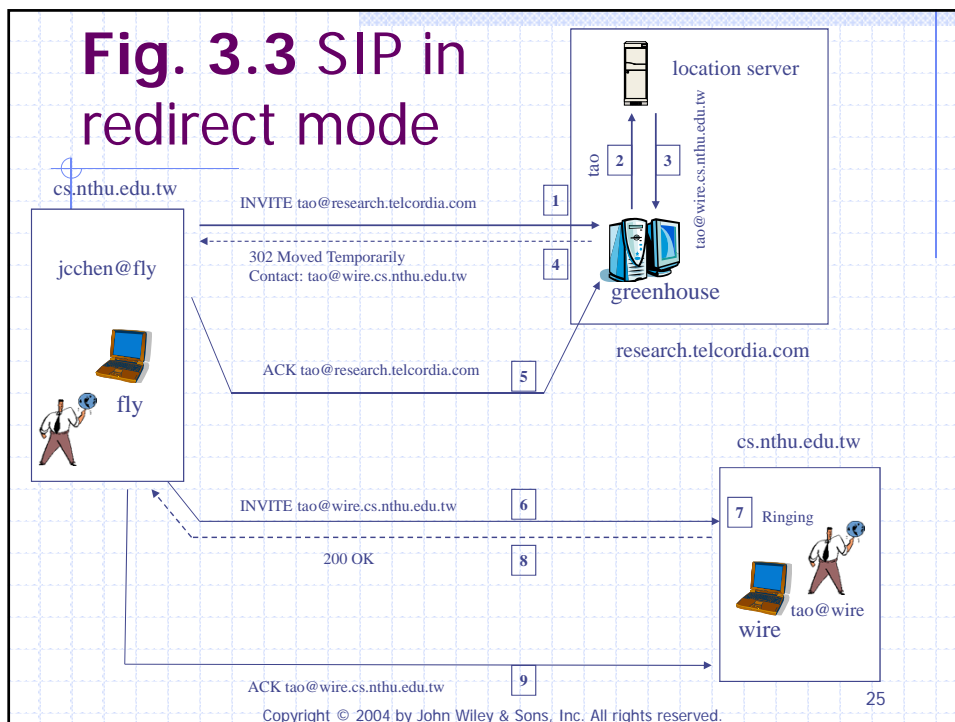
SIP/2.0 200 OK  
Via: SIP/2.0/UDP greenhouse.research.telcordia.com:5060;  
branch=z9hG4bKnashds8;received=207.3.230.150  
Via: SIP/2.0/UDP fly.cs.nthu.edu.tw:5060;  
branch=z9hG4bK776asdhd;received=140.114.79.59  
To: Tao <sip:tao@research.telcordia.com>;tag=a6c85cf  
From: Jyh-Cheng <sip:jcchen@cs.nthu.edu.tw>;tag=1928301774  
Call-ID: a84b4c76e66710@fly.cs.nthu.edu.tw  
CSeq: 123456 INVITE  
Contact: <sip:tao@tao-pc.research.telcordia.com>  
Content-Type: application/sdp  
Content-Length: 121

## ACK

ACK sip:tao@research.telcordia.com SIP/2.0  
Via: SIP/2.0/UDP fly.cs.nthu.edu.tw:5060;  
branch=z9hG4bK776asdhds  
Max-Forwards: 70  
To: Tao <sip:tao@research.telcordia.com>;  
tag=a6c85cf  
From: Jyh-Cheng <sip:jcchen@cs.nthu.edu.tw>;  
tag=1928301774  
Call-ID: a84b4c76e66710@fly.cs.nthu.edu.tw  
CSeq: 123456 ACK  
Content-Length: 0

## BYE

BYE sip:jcchen@cs.nthu.edu.tw SIP/2.0  
Via: SIP/2.0/UDP tao-pc.research.telcordia.com;  
branch=z9hG4bKnashds10  
Max-Forwards: 70  
From: Tao <sip:tao@research.telcordia.com>;  
tag=a6c85cf  
To: Jyh-Cheng <sip:jcchen@cs.nthu.edu.tw>;  
tag=1928301774  
Call-ID: a84b4c76e66710@fly.cs.nthu.edu.tw  
CSeq: 231 BYE  
Content-Length: 0



### 3.1.2 Session Description Protocol (SDP)

- ◆ Designed to describe multimedia sessions
  - convey information of media streams so prospective participants of multimedia sessions could learn the relevant setup information
- ◆ Does not incorporate any transport protocol
  - a common usage of SDP is to embed SDP in the payload of other protocols

## Format

<type> = <value>

- ◆ Name and purpose of the session
- ◆ Activation time of the session
- ◆ Media comprising the session
- ◆ Information, such as address, port number, and format, to receive the media

## Example

```
v=0
o=jcchen 2890844526 2890842807 IN IP4
 140.114.79.59
s=Wiley Book
i=Discussion on book writing
c=IN IP4 224.2.17.12/127
t=2873397496 2873404696
m=audio 49170 RTP/AVP 0
m=video 51372 RTP/AVP 31
m=application 32416 udp wb
```

## Offer/Answer Model

- ◆ For unicast
- ◆ To find common codecs both participants can support
- ◆ Either one of the participants may generate a new offer message to update the session
- ◆ Mandatory for SIP

## Offer (in INVITE)

```
v=0
o=Jyh-Cheng 2890844526 2890844526 IN IP4
  fly.cs.nthu.edu.tw
S=
c=IN IP4 fly.cs.nthu.edu.tw
t=0 0
m=audio 49170 RTP/AVP 0
m=video 51372 RTP/AVP 31
m=application 32416 udp wb
```

## Answer (in 200 OK)

```
v=0  
o=Tao 2890844730 2890844730 IN IP4 tao-  
pc.research.telcordia.com  
s=  
c=IN IP4 tao-pc.research.telcordia.com  
t=0 0  
m=audio 49920 RTP/AVP 0  
m=video 0 RTP/AVP 31  
m=application 32416 udp wb
```

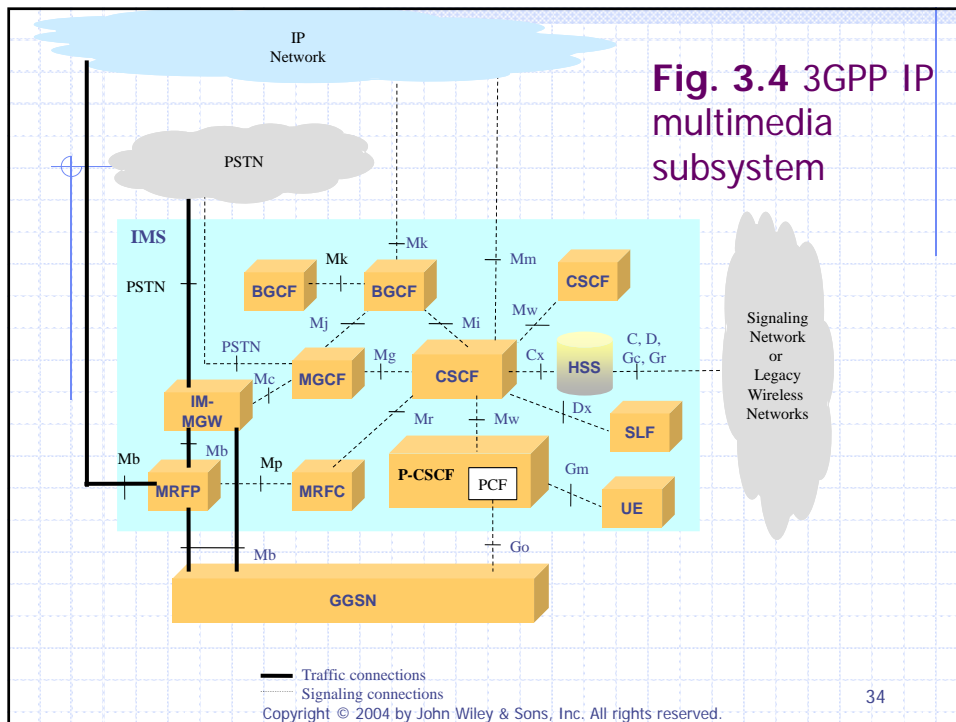
## 3.2 3GPP IP Multimedia Subsystem (IMS)

- ◆ 3.2.1 IMS Architecture
- ◆ 3.2.2 Mobile Station Addressing for Accessing the IMS
- ◆ 3.2.3 Reference Interfaces
- ◆ 3.2.4 Service Architecture
- ◆ 3.2.5 Registration with the IMS
- ◆ 3.2.6 Deregistration with the IMS
- ◆ 3.2.7 End-to-End Signaling Flows for Session Control



### 3.2.1 IMS Architecture

- ◆ Support real-time voice and multimedia IP applications
- ◆ Use SIP to support signaling and session control
- ◆ Call State Control Function (CSCF): a SIP server
  - Serving CSCF (S-CSCF)
  - Proxy CSCF (P-CSCF)
  - Interrogating CSCF (I-CSCF)



**Fig. 3.4** 3GPP IP multimedia subsystem

## Serving CSCF (S-CSCF)

- ◆ Registration: A S-CSCF can act as a SIP Registrar to accept users' SIP registration requests and make users' registration and location information available to location servers such as the HSS.
- ◆ Session Control: A S-CSCF can perform SIP session control functions for a registered user.
- ◆ Proxy Server: A S-CSCF may act as a SIP Proxy Server that relays SIP messages between users and other CSCFs or SIP servers.
- ◆ Interactions with Application Servers: A S-CSCF acts as the interface to application servers and other IP or legacy service platforms.
- ◆ Other functions: A S-CSCF performs a range of other functions not mentioned above. For example, it provides service-related event notifications to users and generates Call Detail Records (CDRs) needed for accounting and billing.

## Proxy CSCF (P-CSCF)

- ◆ A mobile's first contact point inside a local (or visited) IMS
- ◆ Act as a SIP Proxy Server
  - accept SIP requests from the mobiles and then either serves these requests internally or forwards them to other servers
- ◆ Include a Policy Control Function (PCF) that controls the policy regarding how bearers in the GGSN should be used
- ◆ Perform a range of other functions

## Interrogating CSCF (I-CSCF)

- ◆ An optional function that can be used to hide an operator network's internal structure from an external network
- ◆ Serve as a central contact point within an operator's network for all sessions destined to a subscriber of that network or a roaming user currently visiting that network
- ◆ Select an S-CSCF for a user's session based on
  - capabilities required by the user
  - capabilities and availability of the S-CSCFs
  - topological information such as the location of an S-CSCF and the location of the users' P-CSCFs
- ◆ Route SIP requests to the selected S-CSCF
- ◆ Generate CDRs

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## Other Components

- ◆ Media Gateway Control Function (MGCF) and IM Media Gateway (IM-MGW)
  - responsible for signaling and media interworking between PS and CS domains
- ◆ Multimedia Resource Function Processor (MRFP)
  - control the bearer on the M<sub>b</sub> interface
  - process the media streams
- ◆ Multimedia Resource Function Controller (MRFC)
  - interpret signaling information from an S-CSCF or a SIP-based Application Server and control the media streams resources in the MRFP accordingly
  - Generate CDRs
- ◆ Breakout Gateway Control Function (BGCF)
  - select to which PSTN network a session should be forwarded
  - Forward the session signaling to the appropriate MGCF and BGCF in the destination PSTN network

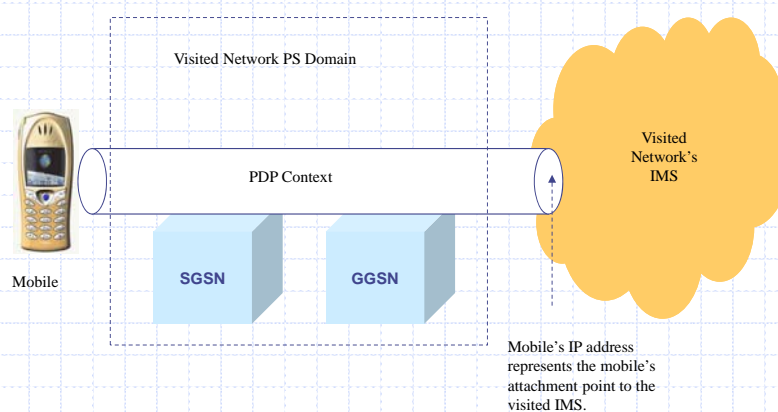
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## 3.2.2 Mobile Station Addressing for Accessing the IMS

- ◆ In order for a mobile user to use the services provided by a visited IMS, the mobile needs to have an IP address (i.e., the mobile's PDP address) that is logically part of the IP addressing domain of the visited IMS.
- ◆ A PDP context will be activated for this address so that the packets addressed to this IP address can be forwarded by the 3GPP packet domain to the mobile.

**Fig. 3.5** Mobile station addressing for accessing IMS services



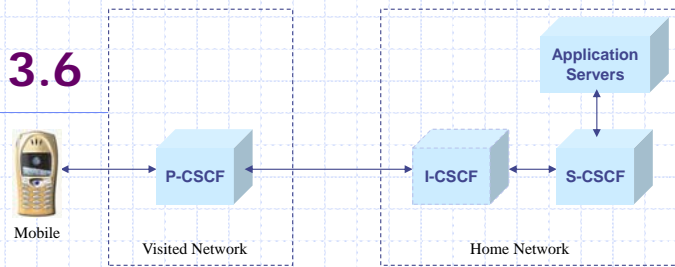
### 3.2.3 Reference Interfaces

- ◆ Interfaces for SIP-based signaling and service control: Mg, Mi, Mj, Mk, Mr, Mw
  - use SIP as the signaling protocol
- ◆ Interfaces for controlling media gateways: Mc, Mp
  - Use H.248 Gateway Control Protocol
- ◆ Interfaces with the Information Servers: Cx
- ◆ Interfaces with external networks: Mb, Mm, and Go
  - IP-based protocols

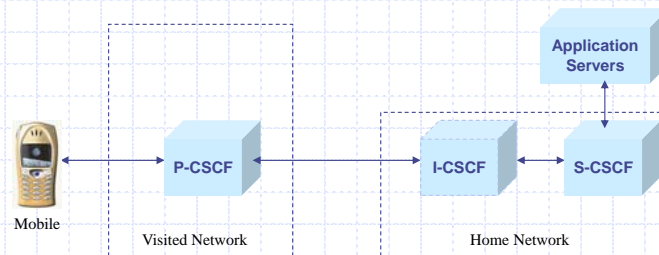
### 3.2.4 Service Architecture

- ◆ A mobile's home network provides service control for the mobile's *Home Subscribed Services* even when the mobile is currently in a visited network.
- ◆ A mobile's S-CSCF will always be a S-CSCF in the mobile's home network.
- ◆ A service platform provides service control for real-time services.

**Fig. 3.6**



(a) Service platform in mobile's home network



(b) External service platform

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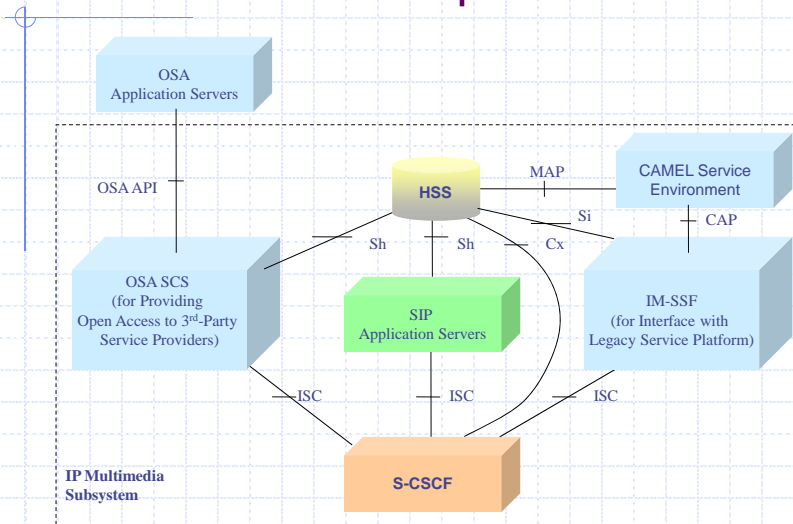
## Service Platforms

- ◆ Three standardized platforms
  - SIP application server
  - Open Service Access (OSA) Service Capability Server (SCS)
    - ◆ Gateway to OSA application server
  - IP Multimedia Service Switching Function (IM-SSF)
    - ◆ Gateway to CAMEL Service Environment (CSE)
- ◆ Same interface: IMS Service Control (ISC)
  - use SIP

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**Fig. 3.7 Interactions between S-CSCF and service platforms**



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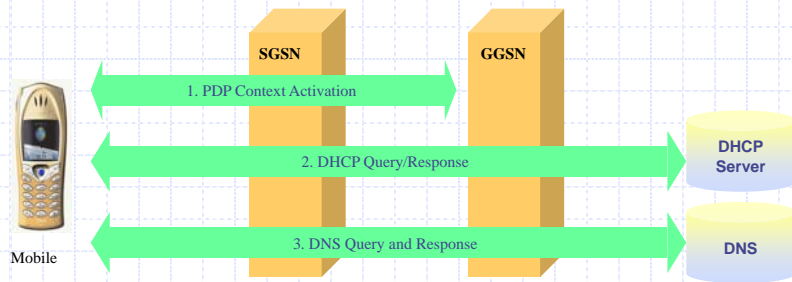
### 3.2.5 Registration with the IMS

- ◆ Local P-CSCF Discovery: discover the IP address of a local P-CSCF in the visited IMS
  - obtain from the visited GGSN as part of the PDP Context Activation process
  - uses DHCP to discover *after* the PDP context is activated
- ◆ Registration with IMS: perform SIP registration with the visited IMS and the mobile's home IMS

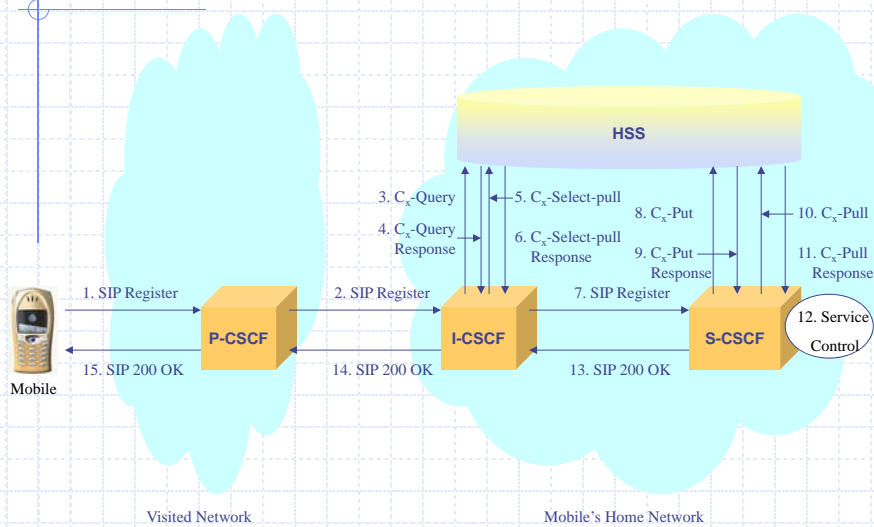
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### Fig. 3.8 3GPP Local P-CSCF discovery



### Fig. 3.9 3GPP IP Multimedia Subsystem registration procedure

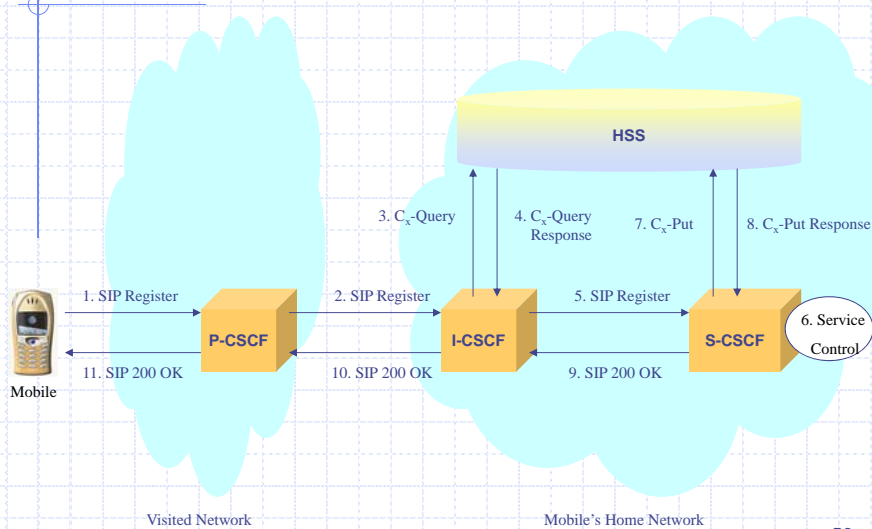




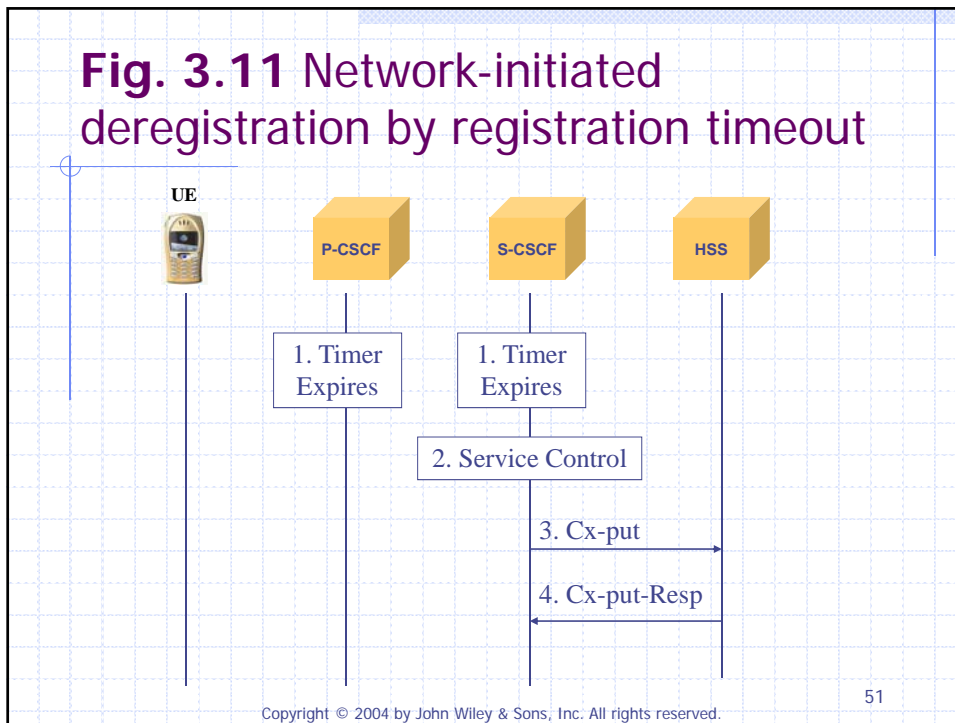
## 3.2.6 Deregistration with the IMS

- ◆ Mobile initiated
- ◆ Network initiated
  - initiated by registration timeout
  - initiated by a network administrative function such as HSS or S-CSCF

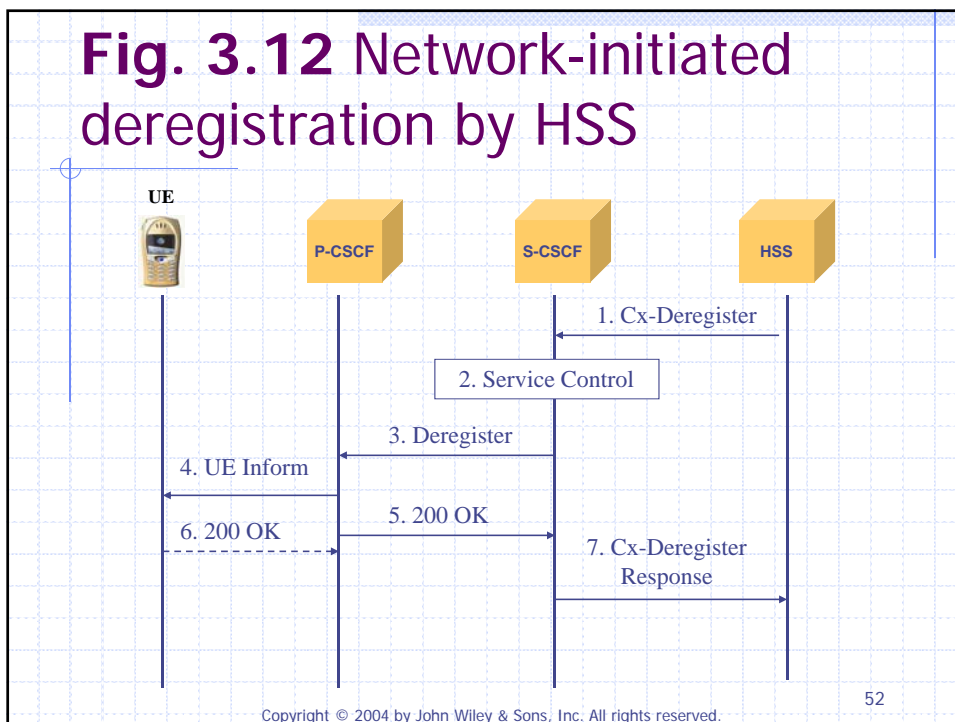
## Fig. 3.10 Mobile-initiated deregistration



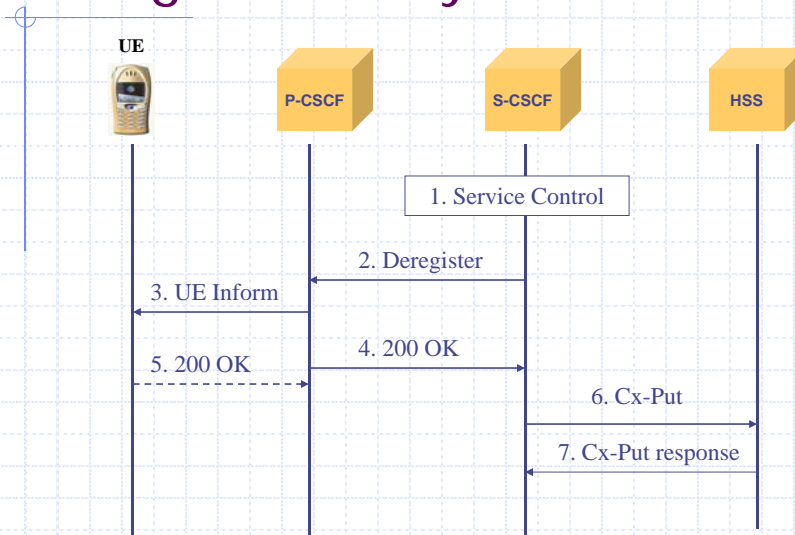
**Fig. 3.11** Network-initiated deregistration by registration timeout



**Fig. 3.12** Network-initiated deregistration by HSS



## Fig. 3.13 Network-initiated deregistration by S-CSCF



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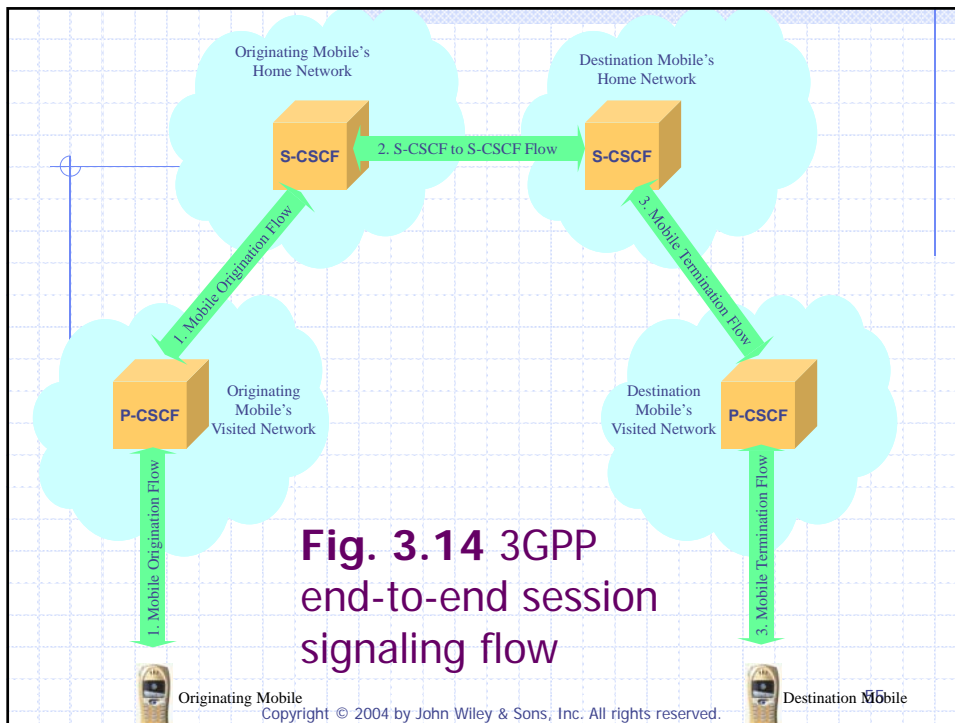
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## 3.2.7 End-to-End Signaling Flows for Session Control

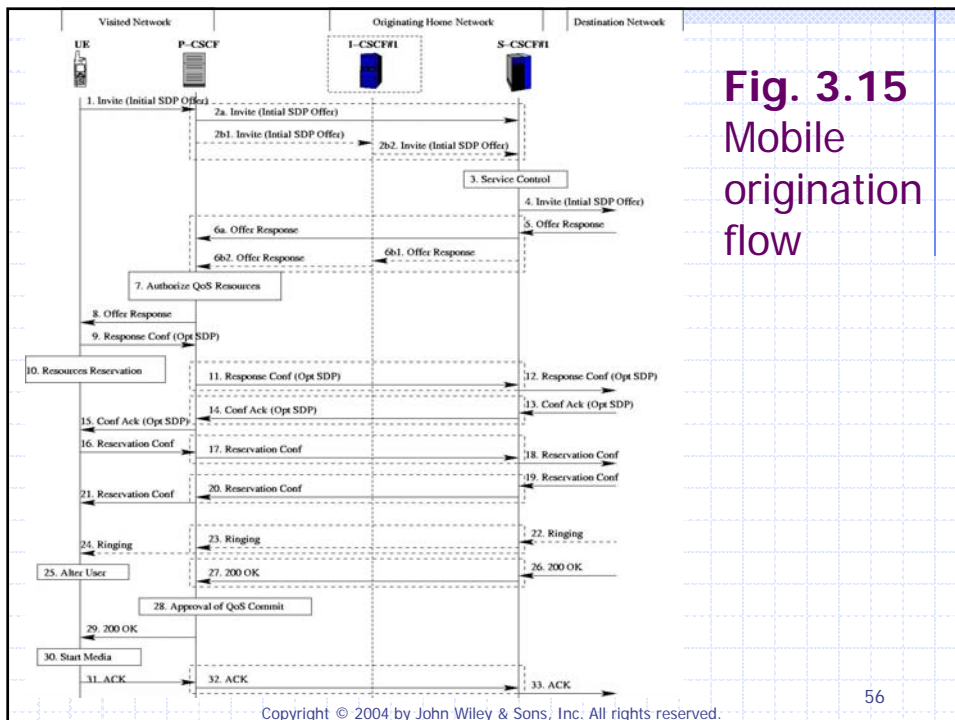
- ◆ Mobile origination flow
- ◆ Mobile termination flow
- ◆ S-CSCF to S-CSCF signaling flow

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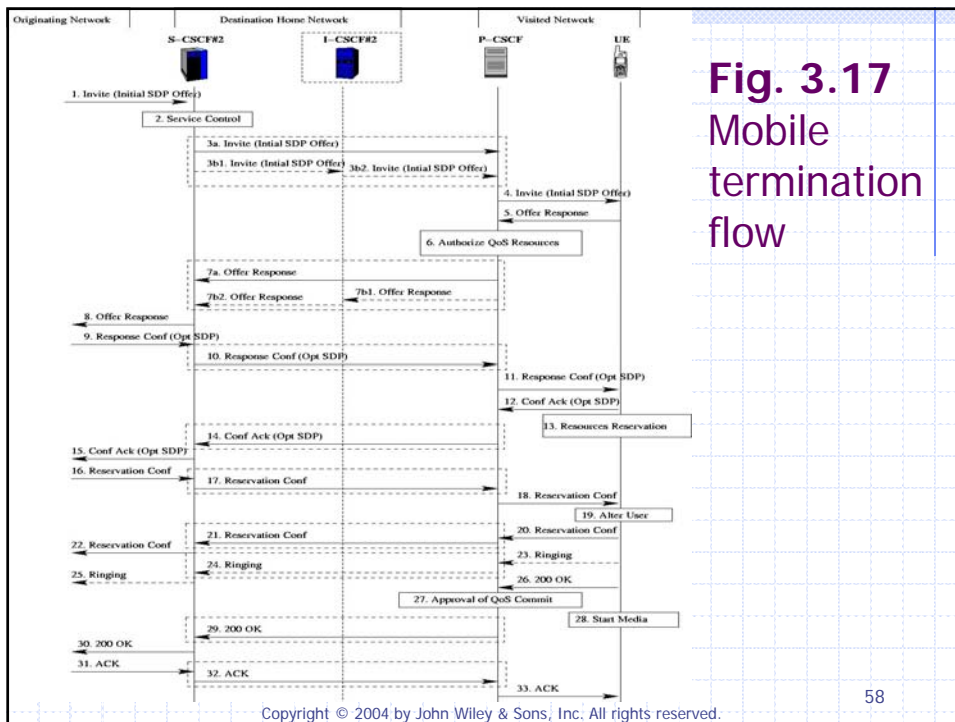
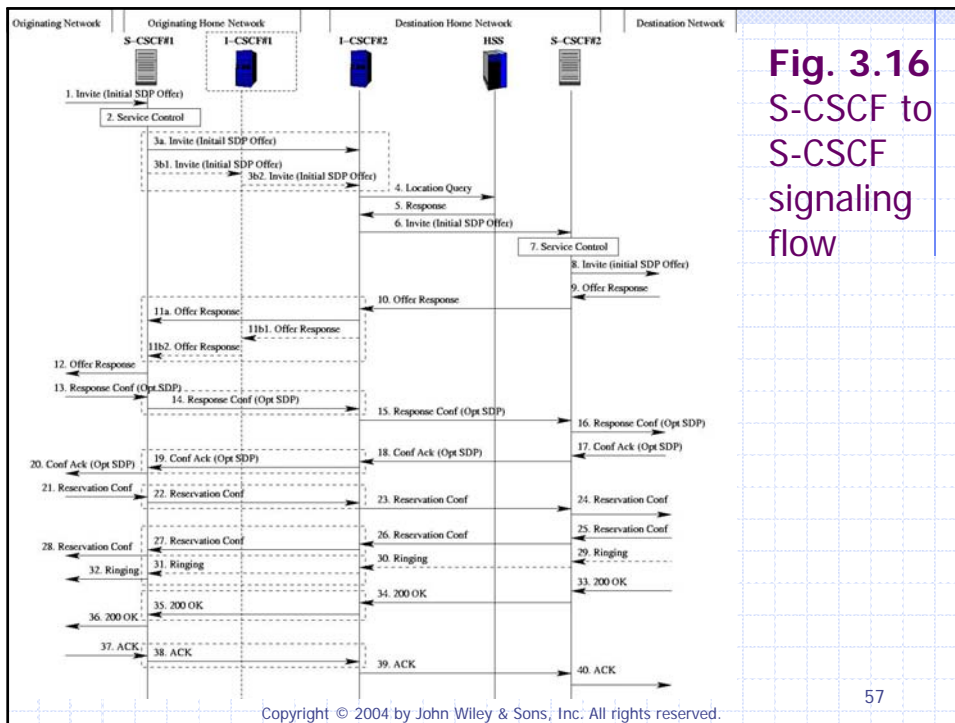
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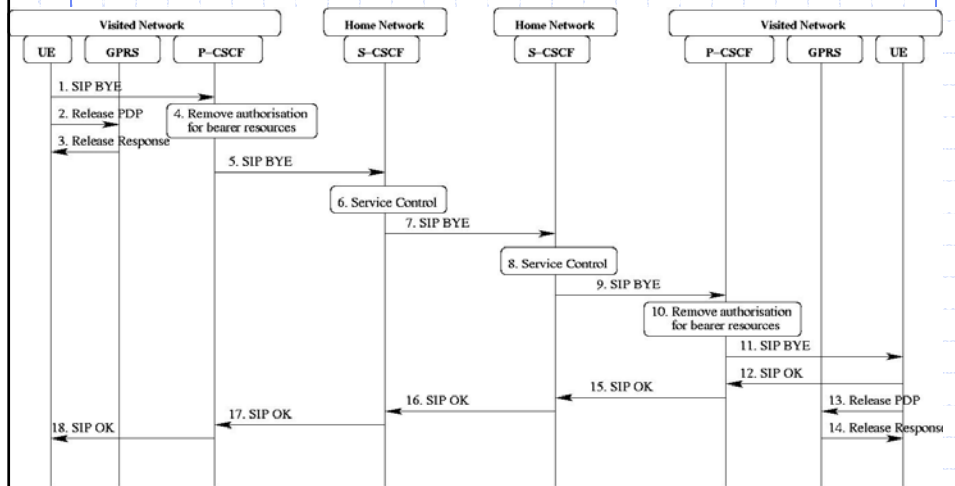
**Fig. 3.14** 3GPP end-to-end session signaling flow



**Fig. 3.15** Mobile origination flow



**Fig. 3.18** Release flow: mobile initiated



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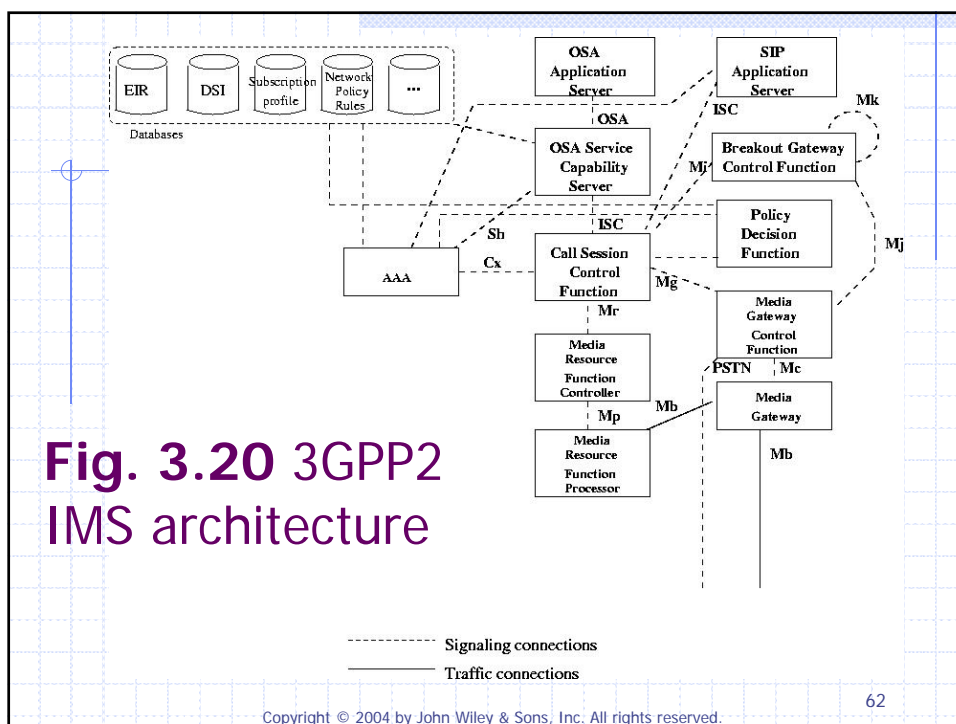
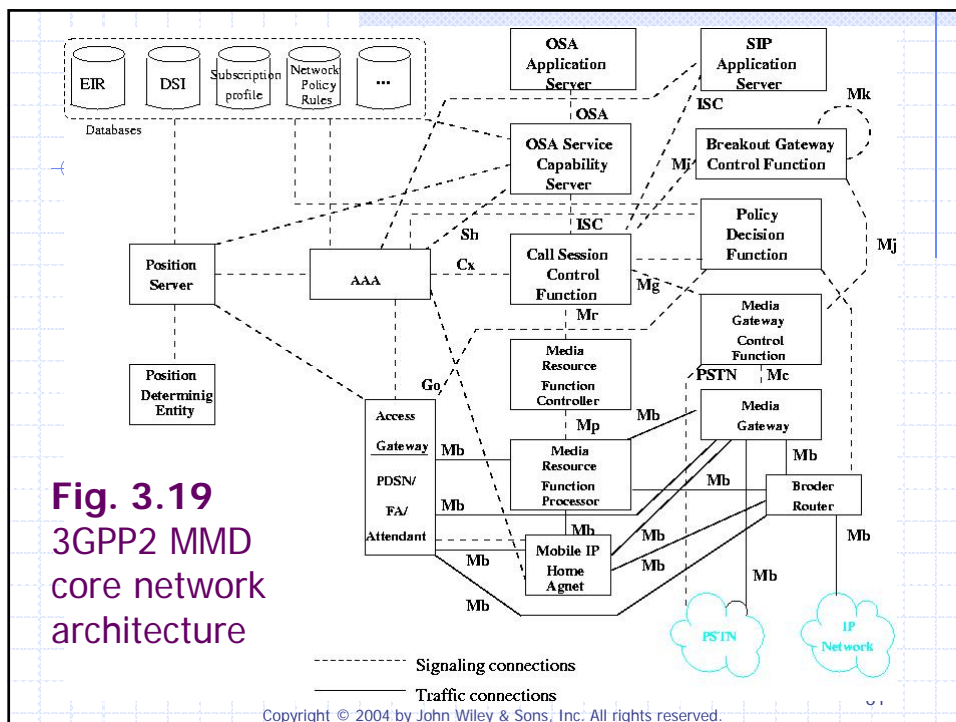
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### 3.3 3GPP2 IP MULTIMEDIA SUBSYSTEM (IMS)

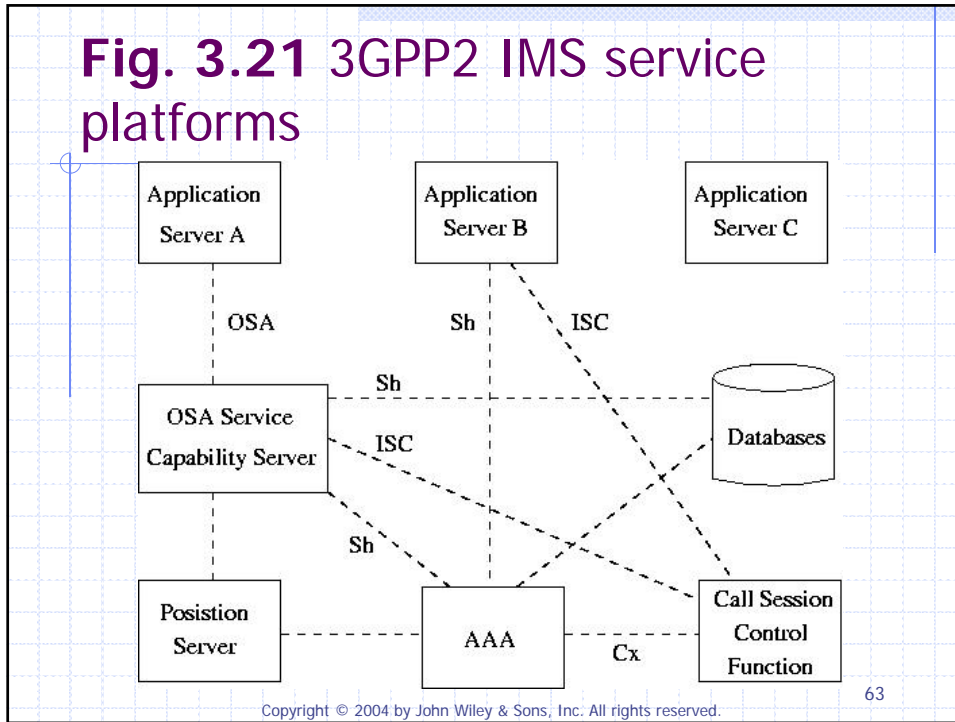
- ◆ 3GPP2 IP Multimedia Domain (MMD):
  - provide end-to-end IP connectivity, services, and features through the core network to subscribers
  - Packet Data Subsystem (PDS): support general packet data service
  - IP Multimedia Subsystem (IMS): provide multimedia session capabilities

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**Fig. 3.21 3GPP2 IMS service platforms**



**Fig. 3.22 3GPP2 IMS service control**

