

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

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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

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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

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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)

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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

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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

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Table 3.1 Structure of a SIP message

Start-line	INVITE sip:tao@research.telcordia.com SIP/2.0
Header Field(s)	Via: SIP/2.0/UDP fly.cs.nthu.edu.tw:5060;branch=z9hG4bK776asdhd5 Max-Forwards: 70 To: Tao <sip:tao@research.telcordia.com> From: Jyh-Cheng <sjcchen@cs.nthu.edu.tw>;tag=1928301774 Call-ID: a84b4c76e66710@fly.cs.nthu.edu.tw CSeq: 123456 INVITE Contact: <sjcchen@fly.cs.nthu.edu.tw> Content-Type: application/sdp Content-Length: 132
Empty Line	
Message Body (Optional)	v=0 t=2873397496 2873404696 m=audio 49170 RTP/AVP 0

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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.

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3.1.1.3 Location Registration

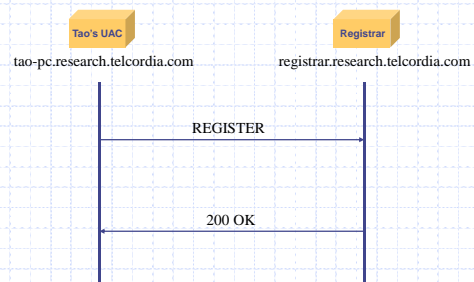
◆ Address of the registrar

- 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

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Fig. 3.1 SIP registration



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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 <sjcchen@research.telcordia.com>
Call-ID: 843817638423076@989sddhas09
CSeq: 2660 REGISTER
Contact: <sjcchen@fly.cs.nthu.edu.tw>
Expires: 3600
Content-Length: 0
    
```

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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 <sjcchen@research.telcordia.com>
Call-ID: 843817638423076@989sddhas09
CSeq: 2660 REGISTER
Contact: <sjcchen@fly.cs.nthu.edu.tw>
Expires: 3600
Content-Length: 0
    
```

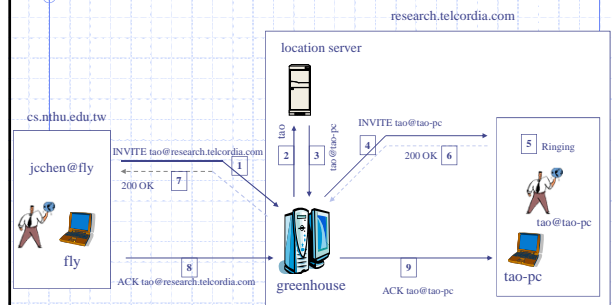
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3.1.1.4 Session Establishment and Termination

- ◆ 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=z9hG4bK776asdhd8
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=z9hG4bK776asdhd8;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
```

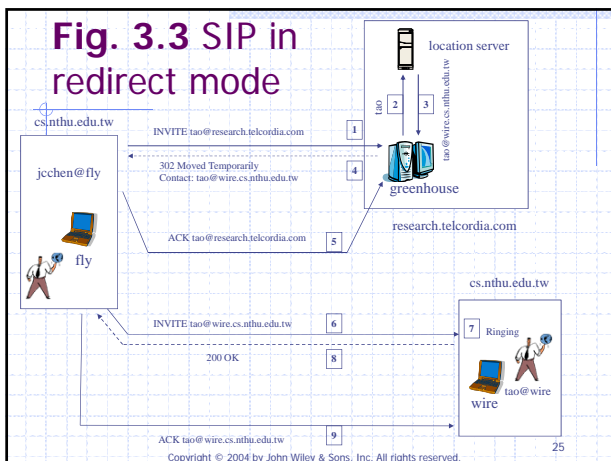
ACK

```
ACK sip:tao@research.telcordia.com SIP/2.0
Via: SIP/2.0/UDP fly.cs.nthu.edu.tw:5060;
    branch=z9hG4bK776asdhd8
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
```

Fig. 3.3 SIP in redirect mode



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)

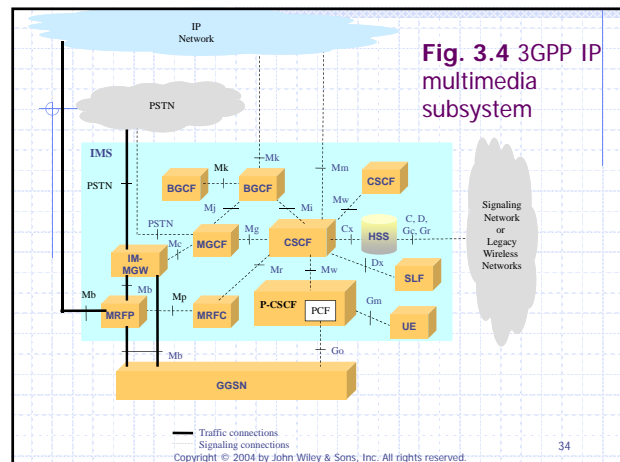
```
v=0
o=Tao 2890844730 2890844730 IN IP4 tao-
pc.research.telcordia.com
S=
c=IN IP4 tao-pc.research.telcordia.com
t=0 0
m=audio 49920 RTP/AVP 0
m=video 0 RTP/AVP 31
m=application 32416 udp wb
```

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)



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_b 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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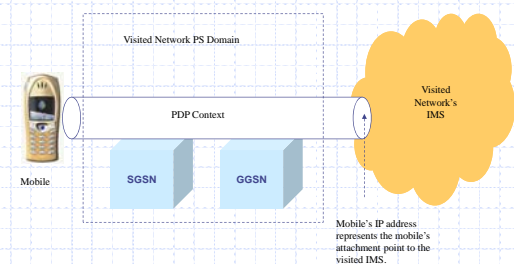
3.2.2 Mobile Station Addressing for Accessing the IMS

- ◆ 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.

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Fig. 3.5 Mobile station addressing for accessing IMS services



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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

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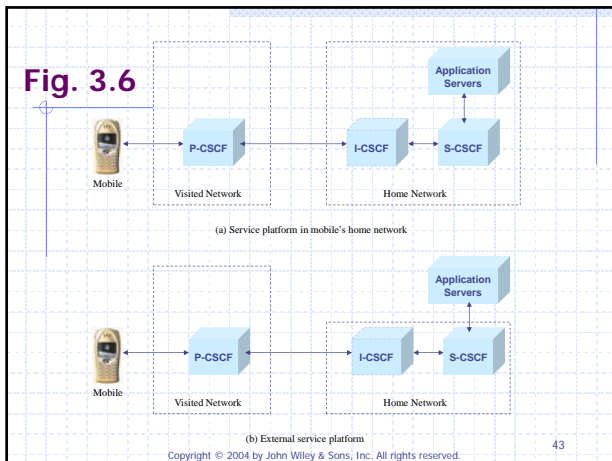
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3.2.4 Service Architecture

- ◆ 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.

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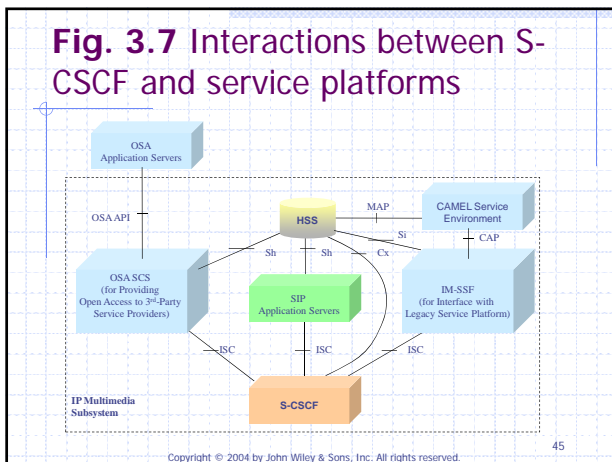
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Service Platforms

- ◆ 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

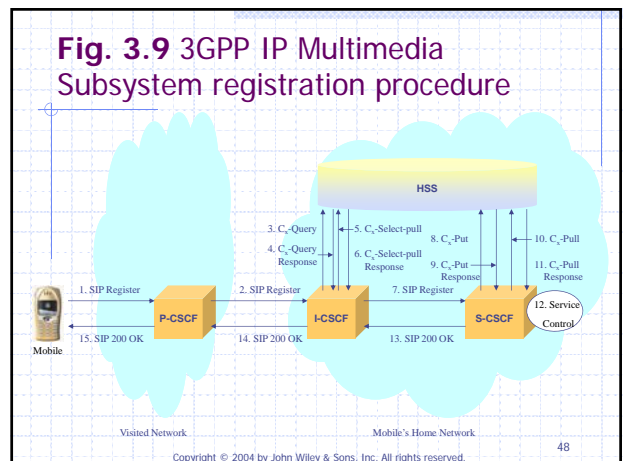
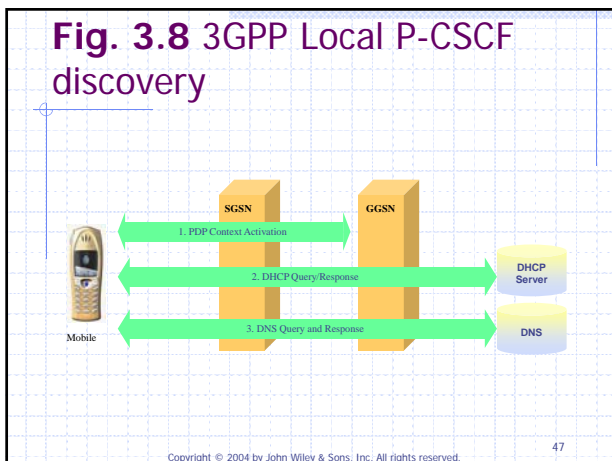
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3.2.5 Registration with the IMS

- ◆ 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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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

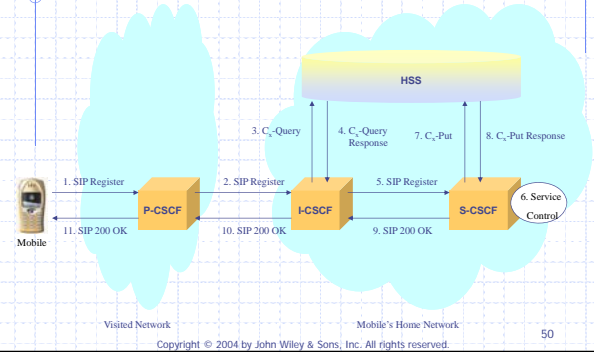


Fig. 3.11 Network-initiated deregistration by registration timeout

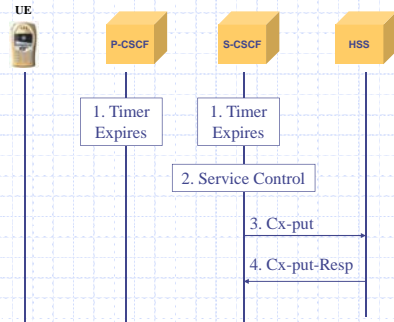


Fig. 3.12 Network-initiated deregistration by HSS

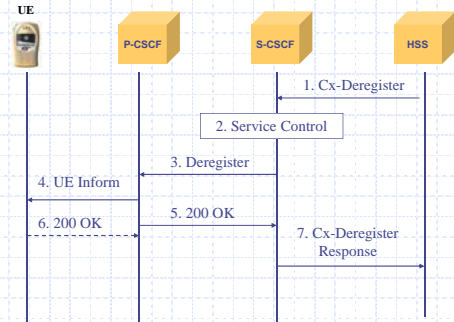
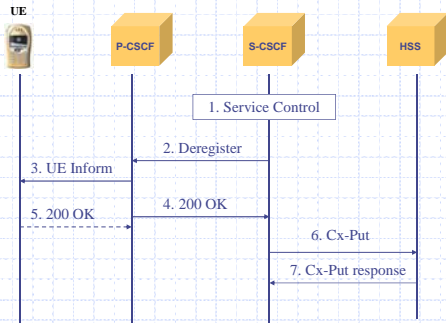


Fig. 3.13 Network-initiated deregistration by S-CSCF



3.2.7 End-to-End Signaling Flows for Session Control

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

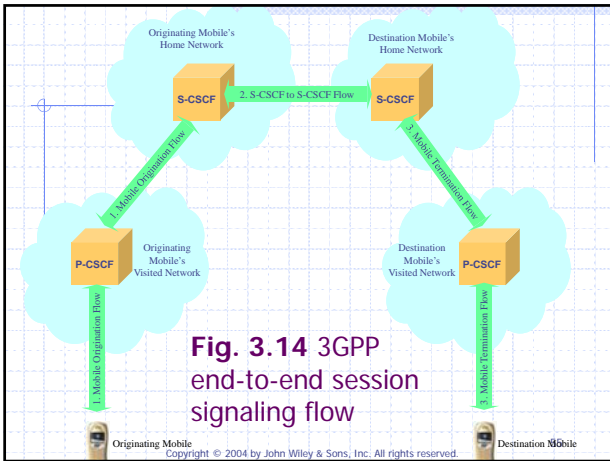


Fig. 3.14 3GPP end-to-end session signaling flow

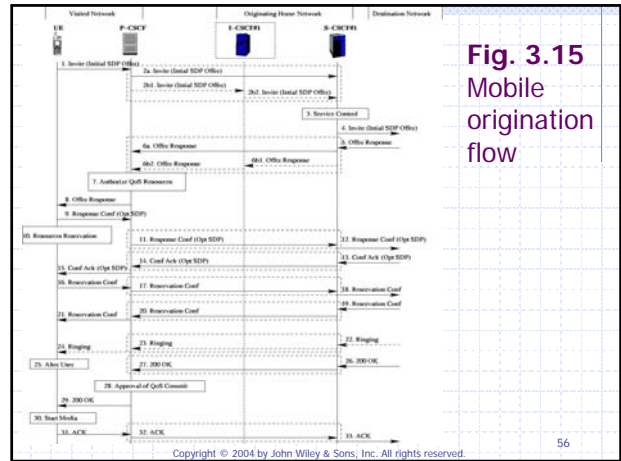


Fig. 3.15 Mobile origination flow

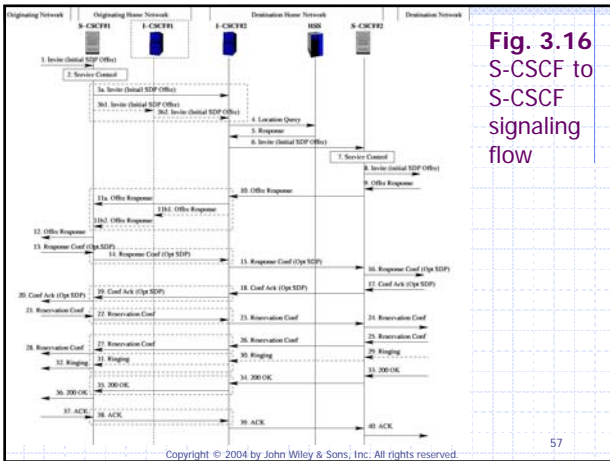


Fig. 3.16 S-CSCF to S-CSCF signaling flow

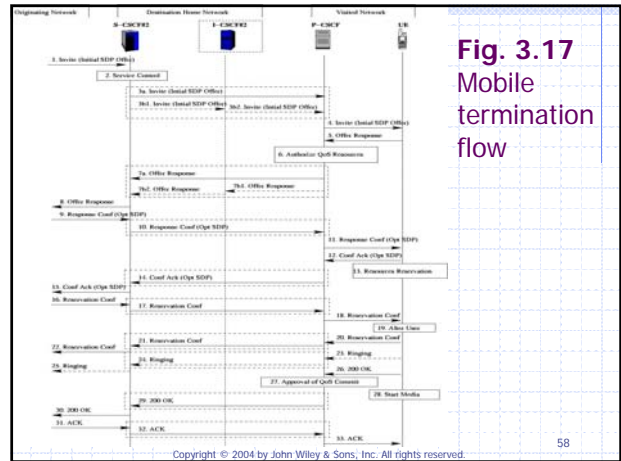


Fig. 3.17 Mobile termination flow

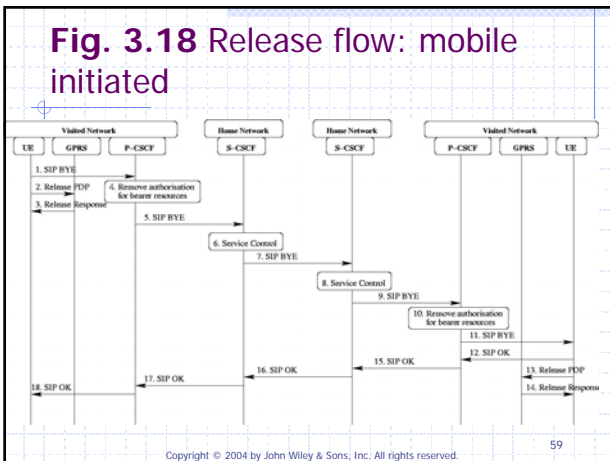


Fig. 3.18 Release flow: mobile initiated

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

