Session Initiation Protocol

Sources

IETF:
RFC 3261: SIP: Session Initiation Protocol
RFC 3262: Reliability of Provisional Responses in SIP (PRACK)
RFC 3265: SIP Specific Event Notification
RFC 3311: SIP UPDATE method
RFC 3398: ISUP to SIP mapping
RFC 3428: SIP Extension for Instant Messaging
RFC 2327: SDP: Session Description Protocol
RFC 3264: An Offer/Answer Model with Session Description Protocol (SDP)

3G Release 5:
3GPP TS 24.228 v5.2.0 (2002-09) Signaling flows for the IP MM call control based on SIP and SDP; stage 3 (Release 5)
3GPP TS 24.229 v5.3.0 (2002-12) IP multimedia call control protocol based on SIP and SDP, Stage 3 (Release 5)
3GPP TS 29.228 v5.1.0 (2002-09) IMS Cx and Dx interfaces, Signaling flows and message contents; (Release 5)

Etc…
SIP Requirements and Fundamentals

- Part of IETF toolkit
  - Reusing other protocols & mechanisms: HTTP, etc.
  - Flexible
  - Extensible
- Moves intelligence to End System entities
  - End-to-end protocol
- Interoperability
- Scalability (although some state in network)
- Service creation easy
- URLs and Addresses are reused
- Same routing as SMTP
- Reuses infrastructure (all applications will use SIP entities for different services)
SIP overview

- Simplicity
  - Ascii based - simple tools for development
  - Lower call setup time than in H.323
  - basic protocol + extensions structure adopted
- Caller preferences, Ability to support many media types
- Runs over UDP or TCP (or SCTP)
- Used between both service and call control entities
- Has been adopted for 3G IP Multimedia signaling
- Originally subscriber signaling, proposed also as network to network signaling
- A lot of development during the last 3…4 years!

SIP Implementation Status of 11/2003

There are several single-operator single-vendor islands offering SIP services, but

The inter-operator or multi-vendor solutions are still very rare, and need to be designed case by case.

This despite the Interoperability Bakeoffs organised by vendors!
SigComp allows compression of Signaling Messages

- RFC 3320 and RFC 3321 specify a layer between the signaling transport and the signaling application
- Uses Global and User Specific Dictionaries to store state data over many SIP sessions
- Overall Compression/decompression architecture is based on a bytecode driven Universal Decompression Virtual Machine
  - Bytecode can be sent in SigComp messages by the Compressor
  - leaves a lot of detail for the implementor

Sip Entities

- User Agents
  - Can act as client and as server
- Servers:
  - Redirect Servers
    - Send back alternative location of the user (similar as HTTP servers)
  - Proxy servers
    - Act on behalf of client (forwards requests)
    - Forking proxies
  - Registrars
    - Accepts registrations and maps public SIP URIs to user locations.
  - Location Servers (not part of SIP architecture)
    - Gives back location of user (received from registrars)
    - E.g. HSS in 3GPP IMS architecture
    - Protocol between Location server and SIP server not defined by SIP specs (e.g. LDAP)
Basic call” Example

- Caller sends INVITE
- Callee can accept, reject, forward the call
- If the callee accepts the call: responds with an optional provisional (1xx), and a final (≥200) response
- The caller confirms final response via ACK
- Conversation
- Caller or callee sends BYE
- BYE is acknowledged by 200 OK
- Low call setup times, post dial delay: 1.5 RTT!
SIP messages have headers and a body

- Headers carry control information and are processed e.g. by Proxies
- Body can be e.g. SDP – session description protocol
  – end-to-end information (cmp H.245) describing session requirements e.g. coding methods, etc
- Message delivery is transaction oriented=
  have request + reply: e.g INVITE+200 OK

User Agent is split into User Agent Client (UAC) and User Agent Server (UAS)

- All Communication follows this transaction model, except 2xx and ACK.
- Server transactions filter incoming requests, absorbing retransmissions
- Only UAS can generate 2xx and only UAC can generate ACK (to success).
A Stateful Proxy can fork a transaction

Forking = multicast of INVITEs to N addresses

Redirect Server pushes processing to clients

Redirect Server properties
- High capacity
- Minimal state overhead
- Service execution pushed to client

17.3.04
Stateful Proxy vs Stateless Proxy

- Maintains call context
- Replicates UAS/UAC to process requests and responses
- Call state and transaction state can be maintained
- Forking proxies require state
- TCP proxies must be stateful for reliability
- Enhanced services require state
- Can collect charging info

- No call context
- Response is not based on UA replication
- Provides client anonymity
- Restricted gateway access
- High processing capacity
- Easier to replicate than the stateful proxy
- Also semi-stateful is possible

UA = User Agent, UAC = UA Client
UAS = UA Server

Full list of SIP methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACK</td>
<td>Acknowledges the establishment of a session</td>
</tr>
<tr>
<td>BYE</td>
<td>Terminates a session</td>
</tr>
<tr>
<td>CANCEL</td>
<td>Cancels a pending request</td>
</tr>
<tr>
<td>INFO</td>
<td>Transports PSTN telephony signaling</td>
</tr>
<tr>
<td>INVITE</td>
<td>Establishes a session</td>
</tr>
<tr>
<td>NOTIFY</td>
<td>Notifies a User Agent of a particular event</td>
</tr>
<tr>
<td>OPTIONS</td>
<td>Queries a server about its capabilities</td>
</tr>
<tr>
<td>PRACK</td>
<td>Acknowledges a provisional response</td>
</tr>
<tr>
<td>PUBLISH</td>
<td>Uploads information to a server</td>
</tr>
<tr>
<td>REGISTER</td>
<td>Maps a public URI with the current location of the user</td>
</tr>
<tr>
<td>SUBSCRIBE</td>
<td>Requests to be notified about a particular event</td>
</tr>
<tr>
<td>UPDATE</td>
<td>Modifies some characteristic of a session</td>
</tr>
<tr>
<td>MESSAGE</td>
<td>Carries an instant message</td>
</tr>
<tr>
<td>REFER</td>
<td>Instructs a server to send a request</td>
</tr>
</tbody>
</table>

Blue methods are candidates for AS processing includes both the base protocol and current(2004) extensions
Notes on SIP methods: INVITE

- Requests users to participate in a session. Body contains description of the session. If someone wants to modify the parameters of the session, he/she must re-INVITE carrying the modified parameters.
- One or more Provisional and one Final response are expected.

Notes on SIP methods: ACK

- Acknowledges the Final Response to INVITE even if INVITE was cancelled → result is 3-way handshake: INVITE-final-resp – ACK.
- Proxies can only ACK non-successful Final Resp.
- Purpose:
  - Let’s the server know that session establishment was successful.
  - Forking may result in many final responses. Sending ACKs to every destination that sent a final response is essential to ensure working over UDP.
  - Allows sending INVITEs without session description. In this case the description is postponed to ACK.
- Has the same Cseq as the INVITE it acknowledges (see later for SIP headers).
Notes on SIP methods: CANCEL

• Purpose: to cancel pending transactions. Will be ignored by completed transactions = final response already sent.
  – useful for forking proxies. If one destination answered, the forking proxy can cancel all other pending INVITEs.
• Has the same Cseq as the request it cancels (see later for SIP headers).

Notes on SIP methods: REGISTER

• Purpose: to register the user’s current location.
• A user can be registered in several locations at the same time. Forking is used to find out where the user wants to answer the session invitation.
• A user can register from anywhere to his registrar → provides mobility.
Notes on SIP methods: OPTIONS

- UA can query a server: which
  - methods and
  - extensions and
  - which session description protocols it supports.
  - which encoding for message bodies the server understands (e.g. compression to save bw).

Some SIP issues

- Parties can release the “call session” but since they have obtained each others IP-addresses, they can continue sending media streams to each other!!
- How to push INVITE to B-party, if B-party does not have a permanent IP address which is most often the case!
- Response messages (e.g. 180) are not reliably delivered. This may cause tear down of the call if it was initiated from ISDN
- If BYE is lost, Proxy does not know that call has ended
- Ascii coding increases the signaling overhead in Radio access
- KeepAlive = re-INVITE mechanism
- PRACK method
- Integration of Proxy with Firewall and NAT
Identification of users

- **sip:user@host[parameters][headers]**
- SIP URIs are like URLs, with prefix sip: which gives schema
  - sip:joe.smith@hut.fi
  - sip:joe.smith@hut.fi?subject=Protocol
  - sip:sales@hotel.xy;geo.position:=48.54_-123.84_120
- Address must include host, other parameters are optional (username, port, etc…)
- Email-addresses can be reused
- “Click-to-call” on web-pages, MM messages, etc… are easily implemented

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Identification of users in 3G IMS in R6

- cmp IMSI in GSM
- cmp. MSISDN in GSM
- SIP URI (RFC 3261) or TEL URI (RFC 2806)
- NAI – Network Access Id (RFC 2486)
- In Release 5 only one Private User id
"Basic Call" call flow

UserA
UserA@atlanta.com
192.168.100.101

UserB
UserB@biloxi.com
192.168.200.201

1) INVITE
2) 180 Ringing
3) 200 OK
4) ACK

Media stream

5) BYE
6) 200 OK

UserA
UserA@atlanta.com
192.168.100.101

UserB
UserB@biloxi.com
192.168.200.201

1) INVITE
2) 180 Ringing
3) 200 OK
4) ACK

Media stream

5) BYE
6) 200 OK
"Basic Call" call flow

1) INVITE
   2) 180 Ringing
      3) 200 OK
   4) ACK

UserA
UserA@atlanta.com
192.168.100.101

UserB
UserB@biloxi.com
192.168.200.201

Media stream

5) BYE
   6) 200 OK

UserA
UserA@atlanta.com
192.168.100.101

UserB
UserB@biloxi.com
192.168.200.201

Media stream

5) BYE
   6) 200 OK
"Basic Call" call flow

1) INVITE

2) 180 Ringing

3) 200 OK

4) ACK

Media stream

5) BYE

6) 200 OK

UserA
UserA@atlanta.com
192.168.100.101

UserB
UserB@biloxi.com
192.168.200.201
Requests invoke SIP methods

- SIP methods are invoked on servers when requests arrive:
  - A REGISTER request sends location information of users to Registrars, registers with the location service
  - An INVITE request invites a user to participate in a session or conference
    - The message body contains a description of the session (usually SDP)
  - ACK requests are used to confirm responses for INVITE, for reliable message exchanges
  - CANCEL requests cancel the pending request of the session
  - BYE requests are used to terminate active sessions
    - Any party of the session can send it
  - OPTIONS requests are used to query information about servers' capabilities
  - PRACK requests are used to confirm provisional responses

SIP responses are classified by first digit

- HTTP look-alike
- Hierarchically organized three digit codes: status code - text associated with the code
- Provisional and final responses:
  - 1xx responses are informational messages e.g., 180 Ringing
  - 2xx response shows a successful transaction e.g., 200 OK
  - 3xx responses are redirect messages e.g., 301 Moved Permanently
  - 4xx responses indicate errors in requests e.g., 400 Bad Request
  - 5xx responses indicate server errors e.g., 500 Version not supported
  - 6xx responses indicate global failures e.g., 600 Busy everywhere
SIP Message Format

- **START-LINE**
  - SIP version used
  - In requests: address and method used
  - In responses: status code

- **HEADERS**
  - Information about call

- **BODY (payload)**
  - Usually SDP message

A Request line contains the Request URI = the name of the user that is the destination. This request URI is used for SIP routing.

To and From header fields

- **To**: specifies the logical call destination
- **From**: specifies the logical call source
- **Present in all SIP messages**

NB: In IMS To and From header field are end to end information and not used nor asserted by the network. Instead the P-CSCF inserts the P-Asserted-Identity header field into the SIP messages indicating the network asserted identity of the originator of the call.
Call-ID and CSeq header fields

- **Call-ID:** It helps to uniquely identify a particular SIP dialog or registration
  - It helps to match requests and responses
  - It helps to detect duplicated messages
- **CSeq:** It is a number that uniquely identifies the transaction in a call
- **Present in all SIP messages**

```plaintext
INVITE sip:bob@biloxi.com SIP/2.0
Via: SIP/2.0/UDP pc33.atlanta.com;branch=z9hG4bKnashds8
Max-Forwards: 70
To: Bob <sip:bob@biloxi.com>
From: Alice <sip:alice@atlanta.com>;tag=1928301774
Call-ID: a84b4c76e66710
CSeq: 314159 INVITE
Contact: <sip:alice@pc33.atlanta.com>
Content-Type: application/sdp
Content-Length: 142
```

Content-Type and Content-Length header fields

- **Content-Type:** It describes the media type of the message body
- **Content-Length:** The number of octets in the message body
  - It is mandatory in all SIP messages.

```plaintext
INVITE sip:bob@biloxi.com SIP/2.0
Via: SIP/2.0/UDP pc33.atlanta.com;branch=z9hG4bKnashds8
Max-Forwards: 70
To: Bob <sip:bob@biloxi.com>
From: Alice <sip:alice@atlanta.com>;tag=1928301774
Call-ID: a84b4c76e66710
CSeq: 314159 INVITE
Contact: <sip:alice@pc33.atlanta.com>
Content-Type: application/sdp
Content-Length: 142
```
Max-Forwards

- Max-Forwards field must be used with any SIP method
- It limits the number for proxies or gateways on the way of SIP message to the destination.

```
INVITE sip:bob@biloxi.com SIP/2.0
Via: SIP/2.0/UDP pc33.atlanta.com;branch=z9hG4bKnashds8
Max-Forwards: 70
To: Bob <sip:bob@biloxi.com>
From: Alice <sip:alice@atlanta.com>;tag=1928301774
Call-ID: a84b4c76e66710
CSeq: 314159 INVITE
Contact: <sip:alice@pc33.atlanta.com>
Content-Type: application/sdp
Content-Length: 142
```

VIA header indicates path taken by the request so far

- Branch parameter is used to detect loops
- Contains transport protocol, client’s host name and possibly port number, and can contain other parameters

```
INVITE sip:bob@192.0.2.4 SIP/2.0
Via: SIP/2.0/UDP server10.biloxi.com;branch=z9hG4bK4b43c2f8.1
Via: SIP/2.0/UDP bigbox3.site3.atlanta.com;branch=z9hG4bK77e4c2312983.1;
   received=192.0.2.2
Via: SIP/2.0/UDP pc33.atlanta.com;branch=z9hG4bKnashds8
   received=192.0.2.1
Max-Forwards: 68
To: Bob <sip:bob@biloxi.com>
From: Alice <sip:alice@atlanta.com>;tag=1928301774
Call-ID: a84b4c76e66710
CSeq: 314159 INVITE
Contact: <sip:alice@pc33.atlanta.com>
Content-Type: application/sdp
Content-Length: 142
```
Record-route and Route

- **Record-Route: header is added by proxy, when proxy wants to stay in the route of all sip messaging**
- **Route is added by User Agent Client, after response came, with all Record-route headers in it (then UAC knows which relays want to stay on the signaling path)**
- **NOT the same as Via: headers**

```
INVITE sip: callee@u2.domain.com SIP/2.0
Contact: sip: caller@u1.example.com
Record-Route: <sip:p2.domain.com;lr>, <sip:p1.example.com;lr>
Record-Route: <sip:p1.example.com;lr>
```

Inserted by proxies p1.example.com and p2.example.com.

```
BYE sip: callee@u2.domain.com SIP/2.0
Route: <sip:p1.example.com;lr>, <sip:p2.domain.com;lr>
```

UA can specify through which proxies this message must go.

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SIP Extensions

- Needed to satisfy additional requirements
- Must conform to design rules
- SIP is not intended to solve every problem (another protocol might be used instead)
Feature Negotiation (OPTIONS)

- **Supported** features can be specified in request and response
  - **Supported** UAC and UAS tell features they support
- **Required** features can be specified in request and response
  - **Require** UAC tells UAS about required options
  - **Proxy-Require** required options for proxy/redirect servers
  - Many extensions use Require and Proxy-Require to specify their support
- New methods can be added without changing the protocol
  - server can respond with **405 Not Supported**
  - returns list of supported methods in **Allow** header
  - client can ask which methods are supported using OPTIONS

---

Reliable Provisional response in SIP

```
INVITE sip:uas@host SIP/2.0
Supported 100rel
```

```
SIP/2.0 180 Ringing Require 100rel
Rseq 223455
```

```
PRACK sip:uas@host SIP/2.0
Rack: 223455 1 INVITE
```

```
SIP/2.0 200 OK (for PRACK)
```

Tells that A-party (UAC) understands reliable responses to 1xx messages

Retransmission algorithm starts

Retransmission algorithm stops

Retransmission of 180

Retransmission of PRACK
QoS support - UPDATE

- **Usage rule for 183-Session-Progress**
  - If “a=qos” appeared in SDP, UAS sends 183 with “Session: qos” and SDP

- **Additional Method - UPDATE**
  - If “a=qos” appeared in SDP with “confirm” attribute, UAS/UAC sends UPDATE with success/failure status of each precondition.
  - 200 OK must acknowledge the UPDATE message
  - user B does not need to be prompted

- **Additional Status Response - 580 Precondition Failure**
  - If a mandatory precondition can’t be met, UAS terminates INVITE with this status response

---

Phone should not ring before QoS and Security are OK

UAC

INVITE

SIP Proxy(s)

183 w/SDP

PRACK

200 OK (of PRACK)

Resource Reservation

UPDATE

200 OK (of UPDATE)

180 Ringing

PRACK

200 OK (of PRACK)

200 OK

ACK

W/SDP = “a-qos:” strength direction
  “a-secure:” strength direction
  strength = mandatory/optional
  |success|failure
  direction = send|recv|sendrecv

UPDATE confirms that preconditions are OK at the originator

PRACK method is used to ensure delivery of 183 and 180

User picks up the phone

Use case: 3G signaling!

SDP = Session Description Protocol (carried in SIP message body)
SIP event notifications tell about remote significant events to the local party

Event-subscriber

SUBSCRIBE

200 (of SUBSCRIBE)

NOTIFY

200

NOTIFY

200

SUBSCRIBE Expires: 0 (unsubscribe)

200

Event-notifier

Generate immediate state response

Generate state change event

Use cases: automatic call-back, automatic buddy lists, message waiting indication, User’s own registration status and “IN triggering”.

SIP MESSAGE provides Instant Messaging capability in Pager mode

Sender

MESSAGE sip:user2@domain.com SIP/2.0
Via: SIP/2.0/TCP user1pc.domain.com;branch=z9hG4bK776g6kse
Max-Forwards: 70
From: sip:user1@domain.com
To: sip:user2@domain.com
Call-ID: asdf8sad77a@1.2.3.4
CSeq: 1 MESSAGE
Content-Type: text/plain
Content-Length: 18
Watson, come here.

200 (of MESSAGE)

Destination

Note:
- body is MIME or S/MIME
- there is no dialog!

Use example:
- maps to SMS in GSM

Issue:
- authentication of sender and charging! Must use Proper security features
More SIP extensions

- **MESSAGE**
  - For instant messaging

- **INFO**
  - To transport mid-session information (very useful in SIP-PSTN gateways to carry all PSTN messages across SIP domains such that do not easily map to any other known SIP message)

- **Automatic configuration**
  - DHCP or Service Location Protocol (SLP)

- **Caller Preferences**
  - New headers: Accept-Contact, Reject-Contact, Request-Disposition (e.g. to express a preference for contacting the user at “fixed”, “business” connection).

- **REFER**
  - For session transfer (Refer-To: and Referred-By: )

- …

**Deployment example: Elisa’s experimental service for BB customers**

- SIP –server recognizes a numbering block, connects calls directly from IP-phone to IP-phone n the block
- Calls to all other numbers are routed to the gateway
- = SIP-server+Gateway are like a PBX
Call Setup Examples based on Generic SIP

Registration example with SIP

Bob
bob@biloxi.com

biloxi.com

REGISTER sip:registrar.biloxi.com SIP/2.0
Via: SIP/2.0/UDP bobspc.biloxi.com:5060;branch=z9hG4bKnashds7
Max-Forwards: 70
To: Bob <sip:bob@biloxi.com>
From: Bob <sip:bob@biloxi.com>;tag=456248
Call-ID: 843817637684230@998sdasdh09
CSeq: 1826 REGISTER
Contact: <sip:bob@192.0.2.4>
Expires: 7200
Content-Length: 0

SIP/2.0 200 OK
Via: SIP/2.0/UDP bobspc.biloxi.com:5060;branch=z9hG4bKnashds7
;received=192.0.2.4
To: Bob <sip:bob@biloxi.com>;tag=2493k59kd
From: Bob <sip:bob@biloxi.com>;tag=456248
Call-ID: 843817637684230@998sdasdh09
CSeq: 1826 REGISTER
Contact: <sip:bob@192.0.2.4>
Expires: 7200
Content-Length: 0
Call Setup example with one proxy

1) INVITE
2) INVITE
3) 180 Ringing
4) 180 Ringing
5) 200 OK
6) 200 OK
7) ACK
8) ACK

Media stream

9) BYE
10) BYE
11) 200 OK
12) 200 OK

GuyA
UserA@here.com
100.101.102.103

Proxy.com
121.110.101.111

GuyB
UserB@there.com
110.111.112.113

Call Setup example with two proxies

1a) INVITE
1b) INVITE
1c) 100 Trying
2a) INVITE
2b) 100 Trying
2c) 180 Ringing
3a) 180 Ringing
3b) 180 Ringing
4a) 200 OK
4b) 200 OK
5a) ACK

Media stream

6a) BYE

Alice
atlanta.com proxy

Bob
Biloxi.com proxy

Biloxi.com proxy

atlanta.com proxy

7a) 200 OK
Call Setup example with two proxies

Alice  atlanta.com proxy  Biloxi.com proxy  Bob
1a) INVITE  1b) INVITE  2a) INVITE
1c) 100 Trying  2b) 100 Trying  3a) 180 Ringing
3c) 180 Ringing  3b) 180 Ringing  4a) 200 OK
4c) 200 OK  4b) 200 OK
5a) ACK

Media stream

atlanta.com proxy  Biloxi.com proxy

atlanta.com proxy  Biloxi.com proxy

6a) BYE
7a) 200 OK

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Call Setup example with two proxies

1a) INVITE
1c) 100 Trying
3c) 180 Ringing
4c) 200 OK
5a) ACK

Media stream

atlanta.com proxy
Biloxi.com proxy

7a) 200 OK

6a) BYE

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Signaling Protocols 13 - 56
Call Setup example with two proxies

1a) INVITE
1c) 100 Trying
3c) 180 Ringing
4c) 200 OK
5a) ACK

Bob

atlanta.com proxy

Biloxi.com proxy

Alice

1b) INVITE
2b) 100 Trying
3b) 180 Ringing
4b) 200 OK

atlanta.com proxy

Biloxi.com proxy

Media stream

2a) INVITE
3a) 180 Ringing
4a) 200 OK

atlanta.com proxy

Biloxi.com proxy

6a) BYE

7a) 200 OK

Registration example with SIP authentication

1) REGISTER
   Call-ID: 123@here.com

GuyA
   UserA@here.com

proxy.com

2) 401 Unauthorized
   WWW-Authenticate: <Challenge>

3) REGISTER
   Call-ID: 321@here.com
   Authorization: <Authorization info>

4) 200 OK
Call Setup example with a non-working proxy

1) INVITE
2) INVITE (6x)
3) CANCEL, BYE
4a) INVITE

5b) 180 Ringing
6b) 200 OK
7a) ACK

4b) INVITE

5a) 180 Ringing
6a) 200 OK

Call Setup example with a Redirect server

1a) INVITE
2) INVITE

1b) INVITE
2) 301 Moved Temporarily
3) ACK
1c) INVITE

4b) 180 Ringing
5b) 200 OK
6a) ACK

4a) 180 Ringing
5a) 200 OK

6b) BYE
7a) 200 OK

8a) BYE
9b) 200 OK

6a) BYE
7b) 200 OK
Services use many protocols

- New services and more flexible service creation should differentiate IP Communications Network from PSTN
- Services should combine different forms of communication, thus multiple protocols are needed:
  - SIP for media sessions and session related services, subscriptions and notifications?, messaging?
  - HTTP for web and transactions
  - SMTP for e-mail
  - RTSP for media streaming
- The use of these protocols is orchestrated by the service logic: context is set up using SIP.

Routing and Service Model in 3G

P1, P4: Outbound Proxies
P2, P3: Registrar Proxies
AS1, AS2: Application Servers

NB: Also AS based on direct processing of call state: There is no Basic call state model like in IN
SIP Entities & Service Capabilities

- **User Agent ( = UAC + UAS)**
  - Can run services, such as forwarding, filtering etc.
  - Not always connected (out of coverage/battery etc.)

- **Redirect Server**
  - Can do services that require only Request-URI change, e.g. translation, parameter addition etc.

- **Proxy Server**
  - Can change certain headers and stay in the signaling path
  - Forking, actions based on responses

- **Back-to-Back User Agent (=both ways User Agent)**
  - Can e.g. issue requests to a call leg or modify SDP, generate ACK and 200OK, like UAC/UAS
  - In many cases necessary

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Application Server in 3G

- **Fuzzy Definition but has SIP+ interface!**
- **Can be a Redirect or Proxy Server or Back-to-Back UA**
- **The key is that it should be *programmable***
  - Routing based on service logic: what to do when user not registered or busy
  - URI translation: Reachability chains
  - Interfaces to other protocols: HTTP, SMTP, RTSP etc.
- **Can be single purpose boxes, or multi-purpose boxes, or controllers who orchestrate things**
3GPP Network Model (preliminary: ...