

H.323, SIP, RTP, RTCP

Računarske osnove Interneta

dr Pavle Vuletić

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Prenos podataka u realnom vremenu

- Protokoli za signalizaciju: H.323, SIP
- Standardi za kodiranje zvuka i slike
- Protokoli za transport podataka u realnom vremenu: RTP, RTCP, SRTP
- Adresni planovi, adrese

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Signalizacija u komunikacionim mrežama

- Služi za uspostavljanje kola (circuit)
- Inchannel
 - inband
 - out-of-band
- Common channel
- Signalizacija između korisnika i mreže
- Signalizacija između komunikacionih uređaja

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H.323

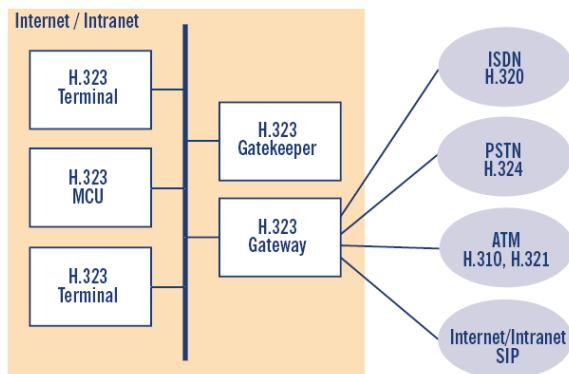
- H.320 – ISDN, H.321 – ATM, H.324 - PSTN
- (1995-1996) H.323 - Niz protokola koji obezbeđuju audio-vizuelnu komunikaciju preko paketskih mreža (LAN)
- (1999) H.323v3 – osnova za IP telefoniju
- (2000) H.323v4

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H.323 komponente

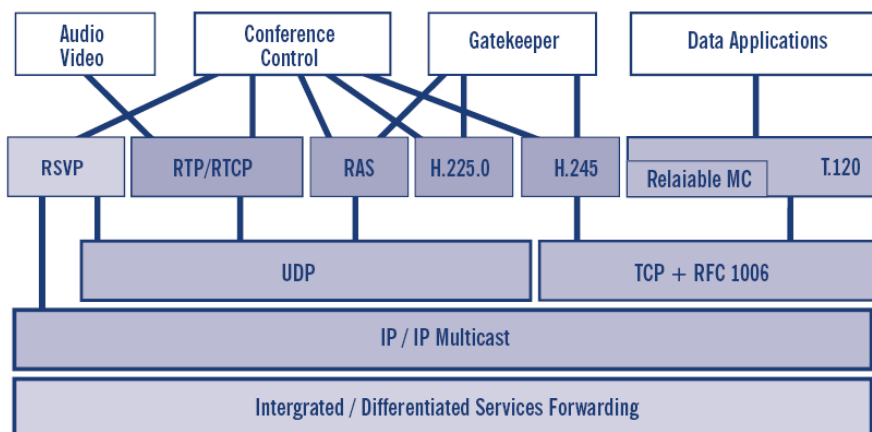
- Terminal
- Gateway
- Gatekeeper
- Multipoint Controller (MC)
- Multipoint Processor (MP)
- Multipoint Control Unit (MCU)



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Mesto H.323 u protokolskom steku



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H.323 kontrolni protokoli

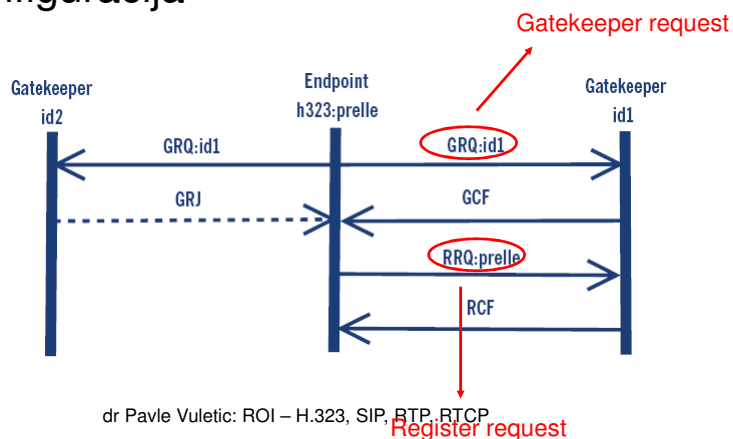
- H.225.0 Registration Admission and Status (RAS)
- H.225.0 Call Signaling (iz Q.931)
 - Optimizacije
 - Više poziva
 - Zadržana konekcija
- H.245 Conference control
 - Formati poruka, protokoli i algoritmi za prenos multimedije, kontrola konferencije,...

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Otkrivanje gatekeeper-a i registracija

- Multicast discovery (224.0.1.41, port 1718)
- Konfiguracija



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Vrste H.323 adresa

- E.164 – PSTN brojevi
- H.323 URL – RFC 3508
 - h323:username@domain.com
- Različita simbolička imena
- IP adrese

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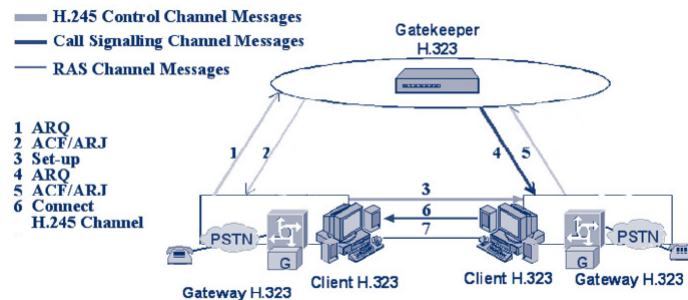
Modeli signalizacije

- Direktna signalizacija
- Rutiranje signalizacije poziva kroz Gatekeeper
- Rutiranje H.245, H.225.0 RAS i H.225.0 kroz Gatekeeper

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Direktna signalizacija



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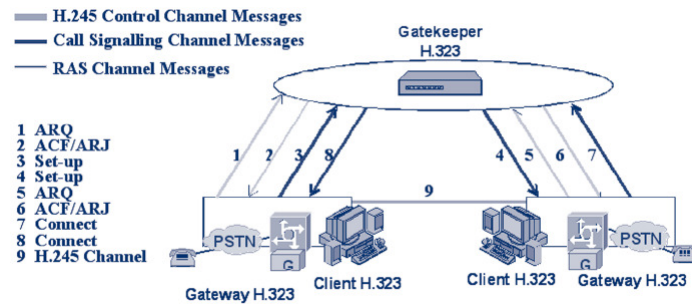
Redosled poruka

- ARQ – Admission Request
- ACF – Admission Confirm (destCallSignalAddress)
- SETUP (ALERTING, CALL PROCEEDING,...)
- CONNECT
- H.245
 - Audiovisual and data capabilities
 - Uspostavljanje specifičnog logičkog kanala
 - Master/slave izbori
 - RTT kašnjenje
 - Druga signalizacija

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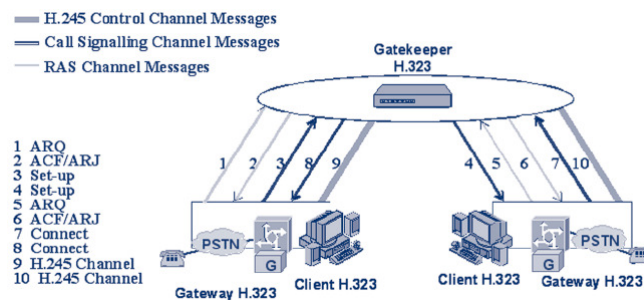
Rutiranje signalizacije poziva kroz Gatekeeper



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Rutiranje H.245, H.225.0 RAS i H.225.0 kroz Gatekeeper



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Faze u komunikaciji

- Uspostavljanje poziva
- Razmena informacija o sposobnostima uređaja
- Uspostavljanje audiovizuelne komunikacije
- Servisi pozivanja
- Završetak poziva

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Uspostavljanje poziva

- Moguće varijante
 - Obe strane bez gatekeeper-a
 - Obe strane na istom gatekeeper-u
 - Samo jedna strana ima gatekeeper
 - Dve strane na različitim gatekeeper-ima (različite zone)
 - FastStart procedura

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Servisi poziva

- Promena propusnog opsega
 - BRQ – Bandwidth Request
 - BCF, BRJ
- Dodatni servisi – H.450

Recommendation number	Recommendation Title
H.450.1	Supplementary Service Framework
H.450.2	Call Transfer Supplementary Service
H.450.3	Call Diversion Supplementary Service
H.450.4	Call Hold Supplementary Service
H.450.5	Call Park and Pickup Supplementary Service
H.450.6	Call Waiting Supplementary Service
H.450.7	Message Waiting Supplementary Service
H.450.8	Name Identification Supplementary Service
H.450.9	Call Completion Supplementary Service
H.450.10	Call Offer Supplementary Service
H.450.11	Call Intrusion Supplementary Service

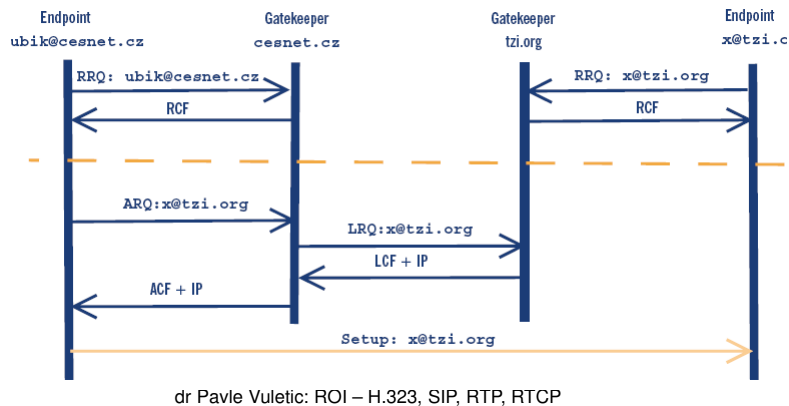
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Završetak poziva

- H.245 ENDSSESSIONCOMMAND
- H.245 RELEASE COMPLETE
- H.225.0 DRQ – DISSENGAGE REQUEST
- Varijante
 - Bez gatekeeper-a
 - Sa gatekeeper-om
 - Prekid zahtevan od strane gatekeeper-a

Uspostavljanje poziva između zona

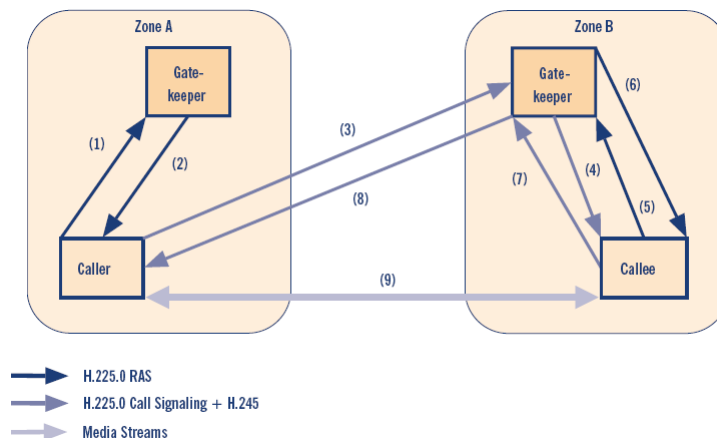
- LRQ može da se pošalje unikastom ili multikastom



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Jedan scenario H.323 poziva

- Gatekeeper A Caller-u šalje adresu Gatekeeper-a B



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Dodatni servisi

- Konferencija – učešće više učesnika u komunikaciji
- Broadcast konferencija – prenos seminara, predavanja multikastom
- Dodatni servisi H.450

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H.235 sigurnost

- Obezbeđuje
 - Autentičnost strana koje komuniciraju
 - H.225.0 RAS poruke imaju token koji je izračunat na osnovu:
 - Deljena lozinka
 - Digitalni potpis
 - Integritet poruka
- Enkripcija tokova nije deo H.235, već je dodata u H.245
- Korišćenje SRTP nije podržano u H.235

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H.323 softver/uređaji

- Hardverski telefoni: Siemens, Cisco, Adtech, Polycom, VCON...
- Softverski telefoni: NetMeeting, Ekiga,...
- Serveri: OpenH323, VOCAL, OpenMCU, Cisco,...
- Gateway: OpenISDN, Asterisk, Cisco,...

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SIP

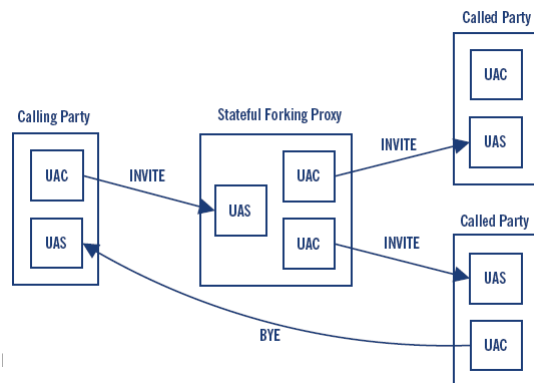
- Session Initiation Protocol
- RFC 3261
- Zasnovan na HTTP
- Konceptija: logika za komunikaciju je u krajnjim uređajima
- end-to-end protokol
 - Skalabilan, distribuiran
 - Više poruka
- SIP URI (Universal Resource Identifier) –
`sip:username@domain.com`

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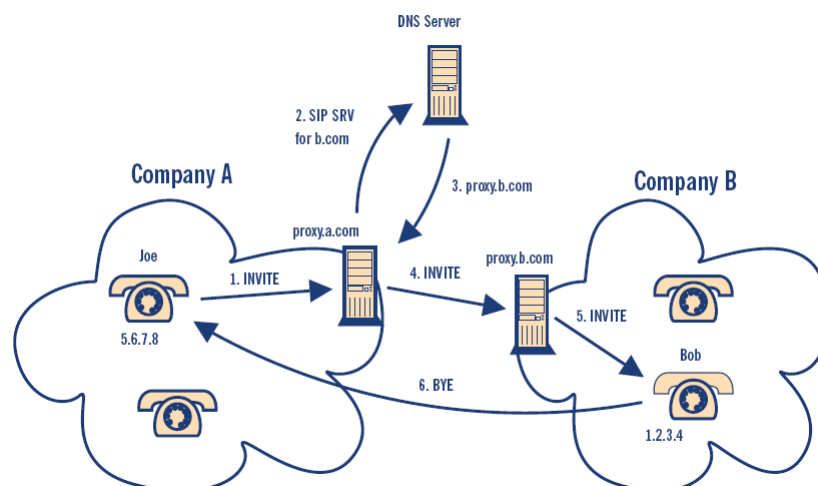
SIP elementi

- User agent
 - User Agent Client (UAC)
 - User Agent Server (UAS)
- Proxy server
 - stateless
 - statefull
- Registrar
- Redirect server



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Proxy server

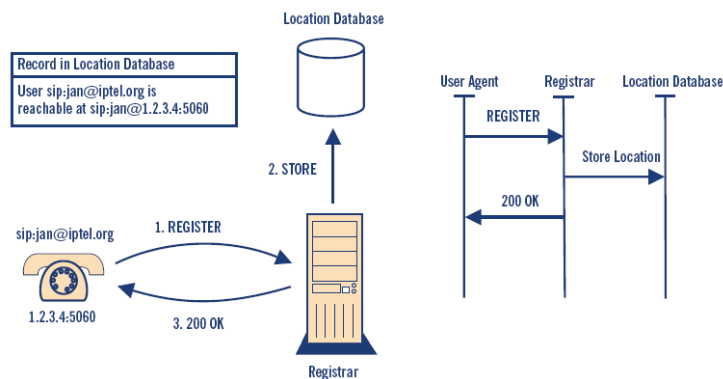


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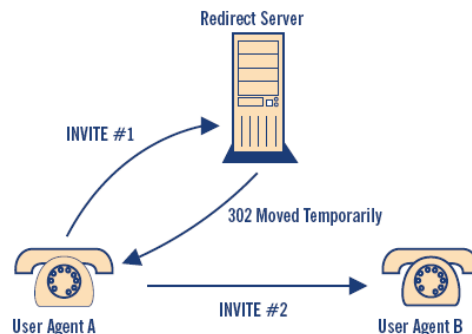
Registrar

- Registracija SIP korisnika i uparivanje URI-IP adresa
- Obično nije poseban uređaj



Redirect server

- Javlja informaciju o mogućim destinacijama pozvanog UA



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SIP poruke

- INVITE
- ACK
- BYE
- CANCEL
- REGISTER

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SIP poruke

- INVITE – poruka kojom se poziva drugi učesnik u razgovoru
- Deo poruke je i SDP (Session Description Protocol)

```
INVITE sip:7170@iptel.org SIP/2.0
Via: SIP/2.0/UDP 195.37.77.100:5040;rport
Max-Forwards: 10
From: "jiri" <sip:jiri@iptel.org>;tag=76ff7a07-c091-4192-84a0-d56e91fe104f
To: <sip:jiri@bat.iptel.org>
Call-ID: d10815e0-bf17-4afa-8412-d9130a793d96@213.20.128.35
CSeq: 2 INVITE
Contact: <sip:213.20.128.35:9315>
User-Agent: Windows RTC/1.0
Proxy-Authorisation: Digest username="jiri", realm="iptel.org",
    algorithm="MD5", uri="sip:jiri@bat.iptel.org",
    nonce="3cef753900000001771328f5aeb8b7f0d742da1feb5753c",
    response="53fe98db10e1074b03b3e06438bda70f"
Content-Type: application/sdp
Content-Length: 451
```

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SDP

```
v=0
o=jku2 0 0 IN IP4 213.20.128.35
s=session
c=IN IP4 213.20.128.35
b=CT:1000
t=0 0
m=audio 54742 RTP/AVP 97 111 112 6 0 8 4 5 3 101
a=rtpmap:97 red/8000
a=rtpmap:111 SIREN/16000
a=fmtp:111 bitrate=16000
a=rtpmap:112 G7221/16000
a=fmtp:112 bitrate=24000
a=rtpmap:6 DVI4/16000
a=rtpmap:0 PCMU/8000
a=rtpmap:4 G723/8000
a=rtpmap: 3 GSM/8000
a=rtpmap:101 telephone-event/8000
a=fmtp:101 0-16
```

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SIP odgovori

- 1xx – Delimični odgovori – 180 Ringing
- 2xx – Pozitivni konačni odgovori – 200 OK
- 3xx – Redirect odgovori
- 4xx – Negativni konačni odgovori (npr. loša sintaksa zahteva)
- 5xx – Problemi u serveru
- 6xx – Zahtev ne može da bude ispunjen ni na jednom serveru (603 Decline)

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SIP OK odgovor

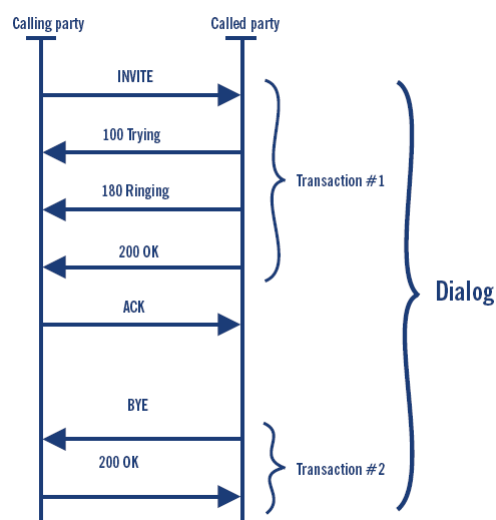
```
SIP/2.0 200 OK
Via: SIP/2.0/UDP 192.168.1.30:5060;received=66.87.48.68
From: sip:sip2@iptel.org
To: sip:sip2@iptel.org;tag=794fe65c16edfdf45da4fc39a5d2867c.b713
Call-ID: 2443936363@192.168.1.30
CSeq: 63629 REGISTER
Contact: <sip:sip2@66.87.48.68:5060;transport=udp>;q=0.00;expires=120
Server: Sip EXpress router (0.8.11pre21xrc (1386/linux))
Content-Length: 0
Warning: 392 195.37.77.101:5060 "Noisy feedback tells:
      pid=5110 req_src_ip=66.87.48.68 req_src_port=5060
in_uri=sip:iptel.org
      out_uri=sip:iptel.org via_cnt==1"
```

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SIP komunikacija

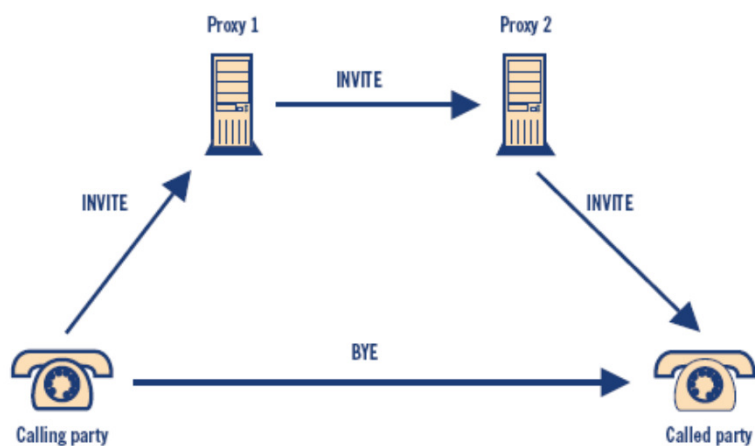
- Transakcije
- Dijalozi



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SIP rutiranje poziva

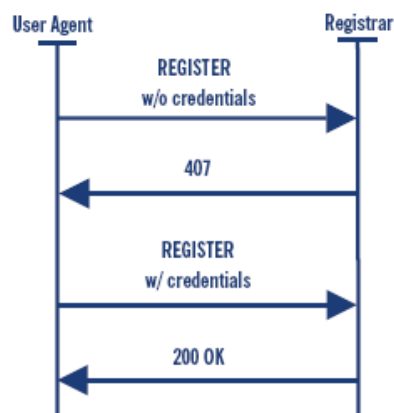


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SIP registracija

- Registracija mora da se periodično obnavlja

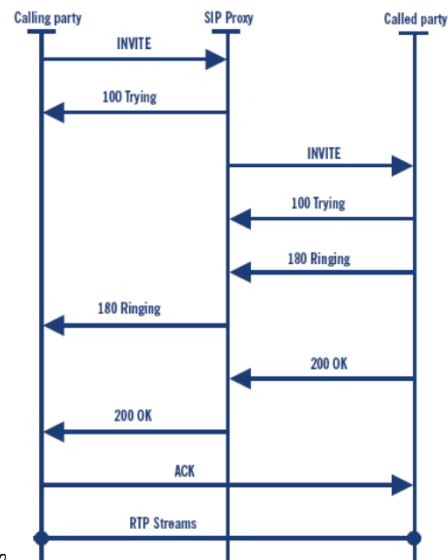


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SIP pozivanje

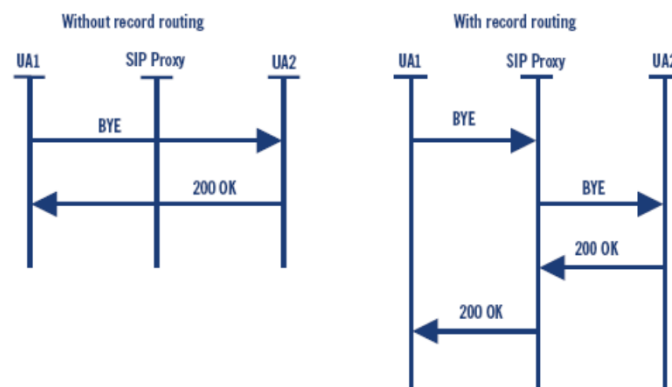
- Trying i Ringing delimični odgovori šalju informaciju da nije potrebno više slati INVITE poruke



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SIP Record Routing

- Kada Proxy vrši “accounting”



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SIP softver/uređaji

- Hardverski telefoni: Siemens, Cisco, Adtech, Polycom, VCON, Nokia E61...
- Softverski telefoni: Windows Messenger, kphone, Linphone, X-Lite,...
- Serveri: VOCAL, SER, AppEngine...
- Gateway: Asterisk, Cisco,...

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Globalna VoIP komunikacija

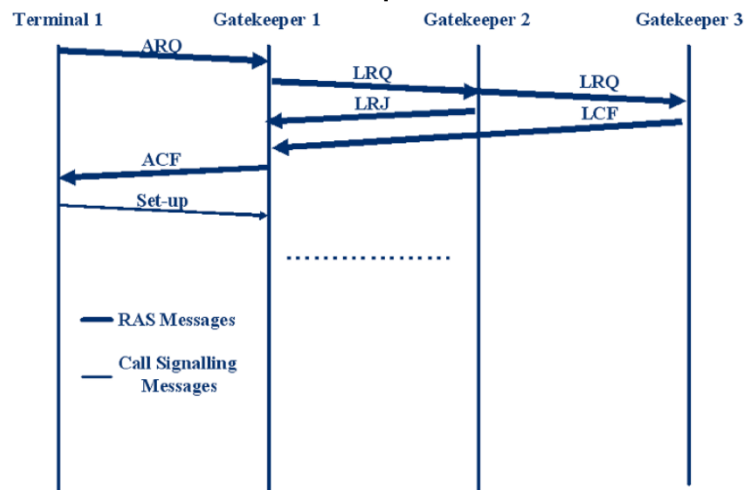
- H.323 LRQ
- H.225.0 Annex G
- TRIP
- SRV RR
- ENUM
- GDS

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H.323 LRQ

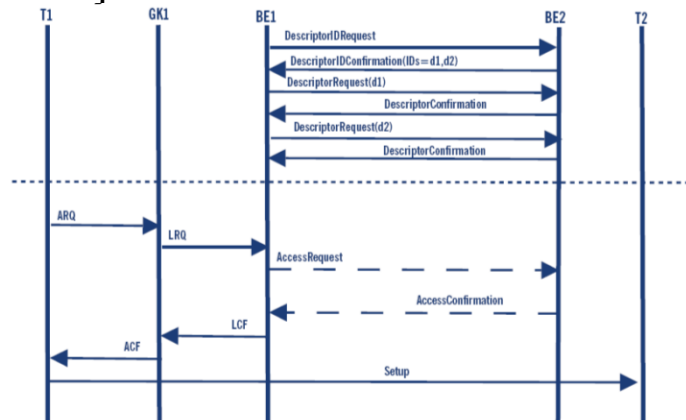
- LRQ – Location Request



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H.225.0 Annex G

- BE – Border Element – Gatekeeper na granici jedne zone



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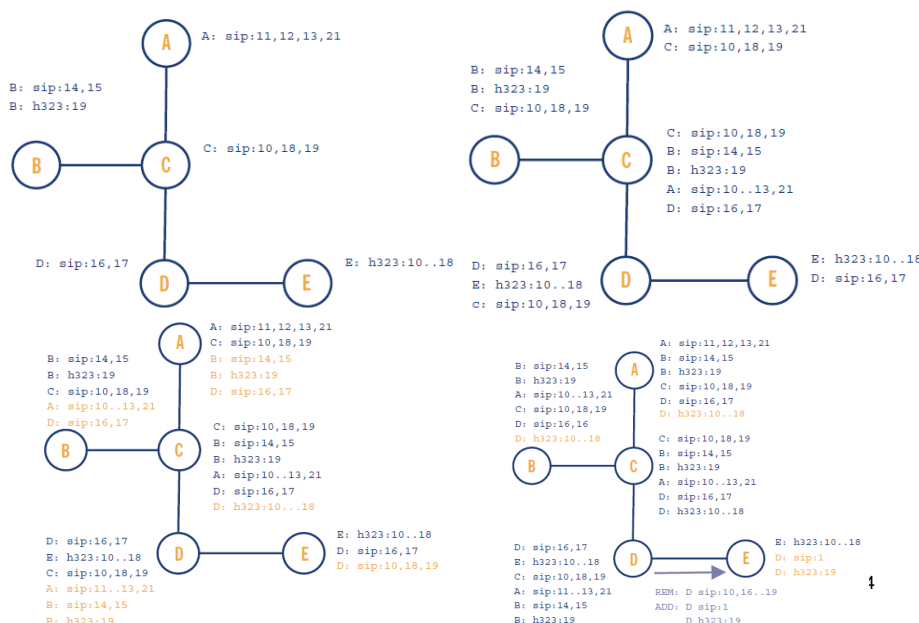
TRIP – Telephony routing over IP

- RFC 3219
- Opisuje način razmene informacija o E.164 brojevima između ITAD (IP Telephony Administrative Domains)
- ITAD ima svoj broj koji dodeljuje IANA
- Može da se koristi i za SIP i za H.323
- Mehanizam funkcionisanja sličan BGP-u

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TRIP – način funkcionisanja



SRV Resource Record

```
$ORIGIN domain.org.
_ldap._tcp SRV 0 1 389 ldap1.domain.org
          SRV 0 3 389 ldap2.domain.org
          SRV 1 0 389 ldap-old.domain.org
*._tcp      SRV 0 0 0      .
*._ucp      SRV 0 0 0      .
```

- `_servis._protokol`
- Prioritet
- Težina
- Port
- Target
- VoIP servisi
- SIP - `_sip`, `_sips`
- H.323
 - `_h323ls`
 - `_h323rs`
 - `_h323cs`
 - `_h323be`

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ENUM

Name – Represents an E.164 number encoded as a domain name. The conversion is done by the following algorithm:

- o All non-digit characters are removed.
+420-123456789 is transformed to 42123456789
- o Dots are inserted between each digit
42123456789 is transformed to 4.2.0.1.2.3.4.5.6.7.8.9
- o Order of digits is reversed
4.2.0.1.2.3.4.5.6.7.8.9 is transformed to 9.8.7.6.5.4.3.2.1.0.2.4
- o To the end is appended string `e164.arpa`
4.2.0.1.2.3.4.5.6.7.8.9 is transformed to
4.2.0.1.2.3.4.5.6.7.8.9.e164.arpa

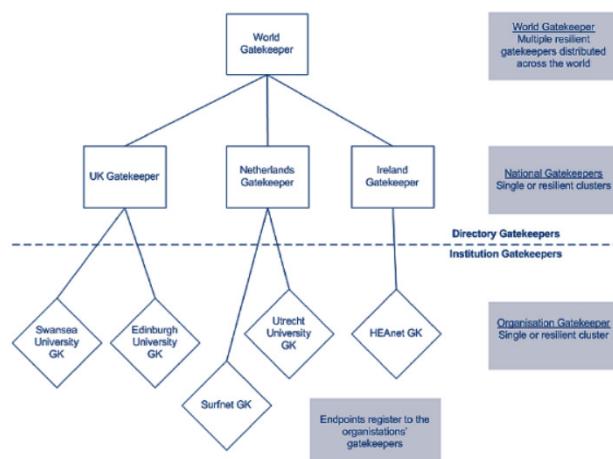
```
$ORIGIN 9.8.7.6.5.4.3.2.1.0.2.4.e164.arpa
IN NAPTR 10 100 "u" "E2U+sip"      "!^.*$!sip:smith@domain.org!" .
IN NAPTR 10 101 "u" "E2U+h323"     "!^.*$!sip:smith@domain.org!" .
IN NAPTR 10 102 "u" "E2U+msg:mailto" "!^.*$!mailto:smith@domain.org!" .
```

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GDS – Global Dialing Scheme

- Za H.323 VoIP 00(IAC) 1(CC) 189(OP) 7201234(EN)



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RTP, RTCP

- RTP – Real Time Transport Protocol
 - Prenos podataka poslatih u realnom vremenu
 - Slanje podataka potrebnih za sinhronizaciju
 - Provera da li su paketi stigli po redu
 - Identifikacija audio i video kodeka
 - Identifikacija pošiljaoca
 - UDP protokol, Port N
- RFC 1889

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RTP, RTCP

- UDP protokol, port N+1
- RTCP – Real Time Control Protocol
 - Informacija o kvalitetu podataka
 - Informacija o broju slušalaca
 - Identifikacija slušalaca
 - Identifikacija pošiljalaca
 - Informacije o prestanku slušanja datog toka

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RTP zaglavlje

```

0          1          2          3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|V=2|P|X|  CC  |M|    PT    |          sequence number         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           timestamp                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           synchronization source (SSRC) identifier            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         contributing source (CSRC) identifiers                 |
|         ....                                                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

```

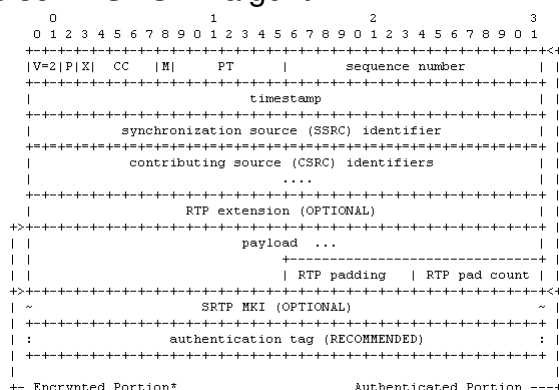
- Sequence number – redni broj paketa
- Timestamp – vreme generisanja datog paketa
- CSRC – izvor(i) koji generišu dati tok

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SRTP – Secure RTP

- RFC 3711
- Obezbeđuje poverljivost, autentikaciju paketa i zaštitu od replay napada
- Koriste se AES i SHA algoritmi



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Standardi za kodiranje zvuka

Standard	Description	Bit rate	MOS
G.711	Pulse Code Modulation using eight bits per sample, sampling at 8000 Hz	64 kbps	4.3
G.723.1	Dual rate speech coder designed with low bit rate video telephony in mind [41]. The G.723.1 coder needs a 7.5 ms lookahead and used one of these coding schemes: * Multipulse Maximum Likelihood Quantisation (MP-MLQ) * Algebraic CELP (ACELP)	6.3 and 5.3 kbps	4.1
G.726	Coder using ADPCM. Contains obsolete standards G.721 and G.723	16,24,32 and 40 kbps	2-4.3
G.727	Five, four, three and two bits per sample embedded ADPCM. The encoding allows bit reductions at any point in the network without the need for coordination between sender and receiver	16,24,32 and	2-4.3
G.728	Low Delay CELP (LD-CELP)	16 kbps	4.1
G.729	Conjugate Structure ACELP (CS-ACELP) These coders need a 5 ms lookahead. * Annex A: Reduced complexity algorithm * Annex D: Low rate extension * Annex E: High rate extension	8 kbps 8 kbps 6.4 kbps 11.8 kbps	4.1 3.7
GSM 06.10	Full rate speech transcoding using Regular Pulse Excitation-Long Term Prediction (RPE-LTP)	13 kbps	3.71
GSM 06.20	Half rate speech transcoding using Vector Sum Excited Linear Prediction (VSELP)	5.6 kbps	3.85
GSM 06.60	Enhanced full rate speech transcoding using ACELP	12.2 kbps	4.48

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Protok glasa

- Kodek G.729 – 8Kbps=8bit/ms
- Paketi se šalju tipično na 20ms -> 160bit=20byte
- Zaglavlja:
 - L2 – 26 bajtova (+12 interframe spacing)
 - IP – 20 bajtova
 - UDP – 8 bajtova
 - RTP – 12 bajtova
- Ukupno -> $20+46=66$ bajtova/20ms = 26.4Kbps

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Standardi za kodiranje slike

- CCIR 601 (ITU-T)
- M-JPEG (ISO)
- MPEG-1 (ISO)
- MPEG-2 (ITU-T + ISO)
- MPEG-4 (ISO)
- H.261 (ITU-T)
- H.263 (ITU-T)
- **H.264/MPEG-4 AVC (ITU-T + ISO)**
- VC-1 (SMPTE)

dr Pavle Vuletic: ROI – H.323, SIP, RTP, RTCP

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