VoIP – early adulthood

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Overview

- VoIP components
- What is different about VoIP?
- Emerging technologies
  - integration of presence, IM and event notification
  - location-based services
  - wireless VoIP
  - multimedia

- Challenges remaining
  - user-programmable services
  - emergency calling
  - CALEA
  - inter-domain
  - spam prevention
VoIP components

- Re-uses whole Internet protocol architecture and transmission infrastructure
  - IP, UDP for transport
  - TLS and S/MIME for security
  - HTTP for configuration

directories

ENUM
H.350

provide URI

signaling

SIP/SDP
H.248
MGCP
H.323

provide destination address

RTP

codecs
(G.7xx, H.26x)
SIP trapezoid

outbound proxy

1\textsuperscript{st} request

SIP trapezoid

2\textsuperscript{nd}, 3\textsuperscript{rd}, … request

registrar

destination proxy (identified by SIP URI domain)

voice traffic

RTP

a@foo.com: 128.59.16.1
Earlier PSTN changes

- starting in 1980s:
  - analog $\rightarrow$ digital transmission
  - in-band $\rightarrow$ out-of-band (SS7) signaling
- end systems relatively unaffected
- few additional services
  - 800#
  - CLASS services (caller ID, call waiting)
- customer relationship largely unaffected
  - except CLECs and reselling
Technology evolution of PSTN

SS7: 1987-1997
Some differences: VoIP vs. PSTN

- Separate signaling from media data path
- But, unlike SS7, same network → lower call setup delay
- Avoid CTI complexity of "remote control"
- Mobile and wireline very similar
- Any media as session:
  - any media quality (e.g., TV and radio circuits)
  - interactive games
- No need for telephone company

Yahoo
  voice service provider (RTP, SIP)

MCI
  ISP (IP, DHCP, DNS)

NYSERNET
  dark fiber provider
PSTN vs. Internet Telephony

PSTN:

Internet telephony:

Belgian customer, currently visiting US
(Early) Adulthood

- “fully developed and mature”
  - Not quite yet, but no longer a teenager
  - probably need another 6 years to be grown up…

- Responsibilities:
  - Dealing with elderly relatives → POTS
  - Financial issues → payments, RADIUS
  - Family emergencies → 911
Why has it taken so long?

- VoIP technology development since 1995
- Web: worked on dial-up, motivated broadband
  - deployment from 1992 to 2000
- VoIP: not usable on dial-up, spurred by residential broadband
- More than just protocols needed:
  - eco-system (management, configuration, OSS, …)
  - interoperability
  - spectrum of products – low to high end
  - interoperation with legacy equipment
Transition to broadband

- Numbers still small, but moving beyond exploratory trials to real deployments
- November 2003: 38% of U.S. home Internet users connect via broadband (Nielsen/NetRatings)
Emerging technologies

- Core VoIP technology largely finished
  - deployment largely due to cost savings, not new services
  - toll and fee bypass
  - integrated infrastructure (LAN & WAN)
  - extend “PBX” reach to home and branch offices
- Presence → from “polling” to “status report”
  - special case of event notification
  - events as common infrastructure for services
  - location-based services
- Integration of IM and VoIP
  - often used in same conference (side channel)
  - IM as initiator of real-time voice/video
Near future: Location-based services

- Finding services based on location
  - physical services (stores, restaurants, ATMs, …)
  - electronic services (media I/O, printer, display, …)
  - not covered here

- Using location to improve (network) services
  - communication
    - incoming communications changes based on where I am
  - configuration
    - devices in room adapt to their current users
  - awareness
    - others are (selectively) made aware of my location
  - security
    - proximity grants temporary access to local resources
Near future: Multimedia

- **Wideband audio**
  - “better than phone quality” → lectures, discussions, speaker phone
  - better codecs → same bandwidth as existing NB codecs
- **Video** phone itself remains niche application
  - given low incremental cost, may be viable
  - useful for sign language
- **Video for group meetings**
  - capture whiteboard

- **Shared applications** (WebEx, etc.)
  - still requires standardization
- **Instant messaging**
  - side channel
- **Better means of coordination (floor control)**
Near future: VoIP over WiFi

- Not fundamentally different from landline VoIP
  - combination cellular + WiFi = wide-area + “cordless” phone
- Small packet sizes make VoIP over WiFi far less efficient than nominal data rate
- Hand-off delay between different base stations → interruptions → CU modified hand-off algorithm
- Delay jitter with high loads → new scheduling algorithms
- L3 hand-off across different network types
Challenge: Global interconnect

- Currently, each VoIP “network” largely isolated
  - interconnect via PSTN even if both endpoints are on IP
  - interconnect via few peering points even if neighbors
- Long-term solution: ENUM DNS listing
  - administration appears difficult
- Short-term for pure-IP (FWD, etc.): special number prefixes
Challenge: Emergency calling

- 911 calling system largely unchanged since 1980s
  - call routing to appropriate destination
  - deliver caller location information
- Fundamental differences for VoIP:
  - may not have phone number
  - may be no “phone company”
  - identifier does not describe location
  - location determination more difficult
- Also use solution for “311” and other location-based call routing systems
## Three stages to VoIP 911

<table>
<thead>
<tr>
<th></th>
<th>spec. available?</th>
<th>use 10-digit admin. number?</th>
<th>mobility</th>
<th>callback number to PSAP?</th>
<th>caller location to PSAP?</th>
<th>PSAP modification</th>
<th>ALI (DB) modification</th>
<th>new services</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1</td>
<td>now</td>
<td>allowed</td>
<td>stationary</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>Dec. 2004</td>
<td>no</td>
<td>stationary nomadic</td>
<td>yes</td>
<td>yes</td>
<td>no (8 or 10 digit)</td>
<td>update</td>
<td>none</td>
</tr>
<tr>
<td>I3</td>
<td>late 2004</td>
<td>no</td>
<td>stationary nomadic mobile</td>
<td>yes</td>
<td>yes</td>
<td>IP-enabled</td>
<td>ALI not needed MSAG replaced by DNS location in-band</td>
<td>GNP multimedia international calls</td>
</tr>
</tbody>
</table>
Challenge: CALEA (lawful intercept)

- Existing models assume congruence of signaling and voice flows
- Challenges:
  - voice service providers outside the US
  - signaling-only providers or no voice providers
  - end-to-end media and signaling encryption (Skype, SRTP)
- Intercept IP traffic, not application
- Assume that long-term, all application traffic (except browsing of public web pages) will have strong encryption
Challenge: User-programmable and context-aware services

- Universal reachability $\rightarrow$ control reachability in time and space by *context*
  - allow callee to decide reachability (defer and decline communication)
  - choose appropriate media (text, automated data response)

<table>
<thead>
<tr>
<th>time</th>
<th>Call Processing Language (CPL), sip-cgi, …</th>
</tr>
</thead>
<tbody>
<tr>
<td>capabilities</td>
<td>caller preferences</td>
</tr>
<tr>
<td>location</td>
<td>location-based call routing</td>
</tr>
<tr>
<td></td>
<td>location events</td>
</tr>
<tr>
<td>activity/availability</td>
<td>presence</td>
</tr>
<tr>
<td>sensor data (mood, bio)</td>
<td>not yet, but similar to location data</td>
</tr>
</tbody>
</table>
Challenge: Spam prevention

- Currently, telemarketing restricted to in-country calling
  - With VoIP, few economical constraints on automated calls from anywhere
  - Also, SPIM (instant message spam)
- Cannot use content-based filtering
- Public key infrastructure (PKI) for individual verification has never scaled
  - provide domain-level verification (~ TLS) in signaling
  - blacklists and whitelists
    - may depend on local domain policies for user verification
  - reputation-based systems
Challenge: Service reliability

- “QoS” $\rightarrow$ service availability
  - loss of network connection
  - loss of infrastructure components
    - DNS, SIP servers, DHCP, ...
  - bursts of packet loss $\rightarrow$ cannot be repaired at end system
  - sustained high packet loss (> 10-15%)

- Current service availability probably around 99.5%
  - realistic goal: 99.9% (10h/year) to 99.99% (1h/year)
Conclusion

- VoIP on cusp of widespread deployment:
  - commercial-grade VoIP products
  - mature standards for key components
  - widespread broadband availability
  - better Internet QoS
- Focus may shift from “bare-bones” VoIP to context-aware communications
- Operational and technical challenges
  - 911, CALEA, network reliability, user-defined services, multimedia
- Thus, roughly where PSTN was in 1980 😊