VoIP Standards for CDMA

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Introduction

• Standards for VoIP and real-time multi-media
  – Not just a replacement for circuit-switched voice
  – Other example services: voice/video conferencing, PTT, Presence and Instant Messaging

• CDMA2000 packet network standards build on results from the IETF and IMS-related standards from 3GPP.

• This presentation gives a roadmap of 3GPP2 specifications.
IETF and VoIP

– IETF provides toolkit for VoIP
– SIP is key protocol, RFC 3261
  • To create, modify, and terminate sessions between users (or devices.) SIP capabilities continue to expand.
– Others include TCP, SCTP, UDP, IP, IPv6, MIPv4, MIPv6, IPsec, RTP, RTCP, RTSP, SDP, DNS, ENUM, DHCP, DHCPv6, DIAMETER, RADIUS, HTTP, RSVP, DiffServ, MSRP, XCAP, ROHC, Sigcomp
– 3GPPs work with IETF to make enhancements as needed, e.g., for better performance in wireless networks
– IETF compatibility enables:
  • leveraging Internet products
  • interworking with Internet services
  • flexible service creation.
IP Multimedia in 3GPP/3GPP2

• 3GPP/3GPP2 standards for IP Multimedia services
  – IP Multimedia Subsystem (IMS) in 3GPP
  – Multimedia Domain (MMD) in 3GPP2 (IMS plus CDMA packet data transport.)
  – 3GPPs decided to harmonize core network. Now nearly identical, see following slide.

• NB, Regulatory issues may cause problems.
  – (VoIP surveillance, tax structure for internet services, E911 and position location, etc.)
Harmonized Architecture
3GPP and 3GPP2

3GPP GPRS Core Network
- SGSN
- GGSN

3GPP2 Packet Data Subsystem
- PDSN
- MIP HA

3GPP RAN
- RNC
- NodeB

3GPP2 RAN
- BSC
- BTS
MMD Architecture - 2

- CSCF: SIP proxy, service controller, network hiding function
- HSS: subscriber database, AAA
IMS/MMD Functional Entities

- **Home Subscriber Server (HSS)** - includes user profiles for the IP Multimedia Subsystem
  - Access from the CSCF uses DIAMETER

- **Call Session Control Function (CSCF)** - provides call control functions
  - **Proxy CSCF**
    - SIP proxy server for the mobile, acting on behalf of MS
    - Forward messages between mobile and other SIP servers
    - Policy control function for QoS authorization
  - **Serving CSCF**
    - SIP registrar, with cooperation from HSS (the location server)
    - Session control call state machine for the registered end-point
    - Interaction with service platforms for service control, by providing service triggers
  - **Interrogating CSCF**
    - Entry point from other networks
    - Allocate or determine the S-CSCF
    - May hide network topology.
3GPP/3GPP2 differences

• 3GPP mandates IPv6, 3GPP2 allows IPv4 + IPv6
• 3GPP2 uses DHCP or configures a P-CSCF address on MS/R-UIM (e.g., SIP URI, IP address.) 3GPP has special GPRS procedure for this.
• 3GPP requires GGSN and P-CSCF to be located in the same network.
• 3GPP2 allows PDSN and P-CSCF to be located in different networks (e.g., PDSN in visiting network and P-CSCF in home network.)
• 3GPP2 packet data service and Mobile IP, vs 3GPP GPRS packet services
• Smart cards optional in 3GPP2
• 3GPP2 allows HTTP digest authentication.
3GPP2 VoIP-related Standards

- Architecture, Security, LMSD
- Call Flows
- Protocol Details
- Access network specifications.

(note – published documents available at www.3gpp2.org)
Architecture, Security, LMSD

- **Stage 1 and Overview Documents**
  - S.R0062, Presence Stage 1
  - X.S0027-001, Presence Architecture
  - X.S0013-000, MMD Overview document

- **Security Documents**
  - S.R0086-A, MMD Security Framework

- **Legacy Mobile Station Domain (LMSD) Documents**
  - (IS-95/2000 circuit mode MS+RAN with VoIP core network)
  - S.R0092, System requirements
  - P.S0002, LMSD - Step 1, incoming PSTN call delivery
  - X.S0012, MSCe-MSCe Signaling Control
  - X.S0018, G.711 PCM voice between MGWs.
Call Flows

• Stage 2 Documents
  – X.S0013-002 IP Multimedia Subsystem (IMS) (based on 3GPP TS 23.228)
  – X.S0013-003 IP Multimedia (IM) session handling; IM call model (based on 3GPP TS 23.218)
  – X.S0013-007 Accounting Architecture (based on TS 32.200)
  – X.S0013-005 IP Multimedia (IM) Subsystem Cx Interface; Signaling flows and message contents (based on TS 29.228)
  – X.S0013-010 IP Multimedia Subsystem (IMS) Sh Interface signaling flows and message contents (based on TS 29.328)
  – X.S0017 Open Service Access (OSA); Application Programming Interface (based on TS 29.198 series)
Protocol & Procedures

• Stage 3 Documents
  – X.S0013-004, IP Multimedia Call Control Protocol based on SIP and SDP; (based on TS 24.229)
  – X.S0013-006, Cx Interface (HSS-CSCF) based on the Diameter protocol; Protocol details (based on TS 29.229)
  – X.S0013-008, Accounting data description (based on TS 32.225)
  – X.S0013-011, Sh interface (HSS-AS) based on the Diameter protocol (based on TS 29.329.)
CDMA Access Network Documents

- Packet Data Serving Node (PDSN)
  - X.S0011-C, Wireless IP Network Standard (IS-835)
- CDMA2000 1x air interface
  - C.S0001 to C.S0006, cdma2000 Family of Standards for Spread Spectrum Systems
  - C.S0047, Header compression/removal service options, allows VoIP to be sent efficiently over the air
- CDMA2000 DO air interface
  - C.S0024-A (IS-856-A), Significant upgrades for supporting QoS sensitive services
  - C.S0063 (TIA-1054), Enhanced Multi-flow Packet Application, eliminates overhead from PPP and octet-based HDLC-like framing. Two-route RLP facilitates seamless BSC-BSC Connected State handoff to eliminate interruption during the VoIP call.
Current Projects

- X.P0011-D, includes MIP6 and QoS support
- X.P00xx, End-to-end QoS
- X.S0013 revision
  - Includes new part for Service Based Bearer Control, X.P0013-012, enables mapping/control of SDP-negotiated QoS to air interface QoS.
- X.P0027, new parts for presence security, protocol, network presence.
- X.P0028, CDMA/WLAN interworking
  - Scenarios 1,2
- X.P00xx, CDMA/WLAN interworking
  - Scenarios 3,4
- X.P0029, IMS Conferencing
- TSB-58-G, to define QoS Profiles
- A-interface
  - IS-878-A / IS-1878-A, QoS support on the A-interface
  - IS-878-B / IS-1878-B, Connected State seamless inter-BSC soft handoff and session transfer
- C.P0023-C, R-UIM cards support for MMD data.
- PN-0196, Lawfully Authorized Electronic Surveillance for cdma2000 VoIP.
Backup slides

• Outline:
  – Requirements/Architectures
  – Call Flows
  – QoS
  – 1x header removal/compression service options
  – Presence/IM.
Wireless Requirements

• Wireline assumptions
  – High processing power, plentiful bandwidth, low delay links

• Wireless has other requirements
  – Devices with limited power, limited bandwidth, not “always on”
  – Links comparatively slow and lossy (could be 5% Frame Error Rate)
  – Mobility issues, including handoff

• SIP characteristics
  – Large messages, text encoding
  – Chatty message exchanges
  – Favors generality and modularity over efficiency

• Using SIP for wireless terminals
  – SIP compression
  – Service implementation on SIP servers, use of SIP proxy servers
3GPP2 Packet Data Subsystem Core Network Architecture Model
LMSD Architecture

Legend
- signaling
- bearer
- signaling and bearer
- part of Service Arch
- not part of Service Arch

Access Gateway (PDSN)

AAA

MSC emulation
Media Gateway

Media Resource Function Processor

Legacy MS Domain Support

HLR emulation
MSC emulation
SCP emulation

Border Router

IP Network

PSTN

TIA/EIA-41

BTS
BSC/RNC + PCF

cdma2000 Access Network

Mobile Station
MMD Core Network Architecture
MMD Application Server Architecture
Mobile Software Architecture

User Interface / Application / System Control

IMS Service Control

Media Processing

Media Resource Control

SIP Protocol Stack

QoS Translation

IP Bearer Transport

IP Bearer Control

Radio Bearer Transport

Radio Bearer Control
IP Multimedia Protocol Stack

- Application signaling and media traffic are transported over IP.
- Example VoIP application protocols:
  - SIP (Session Initiation Protocol) for VoIP signaling
  - RTP (Real-time Transport Protocol) for media transport
MMD High Level Call Flow

1. Mobile
2. BSC/PCF
3. MSC
4. PDSN
5. AAA
6. HA
7. P-CSCF

Traffic Channel

PPP setup and authentication

Mobile IP Registration

P-CSCF Discovery and MMD SIP Registration

MMD SIP Call Setup

MMD Media Bearer Setup
3GPP2 MMD Security

IMPU

NAI

IMS Security Association

MIP MN-HA Authentication (Mobile IP)

CHAP (Simple IP) / MIP FAC (Mobile IP)

CAVE / AKA

End-to-End Security Association (optional)

Mobile Station

BSC/PCF

PDSN

Home Agent

CSCF

Far-End Terminal

Auth. Center

AAA

IMSI

NAI

AAA
Basic SIP Call Flow
Quality of Service Overview

- Quality of Service (QoS) refers to the provision of different quality assurances to different traffic streams, according to application requirements.
- **QoS parameters** for data transport include:
  - Bandwidth, Reliability, Delay and Jitter
- **QoS control mechanisms** include:
  - Admission Control
  - Traffic classification
  - Queuing and policing policies
  - Congestion control
- **Cdma2000 1x and EV-DO** support the provision of different QoS treatments to different application data streams.
Cdma2000 Packet Data QoS Signaling
Application QoS

- Different types of applications with different QoS requirements (traffic classes):
  - Conversational, Streaming, Interactive, Background, and Signaling (system function to support other applications)

- Application QoS requirements are negotiated between end-system applications.
  - Application QoS requirements are later translated into access and transport QoS requirements.

- In 3GPP2 MMD, application QoS requirements are carried in SDP (Session Description Protocol) parameters in SIP messages between SIP end-points.
IP Layer QoS

• Differentiated Services (**DiffServ**)
  – Packets are marked for different QoS treatments
  – Packets with different DiffServ markings are given different QoS treatments by the network
  – Service Level Agreement defines QoS mappings between networks

• Integrated Services (**IntServ**) with RSVP
  – End to end QoS reservation, with path setup for each direction
  – QoS is guaranteed by RSVP-capable routers on the path
  – Does not scale as well as DiffServ

• RSVP parameters are used in 3GPP2 to describe transport QoS in cdma2000 1x and EV-DO packet data networks
  – Carried in QoS signaling between MS and PDSN
  – Carried in QoS signaling between BSC/PCF and PDSN
1x Header Compression/Removal

- **CDMA2000 1x** has defined two zero-byte header compression schemes:
  - **SO-60**: zero-byte header removal
    - No RTP/UDP/IP header generation in the mobile
    - Simpler implementation in the mobile
  - **SO-61**: zero-byte header reduction
    - RTP/UDP/IP header re-generation in the mobile
    - Need ROHC context synchronization headers
    - Support applications running over RTP

- **Properties of zero-byte header compression:**
  - Voice packets fit perfectly in fundamental channel frames
  - No packet data protocol header overhead over the air
  - No wasted radio link resource to carry padding bits
  - Higher radio network efficiency and voice quality.
Header Removal (SO60)

- In reverse direction, HRU in PDSN adds a header to each received codec frame
- In forward direction, HRU in PDSN removes headers
- Speech frames are transported as in circuit switched mode.
LLA-ROHC (SO61)

• Link-Layer Assisted Robust Header Compression (RFC 3242)

• Extended from normal ROHC. Link-layer mechanisms:
  – In order delivery of data over the air link, NO retransmission.
  – Detection of packet loss over the wireless link.
  – Packet type identification to distinguish NHP and other packets.

• Not applicable if UDP checksum is enabled. (e.g. IPv6/UDP case)

• Not applicable if parts of the original headers are encrypted as in IPSEC.
SO60/61 Call Flows

1. Packet data session establishment, authorization and authentication (Main service instance setup)
2. SIP INVITE
3. SIP messages exchanges
4. EOM (SR_ID, SO60/61)
5. SCM
6. A11 RRQ
7. A11PPP
8. 3GPP2 RESV message
9. 3GPP2 RESV/Conf message
10. SIP messages exchanges
11. Packet flow over auxiliary service instance
Cdma2000 VoIP Protocol Headers

<table>
<thead>
<tr>
<th>Header Name</th>
<th>Header Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media header</td>
<td>0+ byte</td>
</tr>
<tr>
<td>RTP header</td>
<td>12 bytes</td>
</tr>
<tr>
<td>UDP header</td>
<td>8 bytes</td>
</tr>
<tr>
<td>IP header (IPv4)</td>
<td>20 bytes</td>
</tr>
<tr>
<td>PPP overhead</td>
<td>4 bytes</td>
</tr>
<tr>
<td>RLP overhead for RS-2 FCH</td>
<td>18 bits (16 bits + padding)</td>
</tr>
<tr>
<td>RLP overhead for RS-1 FCH</td>
<td>19 bits (16 bits + padding)</td>
</tr>
</tbody>
</table>

- Without header compression, the above protocol headers cannot fit in one FCH traffic frame
  - RS1 frame size = 171 bits = 21.375 bytes (EVRC, SMV)
  - RS2 frame size = 266 bits = 33.25 bytes (QCELP)
- “Bundling” can be used to share RTP/UDP/IP/PPP header among multiple voice frames, but this increases media latency.
  - Without header compression, a bundling factor of at least 6 is needed to transport half-rate EVRC frames over RS-1 traffic channel.
Non-Zero-Byte Header Compression

<table>
<thead>
<tr>
<th>Header compression schemes</th>
<th>Minimum header size for compressed RTP/UDP/IP headers</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFC 3095 (ROHC)</td>
<td>1 byte</td>
</tr>
<tr>
<td>RFC 3545 (ECRTP)</td>
<td>2 bytes</td>
</tr>
<tr>
<td>RFC 2507 (for UDP/IP)</td>
<td>(2+12) = 14 bytes</td>
</tr>
</tbody>
</table>

- With non-zero-byte header compression, the following uncompressed protocol overheads also need to be carried:
  - Media header (0+ byte)
  - PPP overhead (4 bytes + byte-stuffing)
  - RLP overhead (2 bytes + padding), assuming FCH
- Carries lower rate codec frames, assuming no bundling
  - ROHC on RS1 FCH only supports half-rate EVRC or SMV mode 4.
  - ROHC on RS2 FCH supports SMV, EVRC, or 13K mode 4.
- Easy to introduce new codecs, but overhead is significant compared to Zero-byte header compression
SIP Compression

• SIP messages are used for MMD signaling
  – Encoded in text, and each can be hundreds of bytes long
  – Long call setup delay over slow and error-prone radio link
  – SIP compression is needed to reduce call setup delay

• SigComp defined by IETF for compressing text-based signaling protocols (e.g., SIP, SDP, RTSP)
  – Used for MMD
  – Universal Decompressor Virtual Machine (UDVM)
    • Can support a wide-range of text-based decompression algorithms
  – SigComp compressor
    • Can send compression algorithm code with the first compressed message to decompressor

• SIP compression algorithms
  – Template-based: taking advantage of static SIP message structure
  – Dictionary-based: using static and dynamic dictionaries
Presence/IM

- 3GPP/3GPP2/OMA focused on SIP/SIMPLE for Presence and Instant Messaging
- SIP Subscribe/Notify and Message methods
- Watcher subscribes to presence events
- XCAP to manage user data (e.g., buddy lists.)
- Work in progress
  - Presence Network Agent uses SIP Publish to declare presence information received from AAA.
Presence Architecture

- CSCFs serve as watcher/presentity proxies
- Network may update presentity (via HSS/AAA interface or presence user agent)
- IM Server and applications connect to CSCF proxies.

Presence suppliers

- Presence External Agent
  (presence information provided by the elements outside of the provider’s network)
- Presence User Agent
  (presence information provided by the user)
- Presence Network Agent
  (presence information provided by the network)

Interfaces Ph, PI, Pc, Pk, and PI are based on existing procedures, e.g., MAP, TIA-41, RADIUS, ISC, Cx, Sh
Acronyms

• 3GPP/2: 3rd Generation Partnership Project/2
• AAA: Authentication, Authorization, and Accounting
• AKA: Authentication and Key Agreement
• AS: Application Server
• BGCF: Breakout Gateway Control Function
• BSC: Base Station Controller
• BTS: Base Transceiver Subsystem
• CDMA: Code Division Multiple Access
• CS: Circuit Switched
• CSCF: Call/Session Control Function
• GGSN: Gateway GPRS Support Node
• GSN: GPRS Support Node
• GPRS: General Packet Radio Service
• HSS: Home Subscriber Server
• I-CSCF: Interrogating CSCF
• ITU: International Telecommunication Union
• IMS: IP Multimedia Subsystem
• IM: Instant Messaging
• MGCF: Media Gateway Control Function
• MGW: Media Gateway
• MMD: IP Multi-Media Domain
• MRF: Multimedia Resource Function
• MS: Mobile Station
• MSC: Mobile Switching Center
• OMA: Open Mobile Alliance
• PCF: Packet Control Function
• P-CSCF: Proxy CSCF
• PDSN: Packet Data Serving Node
• PS: Packet Switched
• QoS: Quality of Service
• RAN: Radio Access Network
• RLP: Radio Link Protocol
• RTP: Real-time Transmission Protocol
• SBBC: Service Based Bearer Control
• S-CSCF: Serving CSCF
• SDP: Session Description Protocol
• SGSN: Serving GPRS Support Node
• SIP: Session Initiation Protocol
• UE: User Equipment
• UMTS: Universal Mobile Telecommunications System
• WCDMA: Wideband CDMA